UNIVERSITI PUTRA MALAYSIA

HISTOLOGY OF THE SWIFLET KIDNEY

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CERTIFICTION

It is hereby certified that I have read this project paper entitled “Histology of Swiflet Kidney”, by Raihan Adnin Binti Ruzaidi and in my opinion it is satisfactory in terms of scope, quality, and presentation as partial fulfilment of the requirement for the course VPD 4999-Final Year Project.

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DEDICATION

I wish to dedicate this Final Year Project to my family

My father, Ruzaidi B. Ismail

My mother, Rashidah Bt. Jaafar

For their passion and compassion in nurturing

My friends

Thank you for your continuous support.

May this will be your inspiration and motivation for your future endeavours

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LIST OF ABBREVIATION

EBN	edible bird nest
CMJ	corticol -medullary junction
H&E	Hematoxylin and eosin

ABSTRAK

Abstrak daripada kertas projek yang dikemukakan kepada Fakulti Perubatan Veterinar untuk memenuhi sebahagian daripada keperluan kursus VPD 4999-Projek Tahun Akhir,

Histologi Ginjal Burung Walit

Oleh:

RAIHAN ADNIN BINTI RUZAIDI

Supervisor: Prof. Datuk Dr. Tengku Azmi Tengku Ibrahim

Ginjal daripada burung walit dikelilingi oleh lapisan tisu penyambung yang sangat nipis menembusi parenkim buah pinggang untuk membahagikan ginjal kepada beberapa lobul. Setiap lobul terdiri daripada medula, korteks dan pelvis. Struktur nefron burung walit, unit fungsi buah pinggang, adalah sangat berbeza berbanding dengan nefron mamalia dan juga berbeza dengan beberapa spesies burung seperti ayam dan burung merpati. Dalam keratan rentas lobul ginjal burung walit, korpuskel renal didapati tersusun dalam satu barisan dorsal kepada korteks- medulla. Sebahagian besar korteks dipenuhi oleh tubul berlingkar proksimal. Tubul berlingkar proksimal digarisi oleh sel-sel kolumnar tinggi dan tersusun selari merentasi ketebalan korteks. Tubul proksimal berakhir di persimpangan korteks-medula dan bersambung terus dengan tubul berlingkar distal yang dibarisi oleh epitelium kuboid menyerupai epitelium yang terdapat pada cabang menurun dan menaik gelung Henle di dalam spesies mamalia. Walau bagaimanapun gelung Henle tidak terdapat dalam nefron ginjal burung walit kerana tiada tubul yang digarisi oleh epitelium skuamus ringkas yang biasanya melapisi gelung Henle. Dengan yang sdemikian nefron burung walit boleh dikategorikan sebagai nefron tanpa gelung Henle. Tubul proksimal didapati memasuki korteks pada jarak yang dekat untuk berada berhampiran dengan korpuskel renal membentuk makula densa yang merupakan salah satu komponen alat juxtaglomerulus. Tubul berlingkar distal yang memasuki korteks dengan jarak yang dekat adalah rasional bagi korpuskel renal berada berhampiran dengan persimpangan korteks-medulla. Tubul berlingkar distal seterusnya membentuk duktus pengumpul. Daripada kajian ini, boleh disimpulkan bahawa ginjal burung walit adalah organ penapisan yang ringkas tetapi amat cekap. Ini boleh dilihat daripada tubul berlingkar distal yang pendek dan tidak mempunyai gelung dan digantikan dengan tubul proksimal. Tubul proksimal yang sangat panjang membentuk kawasan permukaan yang amat luas untuk penyerapan semula filterat.

Kata kunci: *burung walit, histologi ginjal, nefron reptilia, tubul berlingkar proksimal, glomerulus*

ABSTRACT

An abstract of the project paper presented to the Faculty of Veterinary Medicine in partial fulfilment of the course VPD 4999- Final year Project.

THE HISTOLOGY OF THE SWIFLET KIDNEY

By:

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The kidney of the swiftlet is surrounded by a very thin layer of connective tissue which penetrate the kidney parenchyma to divide the kidney into a number of lobules. Each lobule comprised of the cortex, medulla and pelvis. The structure of the nephron in the swiftlet which is the functional unit of the kidney, is markedly different from that of mammal and is also different from that of some avian species namely the chicken and dove. In a cross section of the kidney lobule of the swiftlet, the renal corpuscle is arranged in a row close to cortico-medullary junction. The major part of the cortex is occupied by the proximal convoluted tubules which are arranged in parallel rows traversing the thickness of the cortex. Terminating at the cortico-medullary junction the proximal convoluted tubule continued a short distance into the medulla as the distal convoluted tubule lined by simple cuboidal epithelium resembling the epithelium of the descending and ascending limbs of loop of Henle of mammalian species. The loop

of Henle is however absent as no tubules lined by simple squamous epithelium which normally line the loop of Henle could be observed. Hence the nephron of the swiftlet is loopless and based on its structural organization, the nephron could be classified as the reptilian type.

The distal convoluted tubule in the medulla continued a short distance into the cortex to pass close to the renal corpuscle to form the macula densa which is one of the components of the juxtaglomerular apparatus. The distal convoluted tubule which extend a short distance into the cortex could be the rationale for the renal corpuscle to lie close to the cortico-medullary junction. The convoluted tubules then continue to form the collecting ducts located in the pelvis of the kidney. It can be concluded from this study that the kidney of the swiftlet is simple yet an efficient filtration organ – simple from the point of view that the distal convoluted tubule is very short and without the loop of Henle; it is highly efficient brought about by the very long proximal convoluted tubule which provide a very wide surface area for reabsorption at the glomerular filtrate.

