Complementary information on the biology of Bactrian camels (Camelus bactrianus) in the Mangistau region of Kazakhstan

Zh. Bazarbayeva[1], *O.* Ilderbayev[1*], *A.* Suleimenova[1], *A.* Dukenbayeva[1], *G.* Nurmukhambetova[1], and *A.* Kabylbek[1]

[1]L.N. Gumilyov Eurasian National University, 010008 Astana, Department of General Biology and Genomics, 2 Satpayev Street, Kazakhstan

Abstract. The morphometric body parameters of male and female Bactrian camels, Kazakh Bactrian, were studied. Compared to camels of other breeds, the Kazakh Bactrian turned out to be one of the largest camels, having up to 750 kg for males and 690 kg for females, as well as powerful musculature and thick fur. Sexual dimorphism in body size and weight of males and females has been shown. The height at the withers of males was higher than in females by about 3.2 %, oblique length of the trunk by 4.5 %, chest girth by 1.3 %, and tibia girth by 6.6 % higher than in females. The greatest difference was in the live weight of the animals - 23,4 %. A histological study of one of the important internal organs - kidneys - was carried out, which allow camels to adapt to the conditions of waterless deserts. As a result of histological study of the kidneys of Kazakh Bactrians, the following characteristics of camel kidneys were established: the kidney capsule is rather thick (470±12 μm) and is made up of two layers: a layer of collagen fibres (400 μm) and thin (70 μm) inner smooth muscle cells. The relative thickness of the capsule and the presence of the smooth muscle cell layer within it appear to be related to the kidney's ability to hold high intrarenal pressure while producing highly concentrated urine. The second feature of the Bactrian kidney was that the medullary layer was much thicker than the cortical layer. Their ratio was 1:4. The thick cerebral layer in camels provides relatively long renal tubules and loops of Henle, which are essential for the excretion of concentrated urine.

1 Introduction

The camel has been transporting people and goods in intercontinental caravans since its domestication, connecting different cultures and providing milk, meat and wool. Although the role of the camel in a world of urbanisation, modern transport and high-speed communications is less than in the past, the increasing demand for sustainable milk and meat production, especially in countries affected by climate change and increasing desertification, is drawing the attention of scientists and livestock breeders to camels [1]. Camels are known for their physiological and performance characteristics due to their ability to adapt to harsh

* Corresponding author: oiz5@yandex.ru

climatic conditions in desert and semi-desert areas. The Bactrian camel (Camelus bactrianus), according to Indian scientists, is endangered, so they are making attempts to cryopreserve camel fibroblasts [2]. Thus, the study of biological features of camels is of great interest for various fields of biology and agriculture [3-7].

In Kazakhstan, camel breeding is considered a type of traditional animal husbandry [8-9]. In Kazakhstan, for the first time in the world, the technology of milking camels by machine has been introduced into production, the electromechanical shearing of camels without cutting has been implemented for the first time in the country, and camel milk is produced by industrial technology by preparing shubat (shubat is a Kazakh drinking fermented milk product made from camel milk) and its preservation and drying for a long period of time.

Despite all the conditions for the development of agricultural animal husbandry in our country, camel breeding remains an underdeveloped and not fully explored branch in Kazakhstan compared to other branches of animal husbandry. The development of camel breeding in Kazakhstan allows to master the directions of economic activity in areas unsuitable for the cultivation of conventional livestock (cattle, cattle breeding, horses). Therefore, increasing camel production is one of the main tasks of economic development of agriculture and animal husbandry in the Republic of Kazakhstan.

The choice as an object of histological study of camel kidneys was due to the fact that kidneys are considered an important organ for camels because of their reaction to electrolyte and water balance during dehydration and rapid rehydration of camels due to their residence in desert and semi-desert areas [10-11].

The aim of the work was: to study some parameters of physical development of females and males of Kazakh Bactrian of Mangistau region, as well as to study histological features of their kidneys.

2 Methods and Materials

The research work was carried out in 2021-2023 at the Arys farm, located 40 km from the village of Shaiyr, Mangistau region. 6-8-year-old Kazakh Bactrians (10 males, 10 females) were taken as objects for the study of body parameters.

