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Renal morphology of postnatal suckling of *Hipposideros speoris* (Schnider), Chiroptera; Mammalia

Patil Kishor Gopal

Department of Zoology, Government Institute of Science, R. T. Road, Civil Lines, Nagpur, (M.S.) India- 440001.

Address for Correspondance 54, Old Jagruti Colony, Katol Road, Nagpur 4400013, M.S.) India.
E-mail : drkgpatil@gmail.com

ABSTRACT

Morphologically the kidneys of postnatal sucklings of leaf nosed bat *Hipposederos speoris* having body weight 6.5g show variation in shape. The right kidney is broader at the anterior pole and narrower at the posterior. Both the right and left kidneys are compressed dorsoventrally which gives an edged appearance at the hilar side. The kidneys are differentiated into a thin cortex, a thick medulla which is further divided into an outer and an inner zone. The papilla is conical, thick and long and protrudes outside the kidney, into the ureter through the wide hilus. The calyx separates the papilla from other cortico-medullary components.
Histologically the renal tubules can be differentiated into the Bowman's capsules, the proximal and distal convolutated tubules in the cortex. The medulla comprises the network of large collecting tubules and the very narrow loops of Henle with lumen. In the large papilla collecting ducts with wide lumen open into the wide calyx; few collecting tubules and the thin loop of Henle are also observed in the papilla.

KEYWORDS:

Bat; Cortex; Kidney; Medulla; Papilla; Postnatal; Uriniferous Tubule.

INTRODUCTION

The excretory system of mammals composed of the kidney proper, the ureters and a bladder with accessory structures; which is involved in filtration of toxic substances, removal of excess materials, conservation of water and maintenance of electrolyte balance and hence provides an optimal state conducive for metabolism through the body tissues as well as within intercellular spaces; thus maintain homeostasis. The excretory organs are paired structures and are concerned in collecting waste (Patten, 1968). A strong relationship between mammal's ecological distribution and urine concentrating ability has been established in several mammals (Sperber, 1944). In mammals the factors such as diet and other aspects of an animal's life history influence renal specialization (Carpenter, 1969; Geluso, 1980).

As reported in other mammals the kidneys of chiropterans also exhibit the structural adaptations influenced by the habitats and feeding habits (Studier et al., 1983; Lu and Bleier, 1981). The old world fruit bats (Order- Megachiroptera) possessed kidneys with thick cortex; a thin or undivided medulla and a very short conical papilla; while the neotropical bats with animalivorous feeding habits possesses kidneys with relatively thin cortex, a thick medulla divided into outer and inner zones and a long papilla. The kidneys of adult *H. speoris* also exhibit similar morphology like other microchiropteran bats (Patil, and Janbandhu 2012c).

The development of kidneys at 21 somite stage embryo of *Rhinolophus hipposideros* and on older embryos of *Nyctalus* [= *Vesperugo*] *noctula* were noticed by Van der Stricht (1913). The fetal furrows on the outer surface of embryonic kidneys of *Myotis* and *Plecotus* were observed by Sperber (1944). He also reported that, in these embryonic stages the kidneys shows no differentiation of cortical and medullary components. The histochemistry of protein and glycogen in the prenatal, postnatal kidneys of Indian fruit bat *Rousettus leschenaultia*; the glycogen and protein activity in the kidneys of prenatal embryos at term stages of development and postnatal sucklings of two species of bats, *Megaderma lyra lyra* (carnivorous) and *Hipposederos speoris* (insectivorous) examined by Patil and Janbhandu, 2011c and 2012a). The functional histology is the area of interest, especially when employed or combined with ultrastructural cell biology, cytochemistry or histochemical visualization (Rosenbaum, 1970). The structural and cellular details of metanephric kidneys at term stages of *Hipposideros speoris* are examined in this report.

