Journal of Anatomical Sciences

Email:anatomicaljournal@gmail.com

J Anat Sci 8 (2)

Anatomical Studies of the Adrenal Gland of African Giant Rat (*Cricetomys Gambianus*-Waterhouse, 1840)

[1]Enemali FU, [1]Ayara CO, [2]Agbon AN and [2]Iliya IA

[1] Department of Human Anatomy, Faculty of Basic Medical Sciences, Bingham University, Karu, Nasarawa State Nigeria.

[2]Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria,Kaduna State Nigeria.

Corresponding Author: Enemali F
Email: enemalifelix@gmail.com; +23408167257734

ABSTRACT

This study described the morphologic and microscopic features of the adrenal glands of *Cricetomys gambianus* (Afican giant rat, AGR).Twenty (20) wild AGR comprising of ten males and ten females were used for this study. The AGR were euthanized and adrenal glands harvested and examined morphologically and light microscopically using routine (H and E) histological stains and Potassium Dichromate stain (PDC) for histochemistry. Morphologic data collected were subjected to statistical analysis using statistical tools (*t*-test and Pearson's correlation).Results revealed morphologic features of the AGR adrenal glands as paired structures, located on the superior poles of both kidneys; sexual dimorphism exit in the weight of the glands with the female glands being significantly weightier than that of the males. The length and the width of the male and female adrenal glands do not showed sexual dimorphism when values were subjected compared. Histological studies showed that the adrenal glands were divided into two broad regions, the cortex and the medulla. The adrenals exhibited structures with typical cortical zonation. Histochemical studies revealed medullary cells with high affinity for chromaffin stain, the chromaffin cells.In conclusion, the adrenal gland of the AGR is an oval-shaped paired glands, of broadly two microscopic regions, cortex and medulla. Histoarchitectural features of the gland are similar to that of other mammals.

Key words: Adrenal gland, AGR, Histology, Histochemistry, Morphologic.

INTRODUCTION

Cricetomys gambianus (African giant rat or African giant rat) is a member of the order, *Rodentia*. It is an omnivorous animal, feeding on vegetables, insects, crabs and snails, but prefers palm fruits and palm kernels.[1] The word 'pouched' in the common name refers to the animals' habit of using the cheek pouches to store or carry food. Attempts are being made in Nigeria and other countries in African to domesticate these animals in captivity for food and research.[2] The animals' meat is considered a delicacy and the smoked carcasses of these rodents are often sold in villages and towns.[3] More recently, the animal has been used to sniff out landmines in Mozambique.[4]The morphology of the adrenal gland has been reported for horses, dogs and cats,[5] guinea pig,[6] Wistar rats, buffalo[8]and other mammals.[9]

However, studies on the adrenal glands of the African giant rat (AGR) are few and, due to the unique position of these animals in the mammalian classification, it is pertinent to investigate and documented on the anatomy of these glands. These work described the morphologic and microscopic features of the adrenal glands of AGR.

MATERIALS AND METHODS

In this study, twenty adult AGRs which consisted of ten (10) males and ten (10) females were used. The AGR were captured alive using local metal cage traps in the wild, around Samaru and Bomo villages in Zaria, Kaduna state, Nigeria. AGRs were transported to the Animal House of the Department of Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria placed in metal cages and fed with groundnut pellets and water *ad libitum*. AGRs were acclimatized for two weeks prior to the research.

Animal Euthanization

The animals were euthanized using chloroform.[10] The body weights of AGRs were weighed and recorded to the nearest gram using a laboratory balance (Model P 1210) after which AGR were humanely sacrificed. An incision was made in the ventral midline from the cervical region to the level of the pelvic region and the abdominal cavity was opened. The digestive system was dissected out to gain access to the renal system in the posterior abdominal wall of the AGR and adrenal glands which were located on the superior poles of both kidneys were photographed in their anatomical position before glands were dissected. The weight of adrenal glands of AGR was taken using the digital weighing

balance, while the lengths and widths of the adrenal glands were measured to the nearest millimetre using ruler. Harvested adrenal glands were categorised for histological and histochemical studies. For histological studies, glandswere fixed in Bouin's fluid for 24 hours after which glands were prepared for routine histological examination, stained with Haematoxylin and Eosin (H&E) stains.For the histochemical studies, glands were fixed in Potassium Dichromate (PDC) after which, glands were processed for light microscopy. Slides were studied on the binocular light microscope (HM-LUX, Leitz Wetzlar, Germany) at different magnifications (100 and 250). Photomicrographs were obtained using a computer running imaging software (AmScope MT version 3.0, USA).

