

## Gross anatomical and histological studies of the pancreas in camel (*Camelus dromedarius*) during the second and third trimesters of gestation

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### Abstract

The pancreas is an important gland in the digestive system. This study aimed to investigate the development of the gross anatomy, topography, and histology of the pancreas of the camel foetus (*Camelus dromedarius*). Twelve camel foetuses were used in this study. The pancreas during the second trimester of gestation was divided into a body, a right lobe, and a left lobe. The pancreas has a connective tissue capsule that sends trabeculae to the parenchyma. The connective tissue trabeculae divided the parenchyma into lobules. The pancreas was made up of tubulo-acinar secretory units. A single row of semi-pyramidal epithelial cells that form a small central lumen. The duct system consisted of intralobular ducts, which were lined by simple cuboidal cells. The interlobular ducts were located between the lobules within the connective tissue trabeculae, which were lined by stratified cuboidal cells.

The pancreatic islets in the second and third trimesters were structures diffuse through the exocrine pancreas. The shape of the pancreatic islets is variable form rounded, oval, or irregular in shape. In conclusion, the pancreas of the camel foetus during the second and third trimesters has good developmental features, which may be like those in the adult camel.

**Keywords:** Camel foetus, Pancreas, Anatomy, Histology.

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### Introduction

Camelids have been shown to be able to withstand the harsh conditions typical of semiarid and desert regions because of their unique physiological and morphological characteristics (Bello *et al.*, 2013; Faraz *et al.*, 2019). During the last century, camel investigators have highlighted the mechanisms governing such adaptation, especially anatomical and physiological peculiarities (Aly, 2007).

The pancreas is situated in the duodenum's concavity; on the left, it

reaches the kidney's hilus and touches the spleen anteriorly (Dubios, 1999).

The pancreas is a double function gland that produces digestive enzymes secreted through the duct system (exocrine) and hormones directly in the blood stream (endocrine). The importance of the pancreas in the digestive system is the secretion of zymogen enzymes for the digestion of food. Hormones are also secreted by the islets of Langerhans, and hormonal secretions include glucagon (Alfa), insulin (Beta) cells and other hormones from other endocrine cells (Khatim *et al.*, 1985; Bloom and Fawcett,

1986; Dyce *et al.*, 1987; Gartner and James, 2007; Heller, 2010; Steiner *et al.*, 2010; Hamza, 2018; Iniyah *et al.*, 2019). The endocrine part of the pancreas comprises of five different hormone-secreting cell types: glucagon-secreting  $\alpha$ -cells, insulin-secreting  $\beta$ -cells, somatostatin-releasing  $\delta$  cells, ghrelin-producing  $\epsilon$ -cells, and pancreatic polypeptide-secreting PP-cells (Tsuchitani, *et al.*, 2016).

The pancreas develops from the primitive foregut endoderm, which differentiates into ductal, acinar, and endocrine cells (McGeady *et al.*, 2017). This complex process is probably replicated in the adult pancreas when endocrine cell renewal is required (Peters *et al.*, 2000).

Research concerning the development of the pancreas of the camel foetus in the available literature is scant and reported by; (Abdel-Moneim, 1998; Mohammed, 2019; Mohammed *et al.*, 2019; Ali, 2023). This may be due to the paucity of material available for investigation; therefore, this recent study aimed to study the gross anatomy and histology of the developmental stages of the dromedary camel pancreas during prenatal development.

## Materials and Methods

### Sample collection and preparation

Twelve (12) camel foetuses during the second and third trimesters of gestation (age: 131–311 days) were used in this study. The foetuses were obtained from Tamboul and Nyala Slaughterhouses (Sudan), where the animals were slaughtered under official license and supervision for meat production. The approximate age of the foetuses was estimated by using the following equation adopted by (Elwishy, *et al.*, 1981).

$$GA = \frac{CVRL + 23.99}{0.366}$$

Where GA: Gestational Age in days, CVRL: Crown vertebral-rump length

### Gross anatomy

For the gross anatomical investigation, six camel foetuses from the second trimester were used. The foetuses were fixed in 10% formalin, and carefully dissected. The anatomy and topography of the pancreas were examined.

