

Article

Mature camels (*Camelus dromedary*) with one hump, described anatomically, histologically, and chimerically in southern Iraq

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<http://dx.doi.org/10.21931/RB/CSS/2023.08.03.1>

Abstract

The rumen is the first chamber of the stomach in adult one-humped camels (*Camelus dromedaries*). Twelve samples were studied; an anatomical study showed that the rumen consists of three areas: a smooth upper and two sacs on the side between them, a muscular groove that divides the rumen into two halves, it is connected from the dorsal side to the esophagus, while the ventral side is connected to the reticulum. The inner surface revealed simple zigzag folds from filling and emptying the food. The two sacs contain a sphincter divided into primary mucous columns that arise from the transverse groove and extend from these two columns to another secondary column consisting of chambers or caves. Histologically, two types of epithelium make up the stomach tissue. The first type is the stratified squamous epithelial tissue that lines the dorsal surface of the rumen without dorsal bags; the other type is a simple columnar epithelium lining each of the glandular sacs. The lamella propria appeared as dense connective tissue in areas lined with stratified keratinized squamous epithelium and loose connective tissue in areas lined with simple columnar epithelium. The study also found two types of tubular glands, small and large, in each glandular sac. The tunica muscularis appears in the form of two layers, the transverse and the longitudinal muscle layer; the last layer of the serous layer consists of loose connective tissue. It contains blood vessels and blastocysts, a fibrous layer surrounded by superficial squamous tissue. Histochemistry: Routine H&E staining was used to study histological layers, as well as Mason's stain to detect collagen fibers, and PAS stain for the detection of carbohydrates and mucin in the tissue.

Keywords: rumen; glandular; camel.

Introduction

Camels are one of the most important animals that help people in desert areas, so they take care of them more than other animals, as they accompany them on their travels, carry heavy loads, and travel long distances, as they are animals that endure thirst and hunger. The other, where (1) stated that the rumen wall contains a large number of secretory cells, and he did not specify their function precisely, except because he believed that the glandular part had something to do with the balance of water and salts in the body during the period of thirst, Ruminants' stomachs have four compartments, while camelids' stomachs have three (2). The rumen, divided into many sacs, is the biggest of the four parts. Depending on the

animal's size, it can carry up to 25 gallons of material. Due to its size, the rumen serves as a depository or stocks vat for feedstuffs. It also serves as the primary fermentation vessel. (3) Rumen bacteria digest simple and complex carbohydrates (fiber) and convert them to volatile fatty acids (4). Camels are modified ruminants, sometimes known as "pseudo ruminants. They use foregut fermentation to break down cellulose in fibrous plant species, like ruminants (5).

Materials and Methods

eleven samples were taken from the adult male rumen in the camel's stomach. Their ages ranged from 5 to 10 years. Samples were obtained from the Basrah governorate's modern Zubair slaughterhouse, where samples were taken immediately following slaughter where anatomical measurements and weights were taken. Then, samples were cut with an area of approximately (1.5 x 1.5) cm for each part for histological examination. Next, the samples received the following treatment: Fixation, washing, and decantation, during which the samples were thoroughly cleaned with distilled water and running water before being immersed in formalin at a rate of 10% for 24 hours. ⁶ and ⁷. 2-xylan in two stages for two hours for each stage and then poured into pure paraffin molds and left for 24 hours to harden to cut after that by using a tissue cutting device in a purchase order with a thickness of 5 micrometers and then smeared with the following dyes 1- Hematoxylin and eosin staining to for explain all histological structure, which was prepared according to ⁶ and ⁸, Periodic Acid Schiff (PAS) was prepared according to ⁹, ¹⁰, Mason Trichrome dye, which was prepared according to ¹¹ and ¹².

Results

Anatomical results

The study was designed to show the stomach's appearance, size, shape, and natural position in adult camels in southern Iraq. Where it was observed through this study that the stomach in camels is large and white and located in the abdominal cavity. The rumen is the largest and most comprehensive part of the three-compartment of the stomach; round in shape, it occupies the largest area of the abdominal cavity, extending anteriorly to the diaphragm and caudally to the pelvis inlet at the level of the seventh rib to the twelfth rib show fig 1, Average length of rumen about (57.32± 0.63)cm as in Table (1) as it was empty.

