

Gross Embryonic Differentiation of the Stomach of the One Humped Camel (*Camelus dromedarius*)

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Abstract

An embryonic gross differentiation study was conducted on the stomach of 35 foetuses of the one-humped camel collected from the Sokoto metropolitan abattoir, over a period of five months at different gestational ages. The approximate age of the fetuses was estimated from the crown vertebral rump length (CVRL) and samples were categorised into first, second and third trimester. The mean body weight of the foetus at first, second and third trimester ranged from 1.40 ± 0.06 kg, 6.10 ± 0.05 kg and 17.87 ± 0.6 kg, respectively. The mean weights of the entire digestive system at first, second and third trimester were 0.80 ± 0.07 kg, 2.13 ± 0.04 kg and 4.86 ± 0.08 kg respectively. The mean weights of the digestive tract at first, second and third trimester were 0.53 ± 0.07 kg, 1.03 ± 0.05 and 2.43 ± 0.07 kg, respectively. Camels' stomach was observed to comprise of the voluminous smooth compartment rumen, a relatively small beans shape reticulum and a tubular abomasum at first trimester. At second and third trimester the stomach was found to comprise of a voluminous compartment I (rumen) which is subdivided by a strong muscular pillar into a dorsal smooth part and a ventral coarse part, a relatively small compartment II (reticulum) and a tubiform compartment III (Abomasum). Based on the findings in the study, camels' stomach had little/few similarities with true ruminant in terms of development.

Keywords: Camel; Embryonic differentiation; Gross; Stomach

Introduction

Camels are in the taxonomic order *Artiodactyls* (even-toed ungulates), sub order *Tylopoda* (pad-footed), and Family *Camelidae* [1,2]. They are pseudo-ruminants that possess a three-chambered stomach, lacking the omasum that is part of the four-chambered stomach of the order Ruminantia [2,3]. The true camels (*Camelus dromedarius* and *Camelus bactrianus*) are closely related anatomically to the South American Camelids (Llama, Alpaca, Vicuna and Guanaco [4].

Tylopoda and Ruminantia independently developed forestomach during evolution [2,5]. Species of both suborders of Artiodactyla ruminant have large forestomach with extensive microbial digestion to achieve a superior digestibility of diets rich in cell wall constituents. However, gross anatomy and the microscopic structure of the forestomach mucosa are very different in camelids compared to ruminants [1,6-10].

Research work dealing with morphology, physiology, pathology, gross and developmental anatomy of various organs and system of dromedarian camel has been carried out in many countries using foetal and adult camel [1-3,5,9,11-16] but little attentions have been paid for the developmental changes of the entire stomach of the camel fetus. Thus, paucity of information on the prenatal development of camel stomach exists; hence the present study was undertaken to bridge the information gap.

Materials and Methods

The study was carried out on 35 foetuses of the one-humped camel collected from the metropolitan abattoir, Sokoto using standard animal ethics approved by the government, at different gestational ages. The collected foetuses were then taken to the Veterinary Anatomy laboratory of Usmanu Danfodiyo University; where the weight and age of the foetus were determined. The foetal body weight was measured

using electrical (digital) weighing balance for the smaller foetuses and compression spring balance (AT-1422), size C-1, sensitivity of 20kg X 50g in Kilogram for the bigger foetuses. The approximate age of the foetuses was estimated by using the following formula adopted by El-wishy et al. [17].

$GA = (CVRL + 23.99) / 0.366$, Where GA is age in days and CVRL is the Crown Vertebral Rump Length.

Fetuses below 130 days were designated as first trimester, 13-260 days as second trimester and 261-390 days as third trimester [2]. Crown Vertebral Rump Length (CVRL) was measured (cm) as a curved line along the vertebral column from the point of the anterior fontanel or the frontal bone following the vertebral curvature to the base of the tail. Based on this, foetal samples were divided into 3 main groups as described by Bello et al. [5]. The digestive tract of each fetus was collected by placing the fetus on dorsal recumbency and a mid-ventral skin incision was made *via* the abdomino-pelvic region down to the thoracic, to the neck up to the inter-mandibular space in order to remove the entire digestive tract.

