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Original Article

MORPHOLOGICAL AND RADIOLOGICAL STUDIES ON THE SKULL OF THE NILE CROCODILE (CROCODYLUS NILOTICUS)

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ABSTRACT

Background and Aim: Present study provides with more anatomical information on the structure and form of the bones forming the cranium of the Nile crocodile helps in understanding the interpretation of X ray images and surgical affection of the crocodile heads.

Materials and Methods: The present study was conducted on six heads of the Nile crocodile (Crocodylus niloticus). The heads were removed from their bodies and prepared by hot water maceration technique. The bones of the skull were studied separately and identified by using a specific acrylic color for each bone.

Results: The cranium of the crocodile composed of the cranial bones and the facial bones. The crocodile had four paired paranasal sinuses; the antorbital, the vomerine bullar, the pterygopalatine bullar and the pterygoid sinuses. The mandible of crocodile formed from six fused bones (articular, angular, suprangular, coronoid, splenial and dentary). The X ray images were applied for identifying the paranasal sinuses which their contribution to the morphological organization of the head.

Conclusion: this results show a bony variation between the crocodile, mammals and also the birds that paves the way to the comparative anatomical and radiological studies.

KEY WORD: Anatomy, Radiology, Cranium, Para-nasal sinuses, mandible, Nile crocodile.

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INTRODUCTION

The development of the vertebrate animals varies with the type of living and their feeding habits. The Nile crocodiles are found in a wide variety of habitat types, including large lakes, rivers, and freshwater swamps. In some areas they extend into brackish or even saltwater environments [1,2]. Nile crocodiles display an ontogenetic shift in diet, from insects and small aquatic invertebrates when young, to predominantly vertebrate prey among larger crocodiles. It survives in Africa and large individuals eat zebra, large domestic animals and humans. This evolution affects the shape and features of their bones; mainly their heads in order to accommodate the needs of their surroundings [3,4].

The vertebrate skull was complex structures with multiple evolutionary and developmental sources. There are several modifications in the skeletal apparatus of the large aquatic predators represented in the cranium of the crocodile for investigating the feeding functional morphology [5]. Crocodilians have large, powerful skulls, many cranial bones are pneumatised and have gas-filled cavities (fenestrae) connected to Eustachian tubes of the middle ear and the nasal passages. These may equalize pressure in the inner ear and it helps in lightening the weight of the skull and played an important consideration in the cooling system of the brain, buoyancy and feeding [6,7].

MATERIALS AND METHODS

This work was carried out on six heads of the crocodile which collected from Lake Nasser in Egypt. The crocodile was euthanized using a high dose of gallamine triethiodide more than 4mg/ kg IM cause death [8]. Two heads were used for radiological study by using x-ray with the parameters 53 KV and 5 mAs in the oblique ventrolateral and dorso-ventral positions. The other four heads were prepared and cleaned for the anatomical study.

Manual removal of the skin, tongue, eyes and flesh by using dissecting equipments. The removal of the brain by filling the cranial cavity with water and repeat stirring by using a wire sticks through foramen magnum. The specimens were prepared by boiling or hot water maceration; it was cooking in metal container by using the water-detergent-carbonate solution (Powdered detergent (Tide™) 20cc per 2L water and powdered sodium carbonate 20cc per 2L water) over low heat [9].

The specimens were checked every 10-15 min, then it was rinsed in running water and the soft tissues were manually removed from it. It was soaked for six days in degreasing solutions (100liter water: 30ml ammonia solution) for disappeared the greasy texture then was thoroughly washed by water. The specimens were soaked in hydrogen peroxide (H_2O_2) with a concentration of 3%– 6% for seven to ten days in a sealed plastic container until desired whiteness was obtained, then washing with water to remove any chemical residues [10,11,12].

After the cleaning and bleaching process, the prepared specimens were dried for ten day then several light coats of the plastic spray were applied. The anatomical structures of two skulls were noted and identified of each bone by different acrylic color. Two skulls were cut by using manual bone saw to demonstrate the paranasal sinuses and the entire structures of the skull.

The obtained results were photographed by using digital camera 20 mp, 16x.the [13]. was utilized for denominating the anatomical terms in the study.

RESULTS

The bones of the skull of the Nile crocodile were studied separately. Six photos for the cranium in different views (dorsal, ventral, lateral, caudal and sagittal views) to study the anatomical feature of each bone.

