RESEARCH ARTICLE

Gross Morphological Studies of Rumen of Sheep (*Ovis aries*) Fetus

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Abstract

The present study was conducted on healthy normal embryos and fetuses of either sex of sheep which were collected immediately after slaughter of animals from abattoirs. The embryos/ fetuses were divided as group I (1-75 days of gestation) and group II (76 days to end of gestation) with six specimens from each group. The gross morphological studies showed that at 47 days of gestation, all the four stomach compartments were distinguished and the rumen was a tiny sac-like structure with thin walls and was situated in the left side of the abdominal cavity. Caudal transverse groove, right and left longitudinal grooves were clearly distinct and these grooves separated rumen into dorsal, ventral, caudo-dorsal, and caudo-ventral sacs. The rumen's internal surface was glossy and smooth, devoid of papillae and divided into dorsal, ventral, caudo-dorsal, and caudo-ventral sacs by the formation of left longitudinal, right longitudinal, and caudal transverse cranial transverse pillars. The rumeno-reticular fold was observed at the end of gestation, *i.e.,* 140 days of gestation with tinny papillae and the papillae more developed behind the rumeno-reticular fold.

Key words: Development of rumen, Gestational age of fetus, Gross morphology, Sheep.

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Introduction

Sheep plays a significant role in agriculture economy of several tropical countries and occupies a unique position among livestock. Documentation of embryonic and fetal development is necessary to understand the consequences of harmful influence at various stages of gestation (Evans and Sac, 1973). The ruminant stomach is particularly remarkable for its ability to transform low-quality forage into products of great nutritional value (Garcia *et al.,* 2013). It is developed as an extensive modification of stomach in the form of compartments like rumen, reticulum, omasum and abomasum. The first three compartments are non-glandular part of stomach whereas abomasum is glandular part which functions as a simple stomach. The rumen serves as a fermentative chamber and plays a fundamental role in the breakdown of food on its consequent microbial digestion (Franco *et al.,* 1992). Therefore development, maturation and function of the ruminal structural components are believed to evoke appropriate physiological responses which change with age and diet. As different structures of rumen appear, consolidate and mature at particular age of gestation during the intra-uterine life, documentation of normal embryonic and fetal development is necessary to understand the consequences of harmful influences at various stages of gestation. Among the different components of rumen, ruminal papillae are the vital part which increase surface area and led to increase absorption up to ten times. Therefore this study was aimed to examine the development of rumen from the embryonal to fetal stage till full term gestation in sheep.

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Materials and Methods

The present study was conducted on stomach procured from non-descript sheep embryos and fetuses which were collected immediately after slaughter from abattoirs located in and around Vijayawada, Andhra Pradesh (India). Immediately after collection, the umbilical cord of the embryos and fetuses were ligated properly and these were cleaned with cotton soaked with water to remove the

amniotic fluid and then its crown-rump length (from the forehead to base of the tail) was measured and recorded. The crown rump length (CRL) for each fetus was measured and approximate age was calculated using Richardson's formula (Noakes *et al.,* 2009) as X = 2.1 (Y+17). Where 'X' is the developmental age of fetus in days and 'Y' is crown rump length in centimeters. The crown rump length was measured from the most anterior part of the crown to the base of the tail as described by Rao and Ramayya (2013). In case of fetuses up to 3 cm CRL standard values given by Bryden *et al.* (1972) were used for estimation of age. Embryos and fetuses were divided into 2 groups based on their age *i.e.,* Group I (1 to 75 days of gestation), Group II (76 days to end of gestation). The position of stomach was observed by making an incision on ventral side of the abdominal region. Topographic location, color and shape of different compartments of the stomach were recorded. The stomach was carefully dissected using surgical blades and scissors. After collecting the stomach, segments of the four compartments were separated. The morphology of the rumen was studied. Morphometry was performed on rumen by using Vernier calipers.

