EFFECT OF HABITAT DIFFERENCE, SALT-LOADING AND DEHYDRATION ON THE KIDNEY ULTRA STRUCTURE AND FUNCTION OF TWO SPECIES OF FOXES INHABITING TOW DIFFERENT HABITATS.

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Abstract

Eeffect of different habitat, salt-loading and dehydration on the kidney ultrastructure and function of Red Fox *Vulpes vulpes* and Fennec Fox *Vulpes zerda* are investigated. Red Fox are found in wet habitat, however, Fennec Fox in sand dune habitat of arid areas in desert. Transmission electron micrograph of glomerulus, proximal and distal convoluted tubules are investigated, Blood urea, serum creatinine, and uric acid of the two fox species are done. These investigations are carried out on normal, salt-loaded and dehydrated individuals of the two species.

Glomerulus revealed normal structure with red blood corpuscles within glomerular capillary, endothelial cells, podocytes and podocyte pedicels. In salt-loading and dehydrating *Vulpes vulpes* and *Vulpes zerda* normal glomerular structure are found except degraded podocyte pedicels.

Proximal convoluted tubule (PCT) in normal *Vulpes vulpes* with brush border, plasmalemma, mitochondria and lysosomes are normally found. In salt-loaded animals large number of vacuoles, mitochondria and lysosomes, but in dehydrating ones brush border fragmentation takes place as well as large number of vacuoles, mitochondria and lysosomes. In normal *Vulpes zerda* small number of vacuolation, mitochondria and lysosomes are found. In salt-loading and dehydrating animals large number of vacuoles, mitochondria and lysosomes are found.

Distal convoluted tubule (DCT) in normal *Vulpes vulpes* has large lumen. In salt-loaded animals DCT was found having very narrow lumen and in dehydrating ones DCT with narrow lumen , large number of mitochondria and lysosomes are present. In normal *Vulpes zerda* the DCTwith large lumen, mitochondria and lysosomes. In salt-loaded animals wide lumen, large number of vacuoles, mitochondria and lysosomes are present and in dehydrating ones DCT with very narrow lumen and large intercellular space is present.

The biochemical analysis revealed significant increase ($p < 0.05$) in serum uric acid of investigated fox species by the effect of salt loading. Serum urea concentration decreased significantly ($p < 0.05$) in salt-loading *Vulpes vulpes* put significantly increased ($p < 0.05$) in *Vulpes zerda*, however, the serum creatinine of *Vulpes zerda* was found decreased, it is increased but insignificantly in the blood serum of *Vulpes vulpes*. Also, in the dehydrating animals both uric acid and creatinine are significantly increased ($p < 0.05$) in the serum,

whereas, the concentration of serum urea decreased in *Vulpes vulpes* and increased in *Vulpes zerda*.

Results show marked variations in kidney ultra structure and function of the studied species as the result of different habitat type and in response to dehydration and salt loading

Kidney function; ultrastructure; foxes; habitat; dehydration; salt loading

Introduction

Carnivores are the mammalian species inhabiting different habitats of the world (Macdonald and Reynolds, 2004). Red foxes have been recorded in habitats as diverse as tundra, desert and forest, as well as in city centers. Their natural habitat is dry, mixed landscape, with abundant “edge” of scrub and woodland. They are also abundant on moorlands, mountains, deserts, sand dunes and farmland. In the UK, they generally prefer mosaic patchworks of scrub, woodland and farmland. However, Fennec foxes Vulpes zerda are widespread in the sandy deserts and semi-deserts of northern Africa to northern Sinai (Saleh and Basuony, 1998). It is subsist in arid desert environments, preferring this substrate for burrowing. Stable sand dunes are believed to be ideal habitat (Dorst and Dandelot, 1970), although they also live in very sparsely vegetated sand dunes near the Atlantic coast. The fennec fox is claimed to be the only carnivore of the Sahara living completely away from water sources (Noll-Banholzer, 1979).

The mammalian kidneys are bean-shaped dark red bodies covered by a smooth capsule of thin fibrous connective tissue with convex outer and concave inner borders. The kidney is composed of two distinguishable portions, an outer cortex and inner medulla. The structural unit of the kidney is the nephron. The mammalian nephron has a glomerulus, with afferent and efferent arterioles; Bowman's capsule; proximal convoluted tubule; a loop of Henle consisting of a thin descending limb and an ascending limb with thin and thick portions; a distal convoluted tubule; and collecting duct. The collecting ducts drain into a renal pelvis that empties into the ureter (Lesson *et al*., 1988).

In the kidneys, there are four cell types in the renal corpuscles of all vertebrate species namely endothelial, mesangial, podocytes, and parietal cells (Hentschel and Elger, 1989). The endothelial cells are large flat cells linning the capillaries. The perinuclear region contains the usual complement of cell organelles and frequently bulges into the capillary lumen. The attenuated cell portions are fenestrated by regular, fairly large pores (40 – 70 nm in diameter) in mammals (Hentschel, 1979;

Tisher and Madsen, 1986; Bachmann *et al*., 1988).

Mesangial cells are of irregular shape, frequently stellate with cytoplasmic processes. The cell bodies contain the usual cell organelles (Kriz and Kaissling, 1985; Tisher and Madsen, 1986).

The third type, podocyte cells, is the largest of the four major cell types in the glomerulus. In mammals, they are rather tall cells as compared with many lower vertebrates that are generally equipped with short and low pedicels. Near the basement membrane a narrowed region is formed between the pedicels that has been called 'filtration slit'. Occasionally, two or more membranes span the filtration slit membrane (Elger and Hentschel, 1981; Elger *et al*., 1984; Lacy *et al*., 1987). The perikaryon contains a conspicuously well-developed Golgi complex, free ribosomes, and profiles of granular and smooth endoplasmic reticulum, microfilaments and lysosomes. Microfilaments extend down to the foot processes in mammals. A well-developed alcianophilic glycocalyx covers the cell membrane as well as the filtration slit in the carp (Elger *et al*., 1984), as in the mammalian kidney. Podocalyxin, a sialoprotein, is the major glycoprotein on the podocytes of the mammalian glomeruli (Kerjaschki *et al*., 1984).

The fourth type is the parietal cells, of their squamous epithelium and has a polygonal shape. The perikaryon bulges only slightly into the urinary space. The cytoplasm contains the normal complement of cell organelles. A single cilium may be present. Thick intracellular bundles of microfilaments communicate with filament bundles of the basement membrane in the rat (Mbassa *et al*., 1988).

