Journal of Animal and Veterinary Advances 6 (11): 1273-1276, 2007
ISSN: 1680-5593

Morphometric Studies on the Kidneys of the African Giant Rat (Cricetomys Gambianus Waterhouse)

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Abstract: Morphometric studies were carried out using standard procedures on the kidney of the African Giant Rat (AGR). The average kidney weight was 2.085±0.044 g. The right kidney was significantly ($p<0.05$) heavier than the left. The male kidneys were larger than those of the female and the values obtained were 2.119±0.062 g and 2.053±0.009 g, respectively. The average liveweight of the AGR was 8.63.520±3.74 g. The relative thickness of the medulla was 4.30. The results of the present study provide baseline morphometric data on the kidney of the AGR which had been lacking. The value of the relative thickness of the medulla (4.3), similar to those of the dog (4.2) and the cat (4.8), suggests that the AGR does not have special anatomical adaptation in the urinary system for water economy. The capability to thrive well in arid environment probably lies somewhere else.

Key words: Morphometric studies, kidney, African giant rat, Nigeria

INTRODUCTION

The African Giant Rat (AGR), also known as Gambian rat, is a wild rodent consumed by the rural population in Nigeria (Happlod, 1987). Ajayi (1974) studied its biology and domestication. The smoked carcasses of the AGR are sold in village markets and attempts have been made to breed and rear them in captivity for food (Ajayi, 1975).

Pioneering efforts and attempts at characterization of the reproductive organs have been made in Nigeria, including the reproductive biology (Oke, 1985). Morphometric studies on the reproductive organs (Ogwuegbu *et al.*, 1983), detailed studies of the epididymis (Oke *et al.*, 1988, 1989; Oke and Aire, 1990), the Cowper's (Oke and Aire, 1989) and the Protrate glands (Oke *et al.*, 1995) have been carried out.

The kidney is an important organ involved in the removal of unwanted nitrogenous substances, excess water and the relative maintenance of osmotic concentration of the blood. Certain features of the renal anatomy of different mammals and variations with the aridity of their habitat have been reported (Sperber, 1944). No work has been carried out on the morphometric parameters of the AGR renal system in the North Central Savannah zone of Nigeria that can further contribute to the understanding of the biology of the AGR.

The aim of the present study was to investigate some morphometric parameters of the AGR kidney in order to shed light on the AGR, which has great potential for use as meat source and also as laboratory rodent.

MATERIALS AND METHODS

A total of 46 AGRs, of both sexes, were used for the study. The AGRs were caught alive from Bomo Village in Samaru, Zaria, Kaduna State, Nigeria. Sex difference was taken into consideration. The rats were weighed alive using a weighing balance (Ohaus scale crop) with a sensitivity of 0.1g and the animals were then sacrificed. A mid-ventral abdominal incision was made, the peritoneum reflected and the intestine displayed to gain access to the renal system. The length, weight, thickness and width of the kidneys were measured using a ruler, weighing balance and a vernier calliper, respectively. The kidney volume was determined by water displacement (Scherle, 1970). The organs were weighed using a mettler balance P1210 (Mettler Instrument AG, Switzerland) with a sensitivity of 0.01g.

The kidneys were fixed in buffered-neutral formaldehyde and further processed using the conventional histological procedure. Sections were cut at 5.0 μ and were stained with Haematoxylin and Eosin (H and E). A calibrated micrometer eyepiece was used to measure the thickness of the medulla and cortex.

The data obtained were subjected to statistical analysis using Student's t-test and correlation analysis. Values of $p<0.05$ were considered significant.

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RESULTS

The AGR kidneys were reddish-brown in colour *in vivo*. They were bean-shaped and smooth and covered with a thin fibro-muscular capsule. Each kidney had a cranial and a caudal surface, a medial and a lateral border and an upper and a lower pole. Adipose tissue surrounded the hilus and sides of the kidney. The lateral borders were convex in shape and the medial borders were concave and indented at the hilus. The major renal vessels had their entry and exit at the hilus.

