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Morphologic and Morphometric Studies of Long Bones of One- Humped Camel Fetuses

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ABSTRACT

This work was aimed at studying the morphologic and morphometric anatomy of long bones of camel fetuses across the three trimesters. Twenty four (24) fetuses were used; eight fetuses at each trimester. All the fetuses were aged and dissected to remove long bones from both forearm and hindlimbs. The bones were observed to have the characteristic features (diaphysis and epiphysis) of long bones across the trimesters. The proximal and distal epiphyses were cartilaginous in the first trimester without any distinguishable features. At the second and third trimesters lesser and greater tubercles were distinct on the humerus while the femur had head and condyles at the proximal and distal extremities respectively. The radio-ulna was seen as fused bones at third trimester and the tibia was observed as a single bone across the trimesters. Osteometric results showed increase across the trimesters, with the mean bone length increasing from 1.06 ± 0.04cm in metatarsal at the first trimester to 27.18 ± 6.54cm in metacarpal bone at the third trimester, while the mean weight increased from 0.04 ± 0.01g in metacarpal bone to 80.50 ± 0.82g in the radio-ulna bone. The results of this study provide basics on the developmental features of the long bones of camel fetus and would add to the dearth of information on the camel developmental anatomy.

Keywords: Camel fetus, Long bones, Morphology, Morphometric

INTRODUCTION

The one-humped camel is a typical desert animal that has developed sophisticated physiological adaptation for coping with heat, feed and water scarcity in its dry and rough habitat (Al-Haj *et al*., 2007). The dromedarian camel is one of the most economically important domesticated species in Arabian Peninsula, North Africa and Middle East. Camels have played a vital role influencing every aspect of daily life (Al-Jaru *et al.*, 2011).

Camels have long, strong legs with powerful muscles in the upper part of the legs that allow the animals to carry heavy loads for long distant travels, the camel's long legs also facilitate its browsing of tall shrubs and trees, thus help in energy conservation (Arnautovic, 1997).

Skeletal growth is essential for body growth and carcass quality, growth in length affects bone and muscle characteristics (Abu-Samra, 1981). A developing long bone consists of the epiphyses and metaphyses at each end of the diaphysis (Abu-Samra, 1981). Camels being large bodied animal, which are mostly utilized as a beast of burden, relies on the limbs for supportive, adaptive and protective functions thus, the study of the developmental changes of these long bones is important.

Although some works have been conducted on age related changes in musculoskeletal tissues of one-humped camel during development stage by Sonfada, (2008), and assessment of calcium and phosphorus contents of the calvaria of one-humped camel fetuses (Hena *et al*., 2012), yet more needs to be done on the biology of the skeletal structures of the camel species. The study is generally aimed at evaluating the developmental patterns of the long bones in one humped camel foetuses across the various gestational ages.

METHODOLOGY

Wasted fetuses were collected from Sokoto Central Abattoir through daily visit, from May to July 2014. The fetuses were then transported to the Department of Veterinary Anatomy Laboratory of Usmanu Danfodiyo University, Sokoto, for analyses. The fetuses were cleaned and excess fetal membranes trimmed. They were then weighed using a compression spring weighing balance (sensitivity of 0.1kg) and their Crown vertebral rump length (CVRL) was measured, which a measure is extending from the posterior fontanel and following the vertebral column down to the rump using a tape rule (Butterfly$^{(R)}$). The gestational ages were determined using the formula:

$$GA= (CVRL+23.99)/0.366$$

as suggested by Elwishy *et al.* (1981), and developmental horizons (Sonfada *et al.*, 2012). The fetuses were then categorized into first, second and third trimesters.

Each fetus was placed on lateral recumbence and the uppermost limbs detached from the body and then rotated to the opposite side to detach the uppermost limbs. The forelimbs were detached from the shoulder joints while the hind limbs were detached from the coxo-femoral joints. A straight line incision was made along the longitudinal axis of the limbs, the soft tissues on the limbs (muscles, fascia, tendons and ligaments) were removed using scapel blade and scissors, this way, the long bones were harvested. The bones were studied grossly and photographs were taken using a digital camera (model number: DSC-W310).

Weights of all the long bones of first, second and third trimester fetuses were obtained using Mettler weighing balance and digital electronic balance (CITIZEN SCALES 1 PVT. LTD, model MP- 600, with a sensitivity of 0.01g.) The length and circumference of the long bones were measured using a tape rule (Butterfly$^{(R)}$) and a thread. The circumference of each long bone was measured by taking the average of the circumference at proximal 1/3, middle and distal 1/3 of the long bones.