Kidneys of 5 healthy males of Kazakh Bactrian camel at the age of 3 years were taken as a material for histological study.

Body measurements of experimental animals were carried out in accordance with the 2014 Guidelines for boniting (evaluation) of breeding value and growth of livestock. The following measurements were taken: 1) height between the humps - height at the withers (with a measuring stick) - height from the ground to the point between the two humps in Bactrian camels; 2) oblique body measurements - length from the anterior point of the tibial joint to the point of the femur tibia; 3) thoracic girth - in Bactrian camels through the gap between the two humps and the centre of the sternum; 4) heel girth - measured at the thinnest part of the tibia (at the junction of the upper and middle parts). Live weight was determined by weighing on scales. All measurements were subjected to statistical processing. For histological examination, the organs were fixed in pre-prepared buffered formalin solution. Paraffin sections were stained with hematoxylin-eosin. Microphotographs of preparations were made using an EVOS FLc inverted fluorescence microscope designed for visualisation of cellular structures.

3 Results and Discussion

The general type of physique of the overwhelming majority of Kazakh Bactrian camels is medium to large; the body is long; the head is proportional to the body; the neck is muscular, large; the thorax is broad; the humps are erect, some have one hump or both lying down; hind and front legs are without defects; strong bones; musculature is satisfactory or well developed (Fig. 1).

Fig. 1. 7–8-year-old male breeders of Kazakh Bactrians

The coat of the Bactrian is very thick. On the forehead, a thick, hairy mane grows from the back of the head to the top of the neck and to both sides of the body. The mane grows to the lower part of the neck. Nest-shaped hairs are scattered on the humps. Fur colour is mainly reddish-brown, sandy to very light in females (Figure 2).

Fig. 2. 6-year-old female Bactrian

When female camels were measured, the following data were obtained (Table 1).

Table 1. Torso measurements of Kazakh Bactrian females

Animal no.	Animal height (measured from the ground to the point between the humps) (cm)	Torso oblique length (cm)	Chest circumference (cm)	Cannon circumference (cm)	Live weight (kg)
1	170.5	152.2	225.0	20.1	535.0
2	170.6	150.3	224.3	20.0	526.0
3	171.5	152.3	226.0	20.2	537.8
4	172.5	154.4	225.4	20.0	543.7
5	172.2	156.5	232.3	21.0	568.0
6	173.0	157.6	239.5	21.5	589.7
7	172.2	156.4	240.0	21.2	586.5
8	170.6	155.2	231.0	20.5	560.1
9	171.5	153.2	231.5	20.1	554.1
10	175.0	157.6	240.0	21.1	591.0
Average value	172.0±1.3	154.6±2.5	231.5±6.4	20.6±0.6	559.19±23.9

When measuring male camels, the following data were obtained (Table 2).

Table 2. Torso measurements of male Kazakh Bactrian camels

Animal no.	Animal height (measured from the ground to the point between the humps) (cm)	Torso oblique length (cm)	Chest circumference (cm)	Cannon circumference (cm)	Live weight (kg)
1	178.6	162.3	235.2	23.5	734.1
2	176.5	161.6	234.9	22.7	729.1
3	178.2	162.5	235.5	22.4	735.9
4	175.3	160.5	233.2	22.6	719.7
5	176.9	161.1	231.6	22.1	717.5
6	178.6	159.9	230.5	22.3	708.7
7	176.5	160.1	232.5	23.0	715.8
8	174.5	159.8	231.1	22.9	710.1
9	182.7	165.1	241.7	24.1	767.3
10	180.2	166.2	240.5	24.3	768.6
Average value	177.8±2.4	161.9±2.2	234.7±3.8	23.0±0.7	730.7±21.7

Measuring the body of animals is considered the most accurate way to study their exterior. Evaluation of animals by measuring them allows comparing them with each other. Taking into account the above-mentioned indicators of body parameters, the body type of the vast majority of the studied male camels in the farm was assessed as harmonious, harmoniously strong and muscular.

As a result of studying the body size parameters of camels, we found clear differences between male and female camels. Males had 3.2% more withers height, 4.5% more oblique body length, 1.3% more breast girth and 6.6% more shin girth than females. The greatest difference was in live weight of animals - 23.4%. Highlighting the obtained body parameters, camels in the farm of Mangistau region can be classified as camels of the first class.

