Anatomical peculiarities of the broad-snouted caiman's skull and vertebral column bones *(Caiman latirostris)*

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Abstract
It was noticed that the caiman skull is diaspid, presenting two temporal fossae, one superior (dorsal) and one inferior (lateral). The cranial cavity is reduced compared to the development of the skull, with the orbits and nostrils having a lateral orientation. The occipital has a single articular condyle for the atlas. In front of the first vertebra, atlas, there is an undeveloped proatlas vertebra. The cervical vertebrae have developed transverse processes. There is also a ventral creast on the body of the cervical vertebrae. The thoracic vertebrae have detached transverse processes, which grow towards the end of the region, serving alone for the articulation with the ribs. The sacral region is short, and consist in two vertebrae which articulate with the ilium. The caudal vertebrae bear relatively long neural and haemal spines, forming a ventral arch for the blood vessels.

Keywords: *caiman, peculiarities, skull and vertebral column bones*

Introduction

The broad-snouted caiman (*Caiman latirostris*) is a crocodilian reptile American of medium size (for their group), generally 1,5-2 m long, part of the *Reptilia Class, Crocodylia Order*. This order includes big, predatory and semi-aquatic reptiles, crocodiles *(Fam. Crocodylidae)*, alligators and the caimans *(Fam. Alligatoridae)* and the gavials *(Fam. Gavialidae)*. Found in eastern and central South America, including southestern Brazil, northen Argentina, Uruguay, Paraguay and Bolivia. It is found mostly in freshwater marshes, swamps, and mangroves, usually in still or very slow-moving waters (4,5, 6).

The aim of the study was the highlight of the specific characters of the skull and vertebral colum bones in broad-snouted caiman, having many morphological peculiarities, the knowledge of them being important zoologically, but also clinically, for those animals which are kept in captivity, in zoo parks and can present various pathologies.

Materials and methods

The study was conducted on a corp of a broad-snouted caiman (*Caiman latirostris*), that belonged to Bârlad Zoo. It was a male caiman, 24 years old. For the analysis, the bones were prepared by boiling and cleaning. By using classical anatomical methods there were noticed the particularities of the skull and vertebral column bones. Each bone was examined by observing both its dimensions, the development of certain processes and any difference regarding other species of reptilians. For illustration, they were photographed with the Olympus camera, and they were processed in Adobe Photoshop.

Results and discussions

The dorsal surface of the skull is sculptured with pits, grooves, and ridges. Sculpturing is also present, to a smaller extent, on the lateral and ventral aspect of mandibular surfaces. The oral part of the rostrum is formed by the premaxillae. Located dorsally on the premaxillae is the large opening for the nostrils. Another opening on the premaxillae, is the incisive foramen. The largest bones of the rostrum are the maxillae. The nasals are short and relatively narrow bones that are placed dorsomedially on the rostrum and reach the external naris posteriorly.

The frontal constituting the majority of the medial orbital margins. Anteriorly, the frontal forms an elongated pointed process that is wedged between the prefrontals and nasals. Medially, the orbits are separated from each other by the cartilaginous interorbital septum.

The portion of the skull above and posterior to the eyes is comprised of the postorbitals, squamosals, parietal, and most of the frontal. The posteromedial part of the cranial table is formed by the parietal, which is another relatively large bone.

The postorbitals form the anterolateral portions of the cranial table. Ventrally, the postorbitals send descending, pillar-like processes that form significant portions of the postorbital bars. The postorbital bars are also formed by the ascending processes of the zygomatic ventrolaterally and by the ectopterygoids ventromedially. The squamosals make up the posterolateral parts of the cranial table (fig. 1).

