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Gross anatomy of the skull of hippopotamus (*Hippopotamus amphibius*)

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ABSTRACT

Morphological studies were conducted on the skull of a hippopotamus brought to the Veterinary college for postmortem examination. Skull of the hippopotamus was huge and notable for its little brain case and high supra-orbital ridges. The skull had a larger splanchnocranium than the neurocranium. From the dorsal view, the skull had a watch glass appearance because of its narrow middle portion (at the region of maxillae) and wide caudal and rostral portions. Maxilla showed a large *Eminenta canina* and two infraorbital foramina leading to two separate infraorbital canals. The premaxilla lodged two huge incisors and just above the central incisor, there was a large rough eminence for the elevated nostrils. Three to four large rounded lacrimal bullae were seen on the floor of the bony orbit. Frontal bone presented a strongly convex smooth supra-orbital ridge that formed upper margin of the orbit which projected from the surface of the skull. The median sagittal crest was very high that diverged to accommodate the concave forehead in front. Temporal fossa was very extensive. Caudal surface of the skull showed a concave nuchal surface and the external occipital protuberance was in the form of a crest. The paramastoid process and external auditory process were very short. Bulla tympanica was conical with a pyramidal muscular process. Anatomical peculiarities of the skull and their functional significance are discussed.

Key words: Anatomy, Hippopotamus, Skull.

Hippopotamus is the third largest land mammal and is the heaviest artiodactyl (1.5 – 3 tonnes). Unlike all other large land mammals, hippos are of semiaquatic habits or amphibious in nature, spending most of the time in water and emerge out on to land only at night. The eyes, ears and nostrils of hippos are placed high on the roof of the skull which allows these organs to remain above the surface of water while the animal is being submerged under water. Morphological studies on the skull of this animal are scanty. Hence this work was undertaken to explore the gross anatomical features of the skull in hippo which will enable researchers to correlate with the possible functions and will form a basis for further studies in this huge animal.

The study was conducted on the skull of an adult male hippopotamus brought for postmortem from the Gemini circus to the Department of Veterinary Pathology of College of Veterinary and Animal Sciences, Pookode, Kerala. The skull was prepared for gross anatomical observation as described by Young (1980).

Skull of hippopotamus was huge and notable for its little brain case and high supra-orbital ridges. The skull had a larger splanchnocranium than the neurocranium. The total skull length (straight) was about two feet and the maximum width (straight) was 40 cm at the caudal part of zygomatic arches. From the dorsal view, the skull had a watch glass appearance because of its narrow middle portion (at the region of maxillae) and wide caudal and rostral portions (Fig. 1).

Maxilla was very peculiar with a large *Eminenta canina* (5 cm wide) above the huge upper canine tooth (Fig. 2). *Eminentia canina* is also reported in the maxilla of porcine skull but is comparatively very small (Getty, 1975). Body of the maxilla was concave laterally showing a wide, shallow canine fossa. There were two infraorbital foramina (Fig. 2) which opened above the level of upper 2nd cheek tooth of which the lower one was larger than the upper and lead to two separate infraorbital canals that opened separately in the pterygopalatine fossa. The upper and lower infraorbital canals measured 14 cm and 17cm in length, respectively. Rostral borders of the two maxillae diverged to receive the nasal bones and the premaxillae (Fig. 1). The maxilla reached anteriorly upto the rostral end of the upper jaw. Dorsally the maxilla was related to the nasal bone in the caudal half and premaxilla in the cranial half. Caudal border was in contact with the lacrimal and zygomatic bones. Lower border of the body of maxilla carried alveoli for three premolars and four molars. A long diastema (12 cm) was found between the upper canine and first premolar and a short gap (1 cm) between the first and second premolar teeth.

The huge tusk-like canines and incisors help in intraspecific combat and threat. Molars are of bunodont type and dental formula was 2(2/2,1/1,3/3,3/3)=36. Similar observations were reported in the skull of hippo by Vaughan (1972).

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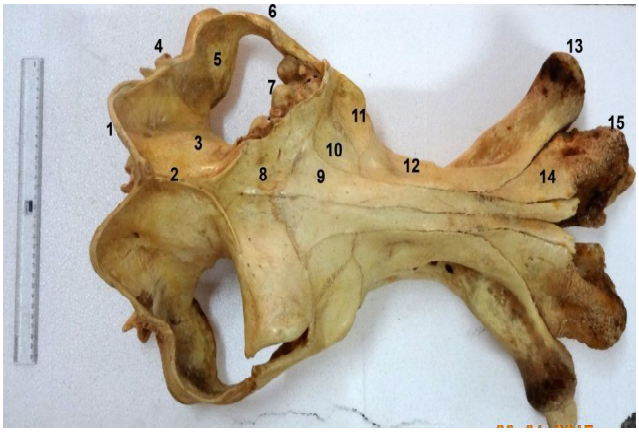

Fig 1: Skull of hippo–Dorsal view

1. Nuchal crest, 2. External sagittal crest, 3. Parietal, 4. External auditory process, 5. Zygomatic process of temporal, 6. Zygomatic arch, 7. Lacrimal bulla, 8. Frontal bone, 9. Nasal bone, 10. Lacrimal, 11. Zygomatic, 12.Maxilla, 13. Eminentia canina, 14. Premaxilla, 15. Rough tuberosity above central incisor

Fig 2: Skull of hippo – Lateral view

1.Zygomatic arch, 2. Supraorbital ridge of frontal, 3. Crest on the zygomatic bone, 4. Double infraorbital foramina, 5. Diastema, 6. Eminentia canina, 7. Canine tooth