Our data confirm the expression of sexual dimorphism in Bactrian camels, females were lighter and shorter than males. This result is consistent with the statement of Arab researchers

(2007) who studied another camel species, namely dromedaries [12], that camels have a very pronounced sexual dimorphism, i.e., male camels are usually taller and heavier than females.

Our studies of physical development of Kazakh Bactrians of the Mangistau population, conducted for the first time, showed their greatest similarity in size and weight with the Sunni population of Bactrians from Mongolia. This may be due to the fact that camels of both groups belong to the Bactrian family and live in approximately the same conditions of harsh climate.

4 Histological study of Kazakh Bactrian kidneys

The studied camel kidneys were without defects, had bean-shaped, smooth surface. The right kidney was smaller than the left kidney. The left kidney weighed about 0.96 kg, was about 18 cm long, 10 cm wide and 8 cm thick. The right kidney weighed about 0.9 kg, was 17 cm long, 9 cm wide, and 7.5 cm thick.

The cerebral layer of the camel kidney was much thicker than the cortical layer. The boundary between the cerebral and cortical layer was clearly visible to the naked eye. The cortical layer of the kidney was about 2 cm and the medullary layer about 8 cm (Figure 3).

Fig. 3. Kidney section of 7-year-old Kazakh Bactrian from the Mangistau population

A relatively thick medulla is a prerequisite for a relatively long Henle's loop. The main effect of the Henle's loop is to produce a high osmotic pressure in the medulla of the kidney, which is necessary to concentrate the urine flowing through the collecting ducts. The longer the Henle's loop, the more concentrated urine is excreted.

Histological examination of the kidney showed that the camel kidney is covered by a connective tissue capsule consisting of an outer and inner layer (Figure 4). The thickness of the capsule was about 470±12 μm. A small number of smooth muscle cells were visible in the inner layer. The contraction of smooth muscle cells of the camel kidney capsule is involved in the regulation of pressure in the kidney. As a result, it can cause an increase in urine concentration. The outer layer of the capsule was much thicker than the inner layer and was about 400±6 μm, the inner about 70±2 μm. The outer layer consisted mainly of dense collagen fibres arranged in a wavy pattern.

It should be noted that the camel kidney capsule is quite thick compared to other farm animals. According to Indian researchers, the camel kidney capsule is the thickest (480.4 μm) compared to sheep (97.5 μm) and cows (47.3 μm). The outer layer of the renal capsule in camel is significantly thicker (396 μm) than in cow (39 μm) and sheep (36 μm). This layer accounts for about 82% of the total thickness of the capsule in camels and cows, but only 37% in sheep (Figure 11) [13].

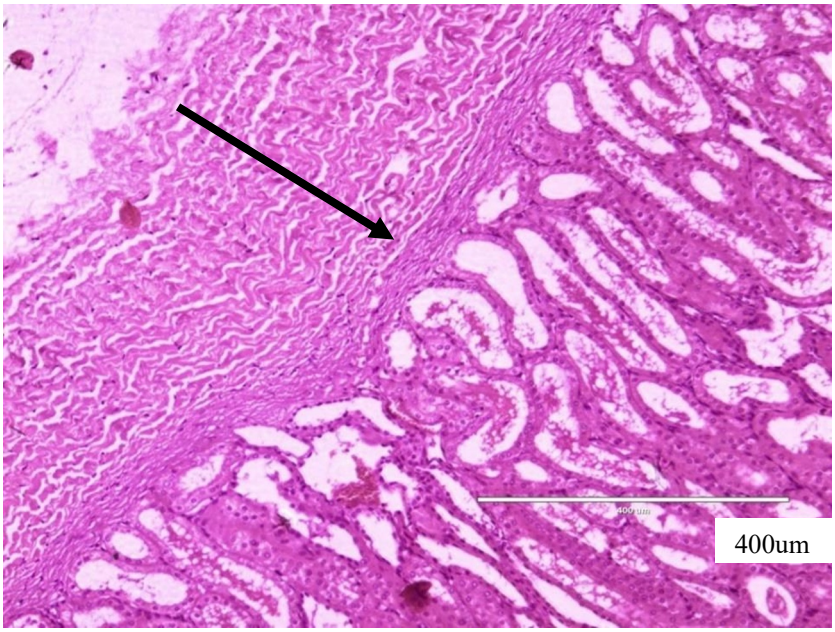

Fig. 4. Kidney capsule of Kazakh Bactrian of Mangistau population. Haematoxylin-eosin. The arrow shows the capsule.