Keywords: *swiflet, histology of kidney, reptilian nephron, proximal convoluted, glomerulus*

1.0 INTRODUCTION

Aerodramus fuciphagus is the one of swiflet species that produce the edible bird nest (EBN). The EBN is currently of considerable economic importance because of it highly nutritious and with anti -viral properties made the bird nest a more valuable food commodity (Ibrahim *et al*, 2009). In addition, EBN consists of highly valued glycoprotein rich with amino acids, carbohydrate, calcium, sodium and potassium (Norhayati *et al.*, 2010). More recently, bird nests have been used as a component in cosmetic products (Zainab *et al*., 2013).

There are more than 24 species of insectivorous, eco-locating swiflets distributed around the world, but only a few produce nests that are deemed "edible" (Koon, 2000). The majority of EBN traded worldwide come from two heavily exploited species, the White nest swiftlet (*Aerodramus fuciphagus*) and the Black nest swiftlet (*Aerodramus Maximus*) (Babji *et al.*, 2011). The EBN used in this study are from the swiftlet species *Aerodramus fuciphagus*. These white nest swiftlets are normally resident birds on islands, but currently they are also distributed on the mainland in large populations (Tan, 2001).

Current researches on swiflet are focused on the commercial importance of the avian species viz. attracting more birds into the bird houses, EBN adulteration, and turning the bird droppings into cash. Limited research had been carried out on the various body system of swiflet. There is thus, a need to understand the anatomy, physiology and nutrition of these species if bird ranching is to be given due to the importance to develop the swiflet industry in this country.

The kidney is an important organ with many functions including production of certain hormones, absorption of minerals and filtration of blood and besides it also plays a very important role in regulating the fluid balance of the body. Likewise, the kidney, can be vary the amounts and kinds of electrolyte eliminated from the body; thus the kidney assist in maintaining a proper salt balance in blood and tissue fluid. To date no report have been published on the kidney of the swiflet, a unique avian species foraging on microscopic insects in the upper strata of the atmosphere. It is also in constant flight from the time it leaves its nest at dawn until dusk when it returns to its nest.

1.1 OBJECTIVE

The present study is to investigate the histological structure of the kidney in the swiflet.

1.2 JUSTIFICATION

Various avian species are known to have different types of nephron viz a mixture of the mammalian (with loop of Henle) and reptilian type (without loop of Henle) as in a chicken and dove. Hence the findings in this study could determine the type of nephron in the swiflet.

1.3 HYPOTHESIS

The hypothesis of the study is the Swiflet has a simple but highly efficient functional unit of the kidney.

2.0 LITERATURE REVIEW

2.1 SWIFLET SPECIES

According to Ibrahim *et al.*, 2009, there are currently 24 species of swiflets recorded in the world. The five most common species found in Malaysia and Borneo Island are *Hydrochous gigas*, *Collocalia esculent* (White belly swift), Asian Palm Swift (*Cypsiurus Balasiensis*), *Aerodramus maxim* and *Aerodramus fuciphagus* (Lim, 2006). *Aerodramus fusiphagus* is a particular species of swiflet that produce EBN and only available in the Southeast Asia region (Ibrahim *et al*., 2009).

The majority of EBN traded worldwide come from two heavily exploited species, the white nest swiftlet (*Aerodramus fuciphagus*) and the black nest swiftlet (*Aerodramus Maximus)* (Babji *et al*., 2011). The EBN used in this study are from the swiftlet species *Aerodramus fuciphagus*. These white nest swiftlets are normally resident birds on islands, but currently they are also distributed on the mainland in large populations (Tan, 2001)

In this study the Brooke taxonamy (1970, 1972) was used to identify the birds which were indicated as below.

Kingdom : Animalia

Phylum : Chordata

Subphylum : Veterbrae

Class : Aves

Order : Apodiformes

Family : Apodidae

Genus : Aerodramus

Species : *fuciphagus, maximus, salangus, volcanorum, gigas, vanokoresis, esculata, germanicus/vestitus, uinicolor*

2.2 AVIAN KIDNEY

The urinary system of the fowl consist of large, paired kidneys, lying symmetrically one on either side of the vertebral column, drained by ureters which open into duodenum of the cloaca and no urinary bladder is present (Hodges, 1974). Each kidney is an elongated, somewhat irregularly-shaped organ of dark brown colour, which is closely applied to the dorsal abdominal wall external to the peritoneum. According to the Spector (1951) the average dimensions of the kidney of a mature fowl is 6 cm long and 1.5cm broad and 1 cm in depth however actual dimensions will vary according to the breed and age.

Each kidney has three distinct sections cranial, middle and caudal lobes. The blood circulation in the lobes are the renal arterial blood supply, the renal venous return and the renal portal system, which is typical in avian species. There is one renal artery per lobe. The renal portal system is made of cranial and caudal renal portal veins which deliver blood to the interlobular spaces.

According to Hodges (1974), the basic unit of the kidney is the lobule which can be seen on the surface as closely packed irregularly polyhedral areas. Each lobule consists of cortical and medullary tissue with the cortical component lying essentially peripherally to the medullary component. The amount of cortical tissue however considerably exceeds that of the medulla in that several cortical lobules drain into a single medullary tract to form a discrete, conical structure, the medullary cone. Subsequently, the cortical tissue layer extends into the depths of the kidney between and surrounding the medullary cones and there is therefore no clear delineation of cortical and medullary layers as in the mammalian kidney. A lobule may thus be said to consist of a single cortical unit and part of shared medullary cone. Each medullary cone drains into a single primary branch of the ureter.

2.3 THE NEPHRON

The basic unit of the avian kidney is the nephron. The ability to conserve ions and/or water may be correlated with the structure of the nephron (Nabipour *et al.*, 2009). The avian kidney is unique in structure among vertebrate kidney in having two types of nephrons those with and without a loop of Henle or respectively referred to as looped and loopless (Braun *et al*., 1972). The loopless nephrons stay within the cortex while the looped nephrons extend from the cortex and into the medullary areas called medullary cones and with each cone, the number of loops of Henle decreases as tip of the con is approached (Layton, 1986).

