ANATOMICAL STUDIES ON THYROID, PARATHYROID AND ADRENAL GLANDS OF THE AFRICAN GIANT RAT (*Cricetomys gambianus Water House*-1840)

BY

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(M.Sc / MED/ 3351/ 2010-2011)

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTERS OF SCIENCE (M.Sc) DEGREE IN HUMAN ANATOMY

DEPARTMENT OF HUMAN ANATOMY

FACULTY OF MEDICINE

AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA

MARCH, 2014.

DECLARATION

I, Enemali, Felix Udawnojo, hereby declare that the work in the thesis titled "Anatomical studies on thyroid parathyroid and adrenal glands of the African giant rat (*Cricetomys gambianus,water house* 1840)" has been performed by me in the Department of Human Anatomy under the supervision of Prof. J.O. Hambolu and Dr. J.N. Alawa.

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis has been previously presented for another degree or diploma at any university.

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CERTIFICATION

This thesis titled "Anatomical studies on thyroid parathyroid and adrenal glands of the African giant rat (*Cricetomys gambianus,water house* 1840)" by Enemali, Felix Udawnojo meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

THIS THESIS IS DEDICATED

To

MY LOVING PARENTS

And to

MY DEARLY BELOVED BROTHERS

And to

MY DEARLY BELOVED SISTER.

ACKNOWLEDGEMENTS

My profound gratitude firstly, goes to my heavenly Father, the God Almighty, for His enduring goodness, mercy and grace prodigally bestowed upon me throughout my educational pursuit for this degree in Zaria.

My sincere gratitude goes to my competent supervisors, Prof .J. O.Hambolu and Dr J. N.Alawa, for their immense guidance, supervision and professional advice throughout the time of this study. I will not fail to express my gratitude to Mr. Yaro, Department of Histopathology, Faculty of Medicine, A.B.U Zaria, for his professional contribution towards the success of this work; to you sir, I say a special thank you.

My heartfelt gratitude goes to my parents, Mr. and Mrs. I. A. Enemali, for their immeasurable love, care and support given to me. To my brothers, very Rev Fr. Wilfred Enemali, Engr. Godwin I. Enemali, King Joseph Enemali, Sir Paul Enemali, Sir Peter Enemali and my beloved sister, Miss Grace Enemali to you all, I say a big thank you.

My sincere gratitude goes to my Head of Department, Dr.Adebisi to you sir, I say thanks for being a teacher, a mentor and a father. To my lecturers: Dr. A. O. Ibegbu, Dr. U. E. Umana, Dr. J. N. Alawa, Mr. S.A. Musa and Mr. Iliya, I say thanks for impacting and building upon my knowledge of Human Anatomy. My thanks also go to all the academic staff of the Department of Human Anatomy, Faculty of Medicine, A.B.U. Zaria for their critical scrutiny and contribution towards perfecting this work.

This section will not be complete if do not acknowledge the tireless effort and support of Mr. Elijah Tokunbo Daniel during the practical phase of this study. To Mr. Peter Akpulu, I say a

special thank you for the histological aspect of this study. Mr. Agbon, Abel Nosereme, I can never thank you enough, and God bless you, sir.

To my one and only sister, I must specially say, thanks for your inexpressible and unquantifiable care, love and support towards the accomplishment of this work.

To my fellow colleagues, Msc/MED/2010 – 2011 class, I say, thanks a million. And, to many more who have contributed in one way or the other to the success of this work which time and space will not permit me to mention; I say, I appreciate you all!

ABSTRACT

African giant rat is currently explored as a laboratory model for scientific research. In this present study, anatomical studies on the thyroid, parathyroid and adrenal glands of the African giant rat (*Cricetomys gambianus,water house* 1840) was evaluated with twenty adult African giant rats of both sexes. The architecture of the glands (thyroid, parathyroid and adrenal glands) was studied by gross observations and light microscopy. The mean weight of the African giant rat (AGR) was 1058.45 $\pm$ 45.46g. Gross studies of the thyroid gland of the AGR showed a bi-lobed organ located on the lateral surface of the trachea. The two lobes of the gland were joined together towards the superior poles by an isthmus. Result showed that the weight of the male thyroid glands was significantly higher than that of the female African giant rat ($P<0.05$). The length and the width of gland do not show sexual dimorphism. Tetraiodothyronine showed sexual dimorphism. Histological studies showed that the thyroid of the African giant rat consisted of follicles surrounded by follicular cells of various shapes suggesting different level of activity of the follicles. Colloids in the follicles were stained positive with periodic acid Schiff stain indicating that glycoprotein was present. Parafollicular cells were present in between the follicles of the glands. Gross anatomy and morphological studies of the parathyroid glands of the African giant rat revealed that parathyroid glands were two pairs situated in the lateral and a little inferior in position to the thyroid gland. Histological studies showed that, the parathyroid glands were richly supplied with blood and the chief cells were abundant and arranged in form of cords throughout the glands. The chief cells were positive when stained with periodic acid Schiff stain which showed that glycoprotein was present. Hormonal assay of parathyroid hormone does not show sexual dimorphism. Gross anatomy and morphological studies of adrenal glands of the African giant rat showed that the paired adrenal glands were located on the superior poles of

both kidneys: left and right kidneys. Result showed that the weight of the female adrenal gland were significantly higher than that of the male adrenal glands. There were no significant differences between the length and width of the male and female glands. Histological studies showed that the adrenal glands were divided into two zones, the cortex and the medulla. The adrenal cortex was seen to be divided into three zones: zona glomerulosa, zona fasciculata and zona reticularis. The Medulla contained the chromaffin cells. The gross, histological and histochemical studies of the thyroid, parathyroid and the adrenal glands of the African giant rat showed sexual dimorphisms and cellular morphology which could explain the biology of the rodent.

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CHAPTER ONE

1.0 Introduction

The African Giant Rat (AGR) (*Cricetomys gambianus, water house – 1840),* also known as the Gambian pouched rat is a native to Africa that belongs to the Rodentia it is a representative of the muridae family (Cooper, 2008). They are called Ewi in Igbo language, Burugu in Hausa and Okete in Yoruba. The African giant pouched rat is referred to as "pouched rat" because of its elastic bag-like mouth cavity that can only be compared to a marsupial pouch (like in Kangaroo) (Ajayi *et al*, 1978). They are nocturnal and nearly inactive during the day. They are very active in the night as they come out in search of food which they collect with their mouth and stored in specially designed chamber in their holes (Cooper, 2008). The food store is comparable to common house-hold food stores. The stores are usually packed with different varieties of food that can sustain the rat in its hole for a very long period of time (Ajayi, *et al*.,1978). The AGR are widely distributed in Nigeria but more dominant in the savannah regions of Nigeria. The rat is rated as a highly intelligent animal with the ability to use varieties of materials like soil, stones, soiled bedding as a plug to the main entrance of its hole during the day and relocates this on return (Ajayi, 1974). The AGR has very long tail with white tip which is the distinguishing feature from other giant rats. It is used as meat delicacy by rural dwellers (Asibeys, 1989, Ayaji,1974) but has great potentials as a laboratory animal. This has led to an increasing amount of interest on the biology of the AGR. The rats have been used to detect land mines in Mozambique by their high acuity of odour perception (Maggie, 2003). Furthermore, attempts are being made to classify this rodent as a laboratory model because of its larger organs compared to Wistar rats which will provide larger tissue specimen for study (Akinloye *et al*, 2007).

1.1 Statement of the problem

The Nigerian wildlife conservation committee has encouraged the domestication of the African giant rat because of its numerous importances (Ajayi, 1978). Although literature on the anatomy of the African giant rat is gradually building up (Ogwuegbu *et al,* 1983; Oke *et al.*,, 1988a,1988b,1988c, 1989a,1989b and 1995, Nzalak *et al,* 2010, Ali *et al,* 2009, Ali *et al*.,2008 and Akinloye *et al,* 2007) there is scarcity of information on the anatomy of its endocrine glands.

1.2. Significance of the study

This study will serve as a base for future investigations regarding the structure, functions or the malfunctions of thyroid, parathyroid and adrenal glands of the AGR.

1.3 Justification of the study

Several investigators have made pioneering efforts to characterise the various systems of this rat. Systems that have been studied include; reproductive (Ogwuegbu *et al*., 1983; Oke *et al.*, 1995, 1988a, Oke *et al.*, 1989, Akinloye *et al.*, 2007, Atkinson *et al.*,2000); digestive (Ali *et al*., 2009, Nzalak *et al*., 2010); nervous (Nzalak.,2002, Nzalak, 2005a, Nzalak,2005b, Ibe *et al.*, 2010, 2010a; Ibe *et al*., 2010b); integumentary (Ibe *et al.*, 2010c), lymphatic (Ibe *et al.*, 2010d) and Comparative (Nzalak *et al*.,2008). Despite the features of the rat that have been studied, the endocrine organs are yet to be fully investigated. This work seeks to describe and document the cellular morphology of the thyroid, parathyroid and the adrenal glands of the AGR. The finding from the study could be useful in the understanding of neuroendocrine system of AGR in its response to the environment.

1.4 Aim of study

The aim of this study was to conduct gross anatomical, histological and histochemical studies on the endocrine glands (thyroid, parathyroid gland, and adrenals) of the African giant rat with the view of providing basic knowledge on the metabolic systems of the African giant rat using these organs.

1.5 Objectives of study

- To investigate the gross anatomy of thyroid, parathyroid and adrenal glands.
- To investigate the histology of thyroid, parathyroid and adrenal glands using haematoxylin and eosin method.
- To conduct histochemical studies on the thyroid, parathyroid and adrenal glands of adult African giant rats using the periodic acid Schiff stain for the demonstration of colloid in thyroid and glycoprotein in the parathyroid gland.
- To conduct hormonal assay on thyroxin, triiodothyrinine and parathyroid hormone.

CHAPTER TWO
LITERATURE REVIEW

2.1 Gross anatomy of the African giant rat

The African giant rat is among the largest muroids in the world, growing up to three feet long including the tail which makes up of the half of their length (Ajayi *et al*, 1978). It is widely distributed from Senegal to Kenya and from Angola to Mozambique. It is found in West African countries including Nigeria (Ajayi *et al*, 1978). The African giant pouched rat is referred to as "pouched rat" because of its elastic bag-like mouth cavity that can only be compared to a marsupial pouch (like in Kangaroo) (Ajayi *et al*, 1978). Apart from it's very large size, the tail is made up of a white tip that did not only distinctively differs it from any other type of rat, but also informed of a belief in some local African communities that, it is a natural torchlight used to aid vision at night (Cooper, 2008). This grey omnivore, with white underbelly, is popularly regarded as a 'pet and pest'. But it is its remarkable behavioral nature and rare intelligence that made them rather more attractive (Ajayi *et al*, 1978).

2.1.1 Temperance

Since African giant rats are relatively new to captivity they can be a bit more unpredictable than fancy rats and temperament can vary quite a bit between individuals (Cooper, 2008).While they often can be good pets, there are some that remain skittish and become aggressive as they get older. However, with regular handling and training, most become quite friendly, gentle and easy to handle (Cooper, 2008). They are very intelligent and playful, and seem to have a tendency to lick their owners, like belly rubs, and collect shiny objects and other treasures (Cooper, 2008).



Fig 2.1: African giant rat. Note the white tip at the end of the tail.

2.1.2 Characteristics of the African giant pouch rat

The most fascinating characteristic of the African giant pouched rat is its high degree of intelligence, sometimes comparable to man. Some of the unique behavioural attributes that are driving this position are:

- **Gathering and storage of food** –

The name 'pouched rat' was derived from the elastic nature of the muscles around the mouth and jaws of the rat which it uses to pack food and materials in a manner comparable to a bag (Cooper, 2008). The mouth can carry large amount of seeds, nuts, and utilities, in quantities larger than the ideal capacity. The food stuffs so collected with the mouth pouch are stored in specially designed chamber in the rat hole (Cooper, 2008). The food store is comparable to

common house-hold food stores. The stores are usually packed with different varieties of food that can sustain the rat in its hole for a very long period of time (Cooper, 2008).



Fig 2.2: African giant rat carrying large amount of food.

Locking of the entrance to its hole:

The AGR is security conscious! Within some few centimetres into its hole is a point that represents a door that must be locked. Once it is inside the hole, two layers of barriers are used to block the entrance of the hole preventing predators (for example, the black Cobra) from entering (Cooper, 2008).

- **Cleaning of its environment**:

The African giant rat has a special chamber, usually built close to the external surface constructed with a thin aeration hole is used as a toilet the chamber is somewhat a toilet with ventilation system to take out odours (Cooper, 2008).

- **Defensive digging of its hole**

The AGR is aware that man is the most notorious predator. Dug holes are rampant in rural areas of southern Nigeria. Hence, it has learnt to dig its holes under large heavy pavements that cannot be destroyed by man, under buildings, at the sides of bridges, and in old termite hills (Ajayi, 1975).