The skull was a triangular in shape, it was elongated and compressed dorsoventrally with long, sharp conical teeth of various sizes and had one root where were set in sockets. The cranium composed of the cranial and the facial components.

The cranial bones consisted of the occipital, sphenoid, parietal, frontal and temporal while the facial components formed of the nasal, premaxillary, maxillary, jugal, palatine, pterygoid, vomer and quadrate. The mandible was formed of six fused bones; the dentary, angular, supra-angular, splenial, coronoid and articular bones.

I- Cranium:

A. The cranial components:

Os occipitalis: The occipital bone constituted the caudal part of the skull. It was composed of a completely fused four bones enclosing a foramen magnum; the supraoccipitalis, basioccipitalis and right, left exoccipitalis.

The supraoccipital (fig. 4A, 5, 6 /1) was a sqamous flat bone that formed the dorsal boundary (roof) of the foramen magnum, and showed a well-developed a single median crest for the attachment of the cervical muscles.

The basioccipital (fig. 4A, 5, 6 /2) was a u-shape, called the basilar part which made the ventral boundary (floor) of the foramen magnum. It had mainly a single spherical shape occipital condyle(fig.4A,4D,5/2a) which articulated with the condyloid fossa of the atlas forming atlanto-occipital joint. It extended rostrally forming the posterior floor of the cerebral cavity and contacted with the exoccipital dorsally in occipital view. A deep depression located between the basioccipital and basisphenoid bones, which had the opening of the median Eustachian tube (foramen intertympanicum) (Fig. 4B/f1). The openings of lateral Eustachian canals (Fig.4B /f2) was presented caudolateral to the median one.

The exoccipitals (Fig. 4A, 6/3) they were two fused bone, they met at the midline dorsal to the foramen magnum and extended laterally forming the paraoccipital processes (fig.4A/3a). These bones were sutured with the squamosal bone dorsolaterally and the supraoccipital bone dorsomedially.

Lateral to the foramen magnum (Fig. 4A, 4D /4), there are four foramina. The ventrolateral foramen represented the external ostium of the osseous cranial carotid canal (Fig. 4D/f3) for the internal carotid passage. The lateral and larger one was the foramen vagus (Fig. 4D/f4) for the passage of the IX, X, and XI nerves and the jugular vein. The medial one was the foramen hypoglossi (Fig. 4D /f5) for the passage of the XII nerve. The dorsolateral foramen was a foramen for facial nerve (VII) (Fig.4D /f6).

Os sphenoidis: The sphenoid bone formed of basisphenoid**,** parasphenoid and alisphenoid. The basisphenoid and parasphenoid appeared to be completely fused. The basisphenoid (fig.4A, 6/5) was located at the rostroventrally to the basioccipital bone. The basisphenoid bone bounded by pterygoids bone rostrally and the basioccipital bone caudally. A deep oval-shaped opening of trigeminal foramen (fig.4C /f7) for the V nerve bounded rostrally by the laterosphenoid (alisphenoid) (fig. 4C/6) and the postorbital bone, caudodorsally by the quadrate bone and ventrally by the pterygoid bone.

Os parietalis: The parietal bones (fig. 1, 6 /7) completely fused with the surrounding bones. It formed the medial margin of the supratemporal fenestrae then curved laterally and became continuous rostrally with the posterior margin of the frontal bone and bounded caudally by the supraoccipital bones caudally and laterally by the squamosal bone.

Os frontale: The frontal bone (fig. 1, 6 /8) was a single broad, completely fused bone, laid between the preorbital and the parietal bones. The anterior margins converged rostrally, the lateral edge was concave and the posterior margin was convex. The frontal formed the ant-erior portion of the supratemporal fenestra. Posteriorly, the frontal met the parietal along an almost transverse suture, posteroventrally, the frontal extensively contacted with the dorsal portion of the laterosphenoids.

Os temporalis: The squamosal (temporal bone) (fig.1, 6 /9) formed the caudolateral margin of the supratemporal fenestra. The caudoventral edge of the temporal bone curved over the otic recess(fig. 3/9a) and contacted to the quadrate bone. The temporal was sutured to the postorbital bone rostrodorsally. The skull of the crocodile was known as diapsid or "two arched" reptile. The skull had paired fenestrae, supra and lateral temporal fenestrae, these fenestrae located at dorsal wall of the skull behind to the large orbits. The supratemporal fenestra (fig.1/ 9b) spherical in shape bounded by parietal bone caudally, squamosal bone caudolaterally and frontal bone rostrally. The lateral temporal fenestra (fig. 1/9c) was triangular in shape and wider than the supratemporal one, bounded by qudratojugal bone caudally, the squamosal bone medially, the jugal bone laterally and the postorbital bone rostrally.