### Histology

For the histological investigation, six foetuses were used to collect histological specimens. Three foetuses were obtained from the second trimester and three foetuses from the third trimester. The specimens were fixed in with 10% buffered formalin. For general histological observations, the specimens of the pancreas were prepared using standard histological techniques and stained with hematoxylin and eosin (H&E) (Bancroft and Stevens, 2008).

## Results

### Gross anatomy and topography of the pancreas in camel foetus

This part of the study was conducted during the second trimester of gestation. The dissected foetuses were between 24-66 cm CVRL (131-246 days). At this stage, the pancreas was situated at the level of the first five lumbar vertebrae. In addition, it was soft, grayish to pink in color. It consists of a body and two lobes. The pancreas was related dorsally to the visceral surface of the liver, adrenal gland and metanephric kidney. It was related medially to the colon and caudally to the duodenum and jejunum (Figure 1 a). The body of the pancreas related cranially to the liver, caudally to the duodenum,

dorsally to the colon and ventrally to the first compartment of the stomach (Figure 1 b). The right lobe was related dorsally to the visceral surface of the liver, medially to the portal vein, laterally to the jejunum and ventrally to the transverse colon (Figure 1 c). The left lobe was related dorsally to the metanephric kidney and adrenal gland. It was related medially to the first compartment of the stomach, caudally to the colon and ventrally to the jejunum (Figure 1 c). At this stage, the pancreaticoduodenal vein (branch of the portal vein) was well developed and passed close to the pancreas (Figure 1 d). The pancreas was compact and had very clear lobulation at this stage of development (Figure 1 d).

### ***Histology of the pancreas in camel foetus***

#### ***Stroma***

A thin connective tissue capsule covers the gland and incomplete trabeculae entered the pancreas in the second trimester of pregnancy (Figure 2, a1 and a2). In the third trimester, the capsule appeared as thick dense connective tissue and send thick trabeculae to divide the pancreas into lobes and lobules (Figure 3, b1 and b2). Additionally, in the third trimester of gestation, interlobular ducts are embedded within the trabecular connective tissue (Figure 3, b3 and b4). As the foetal stage increased, the thickness of the capsule,

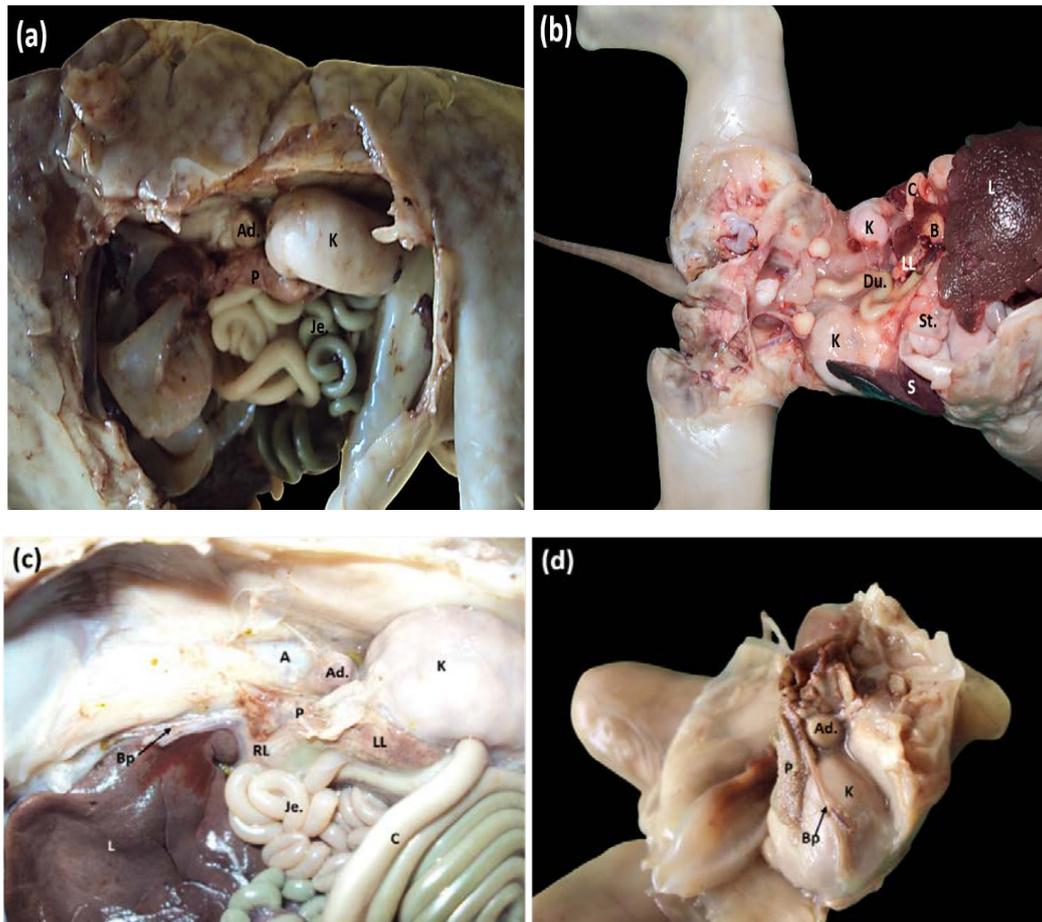
trabeculae and connective tissue net also increased. The blood supply passes through the pancreatic trabeculae (Figure 3, b3).