RESULTS

Twenty four (24) camel fetuses were used, out of the 49 fetuses collected within the period. Plate 1, shows the humerus, of 1st 2nd and 3rd trimester fetuses. Across the three trimesters, the shafts of the humerus were present. The cartilaginous epiphyseal growth plate which was located between the proximal and distal centers of the shaft was also present. In addition, the greater and lesser tubercles at the humeral heads were more prominent in the 2nd and 3rd trimester fetuses. The presence of the epiphyseal growth plate at the proximal and distal epiphysis suggests that in camels the region for growth in length of the humerus occurs at the proximal and distal end of the bone.

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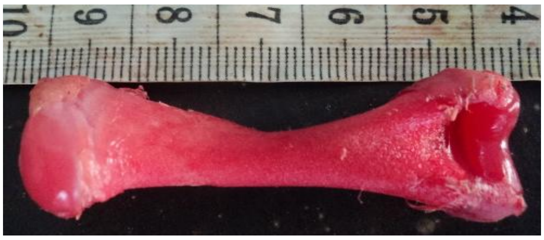
A



C


Plate 1: 1st 2nd and 3rd trimester humerus

The radius appeared as a long cylindrical bone which was loosely attached to the ulna bone, except at the 3rd trimesters where some degree of fusion was seen at the proximal and distal interosseous spaces. The ulna is a long cylindrical bone with the olecranon being prominent at the proximal third of the bone at the 2nd and 3rd trimesters, they were seen to have increased substantially in size and relatively attached to the radius at the third trimester (Plates 2).

A


B


C


Plate 2: 1st 2nd and 3rd trimester radio-ulna

Shafts representing the rudimentary metacarpals are present as two separate bones were at 1st and 2nd trimesters even though fusion has begun. By the 3rd trimester the metacarpal appeared as a single bone with the dorsal aspect having a longitudinal groove, and the palmar aspects of the metacarpal bone is flat across the three trimesters (Plates 3).

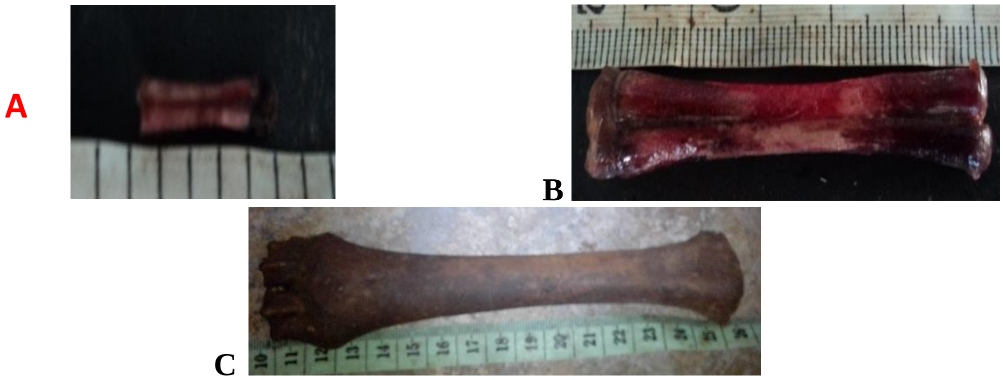


Plate 3: 1st 2nd and 3rd trimester metacarpal

The femoral shaft, proximal and distal growth plates were all present in the three trimesters. In the 1st trimesters the epiphyses were yet to develop at the ends of the shafts. In the 2nd and 3rd trimesters, the proximal ends of the femur have a shallow fovea capitis, greater and lesser trochanters; these were not seen at the first trimester. The proximal ends which form the head of the femur are separated from the shaft by the growth plates. The distal end of the femur develops into the complex trochlea, condyles, and epicondyles at the 2nd and 3rd trimesters (Plates 4).