Hence, the small number of smooth muscle cells in the camel kidney capsule found in the present study may contribute to the reduction of interstitial pressure in the kidney, which probably leads to a decrease in the amount of urine and an increase in urine concentration.

The cortical and cerebral layers are well defined in the adult camel kidney. The cortical layer of the camel kidney has a large number of mature nephrons with large renal tubules consisting of tortuous capillaries (tubules) and visceral epithelium (podocytes) (Fig. 5), the renal tubules are covered with squamous epithelium on the outside. The space between visceral and parietal epithelium is clearly visible on histological preparations (Fig. 6). The renal tubules are located in the central cortex and the cortico-medullary junction.

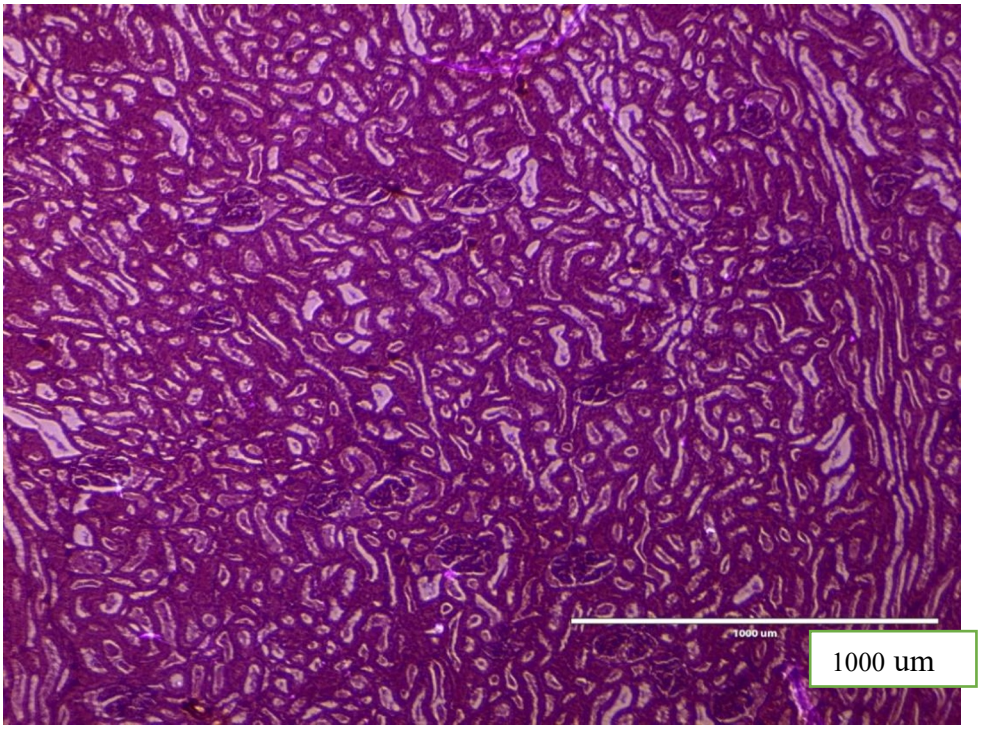

Fig. 5. Cortical layer of the kidney of Kazakh Bactrian. Haematoxylin-eosin.

