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A Study of the Kidney of the Wistar Rat in Northern Guinea Savannah Zone: the Morphometric Aspect

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Abstract: A morphometric study was carried out on the kidney of the Wistar Rat (WR) using standard laboratory procedures. The mean live weight of the Wistar rat was found to be 140.625±3.078 g. The average kidney weight was 0.605±0.012 g. The right kidney, with a mean weight of 0.632±0.012 g, was significantly ($p<0.05$) heavier than the left (0.596±0.022 g). The male kidneys were larger than those of the female and the values obtained were 0.633±0.091 g and 0.572±0.132 g, respectively. The relative thickness of the medulla was 5.6. This value (5.6) indicates a high index for the length of the loop of Henle, which acts as a counter current multiplier system and directly increases the ability of the kidney to produce hypertonic urine. This high index thus suggests that the Wistar rat is anatomically adapted within its urinary system (kidney) for water conservation. Furthermore, the present study has provided a baseline morphometric data on the kidney of the Wistar rat in the Northern Savannah zone of Nigeria.

Key words: Kidney, wistar rat, northern guinea savannah

INTRODUCTION

The Wistar Rat (WR) is a species of rat that is as common as the African Giant Rat (AGR) in this part of the world. It happens to be of equal importance as an environmental nuisance to the human population as the AGR but for its smaller size, it is not readily sought after as food delicacy by the local people.

Studies have been done on some aspects of the biology of this rat in the Southern part of the country. Detailed comparative studies on the haemogram of the Wistar Rat (WR) and African Giant Rat (AGR) (Durotoye and Oke, 1990) and studies on the testicular and epididymal protein of WR and AGR (Adeyemo and Oke, 1990) have been carried out.

The rats thrive very well with restricted drinking water and their kidneys have been speculated to have adaptive mechanism for ion/water homeostasis.

The aim of this present study is to investigate the morphometric parameters of the Wistar rat kidney in order to shed light on any anatomical features that help it to thrive well in the arid zone.

MATERIALS AND METHODS

A total of 44 Wistar Rats (WR) of both sexes were used for the study. These rats were caught alive from Bomo village in Samaru, Zaria, Kaduna State, Nigeria. Sex difference was taken into consideration during this study. The rats were weighed alive using a weighing balance (Ohaus scale crop) with a sensitivity of 0.1 g and the animals were then sacrificed at regular intervals. A mid-ventral abdominal incision was made on each animal, the peritoneum reflected and the intestine displaced 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 0.01 g.

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.

RESULTS

Tables 1-6 show the results obtained during the study. The mean live weight of the Wistar Rat (WR) was 140.625±3.078 g (Table 1). The right kidney with a mean weight of 0.632±0.012 g was seen to be heavier than the left (0.596±0.022 g) (Table 2). The mean kidney weight, length, width and thickness were 0.605±.012 g, 1.543±0.023, 0.852±0.072 and 0.730±0.018 cm, respectively (Table 1 and 3). The medullary and cortical thicknesses of the WR were 0.347±0.023 and 0.365±0.206 cm, respectively while, the ratio of the medullary to cortical thickness was 0.95:1 (Table 2). The relative thickness of the medulla, which is an indicator of the length of the loop of Henle was 5.545. The ratio of the live weight to the kidney was 232.4:1.

Table 1: Live weight, kidney weight and their ratios in the Wistar rat (mean±SEM)

	Live weight (g)	Kidney weight (g)	Ratio of live weight to kidney weight
Wistar rats (n = 40)	140.625±3.078***	0.605±0.012***	232.4:1
Male WR (n = 22)	146.252±8.221^{NS}	0.633±0.091*	231:1
Female WR (n = 18)	133.683±6.283	0.572±0.132	233.7:1

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

Table 2: Right and left kidney weights, renal medullary and cortical thickness and their ratios

	Male (n = 22)	Female (n = 18)	All rats (n = 40)
Right kidney weight	0.640±0.029	0.583±0.004	0.632±0.012
Left kidney weight	0.625±0.025	0.561±0.019	0.596±0.022
Cortical thickness	0.308±0.361	0.190±0.016	0.365±0.206
Medullary thickness			0.347±0.023
Ratio of medullary to cortical thickness	0.346±0.032	0.346±0.044^{NS}	
Relative thickness of medulla	0.68:15.290	1.82:15.805	0.95:15.545±0.360**

