Morphogenesis of Rumen in Goat (*Capra hircus*)

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Abstract

Gross anatomical features of developing rumen was studied in 36 goat foeti of both sex. The primordia of the rumen was noticed on 38 day of gestation between 11th to 13th rib. Rumen was displaced from 8th rib to 1st lumbar vertebrae on 134 day onwards. It was roughly quadrilateral shaped through- out the gestation. The dorsal sac of rumen grew faster than the ventral sac. The cranial and caudal transverse grooves and right and left longitudinal grooves were observed at 46 days and coronary grooves were observed at 50 days of gestation. Well distinguished cranial and caudal pillars were observed on 46 days of gestation. Well developed right and left longitudinal folds were demarcated on 55 and 100 days, respectively. Biometrical parameters viz. length, height, width and diameter increased as age advanced.

Keywords: Goat, Rumen, Morphogenesis.

Introduction

Morphological analysis of goat digestive tract has led to its being classed as an intermediate feeder, situated between concentrate selectors at one extreme and the grass roughage eater at other. Goats have the ability to convert fibrous foods into products of great nutritive value. This ability develops scientific interest on the structure and function of the digestive tract of these animals. The rumen is the most important compartment in the physiological term because it plays a key role in the breakdown and subsequent microbial digestion of cellulose, an essential nutrient for ruminants. Documentation of normal, embryonic and fetal development is necessary to understand the consequences of harmful influences at various stages of gestation (Evans and Sack 1973). Apparently, very little work has been reported on various stages of differentiation and development of the rumen in particularly this species. The present study aims to characterize the main morphological changes occurring in the goat rumen during various stages of gestation.

Material and Methods

The morpho-metrical study was conducted on the developing rumen of 36 goat embryos/foeti. The material was

collected from local slaughterhouse, dystokia and the aborted cases from clinics and farms. Embryos/foeti were divided into 3 groups viz. group I (0 day to 50 days of gestation), group II (51 days to 100 days of gestation) and group III (101 days to till parturition). Each group was comprised of 12 foeti. An approximate age of embryos/foeti was estimated by using formula derived by Singh *et al.,*(1979) in goat after interpolation of formula given by (Hugget and Widdas (1951) in mammals. The abdominal cavity was opened by giving ventro abdominal incision and rumen was exposed by careful dissection. Topographic location, morphological observations and measurements of rumen at different age of fetuses were recorded.

Results and Discussion

In group I, at 38 th day of gestation, the digestive tube showed three dilatations out of which two were noticed on developing greater curvature and third was placed caudally (Fig. 1 and 2). Nickel *et al.* (1973) described that the part of spindle shaped stomach primordium developed into fundus and body of simple stomach enlarged markedly and became rumino-reticulum in ruminants. Noden and De Lahunta (1985) mentioned that the primordium of bovine stomach was first recognized as an enlargement of the foregut cranial to the level of septum tranversarium. The primordia of rumen is formed early in the 6th week of gestation by cranio-dorsal and leftward enlargement of fundus. The primordia for developing rumen and reticulum became prominent as cranial expansion of stomach at 34 days of gestation (McGeady and Sac 1967. At 38th days the cranial one primordia the future rumen was small and placed against 11th -13th rib which became demarcated between cranial border of the 11th rib to 13th rib at 43-53 days and situated between 9th rib to first lumbar vertebrae at 65 days and onwards. This was due to forward growth of the rumen. The position was static in II group and in III group at about 114 days of gestation rumen was extending from 9th rib to second lumbar vertebra. Its dorsal sac was ended at the second lumbar vertebra while the ventral sac was located closed to cranial border of the13th rib. Till term, the position of rumen was the same (Fig. 9). Arey (1954) in mammals, mentioned that the enlarging liver displaces the freely movable cephalic end of the stomach to the left while the caudal end was anchored by the short ventral mesentery and the bile duct; the vitelline artery also assisted in the displacement of the stomach. In adults, it lied between 7th to 8th intercostals space to pelvic inlet Sisson and Grossmans, (1974). Warner (1958) and McGeady and Sac (1967) observed that all the stomach compartments were distinct at 2.0 cm CRL in cattle. Hejazi and Frik-aghaji (2013) reported that ~~the~~ sheep rumen was situated in front of reticulum and

its size was biggest at 38 day of gestation. The dorsal and ventral sacs became demarcated by faint cranial and deep caudal transverse grooves and faint right and left longitudinal grooves at 46 days of gestation (Fig. 3). Dorsal sac was larger and grew faster than the ventral sac. Each groove showed a fold interiorly representing pillar toward the cavity of rumen. Panchamukhi *et al.* (1975) observed the presence of transverse groove at inner lining of the rumen at 2.2 cm CRL in buffalo foetus and external transverse groove at 3.2 cm CRL between dorsal and ventral ruminal sacs. The left and right longitudinal grooves were observed by these authors at 5 cm CRL.