The length, width and diameter of the various segments of the stomach were measured. The length of the rumen was taken from

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the craniodorsal groove to the caudoventral groove and the width as the distance from the dorsal groove to the ventral groove. The length of the reticulum was taken from the cranial groove (rumino-reticular junction) to the caudal groove (reticulo-abomasal junction) and the width as the distance from the dorsal smooth border to the ventral coarse border. The length of the abomasum was taken as the greater length from the reticulo-abomasal junction to the pyloric antrum of the abomasum and the width was taken as the circumference of the organ as described by Malie et al. [4]. The diameter was calculated from their respective circumference. Data obtained were presented in mean \pm standard error of mean and student-t test was employed to analyse the data using SPSS version 17.0 statistical software.

Results and Discussion

The current study attempted to enhance the information about the normal development of the camel stomach. Result of the investigation that there was an increase in the body weight, organ weight and individual segments of the stomach in the fetuses with advancement in gestation period (Table 2). This is in agreement with the observations of Jamdar and Ema [18] and Sonfada [3], who observed obvious body weight increase with advancement of gestation period in different species of animals. Bello et al. [2] suggested that nutritional status and health condition of the dam played a vital role in the development of the fetus hence increase in weight of the fetus (Figures 1-3).

The observed increase in weight, length and diameter of various



Figure 1: Photograph showing camel fetus at 1st trimester with transparent abdominal wall and rudimentary ear canal opening X 75.

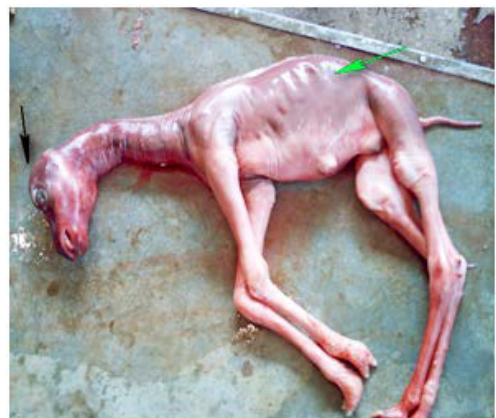


Figure 2: Photograph showing camel fetus at 2nd trimester with thick prominent skin (green arrow) and hair on the upper eyelid (black arrow) and head region. X 75.



Figure 3: Photograph showing camel fetus at 3rd trimester with short densely distributed hair (whitish) all over the body with very small areas of alopecia (black arrow). X 75.

Parameters	First Trimester	Second Trimester	Third Trimester
Number of sample (N)	13	11	11
CVRL (cm)	20.06 \pm 3.0	60.27 \pm 4.0	103.83 \pm 6.0
Fetal weight (Kg)	1.40 \pm 0.6	6.10 \pm 0.5	17.87 \pm 0.6

Table 1: The CVRL and weight of fetuses at various trimesters (mean \pm SEM).

Parameters	First Trimester	Second Trimester	Third Trimester
Rumen (cm)	7.47 \pm 1.67 ^a	13.83 \pm 1.67 ^b	20.75 \pm 1.33 ^c
Reticulum (cm)	1.97 \pm 0.43 ^a	3.47 \pm 0.47 ^b	6.93 \pm 0.27 ^c
Abomasum (cm)	12.67 \pm 2.33 ^a	18.33 \pm 0.40 ^b	25.75 \pm 0.37 ^c
Volume (cm ³)	136.67 \pm 8.30 ^a	283.33 \pm 6.50 ^b	353.33 \pm 7.65 ^c

^{abc}: means on the same row with different superscripts are significantly different ($P < 0.05$).

Table 2: The Length and volume of stomach compartments at various trimesters (mean \pm SEM).

Parameters	First Trimester	Second Trimester	Third Trimester
Rumen (mean \pm SEM)	1.93 \pm 0.17 ^a	6.43 \pm 0.43 ^b	11.50 \pm 1.00 ^c
Reticulum (mean \pm SEM)	1.00 \pm 0.40 ^a	2.63 \pm 0.30 ^b	4.05 \pm 0.20 ^c
Abomasum (mean \pm SEM)	1.33 \pm 0.20 ^a	3.00 \pm 0.23 ^b	4.25 \pm 0.30 ^c

^{abc}: means on the same row with different superscripts are significantly different ($P < 0.05$).