2.2.1 Gross organization of mammalian thyroid gland

Igbokwe, 2010 reported that the thyroid gland of African grass cutter (*Thryonomys swinder anus*) was symmetrical bi lobed organ located on the lateral aspect on the tracheal between the first and third tracheal rings without isthmus. The general histological appearance did not vary greatly from that described for most mammals. The features and sizes of the follicular cells suggest activity of the thyroid of the wild African grass cutter (Igbokwe, 2010). The gross anatomy studies of Camel (*Camelus dromedarius*) revealed that thyroid gland was located near the first ring of the trachea and had two lobes connected by an isthmus, with a reddish brown colour, (Kausar and Shabid 2006). Thyroid lobes of cattle, dog and sheep are asymmetry in position (Mc Donald,2003). Hajorska, 2002 found out that smooth asymmetry of the left lobes in cranial direction in all fetuses in the period from the 32nd to the 36^{th} day of embryonic development of thyroid in sheep In horse the thyroid is connected by an insubstantial isthmus. In the cattle the isthmus is a broad parenchyma tissue and when present is merely connective tissue, (Dyce *et al.*, 2002, Hajorska, 2002). In rat and Mouse an isthmus is present and located at the caudal end of the lobes (Ingbar, 1985).The weight of the thyroid gland is similar in adult male and female Wistar rats. However its relative weight was found to be higher in female than in males, (Capen and Martin, 2003). Both sexes of the adult Wistar rats contained a similar DNA quantity and the sex dimorphism in rat thyroid gland depends upon a difference in the mean volume of thyroid follicular cells with the males having larger cells than the females, (Capen and Martin, 2003). Both sexes contain similar quantity of these cells. The thyroid weight varies between domestic and wild animals and it depends on the size and weight of the animal (Little, 1991).

In humans the thyroid gland lies deep to the strerno hyoid and strerno thyroid muscles, located anteriorly in the neck at the level of the C5 to T1 vertebrae (Moore and Dalley, 2006). It consists of primarily the right and left lobes, anterolateral to the larynx and trachea. A relatively thin isthmus unites the lobes over the trachea, usually anterior to the second and third tracheal rings (Moore and Dalley, 2006). The highly vascular thyroid gland is supplied by superior and inferior thyroid arteries. These vessels lie between the fibrous capsule and loose fascial sheath (Moore and Dalley 2006). Usually the first branches of the external carotid arteries, the superior thyroid arteries descend to the superior poles of the gland pierce the pre tracheal layer of deep cervical fascia and divides into anterior and posterior branches supplying mainly the antero superior aspect of the gland (Moore and Dalley 2006). The inferior thyroid arteries, the largest branches of the thyro-cervical trunks arising from the subclavian arteries, run supero medially, posterior to the carotid sheaths to reach the posterior aspect to the thyroid gland and supply the postero inferior aspect, include the inferior poles of the gland (Moore and Dalley, 2006). The right and left superior and inferior thyroid arteries anastomose extensively within the gland, ensuring its supply while providing potential collateral circulation between the subclavian and external carotid arteries (Moore and Dalley, 2006). In approximately 10% of people, a small unpaired thyroid Ima artery arises from the brachiocephalic trunk or the aortic arch (Moore and Dally, 2006).

The gland is drained by three pairs of thyroid veins usually form a thyroid plexus of veins on the anterior surface of the thyroid gland and interior to the trachea (Moore and Dalley, 2006). The superior thyroid veins accompany the superior thyroid arteries they drain the superior poles of the thyroid gland, the middle thyroid veins do not accompany but run essentially parallel course

with the inferior thyroid arteries, they drain the middle lobes. The usually independent inferior thyroid veins drain the inferior poles (Moore and Dalley, 2006).

The lymphatic vessels of the thyroid gland run in the interlobular connective tissue, usually near the arteries (Moore and Dalley, 2006). From there, the vessels pass initially to pharyngeal, pre tracheal and Para tracheal lymph nodes which drain in turn to the superior and inferior deep cervical nodes (Moore and Dalley, 2006). Laterally, lymphatic vessels located along the superior thyroid vein pass directed to the inferior deep cervical lymph nodes. Some lymphatic vessels may drain into the brachiocephalic lymph nodes or thoracic ducts (Moore and Dalley, 2006).

The nerves of the thyroid gland are derived from the superior middle and inferior cervical sympathetic ganglia (Moore and Dally, 2006). They reach the gland through superior and inferior thyroid per arterial plexuses that accompany the thyroid arteries. These fibers are vasomotor, not secreto motor (Moore and Dalley, 2006). They cause constriction of blood vessels. Endocrine secretion from the thyroid gland is hormonally regulated by the pituitary gland (Moore and Dalley, 2006).

2.2.2 Histological organization of mammalian thyroid glands

Kausar and Shahid (2006), reported that in the cow, pig, dog, buffalo, rabbit and guinea pig,gland has large follicles, which have flattened epithelium while as small ones had columnar epithelial cells. In a study of the thyroid gland of camel, Parafollicular cells were not observed. (Abdel-Margied *et al,* 2002). The conclusion was that this may be due to physiological regression of the gland. Parafollicular cells are located along the basement membranes of the follicles in the follicular epithelium of cow, buffalo, pig and elephant (Little, 1991). The general histological

features of the thyroid gland of grass cutter are similar to those of other mammals (Lawson,*et al.*,1998).

In human the thyroid gland is covered by a fibrous capsule. Septa extend into the gland from the capsule dividing it into lobules. On microscopic examination each lobule is seen to be made up of follicles. Each follicle is lined by follicular cells that rest on a basement membrane. The follicle has a cavity which is filled by a homogenous material called colloid (Singh,2006). Apart from the follicular cells, the gland contains the C- cells or the Para follicular cells which intervene between the follicular cells and the basement membrane. They also lie in the intervals between the follicles, connective tissue stroma surrounding the follicles contain a dense capillary plexus, lymphatic capillaries and sympathetic nerves (Singh,2006). The follicular cells vary in shape depending on their activity. Normally at an average level of activity the cells are cubiodal and the colloid in the follicle is moderate in amount (Singh, 2006). When inactive or resting the cells are flat and the follicles are distended with abundant colloid. Lastly, when the cells are highly active they become columular and colloid is scanty. Different follicle may show different level of activity. The follicular cells secrete two hormones that influence the rate of metabolism of the body (Singh,2006). One of the hormones contains three atoms of iodine in each molecule. This hormone is called triiodothyrinine or T3 the second type contains four atoms of iodine in each molecule called tetraiodothyronine, or T4. T3 is much more active than T4. The activity of follicular cell is influence by the thyroid stimulating hormone produce by the hypophysis cerebri (Singh,2006).The synthesis and the release of thyroid hormone take place in two phases. The first phase thyroglobuline, a glycoprotein is synthesized by granular endoplasmic reticulum and is packed into secertory vacuoles in the Golgi complex. The vacuoles travel to the luminal surface where they release thyrobuline in to the follicular cavity by exocytosis here thyroglobulin

combines with iodine to from colloid (Singh,2006). In the second phase the particles of the colloid are taken into the cell by endocytosis. The iodinated colloid is acted upon by enzymes releasing the T3 and T4 which pass into the cells and are released into the blood. (Singh, 2006). Hormone produce in the gland is mainly T4 (Singh, 2006). In the liver the kidney and some other tissues, T4 is converted to T3 by the removal of one iodine molecule. T3 and T4 circulating in the blood are binded to a protein thyroxin binding globin TBG. The binded form of the hormone is not active (Singh, 2006).

The Parafollicular cells are also called clear cells or light cells. They lie between the follicular cells and their basement membrane (Singh, 2006). They may however lie between the adjoining follicular cells but they do not reach the lumen, with the EM the C- cells show well developed granular endoplasmic reticulum, Golgi apparatus, numerous mitochondria and membrane bound secretory granules (Singh, 2006). C-cells secrete the hormone thyro-calcitonin. This hormone has an action opposite to that of the parathyroid hormone on calcium metabolism. This hormone comes into play when serum calcium level is high. (Singh,2006). It tends to lower the calcium level by suppressing releasing of calcium ions from bone. This is achieved by suppressing bone reasorption by ostseoclasts (Singh, 2006).

2.3.1 Gross and histological organization of mammalian parathyroid gland

The parathyroid gland cells given parathyroid hormone which has a great role in the regulation of calcium metabolism inside the body. The glands are important for life in most animals and human (El-Zoghby,2004 and Bensley, 2007). In camel, parathyroid gland is mainly identical in histological structure to other mammals (Nagpal *et al*, 2001). It is identical to histology of parathyroid glands of goat and cow (Charles *et al*, 2000 and Roy *et al.*, 1999). The fine structure of parathyroid gland cells have been reported by many authors : Munger and Roth ,1999) in

man, (Nagpal *et al.*, 2001) in camel, (Berdahl and Boquist 2000) in horse, (Yano1 *et al*., 2002) in hamster and rat (Utsumi *et al.*, 2004 and Chen *et al*., 2001). In all their studies it was reported that the parathyroid gland contain two types of cells which are chief cells and oxyphil cells. The chief cells of the gland are classified under light microscope into light and dark cells. A second cell type in the parathyroid gland animal species is called the oxyphil cells are not present in human fetal parathyroid gland (Fleicher, *et al.*, 2004). They first appear in late childhood and increase in number following advancement in age often forming nodules in parathyroid of older person. (Fleicher, *et al.*, 2004). Oxyphil cells are absent in chicken and many species of lower animals (Fleicher *et al.*, 2004).The parathyroid glands in normal dog are similar to those reported in other mammals (Berdahl and Boquist, 2000). In mammals and lower species of animal it have seen reported that the oxyphil cells contain glycogen particles and free ribosome, granular endoplasmic reticulum, Golgi apparatus and secretary granule which are poorly developed (Capen and Martin, 2003), suggesting that oxyphil cells of normal parathyroid do not have an active function in the bio synthesis of parathyroid hormone. In most mammals there is a higher oxidation and hydrolytic enzymes activity in the chief cells than in the oxyphil cells (Nakanishi, *et al*., 2004).

In humans, the parathyroid glands are small flattened oval in shape and usually lie external to the thyroid capsule on the medial half of the posterior surface of each lobe of the thyroid gland, or inside its sheath (Moore and Dalley, 2006).The superior parathyroid glands usually lie slightly more than one cm superior to the point of entry of the inferior thyroid arteries into the thyroid gland. The inferior parathyroid glands usually lie slightly more than one cm inferior to the arterial entry point (Moore and Dalley, 2006).Most people have four parathyroid glands. Approximately 50% of people have more, some have two glands. The superior parathyroid

glands are more constant in position than the inferior ones which are usually at the border of the cricoid cartilage (Moore and Dalley, 2006).

The inferior parathyroid glands are usually near the inferior poles of the thyroid gland but they lies in various positions (Moore and Dalley, 2006). The glands are supplied by the inferior thyroid which provides the primary blood supply to the posterior aspect of the thyroid gland where the parathyroid glands are located (Moore and Dalley, 2006). However they may also be supplied by branches from the superior thyroid arteries; the thyroid Ima artery or the laryngeal, tracheal and esophageal arteries. Parathyroid veins drain into the thyroid plexus of veins of the thyroid and trachea (Moore and Dalley, 2006).Lymphatic vessels from the parathyroid glands drain with those from the thyroid gland into deep cervical lymph nodes and Para tracheal lymph nodes (Moore and Dalley, 2006). The nerves supply of parathyroid gland is derived from thyroid branches of the cervical sympathetic ganglia (Adolffaller and Schünke 2004). Like the nerves to the thyroid, they are vasomotor rather than secretomotor because there glands are hormonally regulated (Moore and Dalley, 2006).

The parathyroid glands lie in close relation to the thyroid glands, each gland has a connective tissue capsule from which some septal extend into the gland substance. Within the glands are network of reticular fibers supporting the cells. Many fat cells are present in the stroma of the gland. The gland is made up of cells that are arranged in cords. The cells of the gland are of two main types; Chief cells or the principal cells and the Oxyphil cells. The chief cells are more numerous than the oxyphil cells (Dellman, 1993). With the light microscope the chief cell are seen to be small round cells with vesicular nuclei. They cytoplasm is clear and either mildly eosinophils or basophils. The Oxyphil cells are larger and their cytoplasm contains granules that attain strongly with acid dye (Singh, 2006). Three types of chief cells have been described.

These cells are light, dark and clear cells. The chief cells secrete parathyroid hormone. This hormone tends to increase to the level of serum calcium (Singh, 2006).With the EM, it is seen that the granules of the Oxyphil cells are really mitochondria large number in the cytoplasm true secertory granules are not present. The functions of the Oxyphil cells are not known (Singh, 2006).

2.4.1 Gross and histological organization of mammalian adrenal glands

The adrenal glands are paired endocrine organs located within the abdominal cavity. Hormones are secreted by the adrenal glands, which regulate some metabolic processes and enable the animals to function in a constantly changing environment (Bacha and Wood, 1990). The glands are paired compound, flattened endocrine organs located in retroperitoneal space along the medial cranial poles of the kidneys in most mammals. A macroscopic cross section of the gland reveals that it is compound of distinct cortex and medulla (Prasad *et al.,* 1981 and Rosol *et al*., 2001). Glands are encapsulated by thick connective tissue capsule (Kikuta and Murakami, 2003). In ruminants and swine, the cortex is flesh colored and cream or light yellow. In horses, dogs and cats, the medulla of the gland is reddish brown due to the presence of blood flow in the medullary veins (Gelberg *et al.,* 2000). The adrenal blood flow in horses is increased significantly during both rest and activity. The cortex is divided into three zone in guinea pig (Colby *et al.*,1992) in rats (Moog *et al*., 1998) , in buffalo and mammals (Yilmaz *et al*.,2005, Banks,1993). Some investigators (Bacha and Wood 1990, Junqueira *et al.*, 1995) have reported that zona fasciculata is the widest zone of the cortex and has foamy appearance caused by the presence of numerous lipid vacuoles. Zone fasciculate forms 60% of the cortex (Hussin, 2003) or 70.9% of cortex in rabbit (Kierszenbaum, 2002).

