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Skull of Capybara (*Hydrochoerus hydrochaeris*) - Morphometric Parameters

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ABSTRACT

***Background*:** The capybara (*Hydrochoerus hydrochaeris*) is the largest rodent in the world. They are territorial animals, and live in social groups, commonly occurring in anthropized area, what has attracted the attention of researchers in relation to this animal species, since it is the host of the *Amblyomma cajennese* tick that transmits spotted-fever to humans and are responsible for severe impact on livestock and public health. The skull is a part of the axial skeleton that enclosing the brain, sensory organs and digestive and respiratory structures. Moreover, the phenotypic appearance of the capybara head depends on the shape of the skull. Thus, the aim of this study was to describe the reference values of cranial measurements of capybaras. The knowledge of morphometric parameters of skull is pivotal for veterinary treatment of pathological conditions and taxonomic affiliation.

***Materials, Methods & Results*:** Eight capybaras (*Hydrochoerus hydrochaeris*) skulls were used in this study, irrespective of age and sex. The skulls belonging to the anatomical collection of the Laboratory of Wildlife Anatomy and Anatomical Museum, Department of Anatomy, Universidade Estadual Paulista Júlio de Mesquita Filho, UNESP, Botucatu, São Paulo. A total of 35 morphometric parameters were performed using a digital caliper and 6 cranial indices were calculated. All investigated features were expressed as mean ± standard deviation. Anatomically, capybara skull were elongated, rectangle-like and consisted of cranial and facial bones. The morphometric parameters were used to calculate the following craniometrics indices: skull index (57.86 ± 3.62), cranial index (50.49 ± 2.08), facial index (49.22 ± 3.82), basal index (33.98 ± 0.86), nasal index (26.73 ± 3.1), and the foramen magnum index (149.61 ± 1.07). Moreover, the facial part length (mean 137.90 mm) and cranium part length (mean 87.76 mm) also were calculated. The facial part length was a distance from the cribriform plate of the ethmoid bone to the rostral edge of the incisive bone and, the cranium part length was a distance from the external occipital protuberance to the cribriform plate of the ethmoid bone.

***Discussion*:** This study established morphometric parameters in the capybara skull. The craniometric measurements showed in this study are compatible with reported in other studies in the capybara skull, although the most parameters measured in this study were not calculated in previous studies of the capybara skull. Moreover, none of the cranial indices calculated in this study were previously calculated. Based on some cranial measurements, the 8 capybaras used in this study could be classified into subadult (4) and adults (4). The foramen magnum showed a dorsal triangular notch in the capybara skull differently from described in the *Cavia* spp., and similar to reported to other rodent as Gambian rat and other mammals species such as maned wolf, four-toed hedgehog, and dromedaries. The rectangular shape of the capybara skull is different from that found in other caviids rodents such as Brazilian guinea pig. The capybara skull showed greater development of the facial part in relation to the cranial part, which allows to relate the skull shape with the skull shape presented by dolichocephalics dogs. This feature is commonly reported in large caviomorph rodents. Probably, this morphology is compatible with the ecology and phylogeny of the species.

Keywords: capybaras, craniometry, cranium, veterinary anatomy, wildlife.

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INTRODUCTION

The capybara (*Hydrochoerus hydrochaeris*) is the largest rodent in the world and belongs to the order Rodentia, family Caviidae, and subfamily Hydrochoerinae [15,27]. They are herbivorous animals with semi-aquatic, gregarious and territorial habits [14,17,20,21,26]. The capybara body is large and heavy with body mass averages 48.9 kg and ranges from 35 to 65.5 kg [15].

The scientific interest in capybaras has increased in recent years because they are being found in anthropogenic areas, such as urban and peri-urban parks close to water sources. These rodents are considered the main host for all parasitic stages of tick of the spotted-fever by *Rickettsia rickettsii* infection [11,25,26], and this has great Public Heath importance in Brazil due to its high fatality rates in humans [12,19].