B. The facial components:

Os nasale: The nasal bone (fig.1,5, 6/10) long and narrow bone, tapered rostrally, but diverged slightly as they entered the distinctly pear-shaped external nares(fig.1/10a) as the nostrils were at the tip of the snout. It bounded by the prefrontal caudally, lacrimal and maxillary laterally and premaxilla rosrtrally.

Os premaxillare (Incisive bones) or (Intermaxillary bones): The premaxillary bone (fig.1, 6 /11) was rounded in shape, was extended caudo- dorsally isolating the external nares from the maxillae. It carries the incisors teeth and incisive foramen (fig.1,2 /f8).

Os maxillare: The maxillary bone (fig.1,3,6/ 12)was long and broad, flattened dorsoventrally. It bounded by jugal bone caudally, lacrimal caudomedially, nasal bone medially and incisive bone rostrally.

Os palatinum: The palatine bones were very long bones extended mainly about 2/3 ventral surface of the skull, it consisted of three process; the palatal process of premaxilla, palatine process of maxilla and palatine process of palatine. (fig.

2,6 /13,13a,13b respectively).

The paired palatal fenestrae (fig.2/13c) occurred ventral to the orbits and was elongated oval shape, bounded by the palatine process of maxilla rostrally, the palatine process of palatine medially, the ectopterygoid laterally and the pterygoid bone caudally.

The internal nares (fig.2/13d) were prolonged caudally by palatal process of palatine bone and extended to secondary choanae opened within the pterygoid bone.

Os jugale: The jugal bones or zygomatic bones (fig.1, 2, 3, 6 /14) were long bones, they shared in the formation of the orbit. Each bone extended rostrally connecting the maxilla and lacrimal bone by the infraorbital process (fig.1,6/14a).The orbital margin of the jugal posseses was overlapped by the postorbital process. The lateral ridge at the ventral margin of the jugal bone connected to the ectopterygoid dorsoventrally.

Os pterygoidium: The pterygoid bones were broad flat, completely fused bones which articulated rostrally to the palatine and caudally with the occipitals bones. It formed part of the caudal margin of the palatine fenestra. It was consisted of body and wing, the body (fig. 2,6/ 15) was a broad, transversely concave sheet bearing, unpaired opening along the midline,called the secondary choanae and the wing(fig. 2,4 /15a) extended caudoventrally and overlapped dorsally by ectopterygoid(fig. 2,6 / 15b). The dorsal surface of the ectopterygoid is horizontally placed and contacts the jugal bone and maxillary bone.

Vomer: The vomer bone (fig.4B,5/16) was a single bone that divided the secondary choana (fig.2,4B,5/16a) into two cavities or subfossae called choanal fenestra (fig.4B/16b).

Os qudratum: The quadrate bone (fig.1, 2, 3, 4/ 17) triangular in shape, it laid between the temporal and the qudratojugal bones (fig.1, 2, 3, 6 /18). It has a foramen aereum of cranial pneumatic airspaces: siphonium (fig.4A, 4D /f9).

Os lacrimale: The lacrimal bone (1, 6/19) formed the anteriorlateral margin of the orbit. The lateral margin of this bone was sutured to the dorsal region of the infraorbital process of the jugalar bone. It contacted with the maxilla and prefrontal bone.

Os prefrontale: The prefrontals (preorbital) (fig.1, 3, 6 /20) formed the rostromedial margin of the orbit. The medial extension of the prefrontal bone was prevented contact between the frontal and nasal. Its lateral margin was contact to the lacrimal bone.

Os postorbitale: The postorbital bone (fig.1, 3, 4C, 6 /21) formed the posterolateral margin of the orbit as well as the rostrolateral margin of the lateral-temporal fenestrae separating the orbit from this opening.

The orbit: Seven bones formed the bony wall of the orbit (fig.1/22) the prefrontal, frontal, lacrimal, zygomatic (jugal), postorbital, temporal (squamosal), and sphenoid (basisphenoid and alisphenoid). The rostral wall of orbit formed by the lacrimal bone while its medial wall formed by prefrontal bone and frontal bones and its lateral wall supported by zygomatic bone.