Zona fasciculata in humans in 65% of the gland (Junquiera, *et al,* 1995). Previous reports described that the adrenal medulla contains both types of chromaffin cells (Kierszenbaum,2002). Epinephrine and nor epinephrine granules were reported round-shaped in the rat, hamster, Mouse rodents and in the rabbit (Kierszenbaum, 2002).

In humans, the adrenal glands are located between the superomedial aspect of the kidneys and the diaphragm, where they are surrounded by connective tissue containing considerable amount of fat (Moore and Dalley, 2006). Despite their name, they are separated from the kidneys by a thin septum. The shape and relations of the glands differs on both sides. (Moore and Dalley, 2006). The pyramidal right gland is more apical situated over the superior pole) relative to the right kidney. The crescent shaped left gland is medial to the superior half of the kidney and is related to the spleen, stomach, pancreas and lift cross of the diaphragm (Moore and Dalley, 2006). Each adrenal gland has two parts the adrenal cortex and adrenal medulla. These parts have different embryological origin and different functions (Moore and Dalley, 2006). The adrenal cortex derives from mesoderm and secretes corticosteroids and androgens. These hormones cause the kidneys to retain sodium and water in response to stress, increasing the blood volume and blood pressure. They also affect muscles and organs such as the heart and lungs (Moore and Dalley, 2006). The adrenal medulla is derived from neural crest cells associated with sympathetic nervous system. The chromaffin cells of the medulla are related to sympathetic ganglion cells in both derivation (neural crest cells) and function. (Moore and Dalley,2006). There cells secrete epinephrine into the blood stream in response to signals from presynaptic nerves (Moore and Dalley, 2006). The powerful medullary hormones epinephrine and norepinephrine activate the body to a fight or flight status in response to traumatic stress. They also increase heart rate and blood pressure, dilate the bronchioles and change blood flow

patterns, preparing for physical exertion (Moore and Dalley, 2006). These glands have a profuse of blood from three sources:

- The aorta (one or more middle suprarenal arteries).
- The inferior phrenic artery (6-8 superior suprarenal arteries)
- The renal artery (one or more inferior supernal arteries) (Moore and Dalley, 2006).

The venous drainage of the adrenal glands is into a large suprarenal vein drains into the inferior vena cava whereas the longer left suprarenal vein, often joined by the inferior phrenic vein empties into the left renal vein (Moore and Dalley, 2006) The suprarenal lymphatic vessels arise from the plexus deep to the capsule of the gland and from one in its medulla drain the glands of lymph (Moore and Dalley, 2006). These glands have a rich innervations from the adjacent celiac plexus and the greater thoracic splanchnic nerves. These preganglionic sympathetic fibers pass through the hilum and synapses on the cells in the medulla. The suprarenal cortex receives only a vasomotor nerve supply (Moore and Dalley 2006).

The histology of the adrenal cortex is made up of the cells arranged in cords. Sinusoids intervene between the cords. On the basis of the arrangement of cells the cortex can be divided into three parts which are;

- The outer most layers called the Zona glomerulosa. Here cells are arranged as inverted U-shaped formation. This zone consists of one fifth of the cortex (Singh,2006).
- The next layer is Zona fasciculata. Here the cells are arranged in straight columns, two cells thick. Sinusoids intervene between the columns. This layer forms the middle three fifth of the cortex (Singh, 2006).

- The innermost layer of the cortex that is the inner one fifth is called the Zona reticularis It is so called because it is made up of cords that branch and anatomose with each other to form a kind of reticulum (Singh, 2006).

With the light microscope the cells of the Zona glomerulosa are seen to be small, polyhedral or columnar with basophilic cytoplasm and deeply staining nuclei. (Singh, 2006). The cells of the zona fasciculata are large polyhedral with basophilic cytoplasm and vesicular nuclei. The cells of the zona fasciculata are very rich in lipids. These cells also contain considerable amount of vitamin C. (Singh, 2006). The cells of the zona reticularis are similar to those of the zona fasciculata but the lipid content is less. The cytoplasm is eosinophilic. The cells often contain brown pigment. The cells of the zona glomerulosa produce the mineralocorticoid aldosteron and deoxcoticosterone. These hormones affect the electrolyte balance in the body. The cells of the zona fasciculata produce glucocorticoids cortisone and cortisol (Singh,2006) These hormones have wide effects including the on carbohydrate metabolism and protein metabolism. Cells of this zone also produce small amount of androgen (Singh,2006).Cells of the zona reticularis also produces some glucocorticoids and sex hormones both oestrogen and androgen (Singh,2006).

The medulla of the adrenal gland is made up of groups of cells. The cells are separated by wide sinusoids. Cells are columnar and have basophilic cytoplasm (Singh,2006). These cells are considered to be modified postganglionic sympathetic neurons. The secrete noradrenalin and adrenalin into the blood. (Singh,2006). This secretion takes place mainly at stress (fear, anger) and results in widespread of effects similar to those of the stimulation of the sympathetic nervous system(e.g., increase in heart rate and blood pressure) (Singh, 2006).

CHAPTER THREE

MATERIALS AND METHOD

3.1 Experimental animal and management

Twenty adult African giant rats (*Cricetomys gambianus*), made of ten male and ten female rats were utilized for the study. These animals were captured in the wild live around Samaru and Bomo villages in Sabo Gari local government area of Kaduna State using traps. Thereafter, they were maintained in the animal house of the Department of Human Anatomy Ahmadu Bello University, Zaria, for two weeks before the commencement of the study. Rats were fed throughout the study period with yam, beans and water was allowed *ad libitum*.

3.2.0 Experimental Design

The captured AGR were used for morphometric, morphologic, histological, histochemical and hormonal assays studies. Twelve AGR comprising of six males and six females were used for morphometric, morphologic and hormonal assays studies, four AGR (two male and two females) were used for histological studies and four AGR (two males and two females) were used for histochemical studies.

3.2 1. Morphometric Studies

The live weight of each African giant rat was obtained using the mettle balance P1210 (Mettle instrument AG, Switzerlands) with a sensitivity of 0.01g and weight recorded in grams. Rats were sacrificed using cervical dislocation (Adeyemu and Oke, 1990). The animals were placed in dissecting board with needles.

An incision was made into cervical region, the thyroid and parathyroid glands were dissected. Furthermore, a mid-ventral abdominal incision was made to reflect the peritoneum. The

digestive system was dissected out to gain access to the renal system in the posterior abdominal wall. The adrenal glands were located on the superior poles of the respective kidneys. Photograph of glands were taken before glands were dissected. The weight of various glands was determined using the digital weighing balance while the lengths and widths were determined using ruler.

3.2.2 Histological Studies

The tissues were taken to tissue preparation section histology laboratory Human Anatomy Department, ABU, Zaria. The glands of the AGR were fixed for two days in ten percent buffered formalin by complete immersion. Theses tissues were later processed for haematoxylin and eosin techniques through the following procedures;

Dehydration:

These glands were dehydrated in two changes of graded series of ethanol (70%, 80%, 90%, 95% and 100%). The gradual process was employed to prevent the tissues from sudden shrinkages of the tissue which could distort the cells and consequently alter the results.

Clearing:

The tissues were transferred into two changes of Xylene for two hours for clearing process.

Impregnation:

The tissue were then infiltrated with molten paraffin in an embedding mold and an oven set at 600c

Embedding:

Tissues were allowed to solidify to obtain a homogenous mass containing embedded tissues. The embedded tissues were then mounted on the blocks.

Sectioning:

The mounted blocks were then affixed into a rotator microtome and trimmed into suitable sizes before sectioning. The tissues were then transferred into a water bath of warm water.

Staining:

Clean glass tubes coated with album were used to picked floating tissues from the water bath and kept in a clean and dry place. The slides were then passed through three changes of Xylene for compete removal of wax. They were then dehydrated by passing them through two changes of alcohol, starting from absolute alcohol, followed by graded alcohol (70%, 80%, 90%, 95% and 100%) for two hours. The tissues were then stained with haematoxylin stain for 25 minutes. The stained tissues were placed under gently running water to wash off. Following proper staining the tissues were again dehydrated by passing them through two changes of graded alcohol l (70%, 80%, 90%, 95% and 100%) for two hours. The tissues were then cleared in Xylene. DPX was used as a mountant to mount the tissue on the slides. The mounted tissues were covered with cover slip and allowed to dry. The stained slides were examined using binocular light microscope at different magnification (X100,X200,X300 and X400 respectively). Photomicrographs were obtained using a microscope eyepiece attached to a computer monitor.

3.3.3 Histochemical Studies

For histochemical studies thyroid and parathyroid glands were fixed in bouins fluid while adrenal glands were fixed in potassium dichromate fixative for the identification of chromaffin cells. The fixation of the adrenal glands lasted for 24 hours after which tissue were processed using standard histological method for light microcopy.

The thyroid and parathyroid tissues were removed from the bouins fluid after two days. Tissues were washed in water and oxidized in 5% chromic acid for one hour after which tissues were

washed in running water for one to two minutes. Tissues were then treated with 2% sodium bisulphate to remove the chromic acid. Tissues were then washed in water for 5 minutes after which it was placed in methylamine sliver for about three hours at 60 c. Tissues were then toned in 0.2% gold chlorine solution for about two minutes then rinsed in distilled water. After which tissues were placed in 3% sodium thiosulphate for two minutes and were washed in running water for two to three minutes sections of tissues were obtained and were counter stained with 0.2% acetic acid. Finally, sections were dehydrated, cleared and mounted in DPX . Slides were studied on the binocular light microscope Olympus at different magnifications (X100,X200, X300 and X400 respectively). Photomicrographs were obtained using a microscope eyepiece attached to a computer monitor.

3.2.3 Hormonal Assays

Blood samples were collected at sacrifice via cardiac puncture into ethylene diamine tetra acetic-bottles and were centrifuged. The serum from various samples was used for hormonal assays (triiodothyrinine, tetraiodothyronine and parathyroid hormone). Teraiodothyronine and Triiodothyrinine were assayed using the tetraiodothyronine ELISA kit and triiodothyrinine ELISA kit according to the manufacturer's instructions. A working dilution of washing buffer from the stock solution was freshly prepared. Some of the buffer solution was mixed with 270ml of water. Below is the procedure which was run for both hormones.

Dilute sample with expected hormone (triiodothyronine or tetraiodothyronine) concention over 24ug/dl with the dilute mixture were mixed thoroughly before assaying. The number of microwells were determined and marked in a data sheet with adequate information.This lead to

the incubation stage. The desired number of the microwells were removed and placed in the well holders and 50ul of each reference standard control and test sample were put into appropriate well. Two drops of the enzyme conjugate, biotinylated conjugate for the antibody combining sites for both hormones (triiodothyronine or teraiodothyronine) were made into each microwell. Wells were kept for twenty seconds and sealed with parafilm. Incubation was done at room temperature for sixty minutes. Microwells were washed after cover slips were removed and wells were washed for five times with buffers. Wells were dryed by firmly tapping the plates on the clean paper towel. Colour development was noted calculations were made and readings were taken.

The ELISA Enzyme linked immunosorbent assay method was used for the quantitative determination of the PTH in the samples of 25µl serum of the AGR. All reagents except the calibrators, kit controls and the wash concentrate are ready-to-use. All reagents were stored at 2-8oC, except the wash concentrate, which was kept at room temperature until dilution to avoid precipitation. Assay procedures include:

Sufficient streptavidin coated strips in a holder to run all calibrators were in place. 25 µl of sample was pipette into the designated well. An addition of 50 µl of reagent, biotinylated antibody, was put into each of the wells which already contained the sample. 50 µL of reagent 2, enzyme labelled antibody was added into each of the same wells. The micro plates were covered with aluminium foils to avoid exposure to light and kept for three hours and thirty minutes at room temperature. Aspiration of the fluid was done completely from each of the well and then each well was washed five times with the working wash solution (ELISA washing solution) using an automatic micro plate washer. 150 µl of the reagent, teramethylbenezine substrate, was added into each of the wells with appropriate cover to avoid light exposure and the micro plates

were placed on an orbital shaker or rotator set at 170 + 10 rpm for 30 +5 minutes at room temperature 100 µl of the stopping solution was then added to each of the wells and were mixed gently. The absorbance of the solution in the wells within ten minutes were read using a micro plate reader set to 450 nm against 250 µl of distilled water. Results were recorded.

3.3.0 Statistical analysis of the data

Data on weights, lengths and widths were expressed as mean ± standard error of mean and statistical analysis of the data was analysed using the Student T-test for differences between males and females rats. Correlation analysis was done between weight, length and width of the glands with the concentration of the hormones using student package for social sciences version 17.

CHAPTER FOUR

RESULTS

4.1 General morphology.

The average weight of twenty adult African giant rats was observed to be 1058.42 ± 37.79g. The average weight of male and female AGR were observed to be 1210.00 ± 56.70g and 911.11 ± 24.50g respectively. The weight showed sexual dimorphism with the male significantly higher than the female.

