Original article

Some aspects of the maxillofacial and mandibular anatomy of camels (*Camelus dromedaries*) in Nigeria

Yahaya, A.[1], Olopade, JO.[1,2]*, Kwari, HD.[1] and Hambali, IU.[1]

[1]Department of Veterinary Anatomy, University of Maiduguri, Maiduguri, Nigeria
[2]Department of Veterinary Anatomy, University of Ibadan, Ibadan, Nigeria
*E-mail: jkayodeolopade@yahoo.com; jo.olopade@mail.ui.edu.ng

Abstract

Sexual dimorphism, adaptational and evolutionary trends to the morphophysiology of mastication can be interpreted from maxillofacial and mandibular anatomy of animals. We looked at these regions in camels from three geographical zones in Nigeria. We noticed an isolated case of bilateral longitudinal opening in the nasal bones. Our study also revealed that camels show variations in the morphological arrangement of the incisive, maxilla and nasal bones as well as in the eruption pattern of their first premolar. No geographical variation was seen in camels from the three locations in their palatal morphometrics, but in the nasals, the midline nasal length was longest in camels from Maiduguri and this was more significant than those from Kano. All quantitative nasal and palatal parameters were significantly lower in immature camels when compared with the respective adults. This work provided information on the maxillofacial and mandibular region of the camels that will aid morphophysiological, archeological and adaptational studies of this species.

Keywords: maxillofacial, mandible, camels, regional anatomy.

1 Introduction

The bones of the skull that make up the external configuration of the nasal region of most domestic animals are usually the nasals, lacrimals, maxillae, the incisives and part of the frontal bones (NICKEL, SCHUMMER, SEIFERLE et al., 1986). The arrangement of these bones however shows variations between and within animal species (OLOPADE, 2006; OLOPADE and ONWUKA, 2009; YI, KIM and LEE, 2001). In particular, these variations are seen within the nasal bones (OLOPADE, ONWUKA, KWARI et al., 2006) and the patterns of articulation among the surrounding bones such as the lacrimal, maxilla and incisive, (EVANS, 1993; GETTY, 1975; NICKEL, SCHUMMER, SEIFERLE et al., 1986).

Variations in oral morphological traits can exist within animals of the same species which cause preference for different plant species on rangelands (BAKARE, 2009). The morphology of mandible amongst other factors affects preferences made for different plant species (PÉREZ-BARBERÍA and GORDON, 1999; AMARAL, COELHO, MARUGÁN-LOBÓN et al., 2009). In addition, mandibular morphometrics have been known to exhibit sexual dimorphism (AL-RIFAIY, ABDULLAH, ASHRAF et al., 1997; PRABHU and ACHARYA, 2009).

The camel is a browsing animal and has been shown to spend 81% of their feeding time on herbs and *Acacia* bushes, and only 19% on grasses (ABBAS, MOUSA, LECHNER-DOLL et al., 1995; FARID, SHAWKET and ABDEL-RAHMAN, 1984). Wilson (1984) observed that dromedaries take as much as 90% of their diet from browse plants. Camels usually prefer the large deep rooted trees and in 90% of their total feeding time during the dry season, they are known to consume varying plant species (RUTAGWENDA, LECHNER-DOLL, VON ENGELHARDT et al., 1989). Sexual dimorphism, adaptational and evolutionary trends to the facial and mandibular morphophysiology of camels should thus be a continuous study in these species.

This study looks at some aspects of the maxillofacial and mandibular anatomy of camels in northern Nigeria.

2 Material and methods

In the first part of this study, we observed a total of 150 camel heads just after slaughter and removal of the skin in the Maiduguri abattoir, Borno state for the presence of longitudinal openings in the nasal bones (OLOPADE, ONWUKA, KWARI et al., 2006). Secondly, a total of 41 camels from three states in northern Nigeria (Borno, Kano and Sokoto) were used for a separate morphometric study consisting of 29 adults (15 females and 14 males) and 12 immature camels of equal sexes (2-3 years old), (AL-SAGAIR and ELMOUGY, 2002). The ages of the camels were estimated based on reports of Wilson (1984). The skulls were then macerated using a modification of the hot water maceration technique described by Olopade and Onwuka (2004).