The cortical nephron, which resembles the reptilian type, possess a relatively small glomerulus, representing the great majority of nephrons and is confined to the cortex. The medullary nephron, which resembles the mammalian type possess a large glomerulus, representing only a small proportion of nephron and lies partly within the medulla (Huber, 1917)

Each nephron can be subdivided into one of the perilobular collecting ducts. The interconnection between the proximal and distal convoluted tubules varies according to the type of nephron. In the case of cortical nephrons this consists of a short, narrow tubule while in the case of medullary nephron it consist of long medullary loop passing down into the lobular medulla and back again into the cortex (Hodges, 1974).

In the article of Animal Science Chicken Dissect by Karolina (2001) state that the nephron are responsible for filtering the liquid waste after the digestion, reabsorbing any last useful substances and secreting the waste to dispose it. Each nephron is composed of a renal corpuscle, or a network of capillaries enclosed in the Bowman's capsule, a proximal convoluted tubule leading away from the Bowman's capsule, a loop of Henle if the nephron is mammalian type, a distal convoluted tubule and a collecting tubule that leads to the ureter.

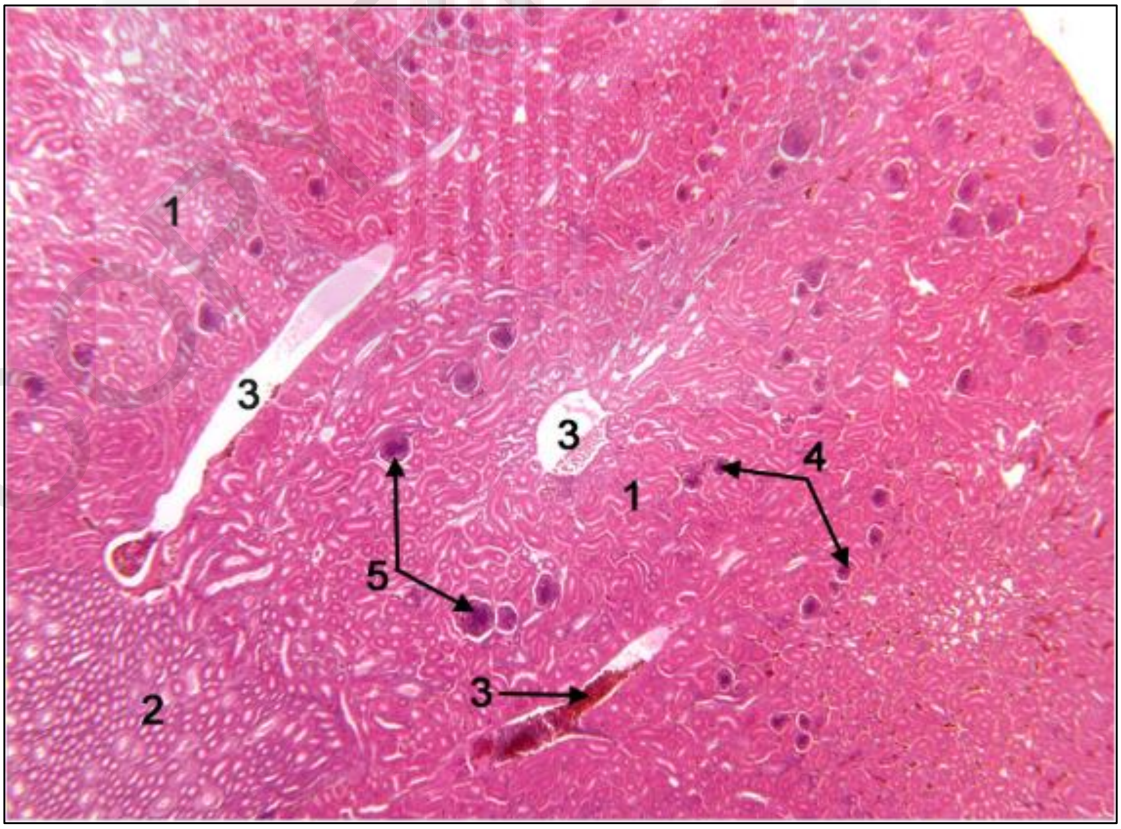

Fig 1: The histological structure of fowl kidney showing the cortex (1), medulla (2), interlobar vein (3), renal corpuscle of cortical nephrons (4) and renal corpuscle of medullary nephrons (5)

The histological structure of the fowl kidney is as shown in figure 1. The cortex occupy most of the lobular area while the medulla occupy small proportion of lobule area. The nephron of the fowl comprising of the reptilian and mammalian types is as depicted in figure 2. The whole structure of reptilian type of nephron are confined in the cortex while the mammalian type extend from the cortex into the medullar area. The convoluted tubules of mammalian type of nephron is within the cortex and its loop descending into the medullary cone. The cortical nephrons has smaller renal corpuscles compared to the medullary nephrons and located at the cortex and the large renal corpuscles of medullary nephrons lie close to the medulla (Abbas, 2012). The renal corpuscle are scattered throughout the cortex which is similar in mammalian kidney.