Statistical Analysis

Data on weights, lengths and widths were expressed as mean ± standard error of mean (SEM) and, data statistical analysis was conducted using statistical tools (Student *t*-test for mean differences between males and females AGRs, and Pearson's correlation for determining relationship between glands' weight and parameters measured). Statistical analysis software used was Statistical Package for the Social Sciences (SPSS) *version* 20.

RESULTS

Morphological Studies

The oval-shaped paired adrenal glands were located on the superior poles of the bilateral (right and left) kidneys (Figure 1). The average body weight of AGR showed sexual dimorphism with the male higher than the female. Mean adrenal weight showed sexual dimorphism with the female significantly ($p<0.05$) higher than that of the male AGR (Table 1).Sexual dimorphism was not observed in the dimensions (length and width) of the adrenal gland. Correlation analysis revealed strong positive relationship ($p<0.05$) between AGR adrenal gland parameters and body weight of AGR in both sexes (Table 2).

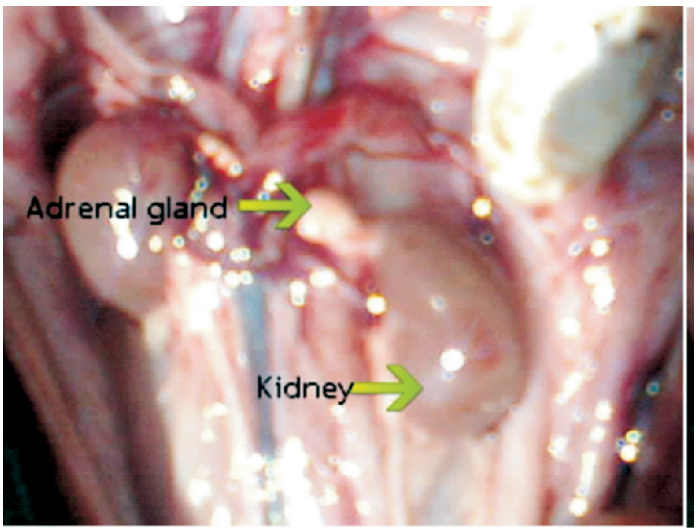

Figure 1: The adrenal glands and the kidneys of the African giant rat.
(*Note, the location of the glands on the superior poles of both kidneys*)

Table 1: Morphometric studies of adrenal glands of the African giant rats (AGR)

Sex	Body weight (g)	Organ weight(g)	Relative organ index	Organ length (cm)	Organ width (cm)
M	1210.00±56.7*	0.30±0.00	0.024±0.001	0.34± 0.01	0.17 ± 0.02
F	911.11±24.5	0.44±0.01*	0.05± 0.001	0.45±0.02	0.22±0.01

n=10; Independent sample *t*- test; *=$p<0.05$, significant when values of male (M) were compared with the female (F).

Table 2: Correlation betweenorgan (adrenal glands) parametersand body weightof AGR

Variables	Organ weight -male (g) (r)	Organ weight - female (g) (r)
Body weight (g)	0.980***	0.935***
Organ width(cm)	0.596**	0.6.00*
Organ length(cm)	0.516*	0.596*

n=10; r=Pearsons'correlation co-efficient; *=p<0.05, **= p<0.01; ***= p<0.001 significant when correlated with organ weight.

Histological and Histochemical Studies

Histological examination revealed that, the AGR adrenal gland comprises of an outer cortical (Cortex) and inner medullary (Medulla)areas. Cells of the adrenal cortex have characteristic features of steroid-secreting cells: acidophilic cytoplasm rich in lipid droplets, with a basophilic central nucleus. The adrenal cortex has three concentric zones in which the cords of epithelial steroid-producing cells are arranged differently. These three zones are: zona glomerulosa, zona fasciculata and zona reticularis. The adrenal medulla was about one-quarter of the gland and was observed to be composed of large cells arranged in cords or clumps (Figure 2).

