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Comparative Anatomical Study of the Kidneys in Cattle (*Bos taurus*) and Camel (*Camelus dromederus*)

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ABSTRACT

Introduction: Comparative anatomy helps scientists in classifying organisms based on similar structures or characteristics. The study was aimed at evaluating the gross and histological similarities/differences in the kidneys of cattle and camel.

Material an Methods: Five pairs of kidneys were harvested from five cattle and five camels, immediately after they were slaughtered. The kidneys were weighed, the length and breadth were measured. The thickness of the cortex and medulla were also measured. Part of the kidneys were fixed in 10% formalin and processed for light microscopy.

Results: Cattles' kidney is lobulated and consists of a thin capsule, cortex, medulla and pelvis while camels' kidney is bean-shaped and consists of cortex, inner and outer medulla and pelvis. The glomerulus of cattle and camels' kidneys are both compacted, their parietal and visceral layers lined by simple squamous epithelium. the kidneys of camels are significantly heavier ($P<0.05$) than those of cattle.

Conclusion: The medulla of cattle's kidneys has few convoluted tubules and numerous collecting duct while that of camels' kidneys has numerous convoluted tubule and few collecting duct, the medulla long and consist of two parts (outer and inner) giving the camel the ability to adapt to the desert land by conserving more water than cattle.
Keywords: Cattle: Camel; Cortex; Kidney; Medulla Pelvis.

Introduction

Comparative anatomy is the study of morphological similarities and variations of organisms (Gaucher *et al*., 2010). The differences in structure helps scientists to classify organisms. Organism's anatomical structures are design to suit their habitats (Campbell and Reece, 2008). The kidneys serve essential functions, such as ultrafiltration and excretion, electrolytes balance, erythrocyte production, blood pressure and pH regulation and reabsorption of glucose and amino acids (Gaschen *et al*., 2000; Yoldas and Dayan, 2014). Structural and functional variation of kidneys are seen in different vertebrates, these have enabled vertebrates to live in forest, desert and swamps (Allam and Abo-Eleneen, 2013).

Camels are even-toed ungulate in the family *Camelidae* and genus *Camelus* that bears distinctive fatty deposits known as "humps" on its back (Werney, 2003). Camels have long been domesticated, they provide food (milk and meat), textiles (fibre and felt from hair) and serve as a means of transportation for passengers and cargo in the desert land. The family *Camelidae* is divided into 3 genera: The old world camel genus *Camelus*, the new world camel genus *Lama* and genus *Vicugna* (Wilson and Reeder, 2005). Two domesticated species of old world camels exist, the one-humped dromedary camel (*Camelus dromedarius*) and the two-humped Bactrian camel (*Camelus bactrianus*). The dromedary camel is the most important livestock in the semiarid regions of North and East Africa and the Arabian Peninsula (Yam and Khomeiri, 2015). Camels are adapted to the desert habitat; this gives them the ability to withstand long periods of time without any external source of water (Rastogi, 2007).

Cattle are domesticated herbivorous mammals of the *Bovidae* family, they are commonly known as cows. They are domesticated because of their mild disposition, relatively simple diet and can provide food (meat and milk), hides and could be used for heavy labour. About 180 breeds of cattle have been identified in sub-Saharan Africa with the zebu cattle (*Bos indicus*) constituting the majority (Hanotte *et al*., 2000). Although the population of the humpless taurine cattle (*Bos Taurus*) are less than that of the zebu cattle, they are found in almost every part of the continent (Mwai *et al*., 2015). African cattles are classified into four categories: the humpless taurine (*Bos Taurus*), the humped zebu (*Bos indicus*), the sanga (taurine and zebu hybrid) and zenga (zebu and sanga hybrid) (Rege and Tawah, 1999). Cattle are adapted to dry environmental conditions and high temperatures of the African continent (Mattioli *et al*., 2000). The study was aimed at evaluating the gross and histological similarities/differences in the kidneys of cattle and camel.

Materials and Methods

Experimental design

Healthy cattle (392-485) kg and camels (426-520) kg for public consumption as certified by a Veterinary

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doctor at Maiduguri abattoir were used for the study. Five pairs of kidneys (left and right) were harvested from five cattle and five camels, immediately after they were slaughtered. The kidneys were weighed with a weighing scale and the length and breadth were measured with a meter rule. The kidneys were cut longitudinally from the cranial to the caudal poles to expose the interior and the thickness of the cortex and medulla were also measured. Part of the kidneys were fixed in 10% formalin, dehydrated in graded series of alcohol, cleared in xylene, embedded in paraffin wax, sectioned at 5µm using a rotary microtome, mounted on a glass slide and stained with haematoxylin and eosin. The slides were observed with a light microscope.

