Explor Anim Med Res,
Vol.11, Issue - 1, 2021, p. 135-139
DOI : 10.52635/EAMR/11.1.135-139

ISSN 2277- 470X (Print), ISSN 2319-247X (Online)
Website: www.animalmedicalresearch.org

Short Communication

A MORPHOLOGICAL STUDY ON THE SKULL OF DROMEDARY CAMEL (*CAMELUS DROMEDARIUS*)

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Received 26 July 20, revised 9 January 2021

ABSTRACT: The present morphological study was carried out on the skull of dromedary camel. The skull of the camel was irregularly pentagonal in outline and was divided into four surfaces *i.e.*, frontal, basal, nuchal and lateral. The frontal region of the skull was wide and orbits were present laterally. The occipital bone formed the entire nuchal surface of the skull. A rough transverse ridge separated the parietal and nuchal surfaces. The mastoid foramen was very large and situated in a deep fossa in the occipital bone. The cornual processes or horn cores were absent. At the rostro-lateral margin of the orbit, a deep fissure, the supraorbital foramen was observed. The maxillary tuberosity and facial crest were absent. The infraorbital foramen was present in the maxilla bone just above the level of a second superior premolar tooth. The premaxilla bone had a narrow, pointed body that was dorso-medially concave. The nasal bones were notched rostromedial. The mandible was long, narrow and dorsomedially concave. The vertical ramus of the mandible was thin and convex caudally with a thick and wide rostral border and less pronounced angles. The coronoid process was almost straight with a slightly pointed end caudally. The condyloid process was large and presented extensive articular surfaces on its lateral surface, which were convex. A shallow mandibular notch was present between the condyloid and coronoid processes. The mandibular foramen was present in the middle of the medial surface of the mandible.

Key words: Dromedary camel, Morphology, Skull, Mandible.

Dromedary camel is found in India, Iran, Iraq, Arabia, Egypt, Sudan, North Africa, Somaliland and many other countries. This animal adapted to the rigorous climate of the desert, where it is subjected to high temperature and the scorching sun rays. Generally, camels are experiencing a resurgence of interest and their importance in the modern era may depend in great part to the complete understanding of their anatomy and physiology.

The camel has so far been used as a pride animal and now the Rajasthan state government has declared it as "State Animal" (Mehta and Dahiya 2015). The camel is renowned for its ability to survive the harsh environment of the desert. For survival in the desert environment, camels have physiological, anatomical and behavioural adaptation mechanisms. Water conservation ability, the unique features of blood, thermoregulation and efficient digestion and metabolism are among the physiological adaptations. Anatomically the nature of skin coat, eye, nostril and lips, large body size and long height and large foot pads contribute to their survival. Moreover, the feeding, drinking, thermal and sexual behaviour of camels also plays a major role in succeeding in their existence in a desert environment (Gebreyohanes and Assen 2017).

The anatomical structures of the skull vary among different animals. The bones of the skull are divided into cranial and facial groups. It lodges the brain, horns, and essential organs for hearing, equilibrium, sight, smell and taste. The skull also forms boundaries of the oral and nasal cavities and supports the pharynx and larynx (Keneisenuo *et al.* 2020). Generally, the composition of the bones that form the external configuration of the nasal region of the skull of various domestic animals is

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composed of the nasal, lacrimal, maxilla, the processus nasalis of the incisive and part of the frontal bone (Nickel *et al.* 1986, Yi *et al.* 1998). The pattern and involvement of these bones in the formation of the nasal region varies among the animal breeds and species. However, these variations involve the pattern of articulation between *os nasale* and the surrounding bones such as the maxilla, *os lacrimale,* and *os incisivum* as has been represented as having a complete suture- or fissure-like structure in various domestic animals (Getty 1975, Miller *et al.* 1975). There is a paucity of literature on the comparative anatomical aspects of the skull of the camel with different domestic animals; therefore, the present study has been designed to elaborate on morphological characteristics of the camel skull.

