



Special Issue:

Emerging and Re-Emerging Animal Health Challenges in Low and Middle-Income Countries

Ontogenesis of Rectum in Local Awassi Sheep Fetuses (*Ovis aris*) During Prenatal Periods

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Abstract | This study aims to investigate the prenatal stages of the rectum in fetuses of Awassi sheep. For this purpose, samples from thirty male and female sheep were taken from the uterus of healthy females, and the crown rump length formula (CRL) was used to classify the samples into four age groups for the prenatal stage. During the first age (50-55) days of gestation, we observed that the rectum wall was slightly wider from proximal part of large intestine, translucent white color and was composed of four histological tunicae: mucosa, pluripotential blastematic layer (submucosa), muscularis externa and finally serosa where the villi are short in height while. At 70-75 days of examination, the rectum was more developed with advancement of gestation and all histological layer was observed with villi in various lengths. At third trimester of gestation (100-105 days and 130-140) days, the rectal villi disappeared, epithelial goblet cells increased in number and density and rectal glands. Tunica muscularis increased in thickness and the mesenchymal layer transformed to connective tissue layer due to differentiation of the most mesenchyme cells to smooth muscle fiber (muscularis interna and muscularis externa). Taken together, the present study showed that the large intestine in local awassi sheep fetuses in the first trimester of gestation was located relatively in the middle part of the abdominal cavity and covered completely by huge liver and where it started to move gradually to the caudal aspect at second trimester, behind the diaphragms, stomach and liver, which appear are translucent wall and whitish in color. On the other hands, at the third trimester of gestation, the wall of large intestine appears elongated musculo-membranous tube with semi-translucent and with more thickness and different colors from pink to pale-yellow. These findings advanced several aspects of the rectum development and offer several markers to be considered during effective assessment of animal health and production potential.

Keywords | Development, Fetuses, Rectum, Prenatal, Sheep, Villi

Received | July 14, 2024; **Accepted** | September 14, 2024; **Published** | October 30, 2024

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Citation | Niyf AM, Al-Jebori JGA (2024). Ontogenesis of rectum in local Awassi sheep fetuses (*Ovis aris*) during prenatal periods. J. Anim. Health Prod. 12(s1): 45-54.

DOI | <http://dx.doi.org/10.17582/journal.jahp/2024/12.s1.45.54>

ISSN (Online) | 2308-2801



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INTRODUCTION

The intestinal development is related to morphological variations, an increasing manufacture of mucus, and the digestive system is adapted to different nutrients and new immunological microorganisms and nutrition antigens

(Tano et al., 2014). From an embryological perspective, the large intestinal tube develops during the development of the endoderm in sheep, and it shares precursor tissues with the organs of the digestive system. Later, during embryogenesis, it includes tissue from all three layers of the trilaminar embryonic disk's germ cells (Franco et al.,

2017). In general, the mesoderm layer gives rise to the epithelium and associated glands, whereas the ectoderm layer gives rise to the mesenteric layer, connective tissues, smooth muscle, and blood vessels, and the extrinsic and intrinsic innervation.

During the large intestine's growth, dazzling molecular tissue interaction is necessary to maintain structural and functional conformism (Kostouros et al., 2020). Early in the embryonic development of ruminants, the cloaca, the chamber that connects the digestive, urinary, and genital systems, is where the hindgut tube ends. It continues in adult reptiles, birds, and amphibians, but in ruminants, it reflects a temporary structural organ. It ends when the urorectal septum (mesenchyme partition) divides the cloaca into the dorsal cavity, which is endless from the end of the hindgut to the creation of the rectum at the end of the first trimester of pregnancy. In contrast, the urogenital sinus and ventral cavity are infinitely large. The top portion of the allantois and urogenital sinus give rise to the urethra and bladder of urine (Fletcher and Weber, 2004).

Currently, there are not sufficient studies on the rectum histogenesis in prenatal developmental stages of sheep's fetuses. Therefore, this study attempts to analyze histomorphological description and the timing of first anlage of the components and parts of rectum at prenatal periods.

MATERIALS AND METHODS

EXPERIMENTAL ANIMALS

The purpose of this work was to describe the histomorphological developmental of rectum in prenatal periods of local awassi sheep's fetuses (*Ovis aris*) where experimental samples are gathered from September to November 2024. The study was conducted on sheep fetuses from pregnant ewes that were slaughtered in Najaf's and Babylon abattoirs for prenatal research. The sheep fetuses at prenatal stages distributed into three groups: first, second and third trimester of gestation according to the gestational age which determined depending on the crown rump length (CRL) by using of following formula (Hejazi et al., 2013; Al-Jebori and Salih, 2022).

$$Y = (2.74X + 30.15)$$

SAMPLE COLLECTION AND LIGHT MICROSCOPE TECHNIQUE

The sheep fetus's cecum was preserved in buffered formalin (10%), dried out using a sequence of increasing alcohol concentrations, cleaned in xylene, and then embedded in paraffin wax. Using a rotary microtome, the blocks were sectioned at 5-6 μ m thickness of slice. According

to Al-Khakani et al. (2019) and Al-Janabi et al. (2022), histological sections were stained with trichrome mason's stain, periodic acid schiff (PAS), and Hematoxyline and Eosin (H and E). Olympus light microscope with USB digital camera attached to computer slides and various magnification settings was used to study the sections (Abbas, 2014).

STATISTICAL ANALYSIS

A computerized program (SPSS) version 21 was used to the statistical analysis of data had done by descriptive statistics

RESULTS AND DISCUSSION

OBSERVATION DURING FIRST TRIMESTER OF GESTATION (50-55) DAYS

The body weight of sheep embryos was about 41.6 ± 0.927 grams, gastrointestinal tract weighted about 2.17 ± 0.050 gram and crown rump length were observed to be 10.4 ± 0.509 cm (Table 1 and Figure 1).



Figure 1: Photograph of sheep fetus using vernier caliper to measure the crown rump length to detect the age of fetus.

MORPHOLOGICALLY

The rectum appeared translucent and white in color tube located at the lower portion of the pelvic cavity. The visual diameter of the rectum was slightly larger than the descending part of the colon containing small amounts of feces green in color and consists of a single cavity, and it was not divided into two portions within thin wall and no saccululation was observed.

HISTOLOGICALLY

Rectum would be undergoing development along with the rest of the intestinal tract and the histological structure would be similar to that of other parts of the large intestine and more development including on several layers from inner to outer: mucosa, undifferentiated mesenchymal tissue (pluripotential blastemic tissue), muscularis externa, and tunica serosa or adventitia (Figure 2).