Fig. 1 Broad-snouted caiman skull in dorsal aspect:
1 — *Incisive foramen*; **2** — *Premaxilla*; **3** — *Maxilla*; **4** — *Nasal*; **5** — *Prefrontal*; **6** — *Frontal*; **7** — *Orbit*; **8** — *Postoribital bar*; **9** — *Jugal/ Zygomatic*; **10** — *Quadratojugal*; **11** — *Quadrate*; **12** — *Inferior temporal fossa*; **13** — *Superior temporal fossa*; **14** — *Postorbital*; **15** — *Squamosal; **16** — Parietal; **17** — Proatlas; **18** — Atlas.*

Fig. 2 Broad-snouted caiman skull in ventral aspect:
1 — *Premaxilla*; **2** — *Incisive foramen*; **3** — *Maxilla*; **4** — Neuro*vascular foraminas*; **5** — *Palatine*; **6** — *Ectopterygoid*; **7** — *Jugal/ Zygomatic*; **8** — *Chonae*; **9** — *Quadratojugal*; **10** — *Quadrate*; **11** — Pterygoid; **12** — *Secondary chonae*; **13** — *Atlas.*

The caiman skull is diaspid, presenting two temporal fossae, one superior (dorsal) and one inferior (lateral). In caimans, the supratemporal fossae usually close with ontogeny or they are small. The zygomatic (jugals) bones are elongated and form the majority of the ventral margins of both the orbits and laterotemporal fossae (2, 8, 9,10).

Fig. 3 Broad-snouted caiman skull with mandible - in occipital view:
1 ─ *Supraoccipital*; **2** ─ *Exoccipital*; **3** ─ *Paracondylar process*; **4** ─ *Proatlas*; **5** ─ *Atlas*; **6** ─ *Ectopterygoid*; **7** ─ *Pterygoid*; **8** ─ *Quadratojugal*; **9** ─ *Quadrate*; **10** ─ Retroarticular process; **11** ─ Mandibular adductor fossae; **12** ─ *Basioccipital.*

Fig. 4 Broad-snouted caiman mandible-dorsal aspect:
1 ─ *Dentary*; **2** ─ *Splenial*; **3** ─ *Coronoid*; **4** ─ *Surangular*; **5** ─ *Angular*; **6** ─ *Mandibular adductor fossae*; **7** ─ *Glenoid fossae*; **8** ─ *Retroarticular process.*

The quadratojugals are located at the posterolateral portions of the skull, contacting the jugals anteriorly and anterolaterally, and quadrates medially. The quadratojugals contribute to the laterotemporal fossae's posterior margins The quadrates are large, found at the posterolateral parts of the skull. The distal or posterior portions of the quadrates bear the quadrate condyles that articulate with the mandibles (fig. 1).

On the ventral surface, the hard palate consist in premaxilla, separated almost entirely by the incisive foramen, together with the wide palatine processes from the maxilla and palatine bones. The alveolar margins bear numerous small openings called neurovascular foramina (8,9). The dorsal surfaces of the palatines together with those of the pterygoids form the nasopharyngeal duct. The large oval openings ventrally on the skull are the suborbital fenestrae. The pterygoids are large, wing-like elements that contact the palatines anteriorly and ectopterygoids laterally (fig. 2).

Posteromedially on the pterygoids are the secondary choanae that are fully enclosed by the pterygoids. The ectopterygoids are robust bones that contact the maxillae and zygamatic dorsally and the pterygoids posteroventrally.

The aboral surface of the skull consist in supraoccipital place dorsal, in sagital plan, a wide exoccipital, that bears two paracondylar process and a small basioccipital. The basioccipital is located medioventrally on the occiput and forms the semispherical occipital condyle (fig.3). The foramen magnum is relative large at the center of the occiput (8,10).

The largest bones of the mandibles are the dentaries. The posterodorsal portions of the mandibles are formed by the surangular bones, while the angulars form the posteroventral. Together with the posterior portions of the dentaries, the anterior of the surangulars and angulars surround the external mandibular fenestrae, the largest openings of the mandibles. Attached medially on both the surangulars and angulars are the articulars bones. Anteriorly on the articulars are the concave fossae (glenoid fossae) that articulate with the condyles of the quadrates. The articulars develop the long retroarticular processes that project posterodorsally.
The smallest bones of the mandibles are the coronoids (fig.4).

