مجلة الدراسات التربوية والعلمية - كلية التربية - الجامعة العراقية
العدد الثالث والعشرون - المجلد الثامن - علوم الحياة - تموز 2024 م
doi.org/10.52866/esj.2023.08.23.13

A Review of Anatomical and Histological feature of the Kidney in Different Species of Birds

Wafaa Barghash Obaid and Nahla A. Al-Bakri
Department of Biology, College of Education for Pure Science (Ibn Al-Haitham), University of Baghdad, Baghdad, Iraq.

Abstract :

The kidneys are important organs for their role in maintaining the balance of fluids in the body and removing waste, excess water and electrolytes from the blood, as well as producing several hormones such as the renin hormone and prostaglandins. the colors ranged from brown to red, and the kidneys varied in volume. Various studies showed that there were differences in the morphological measurements of the right and left kidney in the individual species, also histological studies showed that the kidney is histologically composed of a broad cortical area and a small medullary area and no boundaries are separating the two areas. The cortex tissue contains nephrons, which are reptilian type and mammalian type nephrons, in addition to the proximal and distal convoluted tubules lined with a simple cuboidal epithelium, either the medullary area is represented by structures known as medullary cones randomly distributed in the kidney tissue and contains the thin and thick segments of the Henle's loop, either the cells lining the tubules and the collecting ducts are cuboidal to columnar shape.

Keywords: Aves, kidney, Glomerulus.

استعراض السمات التشريحية والنسجية للكلية في انواع مختلفة من الطيور

وفاء برغش عبيد ، نهلة عبد الرضا البكري
قسم علوم الحياة، كلية التربية للعلوم الصرفة (ابن الهيثم)، جامعة بغداد، بغداد، العراق

مستخلص

تعد الكلى من الاعضاء المهمة لما تقوم به من دور مهم في الحفاظ على توازن السوائل في الجسم وازالة الفضلات والماء الزائد والكهارل من الدم اضافة الى افرازها العديد من الهرمونات كهرمون الرنين والبروستكلاندين. التركيب التشريحي للكلى اظهر ان الكلية في الطيور مكونة من ثلاثة فصوص تختلف اشكالها بحسب انواع الطيور المختلفة، واما الوانها فتراوحت بين الاحمر والبني، كما تختلف الكلى من حيث حجومها. اظهرت الدراسات المختلفة ان هناك اختلافات في القياسات الشكلية للكلية اليمنى واليسرى في افراد النوع الواحد، كما اظهرت الدراسات النسجية ان الكلية مؤلفة نسجيا من منطقة قشرية واسعة ومنطقة لبية صغيرة ولا توجد حدود فاصلة بين المنطقتين. يحتوي نسيج القشرة على النفرونات وهي نفرونات نوع الزواحف ونفرونات نوع اللبائن اضافة الى النبيبات الملتوية القريبة والبعيدة المبطنة بظهارة مكعبة بسيطة، اما منطقة اللب فانها ممثلة بتراكيب تعرف بالمخاريط اللبية موزعة بشكل عشوائي في نسيج الكلية وتحتوي على القطع النحيفة والسميكة لعروة هنلي اما الخلايا المبطنة للنبيبات والقنوات الجامعة تكون مكعبة الى عمودية الشكل.

الكلمات المفتاحية: طيور، كلية ، كبيبات.

1. Introduction:

Birds are important animals, especially poultry, because of their economic importance, and they also play an important role in the biocontrol against insects and rodents that threaten the economy of countries (Alkafagy *et al*., 2019), as a result many studies have been carried out, including Abed study (2020) on the white chocked bulbul and Hamad *et al*. (2021) in their study in ovarian tissue in quail bird.

Other studies dealt with the study of the kidney in birds because of its importance. It is one of the important organs of organism because of its important role in maintaining the balance of fluids in the body and removing waste, excess water and electrolytes from the blood Al-Musawiu and Al-Bakri (2022), in addition to producing some hormones as Renin hormone , that regulate blood pressure, the creates of the necessary Erythropoietin in the production of red blood cells, the also contributes to the prostaglandin, that reduce blood pressure at its height, amino acids and enabling tissues to destroy them and of utilize them (Ali *et al*., 2023). This article aimed to summarize the scientific literature on the morphological description of the kidney and review the morphological changes in it due to the biological diversity of birds and the difference in species between them, and to review the scientific literature on the histological structure and the impact of the environment in which the bird lives on the structure and function of the kidney.

The kidneys in the birds are in the form of elongated irregular organs with a dark brown color that are fragile to the touch William and Braun , (1980) , and is also large compared to the mammalian and reptilian and each kidney consists of three lobes represented by the cranial, middle and caudal lobes (Al-Taai and Nasif , 2020) and take a symmetrical location in a bony depression within the synsacrum called the renal fossa Khadhim and Dauod , (2014), which is extending from the caudal edge of the lung and ending at the caudal end of the synsacrum (Batah , 2012) (Figure 1).

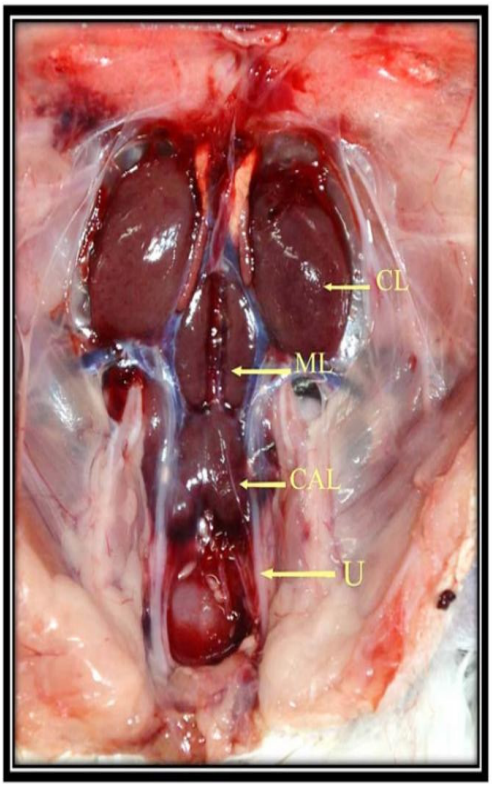

Figure 1: The general appearance of the renal system in the white owl *Tyto alba*, in which the location of the kidney within the body cavity, the three lobes of the kidney and the ureters is shown. Cranial lobe (CL), medial lobe (ML), caudal lobe (CAL), ureter (U). (Khadhim and Dauod, 2014).

