CATRINA (2015), 12 (1): 37-47

Comparative morphological, histological and ultrastructural study of the kidney of Cattle egret (*Bubulcus ibis*) and Squacco heron (*Ardeola ralloides*) birds

Neveen E. R. El-Bakary, Gamal A. Abd-Allah, Shimaa Bassiony
Zoology Department, Damietta Faculty of Science, Damietta University, New Damietta, Egypt

ABSTRACT

Osmoregulation is one of the most important factors determine the presence of vertebrates in its habitat. The renal morphology, histology and ultrastructure of two species of the family Ardeidae, Cattle egret (*Bubulcus ibis*) as a terrestrial bird (from Nahia and Mansurya) and Squacco heron (*Ardeolaralloides*) as aquatic bird (from Manzala lake) were examined. The results were obviously varied, the Cattle egret from Nahia in comparing with the Cattle egret from Mansurya have a few number of reptilian-type nephrons, numerous mammalian- type nephrons. The renal corpuscles have narrowest filtration slits. On the other hand, the Squacco heron showed numerous reptilian-type nephrons, a few number of mammalian-type nephrons, the renal corpuscle has numerous and widest filtration slits and thin basal lamina to increase the filtration surface area. Results illustrated the ability of the Cattle egret to adapt to its terrestrial environment, as these characteristics limit the glomerular filtration rate. On the contrary, the Squacco heron well adapted to its aquatic environment by increasing the glomerular filtration rate.

INTRODUCTION

Avian kidneys have several unique morphological and functional features (Nishimura, 2008). It is complex having two zones, the cortex and medulla where the medulla is arranged as a series of elongated cones intermingled amongst the cortex (Nabipour *et al*., 2009; Al-Ajeely & Mohammed, 2012 and Batah, 2012). The avian kidneys function in filtration, excretion or secretion, and absorption. They filter water and harmful substances from blood. In addition, they conserving water and reabsorbing needed substances (Sabat, 2000; Ritchison, 2008 and Charmi *et al.*, 2009). Aves main excretory product of nitrogen metabolism is the uric acid (Sabat *et al*., 2004; Dudas *et al*., 2005 and Nishimura, 2008). The avian kidneys have two types of nephrons: a reptilian-type without Henle's loop and medullary tissue, and a mammalian-type with both Henle's loop and a renal medulla tissue (Casotti & Braun, 2000; Reece, 2004; Cazimir *et al*., 2008 and Al-Ajeely & Mohammed, 2012). The ability to produce hyperosmotic urine in aves is limited compared to that of mammals (Reece, 2004); whereas the looped nephrons produce concentrated urine, their contributions to ureteric urine produce by loopless nephrons (Nishimura, 2008). According to Woodin *et al*. (2008), the osmoregulation has an important consideration for habitat use, water balance and bioenergetics in both terrestrial and aquatic species. Several studies have attempted to find any correlation between the ability to concentrate urine, the morphology of avian kidney and with the habitat of the species. For instance, Casotti and Richardson (1992) studied the kidney structure of honeyeater birds (Meliphagidae) inhabiting either arid or wet environments. Casotti and Braun (2000) studied the functional morphology of the kidney of three species of sparrow; and Sabat *et al.* (2009) studied Rufous collared sparrow. Bird species in the family Ardeidae (herons or egrets) are found in aquatic habitats worldwide (Kushlan and Hancock, 2005). Cattle egrets were observed to forage for insect-preys, frogs and other invertebrates in various and different types of ecosystem (Sharah *et al.*, 2008 and Meese, 2012). In the Mediterranean region, these birds commonly breed in river deltas, frequently forming dense multispecific colonies surrounded by diverse foraging habitats (Goutner *et al*., 2001). In the current study, the qualitative renal histology and ultrastructure of the two species of the family Ardeidae, Cattle egret (*Bubulcus ibis*) from two habitats and Squacco heron (*Ardeolaralloides*) collected from Manzala lake were examined with a need to conserve either ions or water, respectively.

MATERIAL AND METHODS

Experimental animals

The experimental animals included two different avian species of the family, Ardeidae, which inhabiting different habitats and feed on different diet. Cattle egret (*Bubulcus ibis*) is less tied to watery habitat; it is the most terrestrial heron, being well adapted to many diverse terrestrial and aquatic habitats. The Cattle egret (*Bubulcus ibis*) as terrestrial birds were collected from two different habitats, the first one was "Nahia" where's the birds found on rubbish (group 1). These birds feed exclusively on insects. The second area was "Mansurya" where's the birds were collected from the area adjust to water (group 2).The second species, Squacco heron (*Ardeolaralloides*) inhabits dense, shallow, fresh marshes having nearby cover of tall reeds or dense bushes. It feeds exclusively in freshwater habitats, the prey types it preferred includes frogs, tadpoles, larval and adult aquatic insects, small fresh water fish and various aquatic invertebrates (Goutner *et al*., 2001 and Kazantzidis and Goutner, 2005). Squacco heron (*Ardeolaralloides*); as aquatic birds (group 3), were collected from Manzala lake. Each group consisted of six individuals. The birds were sacrificed, dissected and the two kidneys were removed and were processed using the following techniques.

Histological Technique

The right kidney of the studied species were cut into the three divisions (anterior, middle and posterior) then each division cut transversally and immediately fixed in 10% neutral formalin. The tissue was washed in tap water then dehydrated, cleared, embedded in paraffin

* *Corresponding author:* lbakaryneveen@yahoo.com

wax, cut at 5µm thickness on a rotary microtome and stained using a routine haematoxylin eosin method (Carleton, 1980). Histological sections of kidneys were examined under a light microscope.

Ultrastructural Technique

The right kidneys of the three bird groups were cut into small pieces appropriate 1 mm^3 of the renal corticomedularry tissue excised and fixed in 2.5% glutaraldhyde in 0.1µ sodium cacodylate buffer at pH 7.2 (for 3 hours), the tissue was post-fixed in 1% buffered osmium tetroxide for 1 hour at 4^0 C. This was followed by dehydration in ascending grades of ethanol, cleared in propylene oxide, and embedded in epon (Casotti *et al*., 1998). Semi- thin sections, one micron-thick were cut using LKBV ultramicrotome with the aid of glass knives made by LKB knife maker and stained with 1% toludine blue specimens were reteimmed to the selected areas, ultra-thin sections (60-90nm) were picked upon cupper grides, stained with uranyl acetate and lead citrate (Reynold, 1963) and examined with JEOL transmission electron microscope in electron microscopy unit in Alexandria Faculty of science operating at 60 or 80 KV.

RESULTS

The External Morphology

The kidneys of Cattle egret from Nahia; Mansurya and Squacco heron from Manzala lake are very morphologically similar. Each kidney consists of three divisions, a large cranial, a small caudal, and a middle division. In addition, the dorsal half of the kidneys is situated embedded deeply in the synsacral fossa. In Cattle egret (*Bubulcus ibis*) from Nahia or from Mansurya; the two kidneys are completely separated from each other but in Squacco heron (*Ardeolaralloides*), the caudal divisions of the two kidneys are connected across the midline (Fig. 1).

The Histological Studies

The kidneys of all studied species consist of two zones, the cortex and the medulla. The medulla is arranged in cones of different lengths, which is distributed randomly within the cortex and there is a line of demarcation between cortex and medulla in the kidney of the studied species (Fig. 2). As illusterated in figure (3), the cortical region of bird's kidney presented intensely stained and constituted by glomeruli, proximal and distal convoluted tubule and the two main types of nephrons, a reptilian-type (R) nephrons with smaller glomeruli as compared with the second type a mammalian (Mm) nephrons that possessed loops of Henle. In the investigated species, each renal corpuscle consisted of an outer Bowman's capsule separated by the Bowman's space from a centrally located glomerulus. The kidneys of the Cattle egret taken from Nahia shown relatively less density of reptilian-type nephrons and high density of mammalian- type nephrons evenly distributed throughout the cortex when compared to the kidneys of the Cattle egret taken from Mansurya and Squacco heron, respectively. In all studied species, the cortical collecting tubule consisted of cuboidal epithelium. The cytoplasm of each cell contained a basal nucleus. The tubular lumen was narrow in the kidneys of the Cattle egret taken from Nahia and Mansurya than in the Squacco heron.