MATERIALS AND METHODS

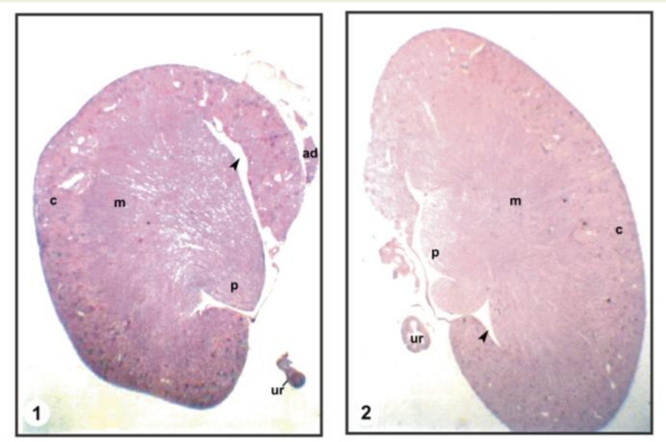
Four preserved specimens of postnatal sucklings of *Hipposederos speoris* were used in this study. The animals were previously collected from underground dilapidated dark rooms of old fort at Ballarshah, Maharashtra, India. The body weight and sex of animals were recorded; the kidneys from the selected specimens were removed, measured and weighted. The weight of kidneys was taken by electronic weighing machine. The kidneys then fixed in different fixatives: Alcoholic Bouin's, Aqueous Bouin's, 10% Formalin for 24 hours. The kidneys were washed overnight in running tap water and dehydrated by passing through different grades of ethyl alcohol, cleared in xylene and embedded in paraffin (58-60^{o}C). The mid sagittal sections of kidneys were cut at 5-7µm with the help of rotary microtome. For routine histology Haematoxylene-eosin technique was used. The stained sections were observed under light microscope. The measurements of micro-structures were calculated with the help of ocular micrometer scale.

RESULTS

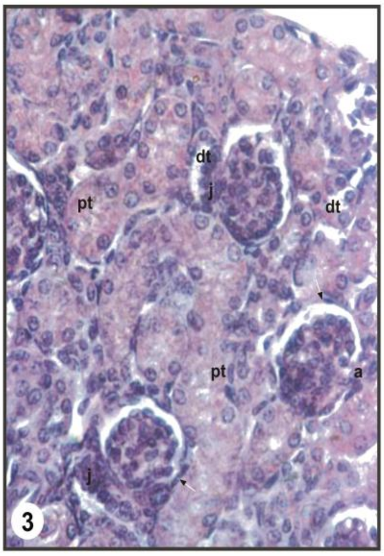
The report is based on the examination of the kidneys in four preserved specimens (all females) of *Hipposederos speoris* at suckling stege. The female postnatal sucklings of *H. speoris* show the variation in shapes. Anatomically the right kidney is broader at the anterior and narrower at the posterior as compare to the left kidney. Both the kidneys are compressed dorso-ventrally giving an edged appearance towards the hilar side; the right kidney being more edged than the left. The mid-sagittal sections of the kidneys examined shows that the kidneys are distinctly differentiated into a thin cortex, a thick medulla which is again divided into an outer and an inner zone. The papilla is conical, thick, long and protrudes outside the kidney into the ureter through the wide hilus. The wide calyx separates the papilla from other cortico-medullary tissues. (Figs. 1 and 2).

Histologically, in the cortex the uriniferous tubules can be differentiated into the Bowman's capsules, the proximal and distal convolutated tubules. In the Bowman's capsule the glomerular cells occupy the spaces in between the glomerular capillaries. The glomerular arterioles and juxta glomerular apparatus are observed at the vascular pole of the Bowman's capsules. The proximal convoluted tubules possess the microvilli at the luminar border. The microvillar brush border is a characteristic feature of the proximal tubules. The distal convoluted tubules with wide lumen are lined by the cuboidal epithelial cells (Fig. 3). In the thick medulla large collecting tubules are also lined by the cuboidal epithelial cells. The thin loops of Henle with very narrow lumen are lined by the squamous epithelial cells (Figs. 4 and 5). In the conical papilla; collecting ducts with wide lumen open into the wide calyx are lined by the columnar epithelial cells. Interstitial cells are observed in the connective tissue; a few collecting tubules and the loop of Henle are also noticed in the papilla in-between the collecting ducts (Fig. 6).

Note: The details of measurements of various components of the postnatal kidneys of *Hipposederos speoris* are given in Tables 1 to 4.



Figures 1 & 2: Midsagittal sections of the right kidney (Fig. 1) and the left kidney (Fig. 2) of the female postnatal suckling of *H. speoris* with a body mass 6.5g. Showing the outer thin cortex (c), the inner thick medulla (m) and the papilla (p). The papilla ends into the narrow calyx (arrowheads) at the wide hilus. Note the varying shapes of the right and left kidneys. ad: adrenal; ur: ureter.