The number of vertebrae is similar across all living crocodylians and usually comprises 9 cervical, 12 thoracal, 5 lumbar, 2 sacral, and depending on the species between 35 and 45 caudal. The vertebrae are procoelous type, the vertebral body is concave anteriorly (vertebral fossa), while caudal aspect is spheroidal convex (articular head) that articulates with the concave anterior of the succeeding vertebra. All vertebrae in living crocodylians are procoelous, except for the atlas, second sacral, and first caudal vertebra (8,10). The first cervical vertebra comprises the atlas-proatlas complex which articulates with the only one occipital condyle. The proatlas has a triangular pyramid appearance, attached to the dorsal aspect of the atlas. The second sacral vertebra is biconcave, by having concave anterior and posterior ends. The posterior articular head on the first sacral vertebra is weakly developed. The first caudal vertebra is biconvex (fig.11), by having semi-spheroidal convex articulatory heads both cranial and caudal.

Axis bears the odontoid process, not very prominent, with a flat dorsal surface, which articulates with the atlas.

Projecting laterally from the neural arches of the cervical and first two thoracic vertebrae are the diapophyseal processes, and projecting laterally from the body are the parapophyseal processes which articulates with the cervical ribs (ventral bony blade), for the cervical region, or with the true ribs, in case of the first 2 thoracic vertebrae. Between the diapophyseal processes and the parapophyseal processes there is a large space corresponding to the transverse foramen in mammals (fig.5). In the cervical region, the articular processes are wide and detached, the spinous process grow in height, from C4 to C9 and also, anteroventrally on the body of all cervical (except the atlas) and first three or four thoracic vertebrae are short and thin ventral crest (1, 3, 4, 7).

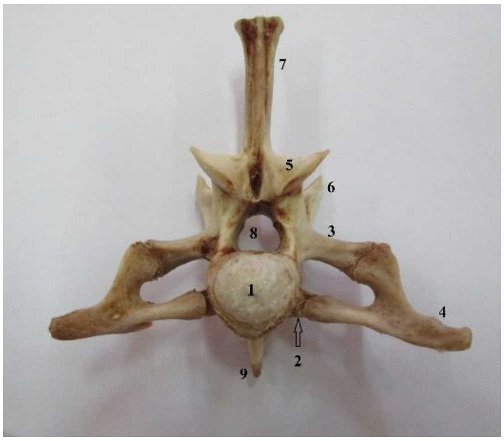


Fig. 5 Cervical vertebra of broad-snouted caiman - caudal view:
1 — *Vertebral body*; **2** — *Parapophyseal process*; **3** — *Diapophyseal (transvers) process*; **4** — *Ventral bony blade/ cervical rib*; **5** — *Caudal articular process*; **6** — *Cranial articular process* **7** — *Spinous process*; **8** — *Vertebral foramen*; **9** — *Ventral crest*.

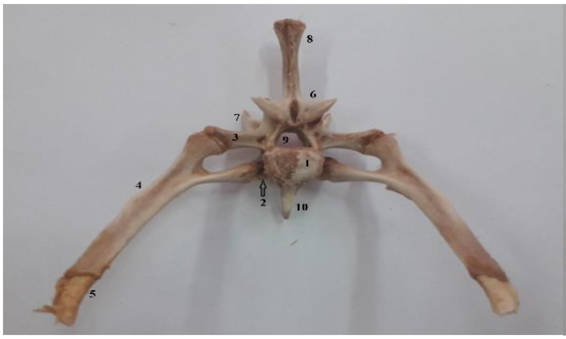
The thoracic vertebrae have transverse processes that grow in length towards the middle of the region and then decrease towards the lumbar region and provide articular surfaces for both the head and the tubercle of the ribs (fig. 6, 7, 8).

The lumbar vertebrae have transverse processes with a constant length, not very detached, together with a constant hight of the spinous processes and wide articular processes, with flat surfaces (fig. 9).