#### ***Parenchyma***

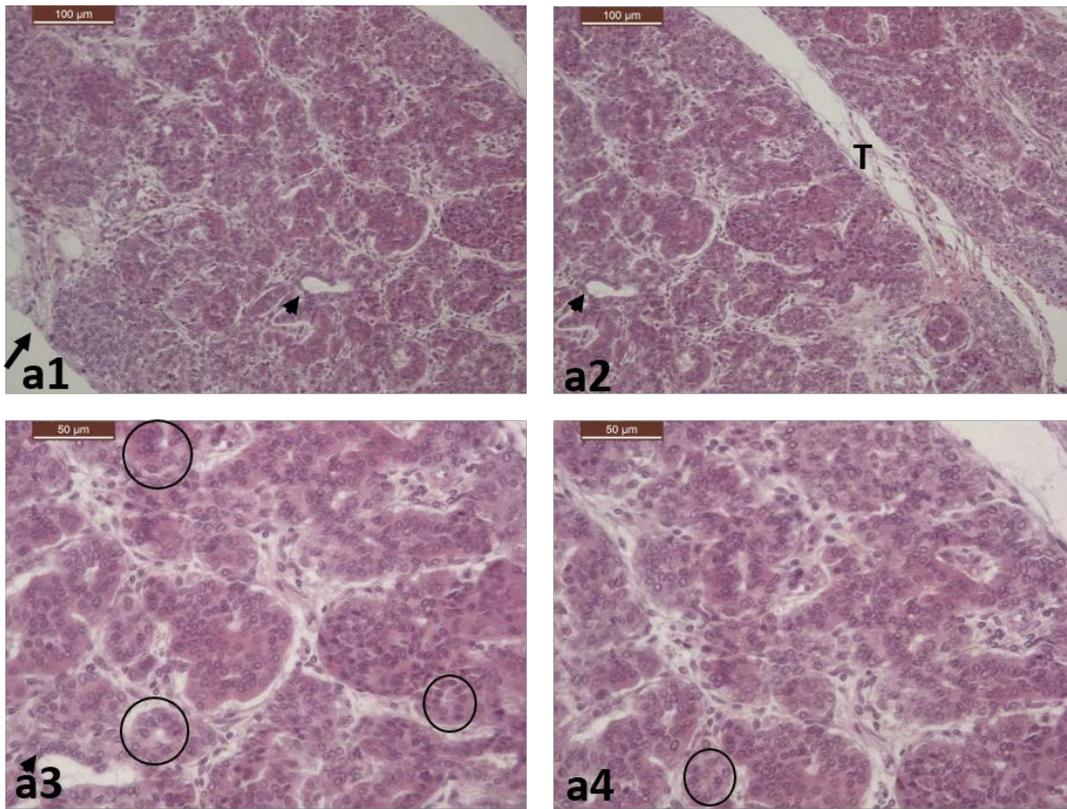
The exocrine portion of the pancreas consists of tubulo-acinar secretory units. These units were made of a single row of semi-pyramidal epithelial cells surrounding a central small lumen (Figure 2, a3). The nuclei were usually located near the base of the cell, although some of them were centrally located. The nuclei were oval and elongated in shape (Figure 3, b5). The connective tissue surrounded the acini.

