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# HISTOMORPHOLOGICAL STUDY OF KIDNEY IN ADULT KESTREL, *FALCO TINNUNCULUS*

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**ABSTRACT : The present study was conducted to investigate the anatomical and histological characteristics of the kidney in Kestrel by incorporation on twelve healthy kidneys from six Kestrel (*Falco tinnunculus*). Samples of kidney were collected from Kestrel, which lives in middle of Iraq. The anatomical investigations appeared that the size of kidney of Kestrel was large relatively with reddish to brown color and both kidneyswere lobulated and positioned retro-peritoneal in the sub-lumbar region of abdomen covered by fibrous connective tissue and fatty tissue. The kidney of kestrel comprised from cranial, middle and caudal lobes and the cranial lobe was the largest one. The right kidney were positioned more cranially than the left one. Histologically, the kidney of Kestrel was covered by very thin capsule. In the parenchyma of kidney there was no apparent demarcation line between cortex and medulla. Two types of nephron were found in the kidney of kestrel. The predominant cortical type which was devoid of loop of Henle and these nephrons are reptilian in form. The medullary type which had a nephronal loop of henle appeared to penetrate the conical medullary region of the lobules and these are mammalian in form.**

***Key words :*** Anatomical, histolomorphology, description, kidney, Kestrel.

## INTRODUCTION

Domestic birds are considered as an important animalistic fortune rings because they provide, meat, eggs and feathers, which used in different purposes, also they are very important in bio protection to harmful insects and rodents (Ajeely and Mohammed, 2012).

Kestrel is belong to the falcon family and one of the most popular birds of prey, it is numerous and widespread all over the world have varied colors, feed on different insects or tiny mammals such as mice, young ground squirrels and sometime feeds even small birds (Clements, 2000; Groombridge *et al*, 2002).

The kidney is the important part of the urinary system that contributes to the maintenance of homeostasis by complicated process that involves filtration, absorption and secretion. It also regulates fluid and electrolyte balance of the body and the site of renin production, which is responsible for blood pressure and erythropoiet in regulation (Ganoon, 2005; Kumar and Kumar, 2018).

The urinary system of the birds consists of paired large and elongated kidneys. There is no renal pelvis or urinary bladder in the bird so that the ureters drain each kidney into the urodeum of the cloaca. Each kidney is partitioned into a cranial, middle and caudal parts. Each partitionconsist of lobules. The lobules consists of a large cortical part and a smaller medullary one that drain into the ureter (Bacha and Bacha, 2000).

Many previous anatomical studieson kestrel did not describe the kidney, therefore, this study was conducted to give a back ground information about the kidney of kestrel by using different anatomical techniques. It is seemed of interest to determine histological and anatomical features of kidney because, it has very important in scientific research and environmental balance in our country.

## MATERIALS AND METHODS

The study was performed on twelve kidneys from six adult Kestrel (*Falco tinnunculus*). All birds were sacrificed by anesthesia with chloroform dropped in cotton pad (AVMA, 2013). Each bird was laid on its back and the abdomen was incised longitudinally and the kidneys were removed carefully and the following parameter were recorded weight of kidneys by using the sensitive balance, Relative weight and dimensions of kidneys (length, width, volume and thickness) by using vernier caliber (Ashley and Reynolds, 1989). The relative weight of the kidneys were calculated according to the formula used by (Federova, 1987).

Histological study, for the histological study of the kidney, samples of 1cm³ were harvested from all kidneys and immersed directly in 10% formalin for 72 hours. After fixation, the specimens were processed by routine histological processing method to get histological sections of 5-6 micrometer (µm) in thickness by the aid of rotary microtome and stained with Harris Hematoxylin and Eosin (Survana *et al*, 2013). Micromorphometric measurement which include renal corpuscle diameter/µm in cortical area and medullary area were done by using the tube camera (AM Scope, China), which was provided with processing software and calibrating kit.