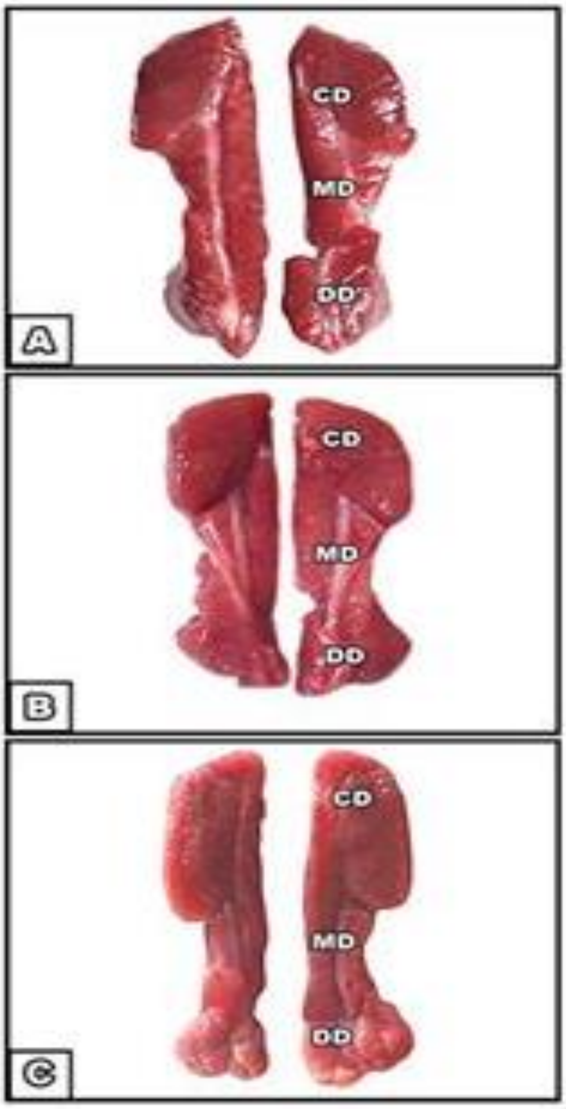

Figure (1): External morphology of the Kidneys of the Cattle egret (*Bubulcus ibis*) from Nahia (A) and the Cattle egret (*Bubulcus ibis*) from Mansurya (B) and Squacco heron (*Ardeola ralloides*) (c), showing cranial division (CD), middle dividion (MD) and caudal division.

As illusterated in Figure (4) the medullary cones contain the descending and ascending limbs of the loops of Henle lay parallel to the medullary collecting ducts. The number of the thin descending limb of the loop of Henle with a large, round, centrally located nucleus found in the Cattle egret from Nahia is more than in the Cattle egret from Mansurya. However in Squacco heron the number of the thin descending limb of the loop of

Henle is less than in the Cattle egret from Nahia and Mansurya. So we predicted that the number of mammalian-type nephrons in Squacco heron were less than those found in the other two groups.

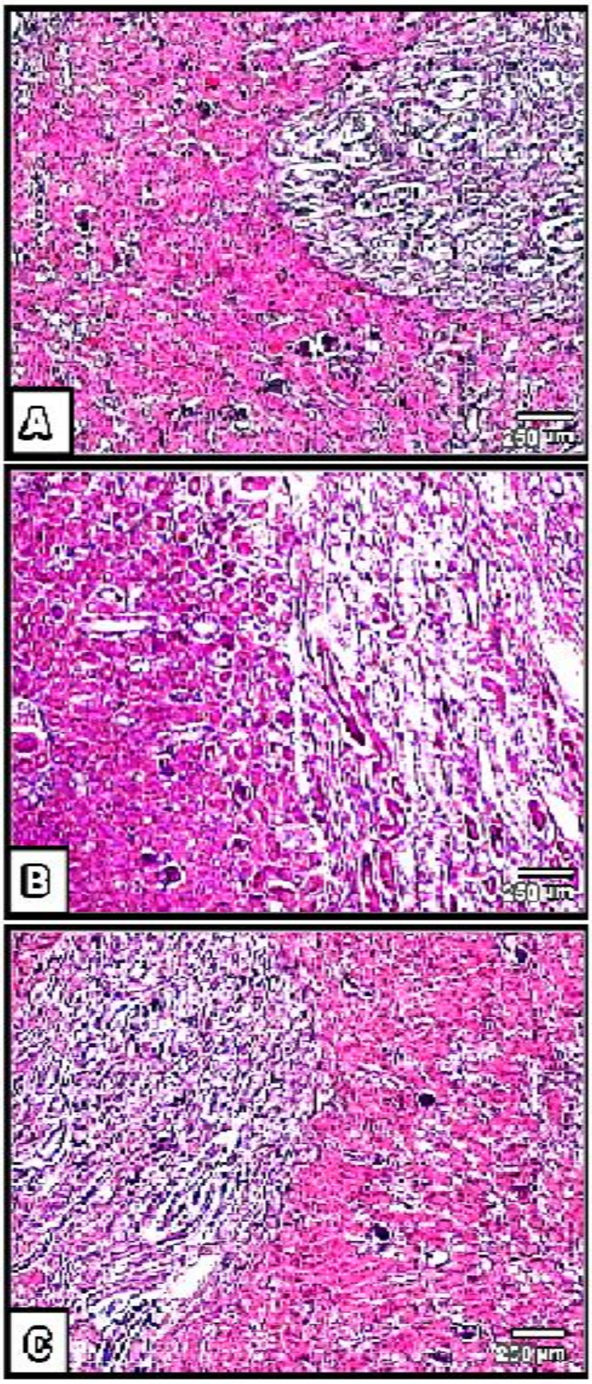

Figure (2): A photomicrograph of transverse sections of the kidneys of the Cattle egret (*Bubulcus ibis*) from Nahia (A) and the Cattle egret (*Bubulcus ibis*) from Mansurya (B) and Squacco heron (*Ardeola ralloides*) (C), Showing the cortex (the intensively stained region) and the medulla (a relatively higher stained region) were arranged in cones of different lengths which were distributed randomly within the kidney. H& E X 40