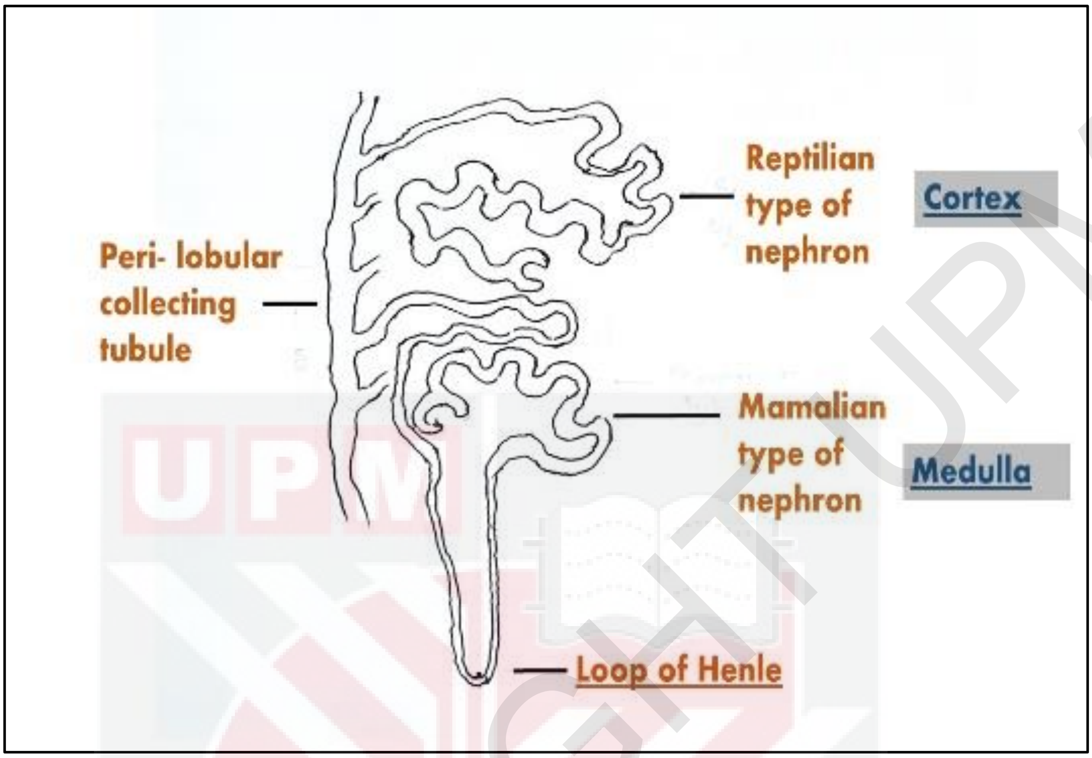

Figure 2

Fig. 2: An illustration of both reptilian and mammalian types of nephron in avian kidney. Noticed that, the renal corpuscle of mammalian type of nephron lie close to the medulla.

According to Sherri (2003), a mammal type of nephron, is capable of concentrating urine and has a high filtration rate, while the reptile type has lower filtration rate and shuts down during heavy salt loads. This strategy conserves water and maximizes urine concentration during osmotic challenges.

3.0 MATERIAL AND METHOD

Six live swiflets (*Aerodramus fuciphagus*) were obtained from a swiflet birdhouse at Kluang, Johor. Following the halal slaughter and laparotomy, the kidney organ was removed and fixed in Bouin's solution for 16 hours.

Following the fixation, the samples were processed in the Histokinette tissue processor, embedded in liquid Paraffin. 4μm thick sections were obtained using the rotatory microtome. Section on glass slides were stained with haematoxylin and eosin and subsequently examined under the light microscope.

4.0 RESULT

Under the light microscope, the kidney of the swiflet appeared lobulated. Each lobule comprised of the cortex, medulla and pelvis (Figure 3).

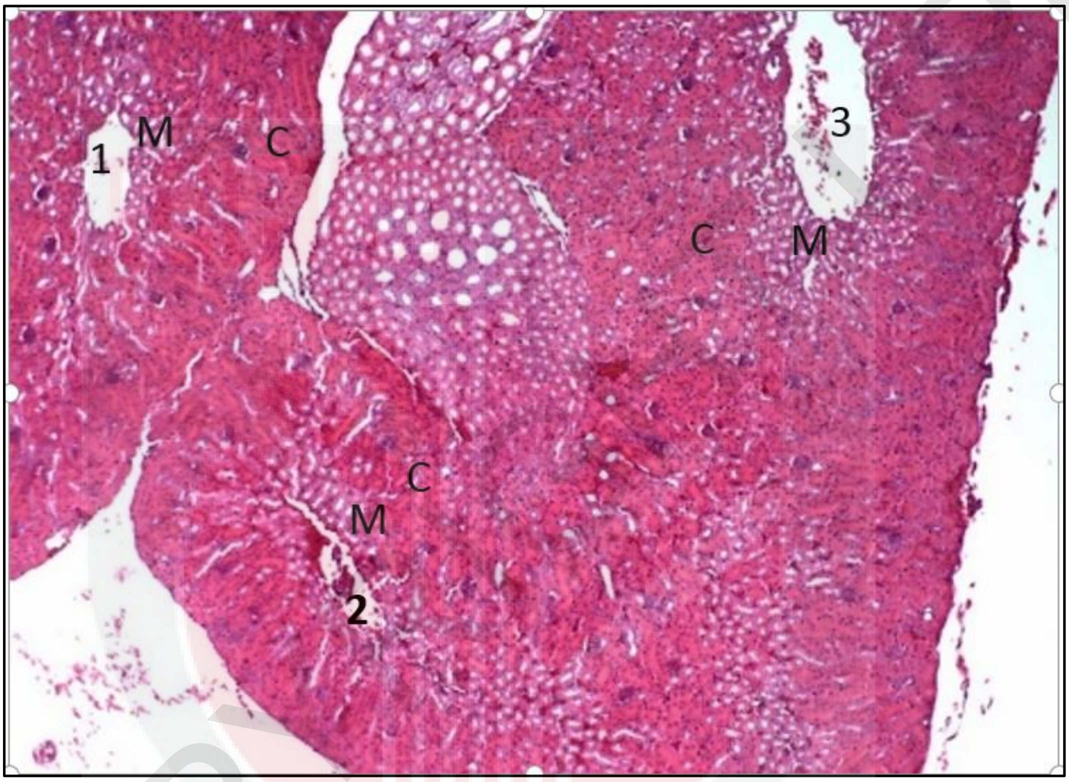

Fig. 3: The lobulated structure of the swiflet kidney showing 3 lobule (1), (2), (3), and each of lobule comprising of the cortex (C), medulla (M) and pelvis (P). H&E x100.