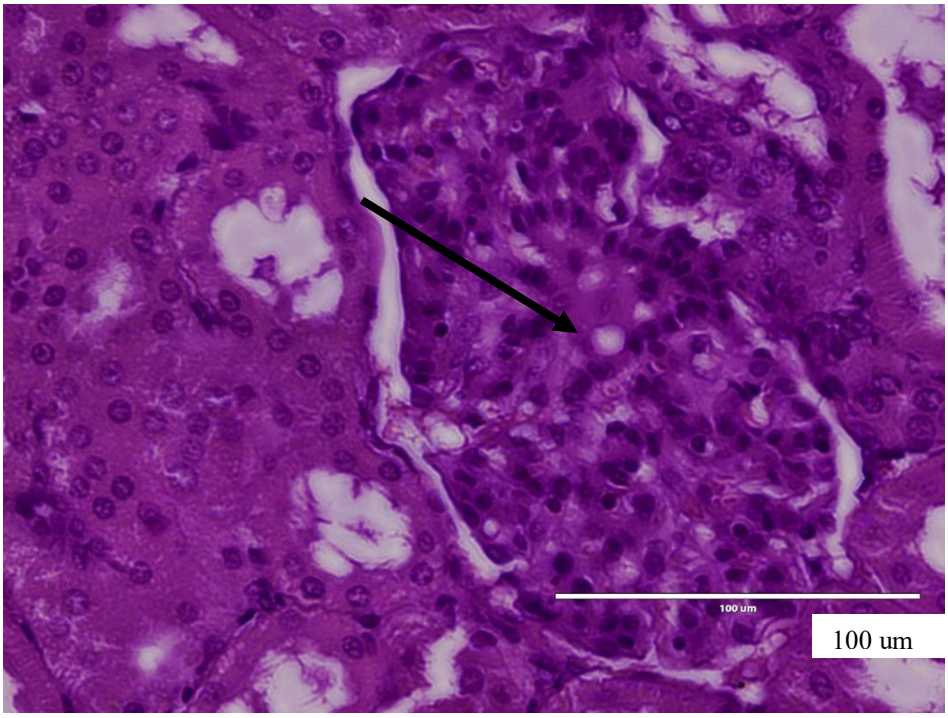

Fig. 6. Kidney calf of the Kazakh Bactrian camel. Haematoxylin-eosin.

Proximal convoluted tubules with a narrow cavity surrounding the renal tubules in the cortical layer are lined with prismatic epithelium and covered with microvilli. Distal convoluted tubules have a wider cavity and are lined with cubic epithelium. There are more proximal tubules and fewer distal tubules (Fig. 7). This may indicate that the proximal convoluted tubule of the Kazakh Bactrian camel is long enough and therefore its ability to reabsorb primary urine is higher than in other animals.

Differences between the sizes of renal tubules of cortical and juxtamedullary nephrons were revealed. The diameter of the former ranges from 190±9 μm (outer diameter of Bowman's capsule) and from 180±8 (diameter of the capillary tubule), and the latter from 250 ±10 and from 240±10, respectively.

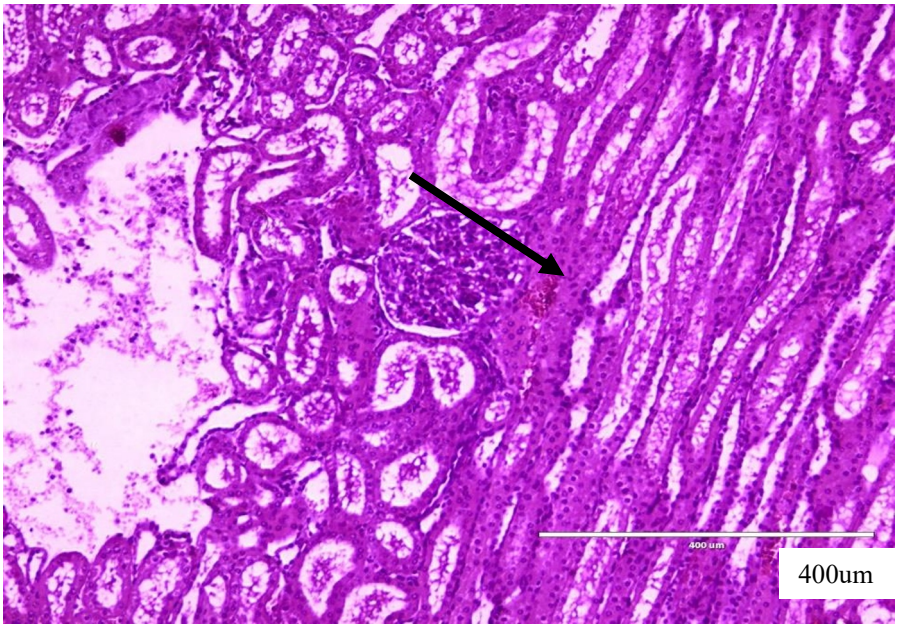

Fig. 7. Juxtamedullary nephrons in the cortical layer of the kidney of Kazakh Bactrian. Haematoxylin-eosin.