Table 3: Mean widths/diameters of the various compartments of the stomach (rumen, reticulum and abomasum) at various trimesters.

segments of the stomach in the study (Tables 1-3) is in line with the findings in bovine, porcine and caprine species by [19-21] respectively. The gastric indices observed in the study showed significant ($P \leq 0.05$) difference in relation to the age and the indices were decreasing with advancement in gestation (body development) and similar developments were seen in the study of Georgieva and Gerov [21] and Bal and Ghoshal [20] in porcine specie; Bello et al. [2,5] in camel specie. The observed increase in volume of the entire stomach with advancement of gestation in the study is in line with the findings previously reported by several studies [2,5,18,20,21]. The mean length and diameter of the rumen, reticulum and abomasum were found to be increasing with advancement in gestation (Table 2 and 3). This observed increase in the study showed to have significant difference in relation to the age ($P \leq 0.05$) and is in line with the observations of [19,22,23]; who study the developmental anatomy of red deer stomach based on gestational period.

From the study, camels' stomach was observed to comprise of the voluminous smooth compartment rumen, a relatively small beans shape reticulum and a tubular abomasum at first trimester (Figure 4). At second and third trimester the stomach was found to comprise of a voluminous compartment I (rumen) which is subdivided by a strong muscular pillar into a dorsal smooth part and a ventral coarse part, a relatively small compartment II (reticulum) and a tubiform compartment III (Figures 5 and 6). This was in line with the observations of many scholars [24,25] but contrary to the findings of [26,27] who reported that during the development of the camel fetus, the abomasum had a constriction or demarcation that showed a primitive omasum but disappear early at post-natal period.

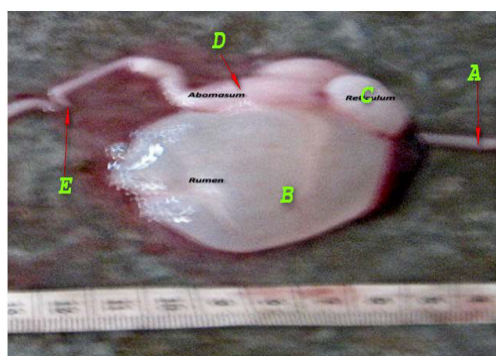


Figure 4: Camel stomach at 1st Trimester showing esophagus (A), rumen (B), reticulum (C), abomasums (D) and small intestine (E).

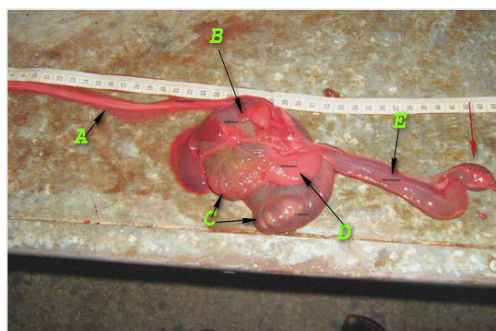


Figure 5: Camel stomach at 2nd Trimester showing esophagus (A), Smooth part of the rumen (B), coarse part of the rumen (C), reticulum (D), abomasums (E) and abomasal antrum (Red arrow).

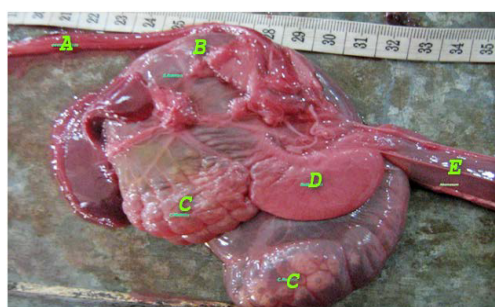


Figure 6: Camel stomach at 3rd Trimester showing esophagus(A), Smooth part of the rumen (B), coarse part of the rumen (C), reticulum (D) and abomasums (E).

The division of the camel stomach into 3 major compartments i.e. rumen, reticulum and abomasum as there was no omasum in all the three phases of the gestational age (Figures 4-6) is in line with the findings of and [24,28] who observed that the abomasum was a long narrow tube-like structure with no constriction. In contrary, the findings of [27] had reported that during the development of the camel fetus, the abomasum has a constriction or demarcation that shows a primitive omasum but disappears at post-natal period.

Lesbre [26] and Leese [29] had stated that the camel has only three compartments compared with the bovine's four compartments, i.e. the missing compartment being the omasum, or third compartment. Hegazi [30] had described the camel as having the same four compartments as other ruminants, but with the external constrictions between the omasum and abomasum being less well defined in the camel. Bello [2] stated that the Llama and Guanaco stomachs consist of only three compartments. Based on the findings, camels' stomach had little/few similarities with true ruminant in terms of development.

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