Few studies on the head anatomy have been undertaken in the capybara such as estimation of the age of capybaras using some morphometric measurements of the skull [5], a tomographic and anatomical study of the orbit and nasolacrimal duct [8], an anatomorradiographic description of the teeth [10], and an anatomical description of the skull using radiography and 3D computed tomography [18]. There is scanty information on the morphometry of skull of capybara; therefore, the aim of this study was to describe the morphometric parameters of the capybara skull using normal morphometrical methods to contribute to gross anatomy of this Neotropical rodent.

MATERIALS AND METHODS

Animals

A total of 8 skulls of capybaras (*Hydrochoerus hydrochaeris*) were used in this study, irrespective of age and sex. The skulls belonging to the anatomical collection of the Laboratory of Wildlife Anatomy and Anatomical Museum, Department of Anatomy, Universidade Estadual Paulista Júlio de Mesquita Filho, UNESP, Botucatu, São Paulo.

Morphometric procedures

Different skull parameters of capybara were obtained by using a digital caliper[1] (Digital Caliper Starrett 798). The measurement pattern and choice of reference points were performed as described in previously studies [5,6,9,24]. Additionally, the following craniometric indices were calculated: skull index (SI), cranial index (CrI), facial index (FI), basal index (BI), nasal index (NI), and the foramen magnum index (FMI). A total of 35 measurements and 6 indices are listed in Table 1 and shown in Figures 1-3. The results were expressed as mean ± standard deviation (SD).

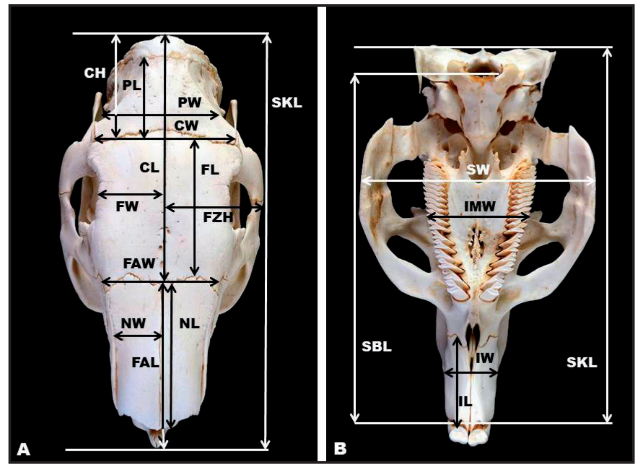

Figure 1. Measurements in the dorsal (A) and ventral (B) views of the capybara skull showing skull length (SKL); skull width (SW); skull base length (SBL); cranial length (CL); cranial width (CW); cranial height (CH); facial length (FAL); facial width (FAW); parietal length (PL); parietal width (PW); frontal length (FL); frontal width (FW); nasal length (NL); nasal width (NW); frontozygomatic height (FZH); intermaxillary width (IMW); incisive width (IW); and incisive length (IL).