Table 1: Body weight, gastrointestinal tract weights and grown rump length of sheep's embryo in different ages of embryonic life.

Crown rump length (cm)	GIT weight (gram)	Body weight (gram)	Parameter age
10.4±0.509A	2.17±0.050	41.6±0.927 A	50-55 day pregnant
19.6±0.678B	67±1.760	266.6±2.088B	70-75 day pregnant
31±0.707C	98.6±3.31	860.2±5.571C	100-105 day pregnant
42.6±0.927D	208.4±4.69	1361.6±6.046D	135-140 day pregnant

Values represent mean ±S.E Different capital letters mean significant differences (P≤0.05) between different age prenataally.

Table 3: Height of rectal villi in sheep fetuses during prenatal periods (µm).

Long villi hieght	Middle villi hieght	Short villi hieght	Parameter age
-	-	18±06 µm	50-55 day pregnant
178±93 µm	76±0.81 µm	51±0.66	70-75 day pregnant
Disappear	Disappear	Disappear	100-105 day pregnant
Disappear	Disappear	Disappear	130-140 day pregnant

Values represent mean±S.E. Different capital letters mean significant differences (P≤0.05) between different age prenataally.

Table 4: Thickness of rectum wall layers in sheep fetuses during prenatal periods (µm).

Serosa	Tunica muscularis	Submucosa	Mucosa	Parameter age
11.60±0.493A	3.54±0.189A	14.1±0.181A	10.64±0.180A	50-55 day pregnant
27.74±0.224B	25.92±0.615B	12.50±0.158B	14.4±0.156B	70-75 day pregnant
29.24±0.348C	34.60±0.481C	25.72±0.659C	11.52±0.149C	100-105 day pregnant
38.58±0.506D	46.88±0.628D	25.20±0.663C	16.22±0.234D	135-140 day pregnant

Values represent mean ±S.E. Different capital letters mean significant differences (P≤0.05) between different age.

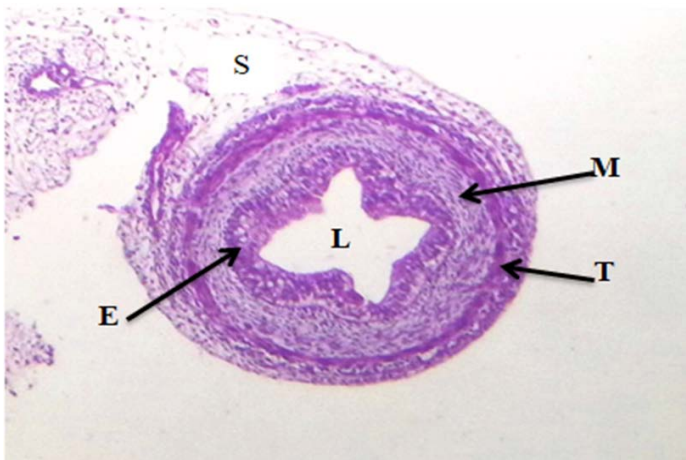


Figure 2: Cross section of rectum at (50-55) days of gestation showing: Epitheliallayer (E), lumen (L), mesenchymallayer (M), tunicamuscularis (T) and serosa (S). (H and E stain, 4X).

The mucosa of the rectum consist of several columnar epithelium cells with different high with distributed of few goblet cell which appeared blue in color with PAS and Alician blue which appear high affinitive with this stain and lumen of rectum star shape like in appearance with premordium of relatively short villi where the thickness of epithelium from the apex of villi to basement membrane about (18±06) µm (Table 3). The thickness of epithelium wall about 10.64±0.180 µm (Table 4) and this may show

a slightly thicker epithelial layer in rectum wall compared to the colon. This may be attributed to the rectum's role in temporary fecal storage and fecal continence. Goblet cells, which secrete mucus, was more abundant in the rectum compared to the other parts of colon (Figure 3).

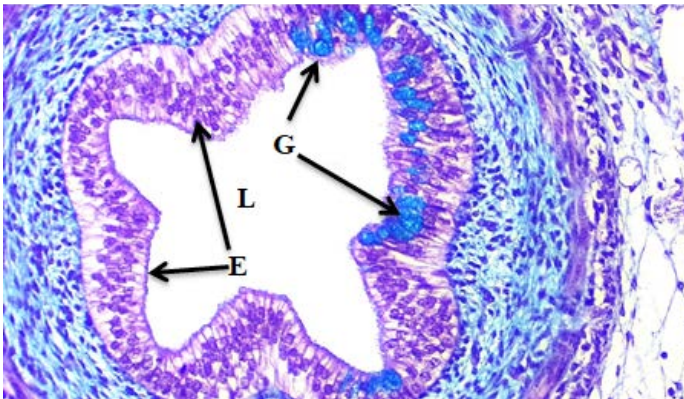


Figure 3: Cross section of rectum at (50-55) days of gestation showing: Epithelial layer (E) stratified columnar cells, Goblet cells (G). (PAS combined Alician blue stain, 10X).

The submucosal layer (also called mesenchymal layer) was measured to be 14.1±0.181 µm in thickness which appear consists of undifferential mesenchymal cell which gives arise to epithelium and muscularis and of contain blood vessels, lymphatics, nerves. This converts gradually to

connective tissue elements (Figure 4). The differences in submucosal thickness of the rectum were minimal at this stage of development.

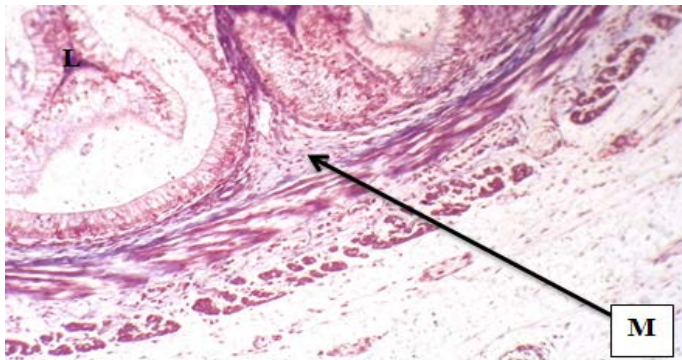


Figure 4: Cross section of rectum at (50-55) days of gestation showing: Undifferentiated mesenchymal layer (M), lumen of rectum (L). (trichrome Masson's stain, 10X).