The outermost layer, zona glomerulosa is composed of cells arranged in irregular ovoid clusters of closely packed, rounded or arched cords of columnar cells with numerous capillaries. The zona fasciculata lies between the zonae glomerulosa and reticularis, with no distinct delineations. It consisted of cells that are arranged in a cord like pattern running towards the medulla. Cords of cells contained large polyhedral-shaped cells, separated from each other by sinusoidal spaces (Figures3 and 4). The zona reticularis is the innermost layer of the adrenal cortex, and lies next to the adrenal medulla. This layer consists of an irregular network of branching cords and clusters of cells separated by numerous sinusoids(Figure 5).The adrenal medulla lies deep to the zona reticularis of the adrenal cortex. This layer**is** composed of clusters of cells with granular, faintly basophilic cytoplasm with numerous capillaries in their fine supporting stroma (Figure 6). Histochemical examination showed chromaffin reaction in the medulla of the adrenal glands which occurred as a result of the oxidation of the stored catecholamine granules of adrenal medullary cells to a brown colour (Figure7).

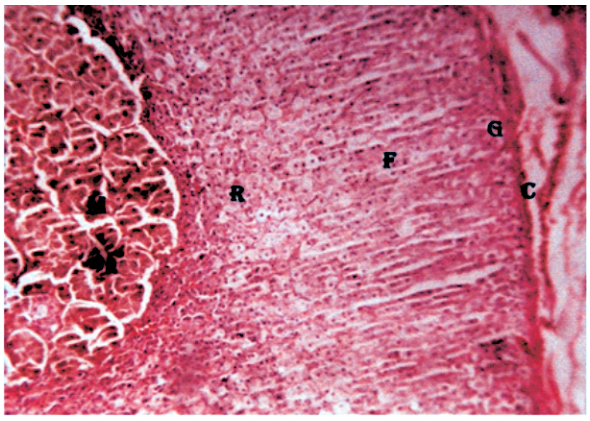

Figure 2: Micrograph of the adrenal gland of the African giant rat.
Capsule(C); Zona fasciculata (F); Zona glomerulosa (G); Zona reticularis (R); Adrenal medulla (M) (H&E, 100)

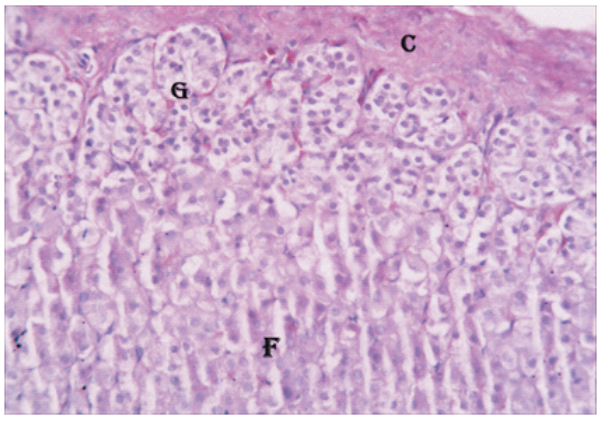

Figure 3: Micrograph of the adrenal cortex of the African giant rat
Cortex (C); Zona fasciculata (F); Zona glomerulosa (G)(H&E, 250)

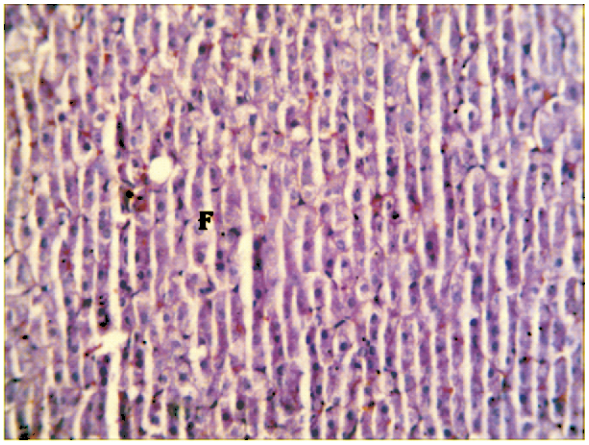

Figure 4: Micrograph of the adrenal cortex- Zona fasciculata (F) - of the African giant rat (H&E, 250).

