IJAE
Vol. 120, n. 1: 49-58, 2015
ITALIAN JOURNAL OF ANATOMY AND EMBRYOLOGY

Research Article - Basic And Applied Anatomy

Comparative morphometric analysis of the gastrointestinal tract of the captive greater cane rat (*Thryonomys swinderianus*) and African giant pouched rat (*Cricetomys gambianus*)

Obadiah Byanet, Akileye O. Abayomi, Tyagher J. Aondohemba

Department of Veterinary Anatomy, College of Veterinary Medicine, University of Agriculture, Makurdi, Benue State, Nigeria

Submitted September 5, 2014; accepted revised December 22, 2014

Abstract

The greater cane rats (*Thryonomys swinderianus*) and African giant pouched rats (*Cricetomys gambianus*) are among the largest rodents in Africa, undergoing domestications for meat and research purposes. The aim of this study was to explore whether there are any quantitative anatomical gastrointestinal adaptations associated with their omnivorous or herbivorous diets. In the African giant rat, the mean gastrointestinal tract length and colon width of the males were significantly higher than their females counterpart ($P < 0.05$ and $P < 0.01$, respectively). In a similar way, the mean gastrointestinal tract weight, stomach length and jejunal width in males greater cane rat were significantly higher than in the females ($P < 0.05$, $P < 0.01$ and $P < 0.01$ respectively). The monogastric, omnivores African giant pouched rats had mean significant stomach length and width than greater cane rat ($P < 0.01$ and $P < 0.01$ respectively). Also, the duodenal length, jejunal and ileal widths were higher in the former than in the latter ($P < 0.05$, $P < 0.05$ and $P < 0.01$ respectively). The monogastric, herbivore greater cane rats had higher mean cecal width and colon length than the African giant pouched rat ($P < 0.01$ and $P < 0.01$ respectively). In conclusion, the African giant pouched rat had larger stomach and longer and wider small intestine, compared to the greater cane rat, which instead had more prominent cecum and wider and longer colon. This suggests that greater cane rats are hindgut fermenting herbivores (cecal fermenter), as is the case in most rodent species.

Key words

Stomach, small intestine, large intestine, morphometry, captivity, light microscopy.

Introduction

The greater cane rats (*Thryonomys swinderianus*), popularly known as grasscutters (GCR) are wild herbivorous rodents, and the second largest African rodents after the Porcupine (Baptist and Mensah, 1986). These rodents are nocturnal and live in marshy areas along the river banks, feeding on aquatic grasses in the wild. Being monogastric herbivores, they are fond of both sweet and salty food and can also

* Corresponding author. E-mail: byaneto@yahoo.com.

http://www.fupress.com/ijae
DOI: 10.13128/IJAE-16474

adapts readily to different diets like leguminous fodder, tubers (cassava, sweet potatoes), fruits (pawpaw, pineapple and mango) and food crops (rice, maize), making them a significant pests in the West African region where they are found (Eben, 2004). According to Adu (2005), the feeding habits of GCRs and other rodents (e.g. rabbits) are directly opposite. Whereas the GCRs prefer to eat stalks to leaves, the rabbits, for example, on the contrary choose the leaves and wastes stem. For local breeders this practice leads to wasted feed resources, especially during the dry season when there is scarcity of grass (Adu, 2005).

The African giant pouched rats (*Cricetomys gambianus*) (AGR) is so-called because of the large, hamster-like pouches on their right and left cheeks. Like GCRs, AGRs belong to the order Rodentia. The AGRs are omnivorous and feed on vegetables, insects, crabs, snails. In West Africa, they prefer palm fruits and palm kernels (Kingdon, 1997).

It is important to note that unlike AGRs, the GCRs like rabbits and guinea pigs practice coprophagy, that is, the re-ingestion of their feces (Cathy, 2006). The behaviour of eating faeces has been observed in lagomorphs, rodents and primates; it serves to improve the absorption of vitamins and microbial proteins (Hirakawa, 2001). In feeding captive GCRs, it is advised that a combination of forages and supplements be given, with forage/grasses be fed in the morning and evening, while supplements be given in the afternoon (Raymond, 2000). From my personal experience, this feeding regime has been adopted by many farmers in some parts of Nigeria.