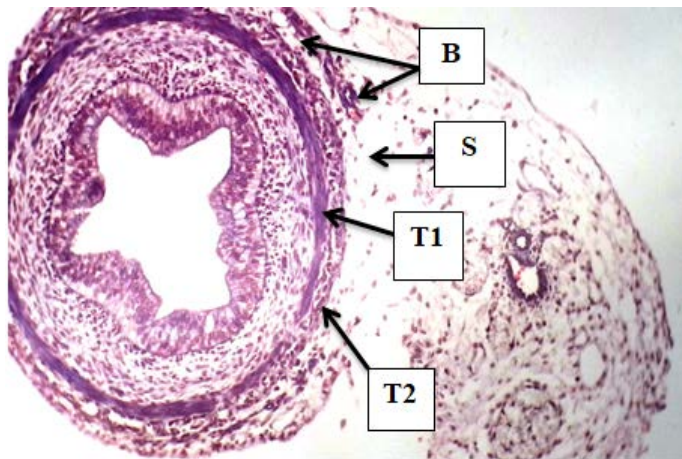


Figure 5: Cross section of rectum at (50-55) days of gestation showing: Inner layer of tunica muscularis (T1), outer layer of tunica muscularis (T2), blood vessels (B). (mason's trichrome stain, 4X).

The muscularis externa of rectum was approximately $13.54 \pm 0.189 \mu\text{m}$ (Table 4) in thickness and consists of premordium of inner circular and outer longitudinal smooth muscle fibers where inner layer was more developed than the other outer layers (Figure 5).

The tunica serosa, the outermost layer of the intestine, provides a protective covering, serosal thickness of rectum was noticed to be about $11.60 \pm 0.493 \mu\text{m}$ (Table 4). There were potentially subtle histological differences between the parts of rectum layers at this stage of fetal development, however, they were not as pronounced as in adult animals. As the fetus continues to develop, regional differences in the structure and function of the intestine may become more evident. The differences between species were due to variation in the gestation period between the different species including ovine 150 days, bovine 280 days, camel 390 days, buffaloes 330 days and human 266 days.

Rectal patch in rectum wall was not developed where few light stained mesenchymal cells which were responsible for meshwork formation around the lymphocytes. Few collagen fibers and blood capillaries were also observed (Figure 4).

OBSERVATIONS AT SECOND TRIMESTER OF GESTATION (70-75) DAYS

The body weight of sheep embryos in current stage (at 70-75 days of gestation) was about $266.6 \pm 2.088 \text{ g}$, gastrointestinal tract weighted about $67 \pm 1.760 \text{ gram}$ (Table 1) and crown rump length was approximately $19.6 \pm 0.678 \text{ cm}$.

MORPHOLOGICAL OBSERVATIONS

Rectum was identified from descending colon and was noticed to be slightly larger in diameter and contain small content of feces. Located in the distal part of pelvic cavity with dark green color, it was different from the previous stage where more medio-caudally to both kidneys were noticed. It continues to descend towards the external opening of the body along with the kidney ureters (Figure 6).

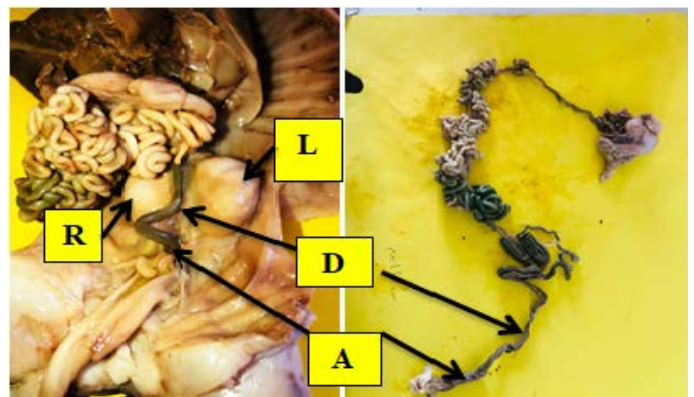


Figure 6: Photograph showing the rectum location in pelvic cavity below the descending colon (D) which extend between left (L) and right (R) kidneys medio-caudally. at 70-75 days of gestation in sheep fetuses.

HISTOLOGICAL OBSERVATIONS

We noticed that the rectal wall at this age was composed of tunica mucosa, tunica submucosa, tunica muscularis and tunica serosa (adventitia) (Figure 7). The tunica mucosa of rectum was approximately $14.4 \pm 0.156 \mu\text{m}$ and was composed of layer of epithelial cells which were simple layer and were columnar in shape with rounded or elongated nuclei slightly located near to the base of epithelial cells. This covered the tips of the intestinal villi and more toward the layer at the base of villi due to these cells undergo to differentiated but still developed. The goblet cells were distributed among the epithelial cells, taking bright blue color by PAS-Alician blue staining and an increase in number of goblet cell along the rectal villi were observed. At their base, from the other parts of large

intestine due to playing critical role by secreted the mucin substance to lubricated the dehydrated feces, constituted a barrier against harmful substance and pathogen (Figure 8).

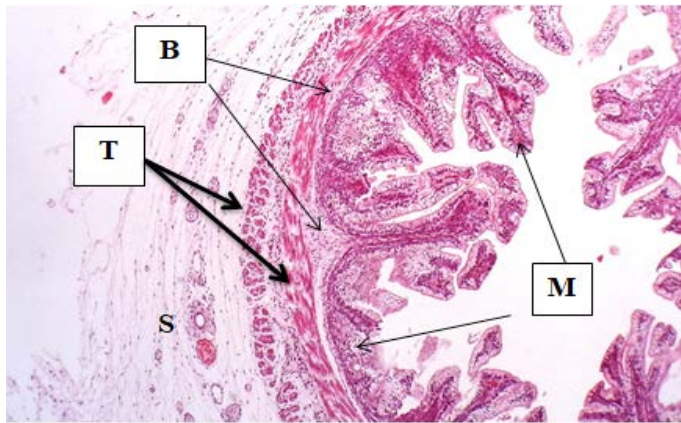


Figure 7: Cross section of rectum at (70-75) days of gestation showing: Tunica mucosa (M), tunica submucosa (B), tunica muscularis (T) and serosa or adventitia (S) (H and E stain, 10X).