In addition to the four typical epithelial cells of the glomerulus, collecting tubule, also in the late distal tubule, a different type of cells, the intercalated cells, has been described in all vertebrate classes (Taugner *et al.*, 1982; Nicholson and Kendall, 1983; Stanton *et al.*, 1984; Kriz and Kaissling, 1985; Madsen and Tisher, 1986; Tisher and Madsen, 1986; Henschel and Elger, 1987; Bachmann *et al*., 1988; Sakai *et al*., 1988). The cytoplasm of these cells is frequently denser than that of the surrounding main cells (dark cells), mitochondria are abundant and not usually associated with basolateral amplifications (mitochondrium-rich cells) and carbonic anhydrase is present (carbonic-anhydrase-rich cells). The apical cell membrane may be greatly amplified by microplicae or microvilli (Hentschel and Elger, 1989).

The epithelium is lined by a layer of brush border which is facing the wide lumen of the proximal convoluted tubule; this border is composed of long, closely packed microvilli (Vimtrup and Schmidt-Nielsen, 1952; Pfeiffer *et al*., 1960; Safer *et al*., 1990) that greatly increase the surface available for reabsorption (Leeson *et al*., 1988). In the cytoplasm of the cells there are apical vacuoles at the base of the brush border (Vimtrup and Schmidt-Nielsen, 1952; Pfeiffer *et al*., 1960; Ericsson and trump, 1966; Safer *et al*., 1990). The epithelial cells of this tubule rest on the thick basal lumina (Vimtrup and Schmidt-Nielsen, 1952; Safer *et al*., 1990) and the boundaries between cells are distinct (Pfeiffer *et al*., 1960). The straight portion is continuous with the convoluted portion in a medullary ray (in the medulla), cells of which are similar to the convoluted ones but are lower in height (Kaissling *et al*., 1975; Leeson *et al*., 1988). The distal tubule is shorter and thinner than the proximal tubule and comprises, a straight portion forming the ascending thick limb of the loop of Henle, previously described and the convoluted portion. Cells of the distal convoluted tubule are cuboidal, lacking a brush border (Leeson *et al*., 1988) but Safer *et al*. (1990) said that the luminal surface of these tubules is lined by a few microvilli. The lining cells are somewhat dome-shaped project towards the lumen and their cytoplasm is clear (Vimtrup and Schmidt-Nielsen, 1952; Pfeiffer *et al*., 1960). The nuclei are large and rounded with fine granules of chromatin and the most of them are located at the apical part of the cytoplasm (Safer *et al*., 1990). The lumen of the distal convoluted tubule is wide and its cells lie on tremendous thickened basal lumina (Leeson *et al*., 1988; Safer *et al*., 1990).

The distal tubule is shorter and thinner than the proximal tubule and comprises, a straight portion forming the ascending thick limb of the loop of Henle, and the convoluted portion. Cells of the distal convoluted tubule are cuboidal, lacking a brush border (Leeson *et al*., 1988) but Safer *et al*. (1990) said that the luminal surface of these tubules is lined by a few microvilli. The lining cells are somewhat dome-shaped project towards the lumen and their cytoplasm is clear (Vimtrup and Schmidt-Nielsen, 1952; Pfeiffer *et al*., 1960). The nuclei are large and rounded with fine granules of chromatin and the most of them are located at the apical part of the cytoplasm (Safer *et al*., 1990). The lumen of the distal convoluted tubule is wide and its cells lie on tremendous thickened basal lumina (Leeson *et al*., 1988; Safer *et al*., 1990).

Mammalian kidneys are important in the regulation of body fluid volumes and electrolyte concentrations and in the elimination of nitrogenous wastes (Degen, 1997).

In mammals the principal end product of protein catabolism is urea, a small, soluble organic molecule. Mammals have no extrarenal route for the excretion of this substance, nor are they able to change the nitrogenous end product according to the availability of water. The only way in which the mammalian kidney can adjust to a limited water supply, therefore, is to excrete urea in a concentrated solution. Consequently, the ability of the mammalian kidney to produce concentrated urine is one of the more important factors in adaptation to water shortage (Schmidt-Nielsen, 1964).

Urea is the main end product of nitrogen metabolism in mammals and, as in most animals, is excreted almost entirely through the kidneys. It is highly soluble in water and permeable to membranes. It requires water for its excretion and generally comprises the largest part of the urine osmolytes (Harmeyer and Mertens, 1980; Kennedy and Milligan, 1980).

Uric acid has a very low solubility in water, 0.00645 g per 100 ml or 0.382 mM. Therefore, uric acid exerts a very low osmotic pressure, and it can be excreted in the urine in solid form. It is formed from the breakdown of purines and also synthesized from amino acid nitrogen. Until recently, the mechanism for uric acid synthesis was unknown (Schmidt-Nielsen, 1964).

In addition to ammonia, urea, and uric acid, several other nitrogenous end products are found. Several other substances, allantoin, allantoic acid, creatinine, and creatine, are excreted in the urine by various animals. However, little is known about their role in adaptation to environment (Schmidt-Nielsen, 1964).

The present study is carried out to investigate the effect of different habitat on the kidney ultrastructure and function of two species of Foxs Red Fox *Vulpes vulpes* and Fennec Fox *Vulpes zerda* . Red Fox inhabeting wet habitat, however, Fennec Fox inhabeting sand dune habitat of arid areas in desert. It also investigated the possible effect of dehydration and salt loading.

Materials and Methods

The present study was carried out on eighteen foxes of two fox species of genus *Vulpes* namely *Vulpes vulpes*, which live in mesic habitat and *Vulpes zerda*, which

live in arid habitat. The investigated animals were captured in their natural habitats of different areas of Egypt. The animals were kept in clean cages; food and water were provided *ad libitum*.

The foxes were divided into three groups as follow: The first (Control group) three fox individuals of each species were collected from their natural habitats without any treatment. The second (Salt-loading group) three fox individuals of each species were fed on a diet containing high salt (4% NaCl) for a 7-day period, and water was provided *ad libitum* (Merino *et al*., 2000). Daily fresh diet was prepared as follows: 250 g of chicken meat and two loaves of bread weighed 200 g were minced together and mixed with 18 g of NaCl. The third (Dehydrating group) three fox individuals of each species were fed on dry diet. Daily fresh diet was prepared as follows: 250 g of chicken meat and two loaves of bread weighed 200 g were minced together. The minced meat and bread were dried in oven at 150°C then left to cool and provided to animals. All animals in this group were deprived of water till loss 10% of their body weight (McNabb, 1968).