C. The paranasal sinuses:

The paranasal sinuses: (sinus paranasales) were air filled cavities between the external and internal lamina of the bones of the skull which were connected to the nasal cavity. There were a four paired paranasal sinuses; the antorbital, the vomerine bullar, the pterygopalatine bullar and the pterygoid sinuses.

The antorbital sinuses: (fig.5, 7, 8, 9 /SA) were a large sinus, included within the maxillary bone. It had a medial diverticulum presented in the palatal process of the maxilla.

The nasal airway had a long nasopharyngeal duct which formed by the vomer, palatine and pterygoid bones. This duct began from the nostril to the pharynx and opens in the secondary choanae. The vomerine bullar sinuses, the pterygopalatine bullar sinus, and the pterygoid sinus aroused from the nasopharyngeal duct.

The vomerine bullar sinuses: (fig. 5,7,8,9/SB) bounded medially by the vomer bone and lateroventral formed by palatal process of palatine bone. The pterygopalatine bullar sinuses (fig.5, 7, 8, 9 /SC) were the largest paranasal sinus in crocodile, enclosing within the palatine and the pterygoid bones.

Fig.1: A photograph showing the crocodile skull. (dorsal view)

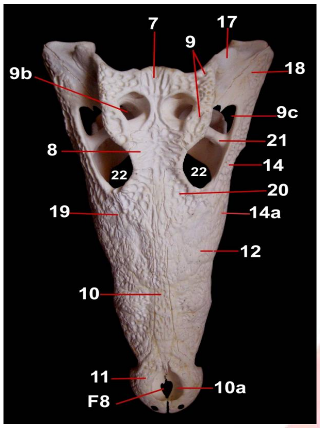


Fig.2: A photograph showing the crocodile skull.(ventral view)

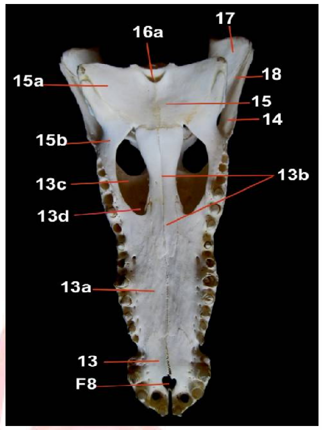


Fig.3: A photograph showing the crocodile skull (lateral view).

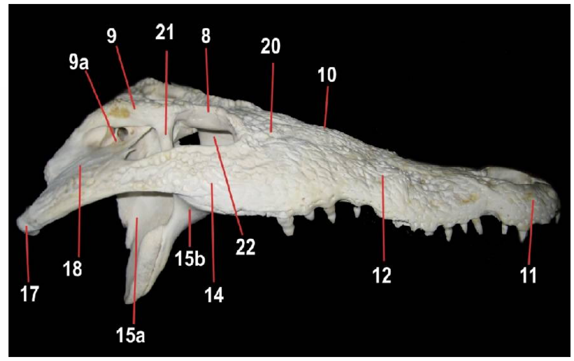


Fig.4: A photograph showing the crocodile skull (occipital view).

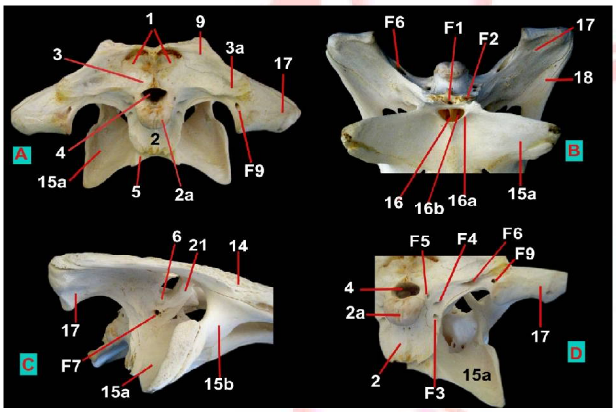


Fig. 5: A photograph showing the crocodile skull (sagittal section).