4.2 Thyroid Gland

4.2.1 Gross and morphological studies

Gross studies of the thyroid gland of the AGR showed that it was a bi-lobed organ located on the anterior surface of the trachea (Fig 4.1). The two lobes were joined together at superior end by an isthmus. Glands were seen as long reddish bodies which were oval in shape with a smooth surface (Fig 4.1). Table 4.1 showed that the mean weight, width and length of the male thyroid gland were significant in relation with the body weight. The same result was observed for the female AGR (Table 4.2). Thyroid weight showed sexual dimorphism with the male significantly higher than the female African giant rat ($P<0.05$) (Table 4.1). No significant difference was observed in the length and width of the glands of the male African giant rat and the female African giant rat. Table 4.2 and 4.3 showed that there was strong positive correlations ($P<0.001$) between the thyroid weight and the weight of the animal for both sexes. This was highly significant. Correlation analysis also showed that there was a no correlation between the hormones (triiodothyrinine and tetraiodothyronine), and thyroid weight for both sexes.

4.2.2 Hormonal assays

The average amount of T3 of the twelve adult African giant rats was observed to be 41.63 ± 0.60ng/ml. The average amount of T3 of male and female AGR were observed to be 41.23 ± 0.27ng/ml and 39.06 ± 0.56ng/ml respectively. T3 showed sexual dimorphism with the male significantly higher than the female ($P<0.05$) (Table 4.1). The average amount of T4 of the twelve adult African giant rats was observed to be 0.98 ± 0.01ng/ml. The average amount of T4 of male and female AGR were observed to be 0.88 ± 0.01ng/ml and 0.68.0.01 ± 0.01ng/ml respectively. T4 did not show sexual dimorphism (Table 4.1).

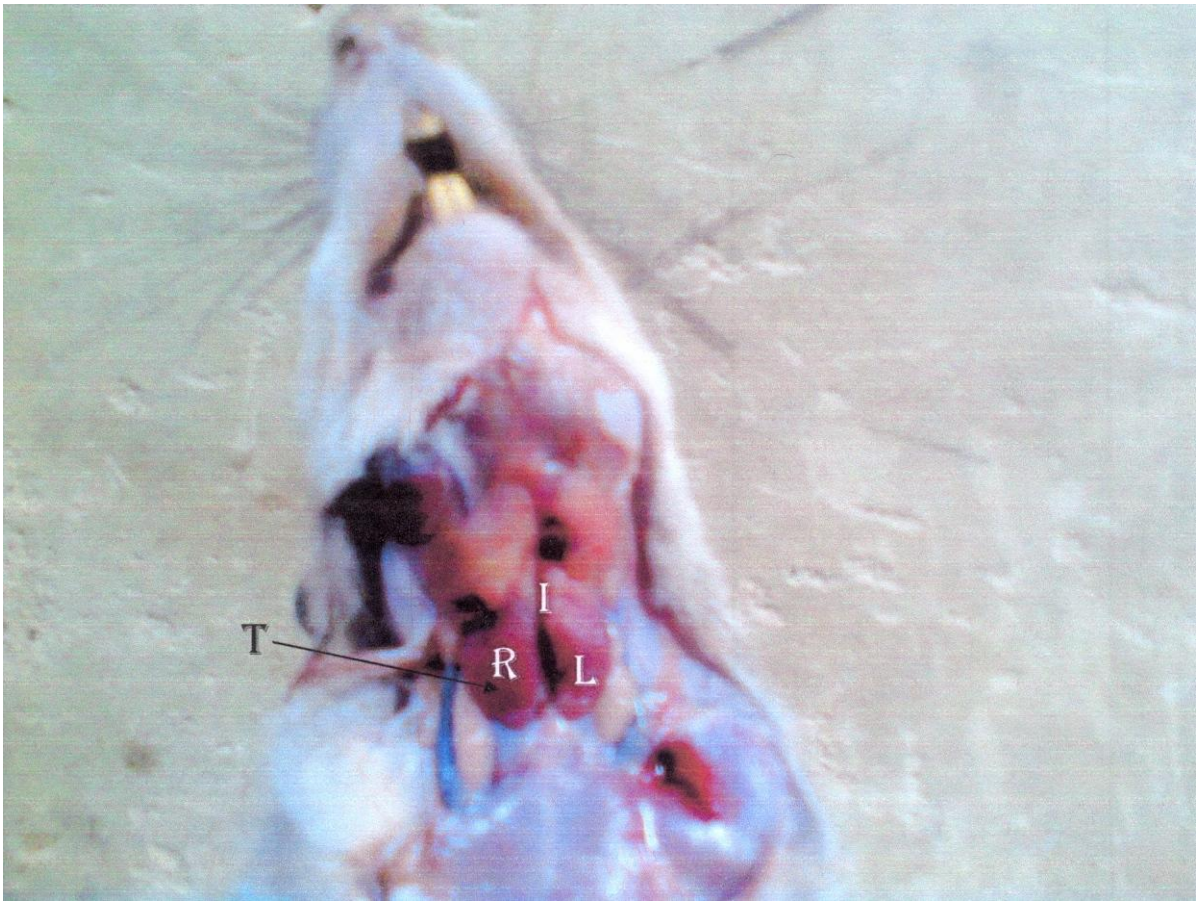


Fig 4.1: The thyroid gland (T) of African giant rat. Note the location of the Isthmus (I) connecting the two lobes (L) of the gland on the anterior end of the thyroid gland of the African giant rat.

Table 4.1: Morphometric studies and hormone assays of thyroid gland of the African giant rat. (AGR)

Sex of AGR	Body weight (g)	Organ weight (g)	Thyroid index (%)	Organ length (cm)	Organ Width (cm)	T3 (ng/ml)	T4 (ng/ml)
M	1210.00 ±56.67*	1.28 ± 0.03*	0.106±0.01	2.12± 0.03	0.56 ± 0.013	39.23 ± 0.27	0.88± 0.01
F	911.11 ±24.45	1.16 ±0.01	0.127±0.01	2.02 ± 0.07	0.16 ± 0.01	41.06 ± 0.56*	0.68± 0.01

Analysis by T-test between M and F

Data is expressed in mean ± standard Error of mean (SEM) of values collected.

*= $P < 0.05$g10(Significant between M and F)

M= Male African giant rat

F= Female African giant rat

T3= Tri-iodothyronine, T4= Tetra-iodothyronine

Table 4.2: Correlation analysis of the weight of endocrine glands of AGR (male) with their body weight, length, width, T3 (ng/ml), T4 (ng/ml) and PTH (pg/ml) hormones production in African giant rat.

AGR(Male)	Thyroid weight(g)	Parathyroid weight(g)	Adrenal weight(g)
AGR(g)	0.954***	0.930***	0.980***
Thyroid length(cm)	0.685**	ND	ND
Thyroid width(cm)	0.581*	ND	ND
Parathyroid length(cm)	ND	0.768**	ND
Parathyroid width(cm)	ND	0.678**	ND
Adrenal Width(cm)	ND	ND	0.586*
Adrenal Length(cm)	ND	ND	0.516*
T3 (ng/ml)	-0.234	ND	ND
T4 (ng/ml)	-0.032	ND	ND
PTH(pg/ml)	ND	-0.078	ND

Pearson Correlation Analysis of data

*=P<0.05 Adrenal width and length compared to adrenal weight, significant.

**= P<0.01 Parathyroid width and length compared to parathyroid weight, more Significant

***= P<0.001 AGR weight compared to thyroid, parathyroid and adrenal weights, most significant.

AGR (Male) = African giant rat (Male), T3= Tri-iodothyronine, T4= Tetra-iodothyronine, PTH=Parathyroid hormone

ND= Not determined

Table 4.3: Correlation analysis of the weight of endocrine glands of AGR (Female) with their body weight length, width, T3 (ng/ml),T4(ng/ml) and PTH (pg/ml) hormones production.

AGR(Female)	Thyroid weight(g)	Parathyroid weight(g)	Adrenal weight (g)
AGR/g	0.854***	0.830***	0.935***
Thyroid length(cm)	0.584*	ND	ND
Thyroid width(cm)	0.501*	ND	ND
Parathyroid length(cm)	ND	0.768**	ND
Parathyroid width(cm)	ND	0.678**	ND
Adrenal Width(cm)	ND	ND	0.516*
Adrenal Length(cm)	ND	ND	0.596*
T3 (ng/ml)	-0.134	ND	ND
T4(ng/ml)	-0.022	ND	ND
PTH(pg/ml)	ND	-0.058	ND

Pearson Correlation Analysis of data

*=P<0.05 Adrenal width and length compared to adrenal weight, significant

**= P<0.01 Parathyroid width and length compared to parathyroid weight, more Significant

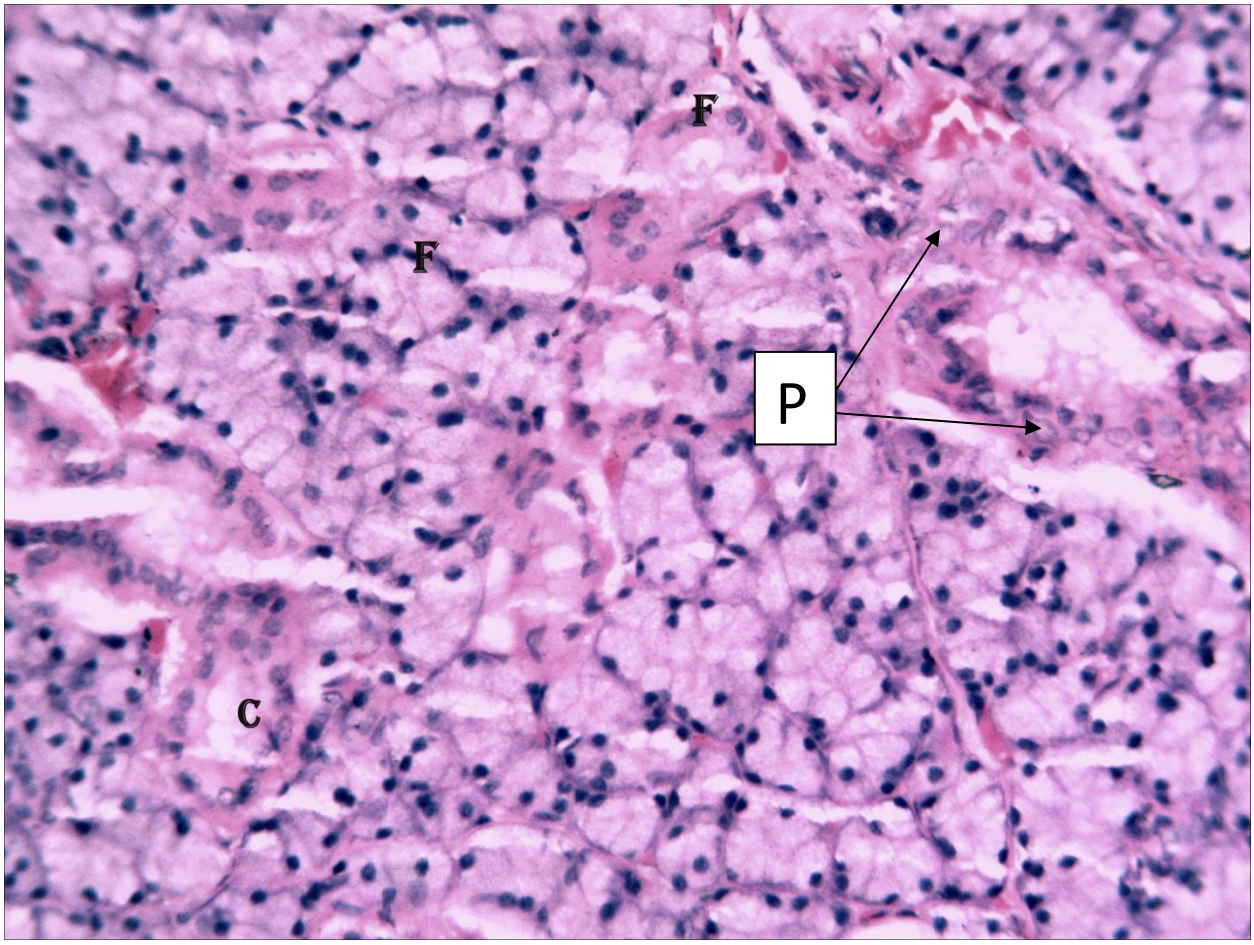
***= P<0.001 AGR weight compared to thyroid, parathyroid and adrenal weights, most Significant.

AGR (Female) = African giant rat (Male), T3= Tri-iodothyronine, T4= Tetra-iodothyronine

ND= Not determined

4.2.3 Histology and histochemistry

The thyroid gland was seen to consist of lobules. Each lobule consisted of an aggregation of follicles, each follicle being surrounded by basement membrane. The shapes of the follicles were round, oval and irregular (plate 1).Follicles include large, medium and small sized ones. Follicles were basically lined by cubiodal epithelium. The small sized follicles were lined by high simple cubiodal epithelium (plate 1). The medium sized follicles were equally lined by simple cubiodal epithelium with flattened nuclei (plate 1). The large sized follicles had low simple cubiodal epithelium (plate 1). Parafollicular cells were also seen between the follicles and the follicular epithelium (Plate 1). A histochemical study reveals that thyroid follicles contained colloid that was PAS positive (plate II). The thyroid gland also consist of a thin net-work of inter follicular tissue made up of fibers and blood capillaries surrounding each follicles. Follicular space of the follicles which filled with colloids some contained only small amount and few were completely devoid of substance (plate I).