For electron microscopic studies, foxes were anaesthetized with diethyl ether. The abdominal cavity was opened; the kidney was exposed and sliced open. The cut surface was immediately flooded with fresh 2.5% glutaraldehyde fixative, then thin slices were removed and chopped into small pieces (less than $1mm^3$), fixed in 2.5% glutaraldehyde in cacodylate buffer at 4°C for 4 hours. They were then post fixed in 1% osmium tetroxide (Salem, 2000). Stained sections were examined with a JEOL 1010 transmission electron microscope at 80 kV.Methods for biochemical studies

Blood sampling and biochemical analysis:

At the end of each experiment, the blood samples were taken in dry clean centrifuge tubes. Serum was separated at 3000 rpm for 15 minutes and kept in plastic vials well stoppered and kept at 20°C until analysis. At the same time, blood samples for haematological analysis were taken into clean tubes containing Na_2EDTA (sodium salt of ethylene diamine tetraacetic acid) as anticoagulant.

Urea enzymatic was determined according to method of Patton and Crouch (1977). Serum uric acid was determined according to method of Young (1995). Creatinine was determined according to method of Henry (1974).

Statistical analysis:

The statistical analysis of the obtained data was done according to Armitage (1974) and Lentner and Wink (1982) and the analysis was revised by Quattro pro for windows program version 2-microsoft windows version 7 and graphics were drown using Harvard graphics program version 4. The obtained data were assessed by calculation of the mean (M), Standard deviation (SD), Student "*t*" – test.

Probability at $P < 0.05$ and at $P < 0.01$.

* = Significant at $P < 0.05$.

Results

1- Electron microscopy observations

Glomerulus

Electron microscopic micrograph of red fox *Vulpes vulpes* and fennec fox *Vulpes zerda* kidneys demonstrates that the basal lamina (BL) of glomerular capillaries (GC) represents one of the most important barriers in the organism body. It separates capillary endothelial cells (EC) from the podocytes (P) of renal glomeruli, assuming the function of a filter that segregates blood (SB) from the primitive urine (PU).

The endothelium of the glomerular capillary is interrupted by numerous pores. These are bridged by a thin membrane or diaphragm. The basal lamina comprises three layers, the lamina rara externa, lamina densa and the lamina rara interna. The lamina rara interna makes contact with endothelial cells and the lamina rara externa with podocyte pedicels (PP).

In normal *Vulpes vulpes* (plate 1A) transmission electron micrographs revealed glomerulus, red blood corpuscles within glomerular capillary, endothelial cells, podocytes and podocyte pedicels. In salt-loading *Vulpes vulpes* (plate 2A) transmission electron micrographs revealed glomerulus, red blood corpuscles within glomerular capillary, endothelial cells, podocytes and degraded podocyte pedicels and in dehydrating ones glomerulus, red blood corpuscles within glomerular capillary, endothelial cells, podocytes and degraded podocyte pedicels (plate 3A).

In normal *Vulpes zerda* (plate 4A) transmission electron micrographs revealed that glomerulus, red blood corpuscles within glomerular capillary, endothelial cells, podocytes and podocyte pedicels. In salt-loading *Vulpes zerda* (plate 5A) revealed glomerulus, red blood corpuscles within glomerular capillary, endothelial cells, podocytes and degraded podocyte pedicels and in dehydrating ones revealed glomerulus, red blood corpuscles within glomerular capillary, endothelial cells, podocytes and degraded podocyte pedicels (plate 6A).

Proximal convoluted tubule

Microvilli of proximal tubule cells of the nephron constitute the so-called brush border (BB). They are longer than those of the striated border, but similar in structural basis.

The interior of the brush border microvilli contains actin-like filaments. This

indicates the ability of speeding up selective reabsorption from the tubular lumen by an active transport mechanism.

In normal *Vulpes vulpes* (plate 1B) the proximal convoluted tubule with brush border, plasmalemma, mitochondria and lysosomes are normally found. In salt-loading (plate 2B) proximal convoluted tubule with brush border, plasmalemma, large number of vacuoles, mitochondria and lysosomes and in dehydrating ones proximal convoluted tubule with fragmented brush border, plasmalemma, large number of vacuoles, mitochondria and lysosomes (plate 3B).

In normal *Vulpes zerda* (plate 4B) the proximal convoluted tubule with brush border, plasmalemma, small number vacuolation, mitochondria and lysosomes are normally found. In salt-loading (plate 5B) proximal convoluted tubule with brush border, plasmalemma, large number of vacuoles, mitochondria and lysosomes and in dehydrating ones proximal convoluted tubule with brush border, plasmalemma, large number of vacuoles, mitochondria and lysosomes (plate 6B).

Distal convoluted tubule

In cells of the proximal and distal nephron tubules, the reabsorbed material is passed on to capillaries via the basal labyrinth. At the same time, microvilli and basal labyrinth contribute to renal excretion, as various substances are eliminated into the secondary urine through the tubules. The substantial amounts of energy utilized in these processes are reflected by the presence of large mitochondria (M) within the renal cells. In addition, each cell contains large lysosomes (Ly), peroxisomes and micropicnoytotic vesicles. The latter are the morphologic expression of albumin reabsorption, since the molecules are able to pass through the glomerular basement lamina by virtue of their smaller size. The formation of basal labyrinth in cells of proximal and distal tubules of the nephron largely increases their surface of contact with the subepithelial space. Deep plasmalemma (PL) infoldings subdivide the cell body into narrow compartments containing mitochondria (M), rough endoplasmic reticulum and lysosomes (Ly). Beneath the cell is a basal lamina (BL) of the epithelium, a capillary basal lamina and an endothelium.

In normal *Vulpes vulpes* (plate 1c(transmission electron micrographs revealed that distal convoluted tubule with large lumen, mitochondria and lysosomes. In salt-loading (plate 2c) distal convoluted tubule without lumen, mitochondria and lysosomes are present and in dehydrating ones (plate 3c) distal convoluted tubule

with narrow lumen and large number of mitochondria and lysosomes are present.

In normal *Vulpes zerda* (plate 4c(transmission electron micrographs revealed that distal convoluted tubule with large lumen, mitochondria and lysosomes. In salt-loading (plate 5c) distal convoluted tubule with lumen, large number of vacuoles, mitochondria and lysosomes are present and in dehydrating ones (plate 6c) distal convoluted tubule without lumen, and large intercellular space is present.

