International Journal of Veterinary Science and Animal Husbandry
Vol. 2(1), pp. 006-012, July, 2015. © www.premierpublishers.org **ISSN:** 2141-5080

IJVSAH

Research Article

Macro–anatomical and morphometric studies of the Grasscutter (*thryonomysswinderianus*), forelimb skeleton

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The Forelimb of the Grasscutter (*Thryonomysswinderianus)* was studied using 12 adult rats of both sexes with mean weights of 5167±0.2023kg and 0.8167±0.1276kg for male and female respectively. Correlation coefficient between length of each bone segment and weight of each animal revealed statistical significance (P < 0.05) in all bone segments except the manus when both sexes (n = 12) were considered signifying a positive relationship between weight of the animal and its bone size. The average total number of bones in the forelimb of the rat is 96 bones. Sexual dimorphism was not noticed. The bones of the forelimb revealed significant differences and similarities in morphology to that of other rodents and domestic animals. The Scapula presented a prominent triangular shaped metacromion and acromion process, the Humerus presented well defined head and distinct deltoid tuberosity protruding from the midshaft. The ulna and radius fuses proximally and distally leaving an expansive interosseus space. There were 8 irregularly shaped carpal bones arranged 3 proximally and 5 distally. Metacarpal and digital bones are 5 on each forelimb with the first and fifth greatly reduced with each digit presenting 3 phalanges.

Key words: Grasscutter, forelimb, bones, Macro-Anatomical

INTRODUCTION

The grasscutter (*Thryonomysswinderianus*) 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 (Sahin *et al*., 2001, Yucel*et al*., 2002, Murshed *et al*., 2003, Nzalak *et al*., 2008, Byanet *et al*., 2008), however none has been documented on the forelimb of this rat. Consequently, this study was conducted to document the appendicular skeleton (forelimb) morphology and morphometry of the Grasscutter thereby establishing a basic science pre-requisite for future biomedical investigation.

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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	N2,250	N2,250	N17,550

MATERIALS AND METHODS

A total of twelve matured grass cutters (*Thryonomysswinderianus*), 6 males and 6 females 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 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 males, 2 females) 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 were 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.
2.5 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

Cold water maceration took 8 days for complete bone recovery, turned the bones white, emitted strong odour and was cheap to prepare. Burial method took 14 days, turned the bones brown, emitted very strong odour and was also cheap to prepare. The chemical method took 8 hours for complete bone recovery, turned the bones ash and was expensive. The chemical method is the best method for the bone preparation of this rat. Table 1.
The total number of bones of the forelimb of the grasscutter (*Thryonomysswinderianus)* is 96. Table 2.
This shows the length of different bone segments of the grasscutter (*Thryonomysswinderianus).* Table 3.
The above table shows that the length of bones increases as the weight of the grasscutter with the exception of the exception of the manus. Table 4.
The three methods of bone preparation (**Maceration, Burial and Sodium hydroxide**) used in the study

Table 2. Number of Bones on the Forelimb of the Grasscutter (*Thryonomysswinderianus*)

Bone	Number
Scapula	2
Humerus	2
Ulna	2
Radius	2
Carpals	16
Metacarpals	10
First phalanx	10
Second phalanx	10
Third phalanx	10
Sessamoid bones	32
Total number	**96**

Table 3. Lengths of different bone segments

	Skeletal parts	Length
Range (cm)	**Mean ± SEM (cm)**	
Scapula	3.5 - 5.5	4.28±0.17
Humerus	3.7 - 5.4	4.39±0.14
Ulna	4.1 - 6.0	4.93±0.16
Radius	3.0 - 4.3	3.68±0.12
Manus	3.0 - 3.3	3.13±0.03

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

	Pearson's correlation coefficient (r)		
Correlated parameters	**Male (n = 6)**	**Female (n = 6)**	**Both sexes (n = 12)**
Weight and Scapula length	0.94**	0.81^{ns}	0.94***
Weight and Humerus length	0.94**	0.72^{ns}	0.93***
Weight and Ulna length	0.94**	0.78^{ns}	0.94***
Weight and Radius length	0.92**	0.74^{ns}	0.89***
Weight and Manus length	-0.71^{ns}	0.80^{ns}	0.43^{ns}

*= Significant correlation (P < 0.05) **= Highly significant correlation (P < 0.01)
***= Very highly significant correlation (P < 0.001) ns= Non significant correlation

