

Some aspects of the neurocraniometry of the African giant rat (*Cricetomys gambianus* Waterhouse)

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Sixteen African giant rats (Cricetomys gambianus Waterhouse), consisting of 8 male and 8 female rats, were used to determine neurocranial measurements of the skulls. The mean neurocranial volume was 5.06 ± 0.05 mL, neurocranial length was 3.33 ± 0.08 cm, and the neurocranial height and index were 1.39 ± 0.04 cm and 41.74%, respectively. The mean whole skull length and height were 6.32 ± 0.06 cm and 2.98 ± 0.05 cm, respectively. The skull without the mandible was 1.83 ± 0.02 cm in height, and the skull index was 28.41 ± 0.58 . The height of the skull of the African giant was approximately half (47%) of the skull length. The mean height and width of the foramen magnum were 0.78 ± 0.01 cm and 0.96 ± 0.02 cm, respectively, while the foramen index was below 100 at 81.46 ± 1.42 . Parameters for the whole skull height and foramen magnum width showed significant difference between both sexes at $p < 0.05$. The foramen magnum showed shape variations and there were multiple hypoglossal foramina in over 87% of the rats. This study, in conclusion, highlighted the possibility of the estimation of the brain density and the use of the African giant rat for cranial pressure experiments. (Folia Morphol 2009; 68, 4: 224–227)

Key words: skull, morphometry, foramen magnum, cranial pressure

INTRODUCTION

African giant rats (AGR) belong to the family Cricetidae and the order Rodentia. They are nocturnal rodents, omnivorous, and feed on vegetation and invertebrates. They inhabit a variety of habitats ranging from arid to temperate areas but need some form of shelter to survive [1, 2]. There are many reported macro-anatomical investigations on the skeletal system of mammals, including the rabbit, the guinea pig, the rat [22], the mink [7], the badger [5, 10] the porcupine [29], the hedgehog [23], and the mole rat [24, 28], but the skeletal systems of AGRs, particularly the neurocranial osteometry, have rarely been investigated in detail, although measurements of

selected parameters of the brain of the African giant rat have been documented by Nzalak et al. [17]. The aim of the present study was to investigate some aspects of the osteometry and morphology of the neurocranium of the AGR as part of an effort to document the basic research data on this rodent.

MATERIAL AND METHODS

A total of 16 adult AGR (8 males, 8 females) with mean body mass of 730.00 ± 41.91 g were used for this study. Maceration of bones was carried out by a modified method of that used by Olopade [20]. Skull measurements were taken using the method of Onar et al. [21], Endo et al. [8], Olopade and Onwuka [19],

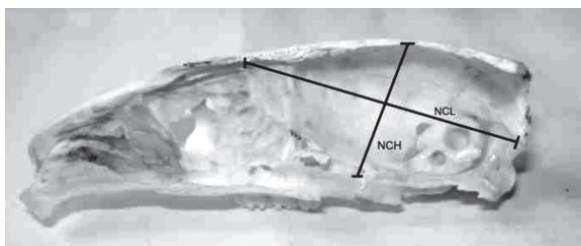


Figure 1. Outline of the mid-neurocranial region of the skull showing dimensions for neurocranial height (NCH) and neurocranial length (NCL).

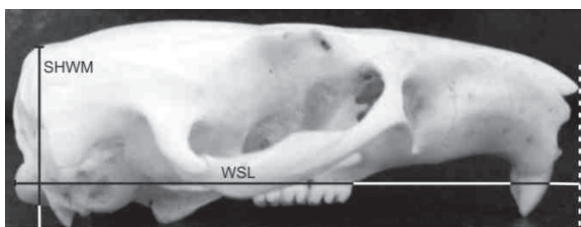


Figure 2. Outline of the skull without the mandible showing dimensions for whole skull length (WSL) and skull height without the mandible (SHWM).

Fernandes et al. [9], and Wysocki [31] and are highlighted herein, with most depicted in Figures 1–5. Neurocranial volume was obtained by filling the macerated neurocrania with fine grains after blocking the related cranial foramina with Plasticine; the contained grains were then measured with a measuring cylinder. The descriptive features observed on the skulls were also documented. The data are reported as mean \pm SE; statistical significance of experimental observations was determined using student's t-test with level of significance set at 5% ($p < 0.05$). All statistical analysis was done using SPSS-15.

Definitions of measured parameters

Neurocranial volume (NCV). The volume of the neurocranium was measured by first using Plasticine to block all the foramina of the intact skull. The neurocranium was then filled with grains from the foramen magnum. When full, the grains were emptied into a measuring cylinder and the volume determined.