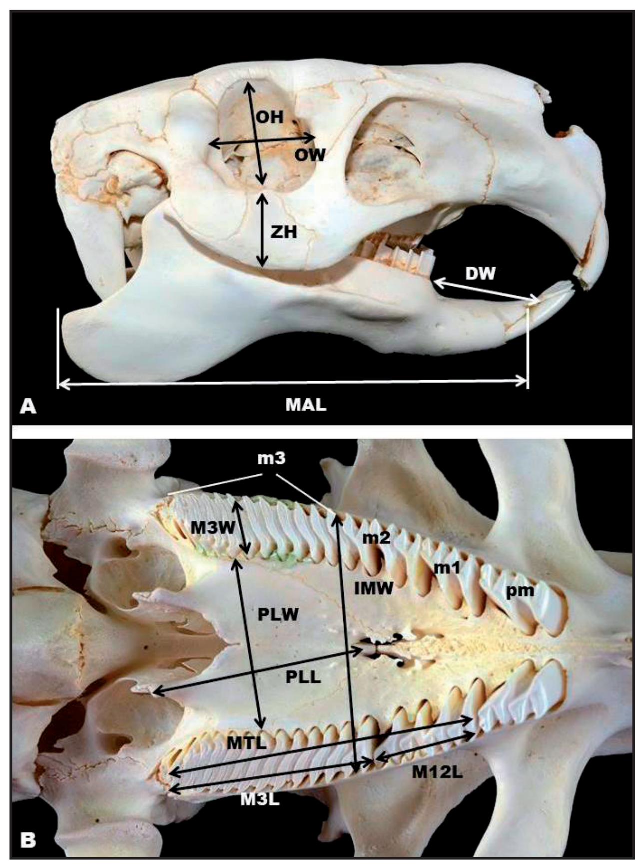

Figure 2. Measurements in the lateral (A) and ventral (B) views of the capybara skull showing orbital width (OW); orbital height (OH); zygomatic height (ZH); diastema length (DW); mandible length (MAL); intermaxillary width (IMW); superior molar teeth length (MTL); superior first and second molars length (M12L); superior third molar length (M3L); superior third molar width (M3W); palatine length (PLL); and palatine width (PLW). Note also the premolar (pm), first (m1), second (m2), and third (m3) molars teeth.

Table 1. Morphometric parameters and indices for the capybara skull bones.

Measurements and Indices	Procedure
1 Skull length (SKL)	Measured from the most caudo-dorsal midline point on the external occipital protuberance to the middle of the rostral margin of the incisive bone
2 Skull width (SW)	Measured from the most lateral point on the zygomatic arches
3 Skull base length (SBL)	Distance between the midpoints of the ventral margin of the foramen magnum to the level of the middle point of the rostral margin of the incisive bone
4 Cranial length (CL)	Distance between the most caudo-dorsal midline point on the external occipital protuberance to the junction on the midline point of the frontonasal suture
5 Cranial width (CW)	Distance between the most lateral points on the frontoparietal sutures
6 Cranial height (CH)	Distance between the dorsal margin of the foramen magnum to the point of the origin of the interfrontal suture
7 Orbital width (OW)	Measured horizontally between the cranial and caudal margins of the orbital rim
8 Orbital height (OH)	Measured perpendicularly between the supraorbital and infraorbital margins of the orbit
9 Facial length (FAL)	Distance from the frontonasal suture to the centre of the incisive bone
10 Facial width (FAW)	Distance between the frontomaxillary sutures of both sides
11 Parietal length (PL)	Distance from the frontoparietal suture to the occipitoparietal suture
12 Parietal width (PW)	Greatest width of parietal bones
13 Frontal length (FL)	Distance between the frontoparietal suture to the frontonasal suture
14 Frontal width (FW)	Distance from the interfrontal suture to the rim of the orbit
15 Nasal length (NL)	Distance from the central point of the frontonasal suture to the cranial end of the internasal suture
16 Nasal width (NW)	Distance across the nasal bones or maximum distance between the internasal suture to nasoincisive suture
17 Frontozygomatic height (FZH)	Distance from the interfrontal suture to the lateral edge of the zygomatic bone
18 Zygomatic height (ZH)	Distance from the dorsal to the ventral margins of the zygomatic bone
19 Occipital width (OCW)	Distance between the most lateral parts of two paracondylar processes
20 Occipital height (OCH)	Distance from the most ventral point of the foramen magnum to the most dorsal, caudal midline point of the external occipital protuberance
21 Intercondylar width (ICW)	Width between the lateral ends of the occipital condyles
22 Foramen magnum width (FMW)	Distance between the two occipital condyles
23 Foramen magnum height (FMH)	Distance between the midpoints of the dorsal-ventral rims of the foramen magnum
24 Dorsal notch length (DNL)	Distance between the middle point of the dorsal margin of the dorsal notch to the middle point of the dorsal margin of the foramen magnum
25 Intermaxillary width (IMW)	Distance across the maxillary bones lateral to the superior third molar tooth
26 Superior molar teeth length (MTL)	Distance between the superior first and superior third molars teeth
27 Superior first and second molars length (M12L)	Distance between the rostral margin of the superior first molar to the caudal margin of the second molar teeth
28 Superior third molar length (M3L)	Distance between the rostral and caudal margins of the superior third molar tooth
29 Superior third molar width (M3W)	Distance between the vestibular and lingual surfaces of the superior third molar tooth
30 Palatine length (PLL)	Distance measured from the rostral mid sutured line of the rostral edge of the interpalatine suture to the caudal nasal spine of the palatine bone
31 Palatine width (PLW)	Maximum distance at the horizontal plate of the palatine bone medial to the superior third molar tooth
32 Diastema length (DW)	Distance between the caudal point of the superior incisive teeth to the rostral point of the superior premolar tooth
33 Incisive width (IW)	Maximum width of the palatine processes of the incisive bone
34 Incisive length (IL)	Distance between the lingual surface of the incisive tooth to the incisivomaxillary suture
35 Mandible length (MAL)	Distance from the rostral margin to the angular process of the mandible
Skull indices	**Calculation method**
1 Skull index (SI)	Skull width x 100/skull length
2 Cranial index (CrI)	Cranial width x 100/cranial length
3 Facial index (FI)	Facial width x 100/facial length
4 Basal index (BI)	Cranial width x 100/basal length
5 Foramen magnum index (FMI)	Height of the foramen magnum x 100/width of the foramen magnum
6 Nasal index (NI)	Width of the nasal x 100/length of the nasal

