

Research Article

## Gross–anatomical and morphometric studies of the Grasscutter (*Thryonomyswinderianus*), axial skeleton

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### Abstract

The Axial skeleton of the Grasscutter (*Thryonomyswinderianus*) was studied using twelve (12) adult rats of both sexes with mean weights of  $1.4167 \pm 0.2023$ kg and  $0.8167 \pm 0.1276$ kg for bucks and does respectively. Characteristics of the bones were studied by gross observation after preparation. Three methods of bone preparation; Maceration, Chemical (Sodium hydroxide) and Burial were employed. The rats were housed and prepared in the Department of Anatomy laboratory, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria. Measurements of different segments of the Axial skeleton were also taken giving a total length of 57.9cm out of which the tail took 15.0cm (26%). Correlation coefficient between length of each bone segment and weight of each animal revealed statistical significance ( $P < 0.05$ ) in all bone segments when both sexes ( $n = 12$ ) were considered signifying a positive relationship between weight of the animal and its bone size. The skull presented an elongated structure of flat bones separated by sutures with the long nasal bones positioned dorsal to the premaxilla only. The vertebral formula of the Grasscutter was C7 T13 L6 S4 C18-23 with no transverse foramen on the 7th cervical vertebra and a prominent mammillary and accessory processes on the lumbar vertebrae. The Thorax presented thirteen (13) pairs of ribs, drumstick clavicle and six (6) sternbrae. The average total number of bones in the Axial skeleton of the rat was eighty eight (88) bones. Sexual dimorphism was not noticed except in the number of coccygeal vertebra which was twenty (20) in the Does and eighteen (18) in the Bucks.

**Keywords:** Grasscutter, Axial skeleton, vertebral formula

### INTRODUCTION

The grasscutter (*Thryonomyswinderianus*) is one of the two species of Cane rats, a small family of African hystricognath rodents, the other species being *Thryonomysgregorianus* commonly called the smaller cane rat (NRC, 1991). It is common in Africa, south of the Sahara (Fitzinger, 1997) and found naturally near marshes and riverbanks (Mills and Hes, 1997). Being the preferred and most expensive bush meat in West Africa (Asibey and Addo, 2000), it is hunted aggressively in the wild, leading to destruction of the environment through setting of bush fires by hunters (Yeboah and Adamu, 1995) thus posing a threat to the ultimate survival of the species. The aforementioned problem has led to an increasing amount of interest in the domestication of this rat (NRC, 1991). An important step towards the domestication of this rat is to understand its biology and adaptation. Literature search revealed that studies have been conducted and documented in areas of reproduction (Addo, 2000), housing and management system (Eben, 2004; NRC, 1991) and brain (Sahinet *et al.*, 2001; Yucel *et al.*, 2002; Murshed *et al.*, 2003; Nzalak *et al.*, 2008; Byanetet *et al.*, 2008), however none has been documented on the complete Axial skeleton of this rat. Consequently, this study was

conducted to document the axial skeletal morphology and morphometry of the Grasscutter's thereby establishing a basic science pre-requisite for future biomedical investigation.

## MATERIALS AND METHODS

A total of twelve matured grasscutters (*Thryonomys swinderianus*) of both sexes (6 bucks, 6 does) were purchased from Otukpo, Benue state, Nigeria. They were transported and housed in customized laboratory rat cages of the Department of Anatomy Laboratory, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria. They were fed with grasses, sweet potato, groundnut pellets, sugar cane and given water *ad libitum* prior to commencement of the study. The rats were weighed using a balance (SALTER model 250) with a sensitivity of 0.1g and euthanized using gaseous chloroform in a confined container.

Three different methods were used to clean the bones, namely: water maceration, burial and chemical (Sodium hydroxide). Four rats (2 bucks, 2 does) were used for each of the three methods.

### Maceration

The rats were dissected using a surgical blade to remove skin, thoracic, abdominal and pelvic contents. The muscles were carefully dissected and teased away to leave the bones with minimal soft tissue attachments. They were then put into different plastic buckets (labelled according to the rat's weights) containing water enough to submerge the bones. The plastic buckets were then covered air tight and placed under the sun for days with change of water every other day after which the water was drained and the bones recovered and dried. The number of days it took for complete maceration was noted and recorded.

