An osteometrical study of the skull and mandible of African four-toed Hedgehog (*Atelerix albiventris*)

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ABSTRACT

Osteometrical characteristics of the skull and mandible of African hedgehog (*Atelerix albiventris*) from Maiduguri, Nigeria were examined. Fourteen (14) hedgehogs skull (including 7 males and 7 females) were used in this study. Twenty four (24) parameters were obtained and measured by traditional morphometry. Univariate analysis of the data revealed gender difference in GML, BBC, WGI, FRO and GLN, which were significantly higher \((p < 0.05)\) in the female hedgehogs. Conversely, the values for NCH and NCI were significantly higher \((p < 0.05)\) in the male hedgehogs. The results obtained in this study will form a good baseline data for comparative anatomical studies between species of hedgehogs and may also find application in the field of morphology, zoo-archaeology, and taxonomic studies.

Key Words: Osteometry, Skull, Mandible, African Hedgehog.

INTRODUCTION

The four-toed African hedgehog (*Atelerix albiventris*) belongs to the order **Insectivora**, family **Erinaceidae**, and genus *Atelerix*[1]. It is widespread in West Africa inhabiting plains, savannas, and grassland [2]. They are small nocturnally active mammals characterized by a short grooved brown or grey spine covering the dorsum of their body [3] with a band of whitish fur running across their forehead [4], and presence of vestigial hallux on their hind foots owing to the name four-toed. It has been domesticated as pet in Europe, and has been focus of a number of biomedical researches.

Macro-anatomical Studies of the skeletal systems of small mammals such as African giant rats[5], rabbits [6, 7], porcupines [8], and badgers [9] have been reported in literatures. However, information on osteometry of skull and mandible profile of African four-toed hedgehog has not been documented in detailed. Adeniyi *et al.* [10, 11] reported on histo-morphology of tongue and dentition, and cerebral cortex histo-morphometry of African hedgehogs, whereas Ozkan [12] described the osteometry of the pelvic limb structures in European hedgehog (*Erinaceuseuropaeus* L). The goal of this study was to establish a baseline data of skull and mandible osteometry in African four-toed hedgehog.
MATERIALS AND METHODS

In the present study, a total of 14 skulls of adult hedgehog (7 males and 7 females) were used. The hedgehogs were procured from local poachers around Maiduguri, Nigeria. Hot water maceration technique was used for the skulls preparation based on works of [13], and [5]. A total of 24 parameters were obtained from the skull and mandible from different views (lateral, dorsal, ventral, and medial) using ruler, vernier calipers, and measuring cylinder. Landmarks on each skull were adapted from [14-16]. The landmarks and methodology of each values obtained are described below and shown in Figures 1-4.