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Plate I: Micrograph of thyroid gland in African giant rat showing follicles of different sizes and at different level of activity. Note the cubiodal epithelium of follicular cells (F) surrounding the colloids (C) of different sizes of the gland.. Note the parafollicular (P) cells between follicles and follicular epithelium (H&E, X 250).

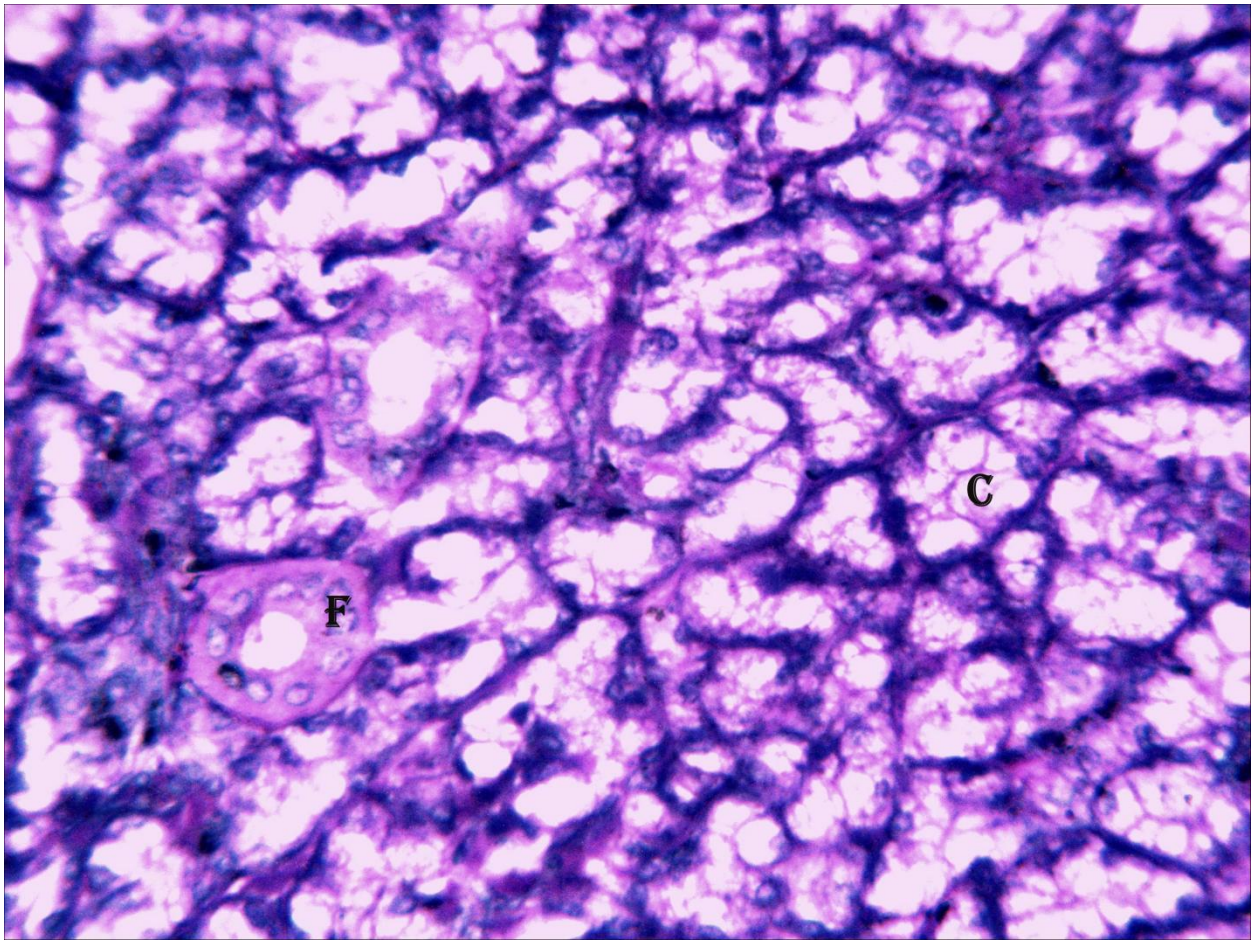


Plate II: Micrograph of thyroid histology of the African giant rat. Glandular duct (F) more consistent and regular epithelium and lumen while follicles are foaming showing presence of colloids (C) stained red with PAS (PAS stain X 250).

4.3 Parathyroid Gland

4.3.1 Gross Anatomy and morphological studies

The parathyroid glands were located on the posterior part of thyroid glands. The glands were inferior and lateral to the thyroid. Each gland was separated from the architecture of the thyroid gland by thin connective tissue capsule that can be easily identified and distinguished from the thyroid capsule. Table 4.4 showed that the mean weight, width and length of the male parathyroid gland were significant in relation with the body weight. The same result was observed for the female AGR (Table 4.4). Parathyroid weight does not showed sexual dimorphism (Table 4.4). The length and width of Parathyroid glands of AGR does not showed sexual dimorphism ($P<0.05$).Table 4.2 and 4.3 showed that there was strong positive correlations ($P<0.001$) between the parathyroid weight and the weight of the animal for both sexes. This was highly significant. Correlation analysis also showed that there was no correlation between the hormone,(parathyroid hormone) and parathyroid weight for both sexes.

4.3.2 Hormonal Assays

The average amount of PTH of the twelve adult African giant rats was observed to be 17.63 ± 0.72 pg/ml. The average amount of PTH of male and female AGR were observed to be 17.10 ± 0.24 pg/ml and 16.10 ± 0.24 pg/ml respectively. PTH does not show sexual dimorphism (Table 4.4). Correlation analysis showed that the amount of the hormone PTH does not correlate with the weight of gland (Table 4.2 and 4.3).

4.3.3 Histology and histochemistry

The glands were seen to be consisted of fibers extended into the substance of the glands divided them into incomplete compartments and consisted of densely packed cellular structures arranged basically in cords (Plate III). The chief cells were abundant and widely distributed throughout the glands with cord like arrangement (Plate III). Oxyphil cells were present in the glands (Plate III). Histochemical studies revealed that chief cells were PAS positive (Plate IV). The parathyroid glands were richly supplied with blood.

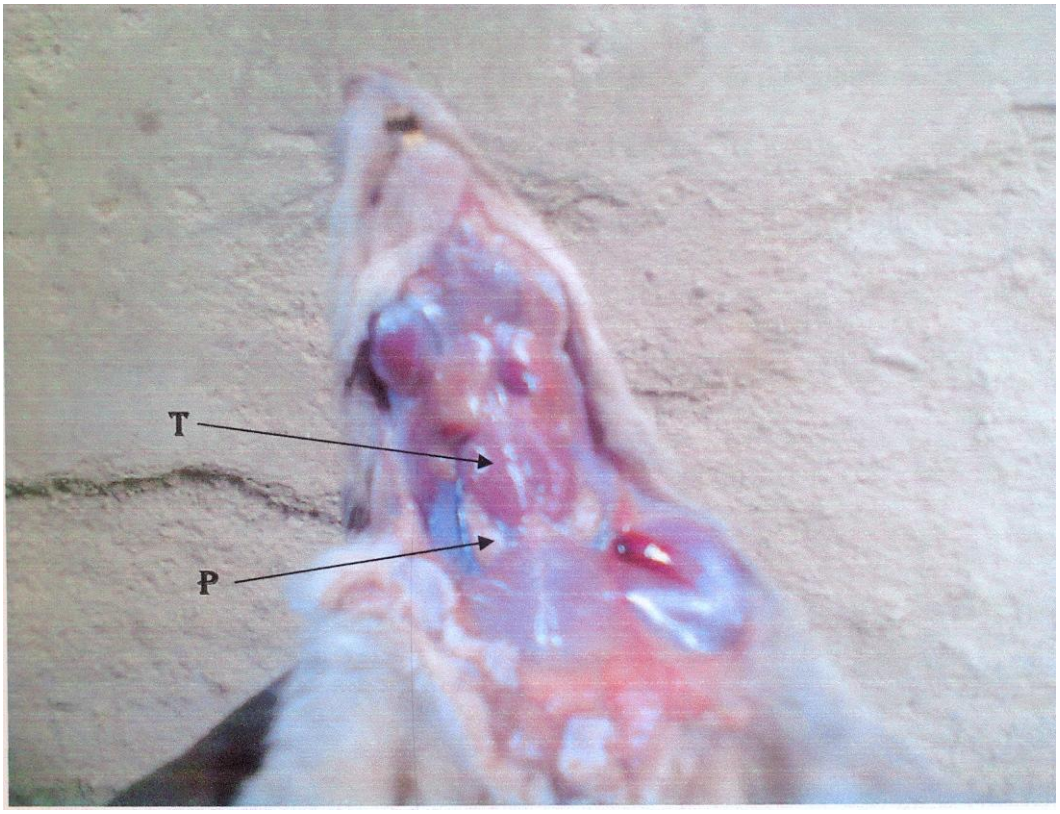


Fig 4.2: The Parathyroid glands (P) of the African giant rat. Note the position of the glands inferior and lateral to the two lobes of the thyroid glands (T).

Table 4.4: Morphometric studies and hormonal assays of parathyroid gland of the African giant (AGR)

Sex of AGR	Body weight(g)	Organ weight (g)	Parathyroid index (%)	Organ length (cm)	Organ Width (cm)	PTH (pg/ml)
M	1210 ± 56.7*	0.04±0.002	0.003±0.01	0.28 ± 0.01	0.11 ± 0.01	17.10 ± 0.24
F	911.11±24.5	0.02±0.001	0.002±0.001	0.021 ± 0.01	0.02 ± 0.01	16.10 ± 0.24

Analysis by T-test between M and F

Data is expressed in mean ± standard Error of mean (SEM) of values collected.

*= $P < 0.05$(Significant between M and F)

M= Male African giant rat

F= Female African giant rat

PTH=Parathyroid hormone

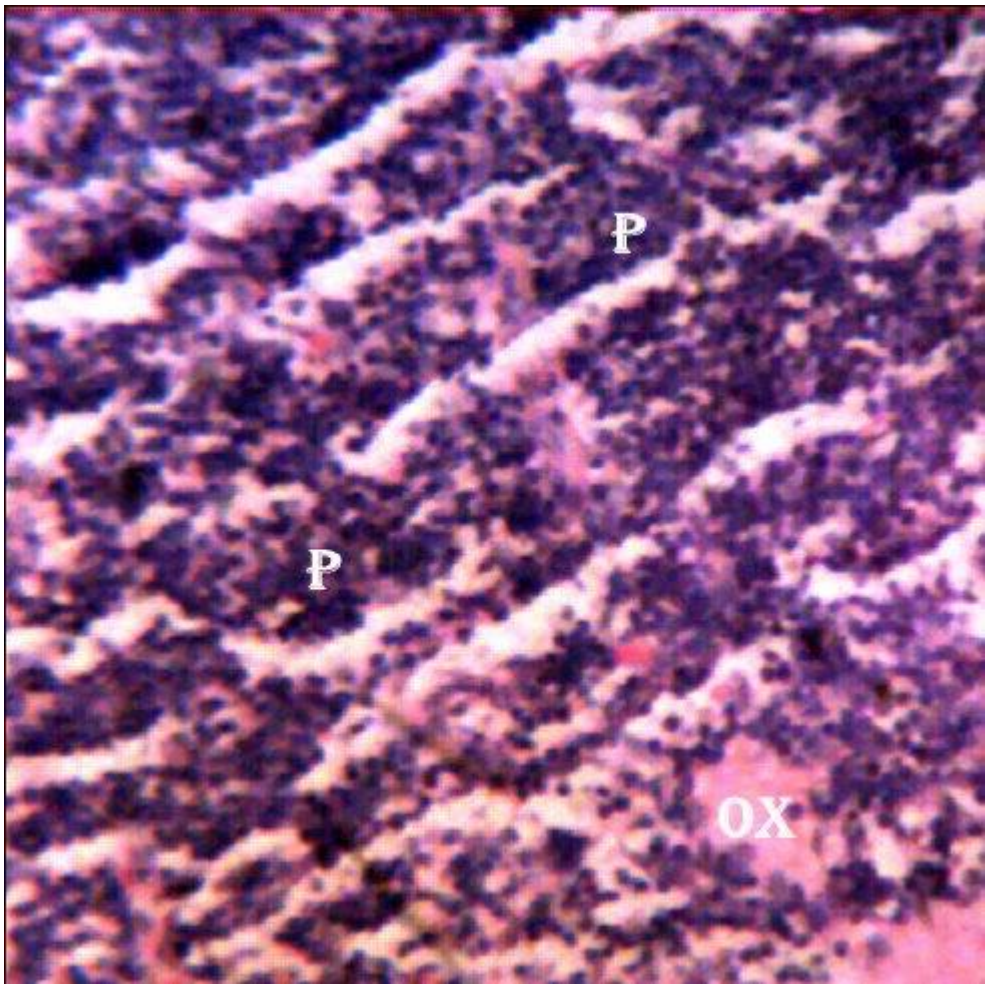


Plate III: Micrograph of the histology of the Parathyroid gland of the African giant rat showing the chief cells (P) and oxyphyils cells (OX). Note the cord like arrangement of the chief cells (H&E, X 250).

