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Osteomorphology of the Appendicular Skeleton of Four-Toed African Hedgehogs (*Atelerix albiventris*) Part (2): Pelvic Limb

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Abstract: The study investigated the morphology and linear dimensions of the bones of pelvic limbs in four-toed African hedgehogs. Five (5) adult hedgehogs of different sexes with mean body weights of 224.2±22.14g, were used. The mean length of the ox coxae was 37.49±2.0mm. The average distance between the mid-acetabulum *and tuber coxae* was 20.98±1.29mm while that of the mid-acetabulum to *tuber ischiadicum* was 6.58±0.47mm. Also the average distance between the *tuber coxae* and the *tuber ischiadicum* was 26.62±1.48mm. Obturator foramen had a sagittal length of about 8.32mm and a width of 5.45mm. The vialletone angle was 131°. The mean length of the femur was 30.89±1.11mm. The mean length of the tibia and fibula was 34.30±1.24mm. A relatively large *foramen obturatum* roughly triangular in shape was observed. The *ala ossis ilii* was oriented dorsolaterally. Both *lineaglutea and fovae obturatum* were absent. The *symphysis pelvis* was formed by *symphysis pubis*, an interpubic ligamentous connection. The *caput femoris* and the *trochanter major* were of equal height. Two (2) prominent and a vestigial trochanters were observed. The tibia and fibula were separated by a *spatium interosseum* at their proximal half but united at their distal half. There were six *ossi tarsi* and the pedis was complete with four digits each with three phalanxes. The hallux was absent. This study has provided a basic research data that will be useful for comparative anatomical studies.

Key words: African Hedgehogs · Vialletone Angle · Pelvic Limb · Bones

INTRODUCTION

Hedgehogs are small nocturnal, insectivorous terrestrial wild mammals, belonging to the order Eulimorphyla, suborder Erinaceomorpha and family Erinacedae [1]. Hedgehogs have a dorsal coat of small, stout spine with a pointed muzzle, short hairy legs with clawed and well-padded toes [2]. They possess a generalize body plan [3]. The limbs and girdle are design for general adaptive function [4]. They are characterized by a reduced or absence of the hallux on their hind limbs [3].

Macro-anatomical studies on the skeletons of small mammals had been reported in the African giant rat [5, 6], mole rat [7], the porcupine [8] and rabbit [9]. On the skeletal systems of hedgehog's species, Ozkan [10] studied the pelvic limbs of European hedgehog (*E. europaeus*). Girgiri *et al*. [11] reported on the morphometrics of the foramen magnum in African hedgehogs (*Atelerix albiventris*). However, basic data on the osteomorphology of the pelvic limb of *A. albiventris* were scarcely found in literature.

MATERIALS AND METHODS

A total of five (5) adult hedgehogs of different sexes were used. The animal were handled in accordance with institutional ethical committee of faculty of veterinary medicine (University of Maiduguri) Nigeria. The pelvic limbs were processed by hot water maceration techniques, as describe by [5] and [12]. All bones of the pelvic limbs were weighed using Metler sensitive balance (model AE 163) with precision of 0.001gram (g). Linear dimensions of the bones were measured using a digital vernier calliper with a precision of 0.001mm and the values were recorded to the nearest 0.01millimeter (mm).Photographs of the

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bones were taken using a Panasonic digital camera (DMC-FH5) 16 mega pixel. The morphological features of the bones were grossly observed and documented. *Nomina anatomica veterineria* (NAV) 2012 was used for the anatomical terminologies.

The definition and description of the landmarks used were presented below;

- Maximum length of the os coxae (MLOC): Distance measured from the rest of the ilium (*crista iliaca*) to the caudal end of the ischial arch (*arcus ischiadicus*) of the os coxae (Figure 1).
- Maximum length of the obturator foramen (*foramen obturatum*) (MLOF): Widest distance measured from the cranial (*cranialis*) to the caudal (*caudalis*) end in its horizontal plane of the obturator foramen (Figure 1).
- The maximum width of the obturator foramen (MWOF): Widest distance measured between the lateral (*lateralis*) and medial (*medialis*) surfaces in its vertical plane of the obturator foramen (Figure 1).
- MMA-TC: maximum distance between mid-acetabulum to tuber coxae (Figure 1).
- MMA-IT: maximum distance between mid-acetabulum to ischial tuber (Figure 1).
- MIT-TC: maximum distance between ischial tuber to tuber coxae (Figure 1).
- The maximum length of the femur (MLF): Distance measured from the highest summit of the head (*caput ossis femuris*) to the distal end (*condylus femuris*) of the femur (Figure 2).
- The maximum width of the femur (MWF): Distance measured between the medial surface (*facies medialis*) and the lateral surface (*facies lateralis*) at the mid shaft (*corpus ossis femuris*) of the femur (Figure 2).
- Maximum length of the patella (MLP): Distance measured between *basis patellae* and distal end of the patella.
- Maximum width of the patella (MWP): Distance measured between the medial and lateral surface of the patella.
- The maximum length of the tibia and fibula (MLT/F): Distance measured between the proximal extremity (*extremita proximalis*) and the distal extremity (*extremita distalis*) of the tibia and fibula (Figure 3).
- The maximum width of the tibia and fibula (MWT/F): Distance measured between the medial surface (*facies medialis*) and the lateral surface (*facies lateralis*) at the point of bifurcation of the tibia and fibula (Figure 3).