2. Anatomical description of the Kidney

2.1. The shape and dimensions of the kidney

The shape and volume of the kidney lobes vary from one species to another in different birds. Abood *et al*., (2014) in a study compared of three species of birds, indicated that the kidney in the harrier and chicken was brown while the kidney of mallard was greyish and each kidney is consisted of three lobes and the lobes showed a color difference. In the harrier strain, the cranial lobe was the largest and most elongated compared to the middle lobe of medium elongation, while the caudal lobe was triangular in shape, as in the ducks. The cranial lobe was small with a circular to oval shape, the middle was elongated and the caudal lobe was larger and more elongated in the middle lobe, while in chickens the three lobes appeared relatively large. Reshag *et al.,* (2016) explained that the kidney in the flamingo *Phoenicopterus roseus*

consisted of three separated lobes from each other, the cranial lobe was oval in shape and the middle lobe was narrow and elongated in shape, while the caudal lobe was the larger and irregular shaped.

In a comparative study of the kidney in domestic chickens, *Gallus gallus* and domestic ducks *Anas platyrhyches* it was observed that the three parts of the kidney division were not completely separate and the difference between the kidneys in the two types in color . The color in ducks reddish brown and in chickens red color in addition to that the caudal part was irregular and large either in chickens the caudal part was oval in shape (Ali and Reshag, 2020).

The boundary between the kidney divisions are not always clearly defined, and can be determined through the location of the large blood vessels through which they pass, such as the iliac artery and the ischium artery King and McLelland (1984) , where Chinsson (1984) stated that the boundary between the cranial and medial parts was determined by the groove occupied by the femoral artery. While the boundary between the middle and caudal parts was determined by the groove occupied by the sciatic artery, most birds that do not belong to Passeriformes, such as fowls, doves and geese, have the parts of the kidney distinct from each other: In Passeriformes, the middle parts of the kidney is not distinguished and fuses to a large degree with the caudal parts (King and McLelland, 1984). On the other hand in canaries, budgerigars and penguins the caudal part of the two kidneys merge into the medium (McLelland, 1990).

The kidneys in birds also differ in terms of their volumes, as they mentioned Abood *et al.* (4014), when studying the kidney in three breeds of birds, that there are differences between the length and width of the three kidney lobes as shown in Table (1).

Table 1: Illustrated the measurements of kidney's lobes and their total lengths (n=5 in each species) (N=15).

Species	Cranial lobe		Middle lobe		Caudal lobe		Total length/ mm
	Length/ mm	Width/ mm	Length/ mm	Width/ mm	Length/ mm	Length/ mm	
Circuc auerogi-nosus	20±0.1	9±0.2	7±0.1	5±0.5	9±0.2	4±0.2	36±2
Anas platy-rhynchos	10±0.3	6±0.1	20±0.1	8±0.2	30±0.2	10±0.1	60±1
Gallus domesti-cus	15±0.2	11±0.1	9±0.3	4±0.4	28±0.2	9±0.2	53±2

Mean±Standerd error

3. Histological and Histochemical feature of the kidney:

3.1 Capsule

The kidney in birds is surrounded by a capsule from connective tissue in the white owl bird *Tyto alba* and the Iraqi black pheasant *Francolinus francolinus*. The kidney in two birds is surrounded by a thin capsule of connective tissue in which the collagen fibers, fibroblast and some reticular fibers have appeared the mean thickness of the capsule is 9.250 µm in the white owl bird and in the Iraqi pheasant bird the mean thickness of the capsule 6.500 µm (Khadhim, 2014).

Researcher Singh *et al*. (2020a) indicated that the kidney in Guinea fowl birds comprises dense connective tissue containing reticular fibers, elastic fibres and collagen fibres. Al-Ajeely and Mohammad (2012) indicated that the kidneys in the squab pigeons were covered with a thin capsule and in adults the capsule appeared very thin, the kidney in quails is surrounded by a thin capsule containing reticular fibres when using Verhoeff's stains Mobini and Abdallahi , (2016) .

3.2. Lobules of the Kidney

The kidney lobules in birds are the basic structural unit, many of which can be observed on the surface of each part of the kidney and they look like irregular multi-face structure combinations that are interconnected (Al-

Ajeely, 2010). King and Mclelland (1984) indicated that many lobules in the kidney that take the form of pear shapes chickens align these lobules with the interlobular vein of the renal portal system, some of them superficial and others are limited by collecting tubules, and each lobule consists of a wide cortex and medulla. The cortex constitutes about 71-81% and the medulla constitutes 5-15% of the total lobule area. Mohammed *et al.,* (2009) in the study of kidney tissue in *Buteo buteo* and Khadhim and Dauod , (2016)in the study of the kidney tissue in the Iraqi black pheasant bird and the Archana *et al.,* (2017) study of the Emu of *Bromains novaehollandae* kidney and ducks *Anas platythynches* that indicated that the kidney lobules consist of a large cortical region and an internal that occupied a small area of the lobule, it was medullary region.