2- Biochemical analysis

Data in table 1 shows means of blood urea, serum creatinine and uric acid in the investigated fox species *Vulpes vulpes* and *Vulpes zerda* control, and during salt-loading and dehydration regimes. Results represented in figures 1, 2 and 3 are showing means of blood urea, serum creatinine and uric acid respectively.

In the normal animals a significant decrease, ($P \leq 0.05$), of urea, creatinine and uric acid was observed. In normal *Vulpes vulpes* means of blood urea, serum creatinine and uric acid were 60.7 ± 10 mg/dl, 9.3 ± 1.6 mg/dl and 2.6 ± 0.3 mg/dl, $n = 3$ respectively. In normal *Vulpes zerda* means of blood urea, serum creatinine and uric acid were 37.7 ± 5.2 mg/dl, 4.1 ± 0.8 mg/dl and 1.3 ± 0.4 mg/dl, $n = 3$ respectively.

In salt-loading *Vulpes vulpes*, a significant decrease, ($P \leq 0.05$), of means of urea concentration, an insignificant increase of means of serum creatinine and a significant increase, ($P \leq 0.05$), of means of serum uric acid compared with control was observed. Means of blood urea, serum creatinine and uric acid were 50.6 ± 3.8 mg/dl, 11.4 ± 1.3 mg/dl and 6.7 ± 1.4 mg/dl, $n = 3$ respectively.

In salt-loading *Vulpes zerda*, a significant increase, ($P \leq 0.05$), of means of urea concentration, a significant decrease, ($P \leq 0.05$), of means of serum creatinine and a significant increase, ($P \leq 0.05$), of means of serum uric acid compared with control was observed. Means of blood urea, serum creatinine and uric acid were 88.3 ± 7.7 mg/dl, 2.8 ± 0.9 mg/dl and 9.01 ± 1.4 mg/dl, $n = 3$ respectively.

In dehydrating *Vulpes vulpes*, an insignificant decrease of means of urea concentration, a significant increase T-test, ($P \leq 0.05$), of means of serum creatinine and a significant increase, ($P \leq 0.05$), of means of serum uric acid compared with control was observed. Means of blood urea, serum creatinine and uric acid were 51.3 ± 5.5 mg/dl, 13.8 ± 2 mg/dl and 3.9 ± 0.6 mg/dl, $n = 3$ respectively.

In dehydrating *Vulpes zerda*, a significant increase, ($P \leq 0.05$), of means of urea concentration, an insignificant increase, ($P \leq 0.05$), of means of serum creatinine and a significant increase, ($P \leq 0.05$), of means of serum uric acid compared with control was observed. Means of blood urea, serum creatinine and uric acid were 42 ± 4.3 mg/dl, 4.4 ± 0.8 mg/dl and 2.6 ± 0.4 mg/dl, $n = 3$ respectively.

Discussion

Kidney ultra structure

In both salt-loading and dehydrating red fox *Vulpes vulpes* and fennec fox *Vulpes zerda*, Electron Microscopy showed that the glomeruli were normal, the proximal part of the convoluted tubule showed no abnormality except presence of large number of vacuoles, the intercellular space was increased and the basement membrane of the pars recta was much thinner than control foxes. All the thin segments of the loop of Henle in outer and inner medulla were of similar appearance. The lumen was narrow and the basement membrane unthickened: the cells showed unusually numerous and slightly separated intercalated lamellas, and, in addition, some cells showed intraluminal papillary projections of their cytoplasm.

The thick ascending limbs and the distal convoluted tubules showed normal features except that the lumina of these parts were a little narrower than control. There is no lateral separation of collecting tubule cells and their cytoplasm shows none of the vacuoles. The capillaries showed no abnormalities. Same observations were reported by Sabour *et al*. (1964).

The formation of basal labyrinth in cells of proximal and distal tubules of the nephron is to increases their surface of contact with the subepithelial space.

In both salt-loading and dehydrating red fox *Vulpes vulpes* and fennec fox *Vulpes zerda*, Electron Microscopy showed the glomeruli were normal, the convoluted part of the proximal tubule showed no abnormality except presence of large number of vacuoles, the intercellular space was increased and the basement membrane of the pars recta was much thinner than control foxes. All the thin segments of the loop of Henle in outer and inner medulla were of similar appearance. The lumen was narrow and the basement membrane unthickened: the cells showed unusually numerous and slightly separated intercalated lamellas, and, in addition, some cells showed intraluminal papillary projections of their cytoplasm.

The interior of the brush border microvilli contains actin-like filaments. This indicates the ability of speeding up selective reabsorption from the tubular lumen by an active transport mechanism.

Biochemical parameters

Urea and creatinine

The present study indicates significant decrease of urea concentration in salt-loading and insignificant decrease in dehydrating, but insignificant increase of serum creatinine in salt-loading and significant increase in dehydrating compared with control *Vulpes vulpes***.** A significant increase of blood urea in both salt-loading and dehydrating**,** but significant decrease of serum creatinine in salt-loading and insignificant increase of serum creatinine in dehydrating compared with control *Vulpes zerda***.**

The observed increase in blood urea and serum creatinine may indicate renal impairment. Urea itself is relatively nontoxic but its serum level is a good indicator of how the kidney could handle products of protein metabolism. Also this rise may be the result of acute tubular necrosis; secondary to decreased renal perfusion or caused by tubulointerstitial disease; or probably a result of renal hypoperfusion (decreased glomerular filtration rate) caused by volume loss. Same observations were reported by Azer (2006).

Serum uric acid

A significant increase of serum uric acid in both salt-loading and dehydrating compared with control *Vulpes vulpes*. And significant increase of serum uric acid in both salt-loading and dehydrating compared with control *Vulpes zerda***.**

Serum uric acid may be raised or remains within the normal range at the time of presentation of acute gout. Hyperuricemia may result from: overproduction (e.g. idiopathic, haematological disorders and in non-malignant increase in cell turnover as in psoriasis), but is more usually the result of poor excretion of urate by the kidney (e.g. renal failure, ketoacidosis, lactic acidosis, severe hypothyroidism, hyperthyroidism, intake of diuretics). Same observations were reported by Azer (2006).

Table (1): Means of blood urea, serum creatinine and uric acid in red fox *Vulpes vulpes* and fennec fox *Vulpes zerda* during salt-loading and dehydration regimes.