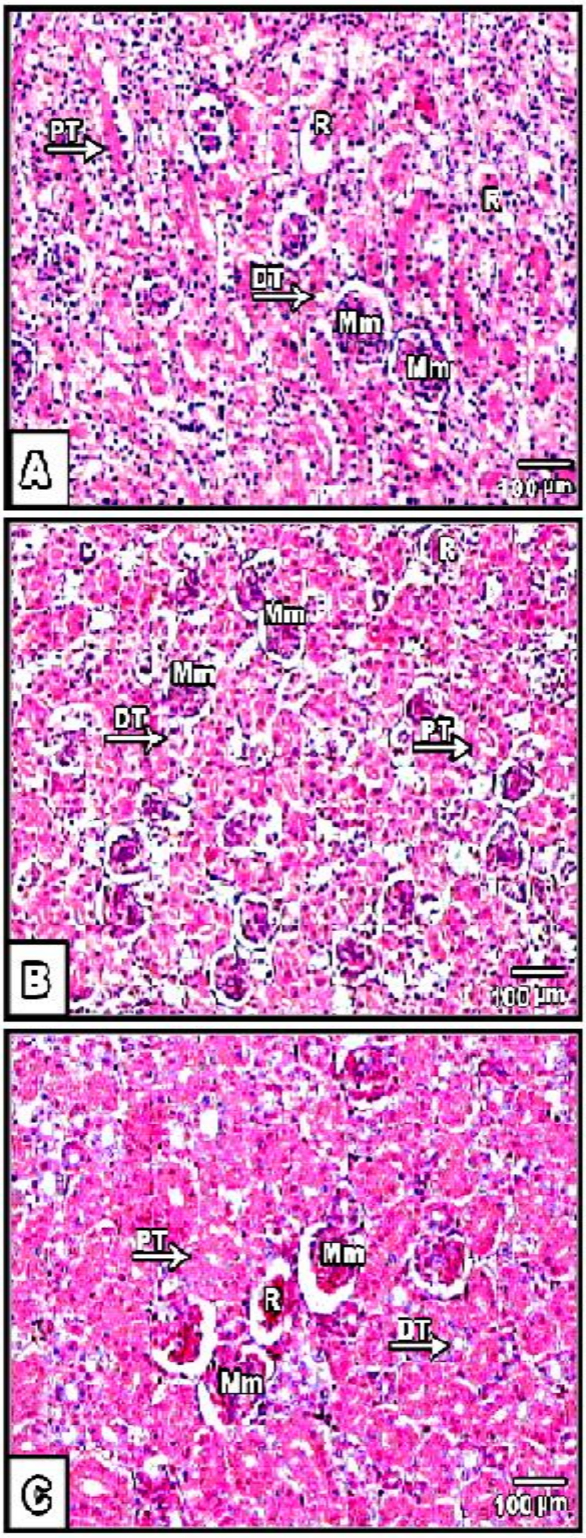

Figure (3): A photomicrograph of transverse sections through the cortical region of the kidneys of the Cattle egret (*Bubulcus ibis*) from Nahia (A) and the Cattle egret (*Bubulcus ibis*) from Mansurya (B) and Squacco heron (*Ardeola ralloides*) (C), Showing the renal capsules of mammalian (Mm), reptilian (R) type nephrons and tubules (PT and DT). H& E X 100

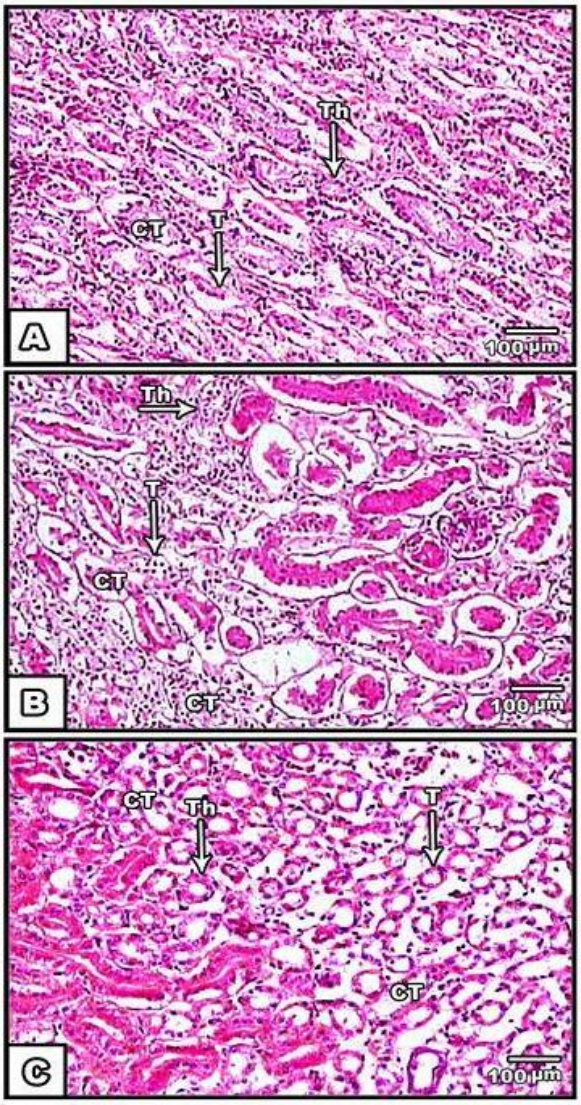

Figure (4): A photomicrograph of transverse sections through the renal medulla of the kidneys of the Cattle egret (*Bubulcus ibis*) from Nahia (A) and the Cattle egret (*Bubulcus ibis*) from Mansurya (B) and Squacco heron (*Ardeola ralloides*) (C), Showing thin descending (T) and thick ascending limbs (Th) of the loops of Henele and collecting tubules (CT). H& E X 100

The Ultrastructural Studies

Because, there were no differences in the ultrastructure of the components of the renal cortex between mammalian and reptilian-type nephrons, the following description of the ultrastructure represented observations made from mammalian-type nephron. In all investigated species, the renal corpuscle consisted of Bowman's capsule and glomerular capillaries were characterized by a large central cell mass of mesangial cells typical of avian kidney. The parietal cell layer of Bowman's capsule was separated from its visceral counter part by Bowman's space and consisted of flattened epithelial cells characterized by elongated nuclei and a paucity of organelles (fig. 5).

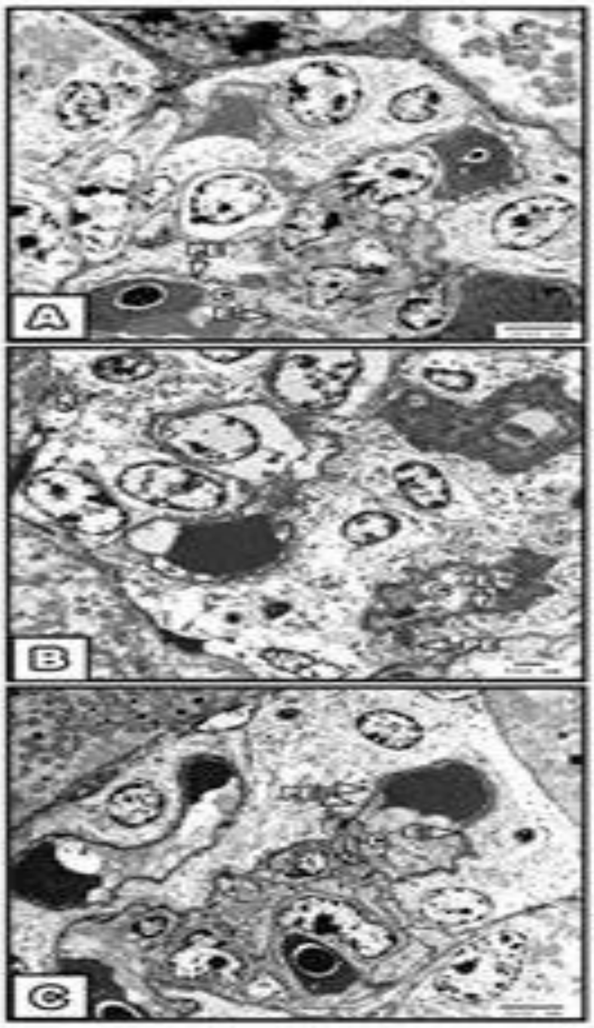

Figure (5): An electron micrograph of a renal corpuscles of the kidneys of the Cattle egret (*Bubulcus ibis*) from Nahia (A) and the Cattle egret (*Bubulcus ibis*) from Mansurya (B) and Squacco heron (*Ardeola ralloides*) (C), Showing podocytes with radiating small pedicles (PE), endothelium (E), capillary lumen (C). X 1500

The visceral layer of Bowman's capsule was comprised of cuboidal cells, each with numerous inter digitating cytoplasmic extensions which terminated on glomerular basement membrane as foot processes or pedicels. Podocyte nuclei had mildly coarse chromatin and were variable in shape. Their cytoplasm was highly granular and rich in organelle. The capillary loops were arranged in a simple fashion circumferential to the central cell mass of mesangium and commonly contained a few red blood cells. Each loop was lined by fenestrated endothelial cells. The endothelium was closely opposed to the glomerular basement membrane which was characterized by a trilaminar structure, comprised of a central lamina densa bound on either side by a lamina rara. The final component of the filtration barrier was present in the form of filtration diaphragms seen linking the adjacent foot processes of podocytes (fig. 6).