The skulls (n=12) of dromedary camel of either sex (n=6 male; n=6 females) were collected from naturally died camel aged about 3-5 years. The camel skulls were collected from different parts of the Jaipur district of Rajasthan from April 2015 to June 2018. The collected head regions were macerated using the hot water maceration technique for 1-2 hours (Choudhary and Singh 2015a,b; Choudhary *et al.* 2016). The macerated skull samples were kept in 4% hydrogen peroxide for one day to make the bones clean, followed by sun-drying for 5 days (Choudhary *et al.* 2015b, 2018, 2019a). These processed samples were utilized for gross anatomical studies. All the procedures involving sample collection were conducted as per the Institutional Animal Ethics Committee (IAEC), which is under Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), Ministry of Environment, Forest and Climate Change, Government of India for the College of Veterinary Sciences and Animal Husbandry, Selesih, Aizawl, Mizoram, Aizawl, Mizoram.

Morphological study and discussion

The skull of the dromedary camel was divided into four surfaces (frontal, basal, nuchal and lateral) for a better understanding of the bones. The skull of the camel was in the form of a four-sided pyramid when examined from the dorsal surface.

The frontal bone (Fig. 1, 2) of the camel was present between the parietals caudally and the nasal bones rostrally. It was wider than its length, joining the nasal bones caudally to form nasofrontal suture that lies rostral to the level of the orbit. These bones presented a depressed area carrying the supraorbital foramen. The cornual process or horn core was absent in camel and as reported in the horse (Getty 1975). However, it was present in ox (Raghavan 1964). In camel, the supraorbital foramen was in the form of a deep fissure situated at the rostromedial margin of the orbit. However, it was located at the root of the zygomatic process in the horse (Getty 1975) and was absent in dogs (Miller *et al.* 1964). The supraorbital foramen on each side of the frontal bones were relatively close to each other as compared to an ox, which were far apart (Dyce *et al.* 2010). In ruminants, it was often double and situated about 2.5 cm medially from the root of the zygomatic process (Getty 1975). The frontal fossa was a characteristic feature observed in the middle part of the frontal surface in camel as also reported in dogs (Miller *et al.* 1964). The zygomatic arch was reinforced from above by the zygomatic process of the frontal bone in the camel, which was not in the case of dogs (Miller *et al.* 1964). In ruminants and dogs, the orbit was formed by lacrimal, zygomatic, and frontal bones as in the horse, the zygomatic part of temporal bones was also involved (Bone 1988). Several small sized foramina for the passage of small vessels were also observed in the middle of the frontal bone in the present study. The orbit had a complete rim in camel as reported in ox (Raghavan 1964) and horse (Getty 1975).

The nuchal surface was formed by squamous and lateral parts of the occipital bone, which also reported in ox (Raghavan 1964), horse (Getty 1975) and dog (Miller *et al.* 1964). The parietal and interparietal bones were located on the nuchal surface and this surface was separated from the roof by nuchal crest also observed in the skull of an ox (Raghavan 1964). In camel, the nuchal crest continued forward as a temporal crest that separates the nuchal surface from the lateral surface of the skull as was also reported in ox (Raghavan 1964) and dog (Miller *et al.* 1964) except in the skull of the horse (Getty 1975). The nuchal surface was parabolic shaped in camel. However, it was extensive pentagonal in outline in case of ox (Raghavan 1964). A median occipital crest extended from the nuchal surface towards the foramen magnum in camel as earlier reported in ox (Raghavan 1964).

The occipital was single bone and the placement of occipital bone in the present study resembled that of a horse (Getty 1975), dog (Miller *et al.* 1964) and blackbuck (Choudhary and Singh 2016). The rough transverse ridge separated the parietal and nuchal surfaces in between the parietal and occipital bone in the camel. The mastoid foramen in the camel was very large and situated in a deep fossa in the occipital bone when compared to an ox, where it lay at the junction of occipital and temporal bones (Raghavan 1964). The sphenoid, ethmoid and parietal bones resembled that of an ox (Raghavan, 1964).

The temporal bones of the camel resembled that of an ox (Raghavan 1964). They were situated between the