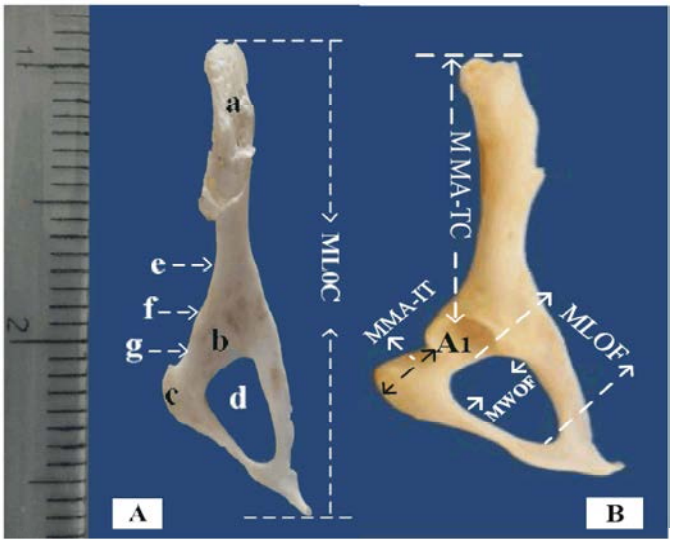

Fig. 1: Sacropelvic surfaces of the os coxae (A), gluteal surface (B); a: alaossiilii; b: corpus ossisischii; c: tuber ischiadicum; d: foramen obturatum; e: incisura ischiadica major; f: tuber ischiadicum; g: incisura ischiadicum minor; A1: acetabulum; MLOC: maximum length of ox coxae; MLOF: maximum length of obturatum foramen; MWOF: maximum width of obturatum; MMA-TC: maximum distance between mid-acetabulum and tuber coxae; MMA-IT: maximum distance between mid-acetabulum and ischial tuber.

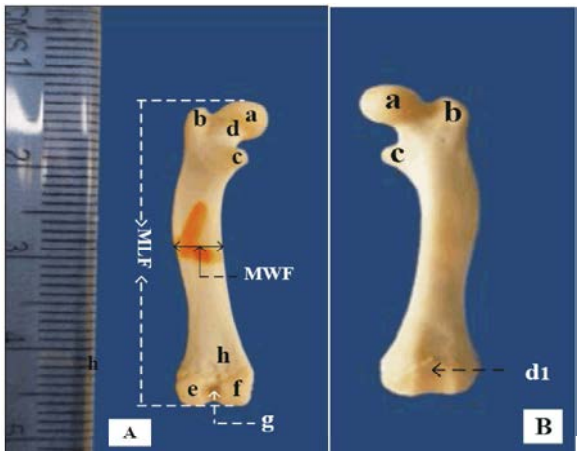

Fig. 2: Caudal (A) and cranial (B) surfaces of the femur; a: caput ossisfemoris; b: trochanter major; c: trochanter minor; d: collumossis minor; d1: trochlea ossisfemoris; e: condyluslateralis; f: condylusmedialis; g: fossa intercondylaris; : fossa poplitei; MLF: maximum length of femur; MWF: maximum width of femur

Fig. 3: Craniolateral view of left (A) and right (B) tibia and fibula; a: spatiuminterosseumcruris; b: corpus fibulae; c: malleolus medialis; d: malleolus lateralis; e: tibial shaft; f: margocranialis; MLT/F: maximum length of tibia and fibula; MWT/F: maximum width of tibia and fibula

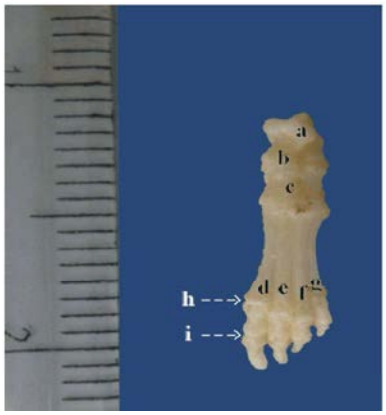

Fig. 4: Dorsal view of the pes; a: calcaneus; b: talus; c: fuse ii and iii os tarsi; d: os metatarsi II; e: os metatarsi III; f: os metatarsi IV; g: os metatarsi V; h: articulatiometatarsophalagus; I: articulationterphalangusproximalis.