Computer package (SPSS) was used to achieve the histomorphometric analysis. Data were presented as means ± SE (standard error) and were analyzed using Duncan's test with significant level set on $P<0.05$ (Systat Software Inc, 2016) (Joda, 2008).

## RESULTS AND DISCUSSION

### Anatomical results

The anatomical result were revealed that the kidney of the adult Kestrel (*Falco tinnunculus*) was relatively large, reddish to brown in color and both kidneys were irregular in shape and positioned retroperitoneal in caudal portion of the upper abdominal cavity and lie symmetrically in bony depressions of the synsacrum, they attached the lunges cranially and the end of the synsacrum bone caudally covered by highly attachments of fibrous connective tissue with few amount of adipose tissue. Each kidney consist of three parts: cranial lobe, middle lobe and caudal lobe. The right kidney positioned more cranially than the left one but at the same distance to the medial plan (Figs. 1, 2). The cranial lobe appeared separated from the middle lobe while the middle and caudal lobes fused together. The result is similar to the result performed by Nabipour and Asadian (2009) in chicken and another researcher (AL-Ajeely and Mohammed, 2012) in racing pigeon.

The kidney of the Kestrel (*Falco tinnunculus*) appeared as irregular structure and possess convex lateral and concave medial borders with dorsal and ventral surface and an upper and lower pole. The hilus located along medial border of kidney. This result agreement with Abdulla *et al* (2013) in the passer domesticus, as in budgerigars, penguin and many other birds. Also the kidneys of kestrel are related with two testes, spleen and parietal layer of gizzard and true stomach, the small intestine and the body of the pancreas and liver (Fig. 2).

The presence of few amount of adipose tissue surrounding both kidney, which act as a good insulator and one of fixatives of kidney in its position, this result come in agreement with Layton (2005), who stated that the kidney is a regulatory organ that tends to maintain stability of the internal body environment (Homeostasis) by regulating fluid balance. In para-sagittal section of kidney, appears two areas; the outer which is darker & granular called cortex, the inner which is reddish which is medulla. The granulation in the of Kestrel (*Falco tinnunculus*) was due to the presence of glomeruli in the cortex (Fig. 3).

The gross morphometric results revealed that there was as light difference in the weight of the two kidneys, the left kidney was weighted about (0.62±0.182 gram) while the right one about (0.70±0.175 gram). This result contrast the results of Al-Azawy (2005), who observed that the right and left kidneys was weighted about (10.1 ±0.176 g) in fowls and about (12.12 ± 0.101 g) in geese (Tables 1, 2, 3). These differences in values could be due to variation in age, breed and environmental factors. In the same manner,the length of right kidney was (23.36±174 mm), while the length of the left kidney ranged (22.80±0.159 mm). The width of the two kidneys were varied, the width of the right kidney was (22.85±0.155) mm, while the left kidney was 24.04±157 mm.

The present results showed that the thickness of the right kidney (16.42±0.144) was lower from that of left one (17.02±0.137) while, the right volume was (1.1 $cm^3$) and left one was (1.2 $cm^3$). High weight of the right kidney may be due to the presence of important organs in the right side of the abdomen like liver, pancreas and may be due to the cranial location of the right kidney which affected by high blood pressure as it is nearer to the heart than the left one (Tables 1, 2, 3).

### Histological results

The present study is performed on adult male Kestrel (*Falco tinnunculus*) to give more details and information about anatomical and histological structures of kidney. The present study claimed that the capsule of the Kestrel's kidney was very delicate composed of thin layer of fine collagen fibers (Fig. 4) in comparison to thick capsule of other mammals like camel (Hussin, 2003) and this great variation in thickness may play a renal functional role. However, the present results revealed that kidney of Kestrel was nourished with capsule with very fine blood vessels interfering with other fibers. This result support that of Al-Azawy (2005) in fowls and geese, who stated that the capsule appeared composed of smooth muscle fiberswith some reticular fibers, while Hodges (AL-Ajeely, 2012) disagrees this finding especially in racing pigeon.