NS = Non-significant difference (p>0.05), ** = Very significant difference (p<0.01)

Table 3: Comparative morphometric values of the kidney in wistar rat (mean±SEM)

	Kidney length (cm)	Kidney width (cm)	Kidney thickness (cm)
Wistar rats (n = 40)	1.543±0.023***	0.852±0.072***	0.730±0.018***
Male WR (n = 22)	1.563±0.028^{NS}	1.378±0.408^{NS}	0.948±0.025^{NS}
Female WR (n = 18)	1.520±0.038	0.750±0.055	0.720±0.026

NS = Non-significant difference (p>0.05), * = Significant difference (p<0.01), *** = Highly significant difference (p<0.001)

Table 4: Correlation coefficient between live weight and kidney length, width, weight and thickness of the Wistar rat

	Male (n = 22)	Female (n = 18)	All rats (n = 40)
Live weight vs. kidney length	0.835***	0.731***	- 0.728***
Live weight vs. kidney width	0.821**	0.763***	0.789***
Live weight vs. kidney weight	0.906***	0.855***	0.879***
Live weight vs. kidney thickness	0.117^{NS}	0.546***	0.357***

NS = Non-Significant difference (p>0.05), ** = Very significant difference (p<0.01), *** = Highly significant difference (p<0.001)

Table 5: Correlation coefficients between live weight and right kidney length, thickness, weight and width of male and female Wistar rat

	Kidney length (cm)	Kidney thickness (cm)	Kidney weight (g)	Kidney width (cm)
Male WR (n = 22)	0.523**	0.247^{NS}	0.119^{NS}	0.019^{NS}
Female WR (n = 18)	0.222^{NS}	0.385^{NS}	0.258^{NS}	0.131^{NS}

NS = Non-significant difference (p>0.05), ** = Very significant difference (p<0.01)

Table 6: Correlation coefficients between live weight and left kidney length, thickness, weight and width of male and female Wistar rat

	Kidney length (cm)	Kidney thickness (cm)	Kidney weight (g)	Kidney width (cm)
Male WR (n = 22)	-0.122^{NS}	0.105^{NS}	0.702***	0.612**
Female WR (n = 18)	0.211^{NS}	0.254^{NS}	0.287^{NS}	0.628**

NS = Non-Significant difference (p>0.05), ** = Very significant difference (p<0.01), *** = Highly significant difference (p<0.001)

The mean live weight of the male and female WR were 146.252±8.221 and 133.683±6.283 g, respectively (Table 1). The mean kidney weights of the male and female WR were 0.633±0.091 and 0.572±0.132 g while, the ratio of the live weight to kidney weight in both the male and female were 231:1 and 233.7:1, respectively (Table 1). The right and left mean kidney weights for the male and female WR were 0.640±0.029 and 0.625±0.025, 0.583±0.004 and 0.561±0.019 g, respectively (Table 2). The ratio of the medullary to cortical thickness for the male and female WR were 0.68:1 and 1.82:1 while, the relative thickness of the medulla for the male and female WR were 5.29 and 5.805, respectively (Table 2).

The male and female mean kidney length, width and thickness were 1.563±0.028 and 1.520±0.038, 1.378±0.408 and 0.750±0.055 cm, 0.948±0.025 and 0.720±0.026 cm, respectively (Table 3). A highly significant (p<0.001) difference was obtained between the live weight and kidney length, live weight and kidney weight and live weight and kidney width (Table 4) except between live weight and kidney thickness in the male WR where a non-significant (p>0.05) difference was observed.

The correlation coefficients between live weight and the length, thickness, weight and width of the male right kidney of WR were 0.523, 0.247, 0.119 and 0.019 while, those for the left kidney were -0.122, 0.105, 0.702 and 0.612, respectively. The values for the right kidney of the female WR were 0.222, 0.385, 0.258 and 0.131 while,

those for the left kidney were 0.211, 0.254, 0.287 and 0.628, respectively (Table 5 and 6).