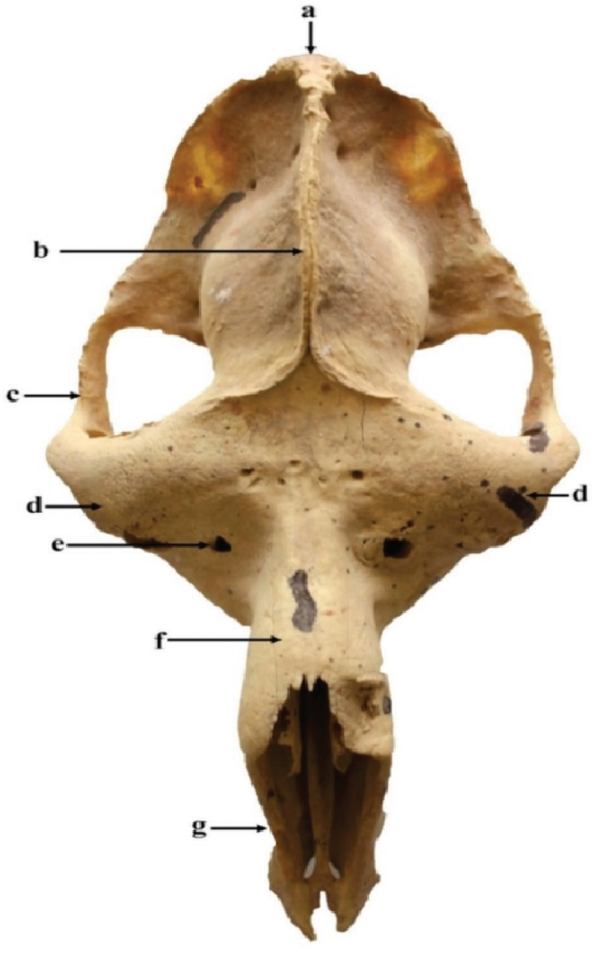

Fig. 1. Dorsal view of the dromedary camel skull.
[Showing nuchal crest (a), external parietal crest (b), zygomatic arch (c), frontal bone (d), supraorbital foramina (e), nasal bone (f) and premaxilla (g)].

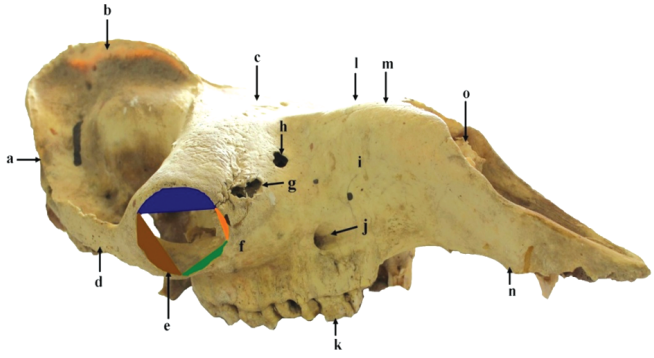

Fig. 2. Dorso-lateral view of the dromedary camel skull.
[Showing occipital bone (a), external parietal crest (b), frontal bone (c), zygomatic bone (d), orbit and part of the skull bones involved in the formation of the orbital rim (e), malar bone (f), lacrimal fossa on the lacrimal bone (g), supraorbital foramen (h), maxilla bone (i), infraorbital foramen (j), second superior cheek teeth (k), nasal bone (l), naso-maxillary suture (m), premaxilla bone (n), anterior part of turbinate bone (o)].

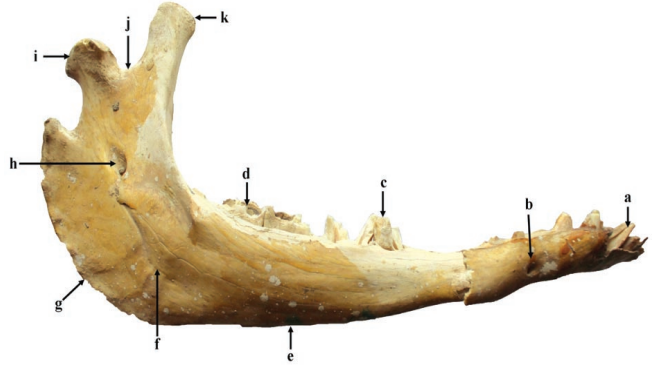

Fig. 3. Medial view of the mandible of the dromedary camel.
[Showing inferior incisor teeth (a), mental foramen (b), inferior premolar teeth (c), inferior molar teeth (d), body of the mandible (e), ramus of the mandible (f), mandibular angle (g), mandibular foramen (h), condylar process (i), mandibular notch (j) and coronoid process (k)].

occipital and parietal behind, the frontal dorsally and the sphenoid ventrally. The temporal bone has squamous and petrous parts that were entirely fused at birth, as reported in ox (Raghavan 1964). In the present study, the lateral surface of the squamous part had a temporal crest, which divided it into two parts and continuous caudally with the nuchal line and rostrally onto the zygomatic process as the temporal line. The petrous temporal consisted of a petrous and tympanic part of which petrous and tympanic parts contained the internal acoustic meatus and external acoustic meatus, respectively as earlier reported in ox (Raghavan 1964) and horse (Getty 1975).