## Parenchyma of the kidney

The histological sections of kidney showed that there is no apparent demarcation between cortex and medulla, the parenchyma of kesyrel kidney appeared to be composed of lobules with large peripherally cortex and small central medullary cone. All these lobules constituted conical shape structure called the lobe (Fig. 5). This fact was stated in wild adult starling *Sturnus vulgaris* by (Nicholson, 1982), who mentioned that the limits of lobule are marked by the interlobular veins, then the interlobular collecting tubules join the perilobular collecting ducts and run parallel to the interlobular veins at the base of the lobule, the perilobular ducts fuse extensively to form the medullary collecting ducts, which eventually feed the primary branches of the ureter. This result come to an agreement with Ritchie *et al* (1994) in birds.

The cortex of the kidneys in Kestrel had wide peripheral area which occupied by broad part of the lobules and consisted of large number of small size renal corpuscle with their glomeruli, proximal convoluted tubules and distal convoluted tubules. The current study appeared that there is two types of nephrons; the reptilian type which noticed in the cortex with and characterized by small glomeruliwhile the mammalian type which characterized by relatively large glomeruli and founded within medulla (Fig. 5). The result of our study in kestrel kidney supporting the results of Casotti (2001) in House sparrows, who stated that the majority of the cortex consist of proximal convoluted tubules followed by capillaries, distal convoluted tubules, collecting ducts and renal corpuscles, which were in most cases, anyway,this result come to an agreement with the results of Sabat (2000) in fowl.

The results of present study revealed that the medullary region in cross section of kidney in kesteral contained bundles of tubules surrounded by a connective tissue which are recognized as collecting ducts and loops of Henle of mammalian-type nephrons (Fig. 6). These results support the results mentioned by Casotti *et al* (2000) in Gambel's quail. The function of individual cones in kestrel occuring the same manner as the renal medulla of mammalian kidney. However, the structural characteristics of the kidney of kestrel may give good information about the function of kidney in birds. These findings coincide with those reported by Chiasson (1984) in pigeon (Beuchat, 1999) in Anna's humming bird and Ritchison (2008) in hone yester. In addition, Layton (2005) showed that the avian kidney, like the mammalian kidney, can regulate blood plasma osmolarity when deprived of water, producing hypertonic urine which localized in the medullary cone.

## The nephrons

The result of the current study in kidneys of Kestrel showed that there are two types of nephrons, the reptilian (cortical) type, which appeared more numerous devoid of loop of Henle, they were located entirely within cortical area and their glomeruli was small and numerous specially at peripheral circumference. The other type of nephron was called the mammalian type or medullary type, which was less numerous and had a loop of Henle extended into medulla and their glomeruli was larger than the previous type (Figs. 5, 7). The results come in agreement with Casotti and Richardson (1993) in honeyeater (Casotti and Braun, 1995) in domestic chicken (Sabat, 2000) in marine birds (Goldstein and Braun, 2005) in passerine birds. Moreover, our result in variance with Dellmann and Brown (2006) in domestic animals.

## Renal corpuscle

The renal corpuscle appeared to be consist of glomerulus represented by a tuft of unbranched capillaries, the afferent arteriole enters and the efferent leaves the glomeruli at vascular pole. The glomerulus appeared surrounded by a double layered Bowman's capsule. The inner layer (visceral layer) consist of podocytes, which characterized by large round or oval nuclei covers the surface of glomerular capillaries while the parietal layer of Bowman's capsule consists of a simple squamous epithelium. Bowman space between the two layers at the urinary pole leads to the PCT. The mesangial cells appeared as small cells with relatively large nuclei were seen attached to the capillaries in the center of the glomeruli (Fig. 8). Actually, Casotti and Richardson (1993) in honeyeaters and Islam *et al* (2004) in chicken had described the structure of glomeruli as in our results. However, Casotti and Braun (1995) in callipepla and *Gallus gallous*, stated that the glomerular capillaries were complicated in looped nephrons more than those of loopless nephrons and this may be related to filtration as capillary complexity increases the surface area available for ultrafiltration.

