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ARTICLE

Anatomical Study of the Variations of the Facial bones in Skull of the Camel *(Camelus dromendarius)* in Nigeria

YAHAYA, A.*[1], OLOPADE, J.O.[1,2] AND KWARI, H.D.[1]

[1]Department of Veterinary Anatomy, University of Maiduguri, Maiduguri, Nigeria, [2]Department of Veterinary Anatomy, University of Ibadan, Ibadan, Nigeria. *Corresponding author: Email: drahmedyahaya@gmail.com, Tel: 08087462857

SUMMARY

The morphological features of facial region of the camel skull were investigated. A total of 42 camel skulls (30 mature and 12 immature) from three geographical locations (Maiduguri, Kano and Sokoto) in Nigeria were used in this study. The morphological features of the nasal region of the camel skulls were observed to be composed of the *os nasale*, *os incisivivum*, *os lacrimale*, *maxilla* and part of the *os frontalale* as reported for other domestic animals. Variations in the morphological arrangement of the incisive, maxilla and nasal bones of the nasal region in camel skulls for both mature and immature animals were observed to show two typical variations as nasomaxilloincisive notch (80%) and nasoincisive notch (20%) in all samples studied. Slit-like fissures were also observed at the frontomaxillary suture area in 90.5% mature and 92% immature camel skulls. These fissures were observed to be either rectangular or oval in shape and bilateral in 95% while in the remaining were either absent or unilateral. However, there were a wide opening on each side of the nasal bone and could be classified into two types (fIssura frontomaxillaris and fissura nasofrontomaxillaris) according to various patterns of articulations of the neighbouring bones. The nasal region morphological information provided in this study will contribute to knowledge of the morphological pattern of the fissures of facial bones in skull that can play a prominent role in osteological investigation or osteoarchaeology, and also offer elements for eventual comparative studies that can be used for tracing origin of the animal.

Key words: Morphology, variations, facial bones, skull, camel

INTRODUCTION

The skull is frequently the major element of the skeleton indicating taxonomic affiliation, and giving information on changes in animals as a result of selection (Bruenner *et al*., 2002). Generally the composition of the bones that form the external configuration of the nasal region of the skull of various domestic animals is composed of *os nasale*, *os lacrimale*, *maxilla*, the processus nasalis of the *os incisivum* and part of *os frontale* (Nickel *et al*., 1986; Yi *et al*., 2001). The pattern and extent of 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; Yi *et al*., 1998; Evans, 1993).

Literature on the morphological variability of the shape and pattern of fissures in the skull of camel is scanty. An early study by Smuts and Bezuidenhout (1987) gave only the different bones that form the nasal region of the skull of camel with no mention of the morphological variability of the pattern of fissures among the bones of the region. Therefore there is the need to investigate the anatomical pattern of fissures among the bones that form the nasal region of the skull of camel found in Nigeria.

The result of this study will contribute to knowledge of the morphological pattern of the fissures that can play a prominent role in osteological investigation, osteoarchaeology, radiographic interpretations and also offer elements for eventual comparative studies that can be used for tracing origin of the camel.

MATERIALS and METHODS

Forty two healthy camels with equal number of both sexes were used for this study. The animals were grouped into two age groups (mature and immature) consisting of 30 mature (5-7 years) and 12 immature (2-3years) animals. The animal's age was estimated using dental formula (Williamson and Payne, 1978; Wilson, 1984). The camel heads were obtained after slaughter in the main abattoirs of Nigerian arid cities (Maiduguri, Kano and Sokoto) and the skulls were then macerated using modification of the hot water maceration technique described by Onar *et al*., 1997 and Olopade and Onwuka, 2004.

After maceration, the relationships between the bones and pattern of fissures that form the nasal region of the skull were observed for documentation. Observations of all the skulls were made by the naked eye, and photographs were taken using a Sony Cyber-shot® 14.1 megapixel camera as required.