Neurocranial length (NCL). From the deepest indentation of the fronto-ethmoidal junction to the middle of the distal surface of the cranium at the level of the cerebral surface of the external occipital protuberance (Fig. 1).

Neurocranial height (NCH). From the deepest indentation of the sella turcica directly dorsal to the inner layer of the root of the cranium (Fig. 1).

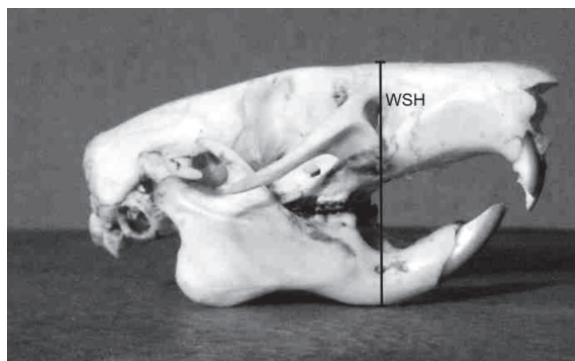


Figure 3. Outline of the whole skull with the mandible showing dimensions for whole skull height (WSH) with the mandible.

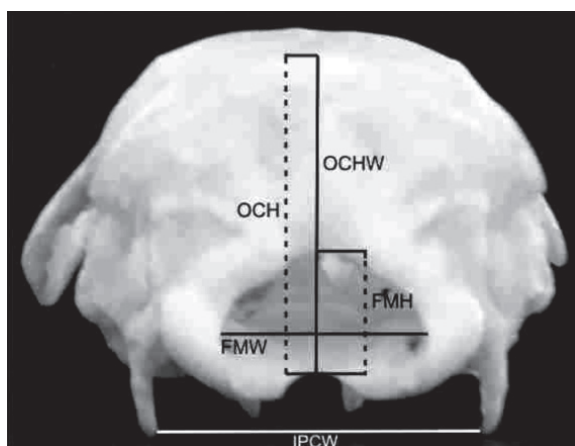


Figure 4. Outlines of the caudal view of the skull showing foramen magnum height (FMH), foramen magnum width (FMW), interparacondylar width (IPCW), occipital height without (OCHW) foramen magnum, and Occipital triangle (OCH) with the foramen magnum. Notice the dorsal arch of the foramen magnum.



Figure 5. Caudal view of 3 male African giant rats showing variations in shape of the dorsal notch/arch of the foramen magnum.

Neurocranial index (NCI) — NCH/NCL (%).

Whole skull height (WSH). From the highest level of the frontal bone to the lowest level of the rostral mandible curve (Fig. 3).

Skull height without the mandible (SHWM). From the level of the highest point of the frontal bone to the base of the jugular process (Fig. 2).

Whole skull length (WSL). From the nasal tip to the caudal-most regions of the occipital bone (Fig. 2).

Whole skull index (WSI) — $WSH/WSL \times 100$.

Foramen magnum width (FMW). Largest width of the foramen magnum (Fig. 4).

Foramen magnum height (FMH). Mid vertical height of the foramen magnum (Fig. 4).

Foramen magnum index (FMI) — $FMH/FMW \times 100$.

RESULTS

The mean neurocranial volume in this study was 5.06 ± 0.05 mL, neurocranial length was 3.33 ± 0.08 cm, and neurocranial height was 1.39 ± 0.04 cm at its highest point. The mean whole skull length and height of the skull were 6.32 ± 0.06 cm and 2.98 ± 0.05 cm, respectively. The skull without the mandible was 1.83 ± 0.02 cm in height, and the skull index was 28.41 ± 0.58 . The mean whole skull height was greater in males than in females, and this was statistically significant. The crista galli was slanted caudoventrally to accommodate the large olfactory bulb of the rat. The foramen magnum width was significant between both sexes at $p < 0.05$; also, the foramen magnum revealed shape variations and the presence of dorsal arches in males ($n = 6$) and females ($n = 2$; Figs. 4, 5). The occurrence of multiple hypoglossal foramina was observed in 87.5% of the rats in this study ($n = 14$); one rat (6.25%) actually had 3 hypoglossal foramina. Side-to-side variation with respect to this feature was observed in this study with two hypoglossal foramina on the left side and a single one on the right in 56.25% ($n = 9$), while 50% ($n = 8$) were actually divided by a bony spicule. The cranial morphometric measurements are shown in Table 1.