The major part of the lobule was occupied by the cortex while the medulla was only a small part of the lobule (Figure 3).

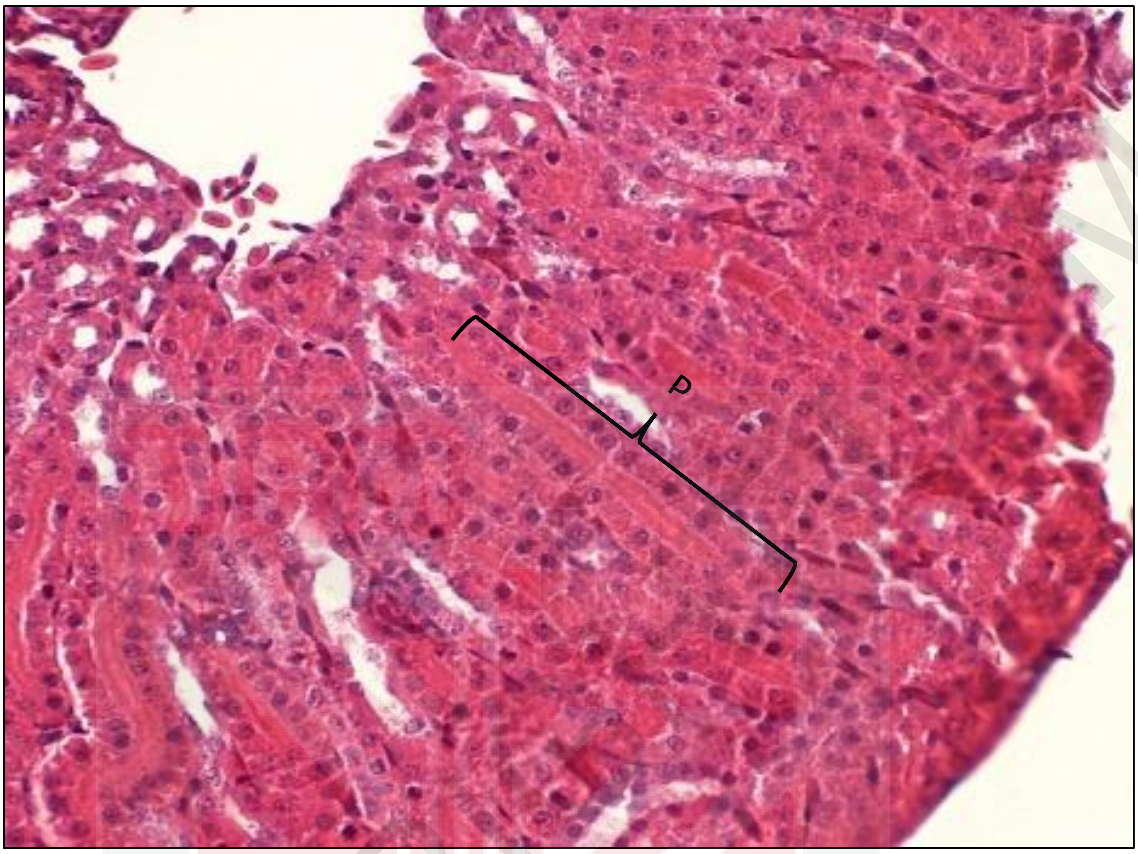

Fig. 4: Proximal tubule in the cortex arranged parallel (P) traversing the thickness of the cortex H&E x40

The proximal tubule which occupied the major part of the cortex did not appear convoluted except at the periphery of the cortex. The tubules were arranged parallel traversing the thickness of the cortex.