The coronary grooves and blind sacs were appeared at 5.0 cm CRL. Ruminal grooves became more prominent from 10 cm CRL onwards in buffalo foeti (Panchamukhi and Srivastava (1975). Hejazi and Frik-aghaji (2013) in foetal sheep noticed that the longitudinal grooves took position by 50 days and blind sacs appeared at 66 days of development in developing rumen. Appearance of grooves differ in present study might be due to variation or shorter gestation period as compared to buffalo. The length of cranial transverse groove was 0 .436 ± .04 and 1.21± 0.18 cm; and caudal transverse groove was 0.767 ±0 .14 and 1.78 ± .18 cm in group II and III, respectively. The length of right longitudinal groove was 0.75 ±0 .12 and 1.97 ± 0.2 cm and left longitudinal groove was0 .82 ± 0.16 and 1.87 ± 0.12 cm in group II and III, respectively. In group II, at 51 days of foetal age, visceral/ right showed prominent cranio- ventral and caudo-ventral coronary grooves while parietal surface revealed faint grooves (Fig 4 and 5). The caudo-ventral coronary groove was deeper and demarcates well defined caudo–ventral blind sac which was pointed and projected outward. Length of right caudo ventral coronary groove was 0 .58 ± 0.13 and 1.61 ±0 .13 cm; and left caudo-ventral coronary groove was 0 .47 ± .08 and 1.05 ± 0.06 cm in group II and III, respectively. Dimensions of the grooves could not be compared due to lack of similar observations in the present available literature. Dorsal and ventral blind sacs became at the same level at 61 days of gestation. Right longitudinal groove started at caudal transverse groove and ran forward and downward at 94 days of age. At about 118 days aged rumen right longitudinal groove divided into two branches. The chief sulcus started at caudal transverse groove, curved upward than forward and downward. The accessory groove curves somewhat ventrally and backward to join the chief groove. A faint caudo dorsal groove was also noticed at this stage. Caudo ventral coronary groove was observed at the junction of caudal transverse groove and right transverse groove and ran straightway downward. At this stage (118 days of

gestation) left longitudinal groove began at the end of cranial transverse groove, ran backward and upward and terminated at the middle of dorsal sac. This groove became prominent by 94 days of age. At full term all the grooves were prominent. However, the dorsal coronary grooves were not observed at any stage of foetal life. In adult ruminant the blind sacs were marked off from remainder of rumen by the dorsal and ventral coronary grooves.

During entire study the shape of the developing rumen was roughly quadrilateral which became caudo-laterally pointed at 120 days of foetal age. Hejazi and Farhoudi (2012) reported that the sheep rumen was quadrilateral in shape in initial stages of pregnancy and changed to rectangular during late stage of pregnancy.

The digestive tube was completely concealed by visceral surface of developing liver at 38 days of gestation. Singh *et al.* (2012) reported that the visceral surface of the developing goat liver was related to the primitive stomach and lesser omentum during early prenatal period (0-50 days). Similar relations of the stomach with the developing liver were also reported in one humped camel by El Hafez (2009). The tube was in contact cranially with septum transversarium. At this age all the sacs of stomach were related dorsally with mesonephros whereas, by 41 days the caudal part of the second sac from the left side and a small part of the third sac was in contact with the developing mesonephros and gonads.

Second and third dilatations were presented on right side of the median plane and were in contact with coils of the developing intestine, pancreatic swelling and covered by mesentery. The first sac which will be the future rumen, had a faint groove on its dorsal side.