Statistical analysis

All values were expressed as mean ± standard deviation (SD), they were analysed with Graph pad prism 5. Two-way analysis of variance (ANOVA) and student T-test were used to determine the difference between and within groups and $p<0.05$ was considered statistically significant.

Results

The kidneys of cattle are light-brown rectangular structures located in the sub-lumbar fossa at dorsal part of their body. The kidneys are lobulated with fat filled groves between the lobes (figure 1A) while the kidneys of camels are white bean-shaped structures located in the sub-lumbar fossa at dorsal part of their trunk (figure 2A).

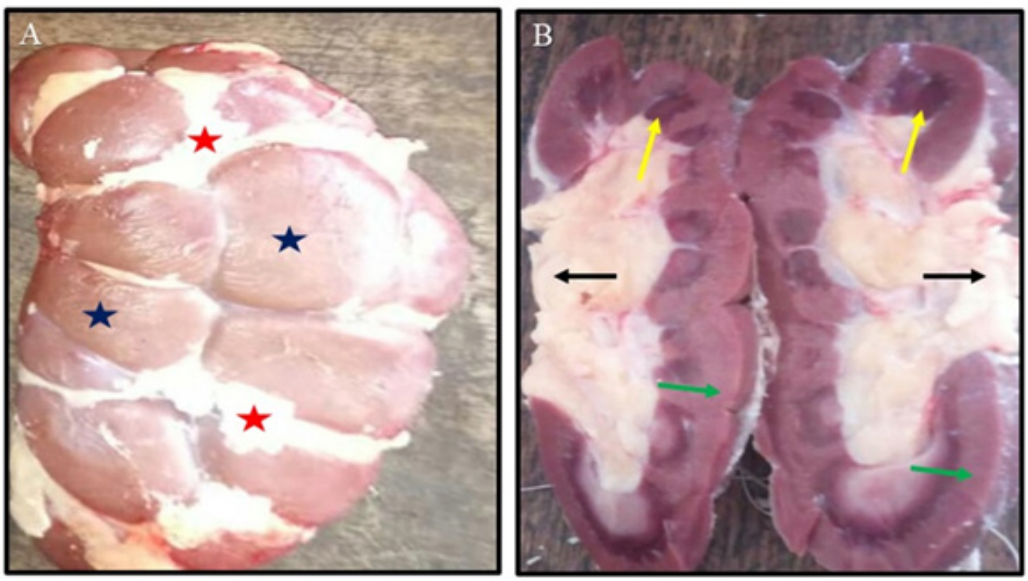

Figure 1. Kidney of cattle: A, whole kidney showing lobules (blue star) and fatty tissues (red star). B, longitudinal section, showing cortex (green arrow), medulla (yellow arrow), and pelvis (black arrow) surrounded by adipose tissues.