The duct system consisted of the intralobular ducts. These ducts were lined by simple cuboidal epithelium (Figure 2, a1, a2 and a3). Interlobular ducts were located between the lobules in the connective tissue septa. They were lined by stratified cuboidal epithelium (Figure 3, b3 and b4).

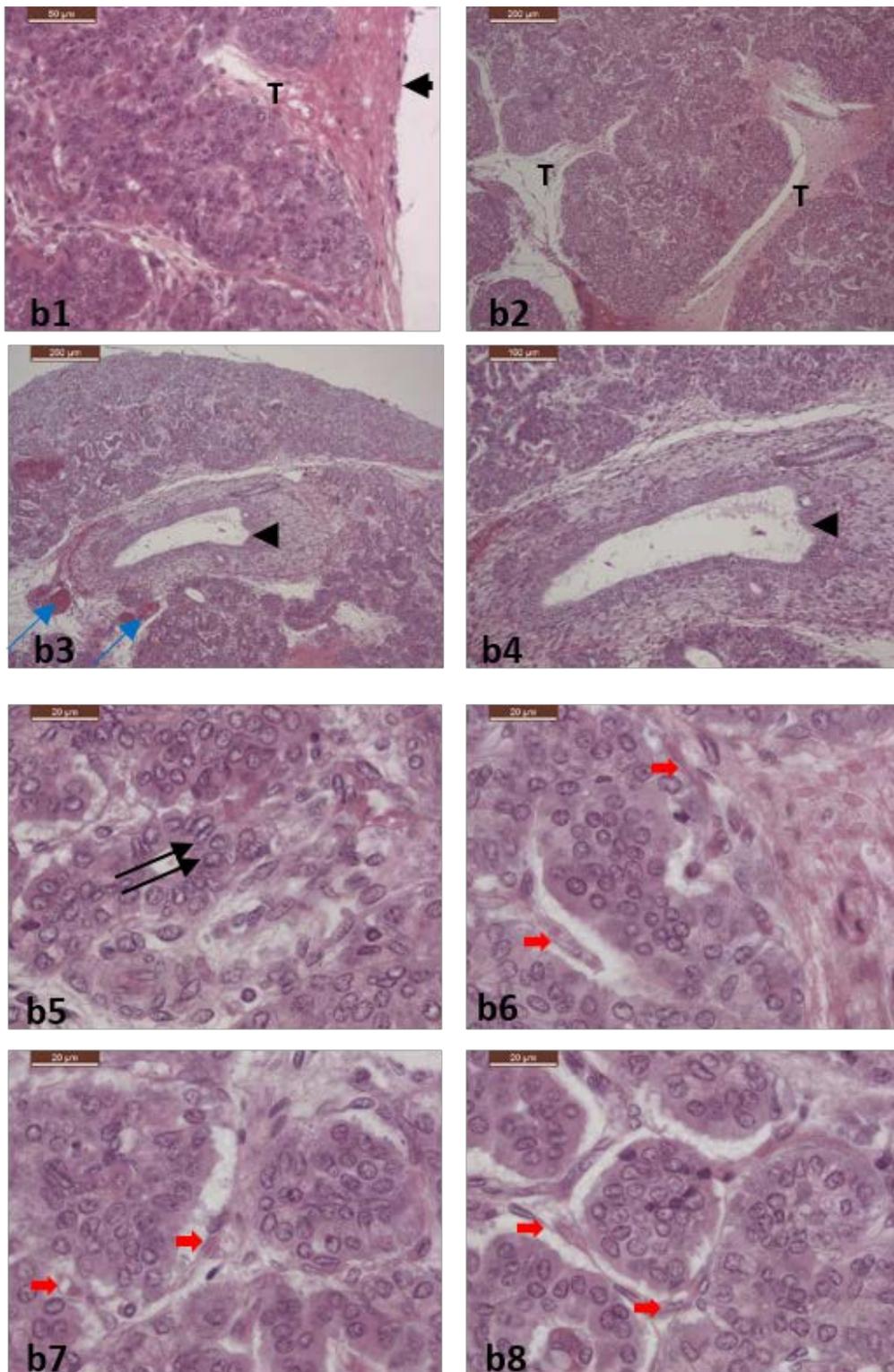
The endocrine portion, which was represented by the pancreatic islets (Islets of Langerhans), appeared as accumulations of different shapes of nuclei among the acini. The shape of islets varied from oval, rounded or irregular surrounded by a thin layer of connective tissue. The pancreas was rich in blood capillaries, especially surrounding the pancreatic islets (Figure 3, b6, b7 and b8).