Measurements of the skull and Mandible;
1. Whole skull height (WSH): From the highest level of the frontal bone to the lowest level of the rostral mandible curve (Figure 1).
2. Whole length of the skull (WLS): From anterior ventral edge of incisive bone to caudal-most edge of occipital condyle along the longitudinal axis of the skull (Figure 3).
3. Skull index (SI): Whole skull height x 100 / Whole skull length
4. Skull height without mandible (SH): From the level of the highest point of the frontal bone to the base of the jugular process (Figure 2).
5. Inter-parietal length (INT): From intersection of sagittal suture and caudal end of parietal bone, perpendicular to caudal end of inter-parietal bone (Figure 3).
6. Greatest length of parietal (PAL): Measured as the overall length of the parietal bone (Figure 3).
7. Greatest length of frontals (FRO): Measured as the overall length of the frontal bone (Figure 3).
8. Greatest length of Nasals (GLN): From longest rostral projection of nasal wings to caudal-most edge of nasal bones (Figure 3).
9. Nasal width (NAS): Measured at rostral point where nasal bone joins premaxilla bone (Figure 3).
10. Nasal index: Nasal width x 100 / Greatest length of nasal bone
11. Breadth of brain case (BBC): Measured as the width at the dorsal root of squamosals (Figure 3).
12. Greatest zygomatic arch width (ZYW): Measured as the distance between outer margins of zygomatic arches, perpendicular to longitudinal axis of the skull (Figure 3).
13. Condylorbasal length of skull (CBL): From caudal most projection of occipital condyles to cranial edge of premaxilla (Figure 4).
14. Basal length of skull (BSL): From most anterior point of lower border of foramen magnum to anterior edge of premaxilla (Figure 4).
15. Width of gap between upper incisors (WGI): Measured as the maximum distance between the upper incisors (Figure 7).
16. Post-palatal length (PPL): From most anterior edge of hard palate to most anterior point of lower border of foramen magnum (Figure 4).
17. Condyle width (OCW): Width between the lateral ends of occipital condyles perpendicular to skull axis (Figure 4).
18. Interparacondylyar width (IPCW): Greatest breadth of the ventromedial end of the jugular process (Figure 4).
19. Neurocranial height (NCH): From the deepest indentation of the sella turcica directly dorsal to the inner layer of the root of the cranium (Figure 5).
20. Neurocranial length (NCL): From the deepest indentation of the fronto-ethmoidal junction to the middle of the distal of the cranial at the level of the cerebral surface of the external occipital protuberance (Figure 5).
21. Neurocranial volume (NCV): Cranial capacity was measured by filling the skull with fine millet grain up to the brim of the foramen magnum. The grain was slightly compressed and the skull was oscillated back and forth for the millet grain to settle evenly. The contents were emptied and measured in a 50 (ml) graduated cylinder.
22. Neurocranial index (NCI): Neurocranial height x 100% / Neurocranial length
23. Greatest mandible height (GMH): Measured as a straight line from rostral edge of first lower incisor alveolus to caudal surface of angular process (Figure 6).

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24. Mandible- ramus height (MRH): Measured from the dorsal edge of coronoid process to ventral edge of angular process (Figure 6).

All data obtained were analyzed using the Statistical Analysis Package (GraphPad Instat® version 3.05), and presented as Mean ± standard deviation. The results obtained between the males and females were further analyzed for intersexual differences using student t-test. The level of significance was set at (p<0.05).

RESULTS

The values for Mean ± SD of the skull and mandible parameters for both sexes were presented in Table 1 – 4. Univariate statistical analysis showed gender differences in 7 parameters (GML, FRO, GLN, BBC, WGI, NCH and NCI) which were all significantly higher (p<0.05) in the female hedgehogs (Table 1, 2 and 3), whereas the mean values for NCH and NCI, were significantly higher (p<0.05) in the male hedgehogs (Table 4).

DISCUSSION

The mean value for GML was significantly longer in the female hedgehogs. This could be related to the size of the skull which is slightly longer in the female hedgehogs. This finding agrees with the work of Squarcia et al. [17] on sexual dimorphism in the mandible of the Armadillo (Chaetophractus villosus). Anatomical diversity of the mandibulo-dental complexes of mammals reflects some adaptation to diet [18], although it may be difficult to predict diets on the basis of morphology in some species [17]. A distinct gender difference was observed in the FRO and GLN which were significantly longer in the females. This is similar with the observation of Squarcia et al. [19] on the rostro-caudal plane of female armadillo skull, and Wlodzimierz et al. [20] on the frontal bones of female raccoon dog.

The mean value for BBC was significantly wider in the female hedgehogs, implying a wider cranial capacity for the brain, probably compensating for the reduced NCH observed in this gender. This agrees with the findings of Kunzel et al. [21] in feline skull.

The upper incisor arguably was the most easily noticeable feature of hedgehog skull, which is widely spaced and slightly projected forward. In this study, the gap of the upper incisor (WGI) was observed to be significantly wider in the females. This gender difference might point to biomechanics of biting when the lower incisor occlude, allowing better handling of relatively larger prey in the female hedgehogs.