At the boundary between the cortical layer and the renal medulla, the renal arteries are arched, from which the intercortical or radial arteries branch to the cortical parenchyma. The latter give off many afferent arterioles, flowing into the renal tubules and forming capillary beds in them.

The diameter of the arc of the artery is about 100 μm. Red blood cells are clearly visible in the artery (Figure 8). Interestingly, their shape is more similar to the ellipsoidal nuclear erythrocytes of non-mammalian vertebrates (e.g., amphibians and reptiles) than to the biconcave discoidal cells of other mammals. Camel erythrocytes are oval in shape, unlike those of other mammals. The oval shape of the red blood cells helps to facilitate blood flow in their dehydrated state. You can also see the presence of marginal bands made up of microtubules, a structure unique to mammals. This microstructure may be related to the ability of erythrocytes to resist the strong osmotic changes in plasma seen with heavy drinking and after a period of dehydration.

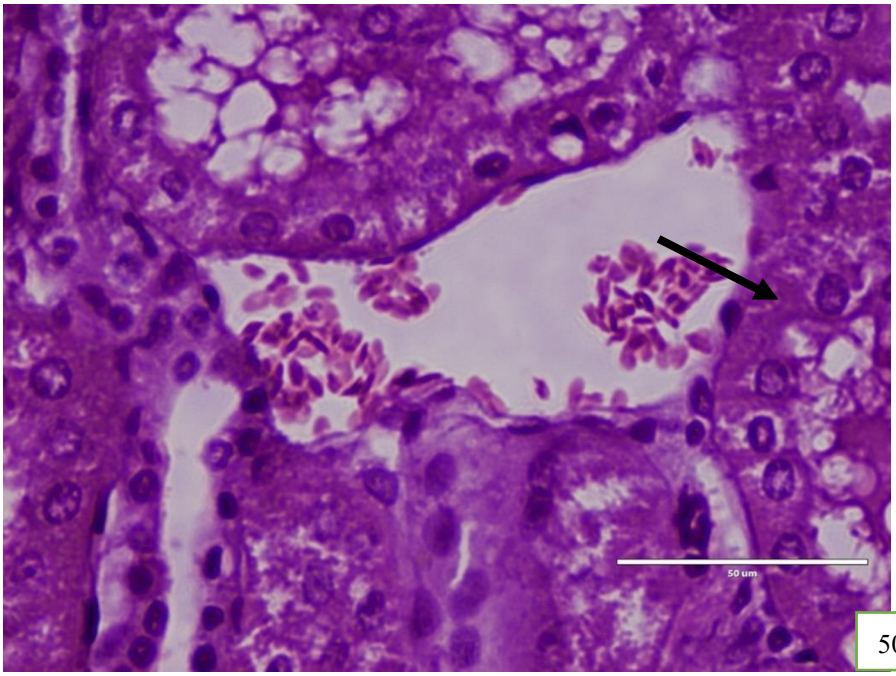

Fig. 8. Kidney of Kazakh Bactrian. Erythrocytes in the lumen of the arcuate artery. Haematoxylin-eosin.

Indeed, camels are known to drink incredible amounts of water in record time. A 600 kg camel lost 200 kg of body weight after 14 days without water, to compensate for the loss, the animal drank 200 litres in 3 minutes. Camel red blood cells are smooth and their overall shape does not change with dehydration. On the other hand, rapid rehydration causes severe oedema of these cells, which take on a rounded shape.

The renal tubules, Henle's loops (bringing and efferent sections) and collecting tubules in the medullary layer of the kidney are relatively long (Fig. 9). The descending Henle's loop is lined with simple squamous epithelium and the ascending segments with simple cubic epithelium. The large collecting duct in the medulla of the camel kidney is lined with high squamous epithelium, and the collecting ducts are lined with low squamous epithelium.