**Figure 1:** (a): Dissected camel foetus of 24 cm CVRL (131 day of gestation) the pancreas (P) is related to the metanephric kidney (K), Adrenal gland (Ad) and jejunum (Je). (b): The dissection of a camel foetus 26 cm CVRL (136 days of gestation) the body of the pancreas (B) and the left lobe (LL) are related to the colon (C), liver (L) kidney (K), Duodenum (Du), stomach (St). Spleen (S). (c): The dissection of a camel foetus 55 cm CVRL (215 days of gestation): the body of the pancreas (P), left lobe (LL) and right lobe (RL) are related to the abdominal aorta (A), Adrenal gland (Ad), pancreaticoduodenal branch of the portal vein (Bp), colon (C), jejunum (Je), liver (L) and metanephros kidney (K). (d): The dissection of a camel foetus 66 cm CVRL (246 days of gestation): the pancreas (P) has clear lobulations, it is related to the adrenal gland (Ad), pancreaticoduodenal branch of the portal vein (Bp) and kidney (K).



**Figure 2:** a: photomicrographs of the histological features of the pancreas of the camel foetus during the second trimester of gestation (1, 2, 3 and 4) the pancreas has thin connective tissue capsule (arrow), connective tissue trabeculae (T), intralobular duct (arrowhead); tubulo-acinar secretory units consist of central narrow lumen (circle). (Hematoxylin and Eosin): (a1 and a2; X20); (a3 and a4 X40).



**Figure 3: b:** photomicrographs of the histological features of the pancreas of the camel foetus during the third trimester of gestation (1, 2, 3, 4, 5, 6, 7 and 8) the pancreas has thick connective tissue capsule (arrow) and thick connective tissue trabeculae (T), oval and elongated nuclei (double arrows), interlobular duct (arrowhead), blood supply: (blue arrows), blood capillaries (red arrows). (Hematoxylin and Eosin): (b1: X40); (b2: X10); (b3: X10); (b4: X20); (b5, b6, b7, b8: X100).

## Discussion

The current gross anatomical results revealed the pancreas of the camel foetus during the second trimester of gestation was grayish to pink in color. This observation agrees with Mohammed (2019) in the foetus of camel. According to Dyce *et al.*, (1987) the pancreas of the cow is a pinkish yellow in color, this disagrees with the current investigation.

According to the current study, the pancreaticoduodenal vein (branch of the portal vein) was well developed during the second trimester of gestation. The pancreaticoduodenal vein passes closer to the pancreas, which disagreed with the previous findings in horse (Dyce *et al.*, 1987). The pancreas in horse has a rounded opening for the passage of the portal vein closer to the caudal border. The ventral surface is directly bound to the right dorsal colon and the base of the cecum, the dorsal surface to the right kidney and the liver (Dyce *et al.*, 1987). Further gross anatomical and histological investigations are needed to identify the development of the pancreas of camel foetus and its relationship to the development of the portal and umbilical blood vessels.

Topographically, the current study showed that the pancreas of the camel foetus was lobulated. This is similar to the pancreas of the dogs, monkeys, and mini pigs (Tsuchitani *et al.*, 2016); the pancreas of the cow is irregular, soft and lobulated (Dyce *et al.*, 1987). The present investigation showed the pancreas of the camel foetus at the second trimester of pregnancy was situated at the level of the first five lumbar vertebrae. This is similar to the findings mentioned by Mohammed, (2019) in the camel foetus and Mustafa *et al.*, (1983) and Masaad, (2007) in the adult camel.

According to the present study, there were topographical relationships of the pancreas of the camel foetus in the second trimester with the stomach, duodenum, visceral surface of the liver, kidney, and large intestine. These findings agree with the observations of Bradley (1959) in dogs, Nickel *et al.*, (1973) in ruminants, Sisson *et al.*, (1976) in horses, and Mustafa *et al.*, (1983); Smuts and Bezuidenhout, (1987); Taha and Abdel-Magied (1998); Masaad (2007) in adult camels and Mohammed (2019) in the camel foetus.