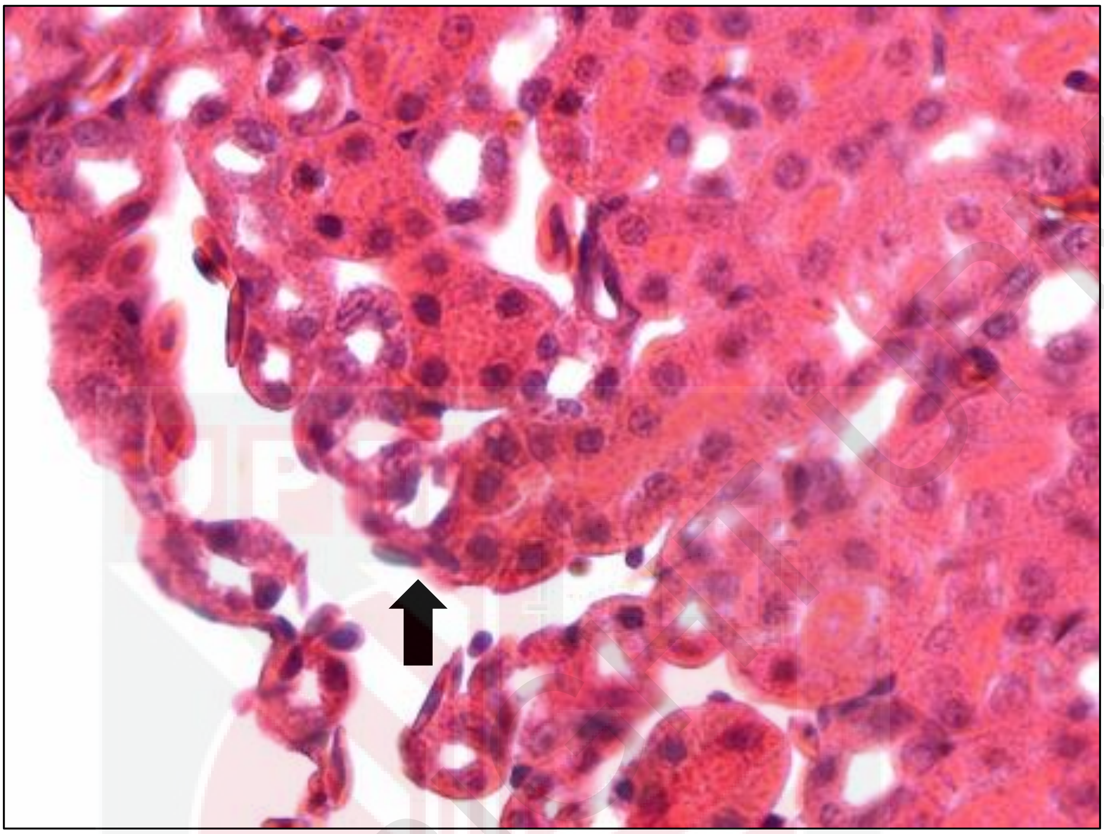

Fig. 5: Proximal convoluted tubule showing a direct connection with the distal convoluted tubule (arrow). H&E x1000.

At the cortico-medullary junction the proximal tubule continued directly into distal convoluted tubule lined by simple cuboidal epithelium (Figure 5). There were no tubule lined by simple squamous epithelium among the distal convoluted tubule in spite of extensive search for this epithelium. The surface epithelium of the collecting ducts appeared fuzzy and the connective tissue around the tubule were highly vascularized (Figure 6).

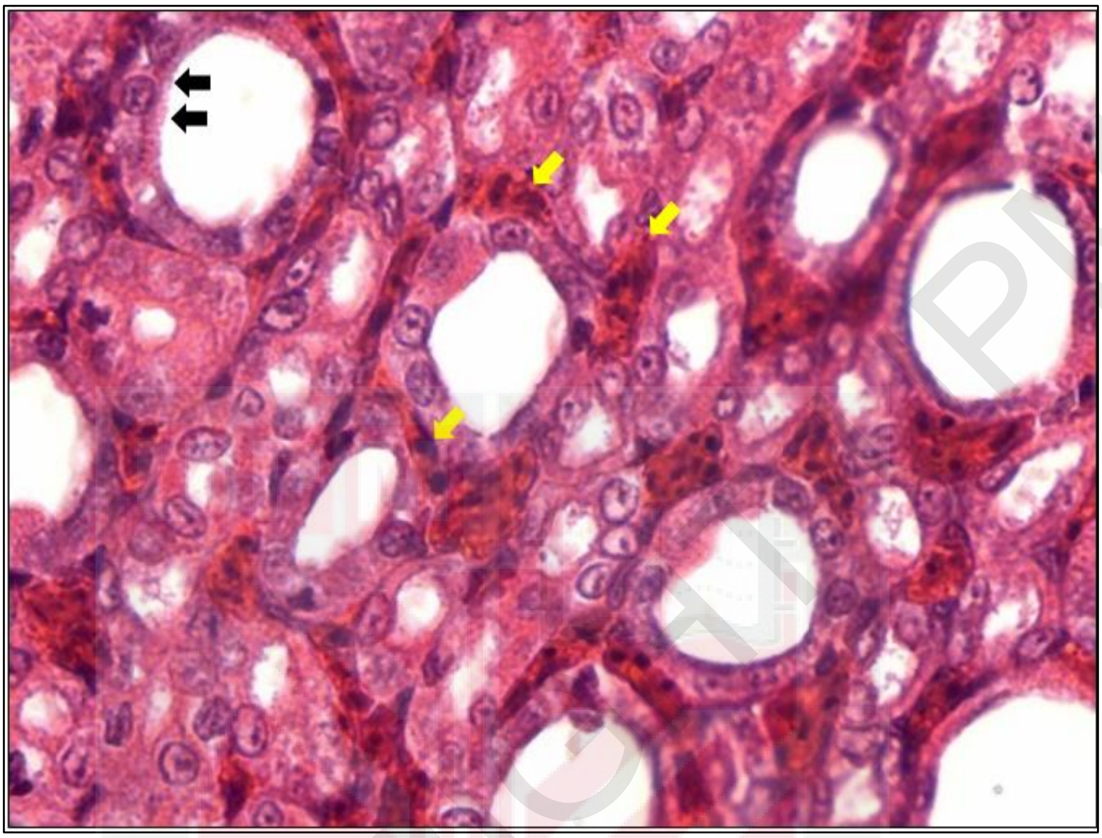

Fig. 6 : The collecting ducts showing a fuzzy epithelium (black arrow) and a highly vascularized connective tissue (yellow arrow). H&E x100

The distal convoluted tubule emerged a short distance into the cortex to meet the renal corpuscle to form the juxtaglomerular apparatus (Figure 7). In this avian species, the renal corpuscle appear to be arranged in a row just above the cortico-medullary junction (Figure 8).