The number, the size of the filtration slits as well as the thickness of the glomerular basal lamina is markedly varied among the studied species. In the Cattle egret taken from Nahia similar to the Cattle egret taken from Mansurya, has less number and narrow filteration slits and thick basal lamina compared to the Squacco heron which has greatest number and widest filteration slits as well as thinnest basal lamina (fig. 6).

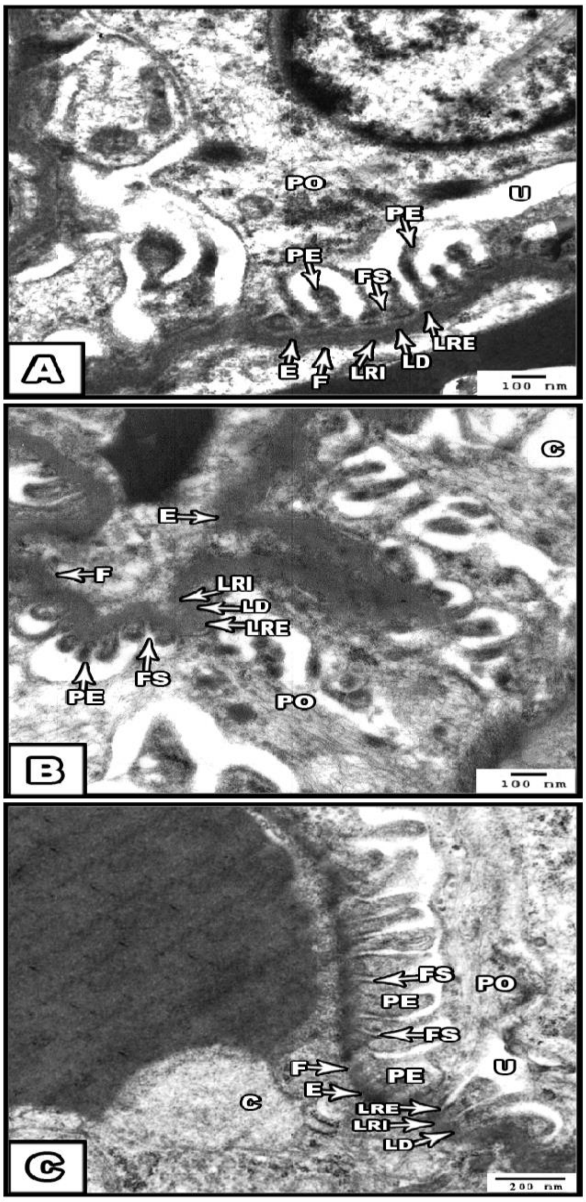

Figure (6): An electron micrograph of a renal corpuscles of the kidneys of the Cattle egret (*Bubulcus ibis*) from Nahia (A) and the Cattle egret (*Bubulcus ibis*) from Mansurya (B) and Squacco heron (*Ardeola ralloides*) (C), Showing the filtration barrier between the lumen of the glomular capillary (Ca), urinary space (U) Bowman's capsule. The filteration barrier composed of capillary endothelium (E) with fenestrations (F), the pedicles (PE) of the podocyte separated by filtration slits (FS) and the interposed basal lamina (BL). Note the three components of the basal lamina; lamina rara intera (LRI), lamina densa(LD), lamina rara externa (LRE). (C). X 7500

In all studied species, the proximal tubule (PT) was characterized by elongated columnar cells crowned by microvilli. Occasionally, PT cells contained a single cilium. As illusterated in Figure (7), apical junctional complexes consisting of tight junctions. Each tubule was bounded by a basement membrane. The length and the abundance of the microvilli of the apical border of the epithelial lining of the proximal tubule are obviously varied, with the Cattle egret from Nahia and Cattle egret from Mansurya having long and more abundance microvilli than the Squacco heron, whereas the latter have the short and the less abundance microvilli among the investigated species.

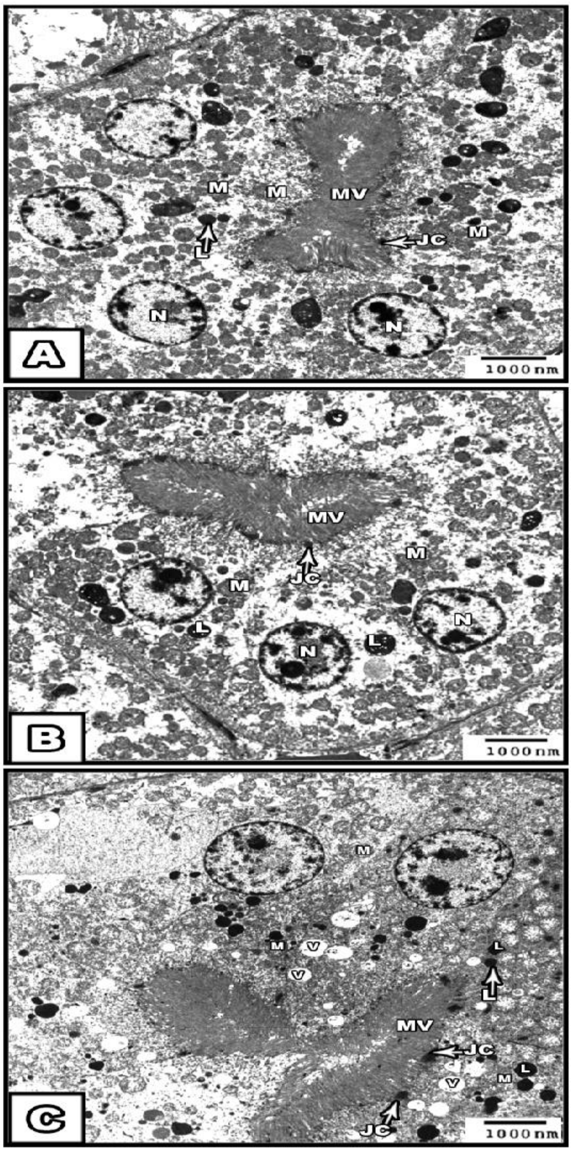

Figure (7): An electron micrograph of the epithelial lining of a proximal tubule of the Cattle egret (*Bubulcus ibis*) from Nahia (A) and the Cattle egret (*Bubulcus ibis*) from Mansurya (B) and Squacco heron (*Ardeola ralloides*) (C), Showing micro villi (MV), mitochondria (M), basal lamina (BL), lysosome (L), nucleaus (N) and junctional complex (JC). X 1500

The Cattle egret from Nahia has relatively numerous numbers of rounded mitochondria in comparison with those of the Cattle egret from Mansurya with distinct densely packed cristae which occupy more area of the renal tubular epithelium. However, Squacco heron show less numbers of rounded mitochondria with less distinct densely cristae. The basal lamina of the Cattle egret taken from Nahia and taken from Mansurya is distinctly thick compared to the Squacco heron which have the thinnest basal lamina among the studied species. The apical situated vacuoles also seen in these cells. The number of the vacuoles, another characteristic of the proximal tubule cells, demonstrated in the Cattle egret taken from Nahia and from Mansurya was less than found in the Squacco heron. The number of lysosomes in squacco heron was lesser than those found in the cattle from Nhia and Mansurya.