The use of AGRs and GCRs as alternative source of animal protein has good acceptability within the West African populace and has led to attempts by farmers and research centers to domesticate these animals in captivity for food and as laboratory animals (Ajayi, 1971). The GCR meat in particular has an excellent taste and is nutritionally superior to other livestock because of its high protein and mineral, but low fat content (Asibey, 1974; Anizoba, 1982; Ntiamo-Baidu, 1998). Economically, production of these rodents may contribute to provide food security, create job opportunities and improve income for rural and urban farmers. Improvement in biology and other areas of research on these rodents may lead to the establishment of more breeding centers that may provide the stock needed by farmers and scientists for production and research purposes. This will reduce the hunting of these animals in the wild with its negative environmental consequences. Knowledge of their basic biology, such as gastrointestinal tract morphology, physiology and feeding needs are considered important to improve their domestication in captivity (NRC, 1991).

The morphological characteristic of the digestive tract of a given animal species is related to the nature of food and feeding habits (Smith, 1989). Despite the obvious knowledge of GCRs and AGRs feeding ecology, little information on their gastrointestinal morphology are found in the literature. Paucity of information on the biology of these rodents is one of the major challenges for the farmers (NRC, 1991). These rodents have structural peculiarities unknown to the scientific world; hence, there is need to generate specific data for them (Adu, 2002). The priority research areas in basic biology of GCRs and AGRs include: digestive and reproductive physiology, feeding habits, feed conversion and growth rate and social behavior both in the wild and in captivity (NRC, 1991).

The gastrointestinal tract of the higher vertebrates and most rodents has been studied extensively but this is not the case with GCR and AGR. For the gastrointestinal tract of the GCR we had earlier described the gross and microscopic features qualitatively (Byanet el al., 2008, 2011). Also, gross anatomical features have been reported for the AGR (Alogninouwa et al., 1996; Ali et al., 2008; Byanet et al., 2010, 2011). The present, quantitative study is aimed at acquiring better knowledge of the biology of these rodents and to explore whether there are anatomical adaptations associated to their herbivorous or omnivorous diet in order to provide a basis for further investigations into the nutrition and ecology of these rodents.

Materials and methods

Source of animals and study location

A total of thirty-one rodents, fourteen GRCs (seven males and seven females) and seventeen AGRs (eight males and nine females), were used in the study. The AGRs were live-trapped in the wild, in Zaria ($11^{0}10/N$, $07^{0}38/E$), located in the Northern Guinea Savannah zone of Nigeria, and reared under laboratory conditions in the Department of Veterinary Physiology and Pharmacology, Ahmadu Bello University, Zaria. They were transferred in laboratory cages to a nearby Veterinary Anatomy Research Laboratory of the same university, where the research was conducted.

The GCRs were purchased from a local breeder farm in Benue ($07^{0}13/N$, $08^{0}05/E$), located in the Southern Guinea Savannah zone of Nigeria. The GCR males used had brownish perineal staining, which is an index of sexual maturity in males (Yeboa and Adamu, 1995). The GCRs were transported by road in wooden laboratory cages which had two compartments (for males and females respectively), measuring 50 cm (height) by 40 cm (width) and 40 cm (length), to the Anatomy Research Laboratory, Department of Veterinary Anatomy, Ahmadu Bello University, Zaria, Nigeria, where they were kept under room temperature for three days before the experiments. They were fed with elephant grass (*Pennisetum purpureum*), supplemented with grower's chick mash and given access to water and feed *ad libitum.*

Experimental procedure

Physical examination revealed that the rodents were clinically healthy and in good nutritional status prior to the study. The animals were anaesthetized with 10-25 mg/kg IM ketamine HCl in a confined container measuring 35 cm in length and 15 cm in width. The body length (distance from the tip of the nose to the tip of the tail) of each animal was measured using twine. The animals were weighed using a balance (Model P 121, Mettler-Toledo, Greifensee, Switzerland).