The mean live weight of the AGR was 863.590±3.740 g (Table 1). It was observed that the right kidney with a mean of 2.210±0.051 g was heavier than the left (2.00±0.055 g) (Table 2). The kidney weight, length, width and thickness were 2.085±0.04 g, 2.482±0.278 cm, 1.443±0.010 cm and 0.865±0.019 cm, respectively (Table 1 and 3). The medullary and cortical thicknesses of the AGR were 0.338±0.012 and 0.198±0.086 cm, respectively, while the ratio of the medullary thickness to the cortical thickness was 1.90:1 (Table 2). The relative thickness of the medulla, which is an indicator of the length of the loop of Henle, was 4.297. The ratio of the liveweight to the kidney weight was 414.2:1.

The live weight of the male and female AGR were 858.00±7.796 g and 869.04 ±8.74 g, respectively (Table 1). The kidney weights of the male and female AGR were 2.119±0.062 g and 2.053±0.009 g, while the ratio of the liveweight to kidney in both the male and female were 405.3:1 and 423.3:1, respectively (Table 1). The right and the left kidney weights for the male and female AGR were 2.181±0.079 and 2.054±0.078 g, 2.147±0.010 and 1.963±0.078 g, respectively (Table 2). The ratio of the medullary thickness to cortical thickness for the male and female AGR were 2.01:1 and 2.08:1, respectively, while the relative thickness of the medulla for the male and female AGR were 4.12 and 4.45, respectively (Table 2). The male and female kidney length, width and thickness were 2.465±0.347 and 1.774 ±0.316 cm, 0.926±0.034 and 2.54±0.068 cm, 1.426±0.00 and 0.826±0.003 cm, respectively (Table 3). A highly significant ($p<0.001$) difference was obtained between the liveweight and kidney length, live weight and kidney weight and liveweight and kidney width (Table 4). No significant ($p>0.05$) difference was observed between the liveweight and kidney thickness.

For the male and female AGR, a highly significant ($p<0.001$) difference was obtained between the parameters (Table 4). An exception was the correlation between the liveweight and kidney thickness, which was not significantly ($p>0.05$) different. The correlation coefficients between liveweight and the length, thickness,weight and width of the male right kidney AGR 0.214,-0.173, 0.641 and 0.738 while those for the left kidney

Table 1: Liveweight, Kidney weight and their Ratios in the African Giant rat (Mean±SEM)

	Live weight (g)	Kidney weight (g)	Ratio of liveweight to kidney weight
African giant rats (n = 46)	863.520±3.740	2.085±0.044	414.2:1
Male AGRs (n = 23)	858.00±7.796^{NS}	2.119±0.062^{NS}	405.3:1
Female AGRs (n = 23)	869.043±8.740	2.053±0.009	423.3:1

NS = Non-Significant Difference ($p>0.05$) between male and female values

Table 2: Right and Left Kidney weights, Renal Medullary and Cortical Thickness and their Ratios

	Male (n = 23)	Female (n =23)	All rats (n = 46)
Right kidney weight	2.181±0.079	2.147±0.010	2.210±0.051^{a}
Left Kidney weight	2.054±0.078	1.963±0.078	2.00±0.055^{a}
Cortical thickness	0.165±0.046	0.166±0.136	0.198±0.086^{NS}
Medullary thickness	0.331±0.021	0.346±0.006	0.338±0.012^{NS}
Ratio of Medulla to Cortical thickness	2.01:1	2.08:1	1.90:1^{NS}
Relative thickness Of Medulla	4.12	4.45	4.297±0.233^{NS}

a = Highly Significant Difference ($p<0.001$) NS = Non-Significant Difference ($p>0.05$)

Table 3: Comparative Morphometric Values of the Kidney in the African Giant rat (Mean±SEM)

	Kidney length (cm)	Kidney width (cm)	Kidney thickness (cm)
African giant rats (n = 46)	2.482±0.278	1.443±0.010	0.865±0.019
Male AGR (n = 23)	2.465±0.347^{NS}	1.774±0.316^{NS}	0.926±0.034^{NS}
Female AGR (n = 23)	2.540±0.068	1.426±0.002	0.826±0.003

NS = Non-Significant Difference ($p>0.05$) between male and female values

Table 4: Correlation coefficients between liveweight and kidney length, width, weight and thickness of the african giant rat

	Male (n = 23)	Female (n = 23)	All rats (n = 46)
Liveweight vs Kidney length	0.789***	0.641***	0.758***
Liveweight vs Kidney thickness	0.289***	0.104^{NS}	0.199^{NS}
Liveweight vs Kidney weight	0.894***	0.830***	0.859***
Liveweight vs Kidney width	0.769***	0.793***	0.827***