Species	Items	Urea (mg/dl)	Creatinine (mg/dl)	Uric acid (mg/dl)
Vulpes vulpes	Control	60.7 ± 10	9.3 ± 1.6	2.6 ± 0.3
	Salt-loading	50.63.8 ± ⋆	ns 1.3 ± 11.4	6.71.4 ± ⋆
	Dehydration	51.3 ± 5.5 ns	13.82 ± ⋆	3.90.6 ± ⋆
Vulpes zerda	Control	37.7 ± 5.2	4.1 ± 0.8	1.3 ± 0.4
	Salt-loading	88.37.7 ± ⋆	2.80.9 ± ⋆	9.011.4 ± ⋆
	Dehydration	424.3 ± ⋆	ns 0.8 ± 4.4	2.60.4 ± ⋆

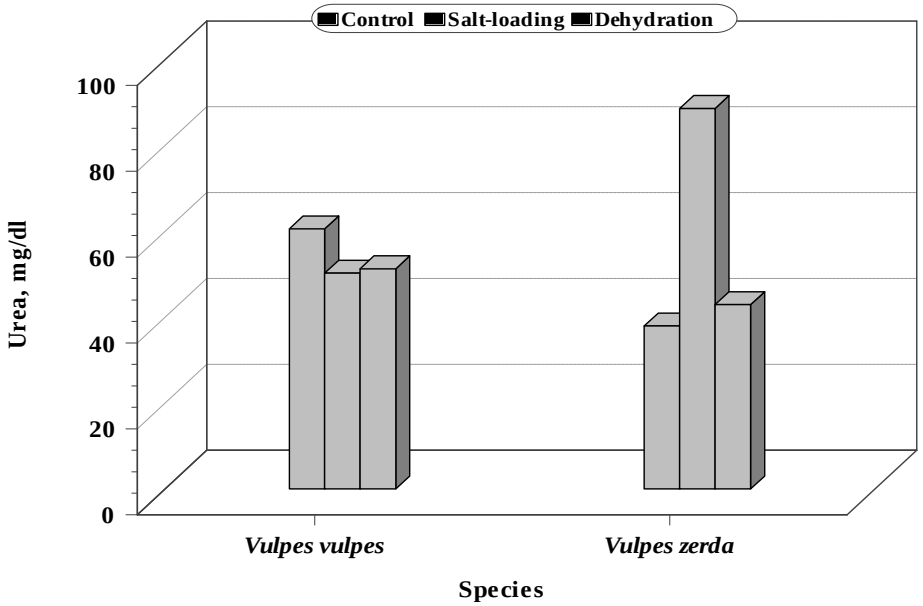


Figure 1: Means of blood urea level of red fox *Vulpes vulpes* and fennec fox *Vulpes zerda* during salt-loading and dehydration regimes

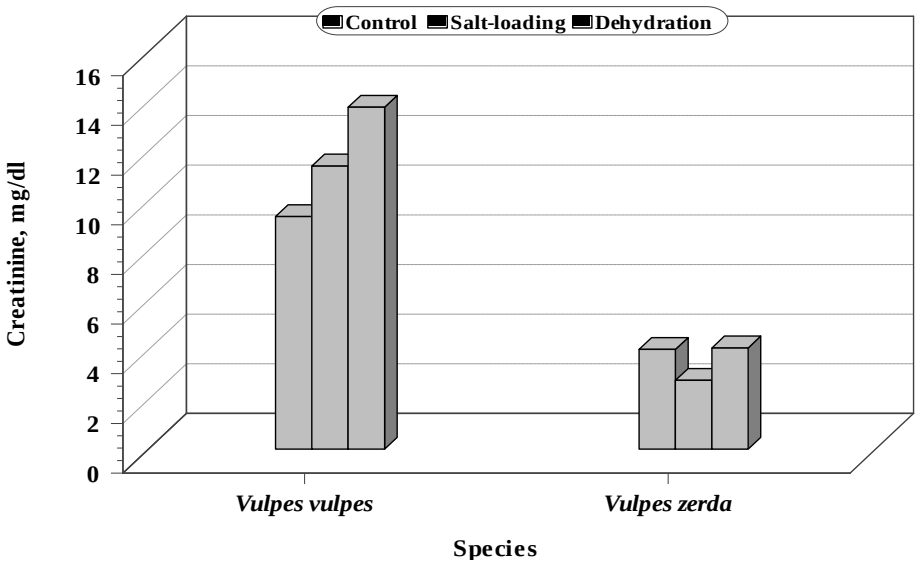


Figure 2: Means of serum creatinine of red fox *Vulpes vulpes* and fennec fox *Vulpes zerda* during salt-loading and dehydration regimes

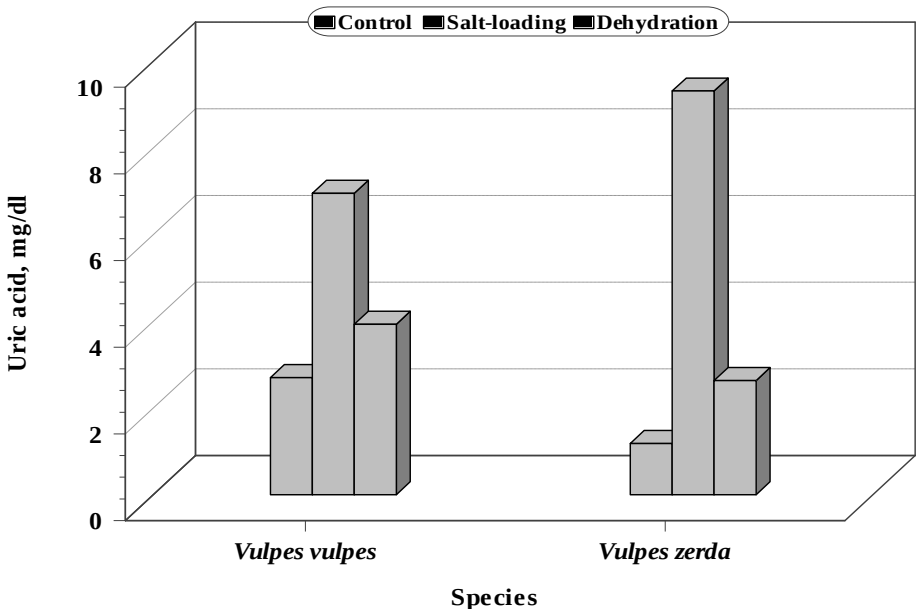
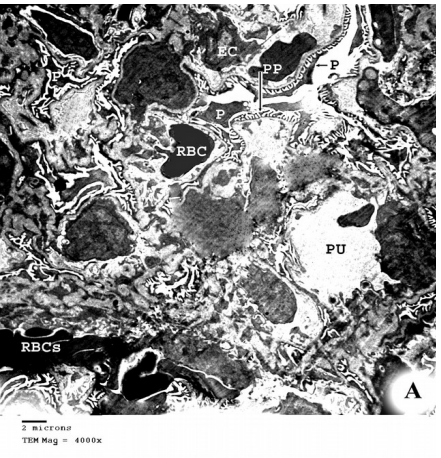
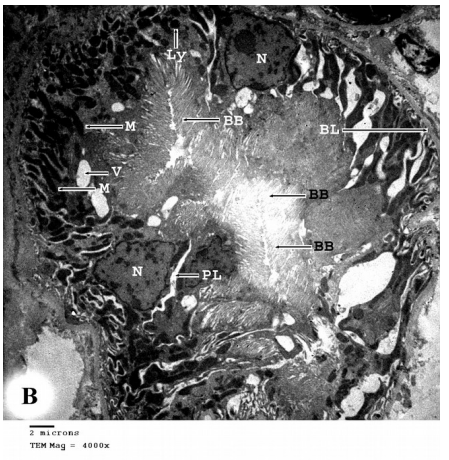