RESULTS

Figure 1: *Dorsolateral view of mature camel skull showing O, occipital bone; T, temporal bone; P, parietal bone; F, frontal bone; M, maxilla; N, nasal bone; I, incisive bone; 1, supraorbital foramen; 2, frontonasal suture; 3, nasomaxillary suture; 4, maxilloincisive suture; 5, fissura frontomaxillaris; 6, orbit. Note the point of union between the nasal, maxillary and incisive bones (arrow) forming nasoincisive notch*

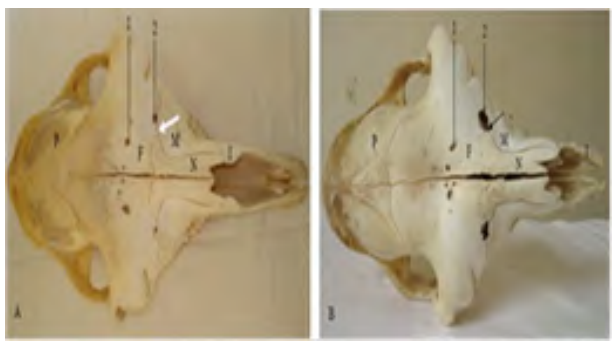

Figure 2(A and B): *Dorsal view of immature camel skull showing P, parietal bone; F, frontal bone; M, maxilla; N, nasal bone; I, incisive bone; 1, supraorbital foramen; 2, nasal fissure (2A, fissura frontomaxillaris and 2B, fissura nasofrontomaxillaris); block arrow, (2A, nasomaxillary suture); arrow (2B, contribution of the lateral part of the nasal, frontal and maxilla bones to form fissura nasofrontomaxillaris).*

The external configuration of the nasal region of the skull of the camel in Nigeria was observed to be composed of the *os nasale*, *os incisivivum*, *os lacrimale*, *maxilla* and part of the *os frontalale* (Figure 1). The face was formed by five bones, the frontal and nasal bones dorsally; the maxillae and lacrimal bones caudolaterally and incisive bone craniolaterally (Figure 1). The frontal bones were situated on the limits of the cranium and face, between the parietals caudally and the nasal bones rostrally. The frontal bones were wider and join the caudal aspect of the nasal bones to form nasofrontal suture which lies slightly rostral to the level of the orbit (Figure 1). These bones have a depressed central area that carries at least a pair of supraorbital foramina and two or more accessory supraorbital foramina at various distances from the midline (Figure 1). The depression is well pronounced in the immature than the mature camels and also wider in the male than the female animals. The nasofrontal part of each frontal bone projects laterally towards the orbits to a greater extent (Figure 1). The nasal bones are situated rostral to the frontal bones and form the roof of the nasal cavity. Each of the nasal bones articulates with the bone of the opposite side, the frontal, maxilla and a time with incisive (Figure 2A). The nasal bones were relatively short. They end with a short median and a long lateral process (Figure 2A). The nasal bones were flanked laterally by the maxillary bones which become constricted in the nasal region to form the slender dorsolateral borders of the region (Figure 1).

Maxillae are the principal bones of the upper jaw that communicate dorsally with the nasal and frontal bones, rostrally with the incisive and caudally with the lacrimal and zygomatic bones (Figure 3). Rostrally, the maxilla at variable lengths contribute to the osseous aperture of the nose (Figure 4A) in 80% of the samples studied whereas in the remaining samples, the maxilla does not contribute (Figure 4B). These observations were noticed in the skull of both mature and immature camels. Two types of articulation patterns were observed, forming nasomaxilloincisive and nasoincisive notches. The first type was the articulation of the maxilla to the nasal bone dorsally and the incisive bone rostroventrally to form nasomaxilloincisive notch that was created

Figure 3: *Rostrolateral view of immature camel skull showing F, frontal bone; N, nasal bone; M, maxilla; I, incisive bone; L, lacrimal bone; Z, zygomatic bone; 1, supraorbital foramen; 2, infraorbital foramen; 3, fissura frontomaxillaris; 4, frontomaxillary suture and block arrow, depressed area that carries supraorbital foramina. Note the rectangular shape of the fissura frontomaxillaris.*

Figure 4(A and B): *Lateral view of nasal region of mature camel skull showing M, maxilla bone; N, nasal bone; I, incisive bone; 4A (X , nasomaxilloincisive notch; 1, nasomaxillary suture; 2, maxilloincisive suture; and 3, infraorbital foramen); 4B (block arrow, nasoincisive notch; 1, nasoincisive suture; 2, maxilloincisive suture; and 3, infraorbital foramen.*

by an interval of varying distance of the maxilla (Figure 4A).