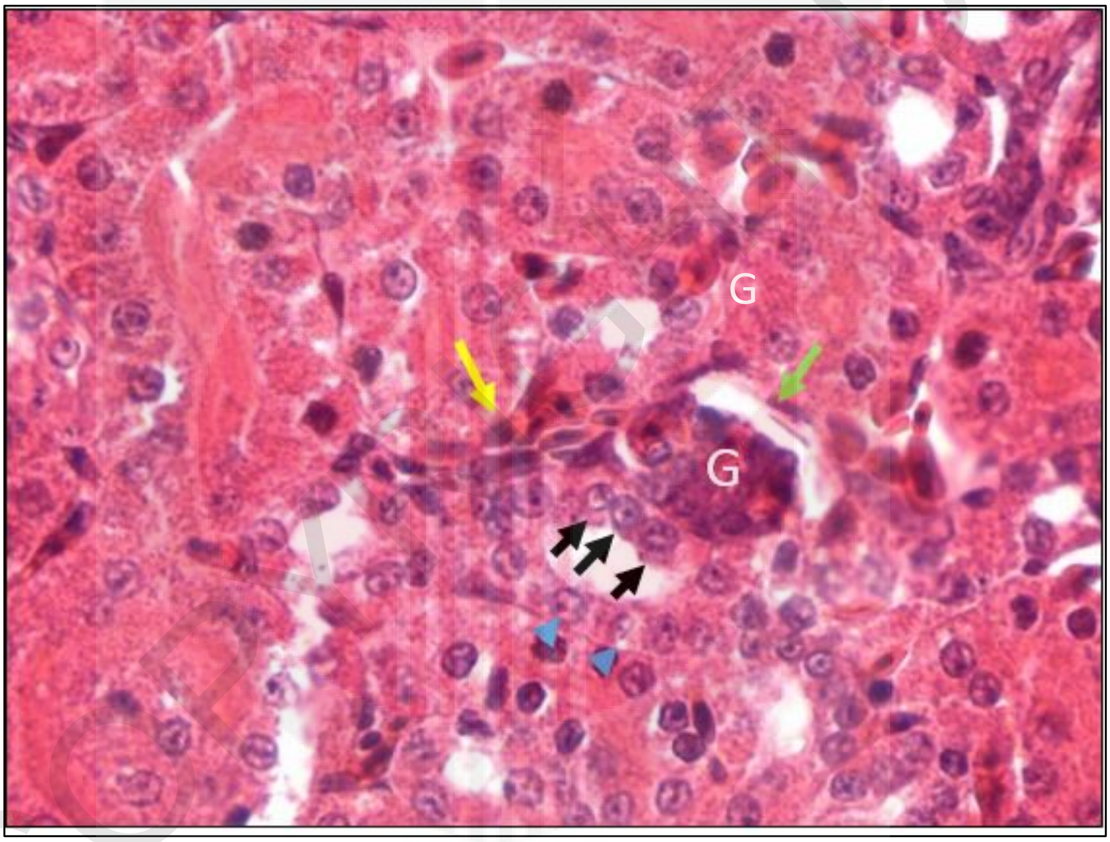

Fig.7: The juxtaglomerular apparatus form by the arteriole (yellow arrow) and macula densa (blue arrow). Glomerulus (G) and capsule Bowman (green arrow). H&E x1000.

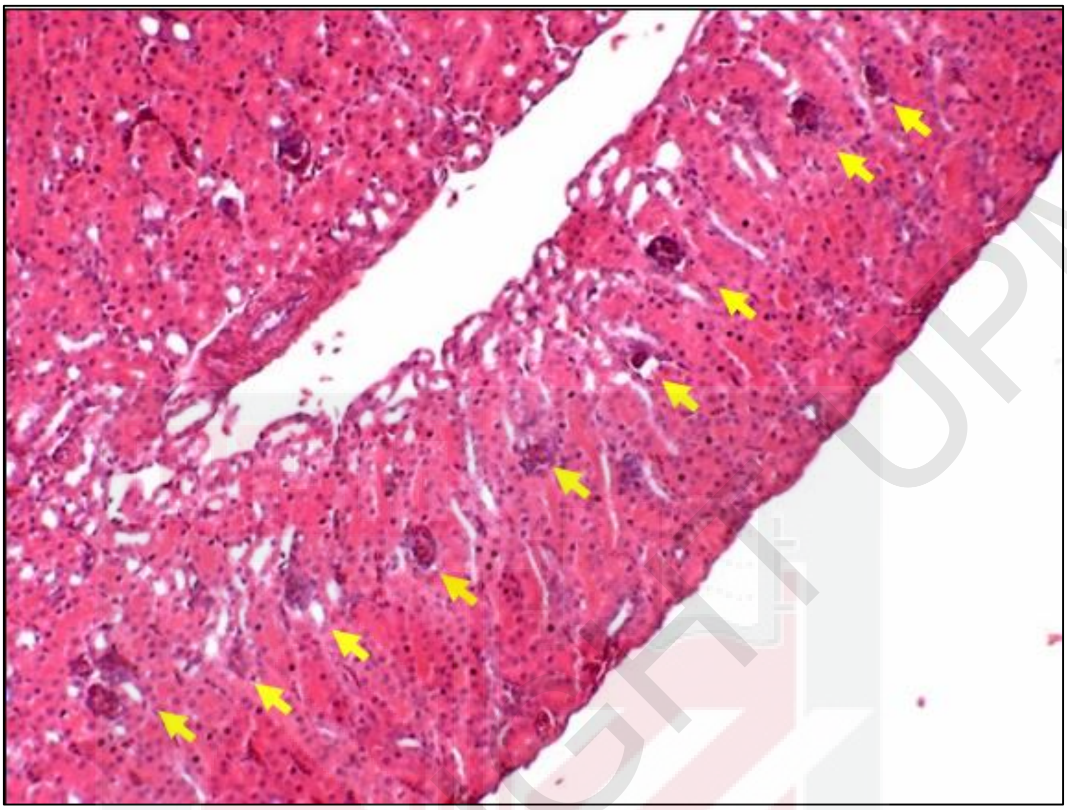

Fig.8: Arrangement of the renal corpuscle (yellow arrow) in a single row at the corticol-medullary junction. H&E x100.