3.3 The renal cortex and medulla

The tissue of the kidney in birds is characterized by the absence of boundaries between the cortex tissue and the medulla tissue as found in the mammalian (Yousif and Rabee., 2019), Siller and Hindle., (1969) indicated that the cortical part of the bird kidney contains both types of nephrons, reptilian type nephron that lose Henle's loop and mammalian type nephron containing the Henle's loop. Casatti., (2001) when studying the kidney in house sparrows found that most of the kidney tissue is made up of the cortex area with a small part of the medulla and the cortex area contains proximal convoluted tubules, distal convoluted tubules and renal corpuscles, while the medulla area contains the thin and thick segments of Henle's loop, the collecting ducts and capillary blood vessels.

The renal medulla in the Gambel's quail bird explained that it is presented by small units (smaller than those found in mammalian) and these units form medullary cones. It contains the collecting duct and the thin and thick segments of Henle's loop Casotti *et al*., (2000).Nabipour *et al.,* (2009) when studying in two types of species; pigeons and owls bird stated that the cortex area occupies a large area compared to the area occupied by the medulla, as well as Mobini and Abdollah.,(2016) indicated the presence of elastic fibers in the connective tissue surrounding the medullary cone of the Japanese quail kidney when using Masson's trichrome stains.

In a study on bird species living in

different environments indicated that birds living in moderate and aquatic environments had a wide cortical area 78-80% and a small medulla area ranging between 6-9%, while birds living in arid regions had a larger proportion of medulla, with a cortex ratio of 78% and medulla 14%, Warui., (1989).

4. Nephron

Nephrons are structural and functional units of the kidney, located in lobules and composed of the glomerulus which is a node of capillaries, the loops of Henle, renal tubules and peritubular capillaries referred by Al-Ajeely , (2010) during his study on pigeons. The kidney of birds has a unique structure that different from the rest of vertebrates. Casotti and Braun., (2000) stated that in sparrow species the kidney contains nephrons missing the loop of Henle, found in the peripheral site of the cortex and called the reptilian or cortical type, while the other type is called the medullary or mammalian type and these extend to the deep parts of the cortex to reach the medulla area.

The kidneys of the desert quail contain reptilian type nephrons in the form of simple tubes that fold on themselves four or three times and the nephrons become more complex towards the core area where the nephrons begin to form close convoluted tubules with many twists, distant tubules and Henle's loops Braun and Dentzler., (1972) .

4.1 Renal corpuscles

The renal corpuscles represent the first and extensive part of the nephron and represent the site of effective plasma filtration in all nephrons, the renal corpuscles in the kidneys of birds show a difference in volumes, Casotti and Richardson., (1993) indicated that the corpuscles in the peripheral cortex area of the kidneys of the honeyeaters *Meli phagid* have diameters of approximately 30 micrometres, while the corpuscles in the juxtamedullary have diameters of up to 40 micrometres.

Dantzler., (2016) found that the renal corpuscle in birds consists of a network of capillaries called glomerulus surrounded by a goblet capsule called Bowman's capsule, the Bowman capsule is a bilayer inner includes the visceral layer consisting of highly specialized squamous epithelial cells called Podocyte, while the outer layer is the parietal layer composed in simple squamous epithelial tissue and the space between the outer and inner layer is known as Bauman's space as men-

tioned by Hobson *et al*., (1988) when studying *Pekin* Ducks and as mentioned by Cazimir *et al.,* (2008) when studying the kidney in the *Coturnix coturnix japonica*. Satchell and Braet ., (2009) indicated that the center of the glomerulus consists of a solid mass of mesangial cells surrounded by capillary loops and the wall of these loops consists of a fenestrated endothelium, it is believed that the mesangial cells secrete a pad similar to the basal plate that closes the lining and therefore they play a supporting role or It may become phagocytic to remove large protein molecules that collect during the filtration process.

The kidney in domestic chicken and desert quail indicated that the glomerular capillaries of the looped nephrons are more complex than those of loopless nephrons. The glomerular capillaries of the first type are centrally arranged around the mesangial tissues of the glomerulus in the form of a dichotomous network, while in loopless nephrons, the capillaries are folded slightly, consisting of a capillary, single capillary with a small amount of glomerular mesangial tissue Casotti and Braun ., (1995). Also Shehan *et al*., (2020) mentioned when studying the kidney in the falcon berigord the appearance of a positive reaction to the components of the glomerulus when treated with Periodic Acid Schiff's (PAS) stains indicating the presence of polysaccharides granules, Reshag *et al*., (2017) indicated the appearance of a strong positive reaction when treated with complex PAS & Alcian blue indication of the presence of acidic and neutral mucopolysaccharide in the components of the glomerulus when in the study of several species of birds.

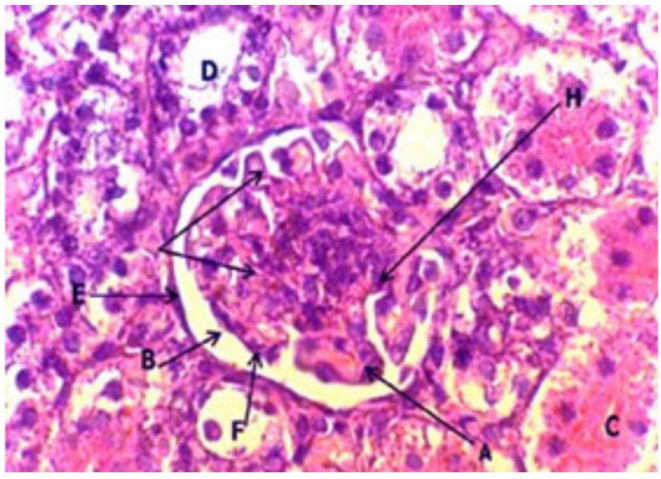

Figure 2: Microphotograph showing medullary regions of the Kidney in Kestrel.
A: podocyte nucleus, B: bowman's space,
C: proximal convoluted tubules,
D: distal tubules, E: parietal layer, F: visceral layer,
H: mesangial cells. H&E, 400X.
About Alkafagy *et al*., (2019).