### Burial

With this method the rats were dissected using a surgical blade to remove skin, thoracic, abdominal and pelvic contents. The muscles were carefully dissected and teased away to leave the bones with minimal soft tissue attachments. The partially cleaned bones were then wrapped with mesh sacs, buried two feet deep in rich humid soil and checked every other day to determine when the bones can be recovered. The recovered bones were washed with water to remove attached soil and then air dried under room temperature. The number of days it took for complete bone recovery was noted and recorded.

### Chemical (Sodium hydroxide)

The rats were carefully dissected using a surgical blade to remove as much soft tissue and internal contents as possible from the bones. The partially cleaned bones were immersed in plastic buckets containing 3% solution of NaOH. The plastic buckets were then placed under the sun and checked every 30 minutes to recover the bones as they were cleaned in order to avoid digestion of the bones by the NaOH. The recovered bones were then washed in running water and air dried under an electric fan. The time it took for complete recovery was also noted and recorded.

### Presentation of bones

Photographs of the bones recovered from the three methods were taken as a whole noting the colour change. The bones were then articulated using glue, noting the number of bones that constituted each segment and their lengths measured.

### Statistical analysis

Graph pad prism version 5.0 was used to calculate the range, mean, standard error of mean of the length of bones and correlation between weight of the rats and length of its bones. P - Values less than 0.05 were considered significant.

## RESULTS

The three methods of bone preparation (**Maceration, Burial and Sodium hydroxide**) used in the study revealed different effects on the bones such as colour change, odour, length of time taken for complete bone recovery and

relative damage. However, all methods showed the ability to separate the extremities of long bones from the shaft during preparation, although this property was seen to reduce in the weightier animals.

Maceration method (at 31°C) in the rainy season took eight (8) days for complete bone recovery which turned the bones whitish and produced a strong odour from the bones. There were no cracks after these number of days.

Burial method which was also done in the rainy season took fourteen(14) days for complete bone recovery. It turned the bone brownish and produced a strong nauseating odour from the bones. No cracks were seen after these number of days.

Chemical method using Sodium hydroxide (3%) at 31°C in the rainy season took approximately eight (8) hours for complete bone recovery. It turned the bones ash as though it had been cooked with the extremities of long bones appearing darker than the shaft. The bones were odourless. However, cracks in smaller bones were noticed in smaller animals.

**Table 1.** Comparison of results from the three methods of bone preparation

Parameters	Maceration	Burial	Sodium Hydroxide (3%)
Time	8 days	14 days	8 hours
Colour change	White	Brown	Ash
Odour Strong	Very	Strong	–
Damaging effect	–	–	Cracks
Preparation cost	N2,550	N2,250	N17,550

**Table 2:** Number of bones in the axial skeleton of the Grasscutter (*Thryonomys swinderianus*)

Bone	Number
Skull	1
Hyoid	1
Mandible	1
Clavicle	2
Sternum	6
Ribs	13 pairs (26)
Cervical vertebra	7
Thoracic vertebra	13
Lumbar vertebra	6
Sacral vertebra	4
Coccygeal vertebra	18-23
<b>Total number</b>	<b>85-90 Av. 88</b>

**Table 3.** Lengths of different bone segments

Skeletal parts	Length	
	Range (cm)	Mean ± SEM(cm)
Skull	7.000 - 9.950	7.8875±0.2270
Mandible	4.500 – 7.600	5.5583±0.2778
Clavicle	1.500 - 2.400	1.7750±0.0808
Sternum	4.200 - 7.000	5.0833±0.2611
Cervical vertebrae	3.300 - 4.000	3.6583±0.1640
Thoracic vertebrae	7.000 - 10.000	7.9750±0.2858
Lumbar vertebrae	5.700 - 7.650	6.5292±0.1782
Sacral vertebrae	3.700 - 5.000	4.3333±0.1416
Caudal vertebrae	11.900 - 18.100	15.0833±0.5297