Many authors (Mustafa *et al.*, 1983; Smuts and Benzuidenhout, 1987; Taha and Abdel-Magied, 1998; Abdel-Moneim, 1998; Masaad, 2007) have studied the pancreas in the adult camel. The pancreas of the camel consists of a narrow body and left and right lobes. The left lobe is larger and longer than the right lobe. At the ventral surface of the body, the pancreatic notch occurs, which is occupied by the portal vein (Mustafa *et al.*, 1983; Sumts and Benzuidenhout, 1987). The present study showed that the pancreas of the camel foetus during the second trimester of gestation, consisting of a body, a left lobe and a right lobe. The left lobe was longer than the right lobe. This observation was like what was described by Mohammed, (2019) in the foetus of camel. Also, same findings were observed in horse and donkey (Nickel *et al.*, 1973; Sisson, *et al.*, 1976; Masaad, 2007).

The current investigation showed that the pancreas in the second and third trimesters of gestation has thin connective tissue capsule, this agrees with the (Bloom and Fawcett, (1986); Eurell and Frappier, (2006); Gartner and James, (2007); Mescher, (2018) in respect to the pancreas capsule in other species. In addition, this study showed that the pancreas had exocrine and endocrine parts; the exocrine

pancreas was lobulated and clearly a tubulo-acinar gland.

The current study showed that the acinar cells of the second and third trimesters of gestation had spherical and central or oval nuclei near the base of the cells. This is like the observation of Dhoolappa *et al.* (2004) in the Indian donkey and Masaad, (2007) in the Sudanese donkey and Mohammed, (2019) in the camel foetus. In this research, the intralobular duct was lined by simple cuboidal cells this observation like that described by Mohammed, (2019) as low cuboidal cells. However, Gemmel and Heath, (1973) found that the intralobular duct was lined by simple columnar cells in sheep. In the present study, the interlobular duct was lined by stratified cuboidal cells in the second and third trimesters of gestation like the findings stated by Mohammed, (2019) in the camel foetus.

The present investigation showed that the shape of the pancreatic islets varied from oval, rounded or irregular surrounded by a thin layer of connective tissue. This observation agrees with Steiner *et al.*, (2010) in the marsupials and some nonhuman primates; Hafez *et al.*; (2015) in the camel, horse, and cow; Mahesh *et al.*, (2017) in the Deccani sheep and Bidri goat; Abdellatif, (2020) in the camel. However, disagrees with Khatim *et al.*, (1985) who stated that the endocrine gland of one humped camel dispersed into islets of the same sizes and cellular components.

The pancreatic islets display various patterns of endocrine cell arrangements (Steiner *et al.*, (2010) in the marsupials and some nonhuman primates; Heller, 2010 reviewed this in the invertebrates to the higher mammals; Hafez *et al.*; (2015) in the camel, horse and cow, this statement agrees with the current study.

According to Mahesh *et al.*, (2017), the distribution of the sheep and goat pancreatic islets inside the exocrine region

of the gland was unequal. According to their size, the islets were divided into small, medium, and large. They were oval, circular, or irregular in shape. The present study agrees with previous studies (AL-Ani, 1987 and Zghair, 2016) in the adult camel and Mohammed, 2019) in the camel foetus.

The results obtained in the present study agree with Ali, (2023) who studied the development of the endocrine part of the pancreas in dromedary camel foetus. This result revealed that during the second trimester of gestation, the endocrine cells were numerous, distributed singly, in cords or clusters throughout the acini. At the third trimester of gestation, most of the endocrine cells were localized in the pancreatic islets (Ali, 2023).

## Conclusion

This study concluded that the first five lumbar vertebrae are where the pancreas of the camel foetus develops at the second trimester of pregnancy. The pancreas consists of a body and two lobes: a right and a left. The right lobe of the pancreas is shorter than the left lobe. The secretory units of the pancreas were tubulo-acinar. The pancreatic islet appeared as an oval, rounded or irregular accumulation of endocrine cells surrounded by a thin layer of connective tissue and blood capillaries. It was concluded that the pancreas of the camel foetus had well developmental features in the second and third trimesters of gestation, like that of adult camels.

## Conflict of Interest

There is no conflict of interest between the authors.

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