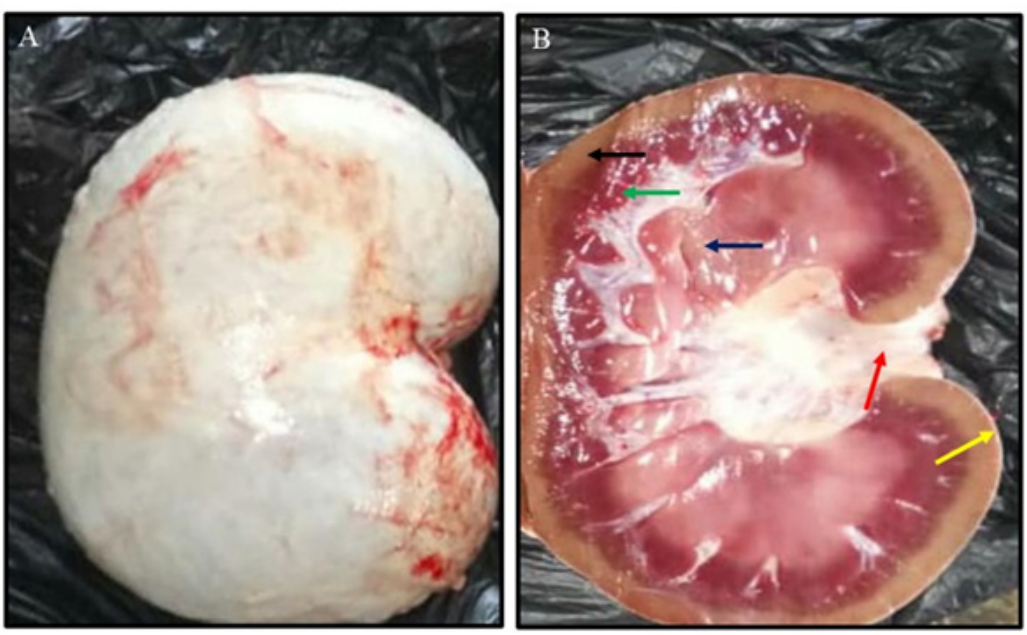

Figure 2. Kidney of camel: A, whole kidney bean shaped covered with white capsule. B, Longitudinal section showing capsule (yellow arrow), cortex (black arrow), outer medulla (green arrow), inner medulla (blue arrow) renal pelvis (red arrow).

The longitudinal section of cattle kidney consists of a thin capsule, a light-brown cortex under the capsule and a dark-brown medulla in each lobule that radiates towards the large pelvis (figure 1B) while that of camels' kidney consists of a thick white capsule, a light-brown cortex with radiant appearance directly located under the capsule, the medulla which is divided into a dark-brown outer part that forms the margin of renal pyramid and a pale inner part directed towards the renal calix and a small pelvis (figure 2B).

The present study has shown that, the kidneys of camels are significantly heavier ($p<0.05$) than those of cattle (figure 3). However, no statistically significant differences ($p>0.05$) were observed in the length and breadth of the kidneys in both cattle and camel, even though Cattles' kidneys are longer than camel but their breath are lesser than those of camel (figure 4). The cortex and medulla of cattle kidneys are relatively of the size but the medulla of camels' kidneys are much longer than the cortex. Both the cortex and medulla of camels' kidneys are significantly longer ($p<0.05$) than those of cattle kidney (figure 5).

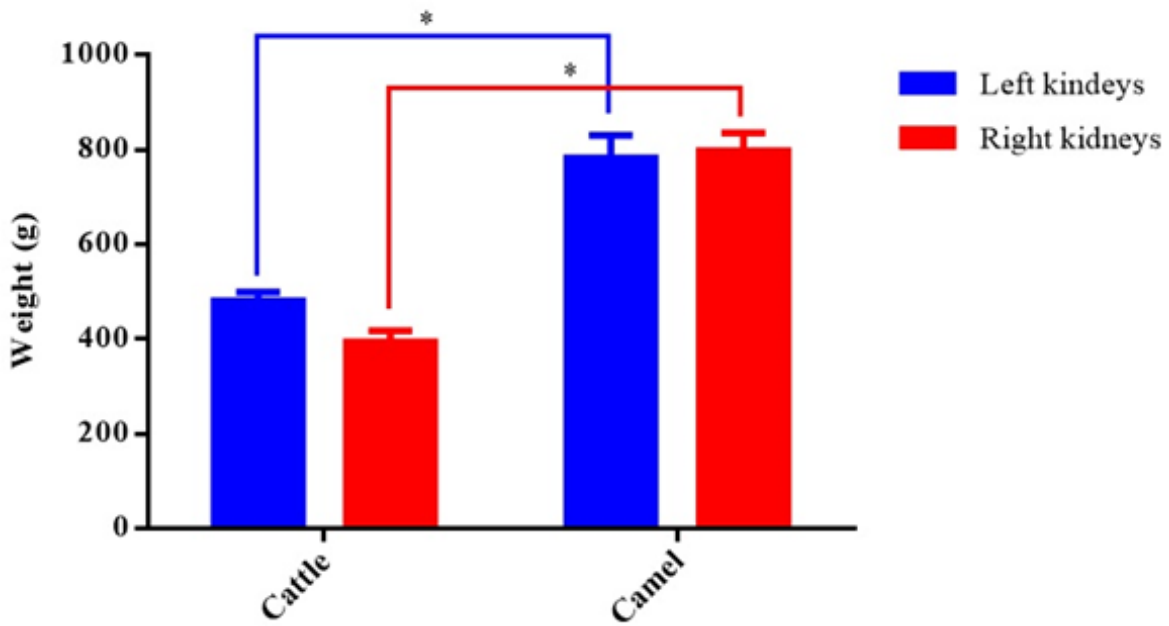

Figure 3. Graph showing the weight of left and right kidneys of cattle and camel. T-test showed statistically significant differences between the weights of both left and right kidneys in cattle and camels ($p< 0.05$). Data presented as mean ± SD, n=5.