After maceration, the relationships of some bones of the maxillofacial region were observed for documentation based on the works of Smuts and Bezuidenhout (1987); the pattern of premolar eruption was also documented. All pictures were taken using a Sony Cyber-shot® 14.1 megapixel camera. In addition, some quantitative variables were measured in the maxillofacial regions in the adult camels and landmarks are listed below.

- Nasal length through the mid-line (**NL 1**): Overall length of the nasal bones through the mid-line (Figure 1);
- Nasal length through the lateral (**NL 2**): Absolute length through the lateral maximum length (Figure 1);
- Nasal width (**NW**): Maximum width of the nasal bone (Figure 1);
- Palate width at molar 1 (**PLW 1**): Width across the median limits of the alveoli of the cheek teeth at molar 1 (Figure 2);
- Palate width at molar 2 (**PLW 2**): Width across the median limits of the alveoli of the cheek teeth at molar 2 (Figure 2);
- Palate length (**PLL**): Length from the midline of the caudal end of the palatine bone to the cranial midline of the palatine part of the maxillary bone (Figure 2); and
- Hard palate length (**HPLL**): Distance from the midline of the caudal end of palatine bone to the rostral midline of the incisive bone (Figure 2).

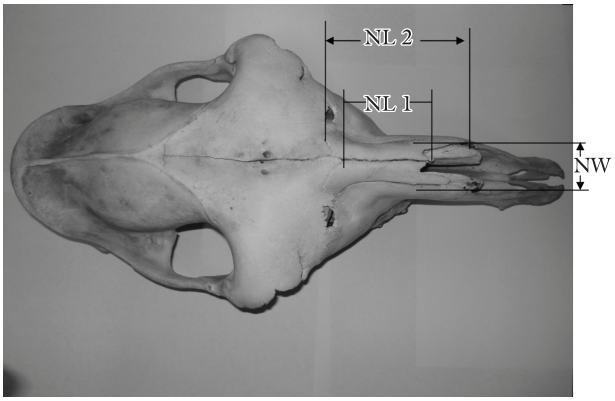

Figure 1. Measurements of the camel skull (dorsal view) showing nasal length through the mid-line (NL1), nasal length through the lateral (NL2) and nasal width (NW) ×125.

3 Results and discussion

A nasal cleft was observed in one of the skulls examined in Borno State. The opening was bilateral and measured 2.9 cm and 3.5 cm in length with a maximum width of 0.4 cm and 0.3 cm on the left and right sides respectively (Figure 3). The morphological appearance was similar to that reported by Olopade, Onwuka, Kwari et al. (2006) in goats. However while this feature was seen in about 70% of Red Sokoto goats, the incidence is camel from our study is less than 1% indicating that this bilateral openings in the nasal bone is an isolated occurrence. A high incidence of such opening may be of clinical importance particularly for semi-intensively kept male camels that get involved in threat attacks like front wrestling (AL-HAMZI and BRAIN, 1993) which may involve the nasal region. Areas of bilateral longitudinal openings in the nasal bones could be areas or resonance during impact and may be prone to fractures (OLOPADE, ONWUKA, KWARI et al., 2006).

The dorsolateral maxillofacial region show two typical variations, in 20% of adult camels, there is a nasoincisive notch due to the presence of a definite incisivo-naso-maxillary junction (Figure 4c), while in the other 80%, a nasomaxilloincisive notch created by an interval of varying distances of the maxilla is seen between the incisive and the nasal bones (Figure 4a, b). The former is similar to that described in goats while the latter resembles the morphological arrangement in sheep (OLOPADE, 2006; OLOPADE, ONWUKA, KWARI et al., 2006; YI, KIM and LEE, 2001).