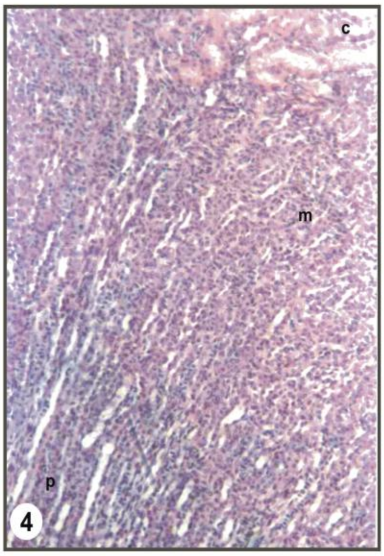
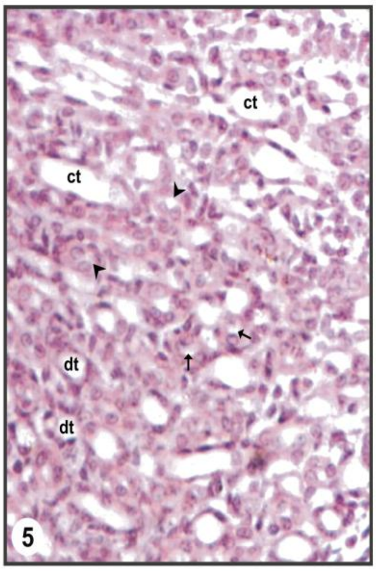


Figure 3.
Part of cortex from the figure 1 magnified to show the Bowman's capsules (long arrows), the juxta glomerular apparatus (j) with macula densa, the proximal convoluted tubules (pt) and the distal convoluted tubules (dt).a: afferent arteriole.

Figure 4.
Cortico-medullary region in low power to show a part of cortex (c), the medulla (m) and the papilla (p).



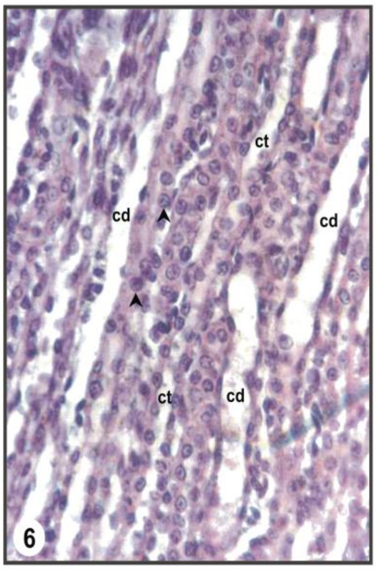


Figure 5: T.S. medulla of the postnatal kidney of *H. speoris* showing different types of uriniferous tubules of varying diameter. The collecting tubules (ct), the small tubules of thin loop of Henle (thin arrow), the proximal tubules (arrowheads) and the distal tubules (dt). Please see text for description.

Figure 6: Papillary region from figure 1 magnified to show large collecting ducts (cd) with wide lumina and the collecting tubules (ct) with narrow lumina. Both the types of tubules are lined by cuboidal epithelial cells with darkly stained nuclei. Arrowheads point towards the interstitial cells with large nuclei.

Table 1. Measurements of Kidneys of Postnatal suckling of *H. speoris*.

Sr. No.	Body wt. in g.	Kidney Measurement in m.m. (Length x Width x Thickness).		Weight of Kidney in g.	
		Right	Left	Right	Left
1	5	3.4 x 2.5 x 2	3.4 x 2.3 x 2.2	0.0103	0.0113
2	6.5	3.9 x 3.26 x 2.4	4.0 x 3.1 x 2.5	0.0140	0.0118
3	6.5	3.85 x 3.15 x 2.6	4.0 x 2.75 x 2.6	0.0114	0.0104
4	6.5	4.8 x 3 x 2.5	5 x 3 x 2.5	0.0147	0.0142

Table 2. Measurements of different parts of Kidney of Postnatal suckling of *H. speoris*.

Sr. No.	Part of Kidney	Height/ Length*	Thickness/ Space*/ Diameter**
1	Collagenous Capsule	--	96.428
2	Cortex	--	445.97
3	Medulla	--	853
4	Papilla	1086.75*	--
5	Calyx	--	100.6*
6	Hilum	--	869*

Table 3. Diameter of different parts of Uriniferous Tubule, Ureter, Renal Artery and Renal Vein in Postnatal suckling of *H. speoris* (in µm).

Sr. No.	Part of Renal Tubule / Ureter / Renal Artery / Renal Vein	External Diameter/ Thickness*	Luminal Diameter
1	Bowman's Capsule	50	--
2	Glomerulus	43	3.38
3	J-Glomerular apparatus	24.9*	--
4	Proximal Tubule	21	2.36
5	Thin Loop of Henle	13.26	4.34
6	Distal Tubule	29.7	10.21
7	Collecting Tubule	22.48	9.6
8	Collecting Duct	26.19	10.14
9	Ureter	297.8	120.7
10	Renal Artery	76.8	25
11	Renal Vein	85.7	50

Table 4. Details of Cells in Different Parts of Uriniferous Tubule Postnatal suckling of *H. speoris*.