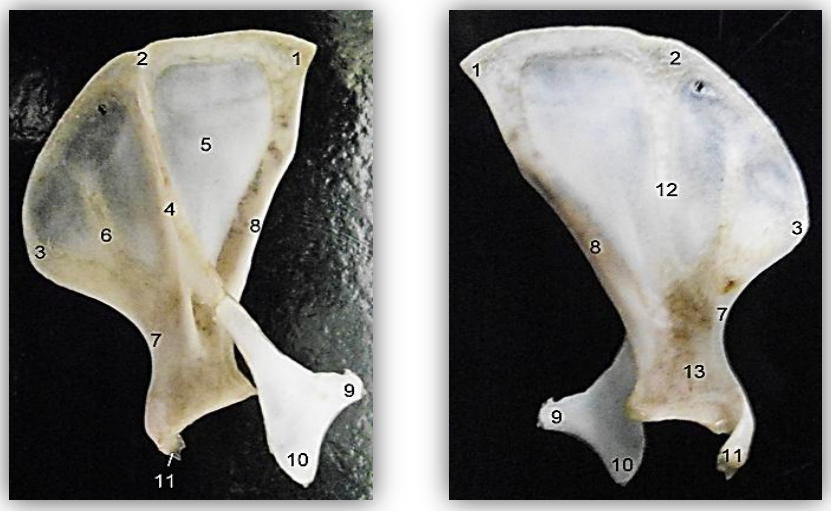
revealed different effects on the bones such as colour change, odour, length of time taken for complete bone recovery and relative damage. However, all methods showed the ability to separate the extremities of long bones from the shaft during preparation, although this property was seen to reduce in the weightier animals.

Maceration method (at 31˚c) in the rainy season took 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.

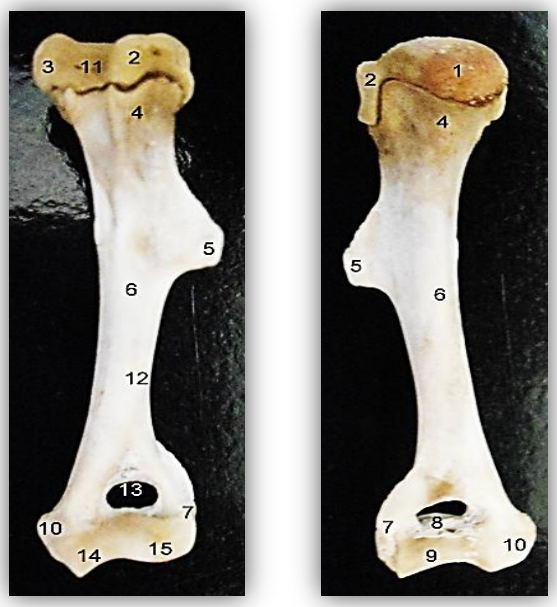
Burial method which was also done in the rainy season took 14 days for complete bone recovery. It turned the bone brownish and produced a strong nauseating odour from the bones. No cracks were seen after these number of days.

Chemical method using Sodium hydroxide (3%) at 31˚c in the rainy season took approximately 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 then the shaft. The bones were odourless. However, cracks in smaller bones were noticed in smaller animals.

The **Scapula** presented a roughly triangular shaped structure with a convex vertebral border and a slightly convex cranial border making the cranial angle indistinct. The caudal border is concave with a pronounced caudal angle. The scapula spine divides the lateral surface almost equally and extends downward (attached by a cartilage) to form a prominent triangular shaped suprahamatus and hamatus processes (1 and 2).



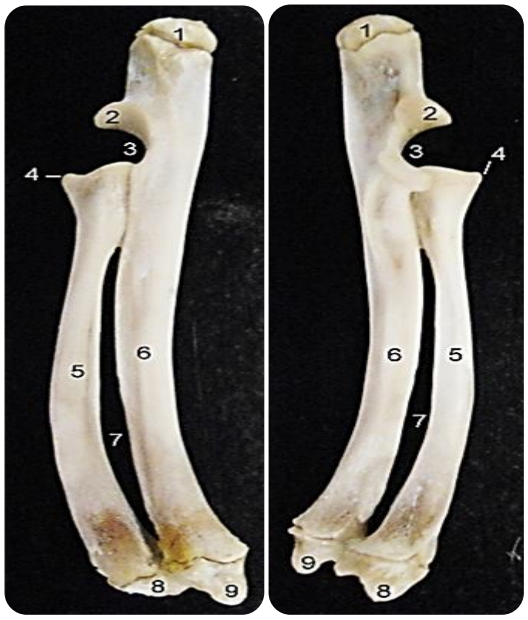
Figures 1 and 2. Scapula, Lateral (L) and Medial (R) view (NaOH preparation)
1, Cranial angle; 2, Vertebral border; 3, Caudal angle; 4, Scapula spine; 5, Supraspinous fossa; 6, Infraspinous fossa; 7, Caudal border; 8, Cranial border; 9, Suprahamatus process; 10, Hamatus process; 11, Coracoid process; 12, Subscapular fossa; 13, Neck.