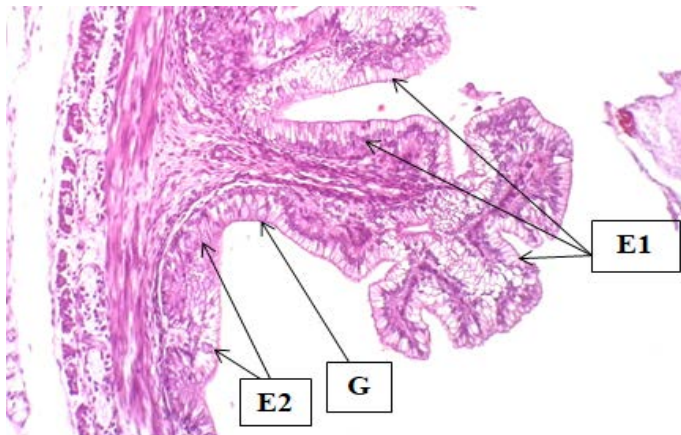


Figure 8: Cross section of rectum at (70-75) days of gestation showing: Simple columnar epithelial cells (E) on the apex of villi, stratified epithelial cells on base of villi (E2) and goblet cells (G). (PAS combined Alician blue stain, 10X).

Rectal villi at this age were different from the rest of the large intestine and can be classified into three type depending on their height: long villi ($178 \pm 93 \mu\text{m}$), middle villi ($76 \pm 0.81 \mu\text{m}$) and short villi ($51 \pm 0.66 \mu\text{m}$) (Table 3). The shape of villi was wider and the long type villi contained side branches, forming short villi on the sides like branched tree. The core of these villi was composed of connective tissue cells and elastic and collagen fiber of lamina propria and measurement of the thickness of this layer with about $4.3 \mu\text{m}$ size. Thin layer of smooth muscle fiber (lamina muscularis) was observed to be about $1.4 \mu\text{m}$ and slight amount of connective tissue substance of tunica submucosa gave arise to the shape of villi as long, wider with several branched on the side of rectal villi (Figure 9).

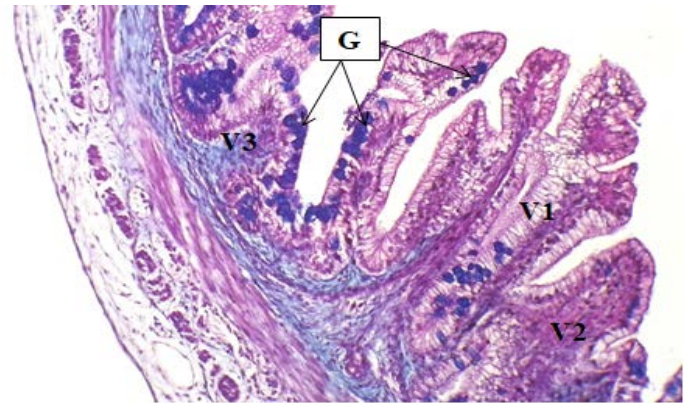


Figure 9: Cross section of rectum at (70-75) days of gestation showing: Rectal villi (V), long villi (V1), middle villi (V2), short villi (V3) and goblet cells (G), (PAS stain, 10X).

Lamina propria and lamina were two layers that were observed at this age of gestation by a thin demarcation line between mucosal and mesenchymal tissue layer (submucosa) (about $14.1 \pm 0.181 \mu\text{m}$) and the cells of the last were more differentiated and taken spindle-shape near to mucosal layer or tunica muscularis to forming smooth muscle fiber (Figure 10).

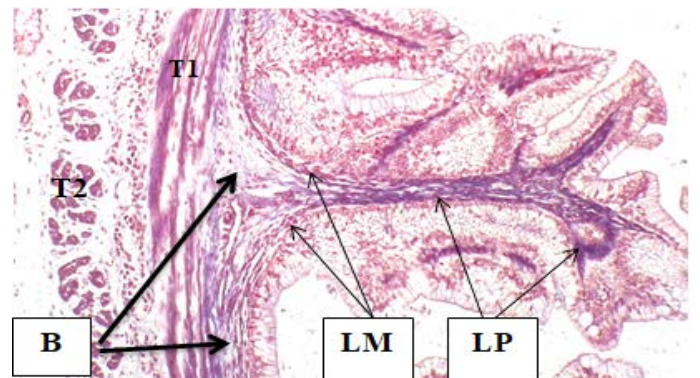


Figure 10: Cross section of rectum at (70-75) days of gestation showing: Lamina propria (LP), lamina muscularis (LM), tunica submucosa, and inner layer (T1), outer layer (T2) of tunica muscularis. (Trichrome massons stain, 10X).

The tunica muscularis of the rectum at this age was clearly distinct because it played an important role in excreting waste. It consisted of two layers, the inner one being circular layer with a thickness of both about $25.92 \pm 0.615 \mu\text{m}$ (Table 4). The outer one being longitudinal layer that appear more developed and growth than other parts of large intestine at same layer where inner circular layer (*Stratum circulare*) of tunica muscularis in rectum compose of developing immature smooth muscle fibers arranged circularly around the rectum not fully distinctly yet but more development than the other layer. The outer longitudinal layer (*Stratum longitudinale*) which appeared at early stages of development and growth composed of mature and immature longitudinal muscle fibers but are

not fully developed. They were arranged longitudinally along the length of the rectum where the differentiation of smooth muscle layers is progressing, marking the initial stages of the development of the tunica muscularis of the rectum in sheep fetuses (Figure 10).

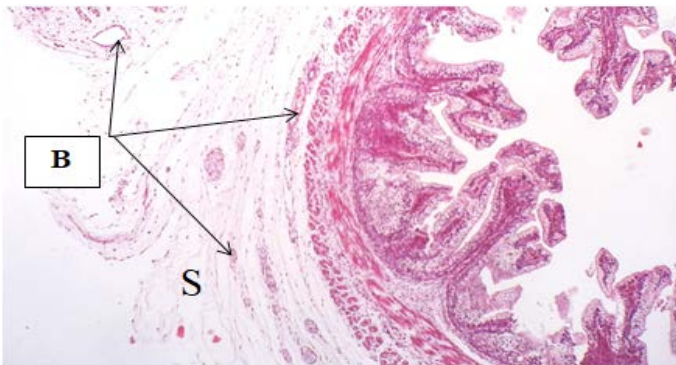


Figure 11: Cross section of rectum at (70-75) days of gestation showing: Tunica serosa (adventitia) (S), blood vessels (B) (H and E satin, 4X).

Tunica serosa (adventitia) consists of irregular connective tissue made of fibroblast cells and some types of fibers such as collagen and elastic, which give elasticity and support to the rectal wall with a clear number of adipose cells, which give more thickness to this layer at this age and the measurement of the thickness of this layer was about $27.74 \pm 0.224 \mu\text{m}$ (Table 4), in addition to the presence of blood and lymphatic vessels (Figure 11).