The longitudinal muscular groove was observed arising from the cardiac orifice that connects the esophagus to the stomach and ends at the beginning of the posterior part of the abomasum, passing through the reticulum and the anterior tubular part of the abomasum, from which columns of which the dorsal and ventral sacs are formed arise. Figure 2,4,

As was observed in this study, the camel rumen contains spaced folds of varying sizes and directions. These folds were formed due to expansion and contraction, the volume of food intake, and during digestion shown in Fig 3). It was also noted that the diameter of the esophagus-ruminal opening (3.06 + _ 0.10) is in Table 2.

It was also noted that the cranial part of the stomach is divided from the inside by a vertical fold of muscle with a thick wall that contains small square papillae, which divide the rumen into two tiny dorso-posterior sacs, which are located on the right side. In contrast, the Dorso cranial sac is relatively large and occupies most of the volume of the rumen, as shown in Figure (2). Also, the internal structure of the dorso-posterior sac appeared, consisting of an average of (8) sporangial columns. These columns appear in the form of longitudinally arranged muscular bundles,

where a secondary transverse fold can be observed between every two longitudinal folds, between which a square area resembling rooms is confined Fig. 4.

As for the other sac, the anterior abdominal sac, it was noted that it is the largest and the longest, but it does not differ anatomically from the dorsal sac except in the location and number of columns, where the rate of The columns are 15 columns, as it was noted that the rooms between the columns are more profound.

Age of camels (years)	Length	Width
(5-7)	57.38±0.63	23.88±0.53
(7-10)	68 .01± 0.1	31.28± 0.52

Table 1: Anatomical morphometric measurements of the rumen.

Age of camels (years)	Diameters
(5-7)	3.06 ±0.10
(7-10)	4.38±0.22

*Different litters in the same column is a mean significant difference $p < 0.05$

Table 2: Anatomical morphometric measurements of esophageal-ruminal opening.



(a)



(b)

Figure 1: (a) shows an internal side of the abdomen showing (1) – rumen,(2) –abomasum, (3) – reticulum, (4)- colon, (5)- spleen (b) external view of the stomach in camels show: (1) dorsal sac, (2) glandular sac Dorso cranial sacs, (3)- glandular sac dorso- posterior sac, (4) reticulum,(5) isthmus, (6) abomasum (tubular part), (7) esophagus groove.



Figure 2: (a) internal view of the non-glandular sac of the rumen shows some fold formed by fullness and emptying of the rumen and shows the absence of papillae, (b) internal view of camel rumen shows: (1) _ esophagus groove, (2) – dorsocaudal sac, (3)- pillars, (4)- isthmus, (5)- vertical fold.

Histological results

The histological study of the camel rumen showed that it consists of four layers that start from the inside towards the outside: mucosa, submucosa, muscular, and serosa. It was observed through the histological examination of the present study that the rumen in camels contains an upper region, which is an extension of the esophagus, where it was noted that it is similar to the last part of the esophagus, which was formed by the mucosa with a stratified squamous keratinized epithelium and lamina properties of connective tissue permeated with blood vessels of various diameter and some fibers like collagen appear blue colored by Masson tydicrom staining and colloidal fiber.

The muscular layer of the mucosa consists of simple bundles of smooth muscles. It was observed that the sub-mucosa layer contains glands, which are an extension of the esophageal glands, in addition to the presence of connective tissue, colloidal and collagenous fibers interspersed with some lymphocytes, fibroblast, and fat cells. The layer called muscularis is composed of thick bundles of smooth muscle fibers arranged in two layers, the inner circular and the outer longitudinal interspersed with connective tissue; it was noted that the last layer, the tunica serous, consists of loose connective tissue and some blood vessels, fat cells and lymphocytes surrounded by a thin layer of simple squamous epithelium surround all of them show fig 5, The body region in the rumen of camels that presence four layers. The mucosa consists of three layers of epithelial: the present study shows that the epithelial layer is a stratified squamous keratinized where it has been observed that the surface layer consists of keratinized; the show next layer, called lamina properea, was found just below the epithelium and appeared in the form of bundles Colloidal and collagenous fibers are held together, and they contain branches of blood vessels and small lymphocytes with them. The muscularis mucosa, located below the lamina proper, consists of scattered smooth muscle fibers intertwined with the submucosal tunica. It was also noted that some cells, such as fibroblast and lymphocytes, were characterized by their small size and interspersed with blood vessels and a meissenrs nervous plexus.