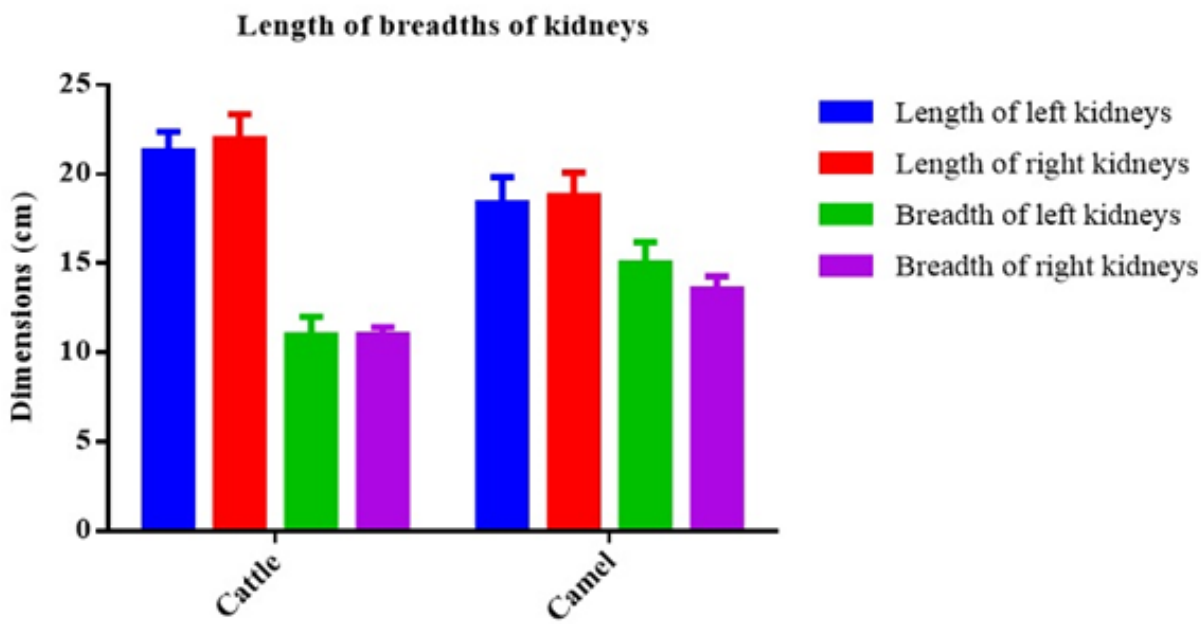

Figure 4. Graph showing the outer dimension of kidneys in cattle and camel. Two-way ANOVA showed no statistically significant differences between the lengths and breadths of cattle and camel's kidneys ($P>0.05$). Data presented as mean ± SD, n=5.