AT THE STARTING OF THIRD TRIMESTER OF GESTATION (100-105) DAYS

The body weight of sheep embryos in current stage at 100-105 days of gestation was about 860.2 ± 5.571 gram and the weight of gastrointestinal tract was about 98.6 ± 3.31 gram (Table 1) and crown rump was measured to be 31 ± 0.707 cm.

MORPHOLOGICAL CHARACTERISTICS

The rectum was straighter and larger in diameter than the rest of the large intestine. The wall of the rectum was thicker, and it course in the middle of the pelvic cavity, connected to the anal canal, which ends with the external opening of the body (Figure 12).

AT THE ENDING OF THIRD TRIMESTER (130-140) DAYS OF GESTATION

The body weight of sheep embryos in current stage at 135-140 days of gestation was about 1361.6 ± 6.046 -gram, gastrointestinal tract weight was about 208.4 ± 4.69 -gram (Table 1) and crown rump length was about (42.6 ± 0.927 cm).

MORPHOLOGICAL CHARACTERIZATION

At this stage of gestation, rectum in sheep fetuses was

beginning to take shape within the pelvic region. It was located posteriorly to the urinary bladder and anterior to the sacrum and coccyx. The rectum was a part of the lower gastrointestinal tract, connecting the colon to the anus, and it plays a crucial role in the storage and elimination of feces. As it enters the pelvis, the descending colon becomes the rectum which passes caudally as the most dorsal part of the pelvic viscera. Most of the rectum was suspended by the meso-rectum, the retroperitoneal space was full of soft tissue rich in fat.

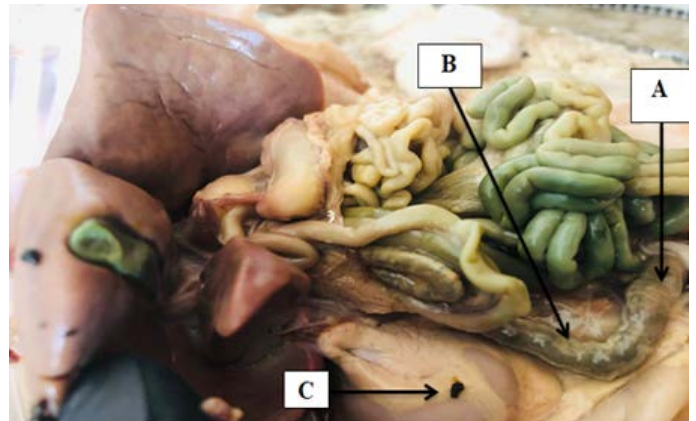


Figure 12: Photograph showing the rectum (A), descending colon (B) and right kidney (C) at 100-105 days of gestation in sheep fetuses.

HISTOLOGICALLY ON 100-105 AND 130-140 DAYS OF GESTATION

The rectal wall consisted of four layers: tunica mucosa, tunica submucosa, tunica muscularis and adventitial layer. Tunica mucosa was clearly observed to be developed with $11.52 \pm 0.149 \mu\text{m}$, and $16.22 \pm 0.234 \mu\text{m}$, respectively. At both ages, it was formed of layer of epithelial cells, lamina propria and mucosa muscularis (Figure 13).

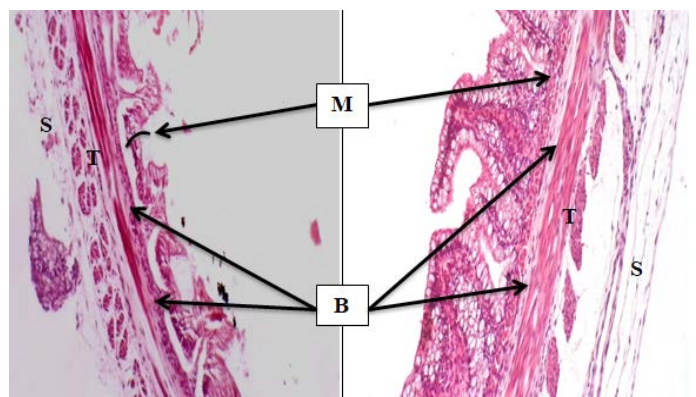


Figure 13: cross section of rectum at (100-105) days (right) and (130-140) days (left) showing: Tunica mucosa (M), tunica submucosa (B), tunica muscularis (T) and tunica serosa (adventitia) (S), (H and E stain, 10X).

The layer of epithelium forming by simple, columnar epithelial cells, the nuclei of these cells be rounded and

located near to the basement membrane with large number of goblet cells distributes among the epithelial layers. This can be detected histologically as being bright blue in colour with PAS-Alician blue staining technique, and its nucleus was close to the base of these cells, leaving a void at its cytoplasmic apexes filled with mucin (Figure 14).

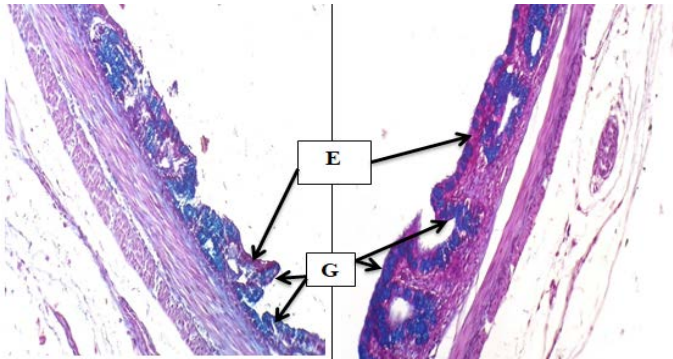


Figure 14: Cross section of rectum at (100-105) days (left) and (130-140) days (right) showing: Simple columnar epithelial cells (E) and goblet cells(G). (PAS combined Alician blue, 10X).

The intestinal (rectal) villi slightly disappeared at this age of gestation due to progressive development of tunica mucosa and as a result of growth of the rectal wall, which led to increased tension of the mucosal layer and the disappearance of the villi.

At the gestational age of 100-105 days of age in sheep fetuses, the lamina propria of the rectum exhibited characteristics typical of early fetal development which were consist of loose connective tissue made by fibroblast cells, collagen and elastic fibers, which provides structural support to the overlying epithelial layer, blood vessels, including capillaries and small veins, would be present within the lamina propria. These vessels supply nutrients and oxygen to the mucosal cells and help remove waste products.