The relatively thick layer of brain matter compared to the cortical layer may be a prerequisite for the relatively long Henle's loop. A relatively long Henle's loop is a prerequisite for concentrated urination.

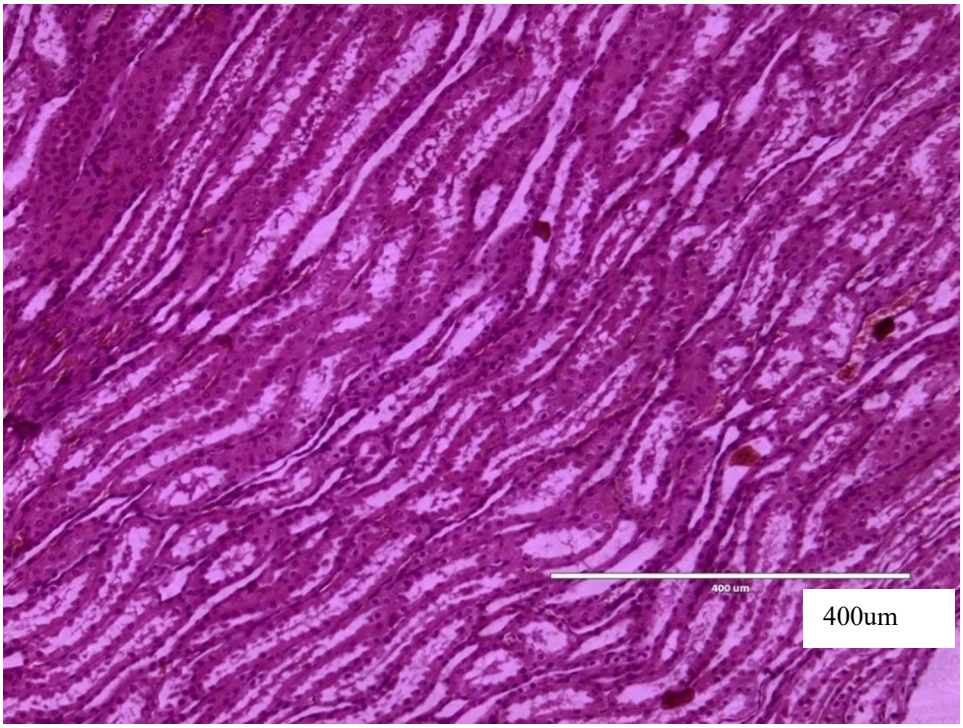

Fig. 9. Renal medulla of the kidney of Kazakh Bactrian. Haematoxylin-eosin.

Many studies of mammalian kidneys have shown that the ability to concentrate urine is related to basic structural features. The first is the relative thickness of the medullary layer of the kidney. This is a measure of the relative length of the Henle's loop and the blood vessels that regulate the final concentration of urine. The relative thickness of the medulla in different mammalian species is directly related to hypertonic urination. The minimum ratio of the cerebral layer to the cortical layer of beavers living in aquatic environments has been found to be 1:4. In our study, the ratio of renal medulla to cortical layer of camel kidney was approximately 4:1.

Considering previous studies on the morphology and histology of the structure of the camel kidney, as well as the results obtained in this study, we concluded that there must be anatomical prerequisites for concentrated urine in the camel kidney. In addition, the role of antidiuretic hormones in urine concentration, which is well defined in some other mammals, has not yet been investigated in the camel.

5 Conclusions

1. The study of body size and weight indices of males and females of the Kazakh Bactrian revealed significant differences. The height at the withers of males was higher than in females by about 3.2 %, oblique length of trunk by 4.5 %, chest girth by 1.3 %, shin girth by 6.6 % higher than in females. The greatest difference was in the live weight of the animals - 23.4 %. This result is consistent with the statement that camels have a pronounced sexual dimorphism, which means that male camels are usually larger and heavier than females. When compared with camels of other breeds, the Kazakh Bactrian was found to be one of the largest camels, having up to 750 kg for males 690 kg for females, as well as powerful musculature and thick fur and similar to the Sunni Bactrian population from Mongolia.