DISCUSSION

The mean neurocranial volume in this study was 5.06 ± 0.05 mL, and the neurocranial index was 41.74%. Since a direct correlation exists between cranial volume and brain volume [11], the values obtained in this study could give a more accurate estimation of brain volume/density in the AGR. Preliminary work has been done on the brain weight of the African giant rat [17], and since the brain weight is known to be 85–90% of the weight of the cranial content [18, 26], the brain density of the AGR can then be assessed from this data. Thus, in addition to being used for landmine detection of tuberculosis [15], the AGR could also be a good experimental candidate for studies of intracranial pressure. The male animals had larger neurocranial dimensions, most likely due to size differences between the sexes.

Table 1. Osteometric analysis of the neurocranial region of the African giant rat skulls

Parameter	Overall mean	Female	Male
NCV [mL]	5.06 ± 0.05	4.98 ± 0.09	5.15 ± 0.05
NCL [cm]	3.33 ± 0.08	3.19 ± 0.05	3.48 ± 0.13
NCH [cm]	1.39 ± 0.04	1.34 ± 0.07	1.45 ± 0.02
NCI (%)	41.74	42.00%	41.67%
WSH* [cm]	2.98 ± 0.06	2.83 ± 0.06	3.14 ± 0.05
SHWM [cm]	1.83 ± 0.02	1.85 ± 0.03	1.80 ± 0.03
WSL [cm]	6.32 ± 0.06	6.36 ± 0.07	6.28 ± 0.10
WSI	28.41 ± 0.58	29.10 ± 0.35	27.71 ± 1.09
FMW* [cm]	0.96 ± 0.02	0.93 ± 0.02	1.00 ± 0.03
FMH [cm]	0.78 ± 0.01	0.76 ± 0.02	0.80 ± 0.00
FMI	81.46 ± 1.42	82.51 ± 1.90	80.4 ± 2.17

NCV — neurocranial volume; NCL — neurocranial length; NCH — neurocranial height; NCI — neurocranial index; WSH — whole skull height; SHWM — skull height without the mandible; WSL — whole skull length; WSI — whole skull index; FMW — foramen magnum width; FMH — foramen magnum height; FMI — foramen magnum index; values presented as mean \pm SE for 16 rats (8 female and 8 male African giant rats); *the values for WSH and FMW differed significantly between the two sexes at $p < 0.05$

The mean whole skull length and height of the skull were 6.32 ± 0.06 cm and 2.98 ± 0.05 cm, respectively. The length and height of the skull was, respectively, about 4 cm and 1.6–2.1 cm in mole rats [29] and 32.2 ± 1.0 in Wistar rats [8]. The whole skull index in the African giant rat was 28.41 ± 0.58 . Dubrul [6] stated that the height of the rat skull is appreciably one-third of the total length, but it was almost half (47%) according to our study of the AGR; this may have a subsequent effect on the gross morphometry of the brain. The mean whole skull height was significantly greater in males than in females — this may be due to size differences between the sexes.

The mean foramen magnum width and height were 0.96 and 0.78, respectively; the equivalent in the rabbit was 1.15 ± 0.04 cm and 0.86 ± 0.04 cm [14, 21], while in the mole rat it was 0.69 cm and 0.61 cm, respectively [25]. The foramen magnum index of the AGR was thus below 100 and similar to that of the rabbit, which was 74.78 ± 4.05 [14, 21], and the mole rat at 88.41 [25], where the foramen magna were relatively wide. The equivalent in the West African Dwarf goat was 102.5 [19]. The foramen magnum width was significantly greater in the male than in the female in our study, although it is speculative whether this translates to the morphometry of the contained spinal cord and meninges.

Various authors have stated that irregularities in the shape of the foramen magnum constitute a crucial problem in Veterinary Medicine and can cause a variety of clinical symptoms, for example, convulsions, ataxias, prolapse of the brain to the medullary canal, and occipital dysplasia [13, 27]. However, Janeczek et al. [12] considered it an ancient characteristic which is compatible with longevity and the absence of major pathology. However, this occurrence needs be verified to ascertain its effect in the AGR.

A recent study on humans and other mammalian species [30] revealed double hypoglossal canals in 43% of cases. In the same study, 28.12% of cases had the hypoglossal canal divided in two by a small bony spicule. The doubling of the hypoglossal canal by a bony spicule is not a rare phenomenon [4]. Fifty percent of the rats in this study had the canal divided by a bony spicule. The clinical significance of this has been attached to the variations in the hypoglossal foramen in humans, and knowledge of this anatomical variation could be important for various fields of medicine [3, 16]. The slanting crista galli evidently accommodates the extensive olfactory bulb of the brain.

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