NS = Non-significant Difference ($p>0.05$), *** = High Significant Difference ($p<0.001$)

Table 5: Correlation coefficients between liveweight and right kidney length, thickness, weight and width of the male and female african giant rat

	Kidney Length (cm)	Kidney thickness (cm)	Kidney weight (g)	Kidney width(cm)
Male AGRs (n = 23)	0.214^{NS}	-0.173^{NS}	0.641***	0.738***
Female AGRs (n = 23)	0.116^{NS}	-0.208^{NS}	0.229^{NS}	0.429*

NS = Non-significant Difference ($p>0.05$), * = Significant Difference ($p<0.05$), *** = Highly Significant Difference ($p<0.001$)

Table 6: Correlation coefficients between liveweight and left kidney length, thickness, weight and width of the male and female african giant rat

	Kidney Length (cm)	Kidney thickness (cm)	Kidney weight (g)	Kidney width(cm)
Male AGRs (n = 23)	0.291^{NS}	-0.085^{NS}	0.310^{NS}	0.421*
Female AGRs (n = 23)	0.044^{NS}	-0.082^{NS}	0.058^{NS}	0.265^{NS}

NS = Non-significant Difference ($p>0.05$), * = Significant Difference ($p<0.05$)

were 0.291,-0.085, 0.31 and 0.421, respectively. The values for the right kidney of the female AGR were 0.116,-0.208, 0.229 and 0.429 while those for the left kidney were 0.044, -0.082, 0.058 and 0.265, respectively (Table 5 and 6).

DISCUSSION

The shape and colour of the kidneys of the AGR observed in this study showed similarity to those reported for Wistar rat (Webster *et al*., 1947; Hebel and Stromberg, 1976) and other rodents like the rabbit (Kozma *et al*., 1974). However, a non-significant difference in the values of the liveweight between the male (858.00±7.786 g) and the female AGR (869.043±8.740 g) obtained in the present study disagreed with the findings of Dunns (1967) and Kozma *et al*. (1974). They reported that the males of Wistar rat and rabbit had heavier liveweight than the female. The weights of the right kidneys of the male and female AGR (2.181±0.079 g and 2.147±0.010 g) and those of the left kidneys of the male and female AGR (2.054±0.078 g and 1.963±0.078 g) indicated that the right kidney was heavier that the left. These findings agreed with those of Dunns (1967), Kozma *et al*. (1974), Akayevsky (1975) and Tayeb (1948), who reported a heavier kidney for male rats, rabbits, mice and camels. Webster *et al*. (1947) reported that an adult male laboratory rat, weighing 200 g, had a kidney weight of 1.80 g, while an adult female of the same weight had a kidney weight of 1.5 g. The New Zealand and Dutch-belted rabbits also showed heavier male kidney weights (Kozma *et al*., 1974) [New Zealand White rabbit male = 0.52±0.012 g, female = 0.510±0.0012 g; Dutch-belted male = 0.73±0.017 g and female = 0.720±0.028 g]. These findings indicated that the right kidney was slightly larger than the left and that the kidneys of the male were generally larger than the female.

The kidney weight represented 0.25 and 0.24% of the liveweight for the male and female, respectively. The total kidney weight of the AGR was 0.24% of liveweight and the values were lower than 0.76 and 0.71% in the Wistar rat obtained by Hebel and Stromberg (1976) and Dunns (1967). The ratio of the liveweight to kidney weight in the AGR was 442:1, while the ratio obtained in the Wistar rat was 220:1 (Webster *et al*., 1947).

The relative thickness of the medulla of the AGR was 4.3 which was similar to those of the dog (4.2) and the cat (4.8) (Schmidt-Nielson and Dell, 1961). These same authors reported a relative thickness of 6.0, 8.4, 9 and 11 for the Wistar, Kangaroo, Jeroboa and Desert rats, respectively. Ruckebuch *et al*. (1991) reported 4.0 for dog and 4.3 for cat. These are also similar to the figure (4.3) obtained in this study. The relative thickness of the medulla is an index of the length of the loop of Henle, which acts as a counter current exchanger system and the relative thickness varies directly with the ability to produce hypertonic urine.