In kidneys of Kestrel, it was revealed that the glomeruli in cortical area were smaller and numerous than the glomeruli in medullary area (Fig. 7). This was stated by Gambaryan (1992) on their study in chick and Casotti and Richardson (1993) in honeyeaters. On the other hand, Goldstein and Braun (1989) found in house sparrow and in white winged doves, that the glomerular dimensions increased with kidney mass and these findings suggested that smaller birds with smaller kidneys have smaller nephrons with smaller glomeruli.

The diameter of cortical (reptilian) renal corpuscles

**Table 1 :** Measurements of the weight, relative weight, length and width of the left kidney.

| Parameter / Kidney | Mean weight (gram) | Relative weight (gram) | Length(mm) | Width(mm) | Thickness(mm) | Volume(cm$^3$) |
|---|---|---|---|---|---|---|
| Right kidney | 0.70±0.17* | 0.035±0.03 | 23.36±17* | 22.85±0.15* | 16.42±0.14* | 1.1 |
| Left kidney | 0.62±0.18 | 0.031±0.02 | 22.80±0.15 | 24.04±16 | 17.02±0.13 | 1.2 |

traits in Kestrel (n= 6)

*Mean there is a significant difference between right and left kidneys.

**Table 2 :** Measurements of the weight, relative weight, length and width of the left kidney traits in Kestrel (n = 6).

| Traits | Mean ± S.D | Min. | Max. |
|---|---|---|---|
| Body weight of Kestrel (gram) | 1992 | 1990 | 1994 |
| Left kidney weight (gram) | 0.62±0.182 | 0.591 | 0.640 |
| Relative weight of kidney (gram) | 0.0311±0.062 | 0.0304 | 0.0320 |
| Length of left kidney (mm) | 22.80±1.120 | 19.47 | 25.01 |
| Width of left kidney (mm) | 24.04±1.155 | 19.02 | 24.99 |
| Thickness of left kidney (mm) | 17.02±0.137 | 15.99 | 17.99 |
| Volume of left kidney (cm$^3$) | 1.20±0.03 | 1.10 | 1.30 |

**Table 3 :** Measurements of the weight, relative weight, length and width of the right kidney traits in Kestrel (n= 6).

| Traits | Mean ± S.D | Min. | Max. |
|---|---|---|---|
| Body weight of Kestrel (gram) | 1992±2 | 1990 | 1994 |
| Right kidney weight (gram) | 0.70±0.175 | 0.690 | 0.730 |
| Relative weight of kidney (gram) | 0.0350±0.033 | 0.0346 | 0.0366 |
| Length of right kidney (mm) | 23.36±0.174 | 20.47 | 25.67 |
| Width of right kidney (mm) | 22.85±0.155 | 19.89 | 25.99 |
| Thickness of right kidney (mm) | 16.42±0.144 | 15.87 | 17.99 |
| Volume of right kidney (cm$^3$) | 1.15±0.01 | 1.03 | 1.20 |

Values represent mean ±S.E at [P≤0.05].

**Table 4 :** Measurements of the renal corpuscle in kidney of Kestrel (n = 6).

| Traits | Mean ± S.D | Min. | Max. |
|---|---|---|---|
| Reptilian renal corpuscle diameter (um) | 18±3 um | 15 | 21 |
| Mammalian renal corpuscle diameter (um) | 34±5 um | 29 | 39 |

was (18±3 μm) while medullary (mammalian) renal corpuscles was (34±5 μm). This variation in size may explain that the glomerular filtration surface would be much greater in the large juxtamedullary population of glomeruli and this could lead to better filtration in these nephrons and maximal concentrating capacity. These findings come in agreement with AL-Agele and Mohammad (2012), who stated that, the glomerular filtration rate of the juxtamedullary nephron is approximately eight times that of nephron in the outer cortex.