Sr. No.	Part of Renal Tubule	Diameter of Cells in µm	Diameter of Nucleus in µm	Shape of cells	No. of Cells in T.S.
1	Glomerulus	5.6	3.3	Irregular	--
2	J-Glomerular Cells	6.44	4.8	Spherical	--
3	Macula Densa	8	4.8	Cuboidal	5
4	Proximal Tubule	10.69	5.1	Columnar	5 to 6
5	Thin Loop of Henle	5.5	3.9	Cuboidal	3 to 4
6	Distal Tubule	5.6	5.5	Cuboidal	6 to 8
7	Collecting Tubule	6.8	5	Cuboidal	5 to 7
8	Collecting Duct	8.4	5.4	Cuboidal	6 to 10
9	Interstitial Cells	8	6.44	Spherical	--

DISCUSSION

In mammals the urinary system is composed of the paired kidneys, ureters, urinary bladder for temporary storage and urethra open outside the body. Like other chiropteran species also in *Hipposideros speoris*, the considerably enlarged thoracic cavity appears to be responsible for the location of kidneys lower in the peritoneal cavity (Patil and Janbandhu, 2012c). Both the kidneys in males and females are of approximately same size and weight (Table 1). In *Hipposideros speoris* the right kidney is placed higher than the left, the kidneys are typically bean shaped, but the right kidney is broader at its anterior pole. In the *H. speoris* the ureters are broader at the hilus due to the protrusion of renal papilla. This phenomenon needs further investigation to establish functional correlation with this physical feature. The ureters in megachiropteran bats studied so far maintained almost uniform diameter throughout its length (Rosenbaum, 1970).

The chiropteran kidney is simple and is divided into an outer cortex, a single medulla converging in straight lines to the pelvis forming the terminal pyramid of papilla. In the species, *Micronycteris hirsuta, Tonatia bidens*, *Uroderma bilobatum*, *Vampyrodes caraccioli*, *Artibeus phaeotis*, *Artibeus jamaicensis* the kidney is divided into an outer thick cortex and an inner medulla which is not further divided into zones. A very short papilla ends into the calyx in the region of the renal pelvis. The cortico–medullary boundary is indistinct as a great number of medullary rays invade into the cortical region which is the characteristic feature of the old world megachiropteran fruit eating bats viz., *Pteropus edulis* and *Pteropus medius* (Sperber, 1944; Studier et al., 1983); *Rousettus leischenaulti* (Patil and Janbandhu, 2011b).

The kidneys of *H. speoris* show the thick medulla divided into an outer and an inner zone and a long conical papilla protruding outside the kidney which is the urine concentrating ability of these bats. Such a condition of medulla and renal papilla is observed in the neotropical insectivorous, piscivorous, carnivorous and sanguinivorous microchiropteran bats (Robin 1881; Sperber, 1944; Mann 1951; Rosenbaum, 1970; Studier et al., 1983; Patil, and Janbandhu, 2012b). The thin cortex of the kidney *H. speoris* indicates that the proximal convoluted tubules are comparatively shorter than the length of long loop of Henle in the thick medulla and a large protruding papilla. The length of the loop of Henle is directly proportional to the medullary and papillary thickness (Bankir and de Rouffignac, 1985). The diet of *H. speoris* mainly includes insect proteins; the dietary habits might be playing more significant role in deciding the urine concentrating ability. The large papillary spaces and the dense interstitial tissue noticed in the developing embryonic kidneys of *megaderma lyra lyra* (Patil and Janbhandu, 2011a; Patil et al., 2012) were not observed in the postnatal kidneys of *H. speoris*.

The interstial cells present in the medullary and papillary region may act as bridges in between the uriniferous tubules and the blood capillaries (Stevens and Lowe, 1993). It is presumed that these cells might be acting as temporary reservoir for the substrates because. The presence of tissue fluid and lymphatic vessels around the blood capillaries and nephric tubules are responsible for transport of substrates across the kidney tissue.

The role of proteins as building material; as precursor of enzymes, hormones, antibodies etc. is already established. The glycogen and lipids act as source of nutrients and energy for the metabolic activities. High protein and glycogen concentration in the microvillar brush border of the proximal tubules indicate its absorptive function by diffusion for water carbohydrates, minerals etc. More protein concentration in the basement membranes of the cells linning the uriniferous tubules in the medulla attributed to the protein rich diet, which may be utilized for metabolic activities and maintaining the histoarchitecture of the kidney. The proximal convoluted tubule is one of the most important sites for active absorption of minerals which are mostly in ionic form. The glycogens present in the cells of proximal tubules of medulla act as energy source used for active absorption (Patil and Janbandhu, 2011c, 2012a).

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