As illusterated in figure (8) the distal tubule (DT) epithelium consisted of cuboidal cells. Mitochondria were fewer; larger and longer than in the PT cells and tended to locate in basal and midcellular slots. Spherical nuclei in the Cattle egret from Nahia and Mansurya and oval nuclei in the Squacco heron were generally central or apical and had mildly coarse chromatin.

The abundance of the mitochondria and the thickness of the basal lamina of the distal tubule were varied; within the Cattle egret from Nahia having numerous elongated mitochondria than with the Cattle egret from Mansurya. In Squacco heron, the number of the mitochondria was lesser than those found in the Cattle egret taken from Nahia and Mansurya. In addition, the Cattle egret taken from Nahia and Cattle egret from Mansurya had thicker basal lamina compared to the basal lamina in the Squacco heron. The luminal cytoplasm of DT showed cytoplasmic extensions in the Cattle egret from Nahia and from Mansurya, whereas the Cattle egret from Nahia had the cell luminal surface bulged apically into the lumen and contained few microplicae (mi). An occasional single apical cilium was noted as were occasional degenerating cell. The cortical collecting tubule consisted of a cuboidal epithelium contained principal and intercalated cells, the ratio of these cell types appeared to be similar between the investigated species. The cell membrane contained infoldings terminated apically at junctional complexes. The cytoplasm of each intercalated cell contained a large nucleus in Squacco heron with numerous mitochondria and free ribosomes. Among the investigated speceis the number of mitochondria and lysosomes increased in the Cattle egret taken from Nahia than those observed in the Cattle egret taken from Mansurya and Squacco heron, respectively (Fig. 9).

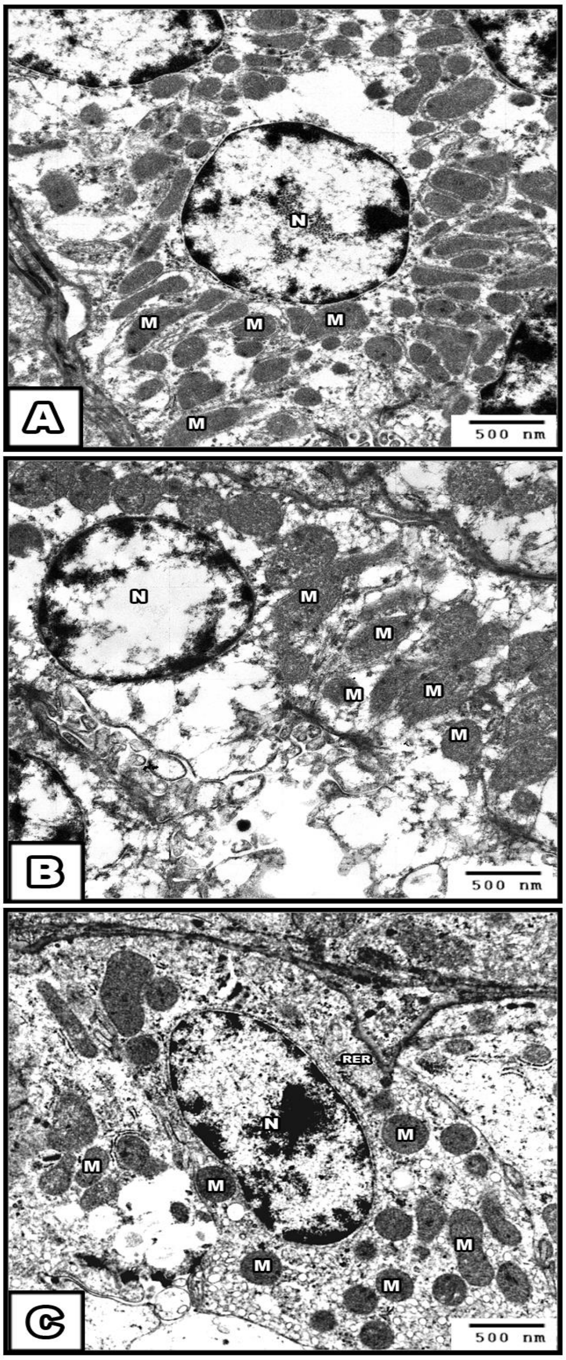

Figure (^): An electron micrograph of a higher magnified part of the epithelial lining of the distal convoluted tubule of the Cattle egret (*Bubulcus ibis*) from Nahia (A) and the Cattle egret (*Bubulcus ibis*) from Mansurya (B) and Squacco heron (*Ardeola ralloides*) (C), Showing the variation in the number, size and shape of the mitochondria (M), rough endoplasmic reticulum (RER).

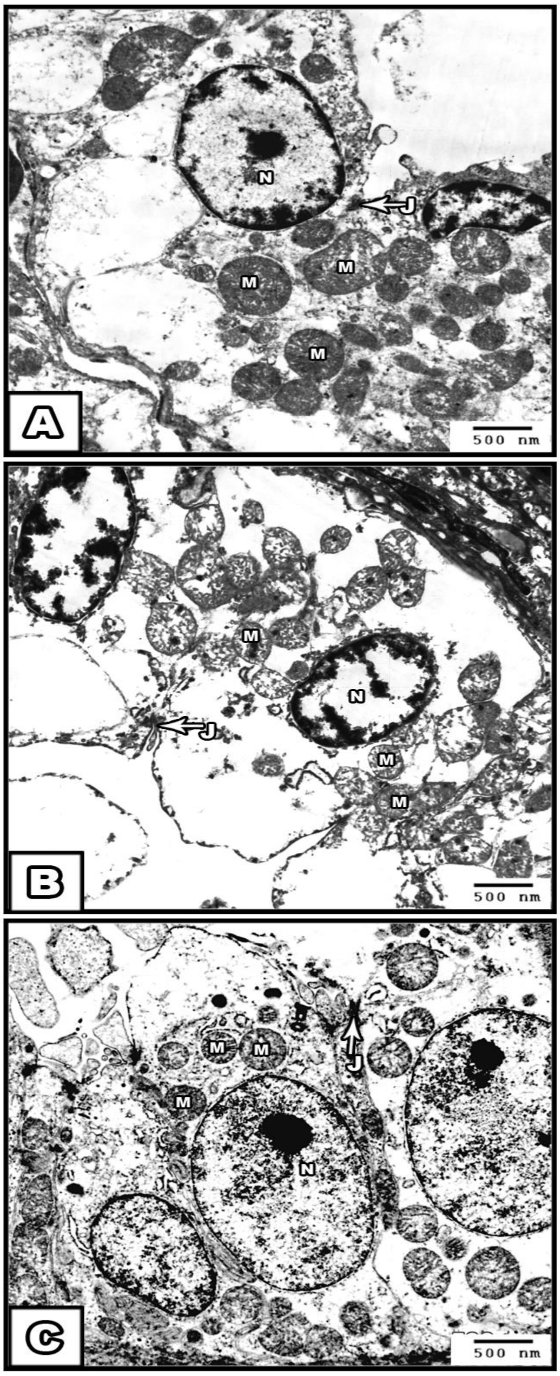

Figure (9): An electron micrograph of the epithelial lining the cortex collecting duct of the Cattle egret (*Bubulcus ibis*) from Nahia (A) and the Cattle egret (*Bubulcus ibis*) from Mansurya (B) and Squacco heron (*Ardeola ralloides*) (C), Showing the mitochondria (M), junctional complex (J) and nucleuse (N). X3000

DISCUSSION

In the presnt study, the cranial division of the kidney of Cattle egret (*Bubulcus ibis)* from Nahia or from Mansurya and of Squacco heron (*Ardeolaralloides*) was the largest division. This is similar to the morphological results of the kidneys of coot bird (*Fulicaatra*) (Batah, 2012) and dissimilar to that described for the desert quail (Braun and Dantzler, 1972), three species of sparrow (Casotti and Braun, 2000), rock dove; collared dove; owl (Nabipour *et al*., 2009) and racing pigeon (Al-Ajeely & Mohammed, 2012), where the caudal division was a large; a small middle, and cranial division was somewhat larger than the middle division. The connection of the two caudal renal divisions in Squacco heron (*Ardeolaralloides*) is in consistent with results of Orosz (1997), he supposed that the caudal divisions may be fused across the midline in some species such as herons, puffins, and penguins.