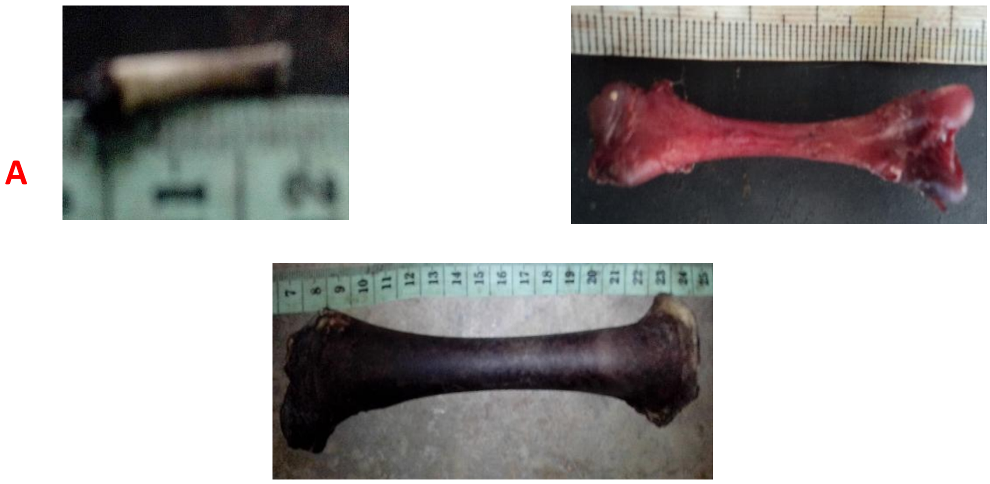


Plate 4: 1st 2nd and 3rd trimester femur

The tibial shaft appeared as a single bone across the three trimesters. The proximal ends were more prominent in the first trimester with rudimentary medial and lateral condyles. Developments of the distal epiphysis are seen at the 2nd and 3rd trimesters with the presence of the tibial tuberosity around the periphery of the cartilage plate. Intercondylar eminences separating the medial and lateral condyles are prominent only at the 2nd and 3rd trimesters. The fibula were completely absent throughout the three trimesters in this study (plates 5).

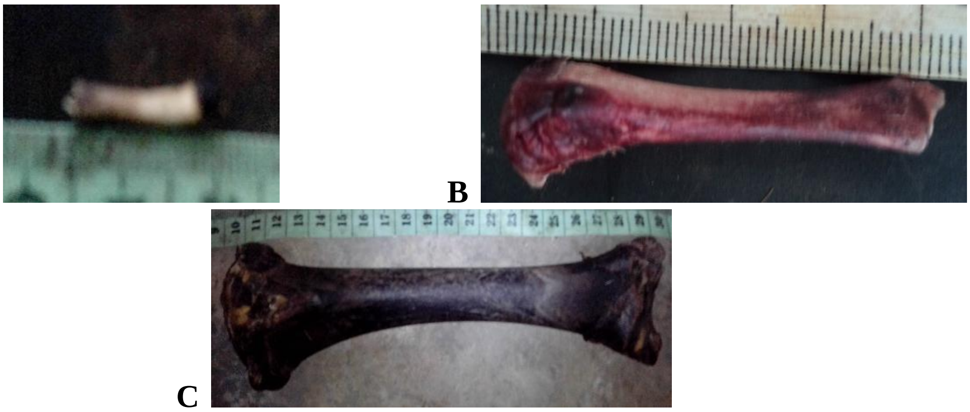


Plate 5: 1st 2nd and 3rd trimester tibio-fibula

The observations of the metatarsal were similar to those of the metacarpal; however the metatarsal was shorter (plate 6).

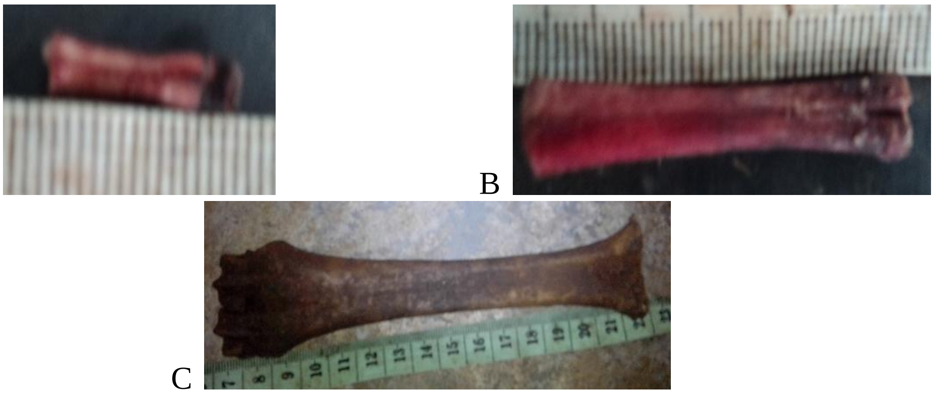


Plate 6: 1st 2nd and 3rd trimester metatarsus

Osteometric results showed increase across the trimesters, with the mean bone length increasing from 1.06 ± 0.04cm in metatarsal at the first trimester to 27.18 ± 6.54cm in metacarpal bone at the third trimester (Table 1), while the mean weight increased from 0.04 ± 0.01g in metacarpal bone to 80.50 ± 0.82g in the radio-ulna bone (Table 2). Metacarpal bone had the least mean circumference 0.05 ± 0.05cm and the humerus had the highest mean circumference 5.72 ± 0.16cm by the 3rd trimester (Table 3).