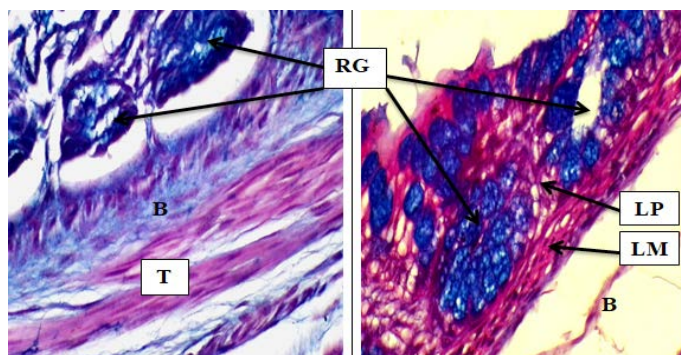


Figure 15: Cross section of rectum at (100-105) days (left) and (130-140) days (right) showing: Rectal glands (RG), lamina propria (LP), lamina muscularis (LM), tunica submucosa (B) and tunica muscularis (T). (PAS combined Alician blue, 40X).

Intestinal glands development, the number of glands within the lamina propria may be relatively highly and these glands, which were present in the mucosa, contribute to mucous secretion and play a role in lubricating the rectal epithelium, the immune cells, such as lymphocytes and macrophages, may be scattered throughout the lamina propria and these cells help defend against pathogens and maintain immune surveillance in the mucosal tissue (Figure 15).

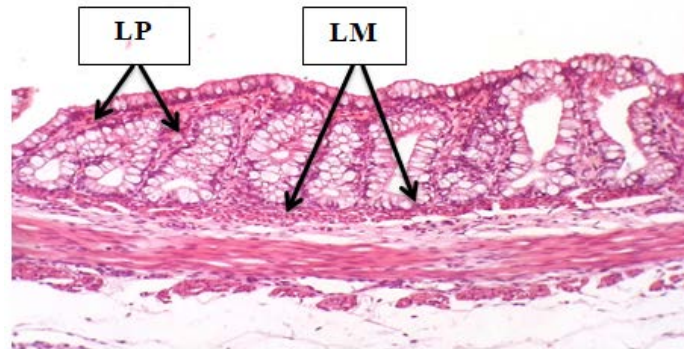


Figure 16: Cross section of rectum at (130-140) days showing: Lamina muscularis (LM) and lamina propria (LP) (H and E stain, 10X).

Lamina muscularis of the rectum were composed of smooth muscle fiber and located at the base of the crypt thicker layer and were very clearly observed (Figure 16). Histological examination reveals the complex organization of smooth muscle fibers within the laminar muscles. The circular muscle layer forms a continuous thick band around the inner circumference of the rectal wall, while the longitudinal muscle layer extends parallel to the length of the rectum. This arrangement allows for the coordinated contraction and relaxation of muscle fibers, enabling peristaltic movement and propulsion of feces, while lamina propria also clearly observed at this age of gestation as loose connective tissue surrounding the rectal gland and be under the epithelial cells layer and separated from tunica submucosa by lamina muscularis (Figure 16).

Tunica submucosa of rectum during third trimester (100-105 and 135-140 days of gestation) undergoes important developmental changes and this tunica was developed and rich in connective tissue components, including collagen and elastic fibres (Figure 17). The thickness of this tunica was $25.72 \pm 0.659 \mu\text{m}$ at 100-105 days and about $35.20 \pm 0.663 \mu\text{m}$ at 130-140 days of gestation (Table 4). There was continuous deposition and organization of these fibers, which contribute to the structural integrity and elasticity of the rectal wall and the blood vessels within the tunica submucosa play a crucial role in supplying nutrients and oxygen to the rectal mucosa, histological examination reveals the presence of small arteries, veins and capillaries that become more developed as pregnancy progresses,

ensuring adequate perfusion of the rectal tissues also this tunica contained lymphatic vessels responsible for draining excess interstitial fluid and immune surveillance (Figure 17).

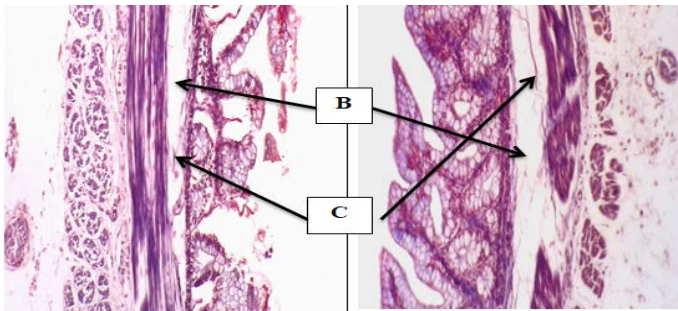


Figure 17: Cross section of rectum at (130-140) days (right) and (100-105) days (left) showing: Tunica submucosa (B) and collagen connectival tissue fibers (C), (Trichrome massons stain, 10X).

The tunica muscularis of the rectum in sheep fetuses during the 100-105 and 135-140 days of gestation undergoes significant development and organization, and this layer is responsible for peristaltic contractions that push fecal material through the rectum and ultimately facilitate its expulsion during birth and after birth. It consists mainly of smooth muscle fibers arranged in two layers: an inner circular layer and an outer longitudinal layer. The thickness of this tunica was about $34.60 \pm 0.481 \mu\text{m}$ at 100-105 days and about $46.88 \pm 0.628 \mu\text{m}$ at 130-140 days of gestation (Table 4) (Figure 18).

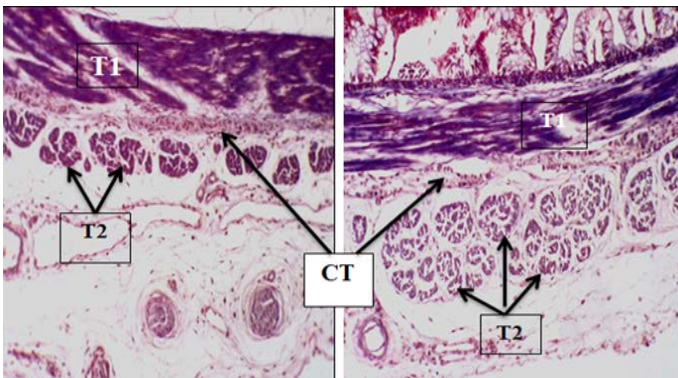


Figure 18: Cross section of rectum at (130-140) days (right) and (100-105) days (left) showing: Inner circular layer of tunica muscularis (T1), outer longitudinal layer of tunica muscularis (T2), separated by layer of connective tissue (CT), (trichrome massons stain, 10X).