The Juxtaglomerular apparatus, which is located near the glomerular hilum at the area of adhesion of the distal tubule with the renal corpuscles and consists of vascular components including the afferent and efferent arteries and tubular components representing the macula densa, which is part of the distal tubule Barajas., (1979) . As indicated by Deef., (2015) during his study on *Fulica atra* and *Gallinula angulata* birds, this macula is a group of specialized cells from the distal convoluted tubules wall and is believed to perform an important sensory function because it transmits chemical signals in the Juxtaglomerular apparatus with controlling vital kidney functions such as renal blood flow, glomerular filtration and renin enzyme release, as indicated by Singh *et al.,* (2020) during their study on Guinea fowl birds.

Kone *et al*., (1986) referred to the shape and distribution of cells adjacent to the glomeruli in the chicken kidney and stated that they contain fine secretory granules with diameters of up to 350 nm and also contain myofibrils in the cytoplasm, three types of these cells were described according to their location, namely A cells located on the walls of the glomerular arteries, V cells located next to the vascular pole of the glomeruli and M cells and called the mesangial type and located in the mesangial area of the kidney (Figure 3).

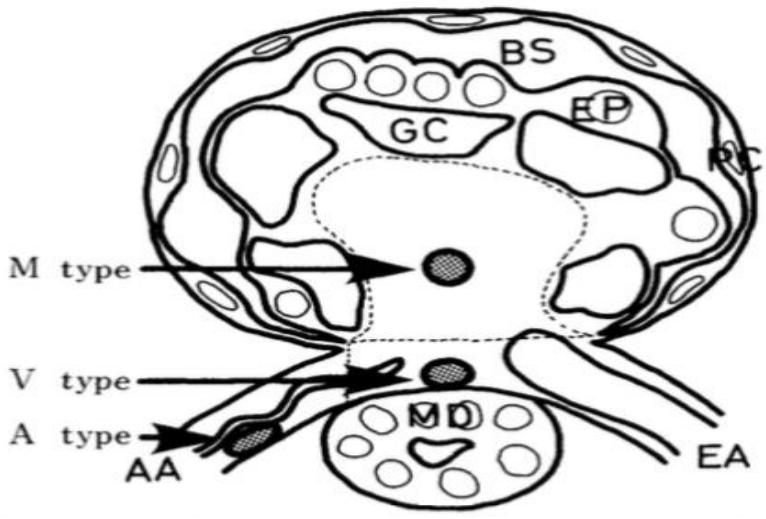

Figure 3: A schematic drawing of the localization of the three types of JG cells. AA: afferent arteriole, BS: Bowman's space, EA: efferent arteriole, EP: epithelial cell, MD: macula densa , GC: glomerular, PC: parietal cell, capillary, about Kone *et al.,* (1986).

The area where the afferent arteriole and the efferent arteriole of the renal corpuscles are located is called the vascular pole opposite this pole is the urinary pole where the capsular epithelium is connected to the cuboidal epithelial of the proximal convoluted tubule Dauod and Israa.,)2021(when studying kidney in the two species of birds Barn Owl, *Tyto alba* and *Francolinus francolinus* birds Barbara and Johan.,(2000).

4.2 Proximal convoluted tubule

The proximal convoluted tubule is directly attached to the urinary pole of the glomeruli at the point where the proximal tubule leaves the renal corpuscle as showed by Casotti and Richardson., (1993) when studying the kidney in honeyeaters and the convoluted tubule near the parietal layer of the Bowman capsule arises at the urinary pole of the renal corpuscle and this is confirmed by Deepa *et al*., (2020) when they study broiler chicken and ducks. Mohammed *et al*., (2009) mentioned during their study on the *Butea butea* that the proximal convoluted tubules represent the basic part of the cortical type of nephrons and represent almost half of the total length of the nephrons and be less than half as several medullary nephrons. The proximal convoluted tubule is easily distinguished in the cross-sections of the kidneys of birds by the presence of the brush border microvillus, because they have at the free surface of the epithelial cells long follicles that collectively form what is known as the brush border, as shown by Batah., (2012) on the *Fulica atra* and Rashag *et al*., (1993) during their study on several species of birds.

Casotti and Richardson, (1993) and Bataille *et al*., (2008) showed on bird wattle and bird species that the volume of the brush border area in the proximal convoluted tubule varies according to the types of birds in the environment in which they live since birds that live in arid regions are characterized by the presence of a brush border thicker and higher than in birds that live in humid areas and this is an adaptation to increase water absorption, because of the proximal convoluted tubule absorbs about 70% of the volume of water. The presence of the brush border increases the surface area to accomplish the act of absorption as referred Sabat., (2000) during his study to saltwater birds. Casotti and Richardson., (1993) pointed out that the proximal convoluted tubule in honeyeater birds is lined with a

cuboidal epithelium and the cytoplasm contains central nuclei and the free surface of the cells contains a brush border thickness of 12 µm and at the basal surfaces of the tubule cells appear many folds of the plasma membrane where some mitochondria gathered arranged parallel to the longitudinal axis of the cell and the presence of mitochondria in these cells indicates the role of these cells in the process of ion transport.

The proximal convoluted tubules in nectarivorous kidneys described by Casotti *et al.,* (1998) as long and may extend in some nephrons up to two-thirds of the descending limb of the Henle loop.

Sehan *et al*., (2020) reported the appearance of positive interaction with the Ab and PAS stains in the study of the Iraqi falcon kidney which is an indication of the presence of polysaccharide compounds in the cytoplasm of the epithelial cells in lobules of the proximal convoluted tubules, and that indicated by Niabipour *et al*., (2009) when studied species of birds and Mobini and Abdollabi., (2016) by studying the Japanese quail kidney.