The second type was the articulation of nasal and incisive bones to form nasoincisive notch (Figure 4B). Both types of the notch were observed in the skull of both immature and mature camels. Incisive bone forms the lateral border of the osseous nasal aperture and it carries a single incisor tooth. The left and right incisive bones do not fuse rostrally (Figure 2A).

Lacrimal bones are situated at the rostral part of the orbit, and extend rostral on the face to the caudal border of the maxilla (Figure 3). It is small in size and is almost triangular in shape in both immature and mature camels (Figure 3). It also articulates dorsally with the frontal bone, ventrally with the maxilla and zygomatic bones. No facial crest or tubercle was present but a prominent infraorbital foramen is observed (Figure 3).

Slit-like fissures were observed at the frontomaxillary suture area (Figure 3) in 90.5% of the mature and in 92% of immature camel skulls, while in the remaining skulls they were either absent (Figure 5B) or unilateral. These fissures were observed to be bilateral (Figure 5A) in 95% of samples while in the remaining, they were either absent or unilateral. On the basis of the articulation of the surrounding bones, two types (Type I and II) of slit-like fissurae were observed. In Type I (fissura frontomaxillaris), there was no continuous articulation of frontomaxillary suture formed between the frontal and maxilla bones (Figure 2A. However, the maxilla and incisive bones made complete articulation with the nasal bone (Figure 3). The entire shapes of the fissurae were either rectangular (Figure 3) or oval (Figure 2A) in shape and were observed in skulls of both mature and immature camels. In Type II (fissura nasofrontomaxillaris), the pattern of articulation was similar to Type I but with

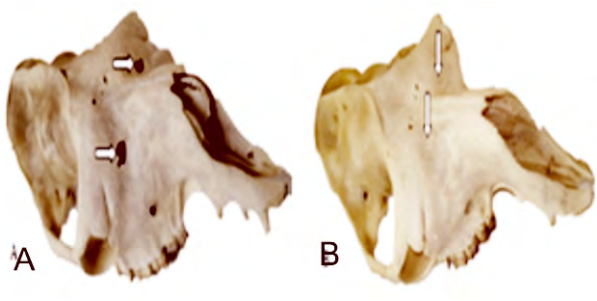

Figure 5(A and B): *A, Dorsolateral view of mature camel skull showing bilateral fissura frontomaxillaris (block arrows) and B, Dorsolateral view of mature camel skull showing no facial fissura (block arrows).*

no continuous articulation between the lateral part of the nasal, frontal and maxilla bones (Figure 2B). This type of fissura was observed in only skulls of immature camels. Both types of fissurae were not consistent with the descriptions given by International Committee on Veterinary Gross Anatomical Nomenclature (2005).

DISCUSSION

In this study, the pattern of articulation among the bones surrounding the nasal region was focused on. Generally, the nasal region of the skull is composed of the *os nasale*, the processus nasalis of the *os incisivum* and rostral part of the *os frontale* in most domestic animals (Nickel *et al*., 1986; Yi *et al*., 2001). The frontal bones in the camel were relatively wide and have a depressed central area as seen in dogs and cats to form the frontal fossa (Shahid and Kausar, 2005). In the goat, Olopade (2006) reported a longitudinal convexity of the frontal bones between the horns. In camel, the frontal depressed central

area carries two or more supraorbital foramina along both sides of the midline of the frontal bones at the level of the orbits. These foramina are relatively closer to each other compared to what is obtained in cattle that are far apart (Dyce *et al*., 2010). In the camel, at least a pair of supraorbital foramina in the frontal depression is usually placed far apart at various distances from the midline. There was no gender difference in the frontal bones of the camel. Unlike in goats, Olopade (2006) observed distinct gender difference. The nasofrontal part of each frontal bone projects laterally towards the orbits to a greater extent so that the width of the two frontal bones between the dorsal margins of the orbit is greater than in the horse (Dyce *et al*., 2010).