Serosal layer of the rectum in sheep fetuses during the third trimester of gestation (100-105 and 135-145 days) with a thickness of about $29.24 \pm 0.348 \mu\text{m}$, $38.58 \pm 0.506 \mu\text{m}$, respectively (Table 4). These features reveal several main features including the mesothelial cells primarily of a single layer of mesothelial cells be flattened in shape and specialized to produce a lubricating fluid that helps

reduce friction between the rectum and surrounding structures within the peritoneal cavity also underneath the layer of mesothelial cells is a layer of loose connective tissue comprised by fibroblast cells, collagen and elastin fibers also large number of adipose cells be observed, small aggregation of lymphatic tissue and blood vessels all that are provided structural support for the serosa and helps anchor it to the underlying layers of the rectal wall (Figure 19).

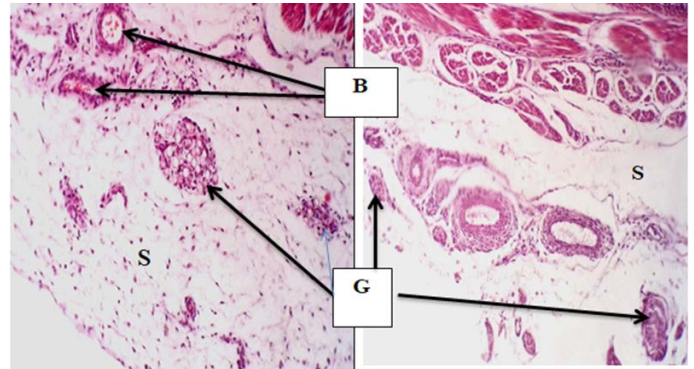


Figure 19: Cross section of rectum at (130-140) days (left) and (100-105) days (right) showing: tunica serosa (adventitia) (S), blood vessels (V) and aggregation of lymphatic tissue (G), (H and E stain, 10X).

The rectum at this age is a transparent and white-walled tube located at the lower portion of the pelvic cavity. The visual diameter of the rectum is slightly larger than the descending part of the colon. It contains very small amounts of feces, and its green color appearance as a result of the transparency of the rectal wall. It consists of a single cavity and is not divided into two parts (thin and sacculation), as is the case in camel embryos at same age. This study differs from Bello et al. (2015) who have described that the rectum is composed of two parts (thin and sacculation parts) in camel embryos at same age. The rectum would be undergoing development along with the rest of the intestinal tract and the histological structure would be similar to that of other parts of the large intestine and more development including on several layers from inner to outer: mucosa, undifferentiated mesenchymal tissue, muscularis externa, and serosa or (adventitia). The previous study agreement with Bello et al. (2015) in camel fetuses at first stage of development which described the rectum like the other parts of intestinal tract forming from four general tunicae and consist of four layers namely: tunica mucosa, tunica submucosa (mesenchymal tissue), tunica muscularis and tunica serosa.

The mucosa of rectum lining by several layer of columnar epithelial cells with goblet cells distributed among them with short villi projected into the lumen. These results are compatible with Ram et al. (2022) in camel and in bovine. They have noticed that the goblet cell appears cleared at

this stage of development.

The tunica muscularis forming by inner circular and outer longitudinal smooth muscle fiber and the outer layer was developed which was in agreement with Singh et al. (2012) who have noticed that the muscularis externa was developed at this stage of gestation from the other portion of large intestine in buffalo fetuses. Rectal patch in rectum wall was not development and this result disagree with the observation made by Indu et al. (2018) in goat fetuses. They also observed that the rectal patch was appearing at 60 days of gestation as continuous band small to medium-size lymphocyte in lamina propria. Few light-stained mesenchymal cells formed meshwork around the lymphocytes.

The location of rectum at second age was aligned to the observations made by Sadler (2006) which described hindgut portion entering postero-caudally region of the cloaca (future anorectal canal), and the allantois enters the anterior region (future urogenital sinus). Breakdown of the cloacal membrane covering this area provides communication to the exterior for the anus and urogenital sinus.

At the same age, the mucosa of rectum lining by simple layer of columnar epithelial cells increased goblet cells appearance at this layer this observation was contradictive to Joubert (1956) who showed the goblet cells may not be observable at any age along the course of gestation in horse fetuses. Bello et al. (2015) have mentioned that the goblet cells be increased with advanced age and be more numerous in the rectum in the fetuses of goat.

Rectal villi appeared in different lengths projected into the rectal lumen and have several lateral branches as was observed. They have described that the villi developed at same age of gestation in bovine fetuses and showed the villi in rectum were shorter in length. Lamina propria and lamina muscularis were observed at this age of gestation by a thin demarcation line between mucosal and mesenchymal tissue layer (submucosa). These results are in agreement with observations made by Esrefoglu and Cetin (2017). They have mentioned that the musculature mucosa stays in differential progressive and be more developed after mid stage of gestation in mammals' fetuses.

The serosal layer of the rectum several key features, including a single layer of mesothelial cells that are primarily flattened in shape and specialized to produce a lubricating fluid that helps reduce friction between the rectum and surrounding structures within the peritoneal cavity. Additionally, a layer of loose connective tissue beneath the layer of mesothelial cells is comprised of fibroblast cells, collagen, and elastin fibers. A large number of adipose cells can be observed, as

well as a small aggregation of lymphatic tissue and blood vessels, all of which provide structural support for the serosa and help anchor it to the beneath. These results align with the observation of Franco et al. (2017) where they have described the structural components of serosal layer of abomasum in deer and sheep fetuses and mentioned the serosal layer formed by flatted mesothelial cells and high cellular connective tissue elements.

CONCLUSIONS AND RECOMMENDATIONS

All gross biometrical parameters of rectum at prenatal development (length, width and thickness) increased with the advanced age of the fetus and there was significant variation in the gross biometry. The rectal wall was comprised of four layers: Epithelium, pluripotential blastemic tissue, premordium tunica muscularis and serosa (adventitia) in the first trimester and at the second and third trimester of gestation the rectum comprised four-layer: epithelium, submucosa, tunica muscularis and serosa. The epithelial layer of rectum be stratified columnar epithelium with goblet cells distributed in different part of this layer and increased also be more density by age of the rectum progressed. Therefore, the epithelial stratified layer transformed to simple layer of columnar epithelial cells. Rectal villi appeared as small elevation of mucosal layer into rectal lumen at first trimester and then exhibited several villi with different length at second trimester. These finding advanced several aspects of the rectum development and offer several markers to be considered during effective assess of animal health and production potential.

NOVELTY STATEMENT

Present report and finding can advanced several aspects of the rectum development and offer several markers to be considered during effective assess of animal health and production potential.

AUTHOR'S CONTRIBUTION

Ali Mobder Niyf and Jafar Ghazi Abbas Al-Jebori confirm contribution to the paper equally.