4.3 Henle's loop

The studies of the kidneys in domestic chickens *Gallus domesticus*, *Passer domesticus*, domesticus pigeon Dehkordi and Hbibi , (2015) and Bacha and Bacha., (2000) in chicken indicated that the Henle's loop consists of a thin segment that arises from the proximal convoluted tubules that suffer during their passage through the medulla area from a gradual decrease in diameter to be thin segment and then change their diameter suddenly to form a thick segment, the thick segment extend to the base of the cortex before they merge with the distal convoluted tubules and the thin segment form part of the descending limb of the Henle loop, while the thick segments form part of the ascending limb of the Henle loop, the thickest part is twice as wide as the thin part and both are lined with cuboidal cells. Also Singh *et al*., (2020b) in Guinea fowl and Al-Agele ., (2012) in *Aquila chrysatos* and Nabipoure *et al.,* (2009) in Rock dove, Collared dove and Owl, noted that the thick piece took on a peripheral position with the thin segments in the medullary cone. Casotti and Richardson., (1993) have indicated that the thin and thick limb of Henle's loop originates from the proximal convoluted tubule and enters the medulla area and is lined with an epithelium composed of one

type of epithelial cell with wide spaces between cells, while in the thick limb it lines two types of epithelial cells.

The thin piece in *Falco tinnuclus* showed a weak interaction with the PAS stains and had a diameter of half the diameter of the thick piece, flat or cuboid cells that were low and lacked the brush border while the thick part was lined with cuboidal cells with a strong interaction with the PAS stains , Alkafagy *et al.,* (2019) .

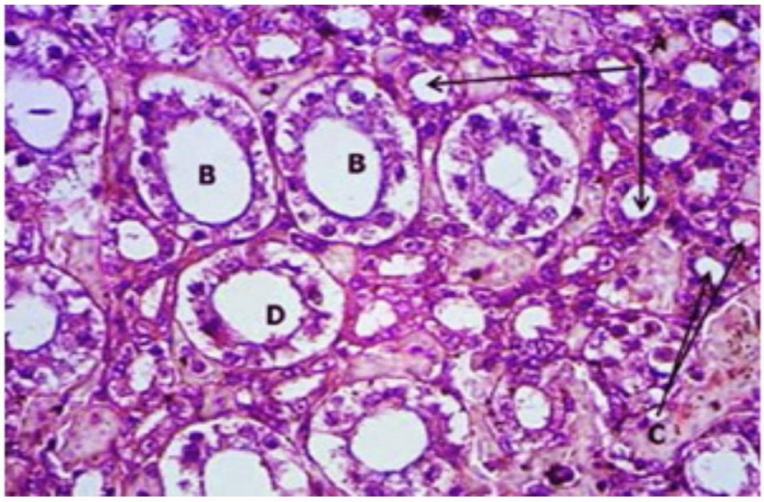

Fig. 4: Microphotograph showing medullary regions of the Kidney in Kestrel. A: collecting tubule, B: collecting duct, C: thin segment of Henle. H&E, 400X. About Alkafagy *et al.* (2019).

4.4 Distal convoluted tubule

The distal convoluted tubule in the cortical nephrons of the starling bird kidney starts from the macula densa in birds. The macula densa represents the beginning of the distal tubule of the cortical nephrons close to the cortical intermediate tubule and in this area can be distinguished two types of cells, which are macula densa cells and adjacent principle cells of the distal tubule, which are closely associated with cortical intermediate tubules. The macula densa cells are in close contact with the glomerulus or with cells adjacent to the glomeruli or adjacent to the efferent arteries or in contact with both and during macula densa they are shorter and more cohesive than the principle cells Nichalson., (1982) .

Casotti and Braun., (1993) in Honeyeaters and Casotti and Braun., (1995) in Sparrows stated that all nephrons in mammals have Henle loops. The distal

tubule starts from the medulla area as a thick ascending limp and the medullary renal units in birds are similar to the renal units of the mammalian in this content, they extend from the glomerulus to the center of the lobule and then the central vein, which many convolutions are formed before passing once to the periphery of the lobule. Alabdallah *et al.,* (2021) on Japanese quail and Bacha and Bacha ., (2000) in chicken indicated that the distal convoluted tubule consists of a simple cuboidal epithelium and cytoplasm that contains a central nucleus and differs from the proximal tubule and the collecting tubule by being devoid of the brush border and the cytoplasm does not contain apical mucopolysaccharide granules.

The distal convoluted tubule reabsorbs sodium ions Na^{+} and calcium Ca^{++} ions, which is an active process controlled by adrenocortical hormones, including aldosterone, and sodium reabsorption is coupled with the secretion of hydrogen ions H^{+} and potassium K^{+} in the distal convoluted tubule as mentioned by Young *et al*., (2014).

4.5 Collecting tubules and collecting ducts

The distal convoluted tubule opens in the collecting tubule and the cells lining the collecting tubules are cuboidal to columnar low with a granular cytoplasm and round nuclei and located near the base of the kidney as explained by Nicholson., (1982) on the starling bird. King and Mclelland., (1984) explained that the collecting tubules in chickens, which pass in the cortex area of the lobule known as the lobule per lobular collecting tubule,either that pass through the endodontic area are known as medullary collecting tubules and gather the tubules of each lobule in a single large duct called the collecting duct. This was also pointed out by Ghaji., (2021) during his study on domestic chickens. Boykin and Braun., (1993) found during their study on chicken and desert quail that the collecting duct begins with the merger of distal tubules for loopless nephrons pairs and meets these primary collecting duct from loopless nephrons only, and the primary collecting ducts merge into pairs and become secondary collecting ducts and then merge pairs of the secondary collecting duct and become tertiary collecting ducts. Tertiary collecting ducts receive the distant tubules of the looped nephron. Thus, the liquid in all types of nephrons comes

since it passes through the cone.