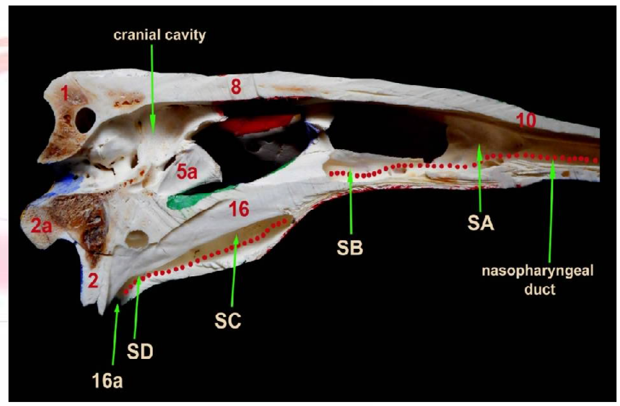


Fig. 6: A photograph showing the crocodile skull (colored bones).

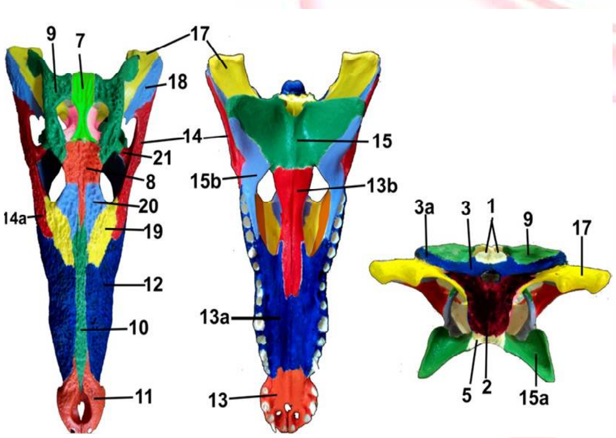
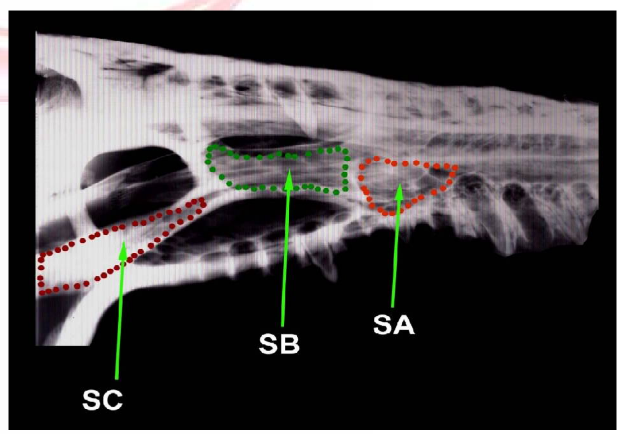


Fig. 7: A Radiograph showing the paranasal sinuses in crocodile skull.(oblique ventrolateral view)



Cranium bone: 1. Os Supraoccipitalis 2. Os basioccipitalis 2a. occipital condyle 3. Os exoccipitalis 3a, paraoccipital processes 4. Foramen magnum 5. Os basisphenoidis 5a. Rostrum of basisphenoid 6. Alisphenoid bone 7. Os parietalis 8. Os frontale 9. Os temporalis(os squamosa) 9a. otic recess 9b. The supratemporal fenestra 9c. The lateral temporal fenestra 10. Os nasale 10a. external nares 11. Os premaxillare 12. Os maxillare 13. palatal process of premaxilla 13a. palatine process of maxilla 13b. palatine process of palatine 13c. palatal fenestrae 14. Os jugale 14a. infraorbital process 15. The pterygoid body 15a. the pterygoid wing 15b. the ectopterygoid 16. Vomer bone 16a. choanae 16b. choanal fenestra 17. Os qudratum 18. The qudratojugal bones 19. Os lacrimale 20. Os prefrontale 21. Os postorbitale 22. The orbit.

Mandible: 23. Articular surface 24. Angular bone 24a. retroarticular process 25. Suprangular bone 26. Dentary 27. Splenial bone 28. Coronoid bone.

Foramina: F1. median Eustachian tube (foramen intertympanicum F2. lateral Eustachian canals F3. external ostium of the osseous cranial carotid canal F4. foramen vagus F5. foramen hypoglossi F6. foramen for facial nerve F7. Oval foramen (trigeminal foramen) F8. incisive foramen F9. Foramen aereum F10. External mandibular fenestra F11. Internal mandibular ffenestra.

Paranasal sinuses: SA. The Antorbital sinus SB. The vomerine bullar sinuses SC. The pterygopalatine bullar sinus SD. the pterygoid sinus.

Fig. 8: A rdiograph showing the crocodile head.