An incision was made on the ventral midline, beginning from the cervical region up to the level of the pelvic region. The abdominal cavity was opened and the regular fat stores around the kidneys, the omentum and the mesenteric were observed in all the animals. The gastrointestinal tract of the each animal was removed by severing the oesophagus just prior to the gastro-oesophageal junction and tied off before dissecting it away from its attachments to the dorsal abdominal wall. After removal of the entire tract, its length was taken and the lengths and widths of the respective sections, such as the stomach, small intestine (duodenum, jejunum and ileum) and large intestine (cecum, colon and rectum) were measured using a twine and standard ruler after removal of any mesenteric attachments.

Data analysis

The generated data were tabulated and expressed as mean and standard error of the mean (SEM). The weights were recorded in grams (g) and dimensions in centimeters (cm). Student *t*-test was used to analyze the differences between males and females of the same species and between species. One-way ANOVA with Dunnett's post-hoc test was performed using GraphPad InStat version 3.00 for Windows 95 (GraphPad Software, San Diego, California, USA; online reference at www.graphpad.com). Values of $P \leq 0.05$ and $P < 0.01$ were recorded and considered significant.

Results

Differences between sexes in the dimensions of gastrointestinal tract segments of the AGR are presented in Table 1. The mean length of the body (1352.5 ± 51.4 cm)

Table 1 – Sexual dimorphism in the gastrointestinal tract of the African giant pouched rat.

Parameter	African giant pouched rat				P value
	Male (n= 8)		Female (n= 9)		
	Min-Max	Mean±SEM	Min-Max	Mean±SEM	
Weight (g)					
Body	1120-1560	1352.5±51.4	960-1500	1301.8±44.43	n.s.
gastrointestinal tract	215-275	212.5±16.87	150-300	209.09±14.90	n.s.
Dimension (cm)					
Body length	70-86	79.98±1.73	65-81	76.45±1.41	n.s.
Gastrointestinal tract length	121.7-206.6	161.63±9.49	132.7-172.3	150.15±3.50	< 0.05
Stomach length	11.8-27.7	21.3±2.01	12.3-21	16.97±0.94	n.s.
Stomach width	2.3-4.5	3.75±0.26	2.3 - 4.9	3.80±0.21	n.s.
Duodenum length	6.5-12.4	9.16±0.77	6.3 - 12	8.76±0.54	n.s.
Duodenum width	0.3-1.0	0.66±0.08	0.6 - 1.2	0.84±0.05	n.s.
Jejunum length	32.90.7	59.95±6.48	32.1 - 69.2	48.08±3.29	n.s.
Jejunum width	0.5-1.0	0.83±0.05	0.6 - 1.0	0.73±0.04	n.s.
Ileum length	8.3-16.2	11.35±1.05	7.3 - 21.3	10.04±1.17	n.s.
Ileum width	0.6-0.9	0.69±0.05	0.5 - 1.0	0.67±0.04	n.s.
Cecum length	10.2-20	14.9±1.46	10.7 - 23.4	13.66±1.06	n.s.
Cecum width	1.3-2.8	2.18±0.15	1.5 - 2.5	1.9±0.10	n.s.
Colon length	31.5-67.1	44.51±4.0	37.0 - 49.7	43.97±1.33	n.s.
Colon width	0.6-1.3	1.0±0.08	0.5 - 1.0	0.73±0.05	n.s.
Rectum length	8.5-13.1	10.56±0.52	70-12.9	9.66±0.77	n.s.
Rectum width	0.5-1.1	0.78±0.08	0.5-0.9	0.69±0.05	n.s.

n = sample size, Min = minimum, Min = maximum, SEM = standard error of mean, n.s. = not significant.

and gastrointestinal tract (212.5 ± 16.87 cm) of males were slightly less than those of females (1301.8 ± 44.43 cm and 209.09 ± 14.90 cm respectively; P not significant). The mean length of the stomach (21.3 ± 2.01 cm) and width of duodenum (0.66 ± 0.08 cm) of males were higher than those of females (16.97 ± 0.94 cm and 8.76 ± 0.54 cm respectively; P not significant). The colon mean length showed no significant difference between sexes, but the width was significantly wider in males (10.56 ± 0.5 cm) than females (9. 66 ± 0.77 cm; P < 0.01). The value of the mean stomach width was the only figure observed to be higher in females (3.80 ± 0.21 cm) than males (3.75 ± 0.26 cm; P, not significant).