Results and Discussion

Exterior of the Rumen

In group I, by 47 days of gestation, the rumen was a tiny sac-like structure with thin walls, which was in contrary to findings of Patra *et al.* (2019), who reported that in sheep fetuses, at 48 days of gestation, large pear shaped right ruminal bud and small quadrilateral left ruminal bud were visible. Hejazi and Farhoudi (2012) and Gupta *et al.* (2018) observed that rumen of sheep and goat fetuses were quadrilateral in shape.

In sheep fetuses, rumen was situated in the left side of the abdominal cavity. This finding was in accordance with the observations of Patra *et al.* (2019) in sheep fetuses at 32 days of gestation. At 47 days of gestation, rumen was creamish white in color. Caudal transverse groove, right and left longitudinal grooves were clearly distinct and these grooves separated rumen into dorsal, ventral, caudo-dorsal, and caudo-ventral sacs (Fig. 1). Patra *et al.* (2019) observed that in sheep, the right longitudinal groove was seen at 48 days of gestation, but the left longitudinal groove appeared at 94 days of gestation.

With its long axis parallel to the fetus's median plane in sheep, it had an ellipsoid form at 53, 61, 64, 68, 69, 70, 72, and 75 days of gestation. Gupta *et al.* (2018) on contrary reported that in goat fetuses, throughout the study period the developing rumen had a roughly quadrilateral shape and around 120 days of fetal life, it became caudo-laterally pointed. Patra *et al.* (2019) observed rumen resembling a bag like structure in sheep fetuses at 63 days of gestation. It features a slightly developed left longitudinal groove and a well-formed right longitudinal groove that continues as a caudal transverse groove. The left longitudinal groove extended obliquely upwards and backwards. The left and right surfaces, as well as the dorsal and ventral boundaries, had a convex shape (Fig. 2). Similarly, Patra *et al.* (2019) noticed that in sheep fetuses, the right and left longitudinal groove were seen at 48 and 94 days of gestation, respectively.

In group I, the dorsal sac of rumen was anteriorly related to reticulum, diaphragm and spleen and posteriorly related to the left kidney and ventral sac of rumen. It was related dorsally to the spleen and sub-lumbar muscles, ventrally to the left lobe of the liver and anterior part of abomasum, parietally to the left abdominal wall, and medially to the intestines. Ventral sac of rumen was related ventrally to the abomasum, left lobe of the liver and anteriorly to the dorsal sac of rumen. It was related dorsally to the sublumbar muscles, medially to the intestines, and parietally to the left abdominal wall and liver lobe (Fig. 3). The caudo-dorsal sac of the rumen was medially associated to the intestines, while the caudo-ventral sac was dorso-medially related to the left kidney in group I. From the duodenum and caudo-ventral sac to the liver's visceral surface, the lesser omentum stretched (Fig. 2). These observations were in concurrence with the findings in goat fetuses by Singh *et al.* (2012) between 47 and 105 of gestation and Gupta *et al.* (2015) between 53 to 106 days of gestation, and by Patra *et al.* (2019) in sheep fetuses between 67 and 121 days of gestation. With increasing gestational age, the rumen dorso-ventral height and cranio-caudal length increased. In group I, dorso-ventral height was bigger than the rumen's width, and the rumen's mean cranio-caudal length was somewhat longer than its dorso-ventral height (Table 1). Similar findings were reported by Hejazi and Farhoudi (2012) in the rumen of sheep fetuses and by Gupta *et al.* (2017) in goat fetuses.