On comparative craniometrical perspective, the mean WHS of hedgehogs in this study was 2.20±0.05cm, which appears to be lower than 2.98±0.06cm reported by Olude et al. [5] in African giant rats (AGR). Equally, the WHS was sexual not dimorphic in Hedgehogs (A. albiventris) unlike what was reported in AGR, where the skull in the males was significantly higher [5]. The mean WLS was 4.08±0.11cm that appear to be lower than 6.32±0.06cm reported by Olude et al. [5], in AGR. Comparatively, the skull was higher and longer in AGR, which could be attributed to apparent variation in size between the two species. Similarly, viscero-cranial dimensions in this study reveal significantly higher NCH in the male hedgehogs, disagreeing to findings in AGR reported by Olude et al. [5]. The mean NCI was significantly higher in the male hedgehogs (A. albiventris), whereas Olude et al. [5] reported no sex differences in AGR. This difference might point to longer viscero-cranial dimension along vertical plane of the skull in this study. Gracia et al. [22] observed a significant correlation between cranial cavity volume and certain lineal measures of the cranium and the cranial cavity in dogs. Similarly, the mean NCI was 48.0±3.74% that was observed to be higher than 41.74% reported in AGR [5]. Indexes are useful in evaluating numerous aspects of craniometric data of the skull, notably to knock-out size factor and determine the gender of the animal retrospectively [23].

To the best of our knowledge, studies on the traditional morphometric dimensions of the skull and mandible of hedgehogs (A. albiventris) were scarcely reported. As such the results obtained in this study, will be useful in comparative anatomical studies between species of hedgehogs and other small mammals. It can also form the basis for osteo-morphology, zoology, and taxonomic studies.
Figure 1: Measurements of the skull of hedgehog (lateral view) showing skull height with mandible in horizontal plane (WSH).

Figure 2: Measurements of the skull of Hedgehog (lateral view) showing skull height without mandible in horizontal axis (SH), Zygomatic arch length (ZAL).
Figure 3: Measurements of the skull of Hedgehog (dorsal view) showing whole length of the skull (WLS), Breadth of Braincase (BBC), greatest length of Interparietal (INT), greatest length of parietals (PAL), greatest length of frontals (FRO), greatest length of nasal (GLN), nasal width (NAS) and greatest zygomatic width (ZYW).

Figure 4: Measurements of the skull of hedgehog (ventral view) showing condylobasal skull length (CBL), Basal skull length (BSL), width of gap of upper incisor (WGI), Post-palatal length (PPL), Interparacodylear width (IPCW), and Occipital condyle width (OCW).

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Figure 5: Sagittal section of the skull of Hedgehog showing Neurocranium height (NCH), and Neurocranium length (NCL).

Figure 6: Measurements of the mandible of Hedgehog (lateral view) showing greatest mandible height (GMH), mandible-ramus height (MRH).

Table 1: Osteometric measurements of the skull and mandible of hedgehog

<table>
<thead>
<tr>
<th>Indices</th>
<th>Overall Mean</th>
<th>Male</th>
<th>Female</th>
<th>Intersexual difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole height of skull (WHS) (cm)</td>
<td>2.20± 0.05</td>
<td>2.21± 0.06</td>
<td>2.19± 0.04</td>
<td>NS</td>
</tr>
<tr>
<td>Whole length of skull (WLS) (cm)</td>
<td>4.08± 0.11</td>
<td>4.07± 0.10</td>
<td>4.09± 0.13</td>
<td>NS</td>
</tr>
<tr>
<td>Skull index (SI) (%)</td>
<td>54.0± 1.12</td>
<td>54.4± 1.42</td>
<td>53.6± 0.82</td>
<td>NS</td>
</tr>
<tr>
<td>Skull Height without mandible (SH) (cm)</td>
<td>1.28± 0.06</td>
<td>1.27± 0.07</td>
<td>1.30± 0.06</td>
<td>NS</td>
</tr>
<tr>
<td>Greatest mandible length (GML) (cm)</td>
<td>3.16± 0.07</td>
<td>3.12± 0.08</td>
<td>3.21± 0.06</td>
<td>*</td>
</tr>
<tr>
<td>Mandible-ramus height (MRH) (cm)</td>
<td>1.49± 0.05</td>
<td>1.49± 0.05</td>
<td>1.50± 0.05</td>
<td>NS</td>
</tr>
</tbody>
</table>

* Significantly different at level of p<0.05.
NS- Not significant
Table 2: Osteometric measurements of the skull hedgehog (Dorsal surface view)