**Table 4.** Relationship between body weight and length of axial skeleton of the grasscutter

Pearson's correlation coefficients (r)			
Correlated parameters	Bucks (n = 6)	Does (n = 6)	Both sexes (n = 12)
Weight and Skull length	0.8731*	0.5671 <sup>ns</sup>	0.8559***
Weight and Mandible length	0.9111*	0.5064 <sup>ns</sup>	0.8764***
Weight and Clavicle length	0.8824*	0.7595 <sup>ns</sup>	0.9046***
Weight and Sternum length	0.8524*	0.8622*	0.8699***
Weight and cervical vertebra	0.7319 <sup>ns</sup>	0.4544 <sup>ns</sup>	0.7708**
Weight and thoracic vertebra	0.7508 <sup>ns</sup>	0.7362 <sup>ns</sup>	0.8404***
Weight and lumbar vertebra	0.8916*	0.4961 <sup>ns</sup>	0.8482***
Weight and sacral vertebra	0.8854*	0.7755 <sup>ns</sup>	0.8503***
Weight and caudal vertebra	0.8228*	0.7649 <sup>ns</sup>	0.8100**

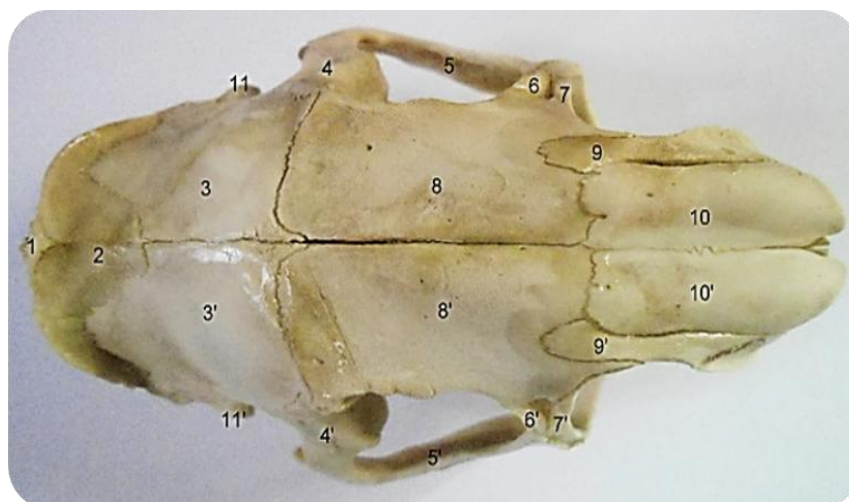
\*= Significant correlation ( $P < 0.05$ ) \*\*= Highly significant correlation ( $P < 0.01$ )

\*\*\*= Very highly significant correlation ( $P < 0.001$ ) <sup>ns</sup>= Non significant correlation

The **Skull** presented flat bones separated by sutures (plate 1.0). The dorsal aspect of the skull presented long nasal bones located dorso-rostrally and joined by the internasal suture. They are joined laterally by the premaxillo-nasal suture to the horizontal part of the premaxilla which houses part of the incisors. The nasal and premaxilla bones form the nasal cavity which contains the nasal concha. The frontal bone joined by the interfrontal suture extends horizontally from the parietal bones to meet with the nasal and premaxilla bones and perpendicularly to meet the maxilla. One interparietal bone crosses the paired parietal bone caudally. Caudo-ventrally, the skull presented the occipital bone which is divided into the squamous part and lateral part. The lateral part comprises the occipital condyle and paramastoid process which borders the foramen magnum.