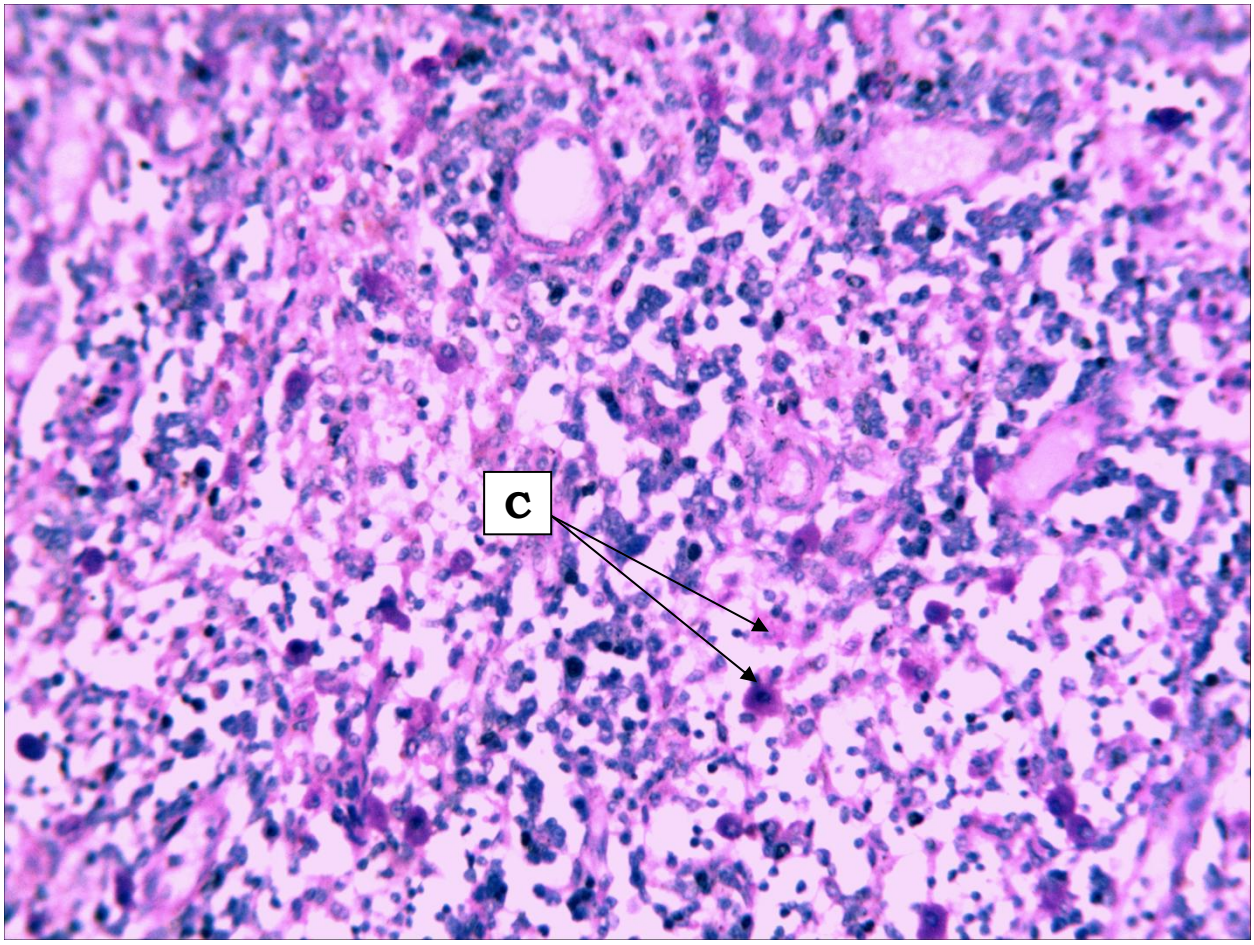


Plate IV: Micrograph of Parathyroid histology of the African giant rat. Note that the chief cells (C) of the parathyroid gland stained positive with PAS (PAS stain X 250).

4.4 Adrenal Glands

4.4.1 Gross anatomy and morphological studies

The paired adrenal glands were located on the superior poles of both kidneys (Fig 4.2).Both adrenal glands were seen to be oval and more nearly round in shape. Table 4.5 showed that the mean weight, width and length of the male thyroid gland were significant in relation with the body weight. The same result was observed for the female AGR (Table 4.5). Adrenal weight showed sexual dimorphism with the female significantly higher than that of the male African giant rat ($P<0.05$) (Table 4.5). the length and width of gland does not show sex dimorphism Table 4.5 showed that the weight of the female adrenal gland were significantly higher than that of the male adrenal gland in African giant rat ($P<0.05$).Table 4.2 and 4.3 showed that the Correlation analysis of the weight of adrenal glands of AGR (both sexes) with their body weight showed positive correlation ($P<0.001$). Correlation analysis also showed that there was positive correlation between the weight of gland and the length and width of gland.

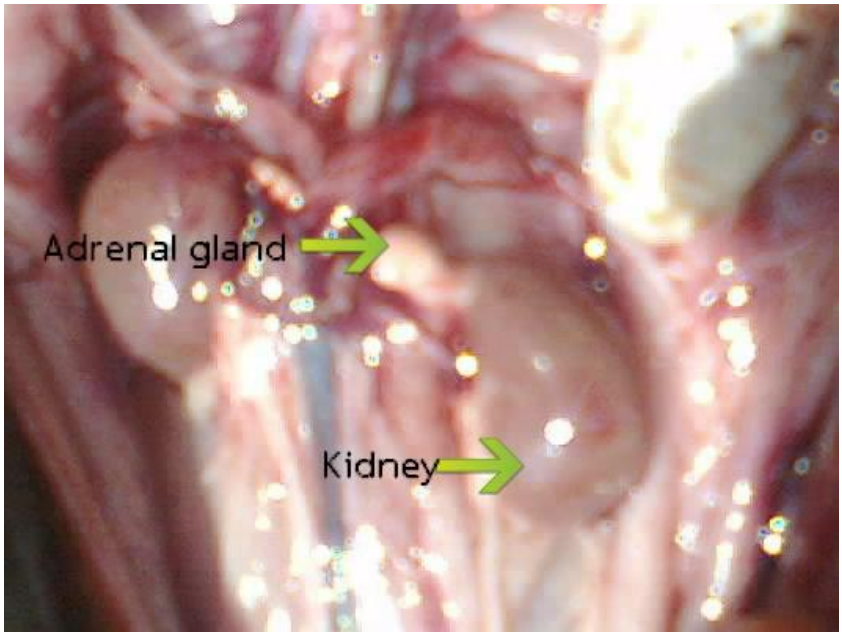


Fig 4.2: The Adrenal glands and the Kidneys of the African giant rat. Note the location of the glands on the superior poles of both kidneys.

Table 4.5: Morphometric studies of adrenal glands of the African giant (AGR)

Sex of AGR	Body weight (g)	Organ weight (g)	Adrenal 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

Analysis by T-test between M and F

Data is expressed in mean ± standard Error of mean (SEM) of values collected.

*= $P < 0.05$(Significant between M and F)

M= Male African giant rat

F= Female African giant rat

4.4.2. Histology and histochemistry

The adrenal gland comprised of cortex and medulla (plate V). The adrenal cortex comprised of three zones with zona reticularis as the largest zone. The zona glomerulosa was composed of cells arranged in irregular ovoid clusters (Plate VI). The zona fasciculata was the middle of the three cortical zones. It consisted of cells that were arranged in a cord like pattern running towards the medulla. The zona fasciculata and zona reticularis were not clearly separated from themselves (Plate 6). The zona reticularis was seen as the innermost layer of the adrenal cortex, and lies next to the adrenal medulla (Plate VI). It consisted of an irregular network of branching cords and clusters of cells separated by numerous wide diameter sinusoids.The adrenal medulla was composed of clusters of cells with granular, faintly basophilic cytoplasm with numerous capillaries in their fine supporting stroma (plate V). The adrenal medulla was about one quarter of the gland. When the gland was fixed in potassium dichromate fixative, the stored catecholamine granules of adrenal medullary cells (chromaffin cells) are oxidised to a brown colour (plate VII).

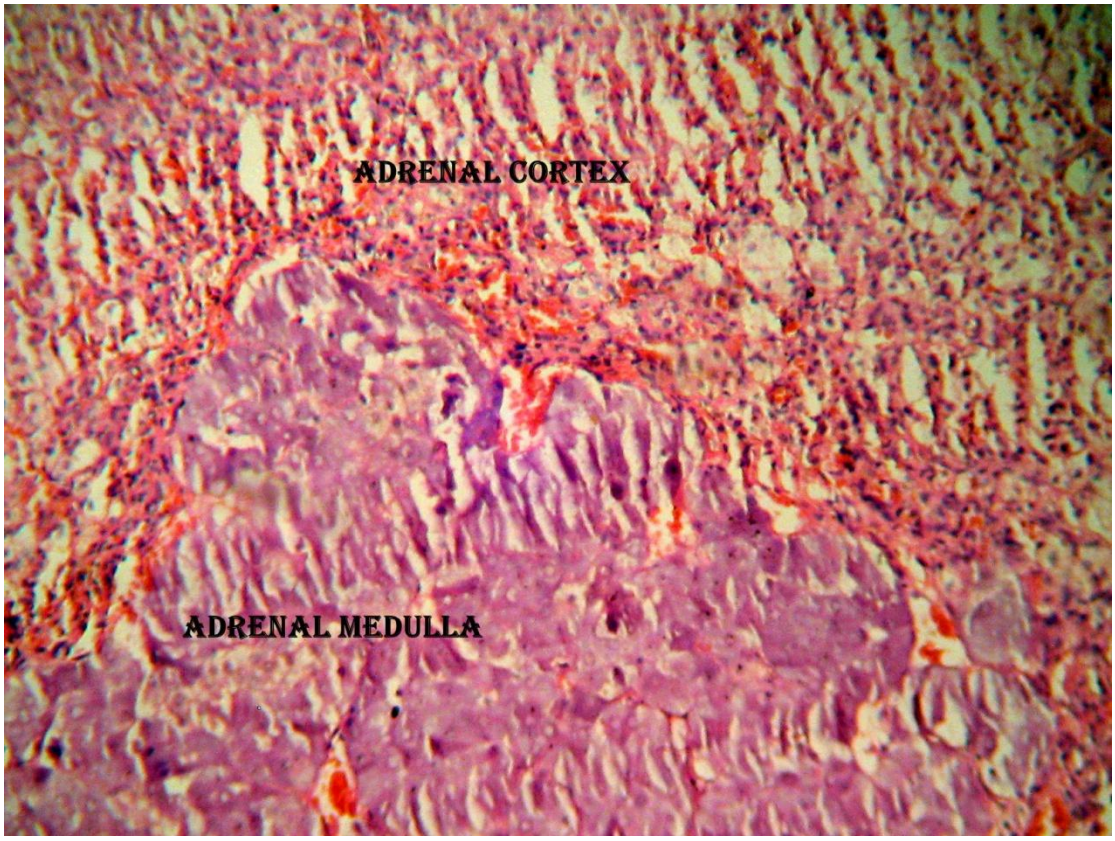


Plate V: Micrograph of the Adrenal gland of the African giant rat. Note the distinction between the cortex and medulla of the gland (H&E, X 250).

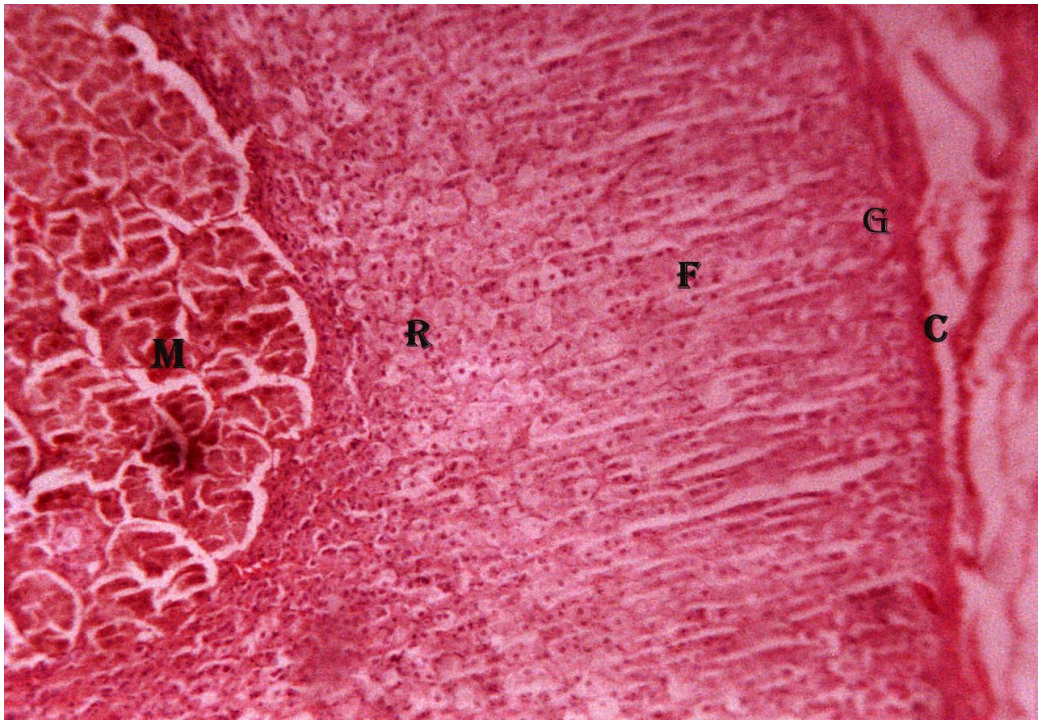


Plate VI: Micrograph of the Adrenal gland of the African giant rat. Note the arrangement of cells which form three Zones of the glands. Cells of the zona glomerulosa (G) were lying immediately behind the capsule (C) and composed of cells arranged in irregular ovoid clusters, the zona fasciculata (F) is the middle of the three cortical zones. It consists of cords of cells, the zona reticularis (R) is the innermost layer of the adrenal cortex, and lies next to the adrenal medulla (M) and consists of an irregular network of branching cords (H&E, X 100).