The presence of demarcation line between cortex and medulla in the kidney of the investigated species is contrast to the kidney of racing pigeons (Al-Ajeely and Mohammed, 2012). The well-developed medullary cones in all studies species indicated their ability to concentrate urine. This is disagree with the observation of McWhorter and MartÍnez Del Rio (1999) on three hummingbird species where the kidney was composed largely of unlooped, reptilian-type nephrons and may lack medullary cones. The observed two main types of nephrons, a reptilian-type (R) nephrons and a mammalian-type (Mm) nephrons is similar to observation on mature racing pigeon (Al-Ajeely & Mohammed, 2012 and Batah, 2012). The size of the glomerular capsules corresponds to the extreme morphological heterogeneity of the nephrons (Braun and Dantzler, 1972). Goldstein and Braun (1989) found in *house sparrow* and in *white winged doves,* that the glomerular dimensions increased with kidney mass.

In the present study, Cattle egret kidney from Nahia had higher denisity of mammalian type nephron and lower denisity of reptilian type nephron than Cattle egret kidney from Mansurya. Squacco heron kidney had the less denisity of mammalian type nephron and high number of reptilian-type nephron. This is oppose with the observation of Goldstein and Braun (1986) on the desert House sparrow (*passer domisticus*) has more mammalian-type nephrons than the white crowned sparrow (*Zonotrichia L eucophris*). Such relative reduction of reptilian-type nephrons may reduce the flow of dilute urine through the collecting urine through the collecting ducts permitting a greater concentration of urine along the medullary cones (Sabat, 2000). The two types of nephrons perform distinct functional roles and variations in tubular ion transport in the birds (da Cruz Höfling *et al*., 2001). The increase in the glomerular size of mammalian nephrons in the Squacco heron may be to increase the filtration surface area. According to Dantzler (2005), the integrated rate of glomerular ultrafiltration is depending on the glomerular capillary area available for filtration and on the water permeability of the capillary wall.

In all studied species, the luminal surface area of the proximal tubule was enhanced by a thick layer of microvilli forming a brush border. According to Nabipour *et al.* (2009), the wide intercellular spaces coupled with extensive cell membrane infolding in proximal tubule are a characteristic of cells that have a high ion and water reabsorption capacity. The cortical collecting tubules also play a role in producing concentrated urine by reabsorbing water from the tubular lumen. In addition, they are also known to secrete mucin, which may aid in eliminating uric acid from the kidney (Casotti, 2001). The medullary cone contain the descending and ascending limbs of the loops of Henle lay parallel to the medullary collecting ducts. This is in consistent with the renal medulla of the *Gambel's quail* where is the renal medulla of birds was divided into smaller units than those occur for most mammalian kidneys and these units; medullary cones are made up of loops of Henle, collecting ducts and vasa recta (Casotti *et al*., 2000).

The high number of the thin descending limb of the loops of Henle in the Cattle egret from Nahia is more than in the Cattle egrete from Mansurya and Squacco heron, so we predicted that the number of mammalian-type nephrons increased in the Cattle egret from Nahia to concentrate urine. This is contrast to the Squacco heron where is the thin loop of Henle decreased in number. Also, this is consisted with the observation of Nabipour (2008) at insectivorous bats; where the loop of Henle was not observed in the kidney of the insectivorous bats. Therefore, the nephrons of bats are loopless (reptilian) type. According to Nabipour (2008), the loop of Henle is responsible for further reabsorption of water from the filtrate, as well as sodium and chloride ions. The countercurrent exchange occurs due to the very close association of the ascending and descending limbs. On leaving the loop of Henle, the tubular fluid has had the majority of some substance reabsorbed, e.g. glucose, water and sodium ions.

In the present study, the kidney of the Cattle egret from Nahia and from Mansurya was similar in its ultrastructural. This has narrow and less number of filteration slits and thicker basal lamina. These illusterated the ability of the Cattle egret to adapted to its terresterial environment. These are consistent with the observation of (Allam and Abo-Eleneen, 2013) who suggested that these characteristics limit the glomerular filtration rate. In the same context, McWhorter *et al*. (2004) found that glomerular filtration rate (GFR) decreases in response to water deprivation in many avian species. These adaptations indicate that nephrons play an important role in coping with the extreme conditions of water deprivation (Dantzler, 2005). But the ultrastructure of Squacco heron kidney show the wide and high number of filtration slits and the thin basal lamina. This suggests that Squacco heron from Manzala lake well adapted to semi- saline water and have higher GFR, where is Manzala lake is a brackish lake (Reinhardt *et al*., 2001) than Cattle egret from Nahia and from Mansurya which has less GFR. Yokota *et al*. (1985) identified the need to eliminate water loads and metabolic wastes as the major factors that tend to increase GFR among vertebrates. In the same context Bennett & Hughes (2003) found that kidneys of marine birds maintain a high GFR and a high tubular reabsorption of Na+ and water. GFR varied significantly among birds from different habitat types. Marine species had a significantly higher GFR and terrestrial arid species had a significantly lower GFR than species from either terrestrial mesic or freshwater habitats, which did not differ significantly from each other (Lyons & Goldstein, 2002 and Bennett & Hughes, 2003). These indicted the ability of Squacco heron to turn over a lot of water and adapted to its aquatic environment.

In all studied species, the length and the abundance of the microvilli of the apical border of the epithelial lining of the proximal tubule are obviously varied, with the Cattle egret from Nahia and from Mansurya was long and more abundant microvilli comparing to those of Squacco heron. As pointed out by Meteyer *et al. (2005), the* proximal tubules are the primary site of uric acid excretion and reabsorption of ultrafiltrate. These observations go parallel with the findings of Casotti and Braun (2000) on sparrows from different habitats. The presence of a well- developed long microvilli play an important role in the increase of the surface area exposed to the lumen to facilitate the movement of large fluid volumes and to absorb a large proportion of fluid from the glomerular filtrate to maintain water balance of arid inhabitant species as previously reported by Cassoti and Richardson (1992) for honey eater (*Melphipha-gidae*). In the same context Sabat (2000) indicated that these morphological features may be indicative of urine concentration ability. According to Cunningham and Klein (2007), wide intercellular spaces coupled with extensive cell membrane infolding in proximal tubule are a characteristic of cells that have a high ion and water reabsorption capacity. The Cattle egret from Nahia has relatively numerous numbers of spherical and elongated mitochondria in comparing to the Cattle egret from Mansurya. However, Squacco heron show less numbers of elongated and spherical mitochondria with distinct densely packed cristae. The basal lamina of the Cattle egret from Nahia and Mansurya was distinctly thick compared to the Squacco heron which had the thin basal lamina. Simon (1982) reported that these cells have basal infoldings and numerous mitochondria are characteristic of ion transporting cells. The number of the lysosomes demonstrated in Cattle egret from Nahia and from Mansurya was higher than found in Squacco heron which indicat the high transport activety in the Cattle egret from Nahia and from Mansurya than in the Squacco heron. In the paralled line with Renfro and Clark (1984) have demonstrated the presence of Na^+-glucose luminal cotransporter (SGLT) in chick proximal tubules and Sutterlin and Laverty (1998) in proximal tubeule cells culture.