The submucosa is the second layer and is located under the tunica mucous, where it consists of connective tissue, colloidal and collagenous fibers, which appear in dark blue when stained with Mason Trichrome dye. The presence of fibroblast and blood vessels of different diameters and some fat cells in a small percentage were

also observed, and no glands were observed in the submucosal area of the rumen, which is considered a non-glandular region. The third layer is the muscularis. This layer is located below the submucosa. The presence of two layers of muscle fibers, where it was observed that the inner layer is arranged circularly and the outer layer is longitudinal, permeating these two layers of connective tissue consisting of colloidal and collagenous fibers, as well as the presence of blood vessels, lymphocytes, fat cells, and fibroblasts, as well as the presence of the Auerbach's nerve plexus. Sometimes, it can be distinguished as a transverse muscle layer, but it may not last.

The last layer is serosa: It was observed that the outer layer is composed of loose connective tissue and that it contains some elastic and colloidal fibers of opposite directions and contains blood vessels and is characterized by the presence of one outer layer consisting of simple squamous epithelium surrounding this. The layer from the outside shows figure 8.

The present study shows that the stomach in adult camels consists of two different regions in the epithelial layer, where they are classified as glandular and non-glandular regions, the dorsal and posterior sacs, and the anterior ventral sac, where a keratinized layer appears consisting of compact cells devoid of nuclei or other structures.

A- The non-glandular region consists of the stratified squamous epithelium; the presence of this epithelium was noted in the columns and a large part of the small chamber; below the keratinized layer are rows of compact, undifferentiated squamous cells. The base layer of the cell contains dark round nuclei, and the rest of their components are light-colored.

The lamina propria appears composed of dense connective tissue with bundles of colloidal fibers and papillae extending toward the submucosa. In this layer, blood vessels, spindle-shaped fibroblast cells with circular nuclei, and lymphocytes were also observed, as shown in Figure 8.

B-glandular region: This area was observed in the small chambers at the bottom of the two sacs in the camels, where it was noted that it contains one layer of simple columnar cells and that it gives a light color and spherical nuclei at the base of a dark color as shown in Figure 6 where it gave a positive interaction with the detector (PAS) it indicates the presence of two types of mucus glands.

The present study also shows that the lamina is very similar to the glandular region, except that it contains two types of glands of different size, either large oval in shape or spherical formed through the alignment of columnar cells with dark nuclei, as their location is close to the basement membrane. The other type of glands was distinguished by their small size, they were spherical in shape, characterized by their cube-shaped cells, interconnected with each other, and their dark oval nuclei located at the base (fig 7). These glands gave a clear differentiation when staining with (PAS) reagent as well as the presence of collagen fibers, which were colored dark blue when staining with Masson Trichrome. It was also observed that there is a thick, narrow part in the middle of the rumen that divides it into two parts called esophageal groove. Where it was histologically studied during the current study and it was found that it consists of a mucous with stratified squamous keratinized epithelium (fig 10) and a lamina propria similar to the other parts of the rumen. Moreover, it does not have any glands in this region; the tunica muscularis contains many thick bundles of smooth muscle, as the inner bundles are circular with multiple layers, and the outer is longitudinal but thicker than the other parts of the rumen, as in figure 9. It also gives a positive interaction with the (PAS)

detector when used to detect about mucus gland. Collagen fibers appear when stained with Mason Trichrome in dark blue and muscle bundles in dark purple.