The sacrum consist only in two vertebrae, the first one being more developed that the second one. The fusion between the vertebrae take place at the level of the bodys and arches, the spinous and transverse processes remain distinct. The transverse processes are robust, short and strong, articulated with ilium through a wide lateral surface.

Fig. 6: The dorsal aspect of the cervical vertebrae

The thoracic vertebrae have transverse processes that grow in length towards the middle of the region and then decrease towards the lumbar region and provide articular surfaces for both the head and the tubercle of the ribs.



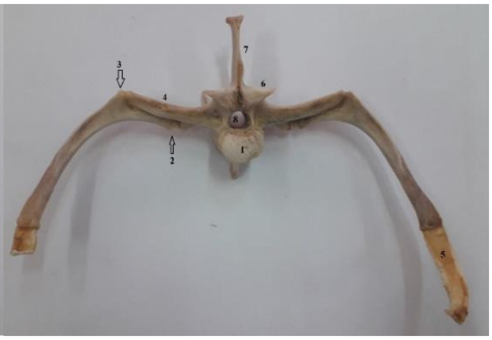


Fig. 7 Second thoracic vertebrae of broad-snouted caiman - caudal view:
1 — *Vertebral body*; **2** — *Parapophyseal process*; **3** — *Diapophyseal (transvers) process*; **4** — *Rib*; **5** — *Costal cartilage*; **6** — *Caudal articular process* **7** —Cranial articular process; **8** — *Spinous process*; **9** — *Vertebral foramen*; **10** — *Ventral crest.*

Fig. 8 Fifth thoracic vertebra of broad-snouted caiman - caudal view:
1 — *Vertebral body*; **2** — *Head of rib*; **3** — *Costal tubercle*; **4** — *Diapophyseal (transvers) process*; **5** — *Costal cartilage*; **6** — *Caudal articular process* **7** — *Spinous process*; **8** — *Vertebral foramen*; **9** — *Ventral crest.*

The lumbar vertebrae have transverse processes with a constant length, not very detached, together with a constant hight of the spinous processes and wide articular processes, with flat surfaces.

The sacrum consist only in two vertebrae, the first one being more developed that the second one. The fusion between the vertebrae take place at the level of the bodys and arches, the spinous and transverse processes remain distinct. The transverse processes are robust, short and strong, articulated with ilium through a wide lateral surface (fig. 10).

The first caudal vertebrae resemble more a lumbar vertebra, with short and flat transverse processes, a wide detached spinous process and well developed articular processes. The body has convex articular surface in both sides (fig. 11). Attached posteroventrally on most caudal vertebrae are the hemal processes with hemal arches placed between two adjacent vertebrae. Posteriorly, toward the tip of the tail region, the caudal vertebrae gradually decrease their dorsoventral heights and lose their transverse, articular and spinous processes, their bodys become more elongated and the posterior convex surface are also getting less prominent, until the small and elongated body are all that remain of the last caudal vertebrae (fig. 12, 13).

Fig. 9 Lombar vertebra of broad-snouted caiman - caudal view:
1 — *Vertebral body*; **2 —** *Transvers process*; **3 —** *Caudal articular process*; **4 —** *Cranial articular process*; **5 —** *Spinous process*.

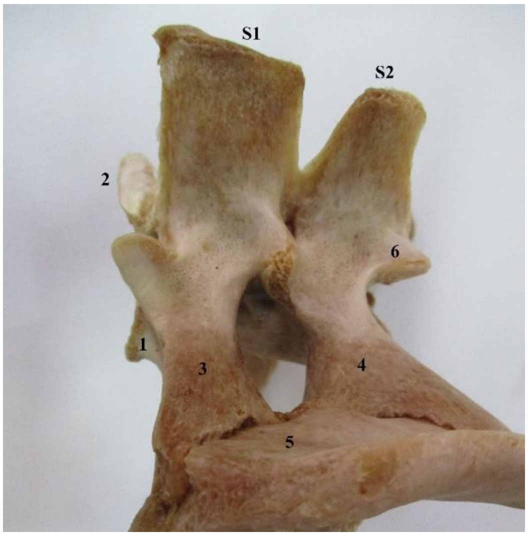


Fig.10 sacral vertebrae in broad-snouted caiman – lateral view:
1 — *Vertebral body*; **2 —** *Cranial articular process*; **3 —** *Transvers process of S1*; **4 —** *Transvers process of S2*; **5 —** *Ilium*; **6 —** *Caudal articular process*