Figure 3: Means of serum uric acid of red fox Vulpes vulpes and fennec fox Vulpes

zerda during salt-loading and dehydration regimes.





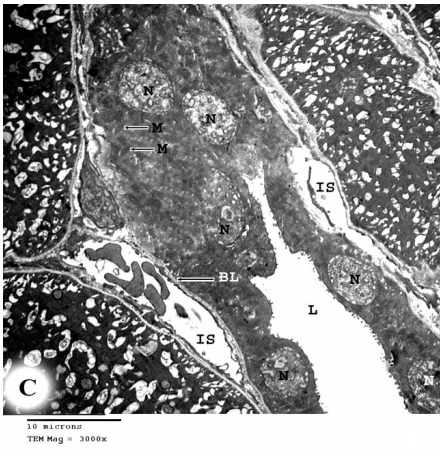


Plate (1): Transmission electron micrograph of normal *Vulpes vulpes* kidney showing glomerulus A, (magnification, 4000x), proximal convoluted tubule B, (magnification, 4000x) and distal convoluted tubule C (magnification, 3000x).
P = podocyte; PP = podocyte pedicels; PU = primitive urine; BL = basal lamina; SB = segregate blood; EC = endothelial cell; GC = glomerular capillary; PL = plasma lemma; N = nucleus; BB = brush border; M = mitochondria; V = vacuoles; L = lumen; IS = interstitial space and Ly = lysosome.

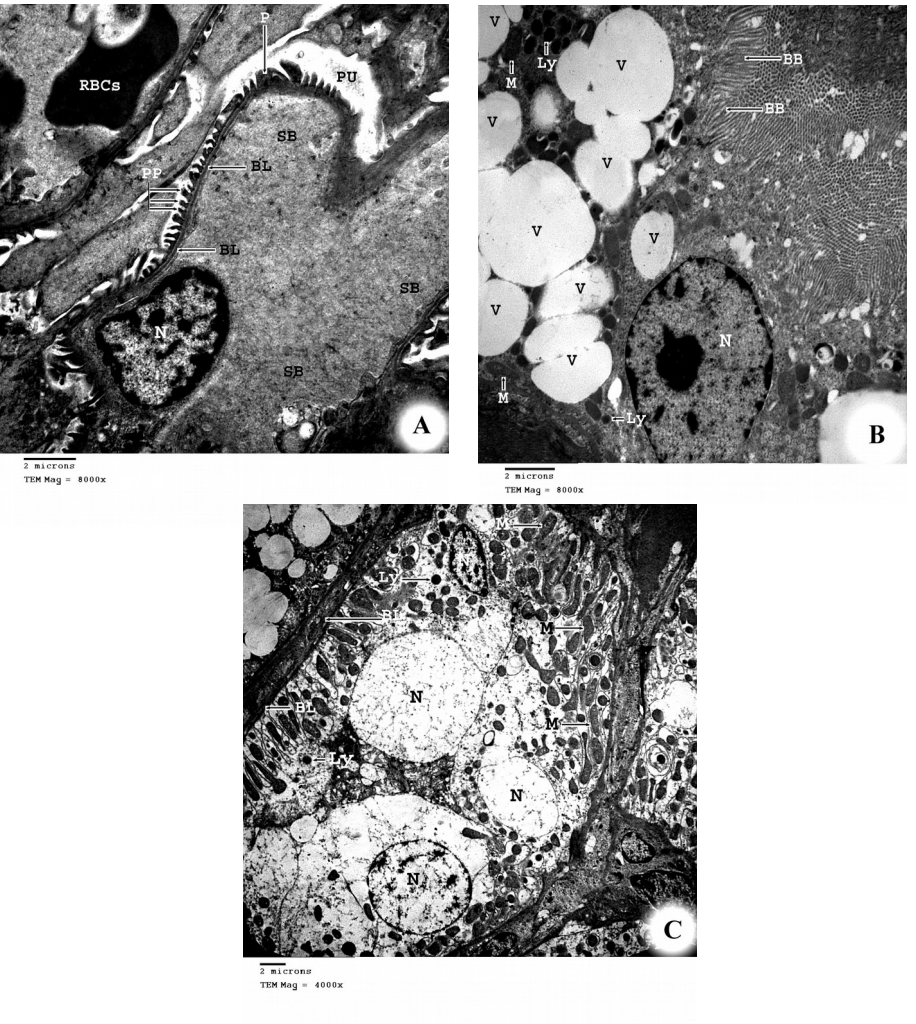
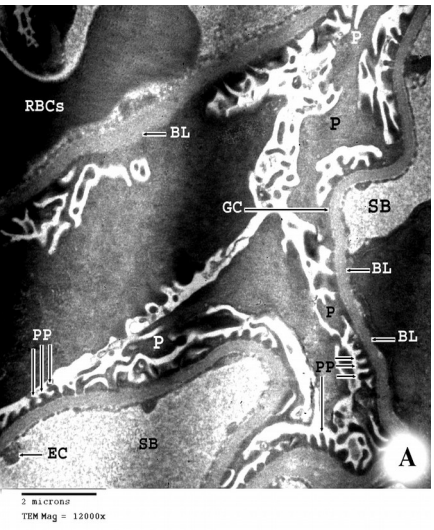
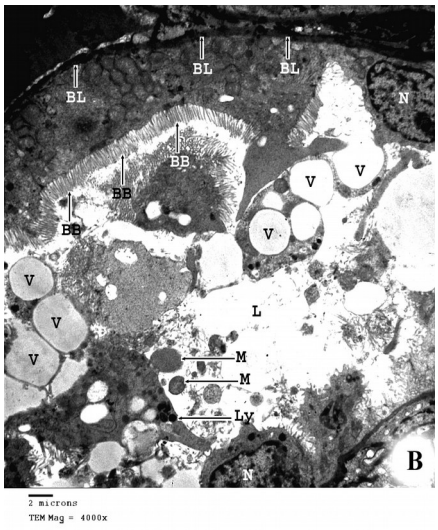