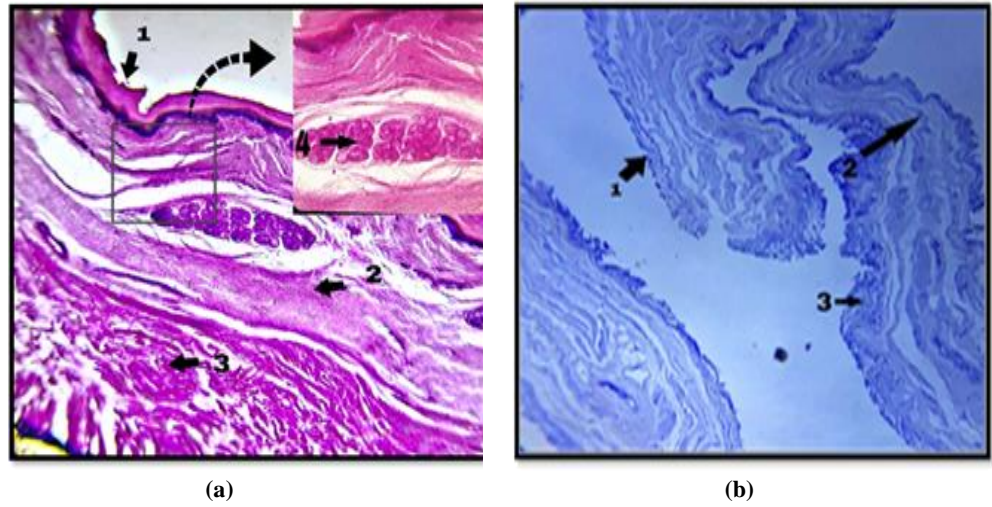


Figure 3: (a) Cross section of cardiac part of rumen junction with esophagus show (A) mucosa, (1) submucosa, (2) muscular (3),(4) esophageal gland (H&E stain 40x). (B)stratified squamous keratinized epithelium ((H&E stain 400x). (C) esophageal gland within submucosa (H&E stain 400x) (b) the cross-section in the glandular region in a ventral sac in the rumen of adult camels' stomachs shows (1) simple columnar epithelium, (2) muscularis mucosa, (3) lamina propria with gland (PAS staining 40x).

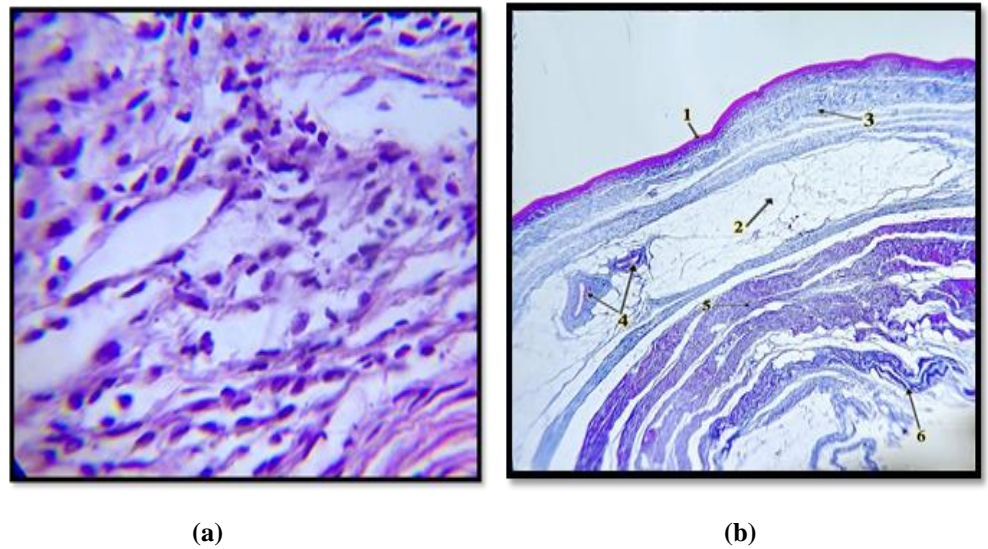


Figure 4: (a) cross-section of the mucosa of the glandular region of the dorsal sac shows (1) a small gland,(2) a large gland, (3)muscularis mucosa (PAS x400), (b) a cross-section of a non-glandular region of rumen body show, show (1) epithelium (stratified squamous keratinized),(2)fat tissue,(3)lamina propria,(4)blood vessel,(5)muscularis,(6)serosa, (mason Trichrome x40).