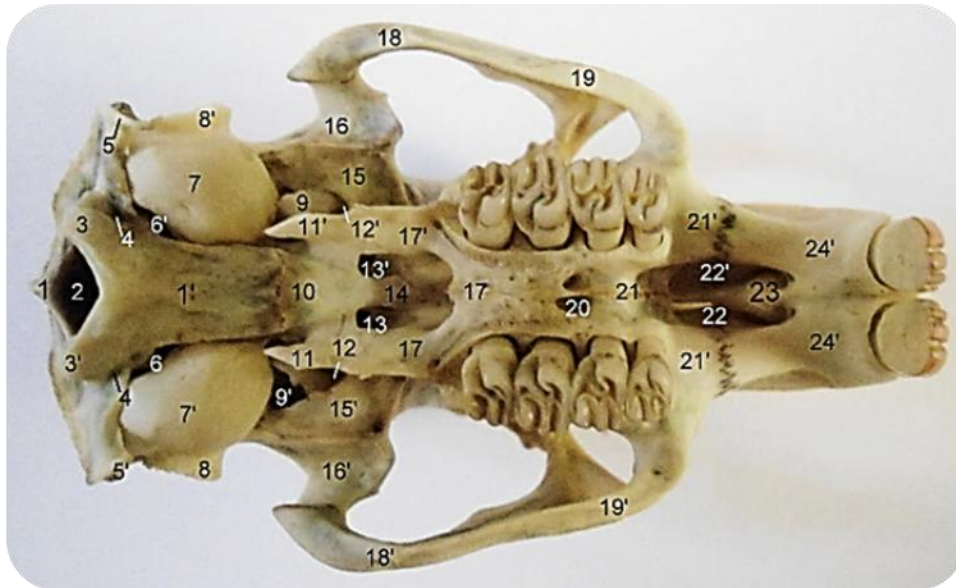
Ventrally, it presented the petrous bone which lodges the internal acoustic meatus. The sphenoid extends from the occipital bone anchoring the pterygoid bone dorsally and joining the squamous bone laterally through its wing. The palatine bone extends from the sphenoid bone to the maxilla. Also located ventrally are the following foramina Hypoglossal foramen, posterior and anterior foramen lacerum, petrotympanic fissure, oval foramen, posterior and anterior palatine foramen (plate 1.1). The maxilla anchors the premolars and molars while the premaxilla anchors the incisors (plate 1.1). Laterally, the squamous bone through its zygomatic process is joined to the zygomatic bone which extends rostrally to meet the malar process of the maxilla and lacrimal bone dorsally. The cranial cavity (plate 1.3) is made up of the occipital, interparietal, parietal, frontal, squamousal, petrous, sphenoid, palatine and ethmoid bones.

The **Mandible** presented a mandibular symphysis. The ramus of the mandible anchors the lower molars and premolars dorsally and the lower incisors rostrally. There is also the condyloid and coronoid processes for articulation with the skull. Laterally, there is a masseteric ridge on the ramus which bears the mental foramina (plate 2.0). The mandibular foramen is located between the condyloid and coronoid processes on the medial aspect of the mandible (plate 2.1). The **Hyoid** bone presented a body and 2 horns segmented by cartilages (plate 2.2 and 2.3).



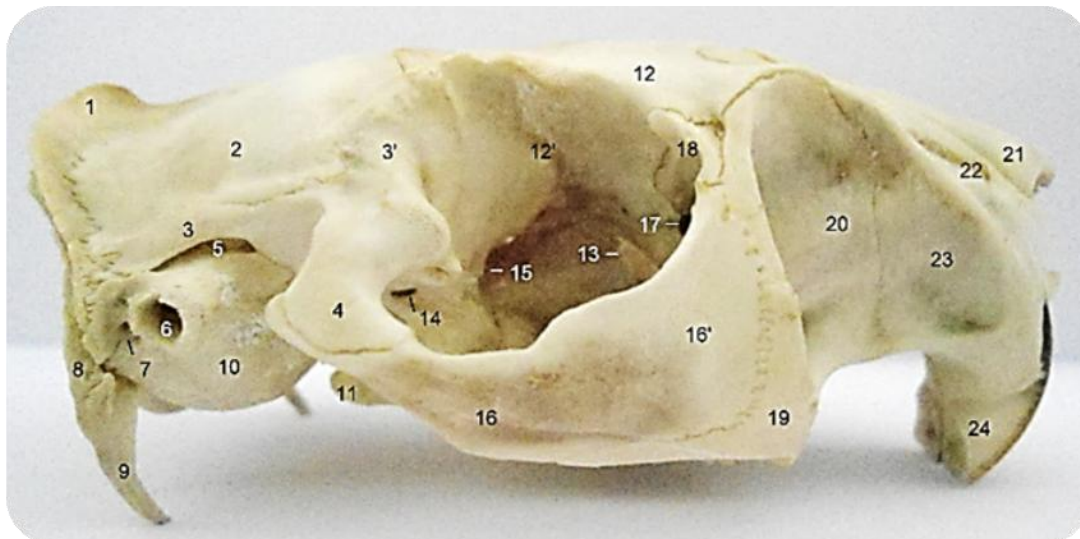
**Plate 1.0** Skull, dorsal view (Burial preparation)

1, Occipital crest; 2, Inter parietal bone; 3,3', Parietal bone; 4,4', Squamosal bone; 5,5', Zygomatic bone; 6,6', Lacrimal bone; 7,7', Maxilla; 8,8', Frontal bone; 9,9', Pre maxilla; 10,10', Nasal bone; 11,11', External acoustic meatus.