DISCUSSION

The gross features of the kidneys of the WR observed in this study showed close similarity to reports on the Wistar rat by Webster *et al.* (1947) and Hebel and Stromberg (1976). The shape and colour were also similar to those of the rabbit as observed by Kozma *et al.* (1974). The live weight of the male (146.252±8.225 g) and the female (133.683±6.283 g) WR were in agreement with the results of Dunns (1967) and Kozma *et al.* (1974).

The mean weights of the kidneys were also similar to the values reported by Rytand (1938). The male kidneys with mean weights (0.640±0.029 g right, 0.625±0.025 g left) were heavier than those of the female (0.583±0.004g right, 0.561±0.019 g left). This finding also agreed with those obtained in animals like the camel (Tayeb, 1948), the rat and mouse (Dunns, 1967) and the rabbit (Kozma *et al.*, 1974).

It is also, in agreement with the results of Webster *et al.* (1947), which showed that the weight of kidney of the adult male Wistar rat was heavier than that of the female of the same weight.

Kozma *et al.* (1974) had observed that New Zealand White rabbit male had a mean kidney weight of 0.52±0.012 g and the female had 0.510±0.012 g. Dutch Belted male had 0.73±0.017 g and the female had 0.720±0.028 g.

The present study also showed that the right kidney was slightly heavier than the left and that the kidney of the male was generally larger than that of the female. The kidney weights represented 0.43% of the live weight for both the male and female WR. However, this observation was lower than the 0.71 and 0.76% values obtained by Dunns (1967) and Hebel and Stromberg (1976), respectively. These differences in values could be due to variations in age, breed and environmental factors, including the diets.

The ratio of the live weight to kidney weight in this study was 232.4:1 and this was not very different from 220:1 value obtained by Webster *et al.* (1947). As regards the kidney length, width and thickness, the values in this study were also similar to those of Hebel and Stromberg (1976). They obtained a mean length of 2.0±0.5 cm, a width of 1-1.5 cm and a thickness of 1.0 cm for the kidney of the Wistar rat. Our values in this study were 1.543±0.023 cm for the length, 0.852±0.072 cm for the width and 0.730±0.018 cm for the thickness.

The relative thickness of the WR medulla was 5.6. The value was similar to that (6.0) recorded by Schmidt-Nielsen and O'Dell (1961) and that (5.9) recorded by Ruckebuch *et al.* (1991) from their works on Wistar rat.

However, the value of 5.6 was greater than the 4.2 recorded in the dog and 4.8 in the cat by Schmidt-Nielsen and O'Dell (1961). Our value of 5.6 was also much less than the 9.0 recorded for Jeroboa rat and 11.0 for the Desert rat by Schmidt-Nielsen and O'Dell (1961).

The relative thickness of the medulla is an index of the length of the loop of Henle that acts as a counter current multiplier system in the body. It is also, an index of the length of vasa recta that acts as a counter current exchanger system. This relative thickness varies directly with the ability of the kidney to produce hypertonic urine. The 5.6 value of the relative thickness in the Wistar rat places it in the category of animals that produce hypertonic urine and thus it is able to conserve water better. It ranks better than the dog and cat but poorer than animals like Desert rat and Jeroboa rat.

It is likely that this special feature working together with other hormonal output in the animal has helped the Wistar rat develop the ability to live with restricted water supply.

REFERENCES

Adeyemo, O. and B.O. Oke, 1990. Comparison of the testicular and epididymal proteins of the African giant rat (*Cricetomys gambianus* Waterhouse) and the laboratory rat. Trop. Vet., 8: 19-27.

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

Durotoye, L.A. and B.O. Oke, 1990. A comparative study on the haemogram of the African giant rat (*Cricetomys gambianus* Waterhouse) and the Wistar rat. Trop. Vet., 8: 29-38.

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

Kozma, C., W. Macklin, L.M. Cymunus and R. Maver, 1974. Biology of the Laboratory Rabbit, 7th Edn, pp: 53-56.

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

Rytand, D.A., 1938. The number and size of mammalian glomeruli as related to the kidney and body weight with method for their enumeration and measurement. Am. J. Anatomy, 62: 507-520.

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 concentrating mechanism in the mammalian kidney. Am. J. Physiol., 200: 1119-1124.

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, kidneys and spleen of laboratory animals. 1 Albino rat. Am. J. Anatomy, 81: 471-514.