The nasal bones of camel were relatively narrower and longer than in cattle and horse as equally observed by Saber (1990) and Dyce *et al*. (2010). The nasal bones firmly fused to the surrounding bones unlike in goat (Olopade, 2006) and cattle (Getty, 1975; Dyce *et al*., 2010) where they were reported not to be firmly fused to the surrounding bones. In camels these bones end with a short median and long lateral processes with the former far more caudal compared to what is reported in cattle to be almost even, while in the horse it is long and pointed extending beyond the nasoincisive notch (Getty, 1975; Dyce *et al*., 2010). This shortening of the nasal bone in camel contributes to the elongation and narrowing of the nasal slit. In this study, the incisive bone was observed to make contact caudodorsally with either maxilla alone or with maxilla and nasal bones, an occurrence that is not seen in the sheep and cattle (Getty, 1975; Dyce *et al*., 2010). The rostral opening of the body of the incisive bone does not unite rostrally and bears only one incisive tooth in camel and this may confer less mechanical strength to the dental pad which may aid injuries in the rostral part of the face and hard palate. The incisive and palatine fissures were smaller and narrower than in cattle. The body of the maxilla is shorter in camel than in cattle and horse (Dyce *et al*., 2010). The maxilla bone along with the protruding orbit largely determines the shape of the skull of the camel. In this study, two types of fissurae (fissura frontomaxillaris and fissura nasofrontomaxillaris) were seen at the frontomaxillary suture area unlike in Korean native goat, where Yi *et al*. (2001) observed several different forms classifying the fissura into four types as Type I and II (fissura nasolacrimalis), and Types III and IV (fissura nasomaxillaris). However, there were different opinions about the fissura nasolacrimalis and fissura nasomaxillaris, depicted only as fissura nasomaxillaris in ruminants (Nickel *et al*., 1986). In Nomina Anatomica Veterinaria (International Committee on Veterinary Gross Anatomical Nomenclature, 2005), the spaces that remain in ruminants between the *os nasale* on one hand, and the *maxilla* and the *os lacrimale* on the other, cannot be regarded as fonticuli and are called fissurae. However, Pohlmeyer (1985) named it the fonticulus, both in deer, that was relatively wide, and in sheep and goats, it was narrow and long. Fissura nasofrontomaxillaris we observed in camel cannot be called fissura nasolacrimalis as in goats due to lack of lacrimal bone presence at the point of articulation among the nasal, frontal and maxillae bones. This is because lacrimal bone is so small in camel and could not extend to the point of articulation between nasal and maxillary bone as reported in ovine, bovine and equine by Getty (1975) and Dyce *et al*. (2010). These fissurae areas could represent an area of weakness in the camel that could be prone to fracture. Viewing the skull dorsolateral, there were two typical union patterns of the facial bones (incisive, nasal and maxilla) that formed the maxillofacial region in both mature and immature camels. The first type was nasoincisive formed by the presence of a definite incisive-naso-maxillary junction, which was clearly reported by Smuts and Bezuidenhout (1987) not to exist in camel. While the second type was nasomaxilloincisive notch which was formed by an interval of

varying distances of maxilla seen between the incisive and nasal bones. The former is similar to that described in goats by Olopade (2006), and Olopade and Onwuka (2009) while the latter resembles the morphological arrangement in sheep (Yi *et al*., 2001), horses and cattle (Getty, 1975; Dyce *et al*., 2010). In future studies, these structures could be investigated amongst camels from different regions of the continents to ascertain their origin, dominant skull profiles, characters that could be attributed to environmental adaptations; and lastly, profile of pure breeds that have lived in other geographical regions over generations.