No geographical variation was seen in camels from the three locations in their palatal morphometrics (Table 1), but in the nasals, the midline nasal length was longest in Camels from Maiduguri and was more significant than those from Kano. The maximum mean of 7.54 cm amongst Maiduguri camels is far shorter than 24.8 cm recorded is horses (EVANS, 1993) though is said that the camel skull resemble that of the equine in outline (SMUTS and BENZUIDENHOUT, 1987). Our observation is due to the fact that the nasal bones of the horses originate far more caudally from the dorsum of the cranium and project further as a midline tip compared to that seen in camels (Figure 1). All quantitative

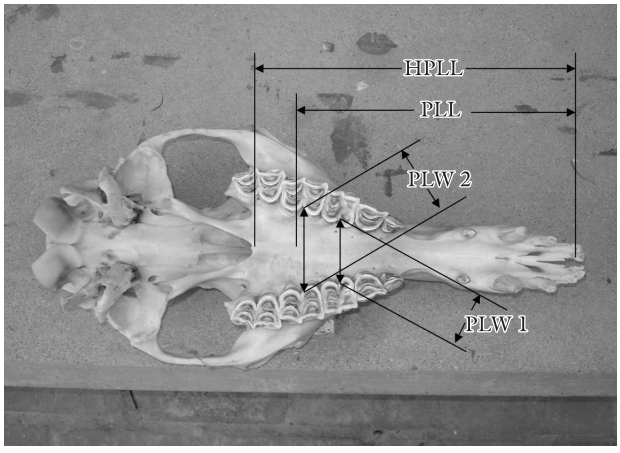

Figure 2. Measurements of the camel skull (ventral view) showing palate width at molar 1 (PLW1), palate width at molar 2 (PLW2), palate length (PLL) and hard palate length (HPLL) ×125.

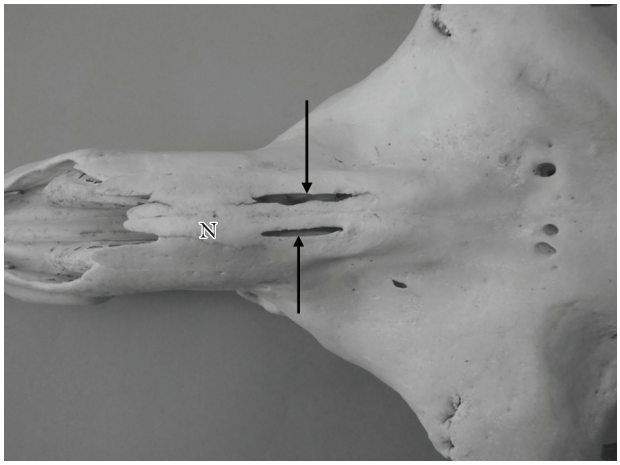

Figure 3. Dorsorostral view of the skull of the camel showing bilateral longitudinal opening (arrows) in the nasal bone (N) ×125.