Fig. 11 First caudal vertebrae in broad-snouted caiman – lateral view:
1 — *Vertebral body*; **2 —** *Transvers process*; **3 —** *Cranial articular process*; **4 —** *Caudal articular process*; **5 —** *Spinous process*.

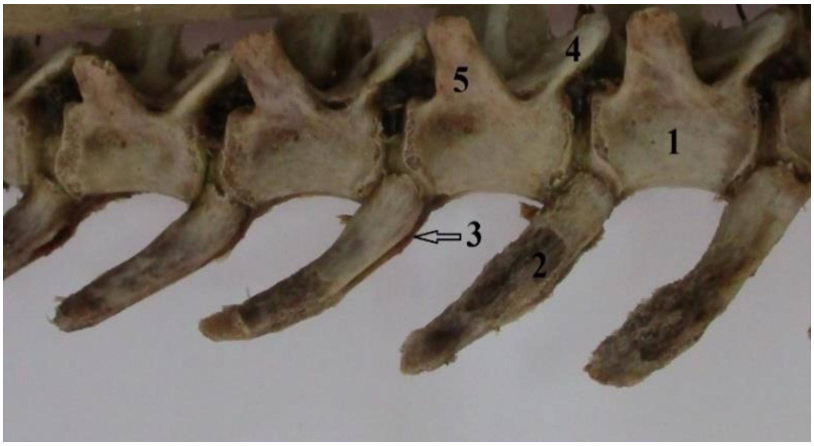


Fig. 12 Caudal vertebrae in broad-snouted caiman – ventro-lateral view:
1 — *Vertebral body*; **2 —** *Hemal process*; **3 —** *Hemal arc*; **4 —** *Cranial articular process*; **5 —** *Transverse process*.

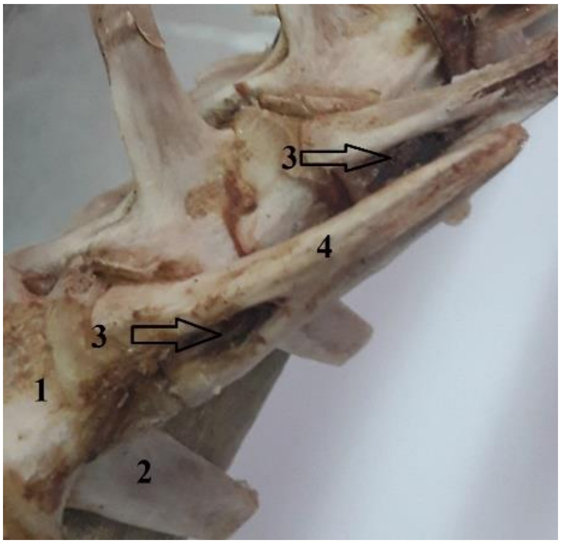


Fig. 13 Caudal vertebrae in broad-snouted caiman – ventro- view:
1 — *Vertebral body*; **2 —** *Transverse process*; **3 —** *Hemal arc*; **4** *Hemal process*.

Conclusions

1. The caiman skull is diaspid, presenting two temporal fossae, one superior (dorsal) and one inferior (lateral).
2. The vertebrae are procoelous type, the vertebral body is concave anteriorly (vertebral fossa), while caudal aspect is spheroidal convex (articular head) that articulates with the concave anterior of the succeeding vertebras.
3. Most caudal vertebrae have attached hemal processes with hemal arches placed between two adjacent vertebrae.

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