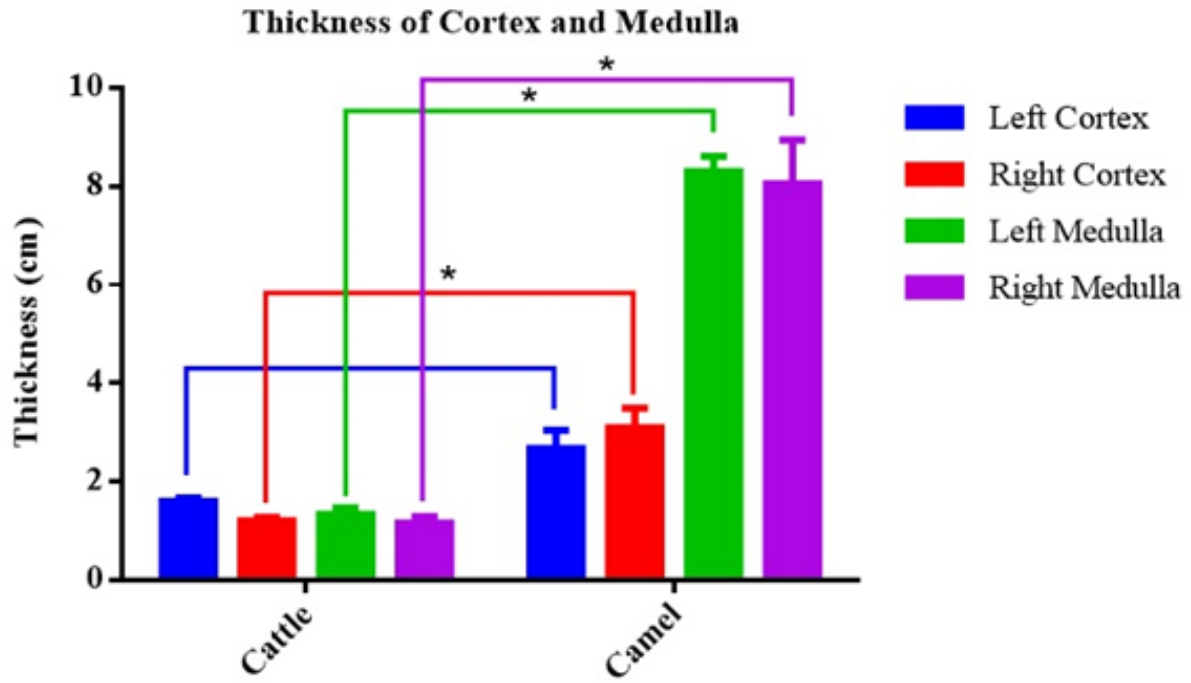

Figure 5. A graph showing the inner dimensions of cattle and camel's kidneys. Two-way ANOVA showed statistically significant differences between the left and right medulla and right cortex of cattle and camel kidneys (P<0.05). Data were presented as mean ± SD. n=5.

The glomerulus of cattle and camels' kidneys are similar; they are both compacted with the parietal and visceral layers lined by simple squamous epithelium (figures 6A&C). The medulla of cattles' kidney has more collecting ducts and less convoluted tubules while the medulla of camels' kidney has more convoluted tubules and less collecting ducts (figures 6B&D). The walls of the convoluted tubules are lined by simple cuboidal epithelium while the collecting ducts are lined by simple squamous epithelium.