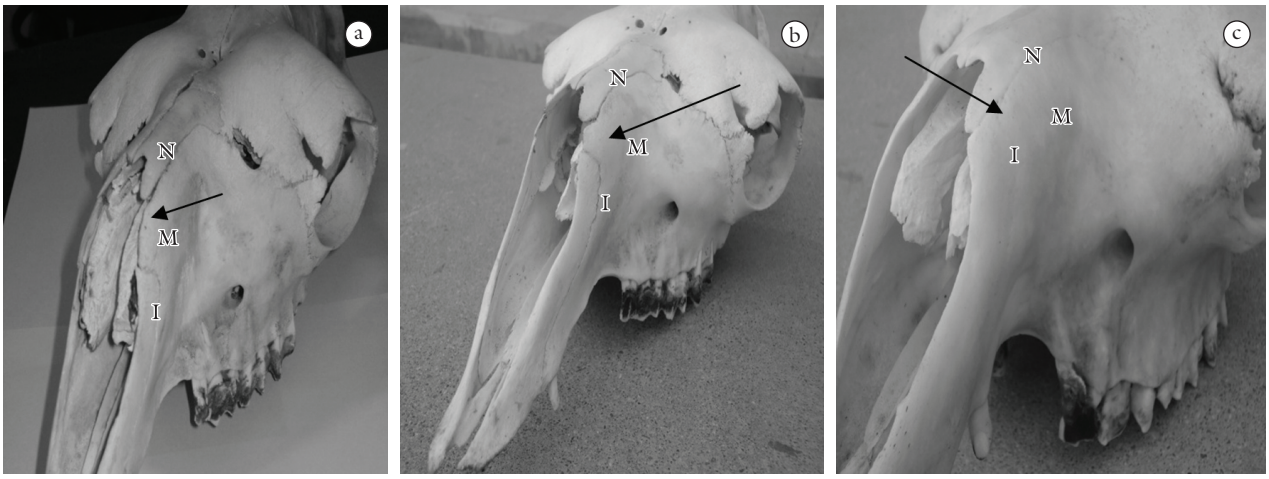

Figure 4. Dorsolateral view of the skull of the camel. A and B show varying distance of the Maxilla (M) (arrows) between the Incisive(I) and Nasal bones(N) while C show point of communication of the three bones ×125.

Table 1. Some Maxillofacial measurements of the skull of camels (*Camelus dromederius*) in Nigeria.

LM	MD	MMD	FMD	KN	MKN	FKN	SK	MSK	FSK	YN	MYN	FYN
NSL1	7.54 ± 0.35[a]	8.10 ± 0.39	6.98 ± 0.51	6.70 ± 0.32	6.58 ± 0.58	6.82 ± 0.34	6.54 ± 0.23	6.84 ± 0.41	6.24 ± 0.12	6.20 ± 0.28**	6.20 ± 0.28	5.67 ± 0.27
NSL2	10.97 ± 0.34	11.68 ± 0.40*	10.26 ± 0.32	10.61 ± 0.36	11.22 ± 0.57	10.00 ± 0.29	10.66 ± 0.21	10.84 ± 0.29	10.48 ± 0.30	8.38 ± 0.29**	8.38 ± 0.29	8.13 ± 0.22
NW	3.39 ± 0.09	3.42 ± 0.12	3.36 ± 0.13	3.32 ± 0.09	3.30 ± 0.14	3.34 ± 0.12	3.21 ± 0.14	3.34 ± 0.27	3.08 ± 0.11	2.87 ± 0.06**	2.87 ± 0.06	2.65 ± 0.06
PLW1	5.48 ± 0.16	5.36 ± 0.30	5.60 ± 0.11	5.51 ± 0.18	5.44 ± 0.23	5.58 ± 0.31	5.29 ± 0.13	5.26 ± 0.17	5.32 ± 0.23	3.57 ± 0.11**	3.55 ± 0.22	3.58 ± 0.08
PLW2	6.58 ± 0.10	6.52 ± 0.17	6.64 ± 0.10	6.55 ± 0.11	6.58 ± 0.20	6.52 ± 0.12	6.43 ± 0.14	6.62 ± 0.25	6.24 ± 0.11	4.43 ± 0.04**	4.47 ± 0.06	4.38 ± 0.05
PLL	22.80 ± 0.40	23.64 ± 0.46*	21.96 ± 0.39	21.93 ± 0.41	22.54 ± 0.44	21.32 ± 0.60	22.25 ± 0.48	22.70 ± 0.74	21.80 ± 0.61	17.33 ± 0.24**	17.55 ± 0.34	17.12 ± 0.35
HPLL	27.44 ± 0.34	28.22 ± 0.36*	26.66 ± 0.31	27.00 ± 0.44	27.56 ± 0.55	26.44 ± 0.66	26.87 ± 0.54	27.56 ± 0.78	26.18 ± 0.69	21.34 ± 0.32**	21.48 ± 0.44	21.20 ± 0.49

All Values are in cm. LM: Landmarks, NSL: Nasal length 1, NSL: Nasal length 2, NW: Nasal Width, PLW1: Palate width at molar1, PLW2: Palate width at molar2, PLL: Palate length, HPLL: Hard palate length, MD:Maiduguri, MMD: Male Maiduguri, FMD: Female Maiduguri, KN: Kano, MKN: Male Kano, FKN: Female Kano, SK: Sokoto, MSK: Male Sokoto, FSK: Female Sokoto, YN: Young, MYN: Male Young, FYN: Female Young; aSignificantly higher than Kano at $P < 0.05$; *Significantly higher than respective gender at $P < 0.05$; **Significantly higher lower than respective adult (MD) at $P < 0.01$.

nasal parameters in our study were significantly lower in immature camels when compared with the respective adults. This implies that significant osteometric growth from most dimensions of the nasal still occur after the age of three. This was the same observation in all the palatal indices that we measured.