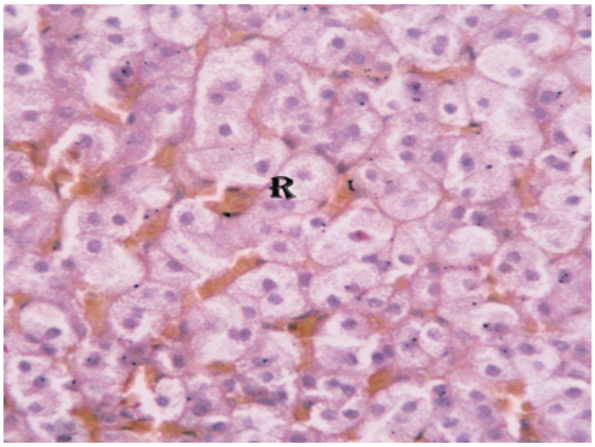

Figure 5: Micrograph of the adrenal cortex - Zona reticularis (R)- of the African giant rat (H&E 400).

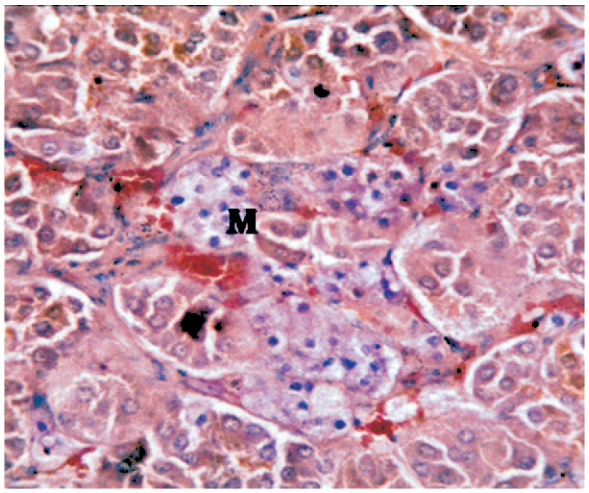

Figure 6: Micrograph of the adrenal medulla (M) of the African giant rat (H&E, 250).

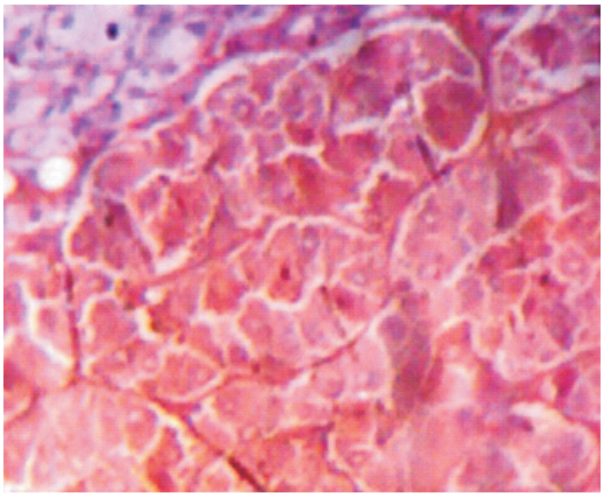

Figure 7: Micrograph of the adrenal gland of African giant rat showing chromaffin reaction of medullary cells. Cortex (C); Chromaffin cells (CC)(PDC, 250)