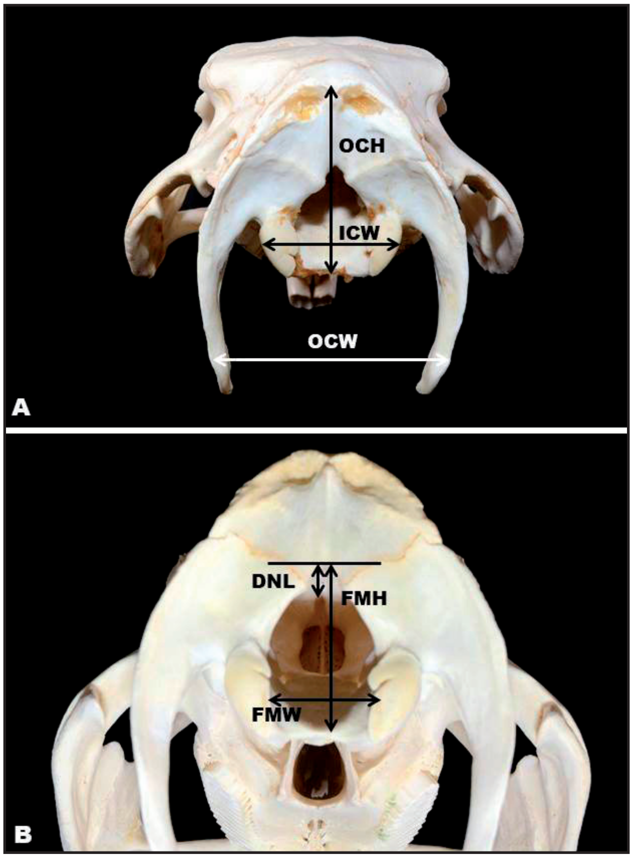

Figure 3. Measurements in the caudal (A-B) region of the capybara skull showing occipital width (OCW); occipital height (OCH); intercondylar width (ICW); foramen magnum width (FMW); foramen magnum height (FMH); and dorsal notch length (DNL).

RESULTS

In the present study, the morphometric parameters in the capybara skull were showed according to the location of the bones. Thus, the parameters were divided into cranial and facial morphometric parameters. The parameters associated to the cranial bones were found in the occipital, parietal, frontal, and temporal bones, while the parameters associated to the facial bones were found in the maxilla, incisive, palatine, nasal, zygomatic, and mandible. Furthermore, morphometric parameters found in the superior molar teeth are also described.