## Proximal convoluted tubule (PCT)

The proximal convoluted tubules characterized by narrow lumen lined with acidophilic high cuboidal cells which possess brush border, with pale oval or rounded nuclei, the PCT's appeared more numerous if compared to the glomeruli and distal convoluted tubule. It was strongly positive with PAS stain (Fig. 9). The microscopic examination of proximal convoluted tubule was similar to that described in different avian species by Nishimura *et al* (1986) in birds and Laverty and Alberici (1987) in birds. However, Casotti and Richardson (1993) in wattle bird and Bataille *et al* (2008) in birds discussed that the volume and surface area of brush border in proximal convoluted tubule were significantly higher due to the greater capacity of the kidney to absorb water and ions. Actually, the intense PAS positive reaction of brush border may be due to the presence of sialic acid in the mucin component. On the other hand, McNabb *et al* (1973) found that the positive reaction to PAS due to presence of sulfated glycoproteins in the different tubule in the kidney of pigeon.

## Henle's loop

The present study revealed that nephrons of kestrel kidney in medullary region had Henle's loop, the thin segment of Henle's loop forms only a part of the descending limb, which was weakly stained with PAS stain and the diameter was about half of a thick segment. The epithelium of thin segment characterized by flattened cells or low cuboidal and lack brush border, whereas the thick segment lined by cuboidal cells with intensively PAS reaction (Fig. 11). These results were compatible with studies of Hodges (1974) in fowl, Braun and Rimer (1988) in Gambels quail, Nishimura *et al* (1986) in quail, Nishimura *et al* (1989) in desert quail, Sutterlin and Laverty (1998) in white leghorn and Casotti and Braun (2000) in sparrow. However, Casotti and Richardson (1993) in honeyeaters, whom found that the thin limb of Henle was lined by one type of epithelium with wide intercellular spaces while the thick limb of Henle lined by two types of epithelial cells each have intercellular spaces but with varying degree of cell membrane infoldings. On the other hand, Nishimura *et al* (1986) statedthe diameter and cellular appearance of the thick limb of the mammalian–type nephrons are similar among various species of birds.

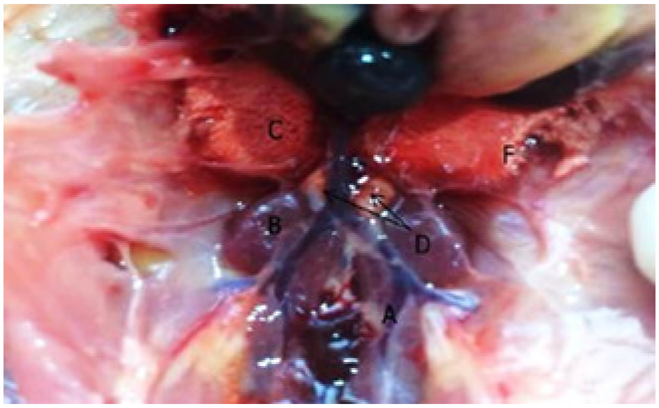


**Fig. 1 :** Photograph illustrate the Kidney in Kestrel. A: Left kidney, B: Right kidney, C: Lung, D: Left and Right adrenal gland.