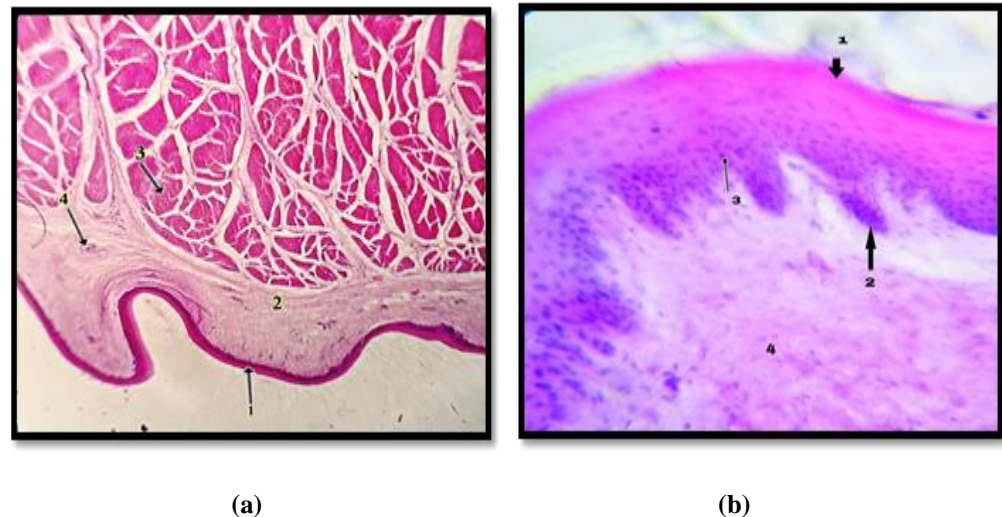


Figure 5: (a) cross-section of esophagus groove in rumen of camels show (1) stratified squamous keratinized epithelium, (2) submucosa, (3) muscularis, (4) (H&E x40), (b) show epithelium layer in the esophagus groove (1) keratinized layer, (2) small papillae, (3) stratified squamous epithelium, (4) lamina properia, (H&E x400).

Discussion

Anatomically :- Through the current study of the rumen in camel of one- hump in south of Iraq, it was found that it differs fundamentally in shape, size and composition from the stomach in other ruminants, during our study, we found that the rumen in the camel with one- hump anatomically composed of three clear areas that can be distinguished visually because of the presence of clear border between each area and the other divided from the middle by a muscular esophageus groove and this corresponds to what was described in the description of the rumen in the research of each of ¹³, ¹⁵, ¹⁴, where we found that the rumen extends from the diaphragm towards the back to the entrance in the pelvis, due to the growth of the rumen in the embryonic stages, and this is consistent with the description of the researcher ¹⁶, ¹⁷, we also noticed that the first chamber contains a smooth surface from the outside, showing the effect of a transverse sloping gutter, dividing the chamber into three sections, the first being dorsal, which is the largest, and two lateral ones, one of them on the right side and the other on the abdominal side, and this is consistent with the description of researchers ¹⁴, ¹⁸. However, researcher ¹⁷ considers these bags separated parts of the rumen; some also considered the second chamber to be part of the rumen, as he described the rumen with three sacs, as he did not notice the sphincter and the clear articulation between the abdominal sac and the second chamber (reticulum) while describing ¹⁶ In his research on European camels with two-humped, he describes the rumen contains two ventricles, the first ventricle, which is divided by a muscular groove into two parts, caudal and cranial, where the second chamber is called the second ventricle of the rumen. Moreover, this is in contrast to what we found in our study, that the rumen contains only two sacs separated from each other by the esophagus groove, and the other is the second chamber from the camel's stomach. Our study of the camel stomach from the outside found that it is smooth and soft when full, but after emptying its contents, zigzag folds appear on its surface, different in length, size and height. This is consistent with the researchers' findings ¹⁹, ¹³ and ¹⁴. A significant difference was also observed in the camel's rumen from other ruminants' inner surfaces. Where. The researcher ²⁰ found that the rumen of a buffalo contains small dark-colored papillae, and this contradicts our current study on camels in southern Iraq, where the presence of these papillae was not observed. It was also