FUNDING

No funding was received.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The experimental procedures were approved by the Institutional Animal Ethics Committee and conducted at Veterinary Medicine Collage, Al-Qasim Green University, Iraq. Ethical regulation of the present work was assigned by university research committee and guidelines of American Veterinary Medical Association (<https://www.avma.org/resources-tools/animal-health-and-welfare/animal-welfare>).

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

REFERENCES

- Abbas A-JJG (2014). Developmental study of metanephroses in local bovine's fetuses during 1st and 2nd Trimester of pregnancy. Euphrates J. Agric. Sci., 6(3): 1-16. <https://www.iasj.net/iasj/download/b349bd1d7d813800>
- Al-Janabi SM, Al-Jebori JGA, Hamza AA (2022). Developmental study of testis in local Awassi sheep fetuses during first and second trimester of gestation. East Afr. Med. J., 99(4): 4701-4710. <https://www.ajol.info/index.php/eamj/article/view/228247>
- Al-Jebori JGA, Salih ZA (2022). Histomorphological developmental study of liver and gall bladder in local Awassi sheep. J. Pharma. Negative Results, 13: 953-963. <https://doi.org/10.47750/pnr.2022.13.S01.114>
- Al-Khakani SSA, Zabiba IMJ, Al-Zubaidi K, Al-Alwany E (2019). Morphometrical and histochemical foundation of pancreas and ductal system in white-eared bulbul (*Pycnonotus leucotis*). Iraqi J. Vet. Sci., 33(1): 99-104. <https://www.iasj.net/iasj/download/8ef3123d73ce74a3>, <https://doi.org/10.33899/ijvs.2019.125521.1043>
- Asari M, Kashiwazaki N, Kawaguchi N, Fukaya K, Kano Y (1986). Developmental changes in the inner surface structure of the bovine large intestine. Cells Tissues Organs, 127(2): 137-141. <https://doi.org/10.1159/000146268>
- Bass LM, Wershil BK (2016). Anatomy, histology, embryology, and developmental anomalies of the small and large intestine. Sleisenger and Fordtran's gastrointestinal and liver disease. 10th ed. Philadelphia, PA: Saunders, Elsevier Inc, pp. 1649.
- Bello A, Onyeausi BI, Sonfada ML, Je U, Hena SA (2015). Embryonic differentiation of the colon of one humped camel (*Camelus dromedarius*): A histomorphology. BiolMed (Aligarh), 7(242): 2. <http://oer.udusok.edu.ng/xmlui/handle/123456789/180>
- Dyce KM, Sack WO, Wensing CJG (2002). Text book of veterinary textbook. 2nd Edn., London, W.B. Saunders Co., pp. 643-644.
- Esrefoglu M, ÇetIn A (2017). Development of small and large

- intestine. Bezm. Sci., 5(1): 36-41. <https://openaccess.bezmialem.edu.tr/entities/publication/d412fe5e-6ac2-4742-ae90-126c146a5f89>
- Fletcher TF, Weber AF (2004). Veterinary developmental anatomy. Minnesota veterinary anatomy courseware Website: <https://www.jacksonskennel.com/uploads/5/0/4/1/50411273/embryolctnotes.pdf>
- Franco A, Masot J, Redondo E (2017). Comparative analysis of the merino sheep and Iberian red deer abomasum during prenatal development. Anim. Sci. J., 88(10): 1575-1587. <https://doi.org/10.1111/asj.12783>
- Hejazi S, Yaghoubi S, Delghandi M, Javid F (2013). Histogenesis study of skin in sheep. Life Sci. J., 10(5s): 194-198.
- Indu VR, Lucy KM, Ashok N, Maya S (2018). Prenatal development of rectal patch in large intestine of goats. Indian J. Anim. Res., 52(2): 232-234. <https://www.indianjournals.com/ijor.aspx?target=ijor:ijar&volume=52&issue=2&article=010>
- Joubert DM (1956). A study of pre-natal growth and development in the sheep. J. Agric. Sci., 47(4): 382-428. <https://doi.org/10.1017/S0021859600040570>
- Kostouros A, Koliarakis I, Natsis K, Spandidos DA, Tsatsakis A, Tsiaoussis J (2020). Large intestine embryogenesis: Molecular pathways and related disorders. Int. J. Mol. Med., 46(1): 27-57. <https://doi.org/10.3892/ijmm.2020.4583>
- Mohassen FW, Al-Jebori JGA (2020). Ontogenies of thyroid gland in Awassi sheep fetuses: Prenatal study. Plant Arch., 20(1): 1096-1100.
- Ram P, Thanvi PK, Dangi A, Siyag RK, Yogi VK, Kumar S, Mal S (2022). Histological studies on the rectum of pig (*Sus scrofa domestica*). Pharma. Innov. J., SP-11(7): 2330-2336. <https://www.thepharmajournal.com/archives/2022/vol11issue7S/PartAC/S-11-6-456-695.pdf>
- Ramkrishna V, Tiwari GP (1979). Prenatal intestinal histology and histochemistry in the goat. Cells Tissues Organs, 105(2): 151-156. <https://doi.org/10.1159/000145119>
- Rodrigues MN, Carvalho RC, Francioli AL, Rodrigues RF, Rigoglio NN, Jacob JC, Miglino MA (2014). Prenatal development of the digestive system in the horse. Anat. Rec., 297(7): 1218-1227. <https://doi.org/10.1002/ar.22929>
- Sadler TW (2006). Gametogenesis: Conversion of germ cells into male and female gametes. Langman's Medical Embryology Lippincott Williams and Wilkins's Wolters Kluwer business, Baltimore/Philadelphia. 12th pp. 10-28.
- Singh O, Roy KS, Sethi RS, Kumar A (2012). Development of large intestine of buffalo. Indian J. Anim. Sci., 82(10): 1200-1202. <https://epubs.icar.org.in/index.php/IJAnS/article/download/24306/11531/52341>, <https://doi.org/10.56093/ijans.v8i10.24306>
- Tano de la Hoz MF, Flamini MA, Díaz AO (2014). Histological and histochemical study of the duodenum of the plains viscacha (*Lagostomus maximus*) at different stages of its ontogenetic development. Acta Zool., 95(1): 21-31. <https://doi.org/10.1111/j.1463-6395.2012.00577.x>
- Wilson T, Araya A, Melaku A (1990). The one-humped camel. An analytical and annotated bibliography 1980-1989. UNSO Technical Publication (UNSO), online: <https://agris.fao.org/search/en/providers/122621/records/6471ec3b77fd37171a712698>