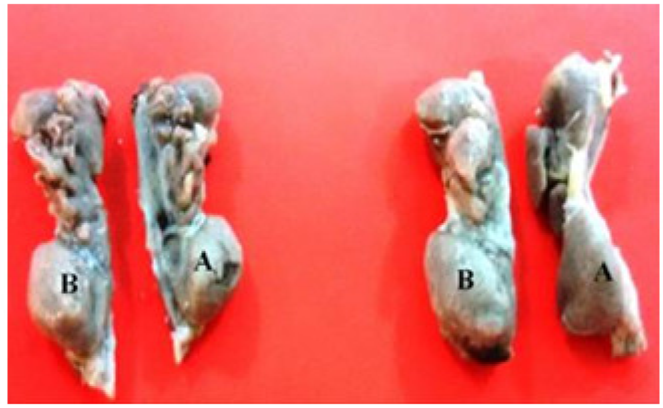


**Fig. 2 :** Photograph illustrate the Kidney in Kestrel. A: Left kidney, B: Right kidney.

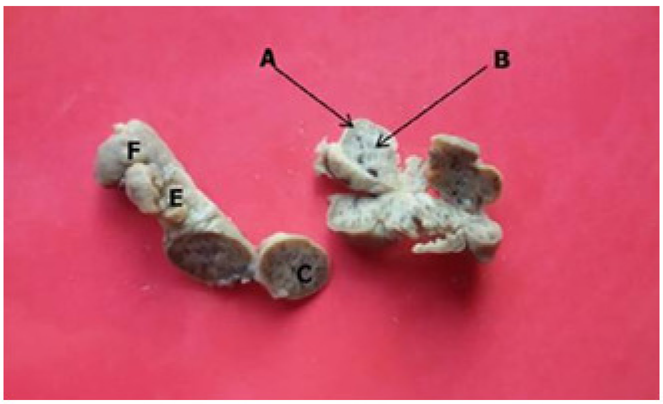


**Fig. 3 :** Photograph illustrate the parasagital section of Kidney in Kestrel. A: cortex, B: medulla, C: cranial lobe, E: middle lobe, F: caudal lobe.

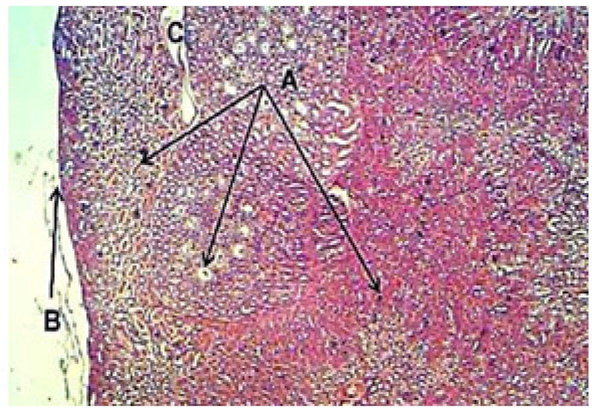


**Fig. 4 :** Microphotograph showing cortical and medullary regions o the Kidney in Kestrel. A: renal corpuscle, B: capsule, C: vein. H&E, 40X.

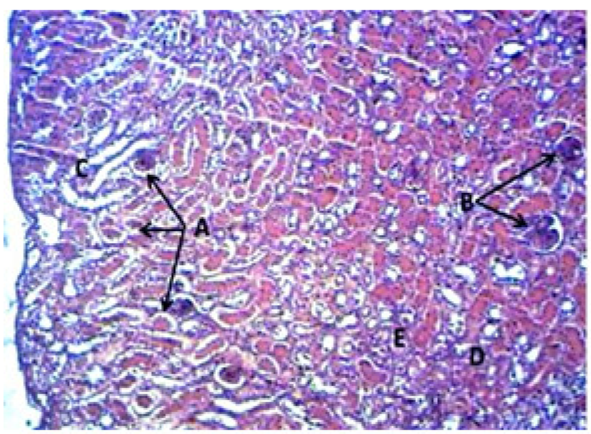


**Fig. 5 :** Microphotograph showing cortical and medullary regions of the kidney in Kestrel. A: *Reptalian glomeruli*, B: *Mammalian glomeruli*, C: cortical area D: medullary area. H&E, 40X.

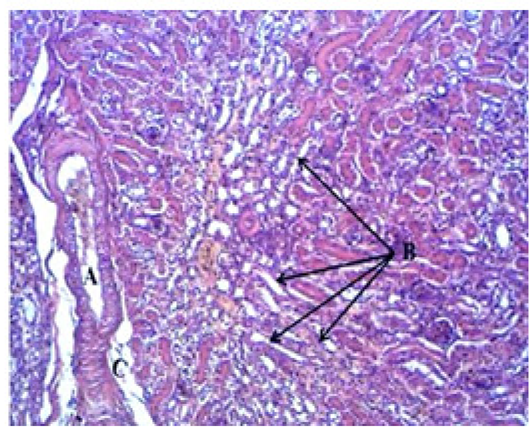


**Fig. 6 :** Microphotograph showing medullary regions of the Kidney in Kestrel. A: interlobular vein, B: medullary area containing bundle of tubules, C: uretral ridicules. H&E, 40X.