Fig. 1: Photograph showing dorsal, ventral sacs and left longitudinal grooves of rumen in sheep fetus at 47 days of gestation. R- Rumen, Re- Reticulum, Ab- Abomasum, D- Diaphragm, J- Jejunum

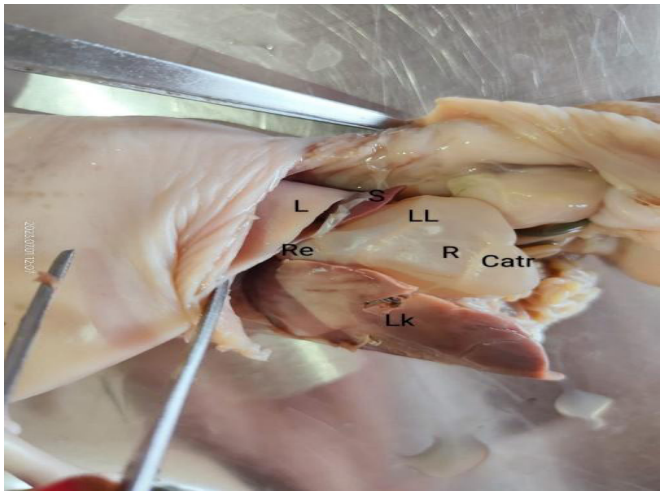

Fig. 2: Photograph showing left surface of the rumen at 75 days of gestation. R- Rumen, Re- Reticulum, L- Lung, S-Spleen, Lk- Left kidney, LL-left lomgitiduinal pillar, Catr- caudal transverse pillar

Fig. 3: Photograph showing rumen, reticulum and abomasum of stomach in sheep fetus at 72 days of gestation. R- Rumen, Re- Reticulum, Ab- abomasums, S-Spleen, J- Jejunum

In group II, rumen stretched from the level of the 10th rib to the 4th lumbar vertebrae at 98, 101, and 140 days of gestation. Similar observations were made by Patra *et al.* (2019) in sheep fetuses from 67 to 121 days of gestation. The left longitudinal groove was more developed compared to group I. Similarly, Hejazi and Erik-aghaji (2013) observed deepened longitudinal clefts in sheep fetuses by 88 days of gestation. In comparison to group I, group II's rumen had greater mean length, width, and height. The relationships, color, and shape were all the same as in group I (Fig. 4, Table 1). Similar observations were made by Hejazi and Farhoudi (2012) in the rumen of sheep fetuses.

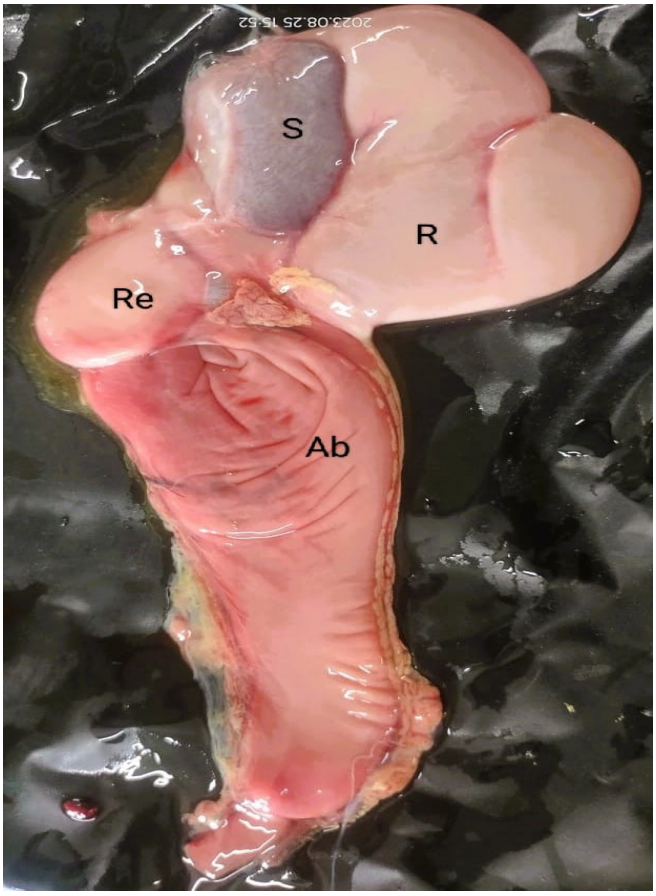

Fig. 4: Photograph showing left surface of rumen in sheep fetus at 140 days of gestation. R- rumen, Ab- abomasums, S-spleen, Re-reticulum