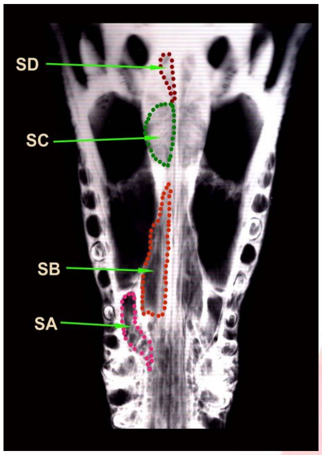


Fig.9: A radiograph showing the paranasal sinuses in crocodile (dorsoventral view).

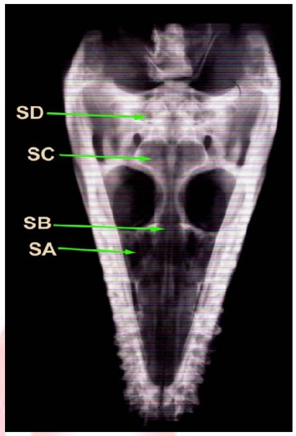


Fig. 10: A photograph showing the left mandible of crocodile skull (lateral view).

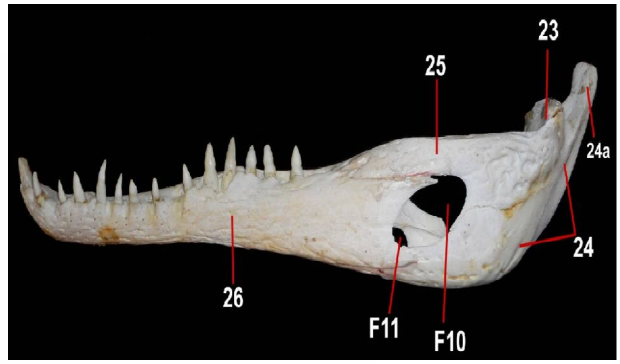


Fig. 12: A photograph showing the color mandible of crocodile skull.

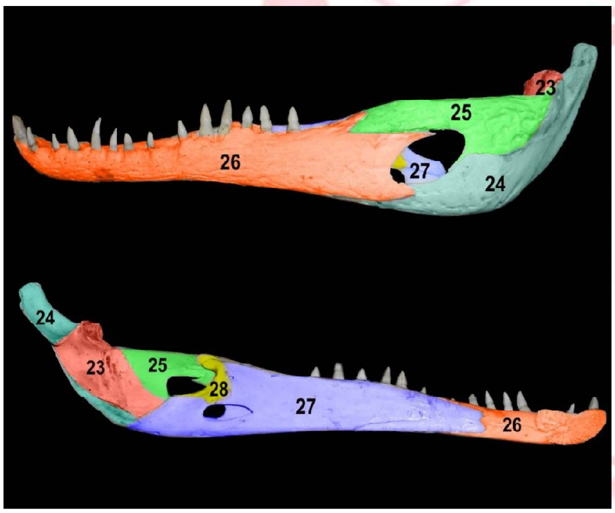
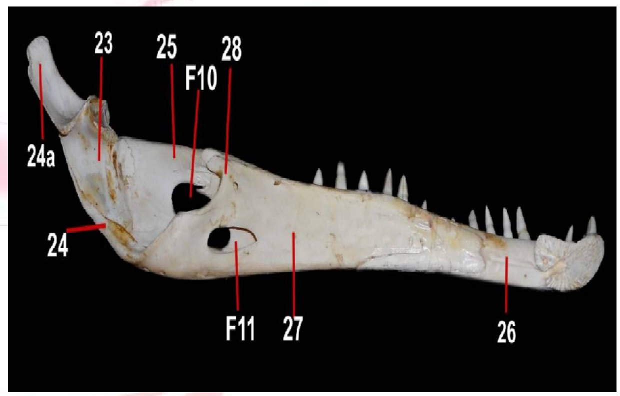


Fig. 11: A photograph showing the left mandible of crocodile skull (medial view).



Cranium bone: 1. Os Supraoccipitalis 2. Os basioccipitalis 2a. occipital condyle 3. Os exoccipitalis 3a, paraoccipital processes 4. Foramen magnum 5. Os basisphenoidis 5a. Rostrum of basisphenoid 6. Alisphenoid bone 7. Os parietalis 8. Os frontale 9. Os temporalis(os squamosa) 9a. otic recess 9b. The supratemporal fenestra 9c. The lateral temporal fenestra 10. Os nasale 10a. external nares 11. Os premaxillare 12. Os maxillare 13. palatal process of premaxilla 13a. palatine process of maxilla 13b. palatine process of palatine 13c. palatal fenestrae 14. Os jugale 14a. infraorbital process 15. The pterygoid body 15a. the pterygoid wing 15b. the ectopterygoid 16. Vomer bone 16a. choanae 16b. choanal fenestra 17. Os qudratum 18. The qudratojugal bones 19. Os lacrimale 20. Os prefrontale 21. Os postorbitale 22. The orbit.