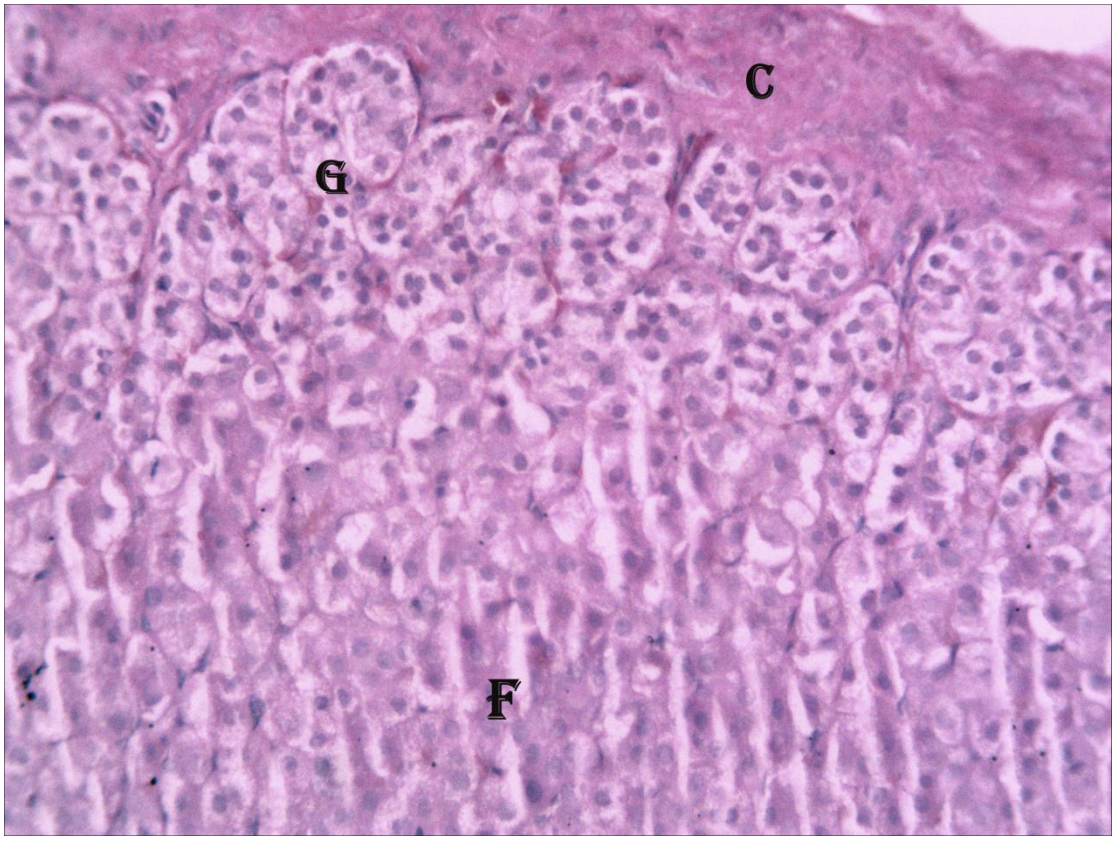


Plate VII: Micrograph of the Adrenal cortex of the African giant rat: the zona glomerulosa (G**).** It lies beneath the capsule (C) and contains secretory cells arranged in oviod clusters. The intermediate zona fasciculata (F**)** consists of parallel cords of secretory cells disposed at right angles to the capsule. (H&E, X 250).

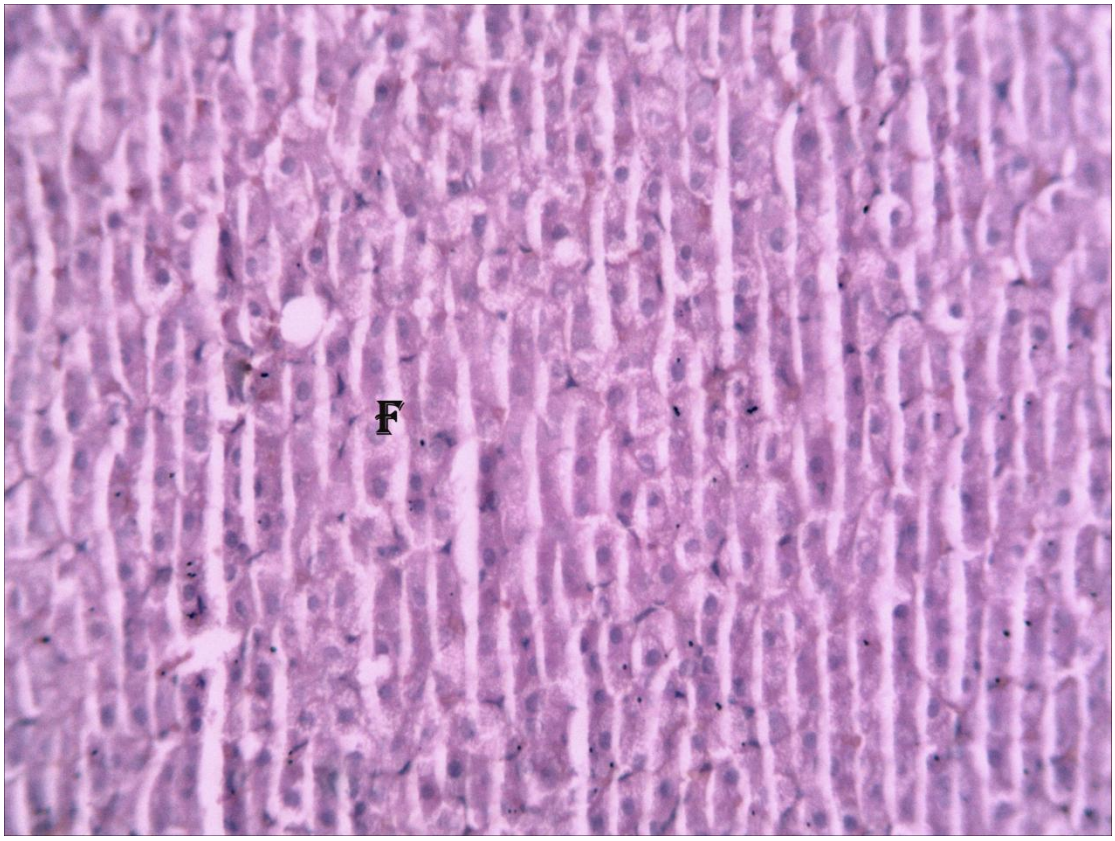


Plate VIII: Micrograph of the Adrenal cortex of the African giant rat: zona fasciculata (F). It is the middle and broadest of the three cortical zones. It consists of narrow and parallel cords of secretory cells (H&E, X 250).

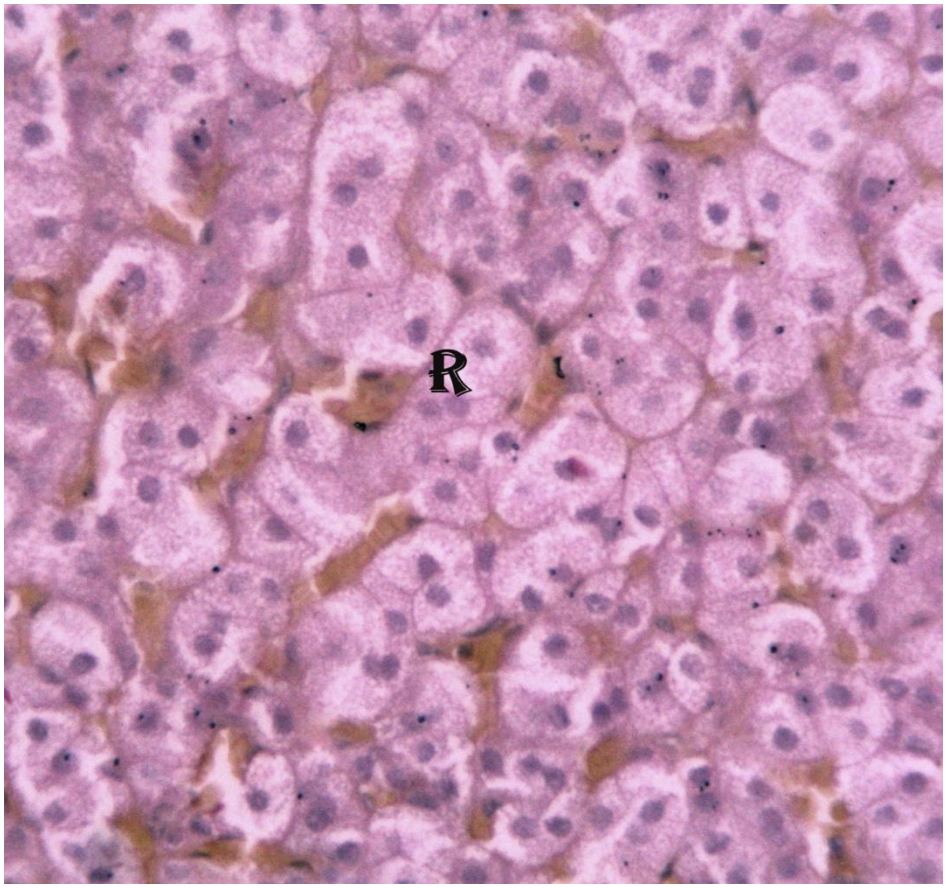


Plate IX: Micrograph of the Adrenal cortex of the African giant rat: zona reticularis (R). The zona reticularis (R) is innermost layer of the adrenal cortex, and lies next to the adrenal medulla. It consists of an irregular network of branching cords and clusters of glandular cells (H&E X 250).

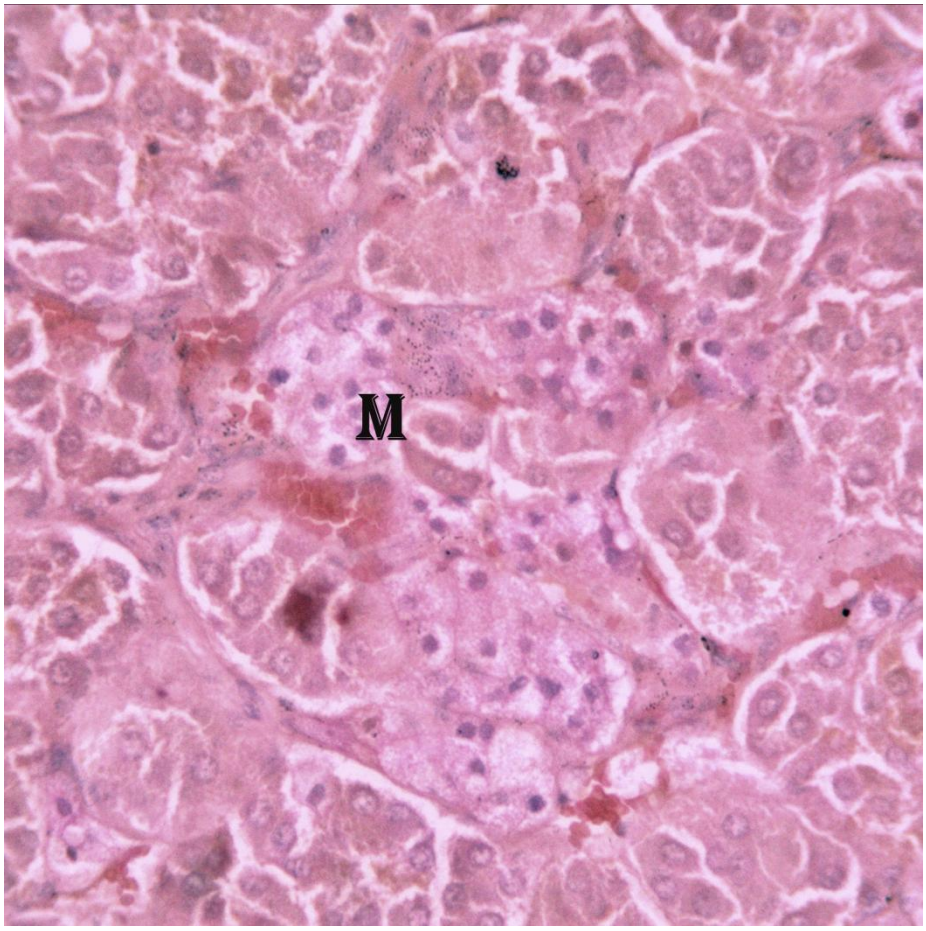


Plate X: Micrograph of the Adrenal medulla of the African giant rat. The adrenal medulla (M) composed of clusters of cells with granular cytoplasm (H&E, X 250).