## Distal convoluted tubule (DCT)

The distal convoluted tubule was not as frequently encountered in sections as proximal convoluted tubule with the lumen appear wider than the proximal convoluted tubule. The lining epithelium of DCT appeared to be low cuboidal cells with absence of brush border and more nuclei in cross-section, the cells less acidophilic than proximal convoluted tubule, also the nuclei of these cells were centrally to Para basal located in position (Fig. 11). This results come in agreement with that Hodges (1974) in fowl, Casotti and Richardson (1993) in honeyeaters and Casotti and Braun (2000) in sparrow. However, Bacha and Bacha (2000) in chicken found that the DCTs are shorter than the PCTs, their cuboidal cells lack a brush border, but the apex may form a projecting bleb of clear cytoplasm that fills much of the lumen.

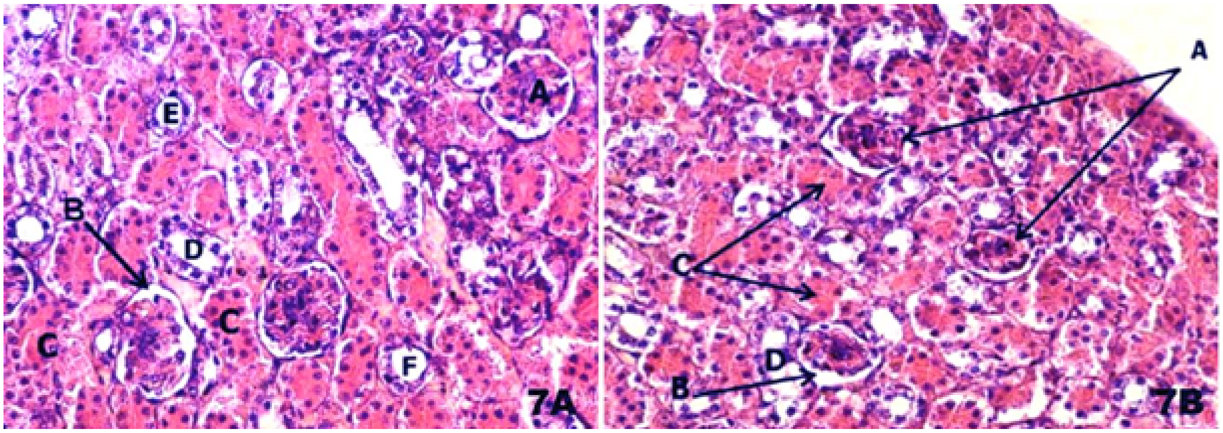


**Fig. 7A :** Microphotograph showing A: mammalian glomeruli of the Kidney in Kestrel., B: bowman's space, C: proximal convoluted tubules, D: distal tubules, E: thin segment of loop of henle, F: thick segment of loop of henle. H&E, 100X.

**Fig. 7B:** Microphotograph showing A: reptalian glomeruli of the Kidney in Kestrel., B: bowman's space, C: proximal convoluted tubules, D: distal tubules, E: thin segment of loop of henle, F: thick segment of loop of henle. H&E, 100X.

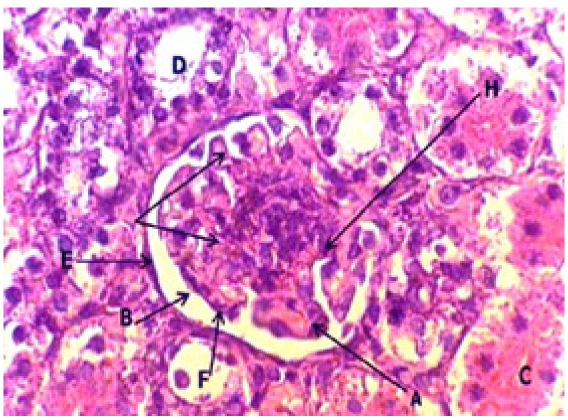


**Fig. 8 :** Microphotograph showing medullary regions of the Kidney in Kestrel. A: podocyte nucleus, B: bowman's space, C: proximal convoluted tubules, D: distal tubules, E: parietal layer, F: visceral layer, H: mesngial cells. H&E, 400X.