Altogether 35 different measurements were taken and 6 different indices were calculated as shown in Figures 1-3. The morphometric parameters of cranium and the facial morphometric parameters in the capybara skull are showed in the Tables 2 and 3, respectively. The results of the 6 indices applied in this study are given in Table 4. The facial part length (mean 137.90 mm) and cranium part length (mean 87.76 mm) also were calculated. The facial part length was a distance from the cribriform plate of the ethmoid bone to the rostral edge of the incisive bone and, the cranium part length was a distance from the external occipital protuberance to the cribriform plate of the ethmoid bone.

Table 2. Morphometric parameters of cranium in the capybara skull.

Measurements	mean ± SD (mm)
1 SKL (Skull length)	216.90 ± 19.96
2 SW (Skull width)	125.49 ± 12.72
3 SBL (Skull base length)	194.32 ± 6.69
4 CL (Cranial length)	130.80 ± 9.13
5 CW (Cranial width)	66.04 ± 4.96
6 CH (Cranial height)	61.42 ± 4.08
7 PL (Parietal length)	62.31 ± 5.78
8 PW (Parietal width)	66.27 ± 6.16
9 FL (Frontal length)	64.44 ± 4.86
10 FW (Frontal width)	78.08 ± 7.58
11 FZH (Frontozygomatic height)	86.52 ± 8.41
12 OCW (Occipital width)	73.04 ± 6.08
13 OCH (Occipital height)	59.56 ± 4.98
14 ICW (Intercondylar width)	39.80 ± 2.42
15 FMW (Foramen magnum width)	21.99 ± 0.56
16 FMH (Foramen magnum height)	32.90 ± 2.71
17 DNL (Dorsal notch length)	37.04 ± 2.32

Table 3. Facial morphometric parameters in the capybara skull.

Measurements	Mean ± SD (mm)
1 OW (Orbital width)	51.10 ± 4.29
2 OH (Orbital height)	43.79 ± 4.83
3 FAL (Facial length)	103.97 ± 13.82
4 FAW (Facial width)	51.17 ± 6.17
5 NL (Nasal length)	74.52 ± 9.27
6 NW (Nasal width)	19.92 ± 3.07
7 ZH (Zygomatic height)	28.08 ± 4.21
8 IMW (Intermaxillary width)	61.86 ± 6.66
9 MTL (Superior molar teeth length)	76.30 ± 7.13
10 M12L (Superior first and second molars length)	21.43 ± 1.89
11 M3L (Superior third molar length)	38.01 ± 3.64
12 M3W (Superior third molar width)	9.75 ± 1.21
13 PLL (Palatine length)	37.32 ± 3.84
14 PLW (Palatine width)	13.32 ± 1.34
15 DW (Diastema length)	64.23 ± 6.93
16 IW (Incisive width)	37.36 ± 16.65
17 IL (Incisive length)	46.21 ± 5.56
18 MAL (Mandible length)	186.33 ± 18.33

Table 4. Skull indices in the capybara skull.

Indices	Mean ± SD (mm)
1 SI (Skull index)	57.86 ± 3.62
2 CrI (Cranial index)	50.49 ± 2.08
3 FI (Facial index)	49.22 ± 3.82
4 BI (Basal index)	33.98 ± 0.86
5 FMI (Foramen magnun index)	149.61 ± 1.07
6 NI (Nasal index)	26.73 ± 3.1

DISCUSSION

The skull is the most complex and specialized part of the mammalian skeleton and is divided into cranium and facial part. In this study, the morphometric parameters in the capybara (*Hydrochoerus hydrochaeris*) skull were evaluated. The various craniometric measurements performed in this study, as well as the calculated cranial indices, were obtained with the aim of contributing to a possible standardization of capybaras skull. All values were compared with literature data. Although the names of measurements and/or indexes may differ from those presented by some reports, the points used and measured correspond to the usual ones presented in the literature.

The findings of the craniometric evaluations serve as support for anatomical studies, helping to identify the species, sex, age, habits, among others features [5,7,22]. The craniometric measurements in this study are compatible with reported in other studies for the capybara skull whose cranial measurement was performed. In this study, the exact differentiation of capybaras and craniometric measurements based on these variables was not possible due to the lack of information such as origin, sex or age of the animals used in this study, since the skulls belonged to the collection of the Laboratory of Wildlife Anatomy and institutional Anatomical Museum.