- The vialleton angle (VA): Measured angle between a linear line from the tuber coxae to the mid-acetabulum and from the mid-acetabulum to the ischial tuber (*tuber ischiadicum*).

The values obtained for the linear dimensions of the pelvic limb bones were expressed as mean± standard deviation (SD) mm. All statistical analysis was performed using (Graph Pad Instant® version 3.05) package.

RESULTS

Morphological Findings

Os Coxae: The ilial wing was vertically oriented and the gluteal line was absent. Only the *spina iliaca dorsalis caudalis* was present. The *tuber sacrali* and *tuber coxae* were prominent. The *cresta iliaca* was thick and convex. The *tuberositas iliaca* was prominent and join to the tuber sacral by a crest. The *facies auricularis* was wide and roughed. *Incisura ischiatica major* was deeper and wider than the *incisura ischiatic minor* and was separated by the *spina ischiaticum*. The *tuber ischiaticum* had only one process and two small eminence craniomedial and caudomedial to it. The *foramen obturatum* was roughly triangular with the base facing craniolaterally. The symphysis pelvis was formed by a ligament connecting the caudal part of the ischial plate.

The vialletone angle was 131° and the average distance from the mid-acetabulum to *tuber coxae* was found to be 20.98±1.29 mm, while the average distance from the mid-acetabulum to the ischial tuber was found to be 6.58±0.47 mm. The average distance from *ischial tuber* to *tuber coxae* was 26.62±1.48 mm.

Femur: There were two prominent trochanters; *trochanter major* and *trochanter minor*. In addition a third trochanter (*trochanter tertius)* was observed. The *trochanter major* and *caput femoris* were separated by the *fossa trochanterica*. The *caput ossi femoris* had a prominent *Collum ossi femoris*. The *trochanter major* was not separated into *pars cranialis* and *pars caudalis*. The *condylus medialis* and *condylus lateralis* were prominent and separated by *fossa intercondylaris*. The *epicondylus medialis* and *epicondylus lateralis* were present. *Fossa supracondylaris was absent*. The *trochlea ossis femoris* was present on the distal extremities and directed cranially.

Table 1: Mean weights, length and width of the bones of the pelvic limbs in African hedgehogs

Parameters (n=5)	Right (mean±SD)	Left (mean±SD)	Overall (mean±SD)
MWTOC (g)	0.27±0.04	0.27±0.04	0.27±0.04
MLOC (mm)	37.40±2.03	37.58±1.96	37.49±2.0
MLOF(mm)	8.38±0.61	8.26±0.59	8.32±0.60
MWOF(mm)	5.34±0.34	5.56±0.52	5.45±.43
MWTF(g)	0.27±0.05	0.28±0.05	0.28±0.05
MLF(mm)	30.90±1.10	30.88±1.12	30.89±1.11
MWF (mm)	3.72±0.31	3.82±0.38	3.77±0.35
MWTT/F(g)	0.24±0.05	0.24±0.04	0.24±0.05
MLT/F(mm)	34.33±1.26	34.26±1.22	34.30±1.24
MWT/F (mm)	2.78±0.40	2.73±0.36	2.76±0.38
MWTP(g)	0.02±1.81	0.02±1.81	0.02±1.81
MLP(mm)	5.47±0.0.07	5.53±0.11	5.50±0.09
MWP (mm)	2.68±0.22	2.71±0.22	2.70±0.22

ABW: Absolute body weight; ABL: Absolute body length; MWTOC: Maximum weight of ox coxae; MLOC: Maximum length of ox coxae; MLOF: Maximum length of obturator foramen; MWOF: Maximum width of obturator foramen; MWTF: maximum weight of femur; MLF: Maximum length of femur; MWF, Maximum width of femur; MWTT/F: Maximum weight of tibia and fibula; MLT/F: Maximum length of tibia and fibula; MWT/F: Maximum width of tibia and fibula; MWTP: Maximum weight of patella; MLP: Maximum length of patella; MWP: Maximum width of patella.