The morphometric data for the body and gastrointestinal tract of male and female GCRs are presented in Table 2. There was no significant difference between the mean body weight of males and females. The mean gastrointestinal tract length noted significantly higher in males (208.93 ± 34.87 cm) than females (83. 41 ± 11.3 cm; P < 0.05). The stomach length and jejunal width were significantly higher in males (15.6 ± 1.46

Table 2 – Sexual dimorphism in the gastrointestinal tract of the greater cane rat.

Parameter	Greater cane rat				P value
	Male (n= 7)		Female (n= 7)		
	Min-Max	Mean±SEM	Min-Max	Mean±SEM	
Weight (g)					
Body	360-2500	1250±349.92	460-2400	880.71±250	n.s.
Gastrointestinal tract	100-425	208.93±43.87	50-125	83.41±11.3	< 0.05
Dimension (cm)					
Body length	43-53.5	47.1±1.49	40-69.5	47.47±3.77	n.s.
gastrontestinal tract length	134-345.9	190.91±28.72	114.1-239	171.44±19.19	n.s.
Stomach length	11.1-21.4	15.6±1.46	7.25-11.5	9.56±0.58	< 0.01
Stomach width	2.3-2.7	2.5±0.07	1.7-3.3	2.37±0.21	n.s.
Duodenum length	6.8-10.1	8.19±0.52	5.2-10.6	7.34±0.81	n.s.
Duodenum width	0.4-1.0	0.70±0.08	0.5-0.9	0.71±0.05	n.s.
Jejunum length	37.9-96	55.6±7.81	22.9-80.7	48.16±7.8	n.s.
Jejunum width	0.7-0.9	0.76±0.04	0.4-0.8	0.54±0.05	< 0.01
Ileum length	7.4-20	11.14±1.8	0.6-11.9	9.89±0.79	n.s.
Ileum width	0.5-0.7	0.56±0.04	0.3-0.7	0.46±0.06	n.s.
Cecum length	11.4-25.3	16.79±2.06	10.2-24.0	15.34±1.77	n.s.
Cecum width	2.2-6.2	3.63±0.48	2.2-6	3.84±0.56	n.s.
Colon length	45-126	74.26±11.02	50.4-148	76.33±14.4	n.s.
Colon width	0.5-1.4	0.91±0.10	0.5-1	0.69±0.063	n.s.
Rectum length	3.8-12.3	9.23±1.09	5-9.3	7.16±0.73	n.s.
Rectum width	0.5-1.2	0.69±0.11	0.3-0.6	0.43±0.05	n.s.

n = sample size, Min = minimum, Min = maximum, SEM = standard error of mean, n.s. = not significant.

cm and 0.76 ± 0.04 cm respectively) than females (9.56 ± 0.56 cm and 0.54 ± 0.05 cm respectively; P < 0.01 for both parameters). The last segment of the gastrointestinal tract, the rectum, had a higher mean width in males (0.69 ± 0.11 cm) than in females (0.43 ± 0.05 cm), but the difference did not reach significance level. In females, the body mean length (47.47 ± 3.77 cm) and duodenal width (0.71 ± 0.05 cm) were slightly higher than those of males (47.10 ± 1.49 cm and 0.70 ± 0.08 cm respectively; P not significant).

Table 3 compares the dimensions of body and gastrointestinal tract between the AGRs and GCRs. The body weight of GCR (range 360 - 2500 g, mean and SEM 997.5 ± 214.64 g) was lower than that of AGR (range 1120 - 1560 g, mean and SEM 1344.7 ± 29.53 g: P not significant). The mean gastrointestinal tract weight (78.72 ± 1.12 g) and

Table 3 – Comparison of the gastrointestinal tract between the greater cane rat and African giant pouched rat.