At 43 days of foetal age, the craniodorsal part of the developing rumen was in contact with the developing spleen and caudo- dorsal part with developing gonads. This relation changed at 46-47 days of age and the dorsal part of rumen along with the developing spleen was in contact with the cranial end of the mesonephros and mesonephric duct, while the ventral part was related with the developing gonads. Caudo-ventral blind sac was in contact with cranial end of mesonephros at 46 days and with coils of intestine and adrenal at 53 days of age.

At 53 days, the dorsal ruminal sac was related to the developing mesonephros and adrenal. In all stages of group II, the rumen was in contact dorsally with septum tranversarium. The left/parietal surface was related to the developing kidney particularly mesonephros, left lobe of pancreas and adrenal. The visceral surface was related to the developing coils of

small intestine, colon, duodenum and omentum. The cranial two thirds of the dorsal sac was in contact with the developing spleen. Singh *et al.* (2012) reported that the visceral surface of left lobe of liver was related with the developing stomach and coils of intestine between 50-60 days of gestation in goat. Pathak *et al.* (2014) reported that the dorsal sac of rumen was related to the cranial surface of left adrenal gland, renal artery, left lobe of pancreas and spleen in goat at 53 days of gestation.

At about 106 days of foetal age, the caudo-ventral blind sac was related cranially with two thirds of the abomasum and caudally with coils of small intestine (fig. 7). With the advancement of age the caudo-dorsal blind sac became free. At about full term stage, the right/ visceral surface of the dorsal ruminal sac was in contact with the developing abomasum (fig. 8).

The internal features of the rumen were recorded after careful incision of rumen through the dorsal sac (fig. 6). Internally both cranial and caudal pillars were observed as a projection like shelves into cranial and caudal end of the ruminal cavity at 46 days of foetal life. Cranial pillar was directed obliquely dorsally and caudally from the ventral wall and its free edge was concave. Whereas, caudal pillar was almost directed horizontally. The thickness of the cranial and caudal pillars were 0.045 ±0 .005 and 0.066 ± 0.007 cm, respectively in group II and became 0.45 ± 0.22 and 0 .16 ±0 .01 cm, respectively in group III. The dorsal and ventral sacs were continuous with each other in the area between the cranial and caudal pillars. The distance between middle of cranial and caudal pillar was 0.68 ± 0.11 and 1.41 ±0 .18 cm, respectively in group II and III. The longitudinal folds connected the cranial and caudal pillars were present in their respective longitudinal grooves. They started from cranial pillar and faded out towards caudal pillar. The right longitudinal fold appeared first and completed at 55 days of foetal rumen. Completion of left longitudinal fold took place at about 100 days of age. Well-developed ventral coronary fold was evident at 55 days of gestation and was completely encircled the ventral blind sac. The right ventral coronary fold was more developed and reached up to ventral margin of ventral sac whereas, left one reached up to the middle. The rumino-reticular fold was present at the junction of rumen and reticulum and became well demarcated at 50 days of foetal age. The distance between rumino- reticular fold and cranial pillar denoted the area of atrium ruminis and was 0.66 ± .08 cm and 1.21 ± .21 cm long in group II and III, respectively.

Under stereo zoom microscope fine roughness was noticed in interior surface of rumen at 55 days, which became sharp at 90 days. Well-defined

papillae became evident by full term. Gracia *et al.,* (2012) reported that the internal surface of goat rumen was smooth, soft and whitish at 75 day and conical ruminal papillae became evident at 113 days of gestation.

Biometrical parameters of rumen recorded in group II and III did not show deviation of general configuration even though there was increase in gross measurements. The craniocaudal length of rumen varied between 0.406 – 2.61 cm with an average of 1.65 ± 0.28 cm in group II and 2.8-6.4 cm with an average of 4.36 ± 0.4 cm in group III. The dorso- ventral height of the rumen varied between 0.317 -2.8 cm with an average of 1.62 ± 0.32 cm in group II and 2.9-5 cm with an average of 4.27 ± 0.25 cm in group III. The length of the rumen was to some extent greater than its height in all groups. Panchamukhi (1973) studied the development of buffalo foetal rumen. Author reported the length and width of buffalo foetal rumen from CRL 2.5- 74 cm and found that in early stages (2.5 cm CRL) the length and width were equal while in later stages (74 cm CRL) length was higher than width. The length and width of rumen were equal (0.05cm) at 38 days and became 5.0 and 4.5 cm, respectively at 100 days of gestation. The width and diameter/ circumference was 3.5 ± 0.57 and 5.1 ± 0.89 cm, respectively in group II and 8.07 ±0 .54 and 11.87 ± 0.76 cm, respectively in group III. The ratio of length of rumen and length of foetus was 0 .114 and 0 .129, respectively in group II and group III. In late stage of pregnancy increase in length of rumen was more as compared to increased length of foetus. The above biometrical parameter showed that the growth of the rumen was faster in the second group followed by third group.