observed that the esophageal groove passed from the esophageal opening to the third chamber through the second chamber, and this corresponds to what was reached by researchers^{13,14}, also, a difference was observed in the lengths and weights of camels in the southern of Iraq for the rumen may be due to feeding on types of thorns, weeds and herbs in that area where it was found the length of the rumen (57.32 ± 0.63) cm, (68.01 ± 0.1) cm, and width (23.88 ± 0.53) cm, (31.28 ± 0.52) cm, while its weights were recorded after emptying its contents (4.35 ± 0.13) kg, (5.61 ± 0.15) kg and differs from what the researchers¹⁶ in his search for European camels with two humps, and¹⁴ for one-humped camels in Sudan histologically : In our study of the one-humped camel rumen showed that it consisted of fourth layer histologically, In present study show the rumen consist of four different areas , where they were found to be under two types of epithelium, where the first was described as stratified squamous keratinized epithelium layer and the other was simple columnar epithelium, this corresponds to the description of each of the researchers²¹ in his study on camel fetuses with one hump, he took four groups of different ages, where he showed through the fourth group, whose ages range between 170-390 days, that they contain simple columnar epithelial tissue in glandular region and this corresponds to our aforementioned study and¹³, in his study on comparative between adult camels and his fetus that show the rumen of adult camels contain two region glandular and non-glandular , the lamina propria in the current results showed that containing dense connective tissue and many capillaries was observed. The presence of some papillae originating from the base of the epithelium in a direction is consistent with the description of both. It was also seen during this study that the upper region of the rumen was called the esophageal region, because it was found similar to the lower region of the esophagus in terms of epithelium with the presence of the esophageal glands, this is agreement with the findings of¹⁷, and¹³, on other hand the present results found two different regions in type of epithelium, the first was called the non- glandular region, where it was lined with keratinized squamous epithelium, and the other was called the glandular region due to the presence of glands in one^{22, 23}, the muscularis mucosa also appeared in the form of thin, scattered and smooth bundles, which the researchers had previously referred to, and this was not mentioned in²⁴, histological examination of the glandular region also confirmed that it is largely lined by simple columnar tissue, while the non-glandular are lined with stratified squamous epithelium containing lamina propria based connective tissue with collagen and colloidal fibers , as for the glandular region, it lines the cyst chambers especially the center of the cyst, it is lined with a simple columnar epithelium and is based on an lamina propria that has many glands under which thin layer of smooth muscle fibers, and this is consistent with the description of¹³ as I share with¹⁷, where he prepared this area as an area false glands, because it contain on the tubular glands¹⁷ also demonstrated that the dorsal surface of the cysts shows an average response to (PAS) reagent, ¹⁹ reported that these glands contain many types of cells, which are different in sizes and their type, surface mucus cell , epithelium cell and , which are positive for (PAS) reagent , adding that these glands are serous glands, and this is in contrast to what was reached in this study, where he found two types of glands, which are simple and different in the type, shape, and appearance of an average positivity for (PAS) reagent, which indicates that it is mucous glands, and these study are identical with the research of each of^{13, 24}, it was also found in previous studies that the non-glandular region in camels differs from the non-glandular region in ruminants, where the researcher²⁰ in his study of stomach of the adult local buffalo mentioned that the non-glandular region

in buffalo contains keratinized epithelium, but it lacks the glandular region, and this confirms the great difference in the stomach of the camel and the stomach of other ruminants, the present study also showed that the simple tubular glands spread on the mucous layer lamina propria, based over the entire muscle. It was also noted that the layer that followed is composed of connective tissue containing collagen fibers, which appeared in blue color when stained with Mason Trichrome dye, where it appeared parallel and overlapping with the muscle layer that lies under it, and this is consistent with what the researchers reached^{13,23}, however,²⁵ that his study in the comparative study of the stomach in the one humped-camel and the domestic goat indicated that the muscular layer of the camel stomach consists of three layers from the inside outward, the inner layer is circular, the middle is oblique, and the outer is longitudinal, and this is in contrast to the results of the current study, which confirmed that the muscular layer. It consists of two layers, an inner and an outer layer. The last serous layer is a loose connective tissue interspersed with blood vessels and collagen fibers, confirmed by researchers¹³. Where the researchers found,^{20, 26} that the non-glandular region forms the largest part of the stomach of ruminants, reaching 77_78% in cattle; when compared with the current study, we find that there is a significant difference in the rumen of ruminants from the rumen of a one-humped camel in southern Iraq. We also noticed a similarity between camels and ruminants in the muscular layer and the mucous and the serous²⁷.

Conclusions

The present study concluded anatomically that the rumen contains a body and two sacs. Histologically, the rumen of adult camels contains four layers: mucosa, submucosa, muscularis, and serosa. The rumen contains two regions (glandular and non-glandular); the glandular region is lined by simple columnar epithelium, and the non-glandular region is lined by stratified squamous keratinized epithelium; the lamina propria in the glandular region contains two types of glands,

Acknowledgments: In this section, you can acknowledge any support not covered by the author's contribution or funding sections. This may include administrative and technical support or donations in kind (e.g., materials used for experiments).

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Received: May 15, 2023/ Accepted: June 10, 2023 / Published: June 15, 2023

Citation: Salan, Z. A.; Ali, S.A.; Sadoon, A.H. Mature camels (*Camelus dromedary*) with one hump, described anatomically, histologically, and chimerically in southern Iraq. *Revis Bionatura* 2023;8 (3) 1. <http://dx.doi.org/10.21931/RB/CSS/2023.08.03.1>