2. As a result of the histological study of the kidneys of Kazakh Bactrians the following characteristics of the camel kidneys were established: the kidney capsule is rather thick (470±12 μm), and is made up of two layers: a layer of collagen fibres (400 μm) and thin (70 μm) inner smooth muscle cells. The relative thickness of the capsule and the presence of a layer of smooth muscle cells within it appear to be related to the ability of the kidneys to hold high intrarenal pressure when producing highly concentrated urine.
3. The second feature of the bactrian kidney was that the renal medulla was much thicker than the cortical layer. Their ratio was 1:4. The thick cerebral layer in the camel provides relatively long renal tubules and Henle's loops, which is a necessary hysophysiological condition for the excretion of concentrated urine.

References

1. I.T. Kadim, I.S. Al-Amri, A.Y. Al Kindi, M. Mbaga, Camel meat production and quality: a review. journal of camel practice and research, **25**, 9-23 (2018) doi: 10.5958/2277-8934.2018.00002.4
2. Rekha Sharma, Himani Sharma, Sonika Ahlawat, R.A.K. Aggarwal, P.K. Vij, M.S. Ta ntia. First attempt on somatic cryopreservation of critically endangered Camelus bactrianus of India, Gene Reports, **10**, 109-115 (2018) doi.org/10.1016
3. B. Faye Role, distribution and perspective of camel breeding in the third millennium economies, Emirats Journal of Food and Agriculture, **27(4),** 318-27 (2015) doi:10.9755/ejfa.v27i4.19906.
4. Lamo et al. Morphometric, haematological and physio-biochemical characterization of Bactrian (Camelus bactrianus) camel at high altitude, BMC Veterinary Research, **16**, 291 (2020) doi: 10.1186/s12917-020-02481-6
5. I. Boujenane, N. El Khattaby, H. Laghouaouta, et al., Morphological diversity of female camel (Camelus dromedarius) populations in Morocco. Trop Anim Health Prod., **51**, 1367–1373 (2019) doi: 10.1007/s11250-019-01813-5
6. M. Dioli, Dromedary (Camelus dromedarius) and Bactrian camel (Camelus bactrianus) crossbreeding husbandry practices in Turkey and Kazakhstan: An in-depth review. Pastoralism, **10(6)** (2020) doi: 10.1186/s13570-020-0159-3
7. B. H. Alhajeri, R. Alaqeely, H. Alhaddad, Classifying camel breeds using geometric morphometrics: A case study in Kuwait. Livest. Sci., **230**, 103824 (2019) doi.org/10.1016/j.livsci.2019.103824
8. S. Akhmetsadykova, E. Shertay, G. Konuspayeva, et al., Phenotypic biodiversity characterization of dromedary camels and hybrids in Kazakhstan. Trop Anim Health Prod., 55(79) (2023) doi:10.1007/s11250-023-03496-5
9. A. Baimukanov, et al., *Monitoring productivity of Kazakh Bactrian and Arvana camels of Kazakhstan population*, IOP Conf. Ser.: Earth Environ. Sci., **604**, 012027 (2020) doi: 10.1088/1755-1315/604/1/012027
10. M.A. Abdalla, Anatomical features in the kidney involved in water conservation through urine concentration in dromedaries (Camelus dromedarius). Heliyon, **6**, e03139 (2020) doi:10.1016/j.heliyon.2019.e03139
11. A. Rezaie, B. Mohamadian, Z. Hossein, Histopathological Investigations on Renal Lesions in Slaughtered Camel (Camelus dromedarius) in North East of Iran. Kafkas Univ Vet Fak Derg., **20(4)**, 501-506 (2014) doi:10.1007/s11250-019-01813-5

12. I.A. Ishag, M.O. Eisa, M.K.A. Ahmed, Effect of breed, sex and age on body measurements of Sudanese camels (Camelus dromedarius). Australia Journal of Basic Applied Science, **5(6)**, 311-315 (2011) 2011292011
13. L. Eissa, I. Ismail, M. Elhassan, R. Yaseen, H. Ali, Comparative histology and histometry of the renal capsule in dromedary she camel (Camelus dromedarius), cow (Bos indicus) and ewe (Ovis aires). J. Camel Res. Prod., **2(1)**, 36-48 (2018)