In all studied species, the abundance of the mitochondria and the degree of the development of the basal infoldings as well as the thickness of the basal lamina of the distal tubule are varied; within the Cattle egret from Nahia having numerous mitochondria and compared with either the Cattle egret from Mansurya or the Squacco heron. In addition to the Cattle egret from Nahia and Mansurya had thick basal lamina comparing to Squacco heron. This is consistent with the observation of Casotti and Braun (2000), where Savannah Sparrow has a lower volume of the distal tubule than the mesic zone species; this may be associated with the higher volume of proximal tubule. It suggests that with more functional area at the level of the proximal tubule less of the filtered load remains to be processed by the distal tubule. The luminal cytoplasm of DT shows cytoplasmic extensions in the Cattle egret from Nahia and from Mansurya whereas the Cattle egret from Nahia has the cell luminal surface bulged apically into the lumen and contained few microplicae. An occasional single apical cilium was noted as were occasional degenerating cell. The distal tubule in the avain nephron passively reabsorbs water and actively reabsorbes sodium chloride from the nephron tubule (Braun and Dantzler, 1997).

In the present study, the high density of mitochondria in the distal tubules of the Cattle egret kidney from Nahia compared to Cattle egret kidney from Mansurya and the Squacco heron kidney, the active site and high degree of electrolyte transport (Kaissling and Le Hir, 1982), since the distal tubules are mainly involved in sodium reabsorption from the tubular fluid as mentioned by Burkitt*et al*. (1993). These observations are in agreement with the findings of Kriz *et al*. (1978) and Kaissling and Le Hir (1982). Moreover, the markedly thick basal lamina of the epithelial lining of both proximal and distal tubules of the Cattle egret from Nahia and from Mansurya support the previous observations of Safer *et al*. (1988) who reported that the nephron of the one-humped camel *Camelus dromedarius* is unique in having an unusually thick basal lamina underlying the epithelial cells of the nephron.

In the present study, the number of mitochondria and lysosomes in the cortical collecting tubule increased in the Cattle egret taken from Nahia than found in the Cattle egret taken from Mansurya and Squacco heron respectively. As with the distal tubules, the cortical collecting tubules also play a role in producing concentrated urine by reabsorbing water from the tubular lumen. In addition, they are also known to secrete mucin, which may aid in eliminating uric acid from the kidney (Casotti, 2001 and Nabipour *et al*., 2009). In the same context, previous studies have found that both the principal and intercalated cells secrete potassium and reabsorb water, sodium and other ions (Grantham *et al*., 1970; Hansen *et al*., 1978; Evan *et al.*, 1980 and Stanton *et al.*, 1984). Nicholson (1982) showed in *S. vulgaris* that the intercalated cells may undertake both potassium and water reabsorption. In the current study, the infoldings in the cell membrane of the cortical collecting tubules suggests the potential for substantial ion and water reabsorption. The principal cells secrete mucus to prevent uric acid precipitation, hence preventing blockage along the tubules of the distal nephron (Guzsal, 1970; Peek & McMillan, 1979). Since uric acid is a means of excreting solutes with minimal water loss, it might be expected that the Cattle egret from Nahia and Squaco heron would have more principal cells and hence produce more uric acid than the Cattle egret from Mansurya as a water conservation strategy. So, in this study, the number of principal cells and the number of dark cells appeared to be different between species.

REFERENCES

AL-AJEELY, R. A. A., AND F. S. MOHAMMED. 2012. Morpho-histological study on the development of kidney and ureter in hatching and adulthood racing pigeon (Columba liviadomestica). I.J.S.N. VOL. **3**(3): 665-677.

ALLAM, A. A., AND R. E. ABO-ELENEEN. 2013. Comparative histological, histochemical and ultrastructural studies of the nephron of selected snakes from the Egyptian area. Biologia **68** (3): 546-558.

BATAH, A. L. 2012. Morphological and histological study for the kidneys of coot bird (Fulicaatra). Bas. J. Vet. Res. **1**1(1): 128-136.

BENNETT, D. C., AND M. R. HUGHES. 2003. Comparison of renal and salt gland function in three species of wild ducks. The journal of experimental Biology **206**: 3273-3284.

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

BRAUN, E. J., AND W. H. DANTZLER. 1997. Vertebrate renal system. In Handbook of physiology: Comparative physiology (ed. W.H. Dantzler), PP. 481-576. New York: Oxford University Press.

BURKITT, H. G., B. YOUNG, AND J. W. HEATH. 1993. Wheater's Functional Histology, 3rd ed. ELPS Churchill Livingstone.

CARLETON. 1980. Carleton's histology technique, fifth edition revised and rewritten by: R.A.B. Drury and E.A. Wallington.

CASOTTI, G. 2001. Effect of season on kidney morphology in house sparrows. The journal of Experimental Biology **204**: 1201-1206.

CASOTTI, G., AND E. J. BRAUN. 2000. Renal anatomy in sparrows from different environments. J. Morphol. **243**: 283–291.

CASOTTI, G., AND K. C. RICHARDSON. 1992. A stereological analysis of kidney structure of honeyeater birds (Meliphagidae) inhabiting either arid or wet environments. Journal of Anatomy **180**: 281-288.

CASOTTI, G., C. A. BEUCHAT, AND E.J. BRAUN. 1998. Morphology of the kidney in a nectarivorous bird, the Anna's hummingbird Calypteanna. J. Zool. **244**: 175–184.

CASOTTI, G., K. K. LINBERG, AND E. J. BRAUN.

2000. Functional morphology of the avian medullary cone. Am. J. Physiol. **279**: 1722- 1730.

CAZIMIR, I., N. CORNILA, S. PREDOI, D. MARTA, AND C. CONSTANTINESCU. 2008. Histo-and ultrastructural aspects concerning renal corpuscle in *corturnix coturnix Japonica*, Lucrari Stiintifice Medicina Veterinara Vol. XL1, Timisqara.

CHARMI, A., M. BAHMANI, M. M. SAJJADI, AND R. KAZEMI. 2009. Morpho-histological study of kidney in farmed juvenile Beluga, Husohuso (Linnaeus, 1758). Pakistan Journal of Biological Sciences **12**(1): 11- 18.

CUNNINGHAM, J. G., AND B. G. KLEIN. 2007. Textbook of Veterinary Physiology. Saunders, St. Louis, PP: 537-564.

DA CRUZ HÖFLING, M. A., C. C. L. PARONETTO, J. C. COGO, L. RODRIGUES-SIMIONI, AND A. C. F. D'ABREU. 2001. Histopathological changes in avian kidney caused by Bothropsinsularis (jararacailhôa) venom and a phospholipase A_2-containing fraction. Histol Histopathol. **16**: 185-195.

DANTZLER, W. H. 2005. Challenges and intriguing problem in comparative renal physiology. J. Exp. Biol. **208** (Pt4): 587–594.

DUDAS, P. L., R. M. PELIS, E .J. BRAUN, AND J. L. RENFRO. 2005. Trans epithelial urate transport by avian renal proximal tubule epithelium in primary culture. The Journal of Experiment Biology, 208: 4305-4315.

EVAN, A., J. HUSER, H. H. BENGELE, AND E. A. ALEXANDER. 1980. The effect of alterations in dietary potassium on collecting system morphology in the rat. Lab. Invest. **42**: 668–675.

GOLDSTEIN, D. L., AND E. J. BRAUN. 1986. Proportions of mammalian-type and reptilian-type nephrons in the kidneys of two passerine birds. J .Morphol. **187**: 173-179.

GOLDSTEIN, D. L., AND E. J. BRAUN. 1989. Structure and Concentrating ability in the avian kidney. Am. J. Physiol. **25**: R501-R509.