In young camels (all from Maiduguri), no sexual dimorphism was seen in the palatal and nasal indices. However, as camels grow older (as seen in Maiduguri adults), there appears to be more profound growth in the linear aspects of the face of males as seen by significantly longer nasal (NSL2), and palatal lengths. These are likely ultimate consequences of male camels having longer skulls. This report is novel in that sexual dimorphism in camels based on craniometric data is hardly reported in the literature.

The first premolar (PI) of the mandible in camels is tusk-like and is found isolated in the diastemal region after the canine tooth. It appears 5-6 months after birth and is never replaced (SMUTS and BENZUIDENHOUT, 1987). We noticed morphological variations in the erupted PI in adult camels. While some camels had a single PI on both halves of the mandible (85% of males, 33% of the females), some had only one on either half (15% of males and 40% females), while some had none (30% females). In an isolated case (7% of females), we noticed presence of two on one half and one on the other (Figure 5). There was thus an apparent sexual dimorphism in the presentation as high variability in PI presentation in camels seems to be more of a female phenomenon. Though preliminary studies (AL-HAMZI and BRAIN, 1993) suggest that camels have similar feeding patterns irrespective of sex, more work is needed to ascertain how variations in PI distribution affect the morphophysiology of mastication in these species.

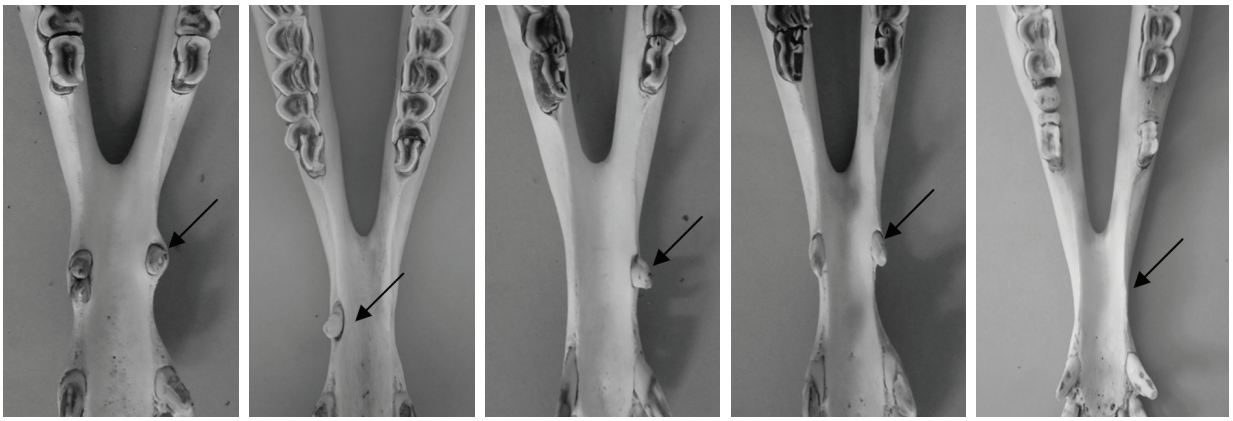

Figure 5. Dorsal view of the mandible of the adult camels in Nigeria showing variations in the eruption of the first premolar, PI (arrow) ×125.

4 Conclusions

This work has in conclusion provided anatomical information on the maxillofacial and mandibular region of the camel as part of an effort to provide baseline research data that will aid morphophysiological, archeological and adaptational studies of this breed.

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