<table>
<thead>
<tr>
<th>Indices</th>
<th>Overall Mean</th>
<th>Male</th>
<th>Female</th>
<th>Intersexual difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interparietal length (INT) (cm)</td>
<td>0.42± 0.06</td>
<td>0.42± 0.04</td>
<td>0.42± 0.07</td>
<td>NS</td>
</tr>
<tr>
<td>Greatest length of parietals (PAR) (cm)</td>
<td>1.22± 0.13</td>
<td>1.22± 0.16</td>
<td>1.23± 0.10</td>
<td>NS</td>
</tr>
<tr>
<td>Greatest length of frontals (FRO) (cm)</td>
<td>1.05± 0.09</td>
<td>0.91± 0.14</td>
<td>1.19± 0.04</td>
<td>*</td>
</tr>
<tr>
<td>Greatest length of nasals (GLN) (cm)</td>
<td>1.15± 0.06</td>
<td>1.10± 0.08</td>
<td>1.21± 0.04</td>
<td>*</td>
</tr>
<tr>
<td>Nasal width (NAS) (cm)</td>
<td>0.32±0.05</td>
<td>0.33± 0.08</td>
<td>0.31± 0.02</td>
<td>NS</td>
</tr>
<tr>
<td>Nasal index (NAI) (%)</td>
<td>27.9±3.95</td>
<td>29.9± 6.28</td>
<td>25.9± 1.63</td>
<td>NS</td>
</tr>
<tr>
<td>Breadth of braincase (BBC) (cm)</td>
<td>1.84± 0.06</td>
<td>1.79± 0.07</td>
<td>1.89± 0.06</td>
<td>*</td>
</tr>
</tbody>
</table>

* Significantly different at level of p < 0.05,
NS- Not significant

Table 3: Osteometric measurements of the skull of hedgehog (Ventral surface view)

<table>
<thead>
<tr>
<th>Indices (cm)</th>
<th>Overall Mean</th>
<th>Male</th>
<th>Female</th>
<th>Intersexual difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condylarbasal length (CBL)</td>
<td>4.12± 0.14</td>
<td>4.09± 0.16</td>
<td>4.15± 0.13</td>
<td>NS</td>
</tr>
<tr>
<td>Basal length of skull (BSL)</td>
<td>3.87± 0.19</td>
<td>3.80± 0.18</td>
<td>3.95± 0.21</td>
<td>NS</td>
</tr>
<tr>
<td>Width of gap between incisor(WGI)</td>
<td>0.24± 0.05</td>
<td>0.21± 0.04</td>
<td>0.27± 0.06</td>
<td>*</td>
</tr>
<tr>
<td>Interaocular width (IPW)</td>
<td>1.62± 0.07</td>
<td>1.64± 0.09</td>
<td>1.61± 0.06</td>
<td>NS</td>
</tr>
<tr>
<td>Occipital condyle width (CNW)</td>
<td>1.00± 0.12</td>
<td>1.00± 0.18</td>
<td>1.00± 0.06</td>
<td>NS</td>
</tr>
</tbody>
</table>

* Significantly different at level of p < 0.05,
NS- Not significant

Table 4: Osteometric measurements of the skull of hedgehog (Medial surface view)

<table>
<thead>
<tr>
<th>Indices</th>
<th>Overall Mean</th>
<th>Male</th>
<th>Female</th>
<th>Intersexual difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurocranial height (NCH) (cm)</td>
<td>0.99± 0.07</td>
<td>1.04± 0.08</td>
<td>0.95± 0.06</td>
<td>*</td>
</tr>
<tr>
<td>Neurocranial length (NCL) (cm)</td>
<td>2.07± 0.08</td>
<td>2.04± 0.08</td>
<td>2.11± 0.09</td>
<td>NS</td>
</tr>
<tr>
<td>Neurocranial index (NCI) (%)</td>
<td>48.0± 3.74</td>
<td>51.1± 3.89</td>
<td>45.0± 3.60</td>
<td>NS</td>
</tr>
<tr>
<td>Neurocranial volume (NCV) (ml)</td>
<td>1.45± 0.09</td>
<td>1.46± 0.10</td>
<td>1.44± 0.08</td>
<td>NS</td>
</tr>
</tbody>
</table>

* Significantly different at level of p < 0.05,
NS- Not significant

REFERENCES