The anatomical structure of the medullary cones does not allow the ejection from one medullary cone to enter a second medullary cone, but all the cones act as parallel units. Nicholson., (1982) also pointed out that the largest per lobular duct is subject to wide fusion to form the medullary ducts, which in turn merge to form the large lower ducts that are associated with the branches of the ureter, and all the cells in the medullary ducts are long columnar and mucin secreting type. Al-Azawy., (2005) reported on chicken and geese that the collecting ducts have a lining consisting of a single row of cuboidal epithelial cells to columnar low and cytoplasm contains many small granules of mucopolysaccharides and basal nuclei or in another direction. Casotti and Richadson., (1993) indicated during their study on the bird wattle that the collecting ducts consist of the proximal segment and the distal papillary duct.

The proximal segment, it consists of a columnar epithelium consisting of light cells, dark cells, and a cytoplasm, each light cell contains a basal nucleus, several mitochondria, a rough endoplasmic reticulum, polysaccharides vesicles and ribosomes, while dark cells contain a cytoplasm on the central nucleus of the site and a number of mitochondria, free ribosomes and the free surface of the cells contains short microvilli either papillary duct lined with columnar epithelium and cytoplasm each cell contains a basal nucleus and Golgi complex and a rough endoplasmic reticulum and polysaccharides vesicles at the apex of cells that interact positively with PAS and Ab stains. The same results werw also noted by Casotti *et al*., (1998) in nectarivorous birds and Singh *et al*., (2020a) study on *Numida melearis* birds.

5. The effect of the environment on the structure and function of the kidneys in birds:

Many studies have dealt with comparative studies between the types of birds aimed at clarifying the impact of the environment in which the bird lives on the growth and functions of the kidneys. The birds are affected by the climatic conditions of desert areas, which may lead to the adaptation properties of birds.

The study carried out by Al-Taai and Nasif., (2020) on the starling bird, which is one of the seasonal birds during the winter, and the pigeon, which

is one of the domestic birds in Iraq and the rest of the countries throughout the year, the study showed that the kidney of pigeons has more advanced nephrons than the starling bird. The kidney of the starling bird is less efficient than the kidney of pigeons because pigeons can live in different environments and therefore have more adaptive qualities (Table 2).

Table 2: Shows the number of kidney corpuscles (1mm) and the volume of their (components) micrometers.

Type of bird	Number of renal corpuscles (1mm)	Volume of renal corpuscles	Volume of glomeruli capillaries	Volume of bowman's space
Starling bird (*Sturnus valguris)*	20.25± 0.23	37.41±0.11	26.66±0.12	10.64± 0.02
Pigeon (*olumba livia*)	16.42± 0.01	56.55± 0.12	47.54± 0.11	8.65± 0.04

Also, the study carried out by Ali and Reshag., (2020) on domestic chickens, which are wild living birds and ducks of waterfowl, showed the result of the study that the kidney of domestic chickens is more efficient than the kidney of ducks. It is characterized by the ability to retain water and produce concentrated urine more than in ducks due to its possession of renal corpuscles of the mammalian type that contain the Henle loop and responsible for the production of concentrated urine. It is diameter in the chicken kidney was 100 microns while the diameter of renal corpuscles in Reptilian type was 62 microns, and the number of renal corpuscles of Reptilian type in ducks ranged from 5-13 per millimeter while in chickens their number ranged from 2-12 corpuscles per millimeter.

Casotti and Richardson., (1992) mentioned when studying two types of honey birds that live in dry environments and two other types of birds that live in wet environment, where the study showed that birds living in dry areas have a larger medullary area than in birds living in humid areas that have a larger cortical area, and this is an adaptation to conserve body water and produce more concentrated urine as shown in Table (3).

Table (3): Shows the volume of the right kidney (mean ±S.E.) in (mm3), cortical and renal medullary of four species of honeyeater birds.

Variable	Wet region		Arid region	
	New Halland honeyeater	Little Wattle bird	Spiny-fronted honeyeater	Whit-fronted honeyeater
Kidney	98.3± 8.0	121.3±13.3	260.3± 20.9	88.5± 4.6
Cortex	81.8± 7.0	162.5±13.2	190.4±19.2	67.1±3.5
Medulla	4.4± 0.5	12.3± 1.1	38.8±2.7	7.1± 0.6

Conclusions:

- All kidneys in birds are consisting of three parts or lobes: cranial, middle and caudal lobes and the boundaries between the kidney parts are not always clearly defined.
- The kidneys in birds differ in volume and color, but they are similar in histological structure, and the lobules are the structural unit of the kidney, which consists of a wide cortical area containing the two types of renal corpuscles, the mammalian type MT containing the Henle loop and the reptilian type RT missing the Henle loop and a small medullary area.
- The composition of the kidney varies in terms of the number of renal corpuscles and their volume and the area of the cortical and medullary area depending on the environment in which the bird lives. Birds that live in dry environments have a medullary area larger than the cortical area and renal corpuscles of the mammalian type. This is one of the adaptive features of dry area birds in order to be able to maintain the water of their bodies and produce more concentrated urine, unlike birds that live in humid environments where they have a large cortical area with more number and smaller renal corpuscles of the reptilian type than corpuscles of the mammalian type.

References:

Abed, A.B (2020). Histological study for development of optic tectum in whit chocked bulbul *Pycnonotus leucotis*; Biochem. Cell. Arch., 20 (2): 5953-59557.

Abood, D.A.; Reshag, A.F.; Azhar, S.K. and Ahmed, M.A. (2014). Comparative anatomical and histological

features of the kidney in Harrier (*Cireus aueroginosus*), chicken (*Gallus domesticus*) and Mallard duck (*Anas platyrhynchos*). Iraq. J. Veter. Med., 38(1), 107-113.

Alabdallah, A.Z.; Nerezzine, A.; Vatnikov, A.; Nikishov, A.A.; Kulikov, V.E.; Gurina, R.R.; Krotova, V.T. and Sapego, Y.N. (2021). Influence of different genders of Japanese quail on the functional state of kidneys. Archives of Raz Institute, 76 (3): 667-680.