Table 2: Mean analysis of the dimensions of the pelvic girdle (ox coxae) in African hedgehogs

Parameters (mm) (n=5)	Right (mean±SD)	Left (mean±SD)	Overall (mean±SD)
MMA-TC	21.11±1.30	20.84±1.28	20.98±1.29
MMA-IT	6.51±0.42	6.64±0.51	6.58±0.47
MIT-TC	26.69±1.34	26.54±1.62	26.62±1.48
VA (0)	-	-	131.25±6.41

MMA-TC: Maximum distance between the mid-acetabulum and tuber coxae; MMA-IT: Maximum distance between the mid-acetabulum and ischial tuber; MIT-TC: Maximum distance between the ischial tuber and tuber coxae; VA:vialletone angle

Patella: The patella presented a concave caudal *facies articularis* and a free convex *facies cranialis.* The *apex patella* was pointing distally. The patella presented three surfaces; *facies dorsalis, medialis and lateralis*. The *basis patella* was directed proximally.

Tibia and Fibula: The tibia and fibula were separated from the proximal half by a wide *spatium interosseum cruris* but united distally. The tibia was larger and thicker than the fibular and presented proximally a *condylus medialis* and a *condylus lateralis* for articulation with corresponding condyles of the *os femoris*. The *tuberosita tibia* was present. Distally there were *melleolus medialis* and *melleolus lateralis* separated by the *cochlea tibiae*. The fibula was thin and attaches to the *caput tibiae* laterally.

Tarsal Bones (Ossa Tarsi): There were six (6) *os tarsi* arranged in three (3) rows. The proximal row consisted of the talus medially and calcaneus laterally. The intermediate row consisted of only the *os tarsi centralea* located distal to the talus. The distal row consisted of three bones, *os tarsi* I which was located caudal to fused *os tarsi* II and III while fused *os tarsi* IV and V in mediolateral sequence.

There were four *ossa metatarsae* interposed between the tarsus and the phalanges. A pair of sesamoid bones was observed in each of the metatarsophalangeal joints. The comparative lengths of the ossa metatarsae were, IV>III>II>V.

Digits (Ossa Digitarum Pedis): Four digits were observed with each consisted of three phalanges. The first digit (hallux) was absent while the distal phalanges were equipped with claws.

Osteometrical Analysis: The values obtained are presented in Table 1 and 2.

DISCUSSION

The presence of a large *foramen obturatum* is characteristics of mammals [13]. A large *foramen obturatum* has also been reported in chinchilla [14], squirrels [15], mole rat [7] and porcupine [8]. In this study, a large *foramen obturatum* was also observed which is roughly triangular in shape with a sagittal length of about 8.32mm and a width of 5.45mm.The *symphysis pubis* in the order insectivora is some time non-existent and always weak. In *Erinaceus*, it is reported to be confined to the pubis [16]. Ozkan [10] reported in *Erinaceus europeus* a ligamentum connection forming the *symphysis pelvina*. Similar findings were observed in this study.

The *fovea capitis femoris* is reported to be absent in porcupine [8] and *E. europeus* [10]. In this study, the *fovea capitis* was present but reduced to an indistinct depression. Similar observation was made by Ajayi *et al.* [9] in New Zealand white rabbit. Saunders and Manton [16] reported that the femur of the insectivore has third trochanter (*trochanter tertius*) which is particularly well developed in *Erinaceaus* and centetes. A third (III) trochanter (*trochanter tertius*) was observed in addition to the *trochanter major et minor* in this study. The fourth (IV) trochanter wasreported to be absent in mammals by Romer [17]. The presence of a third (III) trochanter has also been reported in mole rat by Ozkan [7] and African giant rat (AGR) by Olude *et al*. [5].

Ajayi *et al.* [9] observed that the greater trochanter exceeded the *os carput femoris* in the rabbits while in this study, the *trochanter major* and the *carput ossis femoris* were of the same height.

In this study, the mean length of the tibia and fibula was 34.30mm. The fibula was a slender bone that was separated from the tibia proximally and fused distally. The same finding had been reported in New Zealand white rabbit [9] and AGR [5]. However, this finding is in contrast to the report by Yilmaz *et al.* [8] in porcupine. Pentrot *et al*. [18] reported the distal fusion of the tibia and fibula was an adaptation to stress on the distal crus. This had also been documented as an adaptive feature of diggers, as well as leapers [19, 20].

Four *ossa matatarsalia* were observed and their comparative lengths were IV>III>II>V. Kuru [21] reported that in some species of *Erinaceidae* family, the pedis was complete with four digits. Four digits was also reported in New Zealand rabbit [9], this was in contrast to the five digits reported in African giant rats [5] and *Erinaceus europaeus* [10]. Four digits were also observed in this study, the fifth was vestigial. Their comparative lengths were IV>III>II>V.A pair of four *ossa sesamoideum metatersale* was observed in each of the metatarsophalangeal joints. Similar findings have been reported in E. europeus [10], porcupines [8] and rabbit [22] and in chinchilla [14].

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