In camel, the premaxilla bone formed the anterior bone of the face and consisted of a body, palatine and nasal processes and palatine fissure. Its body was dorso-medially concave, narrow and pointed. It was covered downward in the horse (Getty 1975) and was straight in ox (Raghavan 1964). The palatine fissures of camel were very narrow and outwardly diverging, as also observed in the horse (Getty 1975) but was a large oval opening in ox (Raghavan 1964). The pterygoid was broad above and narrowed below in camel and was thin plate-like situated on either side of the choanae. The nasal bones were notched rostro-medially in camel as reported earlier in ox (Raghavan 1964). However, it was pointed in the horse (Getty 1975) and semi-circular in the dog (Miller *et al.* 1964).

The lacrimal bone was small and situated rostral to the orbit as reported earlier in the horse (Getty 1975), but it was huge in ox (Raghavan 1964). The lacrimal bone

was quadrilateral in shape with a deep lacrimal fossa having a lacrimal canal. The ventral and caudolateral margin of the orbit formed the malar bone in the camel.

The maxilla was very extensive and high in camel as reported previously in ox (Raghavan 1964) when compared it to the horse (Getty 1975). It was concave rostrally and convex posteriorly, which was also observed in the horse (Getty 1975). The infraorbital foramen in the camel was present in the maxilla bone just above the level of a second superior premolar tooth. However, it was located dorsal to the first cheek tooth in ox (Raghavan 1964) and the third cheek tooth in the horse (Getty 1975). There was no maxillary tuberosity in camel as reported earlier in the dog (Miller *et al.* 1964), while facial tuberosity was present in the ox (Raghavan 1964), horse (Getty 1975) and blackbuck (Choudhary and Singh 2016).

The mandible bone (Fig. 3) of the camel was the largest bone of the skull, consisting of two symmetrical halves which were united rostrally forming the body of the mandible, as reported earlier in the horse (Getty 1975). However, the mandible was not completely fused in ox (Raghavan 1964) and dog (Miller *et al.* 1964) and blackbuck (Choudhary *et al.* 2015a). Its body was long and narrow, dorso-ventrally concave having four alveoli for incisor teeth and canine teeth. The ventral border of the mandible was straight as reported earlier in goat (Choudhary *et al.* 2019b) and the alveolar border contained five alveoli for lower cheek teeth with their size increased from the first to the fourth with the fifth molar considerably small. The alveolar border of the mandible carried six alveoli for the lower cheek teeth with no alveoli for the canine tooth in ox, whereas it carried six alveoli for lower cheek teeth and two for the canine tooth in the horse (Getty 1975) and dog (Miller *et al.* 1964). The lateral surface of the mandible was convex from above downward. A "V" shaped intermandibular space was present. The vertical ramus of the mandible was narrow and convex caudally with a thick and wide rostral border and less pronounced angles. The coronoid process was almost straight with slightly pointed end caudally. In the horse, the coronoid process was thin transversally and curved slightly medially and backward (Getty 1975). The coronoid process was extensive and curved caudally in ox (Raghavan 1964), while it was more extensive and bent slightly outward and backward in the dog (Miller *et al.* 1964). The mandibular symphysis was absent in camel as reported earlier in the horse (Getty 1975). However, it was present in carnivores, ruminants and swine (Raghavan 1964, Miller *et al.* 1964, Choudhary *et al.* 2019a). The condyloid process was large and presented a large articular surface on its lateral surface; however, it was concave from side to side in ox (Raghavan 1964). A shallow mandibular notch was present between the condyloid and coronoid processes in the camel. The mandibular foramen was present in the middle of the medial surface as reported earlier in ox (Raghavan 1964) and dog (Miller *et al.* 1964) but was further forward in the horse (Getty 1975).

Conclusion

It can be concluded from the present study that the morphology of the camel skull completely differs from the ruminants; however, few similar characteristics were observed as in canines, equines and swine.

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***Cite this article as:** Choudhary OP, Priyanka, Kalita PC, Doley PJ, Kalita A, Keneisenuo (2021) A morphological study on the skull of dromedary camel (*Camelus dromedarius*). Explor Anim Med Res 11(1): 135-139. DOI : 10.52635/EAMR/11.1.135-139