GOUTNER, V., W. FURNESS, AND G. PAPAKOSTAS. 2001. Mercury in feathers of Squacco heron (Ardeolaralloides) chicks in relation to age, hatching order, growth, and sampling dates. Environmental Pollution **111**: 107-115.

GRANTHAM, J. J., M. B. BURG, AND J. ORLOFF. 1970. The nature of transtubular Na and K transport in isolated rabbit renal collecting tubules. Journal of Clinical Investigation **49**: 1815-1826.

GUZSAL, E. 1970. Histochemical study of the kidneys of domestic fowls. Acta Vet. Acad. Sci. Hung. **20**: 295–299.

HANSEN, G. P., C. C. TISHER, AND R. ROBINSON. 1978. Response of collecting ducts (CD) to disturbances in hydrogen ion (H1) and potassium (K1) balance. Clin. Res. **26**: 264A.

HODGES, R. D. 1974. The Histology of the Fowl. 1st Ed., Academic Press Inc., London, pp: 488-523.

ISLAM, KH. N., M. Z. I. KHAN, M. S. I. SIDDIQUI, M. R. ISLAM, N. S. LUCKY, M. K. HOSSAIN, AND G. N. ADHIKARY. 2004. The Anatomical Studies of the Kidneys of Rhode Island Red (RIR) and White Leghorn (WLH) Chicken During Their Postnatal Stages of Growth and Development. International Journal of Poultry Science **3**(5): 369-372.

KAISSLING, B., AND L. E. HIR. 1982. Distal tubular segments of the rabbit kidney after adaptation to altered Na+ K+ intake. I- structural changes. Cell Tissues Res. **224**: 469-492.

KAZANTZIDIS, S., AND V. GOUTNER. 2005. The diet of nestlings of three Ardeidae species (Aves, Ciconiiformes) in the Axios Delta, Greece. Belg. J. Zool. **135** (2): 165-170.

KRIZ, W., B. KAISSLING, AND M. PSZOLLA, 1978. Morphological characterization of the cells in Henle's loop and the distal tubule. In: New Aspects of Renal Function, edited by H. G. Vogel and K. Ullrich. Amsterdam: Excerpta Medica p. 61-79.

KUSHLAN, J. A., AND J. A. HANCOCK. 2005. The Herons. Oxford University Press, New York, NY, USA.

LYONS, M. E., AND D. L. GOLDSTEIN. 2002. Osmoregulation by nestling and adult American Kestrels (Falco sparverius) Auk **119**: 426-435.

MCWHORTER, J., AND C. MARTÍNEZ DEL RIO. 1999. Food ingestion and water turnover in hummingbirds: How much dietary water is absorbed? The journal of experimental biology, **202**: 2851-2858.

MCWHORTER, J. T., C. MARTÍNEZ DEL RIO, B. PINSHOW, AND L. LIZANNEROXBURGH. 2004. Renal function in Palestine sunbirds: elimination of excess water does not constrain energy intake. The Journal of Experimental Biology. **207**: 3391-3398.

MEESE, R. J. 2012. Cattle egret predation causing reproductive failures of nesting tricolored black birds. California Fish and Game **98**(1):47-50.

METEYER, C. U., B. A. RIDEOUT, M. GILBERT, H. L. SHIVAPRASAD, AND J. L. OAKS. 2005. Pathology and proposed pathophysiology of diclofenace poisoning in free-living and experimentally exposed oriental white-black vultures (Gyps Bengalensis). Journal of Wild life Diseases, 41(4): 707-716.

NABIPOUR, A. 2008. Histological Structure of the Kidney of Insectivorous Bats. World Journal of Zoology **3** (2): 59-62.

NABIPOUR, A., E. ALISHAHI, AND M. ASADIAN, 2009. Some histological and physiological features of avian kidney. J. 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. J. Anat. **134**: 11–23.

NISHIMURA, H. 2008. Urine concentration and avian aqua porin water channels. Plungers Arch. Euro. J.

Physiol. **456**: 755-768.

OROSZ, S. E. 1997. Anatomy of the urogenital system, in Altman, R. B.; Clubb, S. L.; Dorrestein, G. M. *et al*. (eds): Avain medicine and surgery. Philadelphia, PA, Saunders, p 614-622.

PEEK, W. D., AND D. B. MCMILLAN. 1979. Ultrastructure of the tubular nephron of the garter snake Thamno phissirtalis. Am. J. Anat. **154**: 103–128.

REECE, W. O. 2004. Dukes' Physiology of Domestic Animals. Twelfth Edition. Cornell University Press. Ithace, PP: 107-113.

REINHARDT, E. G., D. J. STANLEY, AND H. P. SCHWARCZ. 2001. Human-Induced Desalinization of Manzala Lagoon, Nile Delta, Egypt: Evidence from Isotopic Analysis of Benthic Invertebrates. Journal of Coastal Research **17**(2): 431- 442.

RENFRO, J. L., AND N. B. CLARK. 1984. arathyroid hormone effect on chicken renal brush-border membrane phosphate transport. Am. J. Physiol. 247

REYNOLDS, E. S. 1963. The use of lead citrate at high pH as an electron-opaque stain in electron micros copy. J. Cell Biol. **17**: 208.

RITCHISON, G. 2008. Avian osmoregulation. Urinary system, salt glands and osmoregulation. J. Exp. Biol. **554**: 17-31.

SABAT, P. 2000. Birds in marine and saline environments: living in dry habitats. Revista Chilena de Historia Natural **73**:401-410.

SABAT, P., S. GONZALEZ-VEJARES, AND K. MALDONADO. 2009. Diet and habitat aridity affect osmoregulatory physiology: An intra specific field study along environmental gradients in the Rufous-Collared sparrow. Comparative Biochemistiy and physiology, part A **152**: 322-326.

SABAT, P., E. SEPÚLVEDA-KATTAN, AND MALDONADO, K. 2004. Physiological and biochemical responses to dietary protein in the omnivore passerine Zono trichia capensis (Emberizidae). Comparative Biochemistry and physiology, part A **137**: 391-396.

SAFER, A. M., N. K. EL-SAYED, K. ABO-SALEM, AND R. AL-SHAER. 1988. Ultrastructure of the nephron of the one-humped camel, Camel usdromedarius. J. Morphol. **198**: 287-304.

SHARAH, H. A., E. A. ALI, AND I. D. MOHAMMED. 2008. The Feeding Behavior of the Cattle Egrets, (Bubulcus ibis L.) in Northeastern Arid Zone of Nigeria. J. Agri. Soc. Sci. Vol. **4**(1).6-12.

SILLER, W. G. 1981. Renal pathology of the fowl. J. Av. Pathol. **10**: 187-262.

SIMON, E. 1982. The osmoregulatory system of birds with salt glands. Comparative biochemistry and physiology **71** A: 547-556.

STANTON, B., D. BIEMESDERFER, D. STENTON, M. KASHGARIAN, AND G. GIEBISCH. 1984. Cellular ultrastructure of Amphium a distal nephron: effects of exposure to potassium. Am. J. Physiol. **247**:C204–C216.

SUTTERLIN, G. G., AND G. LAVERTY. 1998. Characterization of a primary cell culture model of the avian renal proximal tubule Am. J. Physiol. Regul. Integr. Comp. Physiol. **275**: R220-R226.

WOODIN, M. C., T. C.MICHOT, AND M. C. LEE. 2008. Salt gland development in migratory redheads (Aythya Americana) in saline environment on the winter range, Gulf of Mexico, USA. Acta Zoologica Scientiarum Hungaricae **54**: 251-264.

YOKOTA, S. D., S. BENYAJATI, AND W. H. DANTZLER. 1985. Comparative aspects of glomerular filtration in vertebrates. Renal Physiol. Basel. **8**: 193- 221.