Mandible: 23. Articular surface 24. Angular bone 24a. retroarticular process 25. Suprangular bone 26. Dentary 27. Splenial bone 28. Coronoid bone.

Foramina: F1. median Eustachian tube (foramen intertympanicum F2. lateral Eustachian canals F3. external ostium of the osseous cranial carotid canal F4. foramen vagus F5. foramen hypoglossi F6. foramen for facial nerve F7. Oval foramen (trigeminal foramen) F8. incisive foramen F9. Foramen aereum F10. External mandibular fenestra F11. Internal mandibular ffenestra.

Paranasal sinuses: SA. The Antorbital sinus SB. The vomerine bullar sinuses SC. The pterygopalatine bullar sinus SD. the pterygoid sinus.

The pterygoid sinuses (fig. 5, 8, 9 /SD) were located at the pterygoid bone just rostral to the secondary choanae.

II- The mandible:

It formed by the two halves fused together at median mandibular symphysis via dentary bone. Each half of the mandible was composed from six fused bones; articular, angular, supra-angular,coronoid,splenial and dentary.

The articular bone (fig.10, 11, 12 /23) had a two surfaces, concave medial articular surface and large convex lateral surface, both surfaces for articulation with the condyle of the quadrate bone.

The angular and **the suprangular bone** (fig. 10, 11, 12/24, 25) formed the angle of the jaw. The dentary bone (fig. 10, 11, 12/26)formed the body of the lower jaw at its outer surface which beard (14-15) sharp conical lower teeth at its alveolar border while the inner surface of mandible mainly composed by the splenial and coronoid bones(fig. 10,11,12/27,28). The mandible occupied an oval-shaped external and internal mandibular fenestra (fig. 10, 11 /F10, F11).

DISCUSSION

All species of crocodilian were represented by large skull with around 1 m in length, characterized by having an extremely broad, long, and dorsoventrally compressed (duck-faced) rostrum with many small teeth, a slender mandible, tiny mandibular symphysis and a relatively the large infratemporal fenestrae, that similar to that described by [14].

The occipital bone constituted the caudal part of the skull. It was composed of a completely fused four bones enclosing a foramen magnum. The supraoccipitalis, the basioccipitalis and two right and left exoccipitalis, this finding similar to [15] in Crocodylian. Our result similar to [16], mentioned that the supraoccpital bone was flat, strongly concave and the basioccipital was a u-shaped bone, but that incompatible with [15] mentioned that the supraoccipital was tall, narrow while the [17] noted that the basioccipital was a rectangular and [18] added that the basiooccipital bone beard marked median crest, came together with occipital tubera for attaching the tendons of basioccipital vertebralis M. and occipitatransversalis profundus M.

The present study reported that only single occipital condyle, which articulated with the condyloid fossa of the atlas, our observation agreement with [19, 20, 21] in domestic bird, while [22, 23] in rabbit, [24] in domestic animals and [25] in the dog and cat reported two occipital condyles for articulation to the atlas. In accordance with [17, 26], a deep depression located between the basioccipital and basisphenoid bones, which had the singular opening of the median Eustachian tube (foramen intertympanicum) and The paired openings of lateral Eustachian canals.

The results applied in this study were in agreement within [7,18,27] (in Crocodiles, the exoccipitals met at the midline, dorsal to the foramen magnum and extended laterally forming the paraoccipital processes. It was sutured with the squamosals dorsolaterally and the supraoccipital dorsomedially [28]. added the exoccipital processes were long and extended ventrally forming part of the occipital tubera.

Concerning to [27,29], there were four foramina lateral to the foramen magnum. The ventrolateral foramen was for internal carotid passage. The other three foramina were horizontally aligned. The lateral and larger one was the foramen vagus for the passage of the IX, X, and XI nerves and the jugular vein. The medial one was the foramen hypoglossi for the passage of the XII nerve. The dorsolateral foramen was a foramen for facial nerve. While [30] added that a foramen aereum of cranial pneumatic airspaces in siphonium.