Parameter	Animal Species				P value
	Grater cane rat (n = 14)		African giant rat (n = 17)		
	Min-Max	Mean±SEM	Min-Max	Mean±SEM	
Weight (g)					
Body	360-2500	997.5±214.64	1120-1560	1344.7±29.53	n.s.
Gastrointestinal tract	40-69.5	46.84±1.95	65-86	78.72±1.12	< 0.01
Dimension (cm)					
Body length	50-425	139.92±26.76	125-300	214.71±11.75	< 0.05
Gastrointestinal tract length	114.1-239	167.41±11.1	121.7-206.6	156.81±4.86	n.s.
Stomach length	7.25-21.4	12.08±1.0	11.8-27.7	18.89±1.21	< 0.01
Stomach width	1.7-3.3	2.42±0.11	3.4-4.9	3.95±0.11	0.01
Duodenum length	5.2-10.6	7.564±0.06	6.3-12.4	8.92±0.50	n.s.
Duodenum width	0.4-1.0	0.73±0.04	0.3-1.2	0.77±0.06	n.s.
Jejunum length	22.9-80.7	48.23±4.21	32-90.7	52.2±3.62	n.s.
Jejunum width	0.4-0.9	0.65±0.04	0.5-1.0	0.78±0.04	< 0.05
Ileum length	6.6-14.7	9.66±0.64	7.3-21.3	10.78±0.89	n.s.
Ileum width	0.3-0.7	0.51±0.04	0.5-1.0	0.68±0.035	0.01
Cecum length	10.2-24	15.46±1.12	10.2-23.4	14.22±0.95	n.s.
Cecum width	2.2-6.2	3.75±0.36	1.5-2.8	2.09±0.08	0.01
Colon length	45-148	69.87±7.94	31.5-67.1	44.52±1.99	0.01
Colon width	0.5-1.4	0.84±0.06	0.5-1.3	0.84±0.06	n.s.
Rectum length	5.0-12.3	8.68±0.62	7.0-13.1	10.08±0.47	n.s.
Rectum width	0.3-1.2	0.56±0.07	0.5-1.1	0.73±0.05	n.s.
SI length	-	74.93	-	80.46	-
LI length	-	100.28	-	69.97	-

n = sample size, Min = minimum, Min = maximum, SEM = n = sample size, Min = minimum, Min = maximum, SEM standard error of mean, SI = small intestine, LI = large intestine, n.s. = not significant.

body length (214.71 ± 11.75 cm) were significantly higher in AGR than GCR (46.84 ± 1.95 g and 139.92 ± 26.76 cm; $P < 0.01$ and $P < 0.05$ respectively). Also, the mean width of the stomach (3.95 ± 0.11 cm) and ileum (0.68 ± 0.04 cm) of AGR were wider than those of GCR (12.08 ± 1.0 cm and 2.42 ± 0.11 cm respectively; $P < 0.01$ for both parameters). Furthermore, the differences between AGR and GCR in rectal width (0.73 ± 0.05 cm and 0.56 ± 0.07 cm respectively) and duodenal length (8.92 ± 0.50 cm and 7.56 ± 0.06 cm respectively) were statistically significant ($P < 0.05$).

The longest gastrointestinal tract segment in this study was noted to be jejunum (52.2 ± 3.62 cm) in AGR and colon (69.87 ± 7.94 cm) in GCR. The cecal mean length and width of GRC (15.46 ± 1.12 cm and 3.75 ± 0.36 cm) were higher than those of AGR (14.22 ± 0.95 cm and 2.09 ± 0.08 cm respectively; $P < 0.01$). Also, the colon length of GCR (range 45 - 148 cm, mean and SEM 69.89 ± 7.94 cm) was longer than that of AGR (range 31.5 - 67.1 mean and SEM 44.52 ± 1.99 cm; $P < 0.01$) (Table 3).