Table 1: Mean Lengths (±SEM) of the various long bones from forelimbs and hind limbs across the first, second and third trimester fetuses

Bone Type (cm)	1st Trimester (n=8)	2nd Trimester (n=8)	3rd Trimester (n=8)
H	1.26±0.08	3.74±0.41	12.42±0.18
R/U	1.55±0.13	4.93±0.52	20.12±0.36
MC	1.1±0.06	3.72±0.39	27.18±6.54
F	1.52±0.12	4.56±0.35	14.87±0.24
T/F	1.75±0.16	4.78±0.39	16.85±0.45
MT	1.06±0.04	4.71±0.39	15.95±0.46

H=Humerus, R/U=Radio-ulna, MC=Metacarpal, F=Femur, T/F=Tibio-Fibula; MT=Metatarsal

Table 2: Mean Weights (±SEM) of the various long bones from forelimbs and hindlimbs across the first, second and third trimester fetuses

Bone Type (g)	1st Trimester (n=8)	2nd Trimester (n=8)	3rd Trimester (n=8)
H	0.05±0.01	0.85±0.11	62.15±0.67
R/U	0.11±0.04	1.02±0.13	80.5±0.82
MC	0.04±0.01	0.84±0.13	49.12±4.21
F	0.14±0.02	0.84±0.11	75.43±1.27
T/F	0.18±0.08	0.91±0.12	55.2±1.23
MT	0.10±0.03	0.61±0.11	52.62±3.22

H=Humerus, R/U=Radio-ulna, MC=Metacarpal, F=Femur, T/F=Tibio-Fibula; MT=Metatarsal.

Table 3: Mean Circumference (±SEM) of the various long bones from forelimbs and hind limbs across the first, second and third trimester fetuses

Bone Type	1st Trimester (n=8)	2nd Trimester (n=8)	3rd Trimester (n=8)
H (cm)	0.65±0.07	1.94±0.26	5.72±0.16
R/U (cm)	0.91±0.12	1.94±0.19	5.66±0.18
MC (cm)	0.5±0.05	1.90±0.23	5.41±0.22
F (cm)	1.94±0.26	2.10±0.17	5.23±0.22
T/F (cm)	1.94±0.19	2.17±0.16	5.67±0.19
MT (cm)	1.90±0.23	1.56±0.09	5.40±0.18

H=Humerus, R/U=Radio-ulna, MC=Metacarpal, F=Femur, T/F=Tibio-Fibula; MT=Metatarsal.

DISCUSSION

The bones (humerus, radio-ulna, metacarpal, femur, tibio-fibula and metatarsal) studied were observed to possess typical long bone characteristics with diaphysis connecting the two epiphyses (Shapiro, 2008). According to Shapiro, (2008) these regions are established by the middle of the embryonic stage and go through proportional changes in size until skeletal maturity.

The epiphyses are responsible for the transverse and spherical growth of the ends of the bone, the shaping of the articular surfaces, and the longitudinal growth of the metaphyses and the diaphysis (Miller, 1993). A small amount of longitudinal growth also occurs with interstitial expansion of the epiphyseal cartilage, including the undersurface of the articular cartilage (Urist, 1985).

Tibia was observed to be the longest; this is in line with the findings of Kadim *et al.* (2002) who stated that tibia was the longest and thickest. Radio-ulna bones exist as separate bones in the first trimester and was seen as a single bone with interosseos spaces as evidence of union of the two bones as early as second trimester. This fast union of these bones may indicate high level of bone minerals and very active bone growth in the species. This may probably be the first report on the radio-ulna at fetal level.

The growth plate and the metaphyseal region were observed in the present study; these represent the growth component of the bone and can be seen clearly in bones of young animals (Makkaway *et al*., 1988).

Several factors have been reported to influence the growth and development of bone tissues. Vaughan, (1980) classified these factors into two main groups: Endogenous (genetic and hormonal) and Exogenous (environmental and dietary) factors. These two broad factors also interact with each other to affect bone development and growth (Lawrence and Fowler, 1997). Of these factors, the endogenous factor is of more relevance to this study since the nutritional status of the dams from which the fetuses were collected was not considered.

Bone growth in weight and length depends primarily on the amount of calcium salt deposited during ossification (Richardson *et al.,* 1976). This in turn depends on the quantity of the mineral in animal feed, and the ability of the animal to use the mineral for bone calcification (Sivachelvan *et al.*, 1996). In this studies however, the nutritional status of the dams from which the fetuses were recovered were not known but there was a general increase in the bone weights and lengths across the trimesters, with higher values recorded at the third trimester stages.

Conclusively, this study attempts to present the osteomorphological pattern of the developing long bones across the trimesters of the gestational period in the one-humped camel, which was seen to be isometric.

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