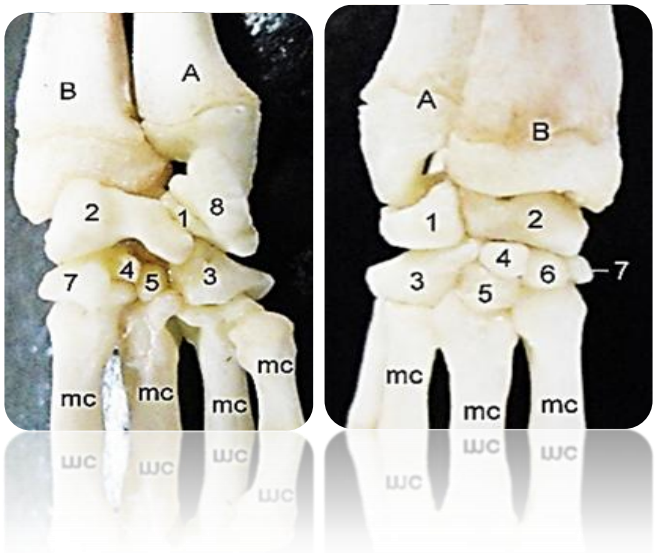
Figures 3 and 4. Humerus, Cranial (R) and Caudal (L) view (Maceration)
1, Head; 2, Greater tubercle; 3, Lesser tubercle; 4, Neck; 5, Deltoid tuberosity; 6, body; 7, Lateral epicondyle; 8, Olecranon fossa; 9, Trochlea; 10, Medial epicondyle; 11, Intertuberalsulcus; 12, Sulcus m. brachialis; 13, Supratrochlear fossa; 14, Medial condyle; 15, Lateral condyle

The **Humerus** presented two extremities (proximal and distal). The proximal extremity presents a prominent head, well defined neck and two tubercles (greater and lesser) separated by a sulcus m. brachialis. It also presents a distinct deltoid tuberosity protruding from the middle of the shaft. The distal extremity presents the olecranon fossa, lateral and medial epicondyle, lateral and medial condyle cranially, trochlea and supratrochlea fossa caudally (Fig. 3 and 4).

The Ulna is the longer of the forearm bones and attaches to the Radius proximally and distally leaving an expansive interosseus space. Each bone ends up distally with a styloid process (Fig. 5 and 6).



Figures 5 and 6. Ulna and Radius, Lateral (R) and Medial (L) view (Burial preparation)
1, Olecranon; 2, Anconeal process; 3, Incisuratrochlearis; 4, Tuberositas radii; 5, Body of Radius; 6, Body of Ulna; 7, Interosseus space; 8, Styloid process of Radius; 9, Styloid process of Ulna.



Figures 7 and 8. Carpus, Dorsal (R) and Volar (L) view (Maceration)
A-Ulna; B-Radius; mc- Metacapal bone; 1, Os carpi radiale; 2,Os carpi Intermedium and Os carpi ulnare; 3, Hamate; 4, Centrale; 5, Capitate; 6, Lesser multangular; 7, Greater multangular; 8, Pisiform.

The **Carpus** presented a series of 8 nodular bones with more or less irregular shapes and flattened articular surfaces.
The bones are arranged in two rows of 3 proximally and 5 distally (Fig. 7 and 8). The proximal rolls articulate dorsally with the radio-ulna bone while the distal rolls articulate with the metacarpals.

Metacarpal and digital bones are 5 on each forelimb with the first and fifth greatly reduced. All the digits present 3 phalanges. On the volar surface of each metacarpophalangeal joint are 2 sessamoids. Also on the volar surface of each first interphalangeal joint are 2 sessamoids. The second interphalangeal joint has no sessamoid bones.