The present study focussed on the morphometric measurements of the kidney of the African Giant rat. Considering the values of the relative thickness of the medulla in the above rats (AGR, Wistar, Kangaroo, Jeroboa and Desert rats), the AGR appeared the least equipped for the production of hypertonic urine that leads to conservation of water in arid environment. The relative thickness of AGR (4.3) does not suggest any special anatomical adaptation in the urinary system for water economy. However, studies by Tisher (1971) have shown that rhesus monkey produced concentrated urine in the absence of a well-developed inner medulla and loop of Henle. Moutairou *et al*. (1996) have also suggested that protein binding mechanism involving calbidin might be responsible for the ability of the AGR to live with restricted drinking water. The ability to conserve water may lie somewhere else in AGR and further studies will be needed to elucidate this.

REFERENCES

Ajayi, S.S., 1974. The Biology and Domestication of the African Giant rat (Cricetomys gambianus Waterhouse). PhD Thesis, University of Ibadan.

Ajayi, S.S., 1975. Domestication of the African Giant rat (Cricetomys gambianus Waterhouse). Department of Forest Resource Management, University of Ibadan, pp: 1-44.

Akayevsky, R., 1975. Anatomy of Domestic Animals. Kolos Publishing House, Moscow (in Russian), pp: 592.

Dunns, T.B., 1967. Pathology of Laboratory Rats and Mice. In: Ernest Cotchen and E. Row-Forje (Eds.). Blackwell Scientific Publication, pp: 149.

Happlod, R.R. 1987. The Mammals of Nigeria. Clarendon Press Oxford, pp: 124-125.

Hebel, R. and M.W. Stromberg, 1976. Anatomy of the Laboratory rat. William and Wilkins Company, pp: 62-65.

Kozma, C., W. Macklin, L.M. Cymunus and R. Marer, 1974. The Biology of the Laboratory Rabbit. In: Weisbroth S.H., Flalt, R.E. and Kraus, A.L. (Eds.). Academic Press, pp: 53-56.

Ogwuegbu, S.O., B.O. Oke and T.A. Aire, 1983. Histomorphometric, histochemical and microstereological studies on the accessory gland of the male African Giant rat (Cricetomys gambianus Waterhouse). Afr. J. Ecol., 21: 329-333.

Oke, B.O. 1985. Effect of season on the reproductive organs of the male African Giant rat (Cricetomys gambianus Waterhouse) in Ibadan, Nigeria. Afr. J. Ecol., 23: 67-70.

Oke, B.O., T.A. Aire, O. Adeyemo and E. Heath, 1988. The structure of the epididymis of the African Giant rat (Cricetomys gambianus Waterhouse). Histological, histochemical and microstereological studies. J. Anatomy, 160: 9-19.

Oke, B.O. and T.A. Aire, 1989. The bulbourethral (Cowper's) gland of the African Giant rat (Cricetomys gambianus Waterhouse). Veterinaski Archiv, 59: 267-274.

Oke, B.O., T.A. Aire, O. Adeyemo and E. Heath, 1989. The ultrastructure of the epididymis of the African Giant rat (Cricetomys gambianus Waterhouse). J. Anatomy, 165: 75-85.

Oke, B.O. and T.A. Aire, 1990. Ultrastructural evidence of secretion in different zones of the Caput epididymis of the African Giant rat (Cricetomys gambianus Waterhouse). Veterinarski Archiv, 60: 207-212.

Oke, B.O., O.A. Oke and T.A. Aire, 1995. The prostrate gland of the African Giant rat (Cricetomys gambianus Waterhouse). Veterinarski Archiv, 65: 115-125.

Ruckebuch, Y., L. Phanef and B.C. Decker, 1991. Physiology of Small and Large Animals. 5th Edn., pp: 150.

Scherle, W., 1970. A simple method for volumetry of organs in quantitative stereology. Mikroscopic, 26: 57-60.

Schmidt-Nielsen, B. and R. O'Dell, 1961. Structure and concentration mechanism on the mammalian kidney. Am. J. Physiol., 200: 119-124.

Sperber, J., 1944. Studies on the mammalian Kidney. Zoological Bull., 22: 249-432.

Tayeb, M.A.F., 1948. Urinary system of the camel. J. Am. Vet. Med. Assoc., 113: 568-572.

Webster, S.H., E.T. Liljegreen and D.J. Zimicen, 1947. Body weight ratios for liver, kidney and spleen of laboratory animals I. Am. J. Anatomy, 81: 471-514.