Plate (2): Transmission electron micrograph of salt-loading *Vulpes vulpes* kidney, showing glomerulus A, (magnification, 8000x), proximal convoluted tubule B, (magnification, 8000x) and distal convoluted tubule C (magnification, 4000x).
P = podocyte; PP = podocyte pedicels; PU = primitive urine; BL = basal lamina; SB = segregate blood; EC = endothelial cell; GC = glomerular capillary; PL = plasma lemma; N = nucleus; BB = brush border; M = mitochondria; V = vacuoles; L = lumen; IS = interstitial space and Ly = lysosome.





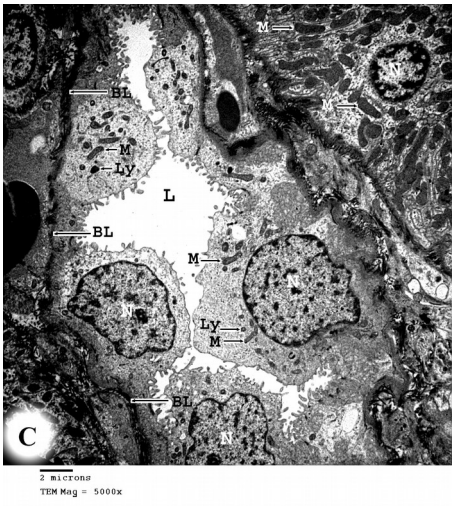
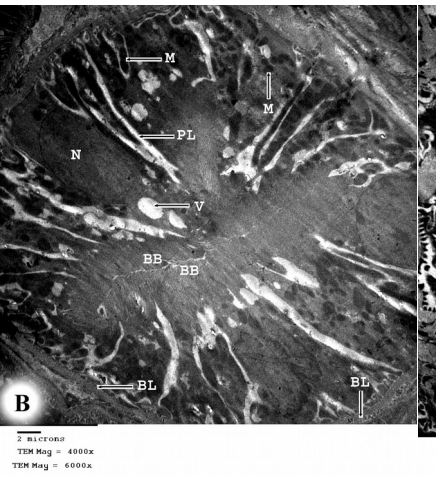


Plate (3): Transmission electron micrograph of dehydrating *Vulpes vulpes* kidney, showing glomerulus A, (magnification, 12000x), proximal convoluted tubule B, (magnification, 5000x) and distal convoluted tubule C (magnification, 4000x).
P = podocyte; PP = podocyte pedicels; PU = primitive urine; BL = basal lamina; SB = segregate blood; EC = endothelial cell; GC = glomerular capillary; PL = plasma lemma; N = nucleus; BB = brush border; M = mitochondria; V = vacuoles; L = lumen; IS = interstitial space and Ly = lysosome.



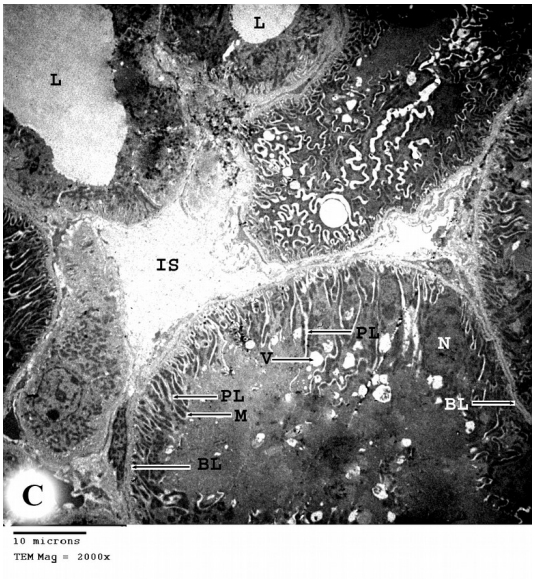
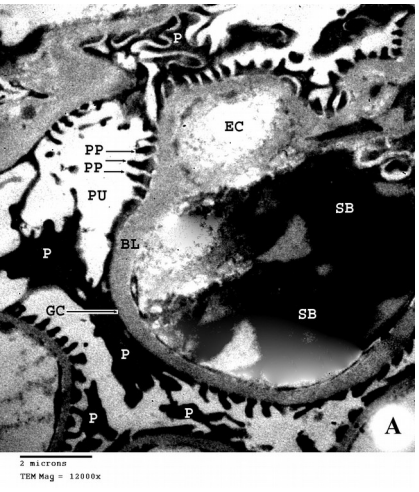
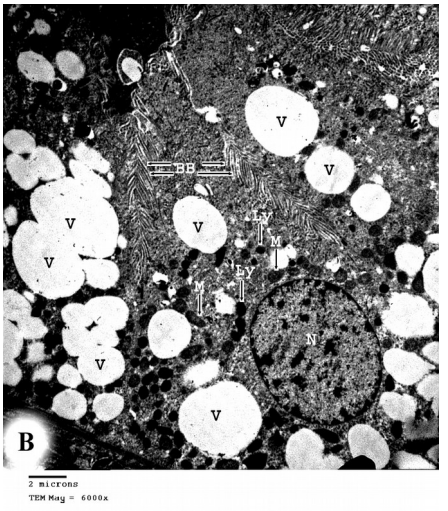


Plate (4): Transmission electron micrograph of normal *Vulpes zerda* kidney, showing glomerulus A, (magnification, 6000x), proximal convoluted tubule B, (magnification, 4000x) and distal convoluted tubule C (magnification, 2000x).
P = podocyte; PU = primitive urine; BL = basal lamina; RBCs = red blood corpuscles; EC = endothelial cell; GC = glomerular capillary; PL = plasma lemma; N = nucleus; BB = brush border; M = mitochondria; V = vacuoles; L = lumen and IS = interstitial space.