**Plate 1.1 Skull, Ventral view (NaOH preparation)**

1,1', Occipital bone; 2,2', Foramen magnum; 3,3', Occipital condyle; 4,4', Hypoglossal foramen; 5,5', Paramastoid process; 6,6', Posterior foramen lacerum; 7,7', Tympanic bulla; 8,8', External acoustic meatus; 9,9', Petro-tympanic fissure; 10, Basisphenoid; 11,11', Pterygoid process; 12,12', Oval foramen; 13,13', Anterior foramen lacerum; 14, Presphenoid; 15,15', Wing of sphenoid; 16,16', Squamosal bone; 17,17', Palatine bone; 18,18', Zygomatic bone; 19,19', Malar process of maxilla; 20, Posterior palatine foramen; 21,21', Maxilla; 22,22', Anterior palatine foramen; 23, Palatine process of premaxilla; 24,24', Premaxilla.



**PLATE 1.2 Skull, lateral view (Burial preparation)**

1, Interparietal bone; 2, Parietal bone; 3,3', Squamosal bone; 4, Zygomatic process of Squamosal bone; 5, Post glenoid foramen; 6, External acoustic meatus; 7, Stylomastoid foramen; 8, Occipital bone; 9, Paramastoid process; 10, Tympanic bulla; 11, Pterygoid process; 12,12', Vertical and horizontal parts of frontal bone; 13, Spheno-palatine foramen; 14, Oval foramen; 15, Anterior foramen lacerum; 16,16', Zygomatic bone; 17, Infra-orbital fissure; 18, Lacrimal bone; 19, Malar process of maxilla; 20, Maxilla; 21, Nasal bone; 22, Vertical part of premaxilla; 23, Horizontal part of premaxilla; 24, Incisors; 25, Optic foramen.



**Plate 1.3 Skull, Sagittal section (Burial preparation)**

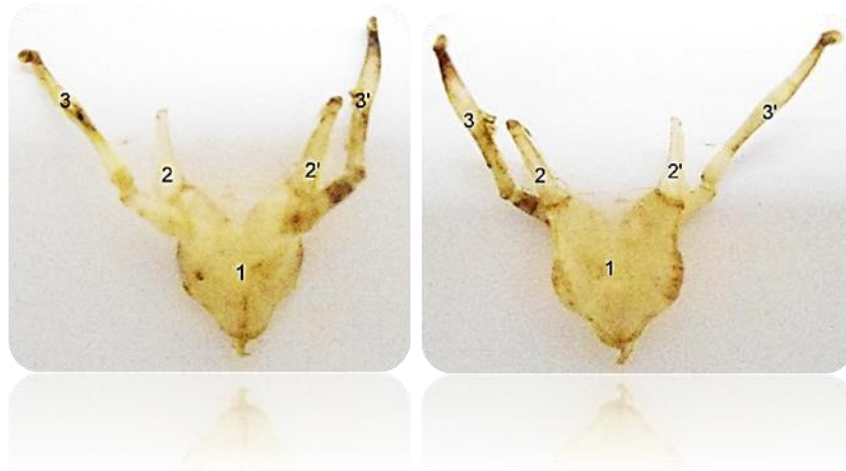
1, Paramastoid process; 2, Occipital condyle; 3, Interparietal bone; 4, Parietal bone; 5, Frontal bone; 6, Ethmoid bone (perpendicular plate); 7, Palatine bone; 8, Presphenoid; 9, Pterygoid bone; 10, Basisphenoid; 11, Pterygoid process; 12, Maxilla; 13, Premolars; 14, Ethmoid bone (lateral masses); 15, Cribriform plate; 16, Dorsal turbinate bone; 17, Dorsal nasal meatus; 19, Ventral turbinate bone; 20, Premaxilla; 21, Incisors; 22, Cranial cavity; a, Posterior foramen lacerum; b, Internal acoustic meatus; c, Facial canal; d, Post glenoid foramen; e, Petro tympanic fissure; f, Oval foramen; g, External acoustic meatus; h, Sphenopalatine foramen; i, Anterior foramen lacerum.