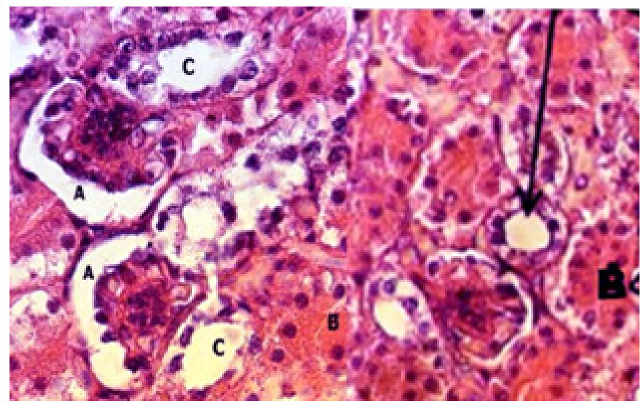


**Fig. 9 :** Cross-section in cortical region of kidney in kesteral showing reptilian glomeruli. A- Bowman space B- proximal convoluted tubule C-distal convoluted tubule, (arrow): collecting tubule (H & E. X400).

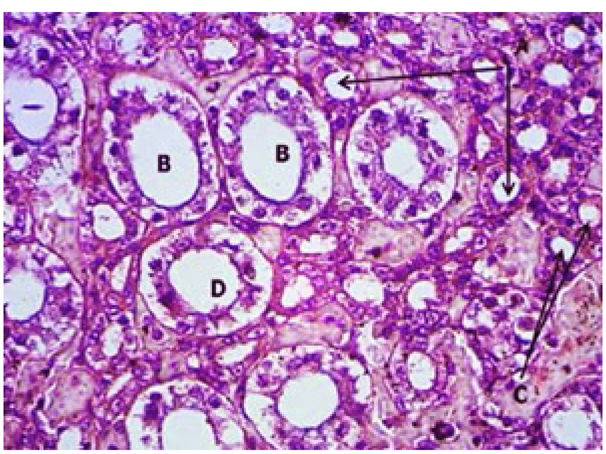


**Fig. 10 :** Microphotograph showing medullary regions o the Kidney in Kestrel. A: collecting tubule, B: collecting duct, C: thin segment of henle. H&E, 400X.

## Collecting tubule

In Kestrel, the collecting tubules were lined by one layer of pale cells with cuboidal to low columnar shape which stained lightly with routine stain. The nucleus appears large and cell borders were distinct. It observed intermediate in size between PCT and DCT. This is supported by Casotti and Richardson (1993) in honeyeaters and Casotti *et al* (1998) in Anna's humming bird. However, Casotti and Richardson (1993) suggested that the infoldings in the cell membrane of the cortical collecting tubules potential for substantial ion and water reabsorption.

Collecting ducts appeared to be lined with simple cuboidal to simple columnar epithelial cells. The sections of collecting ducts were more numerous at the base of the cones and showed a rapid decrease toward the tip of the medullary cones (Figs. 10, 11). These findings coincide with those reported by Nicholson (1982) in starling, Casotti and Richardson (1993) in honeyeaters and Casotti *et al* (2000) in Gambel's quail. However, Casotti and Richardson (1993) and Layton (2005) in Japanese quail found that the ultrastructure of collecting duct cell was typical of cellsthat absorb water passively into the interstitium. In addition, Casotti and Braun (2000) in sparrows found that the principal cells of collecting duct secret mucous to prevent uric acid precipitation, thus preventing blockage of the tubule lumen.

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