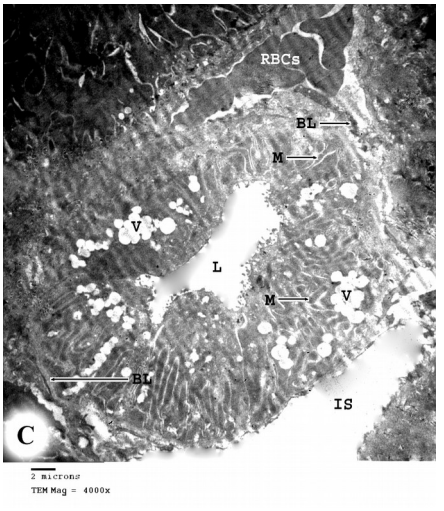


Plate (5): Transmission electron micrograph of salt-loading *Vulpes zerda* kidney, showing glomerulus A, (magnification, 12000x), proximal convoluted tubule B, (magnification, 6000x) and distal convoluted tubule C (magnification, 4000x).
P = podocyte; PP = podocyte pedicels; PU = primitive urine; BL = basal lamina; SB = segregate blood; EC = endothelial cell; GC = glomerular capillary; PL = plasma lemma; N = nucleus; BB = brush border; M = mitochondria; V = vacuoles; L = lumen; IS = interstitial space and Ly = lysosome.

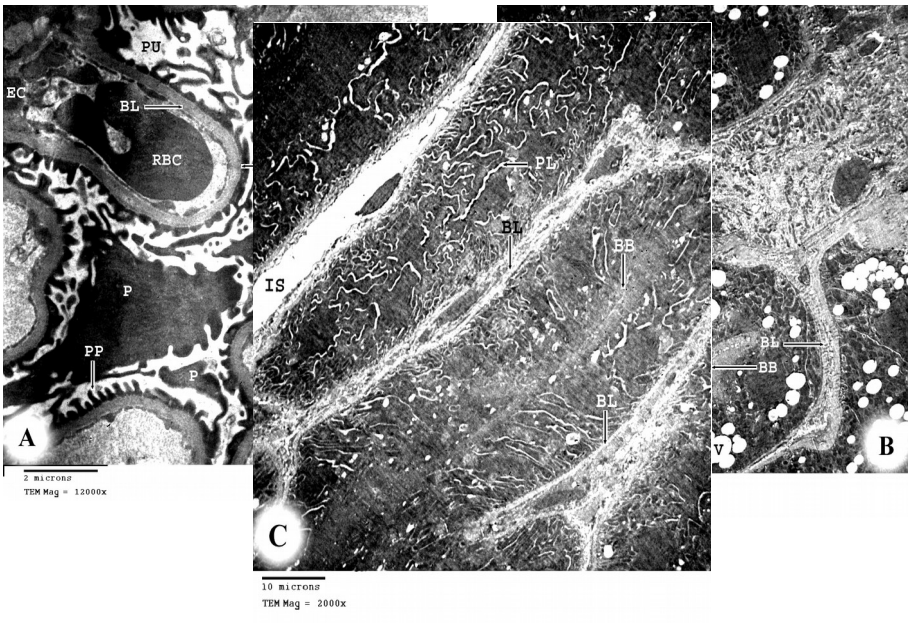


Plate (6): Transmission electron micrograph of dehydrating *Vulpes zerda* kidney, showing glomerulus A, (magnification, 12000x), proximal convoluted tubule B, (magnification, 2500x) and distal convoluted tubule C (magnification, 2000x).
P = podocyte; PP = podocyte pedicels; PU = primitive urine; BL = basal lamina; SB = segregate blood; EC = endothelial cell; GC = glomerular capillary; PL = plasma lemma; N = nucleus; BB = brush border; M = mitochondria; V = vacuoles; L = lumen; IS = interstitial space and Ly = lysosome.

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أثر اختلاف الموطن البيئى وزيادة الملوحة والعطش علي التركيب الدقيق ووظيفة الكلى لنوعين من الثعالب القاطنة لبيئتين مختلفتين

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تمت دراسة تأثير أختلاف الموطن البيئى وزيادة الملوحة والعطش على التركيب الدقيق ووظائف الكلى للثعلب الأحمر وثعلب الفنك . وجد الثعلب الأحمر قاطنا بيئة رطبة بينما وجد ثعلب الفنك قاطنا بيئة الكثبان الرملية فى الأراضى الصحراوية الجافة . تم عمل دراسة للتركيب الدقيق للكلى باستخدام الميكروسكوب الألكترونى كما تمت دراسة نسب البولينا وحمض البوليك والكرياتينين فى الدم فى الظروف الطبيعية وتحت تأثير زيادة الملوحة والعطش وخلصت النتائج لما يأتى:

فيما يتعلق بالتركيب الدقيق للكلية لوحظ تركيب طبيعى للكبات فيما عدا تحطم خلايا بودوسيت فى كلا النوعين من الثعالب نتيجة التعرض لنقص الماء و زيادة الملوحة.

لوحظت بعض التغيرات في خلايا الأنيبيبات الملتفة القريبة مثل وجود العديد من الفجوات والميتوكوندريا والليسوسومات بتأثير نقص الماء وزيادة الملوحة فى كلا النوعين. أما الانيبيبات الملتفة البعيدة فقد لوحظ ضيق شديد فى تجويفها بتأثير نقص الماء وزيادة الملوحة فى كلى الثعالب الحمراء ووجدت نفس المشاهـدات فى كلى ثعلب الفنك بتأثير نقص المياه دون زيادة الملوحة.

أظهـرت التحاليل زيادة ملحوظة فى نسب حمض البوليك في مصل الدم فى كلا النوعين من الثعالب بتأثير زيادة الملوحة كما أنخفضت نسبة البولينا

فى مصل الدم فى الثعلب الاحمر بينما زادت فى ثعلب الفنك لنفس السبب.

أنخفضت نسبة الكرياتينين فى مصل الدم لثعلب الفنك كنتيجة لزيادة الملوحة. بينما أدى نقص المياة الى زيادة ملحوظة فى حمض البوليك و الكرياتينين فى كلا النوعين من الثعالب كما زادت نسبة البولينا في مصل الدم فى ثعلب الفنك وقلت فى الثعلب الاحمر نتيجة لنفس التأثير.

أظهـرت النتائج تغيرا ملحوظا فى تركيب ووظيفة الكلي فى كلا الوعين من الثعالب موضع الدراسة بتأثير أختلاف الموطن البيئى وبتأثير قلة المياه وزيادة الملوحة.

et al.,