The sum of the length of the small (duodenum, jejunum and ileum) and large (cecum, rectum and rectum) intestinal segments was 74.93 cm and 100.28 cm in GCR and 80.46 cm and 69.97 cm in AGR, respectively, therefore the ratio of small to large intestine length was 0.75 in GCR and 1.15 in AGR.

Discussion

The gross morphology of the digestive tract of the GCR and AGR in this study fits well with our earlier qualitative descriptions for these species (Ali et al., 2008; Byanet et al., 2008, 2010, 2011) and with the report of Rudolf and Stromberg (1976) for laboratory rat. In the present study, our priority was the quantitative analysis of the gastrointestinal tract in these species. Even though the general pattern is common to all rodents, there are peculiarities in the quantitative features, which may shade light on the correlation between structure and feeding habit. In the wild, AGRs are monogastric omnivores, which make them easy to feed in captivity (Mary, 1997), and GRCs are monogastric herbivores. Some farmers prepare GCRs diet in captivity with 80% grasses (*Penisetum pupureum* and *Panicum maximum*), plus a mixture of corn, wheat and mineral salts (Jori et al., 1995). Magnan (1912) had earlier demonstrated a correlation between gastrointestinal tract structure and diet. Also, Kotze et al. (2006), upon working on the gastrointestinal tract of the herbivore cape dune mole-rat (*Bathyergus suillus*), the largest mole-rat which feeds on low nutritional food such as grasses, concluded that the large cecum and ascending colon in this species may be associated to adaptation to diet.

The mean gastrointestinal tract weight was significantly higher in AGR than GRC. Jori et al. (1995) reported an average weight of full grown GCR between 2000 - 4000 g in females and 3000 - 6000 g in males, with a body length of 60 - 85 cm, while we have found a maximum weight of 2500 g in the GRC (Byanet et al., 2008, and the present report). GCR is therefore similar to the African brush-tailed porcupine (*Atherurus africanus*, Gray, 1842), another important rodent in Africa that is said to weigh 3000 g with body length of 40 - 50 cm (Jori, 1998). These values are higher than those documented for full grown AGR by several studies: 1000-1400 g (Kingdon, 1997), 999.66 g (Ibe et al. (2010) and 1310 g for males and 1200 g for females (Dzenda et al., 2011). Hence, on the average, GCR is bigger than AGR, at variance with what found here.

The reason for the present results may be that most of the GRC used in this research were comparatively young.

In the present work, the gastrointestinal tract of AGR was slightly longer than that of the GCR, anyway insignificant, while the stomach of the former was significantly longer and wider than that of the latter. The size of the stomach in AGR may be associated with them being monogastric omnivores. Similar to AGR, among rodents, the stomach of rat has been described also as monogastric compound, divided into two parts: proventriculus (non-glandular) and glandular (Rudolf and Stromberg, 1976). Variations in weight and size of the stomach have been shown to be related to the dietary habit. According to Sherwood (2002), the main function of the stomach is to break large molecules of food substances into smaller ones, so that they can easily be absorbed in the intestine.

According to Mary (1997), AGRs are hoarders and if offered them one of their favorite foods they will take as much as they are allowed. Unlike rats and GCRs, AGRs have cheek pouches like a hamster, which allow them to gather up several kilograms of nuts per night for storage underground. It has been known to stuff its pouches so full of date palm nuts so as to be hardly able to squeeze through the entrance of its burrow. Devyn *et al*. (2000) reported that when a large quantity of food is consumed regularly, it will cause the distension in the elastic muscles of the stomach and hence the growth of the organ. In agreement with Devyn *et al*. (2000), the larger stomach size in the AGR may be due to their voracious feeding habit as compared with GCRs, which as herbivores are hindgut fermenters (Cathy, 2006).