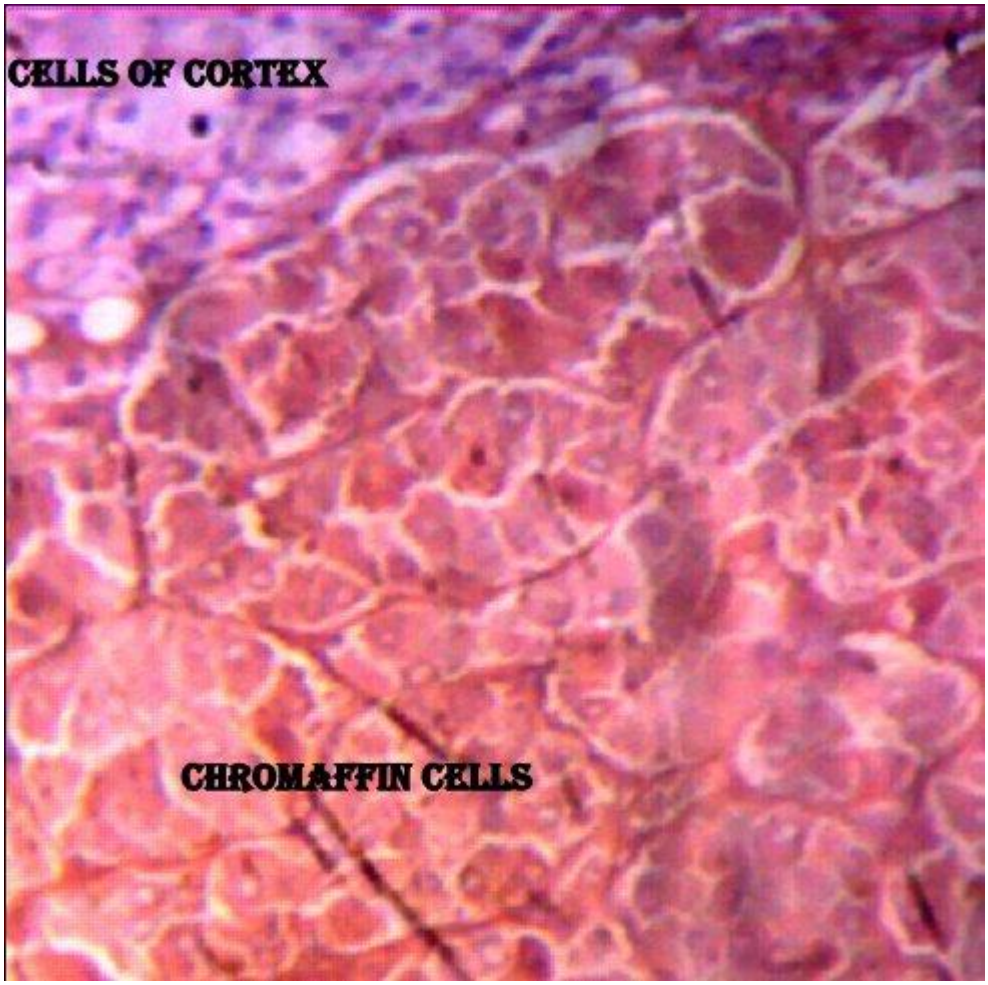


Plate XI: Micrograph of the Adrenal gland of African giant rat fixed with potassium dichromate fixative. Cells of the medulla showed brown coloration from chromaffin reaction (H&E, X 250).

CHAPTER FIVE

DISCUSSION

5.1 Thyroid gland

In this study the location of thyroid gland in AGR is similar to other mammals like the Wistar rat (Ingbar, 1985) and in humans (Moore and Dalley, 2006). The glands were seen at the level of the first ring of trachea and consisted of two lobes on both sides and isthmus connecting these lobes. In the mice, the thyroid gland consisted of two elongated oval lobes, one on each side of the trachea, joined near their posterior poles by a thin isthmus crossing the trachea ventrally, but in the AGR, the isthmus was seen connecting the two lobes in the anterior end of the glands. The gland appeared reddish brown in color which is similar to the findings in Grass cutter (Igbokw, 2010). Variation in the weight of the gland was in line with past report on Wistar rat (Ingbar, 1985) and mammals (Ameda, 1987) . Furthermore, study have shown that the weight of thyroid glands in the female mice were heavier than those of their male rat counterpart. However, this was not the case in this study as the weight of male thyroid gland was more than their female counterpart. The length and width of the thyroid glands of AGR were more than that of mice but it was less than that of pig, dog and humans (Venzke, 1975). Correlating the weight of gland with the body weight showed that there was positive correlation which was statistical significant.

The general histological features of the thyroid glands of AGR were similar to those of other mammals (Abdel-Wahab *et al.,*1970 and Abdel-Magied *et al,* 2000). The histological sections also revealed that the shapes and sizes of these follicles were not the same. Some of the follicles were large, others were medium and some were small. This is in agreement with the report of Hartoft-Nielsen *et al,* (2005) in several mammals. The general large follicle containing large amount of colloid was not observed (Kausar and Shahid 2006) and Mathur (2004) reported that in the cow, pig, dog buffalo rabbit and guinea pig, large follicles have cubiodal epithelial cells. The present observations are in agreement with these findings. Variations in follicular sizes and

epithelial height in thyroid gland of AGR are in agreement with those seen in humans and other mammal (Abdel-Margied *et al,* 2000). Hormonal assays result suggested that the follicular cells were actively involved in the production of the thyroid hormones, triiodothyrinine and tetraiodothyronine. The variation in the size of the follicles and heights of the follicular cells suggest that follicles and follicular cells have different level of activity within the gland. Actually the sceretory thyroid tissue is composed of smaller follicular cells lined by cubiodal cells while less active tissue is characterized by larger follicles lined by flat epithelial cells and contain large amount of colloid. Thyroid activity as measured by secretion rates is different in females and male with the T3 significantly higher in female than in male. This is in agreement with findings in mice and rats (Abdel-Margied *et al,* 2000). Parafollicular cells (C-cells) were found in the gland. This is agrees with the observation made in cow, buffalo, pig and in elephant (Little, 1991) and in rats. Parafollicular cells are responsible for the secretion of a hormone called calcitonin, which is a physiological antagonist to parathyroid hormone and therefore lowers blood calcium levels by suppressing the oesteoclastic resorption of bone (Singh, 2006). The follicles were PAS positive an indication that the follicular cells were actively involved in the formation of colloids present in the follicles.

5.2 Parathyroid glands

The parathyroid glands in most animal species consisted of two pairs of glands in the anterior cervical region (McDonald,2003). Similar findings were made in the present study. There was no significant difference between the weight of male and female parathyroid glands of AGR. This does not agree with findings in mice and Wister rats where the female organs are significantly higher in weight than that of the males (Chen, 2001). There was no significant difference between the width and the length of the parathyroid glands of male and female parathyroid gland of the AGR. Correlating the weight of gland with the body weight showed that they was positive correlation which was statistical significant. Other parameters like the length and the width were

also significant when correlated with the weight of the gland. This agrees with findings in rat and mice (Chen, 2001).

The AGR parathyroid gland was identical in histological structure to other mammals. Nagpal *et al*,2001 in Camel, Charles *et al.*, 2000, in cow and Roy *et al.*, 1999 in goat,in hen (Fujii,1972),Yanol,*et al* 2002 in hamster and in rodents (Chen, 2001). The parathyroid glands regulate serum calcium and phosphate levels via parathyroid hormone (parathormone, PTH) which hormonal assays suggests that the hormone does not show sexual dimorphism in this study. Present evidence indicates that the parathyroid glands have the chief cells which are responsible for the production of parathyroid hormone (Singh, 2006). The chief cells were arranged basically in forms of cords. This arrangement is different from that of humans were cells are arranged in various forms; cords, semi follicles and follicles (Singh, 2006), but agrees with findings in rodents (Nakanishi,*et al* 2004). The chief cells are responsible for the production of parathyroid hormone (Singh, 2006, Weymouth and Sheridan,1999), hence chief cells were PAS positive. Chief cells were positive because the PTH is basically a glycoprotein. The second cells type in the parathyroid glands Oxyphil cells, were also identified in AGR.These findings were similar to those of rats and other lower animals (Fleicher *et al.*, 2004). Oxyhpil cells are not present in human foetal parathyroid gland. They first appear in late childhood and increase in number with advancement in age, often forming nodules in the parathyroid gland of older persons, (Fleischer, 2004). The significance of oxyphil cells in the pathophysiology of parathyroid glands has not been elucidated but they are not known to be involved in the synthesis of parathyroid hormone (Singh, 2006).

5.3 Adrenal glands

The adrenal gland, were two in number as observed in other rodents (Colby,*et al*., 1992 and Koko *et al.*, 2004). The adrenal glands of males and females rats differ in size and appearance, those of females being consistently larger and more opaque due to the presence of more lipids (McDonald, *et*

al.,2003). The present study agrees with findings in other rodents (McDonald, *et al*.,2003). There was no significant difference between the length and the width of male and female adrenal glands. Correlating the weight of gland with the body weight showed that they was strong positive correlation which was statistical significant. Other parameters like the length and the width were also significant when correlated with the weight of the gland. Meaning, the larger the gland, the more the length, and the width. The adrenal gland consists of two parts, cortex and medulla**.** and this agrees with findings rodents (Gersh and Grollmann,1999) and mammals (Dyce,*et al* 2002). The histology of the cortex showed that the cortex in divided into three zones which are zona glomerulosa ,zona fasciculata and zona reticularis. This agrees with findings rodents and mammals (Koko *et al.,* 2004). There was no clear distinction between zona glomerulosa and zona fasciculata. This result is not similar to man where zones are clearly separated from each other (Singh,2006). The capsule was seen to be quite thin. The adrenal cortex is essential to life. It controls the electrolyte and water distribution in the body and maintains proper carbohydrate balance. Zona glomerulosa was identified. It was the outer most narrow zone of the adrenal cortex. This agrees with findings on the adrenal cortex of other rodents (Moog, *et al,* 1998). Immediately after the zona glomerulosa is Zona fasciculata. Zona Fasciculata was not clearly separated from the zona glomerulosa as in the case of human and other higher mammals (Singh,2006). The zona reticular is clearly separated from zona fasciculate. Zona fasciculata was the largest of the zones. This findings is similar to that of man and other mammals (Junqueira,*et al,* 1995). Cells were seen to be arranged in irregular cords separated by sinusoid (clear space) giving the arrangement of mesh work. This finding is in agreement with finding on the adrenal cortex of domestic animals (Bank,1993).

The medulla of the adrenal gland of AGR was completely separated from the cells of the cortex. This agrees with findings in rodents and mammals (Moog, *et al* 1998, and Marthur,2000). The medulla was seen to be highly vascularised. Cells are rich in chromaffin substance hence were

able to pick the chromaffin stain. The chromaffin cells were clearly identified. Chromaffin cells are responsible for the production of adrenalin and noradrenalin. Secretions is passed directly into the blood (Singh,2006). Chromaffin cells of the medulla picked the potassium dichromate stain hence cells became brown in colour. This has being observed in many animals (Hussin, 2003).Basically the histology of the adrenal gland does not vary greatly from those of other mammals.

CHAPTER SIX

SUMMARY CONCLUSION AND RECOMMENDATION

6.1 Summary

The mean weight of AGR was observed to be 1058.42 ± 37.79g. Gross studies of the thyroid gland of the AGR showed that it was a bi-lobed organ joined together towards the anterior end by an isthmus and located on the lateral surface of the trachea. The weight of the male thyroid gland were significantly higher than that of the female African giant rat($P<0.05$). Follicles which were PAS positive include large, medium and small sizes were lined by simple cubiodal epithelium. Hormone assay showed that triiodothyrinine was significantly higher in female than in male. Parafollicular cells (C-cells) were present. The parathyroid glands were inferior and lateral to the thyroid glands. The weight of the male parathyroid gland was not significantly higher than that of the female African giant rat ($P<0.05$). The glands consisted of densely packed chief cells which were PAS positive and arranged basically in cords. Oxyphil cells were present. Hormone assays showed that there was no significant difference in the amount of parathyroid hormone (PTH pg/ml) in male and female AGR. The paired adrenal glands were located on the superior poles of both kidneys. Both adrenal glands were seen to be oval or more nearly round in shape. The weight of the female adrenal gland were significantly higher than that of the male adrenal gland ($P<0.05$).Histological studies showed that adrenal glands have cortex and medulla. The adrenal cortex comprised of three zones; Zona glomerulosa, zona fasciculate and zona reticularis. Chromaffin cells of the medulla were identified.

6.2 Conclusion

The gross, histological and histochemical studies of the thyroid, parathyroid and the adrenal glands of the African giant rat showed sexual dimorphisms and cellular morphology which could help in understanding the biology of the rodent.

6.3 Recommendation

Further studies on expression of genes and neurochemical characteristics are required to understand the physiology of the endocrine glands.

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