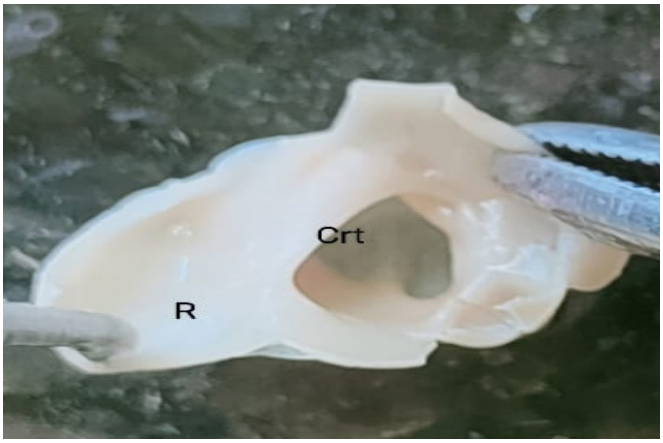

Fig. 5: Photograph showing internal surface of rumen in sheep fetus at 53 days of gestation. R- Rumen, Crt- Cranial transverse groove

Table 1: Morphometric details of rumen in different age groups of sheep embryos/fetuses (Mean ± SE)

Groups	Cranio-caudal length of rumen (cm)	Dorso-ventral height of rumen (cm)	Width of rumen (cm)
Group-I (0-75 Days)	1.66±0.25	1.35±0.16	1.06±0.31
Group-II (76-150 Days)	3.51±0.51	3.10±0.59	3.66±0.68

Interior of the Rumen

In group I, at 47 days of gestation, the rumen's internal surface was glossy and smooth, devoid of papillae, which was in accordance with Garcia *et al.* (2012) in goat fetuses at 75 days of gestation and Patra *et al.* (2019) in sheep fetus between 32 and 111 days of gestation. The interior of the rumen was divided into dorsal, ventral, caudo-dorsal, and caudo-ventral sacs by the formation of left longitudinal, right longitudinal, and caudal transverse cranial transverse pillars that concurred with findings of Patra *et al.* (2019) in sheep fetus between 32 and 63 days of gestation. The rumeno-reticular fold was found around day 50 of gestation in sheep as was reported in goat fetus by Gupta *et al.* (2015). At 53 days of gestation, the interior of the rumen was smooth and had a cream-white color. When compared to 47 days of gestation, the rumeno-reticular fold, right and left longitudinal pillars, cranial transverse pillars, and caudal transverse pillars all grew in length and thickness (Fig. 5).

In group II, within the rumen, papillae were not seen at days 76, 84, 98, or 101 of gestation (Fig. 6). This observation was in accordance with findings of Garcia *et al.* (2012) in goat fetuses for appearance of papillae at 113 days of gestation and Patra *et al.* (2019) in sheep fetus between 32 and 111 days of gestation. On the contrary, Gupta *et al.* (2018) observed slight roughness of mucosal surface in goat fetus at 90 days of gestation. This variation might be due to species difference.

Mucosal walls were studded with tiny papillae at 140 days of gestation in sheep fetuses. Compared to other areas, the dorsal sac mucosa just behind the rumeno-reticular fold had more developed papillae (Fig. 7). Compared to group I, group II revealed greater length and thickness in the rumeno-reticular fold, right and left longitudinal pillars, cranial transverse pillars, and caudal transverse pillars (Table 2). The mean thickness of the ruminal wall increased from group I to group II (Table 3). Similarly, Gupta *et al.* (2018) observed rough mucosa by 145 days of gestation in goat fetuses due to well-developed papillae.