DISCUSSION

In this study, the anatomical features of the adrenal glands of AGR were examined using morphologic and microscopic approaches. The adrenal glands of AGR are paired bilateral structures as observed in other rodents and mammals.[12] The adrenal glands of male and female AGR differ in size and appearance, those of females being consistently larger and more opaque. The present study agrees with findings in other rodents, like the Wistar rat. These differences could be due to the presence of more lipids.[13] In this study, no remarkable dimensional (length and the width) differences were observed between the adrenal glands of male and female AGR. This implies the absence of sexual dimorphism in dimensional parameters of the gland. This is in concordance with the findings in rodents, such as Wistar rat and *Thryonomys swinderianus* (Grass cutter), and mammals, such as *Homo sapiens* (humans). Striking relationship was observed between the mean weights of gland with parameters like, body weight, organ (gland) length and width. This suggest that, the weightier/ larger the AGR, the larger the gland and thus, the length and the width of the gland. Findings are in consistence with reports in mammal; wistars[14]; cat[15]. Microscopic examination of the AGR adrenal gland consists of two regions; cortex and medulla, which agrees with findings in Wistar rats [16] and mammals.[17]Deep to the thin-layered renal capsule, histoarchitecture of the cortex is zonatedinto three zones: zonae glomerulosa, fasciculata and reticularis. This pattern agrees with the architecture reported in rodents and other mammals [17]. The adrenal cortex is essential to life; it controls theelectrolyte and water distribution in the body and maintains proper carbohydrate balance. The characteristic pattern of irregularly arranged clusters of closely packed, rounded or arched cords of columnar cells observed in the zona glomerulosa region of the adrenal cortex in this study, is in concordance with the findings reportedby other researchers in

otherrodents.[16]However, this disagrees with findings in horses where the columnar cells of the zona glomerulosaare specifically tall.[18] Thecells of the zonaglomerulosain the adrenal cortex produce mineralocorticoid hormones,primarily aldosterone. Aldosterone release is initiated via the renin-angiotensin pathway in response to decreased arterial blood pressure and low levels of sodium in the plasma.[20] In this study, the zona fasciculata which was juxtaposed to zona glomerulosa shows no distinct delineation as in the case of humans and other higher mammals. This finding is in consonance with the report of Ibe *et al*.[19]The zona fasciculata, consisted of large polyhedral cells that were arranged in a cord like pattern running towards the medulla. This histoarchitectural pattern agrees with that reported in rats[16]. The histoarchitectural pattern of the zona reticularis observed in this study is in agreement with the findingsof the adrenal cortex of somemammals, such as bats,[21] goat,[22] sheep[23] and donkey.[24]The medulla of the adrenal gland of AGR was completely separated from the cells of the cortex. This agrees with findings in some mammals[25]such as rodents, *camel*[26] and *deer*.[27]The highly vascularised medulla was composed ofcells with high affinity for chromaffin stain, thus are rich in chromaffin substance and referred to as Chromaffin cells. Chromaffin cells are responsible for the production of catecholamines; adrenalin and noradrenalin.[17, 18] Secretions are passed directly into the blood. Chromaffin cells of the medulla picked the potassium dichromate stain hence cells became brown in colour. Basically, the histology of the AGR adrenal gland does not vary greatly from those of other mammals.

CONCLUSION

The adrenal gland of the AGR is an oval-shaped paired glands, of broadly two microscopic regions, cortex and medulla. Histoarchitectural features of the gland is similar to that of other mammals.

ACKNOWLEDGEMENTS

I wish to acknowledge and appreciate the following research assistant: Elijah Tubok and the Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria for proving the facilities to conduct this research.