AL-Agele, R.A.A. (2012). Study the Anatomical Description and Histological Observation of the kidney in Golden Eagles (*Aquila chrysaetos*). The Iraqi J. Vet. Med.,36 (2): 145-152.

Al-Ajeely, R.A.A. (2010). *Anatomical histological study on the development of kidney and ureter in hatching and adulthood in racing pigeon Columba livia domestica.* MSc. Thesis, Collage of Veterinary Medicine, University of Baghdad.

Al-Ajeely, R.A.G.A and Mohammed, F.S.(2012); Morpho-histological study on the development of kidney and ureter in hatching and adulthood racing pigeon (*Columba livia domestica*). I.J.S.N., 3 (3): 665-677.

Al-Azawy, N.H. (2005). *Comparative anatomical and histological study of kidney in domestic fowls and geese*. MSc. Thesis, College of Veterinary Medicine, University of Baghdad.

Ali, M.A. and Reshag, A.F.(2020). Comparative morphohistological study of the kidneys in domesticus fowl (*Gallus gallus*) and domesticus duck (*Anas platyrhynchos*). Plant Arch., 20 (2): 6344-6348.

Ali,A.H.; Al-Bakri, N.A. and Al-arami, A.M.J. (2023). Glomerulogenesis and histomorphometric in *Mus musculus* embryo. Ibn Al-Haitham Journal for Pure and Applied Science, 36 (2): 14-24.

Alkafagy, S.M., Ghazi, J. and Alhaaik, A.G. (2019). Histomorphological study of kidney in adult kestrel, *Falco tinnunculus*. Biochem. Cell. Arch., 19(2): 3927-3933.

Al-Musawiu,B.J.and Al-Bakri, N.A.(2022).Effect of Hydroxychloroquine Drugs on Amino Acids in the Kidneys of White Mice (*Mus musculas*). International Journal of Drug Delivery Technology, 12(4):1590-1594.

Al-Taai, S.A.H. and Nasif, R.H. (2020). Comparative histomorphological study of kidneys in pigeon (*Columba livia*) and starling birds (*Sturnus valguris*). Indian J. Forensie Med. Toyicology, 14(4), 1707-1713.

Archana, K.; Nagamalleswari, Y.; Raju, N.K.B.; Kishore, P.V.S.; Kishore, G.S.S.; Chandana and Raga, K. (2017). Comparative microanatomical fratures of the renal cortex in Emu (*Dormaius novaehollandiae*) and duck (*Anas platyhynchos*). Int. J. Sci. Enveron. Technol, 6(4), 2706-2711.

Bacha, W.L. and Bacha, L.M. (2000). Color Atlas of Veterinary Histology, 2nd ed. Balado Lippcott Williams and Wilkins, Maryland, Pp: 163-174.

Barajas L. (1979). Anatomy of the juxtaglomerular apparatus. Am J Physiol 237: F333–F347.

Barbara, Y. and John, W.H. (2000). Functional histology text and colour atlas (3rd ed .). London, New York, Academic Press: 286-290.

Batah, A.L . (2012).Morphological and Histological study for the kidney of Coot Bird (*Fulica atra*). Bas.J.Vet. Res., 1(1):128-136.

Bataille, A.M.; Goldmeyer, J. and Renfro,J,L;(2008); Avian renal proximal tubule epithelium urate secretion is mediated by Mrp4; Am. J. Physiol. Regul Integr Comp Physiol., 295:R2024-R2033.

Boykin, S.L.B. and Braun, E.J. (1993). Entry of nephrons into the collecting duct network of the avian kidney: A comparison of chickens and desert quail. J. Morpho., 216(3): 259-269.

Braun, E.J. and Dantzler, W.H. (1972). Function of mammalian-type and reptilian-type nephrons in kidney of desert quail. Am J Physiol., 222(3): 617-629.

Casotti, G. (2001). Effect of season on kidney morphology in hous sparrow. J.Exp. Bio., 204:1201-1206.

Casotti, G. and Braun, E.J. (1993). Structure of the glomerular capillaries of the domestic chicken and desert quail. J. Morphol., 224(1): 57-63.

Casotti, G. and Braun, E.J. (1995). Structure of the Glomerular Capillaries of the Domestic Chicken and Desert Quail. Journal of Morphology, 224: 57-63.

Casotti, G. and Braun, E.J. (2000). Renal anatomy in sparrows from different environment. J.Morphol. 243(3): 283-291.

Casotti, G. and Richardson, K.C. (1993). A qualitative analysis of the kidney structure of *Meliphagid* honeyeaters from wet and arid environments. J. Anat., 182: 239-247.

Casotti, G.; Beuchat, C.A. and Braun, E.J. (1998). Morphology of

the kidney in Nectarivorous birds, the Annas humming bird Calypte anna. J.Zool; 244: 175-184

Casotti, G.; Lindberg, K.K. and Braun, E.J. (2000). Functional morphology of the avian medullary cone. Am J. Physiol. Regul. Integr. Comp. Physiol., 279, R1722-R1730.

Chiasson, R.B. (1984). *Laboratory anatomy of the pigeon*, 3rd ed. Mc Graw-Hill companies, Inc., Pp: 63-87.

Dantzler, W.H. (2016). Comparative physiology of the vertebrate kidney. 2nd Ed., American Physiology Society, pp, 16-36.

Dauod, H.A. M and Israa, A .A. (2021). Comparative histomorphological study on the kidney of two Iraqi birds (Barn Owl, *Tyto alba* (scopoli, 1769) and black Iraqi partridge, *Francolinus francolinus* (linnaeus, 1760). Journal of Genetic and Environmental Resources Conservation, 9 (1): 219-226.

Deef, L.E.M. (2015). Histo and Ultra structural Aspect concerning Renal corpuscle in *Fulica arta* and *Gallinula angulate* (Avies: Gruiformse). International Journal of Advanced Research, 3(1):1833-1838.