As GCR feeds on comparatively low nutritional food such as grasses (approximately 80%), the observed significantly higher mean cecal width and colon length in this species than in AGR may be viewed as a morphological adaptation to their diet habit. In herbivores, Stevens and Hume (1995) noted that the relative increase in size of the ceacum and ascending colon showed hindgut fermenter ability, where carbohydrates are broken down by microbial activity. Hindgut fermenters have been divided into cecum and colon fermenters (Hume and Sakaguchi, 1991), colon fermentation being observed in larger animals (such as horses, elephants and rhinos) and cecum fermentation in smaller animals like rodents (rabbit, guinea pig and chinchilla) (Cathy, 2006). The pattern found in GCR, with enlarged cecum and colon, is reminiscent of that of rabbit or guinea pig and indicates that GCR may also be classified as a cecum fermenter, as an adaptation to herbivorous diet. According to O' Malley (2005), the cecum of rabbit is large and contains 40% of the intestinal contents, having 10 times the capacity of the stomach, and rabbit is considered a typical cecal fermenter.

It would be of interest to obtain measurements from wild AGRs and GCRs and compare them with those from captive rodents presented here. These studies may help breeders to optimize diets for these species in captivity and veterinary clinicians in taking care of these important African rodents.

References

Adu E. K. (2005) Constrains to grasscutter production in Ghana. Proc. In: Antoh T., Weidinger R., Ahiaba J., Carrilo A., Eds. International Forum on Grasscutter (Institute of Local Government Studies, Accra, Ghana, December, 12-16). Ministry of Food and Agriculture, Accra, Ghana. Pp. 44-50.

Adu E. K., Yeboah S. (2002) Experiences of a research Institute on grasscutter farming in Ghana. Animal Research Institute, CSIR, Ghana. Pp. 1-5.

Ajayi S. S. (1971) Wildlife as a source of protein in Nigeria: Some priorities for development. The Nig. Field 36: 115.

Ali M. N., Byanet O., Salami S.O., Imam J., Maidawa S.M., Umosen A.D., Alphonsus C. Nzalak J.O. (2008) Gross anatomical aspects of the gastrointestinal tract of the wild African giant pouched rat (*Cricetomys gambianus*). Sci. Res. Essay 3: 518-520.

Alogninouwa T., Agba K. C., Agossou E., Kpodekon M. (1996) Anatomical, histological and functional specificities of the digestive tract in the male grasscutter *(Thryonomys swinderianus,* Temminck 1827). Anat. Histol. Embryol. 25, 15-21.

Anizoba M. A. (1982) Reproductive cycles of the African Giant rat (*Cricetomysgambianus* 1840) in the wild rodentia. Rev. Zool. Afr. 96: 833-840.

Asibey E. O. A. (1974) Wildlife as a source of protein in Africa south of the Sahara. Biol.Conservation 6: 32-39.

Baptist R., Mensah, G. A. (1986) The cane rat farm Animal of the future in Benin and West Africa. World Animal Rev. 60: 2-6.

Byanet O., Nzalak J.O., Salami S.O., Nwogu I.C., Bosha J.A. (2008) Macroscopic studies of the gastrointestinal tract of the African grasscutter (*Thryonomys swinderianus*). Vet. Res. 2: 17-21.

Byanet O., Salami S.O., Ali M.N., Imam J., Maidawa S.M., Umosen A.D., Alphonsus C., Nzalak J.O. (2010) The macro-anatomy of the stomach of wild African giant pouched rat (*Cricetomys gambianus*). Sahel J. Vet. Sci. 9: 69-72.

Byanet O., Abdu P.A., Shekaro, A. (2011) Histomorphology of the gastrointestinal tract of domesticated grasscutter (*Thyronomys swinderianus*) in Northern Nigeria. J. Res. Biol. 6: 429-434.

Cathy A. J. (2006) Anatomy and physiology of the rabbit and rodent gastrointestinal system. Association of Exotic Mammal Veterinarians 2006 Proceedings. Pp. 9-14. On line at: www.aemv.org/documents/2006_aemv_proceedings_2.pdf, accessed Dec 10, 2014

Devyn M.S., Rayetta C., Grast N., Theodosio C.J., Clifford J.T., Nanette, M.N. (2000) Evolution relationships between the amphibian, avian and mammalian stomachs. Evol. Dev. 2: 348-359.