5.0 DISCUSSION

Reconstruction the histological structure of the nephron into a structural organization in the swiflet as is depicted in figure 9

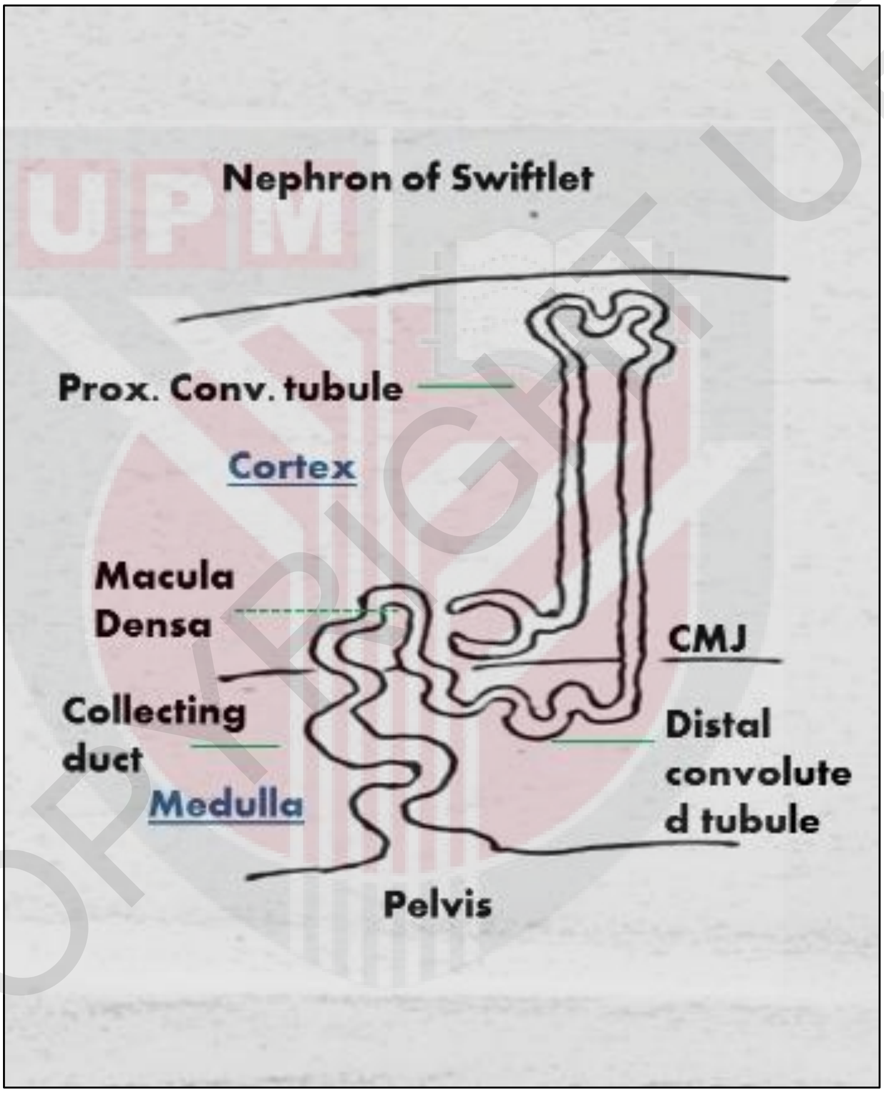

Fig. 9: Structural organization of the nephron of swiflet resembling that of the reptilian type.

The proximal tubule is only convoluted at the periphery of the cortex. Compared to mammalian kidney the nephron in the swiflet is very simple comprising only of the renal corpuscle, proximal convoluted tubule, distal convoluted tubule and collecting duct without the ascending and descending limb and the loop of Henle. Absence of the loop of Henle is justified by the absence of simple squamous epithelium which normally line the loop of Henle. In the absence of the Loop of Henle, the nephron of the swiflet is loopless and resembles that of the reptilian nephron found in coot birds (Abbas, 2012).

It is interesting to note that the renal corpuscle in the kidney of the swiflet is arranged in a row short distance dorsal to the cortico-medullary junction. This arrangement at the renal corpuscle could be due to the short distal convoluted tubule which did not emerge far into the cortex. The renal corpuscles therefore had to be located close to the macula densa of the distal convoluted tubule to form the juxtaglomerular apparatus. Thus the possible rationale for the renal corpuscle to be arranged in a row a short distance dorsal to the cortico-medullary junction.

In this study, it is hypothesized that the nephron in the kidney of the swiflet is simple but highly efficient. There are ample evidence to support that the hypothesis is true which are as follow:

i) The nephron is simple being devoid of the ascending and descending limbs and the loop of Henle which categorises this nephron as the reptilian type.

ii) In the absence of the ascending and descending limb and loop of Henle and a short distal convoluted tubule allowed a longer proximal convoluted to be accommodated in the lobule of the kidney. A longer proximal convoluted tubule provide a greater surface area for the reabsorption of the filtrate which make the nephron highly efficient.

iii) The efficiency of the nephron in this avian species could be further enhanced by the involvement of the collecting duct in the reabsorption of the glomerular filtrate. This is evidenced by the fuzzy nature of the epithelial surface lining the collecting duct. The fuzzy structure could be microvilli which if present could further increased the surface area of the individual tall columnar for the absorptive of glomerular filtrate. The connective tissue around the collecting duct can also observed to be highly vascularized. Substances reabsorbed from the filtrate will diffuse directly into the capillaries.

6.0 CONCLUSION

It is concluded that from this study that the nephron in the kidney of the swiflet though simpler and made up of only reptilian type is however highly efficient being provided with a very extensive area for reabsorption of the glomerular filtrate.

Enhanced reabsorption of the glomerular filtrate could also occur in the collecting ducts brought about by the microvilli on the surface epithelium of the collecting ducts. However an electron microscopic study on the fuzzy coat at the collecting duct need to be carried out to justify this additional function of the collecting duct.

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