The age categories of capybaras was estimated based on some cranial measurements (FW, FZH, IMW, SW, PW, M12L, M3L, M3W, and MTL) and the suture closure pattern found on the ventral surface of the skull [5]. If we take these measurements into account, the capybaras in this study could be classified into subadult (4) and adults (4), some in the transition between these age categories, although some of the skulls were broken in the ventral surface, which made the estimate of age based on the closure of these sutures unreliable for the animals in this study, so we did not use this division of animals into 2 groups: subadults and adults.

Capybaras were divided into young and adults specimens according to craniometric measurements (SKL, CL, CW, SW, and SL) and body weight [8]. Considering what was proposed in the previous studies [5,8], in this study, 5 animals had well-defined age categories (capybaras 1, 4, 5, 6, and 8), 3 identified as subadults and 2 as adults. The other capybaras, on the other hand, present mixed cranial measurements between the 2 ranges, which could indicate a transition period within the animals' development, when it is not possible to differentiate them accurately. The capybaras 3 and 7, for example, showed divergences for the values reported previously [8]. The capybara 2 presented mixed results for both studies [5,8]. However, carrying out the measurements on the skulls of animals of similar age could explain the homogeneity observed in the mean values of the measurements performed.

The skull of capybara has a rectangular shape, different from that found in other caviids rodents such as *Cavia aperea*, which has a more piriform skull [2]. The length of the facial part was, on average, 137.90 mm (from the level of the cribriform plate of the ethmoid bone to the rostral end of the incisive bone) compared to the length of the cranium part, which was 87.76 mm (from the external occipital protuberance to the cribriform plate of the ethmoid bone), which demonstrates greater development of the facial part in relation to the cranium part. Similar results led to the comparison of the skull shape of capybaras with the shape found in dolichocephalics dogs [8]. Furthermore, probably the large caviomorph rodents show more elongated faces, whereas some of the smaller ones have shorter face part [1]. The findings of this study are in agreement with this statement, since capybara is the largest extant rodent in the world.

Some morphometric parameters measured in this study are the same as those previously calculated [5,8]. In this case, these parameters did not differ much from the measurements reported by these authors for the skull of adult capybaras, for example, we can mention the intermaxillary and parietal widths, which were on average 61.86 mm and 66.27 mm, respectively. In the previously analysis, the intermaxillary and parietal widths were 63.09 mm and 73.87 mm, respectively [5]. It is noteworthy that none of the cranial indices calculated in this study were calculated by the aforementioned authors, which made it not possible to compare all the findings of this study.

The capybaras of this study showed a dorsal triangular notch in the outline of the foramen magnum, different to what is reported for *Cavia* spp., where the foramen magnum has a straight or convex dorsal rim [2]. This notch has already been described in some rodents such as Gambian rat (*Cricetomys gambianus*) [16], and in other mammals species, such as four-toed hedgehog (*Atelerix albiventris*) [4], maned wolf (*Chrysocyon brachyurus*) [23], and dromedaries (*Camelus dromedaries*) [28]. In dogs, this contour profile of the foramen magnum has already been considered a morphological change present in these animals, however, recent studies consider this fact to be just an anatomical variation that does not cause harm in dogs [13], which is quite common in brachycephalic breeds and therefore has no functional meaning [3].

CONCLUSIONS

Based on the results of this study, it is possible to show that the capybaras have a rectangular skull with greater development of the facial part in relation to the cranium part. Probably, this morphology is compatible with the ecology and phylogeny of the species. From the results in the present study, some morphometrical parameters are similar with reported in the literature, although few parameters were previously measured in the capybara skull. Moreover, the morphometrical parameters of the capybara skull will serve for other comparative studies and in clinical veterinary practice.

MANUFACTURER

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***Ethical approval*.** All procedures, treatments and animal care were in compliance with the Institutional Ethics Committee on the Use of Animals of the School of Veterinary Medicine and Animal Science, UNESP (CEUA 212/2018).

***Declaration of interest*.** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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