REFERENCES

BRUENNER, H., LUGON-MOULIN, N., BALLAUX, F., FUMAGALLI, L. and HAUSSER, J. (2002). A taxonomical re-evaluation of the Valais chromosome race of the common shrew *Sorex araneus* (Insectivora: Soricidae). *Acta Therio,* Vol. 47: 245 – 275.

DYCE, K.M., SACK, W.D.O. and WENSING, C.J.G. (2010). Textbook of Veterinary Anatomy, 4th edition, Saunders Elsevier, China, 57 – 65.

EVANS, H.E. (1993). Miller's Anatomy of Dog, 3rd edition, Philadelphia, PA: Saunders, 148 – 157.

GETTY, R. (1975). The Anatomy of the Domestic Animals, Vol. I, II, 5th edition, Philadelphia, PA: Saunders, Philadelphia, 337 – 338, 766 – 770, 1241 – 1246 and 1472 – 1478.

INTERNATIONAL COMMITTEE ON VETERINARY GROSS ANATOMICAL NOMENCLATURE (2005). Nomina Anatomica Veterinaria, 5th edition, Hannover, Columbia, 22

NICKEL, R., SCHUMMER, A., WILKENS, K., WILLE, H. and FREWEIN, J. (1986). The Anatomy of the Domestic Animals", Volume I, "The Locomotor System of the Domestic Mammals" Berlin: Verlag Paul Parey, 113 – 120, 139 – 147 and 150 – 160.

OLOPADE, J.O. and ONWUKA, S.K. (2004). Morphometric Studies of the Craniofacial Region of the West African Dwarf Goat in Nigeria, *International Journal of Morphology,* Vol. 22(2): 145 – 148.

OLOPADE, J.O. (2006). Morphometric analysis of the skull of three breeds of goats in Nigeria, Ph.D Thesis, Department of Veterinary Anatomy, University of Ibadan, Nigeria.

OLOPADE, J.O. and ONWUKA, S.K. (2009). Morphometric analysis of the skull of the Sahel goat breed: Basic and clinical anatomy, *Italian Journal of Anatomy and Embryology,* Vol. 114(4): 167 – 178.

ONAR, V., MUTUŞ, R. and KAHVECIOĞLU, K.O. (1997). Morphometric analysis of the foramen magnum in German shepherd dogs (Alsatians), *Ann Anat.,* Vol. **179**: 563 – 568.

POHLMEYER, K. (1985). Zur vergleichenden Anatomie von Damtier, Schaf und Ziege. Osteologie und Postnatale Osteogenese, Berlin: Verlag Paul Parey, 207 – 224.

SABER, A.S. (1990). Radiographic anatomy of the dromedary skull (*Camelus dromedarius*), *Vet. Radiology,* 31: 161 – 164.

SHAHID, R.U. and KAUSAR. R. (2005). Comparative gross anatomical studies of the skull of one-humped camel (*Camelus dromedarius*), *Pakistan Vet. J*., 25(4): 205 – 206.

SMUTS, M.M.S. and BEZUIDENHOUT, A.J. (1987). Anatomy of the dromedary, Clarendon Press, Oxford, UK.

WILLIAMSON, G. and PAYNE, W.J.A. (1978). An introduction to animal husbandry in the tropics, 3rd edition, Longman, London, 755.

WILSON, R.T. (1984). The Camel, Longman, London & New York, 60 – 65.

YI, S.J., LEE, H.S., KIM, J.S. and KANG, T.C. (1998). The comparative anatomical study of the parietal region of the skull of the Korean native goat (*Capra hirucus*), *Anat. Histol. Embryol.* 27, 323 – 325.

YI, S.J., KIM, J.S. and LEE, H.S. (2001). Comparative Anatomical Study on Fissura Nasolacrimalis and Nasomaxillaris in Skull of the Korean Native Goat (*Capra hircus*), *Anat. Histol. Embryol*. 30, 133 – 134.