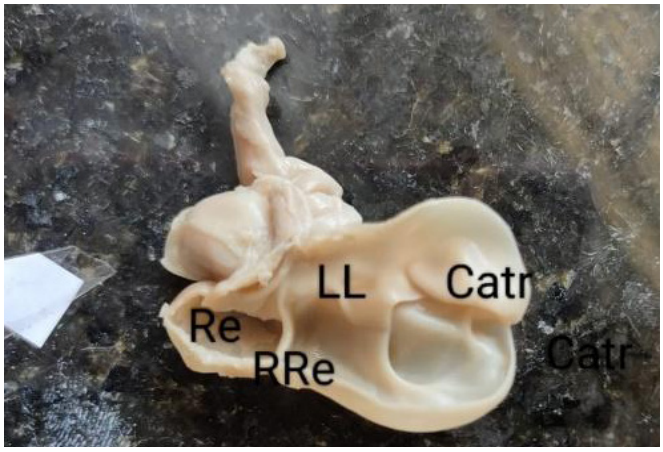

Fig. 6: Photograph showing internal surface of rumen in sheep fetus at 83 days of gestation. Re- reticulum, RRe-rumino-reticular fold, LL-left lomgitiduinalpillar, Catr-caudal transverse pillar

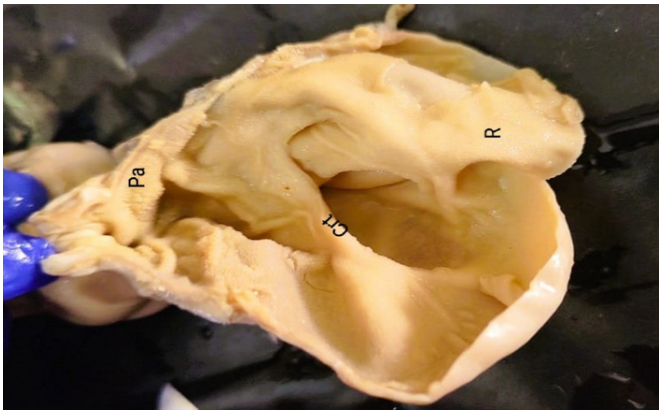

Fig. 7: Photograph showing internal surface of rumen in sheep fetus at 140 days of gestation. R- Rumen, Crt- Cranial transverse groove, Pa- papillae

Table 2: Morphometric details of internal structure of stomach in different age groups of sheep embryos/fetuses (Mean ± SE)

Parameters	Group-I (0-75 Days)	Group-II (76-150 Days)
Length of rumeno-reticular fold (cm)	0.41±0.04	0.63±0.02
Thickness of rumeno-reticular fold (cm)	0.04±0.005	0.10±0.01
Length of cranial pillar (cm)	0.62±0.07	0.90±0.22
Thickness of cranial pillar (cm)	0.04±0.004	0.07±0.001
Length of caudal pillar (cm)	0.13±0.02	0.30±0.07
Thickness of caudal pillar (cm)	0.04±0.003	0.08±0.006
Length of reticular groove (cm)	0.32±0.02	0.70±0.13

Table 3: Morphometric details of thickness of stomach wall in different age groups of sheep embryos/fetuses (Mean ± SE)

Groups	Wall thickness (cm)			
	rumen	Reticulum	Omasum	Abomasum
Group-I (0-75 Days)	0.02±0.003	0.04±0.004	0.03±0.002	0.02±0.001
Group-II (76-150 Days)	0.04±0.004	0.07±0.002	0.06±0.006	0.03±0.001

Conclusion

The gross morphological features of rumen of sheep (*Ovis aries*) fetuses studied over entire gestation showed that at 47 days of gestation, all the four stomach compartments were distinguished and the rumen was a thin walled tiny sac-like structure. Rumen was situated in the left side of the abdominal cavity. Caudal transverse groove, right and left longitudinal grooves were clearly distinct and separated rumen into dorsal, ventral, caudo-dorsal, and caudo-ventral sacs. The rumen's internal surface was glossy and smooth, devoid of papillae. The mean thickness of the ruminal wall increased with advancing gestation. Compared to early fetuses, late fetuses revealed greater length and thickness in the rumeno-reticular fold, right and left longitudinal pillars, cranial transverse pillars, and caudal transverse pillars.

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