Dzenda T., Ayo, J.O., Lakpini, C.A.M., Adelaiye, A.B. (2011) Seasonal and sex variations in live weights of captive African giant rats (*Cricetomys gambianus*, Waterhouse) in the guinea savannah zone of Nigeria. Int. J. Zool. Res. 7: 49-58.

Eben A. B. (2004) Grasscutter: importance, habitat, characteristics, feed and feeding, breeding and diseases. Centre for Biodiversity Utilization and Development (CBUD), Kumasi, Ghana. Pp. 1-4.

Hirakawa H. (2001) Coprophagy in leporids and other mammalian herbivores. Mammal. Rev. 31: 61–80.

Hume I. D., Sakaguchi S. (1991) Patterns of digesta flow and digestion in foregut and hindgut fermenters. In: Tsuda T., Saaski Y., Kawashima R., Eds. Physiological Aspects of Digestion and Metabolism in Ruminants. Academic Press, San Diego, CA. Pp. 427-451.

Ibe C.S., Onyeanusi B.I., Hambolu J.O, Ayo J.O. (2010) Sexual dimorphism in the whole brain and brainstem morphometry in the African giant pouched rat (*Cricetomys gambianus*, Waterhouse 1840). Folia Morphol. 69: 69-74.

Jori F., Mensah G. A., adjanohoun E. (1995) Grasscutter thyronomy prudence: an example of rational exploitation of wildlife. Biodiv. Conservation 4: 257-265.

Jori F. (1998) Évaluation de la diffusion de l'aula condiculture au Gabon. Acquis, Vsf report, Libreville. P. 41.

Kingdon J. (1997) African giant rat. In: The Kingdon Field Guide to African Mammals. Academic Press, London. Pp.199-200.

Kotze S., Van der MerweH.E.L., O'Riain M. J. (2006) The topography and gross anatomy of the gastrointestinal tract of the Cape Dune mole-rat (*Bathyergus suillus*). Anat. Histol. Embryol. 35: 259-264.

Magnan A. (1912) Le régime alimentaire et la longeur de l'intestin chez les Mammifères. C.R. Acad. Sci. (Paris) 154: 129-131.

Mary A. I. (1997) African giant pouched rats ...as pets. Rat & Mouse Gazette Jul/Aug. Pp. 1- 8. On line at: www.rmca.org/Articles/giant.htm, accessed Dec 10, 2014.

NRC, National Research Council (1991): Micro-Livestock: Little Known small animals with a promising economic future. National Academy Press, Washington D.C. Pp 192-282.

Ntiamo-Baidu Y. (1998) Wildlife development plan 1998-2003. In: Sustainable Use of Bush Meat. Wildlife department, Ministry of Lands and Forestry, Accra, Ghana.

O'Malley B. (2005) Clinical Anatomy and Physiology of Exotic Species: Structure and Function of Mammals, Birds, Reptiles and Amphibians. Elsevier Saunders, London, UK.

Raymond H. O. (2000) Grasscutter Farming. Raymond-Hill Communications and Fresh Dew Consult, Accra, Ghana. Pp 1-26.

Rudolf H., Stromberg M.W. (1976) Digestive system. In: Hebel R., Stromberg M.W. (Eds.) Anatomy of the Laboratory Rat. Williams and Wilkins, Baltimore, USA. Pp. 43-51.

Sherwood L. H. (2002) Human Physiology: From Cells to System, 5th edn. Brooks Cole, Pacific Grove, CA. P. 604.

Stevens C.E., Hume I.D. (1995) Comparative Physiology of the Vertebrate Digestive System. Cambridge University Press, Cambridge.

Smith L. S. (1989) Digestive functions in teleost fish. In: Halbert J.E. Ed. Fish Nutrition. Academic Press, San Diego. Pp. 331-421.

Yeboa S., Adamu, E.K. (1995) The cane rat. Biologist 42: 86-87.