Deepa, K.P.; Sreerjini, A.R. and Soumya, C.B. (2020). Comparative histological studies on the renal cortex in broiler chicken and broiler duck. The Pharma Innovation Journal, 9(8): 129-131.

Dehkrodi, R.A.F. and Habibi, A. (2015). Sterological and electron microscopic study on the internal organization of the urinary secretory units in the three species of birds, Journal of Applied Research, 43(1):118-124.

Gazimir, I.; Oornila, N.; Predoi, S.; Marta, D. and Constantinescu, C. (2008). Histo-And Ultrastructural aspects concerning renal corpuscle in Coturnix coturnix Japonica. Lucrari Stiintifice Medicin Veterinary; 41:64-72.

Ghaji, M.S. (2021). Morphmetrical and histological changes in domestic chicken kidneys in response to salinated water. Indian J. Forensic Medicine and Toxicology, 15(3): 3738-3742.

Hamad, M.H.; AL-Bakri, N. and Labi, A.R. (2021). Effect of ginger alcoholic extract on the overy tissue in quail. Journal of Physics: Conference series, 1879(2):1-4.

Hobson, S.M.S.; Rao, P.V.V.P. and Bhatnagar, M.K. (1988). Ultrastructural alterations in the kidneys of poking Dueks Felt methylemercury. Can, J. Vet. Res., 52: 89-98.

Khadhim, I.A.A. and Dauod, H.A. (2014). Morphological description and histological structure of kidney in barn owl *Tyto alba*. Ibn Al-Haitham Journal for Pure and Applied Science, 27(3): 45-59.

Khadhim, T.S.A. (2014). Morphological description and histological structure of kidney in two species of Iraqi birds barn owl (*Tyto alba*, Scopoli, 1769) and black partridge (*Francolinus francolinus*, Linnaeus, 1766). MSc. Thesis, College of Education for Pure sciences (Ibn Al-Haitham), University of Baghdad, 188pp.

Khadim, I.A.A and Dauod, H.A. (2016). Morphological Description and Histilogical Structure of Kidney in Iraqi Black Partridge *Francolinus francolinus* (Linnaeus, 1766). Journal of Madenat AL-Elem University College, 2(8):58-75.

King, A.S. and McLelland, J. (1984). Birds their structure and function. 2nd ed. Bailliere, Tindall, London, Pp: 175-182.

Kone, Y.; Hashimoto, Y.; Kitagawa, H.; Kudo, N. and Murakami K. (1986). Immunohistochemical demonstration of juxtaglomerular in kidney of domestic mammals and fowls. JPN J. Vet. Res., 34: 111-123.

McLelland, J. 1990. *A colour atlas of avian anatomy*, 1st ed. Wolfe publishing Ltd., London, Pp: 75-81.

Mobini, B. and Abdollahi, M.H. (2016). Effect of sex on histological and histochemical structures of different parts of the kidney in Japanese quail. Poultry Science, 95:2145-2150.

Mohammed, A.H.S.; Mohod, A.A.H. and Madkhor, S.R. (2009). Histological study of kidney of seteppe buzzard (Bioleo b, vulipinus gloger). Al-Kuffa Univer. J. Boiol., 1(2), 1-7.

Nabipour, A.; Alshahi, E. and Asadian, M. (2009). Some histologiacal and physiological features of avian kidney. Appl. Anim. Res., 36, 195-198.

Nicholson, J.K. (1982). The microanatomy of the distal tubules, collecting tubules and collecting ducts of the starling kidney. Journal of Anatomy, 134: 11-23.

Reshag, A.F.; Abood, D.; Ab. and Dawood, M.S. (2016). Anatomical and histological study of the kidneys and salt glands in great flamingos (*Phoenicopterus roseus*). The Iraqi Journal of Veterinary Medicine, 40(1): 140–146.

Reshag, A.F.; Dhyaa, Ab.A. and Ektifaa, S.K. (2017). Histological and histochemical characteristics of the kidneys in different avian species. Aus-

tralian Journal of Basic and Applied Science, 11(16): 36-44.

Sabat, P. (2000). Birds in marine and saline environments: living in dry habitats. Rev. Chil. Hist. Nat., 73(3): 401-410.

Satchell, S.C. and Braet F. (2009). Glomerular endothelial cell fenestrations: an integral component of the glomerular filtration barrier. Am J Physiol Renal Physiol., 296(5): F947-56.

Shehan, N.A.; Hussein, H.A.; Da'aj, S.A. and Ali, S.A. (2020). Morphology, histology and histochemical study of kidneys in the Iraqi falcon (Falcon berigora). Biochem. Cell. Arch., 20 (Supplement 2): 000-000.

Siller, W.G. and Hindle, R.M. (1969). The artierial blood supply to kidney of the fowl. J. Anat., 104 (1), 117-135.

Singh, G.; Joshi, H. and Meshram, B. (2020a). Different histochemical observation on the kidney of guinea fowl (*Numida meleagris*). Journal of Entomology and Zoology Studies, 8(2):1716-1719.

Singh, G; Joshi, H. and Meshram, B. (2020b). Histological study on the kidney of guinea fowl (*Numide meleagris*). Online International Interdisciplinary Research Journal, 10 (3): 10-22.

Warui, C.N. (1989). Light microscopic morphometry of the kidney of fourteen avian species. J. Anat., 162:19-31.

William, H. D. and Braun, E.J. 1980. Comparative nephron function in reptiles, bird and mammals. Am. J. Physiol., 239(3): 197-213.

Young, B.; O'Dosd. G. and Woodford, P.S. (2014). Wheaters Functional Histology. A text and color atlas, 16th ed. Elsevier Churchill Livingstone, Philadelphia, United state.Pp: vii-452.

Yousif, R.R. and Rabee, F.O. (2019). Anatomical and histological study of kidney, ureter and urinary bladder in male guinea big (*Cavia porcellus*). The Iraqi Journal of Veterinary Medicine, 43(1): 75-84.