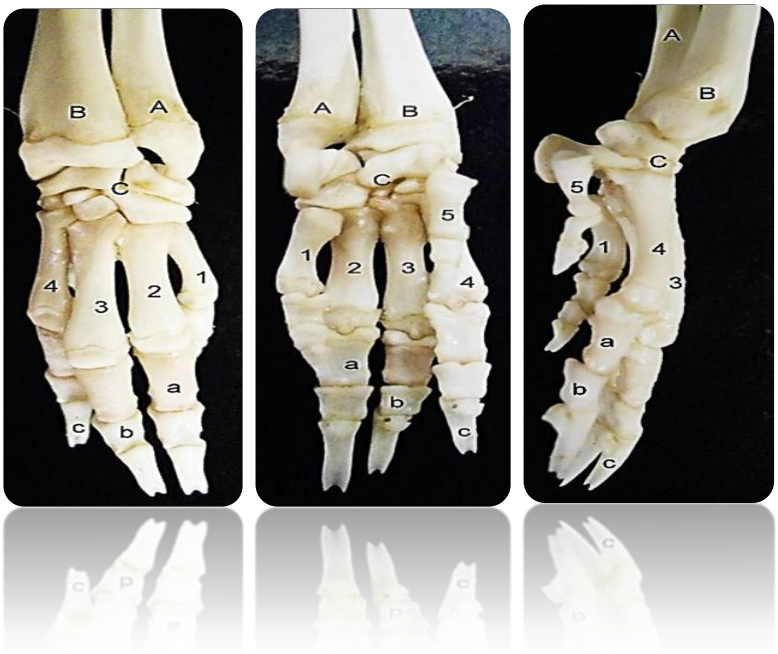


Figure 9. Manus, Dorsal (L), Volar (M) and Lateral (R) view (Maceration)
A-Ulna; B-Radius; C-Carpus; 1, 1st metacarpal; 2, 2nd metacarpal; 3, 3rd metacarpal; 4, 4th metacarpal; a-Proximal phalanx; b-Medial phalanx; c-Distal phalanx.

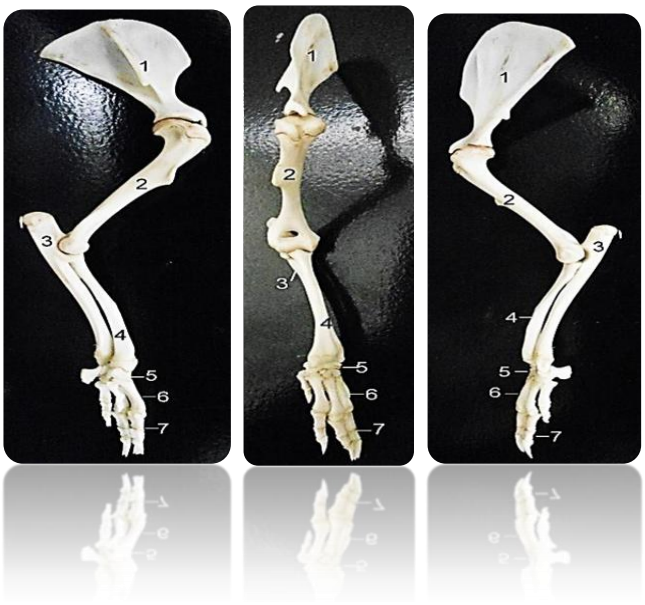


Figure 10. Forelimb, Lateral (L), Cranial (M) and Medial (R) view (Maceration)
1, Scapula; 2, Humerus; 3, Ulna; 4, Radius; 5, Carpus; 6, Metacarpals; 7, Digits.

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 halls. 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 male grasscutter (5167±0.2023kg) is greater than that of the female (0.8167±0.1276kg) 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 hamatus and suprahamatus processes seen on the scapula of the grasscutter have also been reported in other rodent species (Rudolf and Stromberg, 1976; Ozkan *et al*., 1997) and carnivorous animals (Sisson and Grossman, 1975). The presence of the distinct deltoid tuberosity on the shaft of the humerus agrees with reports on other rodents but differ in morphology. The supracondylar foramen seen on the distal extremity of the humerus is similar to what is reported for cats (Dyce *et al*.,2002).

The Ulna and radius presented no significant differences from the typical mammalian bones except for its extensive interosseus space. The number and arrangement of the manus is typical of the rodentia order and agreed with the work of Green (1968) on the albino rat. The arrangement of the carpal bones into two rows agrees with what is obtainable in other mammals such as horse, pig, dog, cat and ruminants (Sisson and Grossman, 1975). The observation of five digits in this rat is consistent with what is reported in other rodent species such as the african giant rat (Oludee*t al.,* 2010, Salami *et al*., 2011) and albino rat (Green, 1968). The arched and pointed shape of the distal phalanges is for easy burrowing and shovelling (Fitzinger, 1997).

ACKNOWLEDGEMENT

Technical staff of Department of Veterinary Anatomy, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria.

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Accepted 29 September, 2014.

Citation: Onwuama KT, Ojo SA, Hambolu JO, Dzenda T, Salami OS (2015). Macro–anatomical and morphometric studies of the Grasscutter (thryonomysswinderianus), forelimb skeleton. International Journal of Veterinary Science and Animal Husbandry 2(1): 006-012.