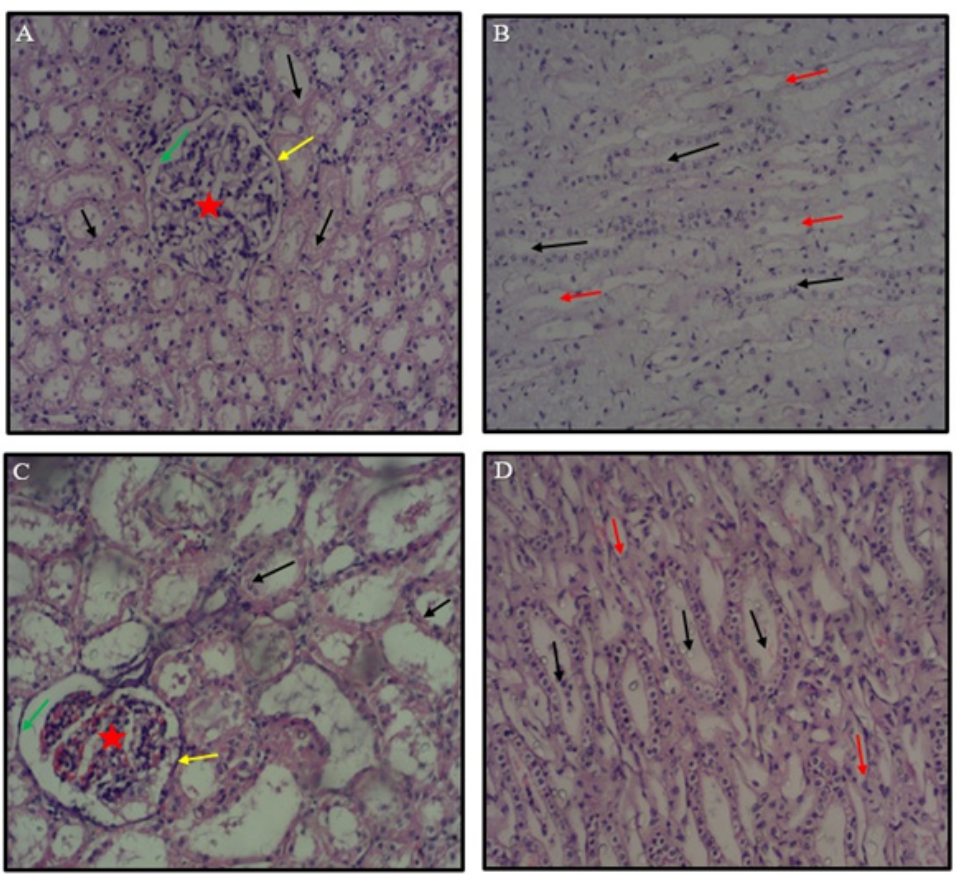

Figure 6. Photomicrograph of cattle and camels' kidney showing; glomerulus (red star), bowman's capsule (yellow arrows) and bowman's space (green arrows), convoluted tubules (black arrows) and collecting duct (red arrow). A & B= cattle cortex and Medulla, C & D= camels' cortex and medulla. H&E x400.

Discussion

The position and colour of the kidneys varies in different vetebrates unlike the cattle and camels, the kidneys of most birds (domestic fowl, dove, owl, harrier, chicken and ducks) extend from the caudal margin of the lungs into the synsacral fossa (Nabipour *et al*., 2009; Abood *et al*., 2014), while those of turtles and most lizards except monitor lizards are located in the pelvis (Holz, 2020). In some fishes and most mammals including humans, the kidneys are located retroperitoneal, exterior to the dorsal wall of the body cavity (Morovvati *et al*. 2006), but unlike mammals, the kidney of fishes is divided into three parts; a head, body and caudal (tail) part (Charmi *et al*., 2009; Morovvati *et al*., 2012). Just like the cattle, the kidneys of most birds (Chicken, Pigeon, emu, Common coot, swamps, ducks and Flamingoes) and fringed-toed lizard are lobulated and consist of three lobes (Yari and Gharzi, 2013; Michalek *et al*., 2016; Reshag *et al*., 2017). Among dipnoans fishes' genera, the kidneys of *Protopterus* and *Neoceratodus* are short, stout, lobular and lying posteriorly in the body cavity but those of *Neoceratodus* are more lobular than those of *Protopterus* (Wake, 1986).

The kidneys of harrier, emu, chicken, most fishes and humans are brown in colour while in the ducks the colour is grayish (Abood *et al*., 2014; Apriliani, 2017). Previous study reported the kidney of Holstein cattle to be lobulated and that of camels as bean-shaped with a strong, thick and adhesive capsule (Kojouri *et al*., 2014; Akosman *et al*., 2018). Earlier study that reported medulla externa and medulla interna in the kidney of two-humped Bactrian camel (Xu *et al*., 2009). The cortex of mammalian kidney was reported as having cup-shaped with inverted margins that surrounds the medulla (Kriz and Kaissling, 2013), while the avian kidney lacks renal pelvic, thus it is drained through a pair of ureter (Sreeranjini *et al*., 2010). The avian cortex and medulla are located in each lobule just like the cattle (Abood *et al*., 2014).

Just like other vertebrates (birds, reptiles and mammals), the cortex of cattle and camels' kidney consist of the glomerulus and bowman's capsule but unlike the kidneys of cattle and camels', the kidney of fishes has aggregation of lymphoid tissue because they play a major role in Haematpoiesis (Silva and Martinez, 2007; Apriliani, 2017; Maurya *et al*., 2018). Because the medulla of camels' kidney is longer than those of cattle and the convoluted tubules in camels' kidney extend into the medulla, camels are able conserve more water and produce more concentrated urine than cattle. Previous study suggests that the longer the length of medulla, the higher the concentration of urine (Xu *et al*., 2009). The medulla of kidneys of dove, owl and snakes were similar to the ones reported in the present study as having convoluted tubules and collecting ducts (Nabipour *et al*., 2009; Allam and Abo-Eleneen, 2013).

Conclusion

Cattle kidneys are lobulated and covered by light-brown capsule while those of camel are bean-shaped and covered by a thick white capsule. The medulla of cattle's kidneys has few convoluted tubules and numerous collecting duct while the medulla of camels' kidneys has numerous convoluted tubule and few collecting duct, the medulla long and consist of two parts (outer and inner) giving the camel the ability to adapt to the desert land by conserving more water than cattle.

Ethical Statement

The research was approved by the Department of Human Anatomy Ethical Committee (Code No. UM/HA/UGP18.19-036) and was conducted according to the ARRIVE Guidelines.

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