**PLATE 2.0 Mandibular half, Lateral view (Burial preparation)** 1, Incissor; 2, Mental foramina; 3, Premolars; 4,4', Horizontal and vertical parts of ramus of Mandible; 5, Masseteric ridge; 6, Coronoid process; 7, Condylod process; 8, Mandibular angle.



**Plate 2.1 Mandibular half, medial view (Burial preparation)** 1, Incissor; 2, Symphysis; 3, Inter-alveolar border; 4, Premolars; 5, molar; 6, Horizontal and vertical parts of ramus of mandible; 7, Mandibular angle; 8, Coronoid process; 9, Mandibular foramen; 10, Condylod process.



**Plate 2.2** and 2.3 Hyoid bone, Cranial (L) and Caudal views (R) NaOH preparation  
1, Body; 2,2', Lesser horn; 3,3', Greater horn.

The **Vertebral Column** consists of 7 cervical vertebrae, 13 thoracic vertebrae, 6 lumbar vertebrae, 4 sacral vertebrae and 18-23 caudal vertebrae. The 6th cervical vertebrae presented a plate of bone extending ventrally (ventral process) from the transverse process. The 7th cervical vertebrae presented no transverse foramen as seen in other cervical vertebra.

The 2nd to 11th thoracic vertebrae appeared similar morphologically with an increase in prominence of the spinous process (plate 3.1). The 12th and 13th thoracic vertebra appeared similar morphologically to the lumbar vertebra and possessed mammillary process in between the articular and spinous processes (plate 3.1).

The lumbar vertebra presented prominent mammillary process cranially and anapophysis caudally. The transverse process of the 6th lumbar vertebrae is most prominent.

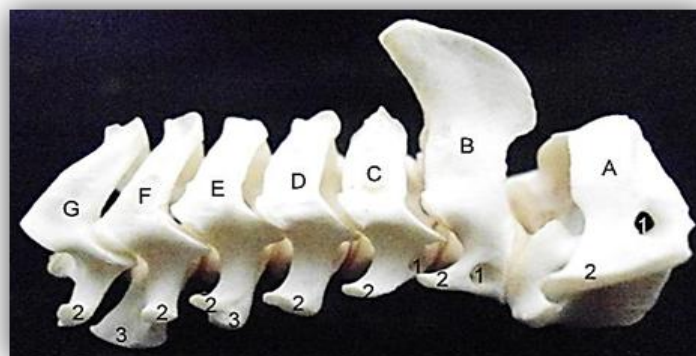
The sacrum presented dorsal and ventral foramina and unfused spinous processes while the 1st sacral vertebrae presented wings (transverse process) for articulation with the ilium (plates 3.3).

The coccygeal vertebra presented an average of 20 bones with its cranial, middle and caudal portions being of different sizes and morphology (plate 3.4).

The **ribcage** presented 13 pairs of ribs with 7 pairs sternal and 6 pairs asternal out of which 2 pairs are floating. Each segment of the axial skeleton was measured giving a total length of 45.5cm out of which the tail takes 33.2% (15.1cm).

The **clavicle** which is attached cranially to the scapula and caudally to the sternum presented drumstick morphology with a body and two extremities (plate 4.2 and 4.3).

The **sternum** has 6 sternebrae with the manubrium longer than others. They provide articular surfaces for cartilage articulation. The xyphoid cartilage, a relatively small flat structure extends at the caudal end of the 6th sternebrae (plates 4.5 and 4.6).



**Plate 3.0. Cervical vertebra, Lateral view (Above). Maceration**  
1, Transverse foramen; 2, Transverse process; 3, Ventral process; A-G,  
First to Seventh Cervical Vertebra



**Plate 3.1.** Thoracic vertebra, Lateral view (Maceration)  
1, Spinous process; 2, Transverse process; 3, Intervertebral foramen; 4, Body; 5, Mammillary process; 6, Body; 7, Transverse process.



**Plate 3.2** Lumbar vertebra, Lateral view (Maceration)



**Plate 3.3** Sacral vertebra, Lateral view (Maceration)  
1, Spinous process; 2, Articular process; 3, Wing of Sacrum; 4, Auricular surface





**Plate 3.4.** Cranial (A), Middle (B) and Caudal (C) portion of coccygeal vertebra, Dorsal view (NaOH preparation)



**Plate 4.0.** 1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 8th Ribs, lateral view (NaOH preparation)



**Plate 4.1.** Clavicle, Lateral (R) and Medial view(L) (NaOH preparation)  
 1, Head; 2, Neck; 3, Tubercle; 4, Sternal extremity; 5, Cranial border; 6, Caudal border; 7, Sternal end; 8, Body; 9, Acromial end.