REFERENCES

1. Cooper RG, Erlwanger KH. Hyperzincaemia in a pet African giant rat (*Cricetomys gambianus* Waterhouse, 1840). *J S Afr Vet Assoc*. 2007: 78(3):163–165.
2. Cooper, R.G. Care, Husbandry and Disease of the African giant rat. *Journal of South Africain South African Veterinary Association* 2008:79 (2): 62-66.
3. Carrington, D. Hero rats sniff (and snuff) out landmines and TB. http://edition.cnn.com/2014/09/26/world/africa/hero-rats-sniff-out-landmines-and-tb/. Accessed February 23, 2017
4. Gelberg, H. Cockerell, G.L. Mirror R.R. A light and electron microscopic study of a normal medulla and a pheochromocytoma from a horse. *Veterinary pathology journal* 2000:16:395-404.
5. Nzalak, J. O.; Onyeanusi, B. I. & Salami, S. O. Macrometric study of the digestive system of the African giant rat (Cricetomys gambianus, Waterhouse 1840). *Eur. J. Anat.*, 2012:16(2):113-8,.
6. Olude, M. A., Olopade, J. O., Ihunwo, A. O. Adult neurogenesis in the African giant rat (*Cricetomys gambianus*, Waterhouse). Metabolic Brain Disease. 2014:29(3): 857-66
7. Kierszenbaum A.L. *The Adrenal gland. In: Histology and cell biology:an introduction to pathology* . 2002:510-511
8. Yilmaz S. and Girgin A. Light and electron microscopic observations on the structure of the porcupine *(Hystrix cristata)* adrenal gland. *Veterinar.* 2005
9. Olude, M. A., Ogunbunmi, T. K., Olopade, J. O., Ihunwo, A. O. The olfactory bulb structure of African giant rat (*Cricetomys gambianus*, Waterhouse 1840) Cytoarchitecture. *Anatomical Science International.* 2014: 89(4): 224-31.
10. Atkinson, W.B, F. Wilson, and S. Coates. The nature of the sexual dimorphism of the submandidibular gland of the mouse. *Journal of Endocrine.* 2000:65: 114-117.
11. Rosol T.J., Yarrington J.T., Latendresse J. and Capen C.C. Adrenal Gland: Structure,function and mechanisms of toxicity. *Toxicologic pathology*, 2001:29(1): 41-48
12. Kanczkowski W, Sue M, Zacharowski K, Reincke M, Bornstein SR. The role of adrenal gland microenvironment in the HPA axis function and dysfunction during sepsis. Mol Cell Endocrinol 2015:408:241–8.
13. Ibe, C. S., Onyeanusi, B. I., Hambolu, J. O. Functional morphology of the brain of the African giant pouched rat (*Cricetomys gambianus,* Waterhouse, 1840). *Journal of Veterinary Research*. 2014:81(1)41-48
14. Mughal IA, Qureshi AS Tahir MS, Some Histological observations on postnatal growth of rat adrenal gland with advancing age. Internat. J. Agri. & Biol. 2004: 6(2): 413-417
15 Westropp JL, welk KA, Buffington CA. Small adrenal gland in cats with feline interstitial cystitis, *Journal of Urology*, 2003: 170: 2494-2497
16. Koko V., Djordjeviae J., Cvijiae G. and Davidoviae V. Effect of acute heat stress on rat adrenal gland: morphological and sterological study. *Experimental biology* 2004:207: 4225-4230
17. SinghInderbir. *Text book of Human Histology* fifth edition Jaypee Brothers Medical

publishers (P) Ltd New Delhi. 2006:313-318

18. Bacha, W. J. & Bacha, L. M. *Color Atlas of Veterinary Histology.* Philadelphia, Lippincott Williams & Wilkins. 2000
19. Ibe CS, Salami SO, Onyeanusi BI. Macroscopic anatomy of the lower respiratory system in a nocturnal burrowing rodent: African giant pouched rat (*Cricetomys gambianus*, Waterhouse 1840). *Anat Histol Embryol*. 2014: 40(2):112–119.
20. Kikuta A. and Murakami T. Microcirculation of the rat adrenal gland: A scanning electron microscope study of vascular casts. *American Journal of Anatomy.*2014: 164: 19–28
21. Chavhan PR, Dhamani AA, Misar SD. Histoarchitectural changes in the adrenal gland of female bat (*taphozous kachensis)* during estrus and pregnancy.*J. Zol*. 2011
22. Dimova T. Histological features of goat adrenal gland during puberity. comptes rendusde l'Academie bulgare des Scinces. 2003: 56(4)
23. Mescher AL. Junqueira's Basic Histology. 12th ed. Chapter 20, McGraw-Hill Companies. 2000
24. Hussin, A.M . Anatomical and histological study on the adrenal gland of the local donkey (*Equus asinus*). Iraq. *Journal VeterinaryScience.* 2003:129-132

25 Clark LS, Pfeiffer DC, Cowan DF. Morphology and histology of the atlantic bottlenose dolphin (*Tursiops truncatus)* adrenal gland with emphasis on the medulla. *Anat. Histol. Embryol*. 2005:34(2): 132-40

26 *El-Nahla SM, Imam HM, Moussa AE, Elsayed AK, Abbott LC. Prenatal development of the adrenal gland in the one-humped camel (Camelus dromedarius). Anat Histol Embryol.* 2011:*40:169–86.*

27 *Erdoğan S, Pérez W. Arterial vascularization and morphological characteristics of adrenal glands in the Pampas deer (Ozotoceros bezoarticus, Linnaeus 1758). Anat Histol Embryol.* 2014:*43:369–74*