The oval foramen for the trigeminal nerve was bounded by the laterosphenoid (rostrally), quadrate (caudo-dorsally), pterygoid (caudo-ventrally) and with the basisphenoid (rostro-laterally). The same results was described by [31,32].

In agreement with, [17,33] in crocodile, recorded that the parietal bones completely fused with the surrounding bones. They were contact to the frontal bone. This finding similar to [19,20,21] in domestic bird, while [24] in domestic animals and [25] in the dog and cat reported paired parietal bones.

The frontal bone was a single broad, completely fused bone, laid between the preorbital and the parietal bones. Our results were agreement with [17,33], in crocodiles, [19] in domestic bird. But [22] in rabbit, [24,34] in domestic animals and [25] in the dog and cat, stated that both frontal bones extended on the dorsal surface of the skull, united to each other by a suture along the mid line.

The present study revealed that the temporal bone was formed of squamous part which constituted the caudo-lateral margin of the supratemporal fenestra. The squamosal bone was tall and long and formed the caudo-dorsal margin of the skull with the supraoccipital bone. This result similar to what was reported by [7,16,31].

The crocodile skull was known as diapsid or “two arched” reptiles. In agreement with [35] asserted that, the skull had paired superior and lateral temporal fenestrae located at lateral wall of the skull behind to the large orbits. The quadratojugal and jugal bones formed the ventral border of lateral fenestrae, while the skull of the mammals characterized by absence of fenestrae that stated by [24,34].

The current study approved that the orbits were wider than supratemporal and lateral temporal fenestrae that disagreement with [28] in Crocodylian *Mourasuchus natives* recorded that, the orbits were smaller than the infratemporal fenestrae, and had a reduced supratemporal fenestrae.

Also [15] stated that, *M. nativus* differs from *M. amazonensis, M. arendsi*, and *M. atopus* by the absence of marked knob at the margin of the orbit, and from *M. atopus* and *M. amazonensis* by the presence of a supratemporal fenestra surrounded rostrally by the postorbital and parietal bones. The skull of *M. nativus* was also characterized by the presence of paired squamosal eminences.

Our results were, therefore, compatible with the view mentioned by [36], seven bones formed the bony wall of the orbit: the prefrontal, frontal, lacrimal, zygomatic, postorbital, temporal (squamosal), and sphenoid (basisphenoid and alisphenoid).

The large palate was formed by the premaxillary, maxillary and palatine bones, the paired palatal fenestrae occurred ventral to the orbits. The internal nares appeared unpaired along the midline that prolonged caudally by palatal process of palatine bone and extended to secondary choanae opened within the pterygoid bone as had been suggested by [37,38,39].

The present study as well as that of [40] in chicken, revealed that the jugal bones (zygomatic bones) consisted of three fused bones; the jugal processes of maxillary bone, the proper jugal and the quadratojugal bone.

In according with [16] in *Mourasuchus*, the presence of enlarged skull with a wide narial aperture surrounded by a large narial fossa and an oval incisive foramen entirely surrounded by the premaxillae, nasal bone.

A more likely interpretation of our findings was supported by [41,42], the nasal airway was very long in crocodilians, owing largely to their extensive secondary palate. The long nasopharyngeal duct formed by the vomer, palatines and pterygoids. Regarding with the paranasal sinuses of crocodile aroused from the nasopharyngeal duct. Our observation and [43] mentioned that four paired sinuses were present; the antorbital, the vomerine bullar, the pterygopalatine bullar and the pterygoid sinuses but [42] reported that these sinuses were absent in mammals while [44] in birds, noted that the antorbital sinus only a single paranasal sinus as crocodilians.

The antorbital sinus (the caviconchal sinus) was enclosed laterally within maxillary bone; like the mammalian maxillary sinus but in large alligators had a medial diverticulum inflating the palatal process of the maxilla, that investigation supported by [41,44].

Crocodilians have a range of other paranasal sinuses arising from the nasal cavity proper, such as, in alligators, the postvestibular sinus that recordrd by [41].while in this study, the crochodylus niloticus characterized by absence of this sinus.

The present study as well as [45,46,47] revealed that the mandible of crocodile formed of six fused bones (articular, angular, suprangular, coronoid, splenial and dentary) [47]. showed a comparison between reptiles and mammals such as reptiles had at least four bones in the lower jaw (articular angular,coronoid and dentary) while mammals had only one bone; the dentary.

Conflicts of Interests: None

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