The premaxilla (23 cm long) was well developed with two huge incisors (diameter - 2.5 cm). Just above the central incisor there was a large rough eminence (Fig. 2) which was even larger than the *eminentia canina*. The broad rostral portions of the premaxillae lodge the wide muzzle and the elevated nostrils. The elevated nostrils of hippos allow these organs to remain above the surface of water while the animal is being submerged under water. Caudally, the pointed end of premaxilla fitted into the 'V'-shaped notch formed by the maxilla and nasal bone (Fig. 1). The nasal bones were very long (33 cm) with pointed ends cranially and caudally (Fig. 1). Caudally, the two nasal bones together formed a pointed projection that was received into the notch formed by the frontal bone. Cranial ends of the nasal bones were diverged to form a 'V'-shaped notch (Fig. 1). The body of the nasal bone was arched ventrally at the junction between the rostral and middle third.

Lacrimal bones were small (length, 10 cm and width, 4 cm), wide in the middle and narrow towards either ends and were concave (Fig. 1). Lacrimal foramen was absent (Fig. 1). Large rounded lacrimal bullae (3 to 4 in number) were seen on the floor of the bony orbit (Fig. 1). Zygomatic bone was very large (24 cm long) and was characterized by a long crest (14 cm long) which formed the roof of the maxillary fossa (Fig. 1). Zygomatic arch was wide (5 cm) and plate-like (Fig. 2) as in the skull of pigs (Getty, 1975).

Frontal bones were rectangular having a transverse width of 13 cm and cranio-caudal length of 7 cm. The frontal bone met its fellow to form a deeply concave forehead (Fig. 1). It gradually increased in height towards the orbit and presented a strongly convex smooth supra-orbital ridge that formed upper margin of the orbit which projected from the surface of the skull (Fig. 2). This is one of the characteristic features of the hippo skull which allows the eyes to remain above the surface of water while the animal is being submerged under water. Parietals were very extensive and formed the roof of the cranium as in equines and pigs (Nickel *et al.*, 1986). The median sagittal crest was very high (7 cm long and 3 cm high) that diverged to accommodate the concave forehead in front (Fig. 1). The temporal fossa was very extensive with a medial-lateral distance, of 15 cm and cranio-caudal distance of 12 cm as reported by Raghu *et al.* (2014) in giraffe. The well-developed nuchal crest formed the highest point of the skull (Fig. 1) as in pig , horse and dog (Nickel *et al.*, 1986). The rim of the bony orbit was open as in dog, pig and elephant (Nickel *et al.*, 1986) and had a gap of about 3 cm.

Caudal surface of the skull had a concave nuchal surface as seen in the case of porcine skull (Nickel *et al.*, 1986). Unlike in pigs, the external occipital protuberance was present and was in the form of a crest (8 cm long). Supraoccipital bone was very wide and presented a distinct convex crest on the lateral aspect. Foramen magnum was 6 cm wide and had a semicircular notch on the dorsal margin. The condylar fossa was wide and lodged the hypoglossal foramen (Fig. 1). The paramastoid process was very short and tuberous and underdeveloped. On the other hand, the mastoid process was very well developed and was directed laterally. Basioccipital was short (5 cm long) and the basilar tubercles were very small. The external auditory process was least developed and the external auditory meatus was small with a diameter of 0.5 cm. Bulla tympanica was conical and the muscular process was pyramidal and the two were separated by a wide notch.

Zygomatic process of temporal bone had a saddle shaped condyle for articulation with the condylar process of

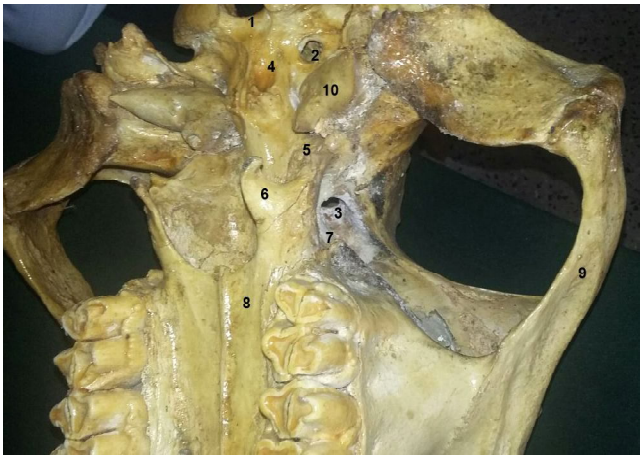

Fig 3: Skull of hippo – Ventro-lateral view

1.Foramen magnum, 2. Hypoglossal foramen, 3. Foramen orbitorotundum, 4. Basioccipital, 5. Basisphenoid, 6. Hamulus pterygoideus, 7. Presphenoid; 8. Palatine; 9. Zygomatic arch; 10. Bulla tympanica

mandible. Postglenoid process was very large and tuberous. Similar to that of porcine skull, the caudal border of post sphenoid was notched to form the carotid, oval and spinosal notches (Dyce *et al*., 1987). The foramen ovale was absent (Fig. 3). Foramen orbitorotundum was well developed (Fig.3).

Pterygoid bone was well developed with a distinct hamulus pterygoideus (Fig. 3). Palatine bones were also well developed and the horizontal part of palatine bone (10 cm long) formed about caudal one-third of the bony palate. Rostral palatine foramina were one or two on each side and were located in the palatine process of maxilla. Rostral part of the bony palate comprising of the palatine process of maxilla and premaxilla showed numerous small foramina and the surface was roughened. Table surface of the cheek teeth showed triangular or clove-shaped infundibula (Fig. 3).

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