**Plate 4.2.** RIB CAGE, Lateral view (Burial preparation)  
3, Ribs; 4, Thoracic vertebra



**Plates 4.5 and 4.6.** Sternum, Ventral (R) and Dorsal (L) view (NaOH preparation)  
1, Xiphoid cartilage; 2, Sternal cartilage; A-E, Sternabra; F, Manibriumsterni.

## DISCUSSION AND CONCLUSION

The results obtained from the three methods of bone preparation employed in this study showed that all three methods possess advantages and disadvantages which determines the best suitable for use in small animals.

Sodium hydroxide produces no odour and recovers the bones quickly than other methods. This makes it suitable for faster skeleton extraction when needed urgently. However, it is relatively expensive when compared to the other methods and it dissolves smaller bones into bone hells. The flesh of the animal is not dissolved at the same time by the chemical therefore bones need to be removed from the chemical as soon as the flesh dissolves. Some bones with much flesh like the skull and vertebral column need more exposure time which leads to cracks and softening of bones. Also, the appearance of the bones after recovery is not aesthetic as the extremities of long bones appear darker although whitening can be achieved by use of a bleaching agent.

Maceration takes longer time, produces strong and distasteful odour but is suitable in terms of less bone damaging effect, whitening of the bones and affordability.

Burial method takes the longest time in this animal, produces very strong nauseating odour and turns the bones brownish. However, its suitability is based on the fact that it is not expensive and does not damage bones except when left longer in the soil for more than two weeks.

The mean weight of the buck ( $1.4167 \pm 0.2023$ kg) is greater than that of the doe ( $0.8167 \pm 0.1276$ kg) which agrees with the findings of Merwe (2000). The statistical significance ( $P > 0.05$ ) and positive  $r$  values obtained signifies that the weights of grasscutter positively affect the length and size of its bones, that is the weightier the animals, the longer its length of bones.

The average number of bones in the Axial Skeleton of the grasscutter (*Thryonomys swinderianus*) is eighty eight (88). This number is not static for all members of this species as variation in the number of coccygeal vertebrae of each animal will alter it. The number is also different from other members of the rodent family such as African giant rat (*Cricetomys gambianus*) which has an average of 91 bones in its axial skeleton (Salami *et al*, 2011; Onwuama *et al*, 2013).

The study of the axial skeleton of the grasscutter (*Thryonomys swinderianus*) revealed significant similarity and differences in morphology to that of other rodents and domestic animals.

The Skull which appeared elongated presented flat bones separated by sutures. This is true of most rodents except for the guinea pig which contains partly cartilage and partly fibrous membrane with total of six suture joints (Animal corner, 2009). The long nasal bones are positioned dorsal to the premaxilla bone only; together they form the nasal cavity. This is different from most domestic animals in which the nasal bones are dorsal to both maxilla and premaxilla bones (Sisson and Grossman, 1975). This finding may not be unconnected to the fact that the grasscutter is a burrowing animal and therefore needs a simple and straight passage for the low oxygen tension in the burrow. The pterygoid bone unlike reported in the African giant rat (Onwuama *et al*, 2013), Albino rat (Green, 1968) and the laboratory mouse (Cook, 1965) does not divide into two processes.

The vertebral formula C7 T13 L6 S4 C18-23 is similar to most rodents with the exception of the coccygeal vertebra. The absence of a transverse foramen on the 7th cervical vertebra is also in agreement with the African giant rat (Onwuama *et al*, 2013), Albino rat (Green, 1968) and laboratory mouse (Cook, 1965). The mammillary process and anapophysis (accessory process) are very prominent on the lumbar vertebrae. In domestic animals, these processes may or may not be present depending on the species. The cranial, middle and caudal portions of the coccygeal vertebra presents differences in size and morphology typical of any other mammalian coccygeal bones.

The presence of a clavicle in the grasscutter is a common feature of the rodent family. It is one of the characteristics of a burrowing animal (Green, 1968). Its presence has also been reported in guinea pig (Wagner and Manning, 1976), rabbit (Ucar *et al*, 1985) and mole rat (Ozkan, 2007).

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