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Fig (1): A photograph of 41st day of gestation of goat foetus showing in situ position of the developing stomach (arrow).

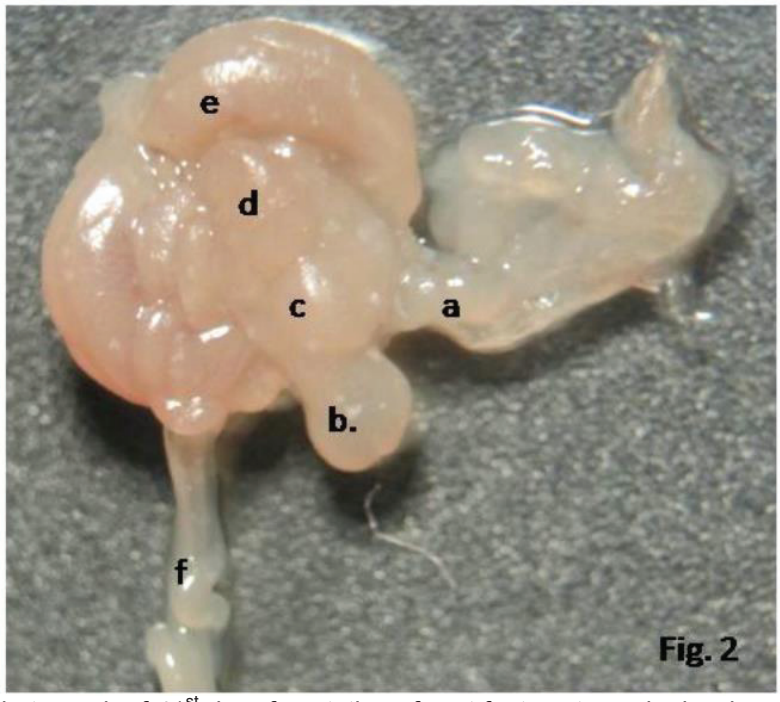

Fig (2): A photograph of 41st day of gestation of goat foetus stomach showing: a. oesophagus; b. rumen; c. reticulum; d. abomasum; e. mesonephros and f. small intestine

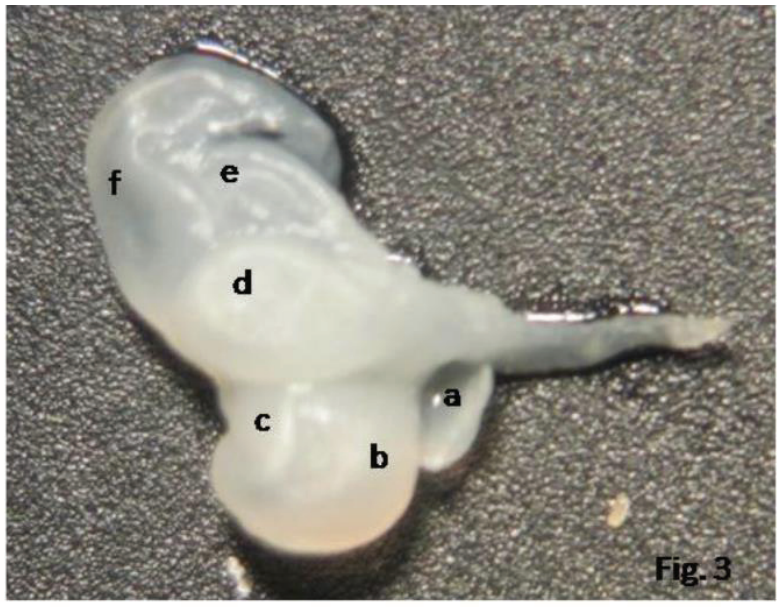

Fig (3): A photograph of 46th day of gestation of goat foetus showing a. spleen; b. dorsal sac of rumen; c. ventral sac of rumen; d. reticulum; e. omasum، f. abomasum.

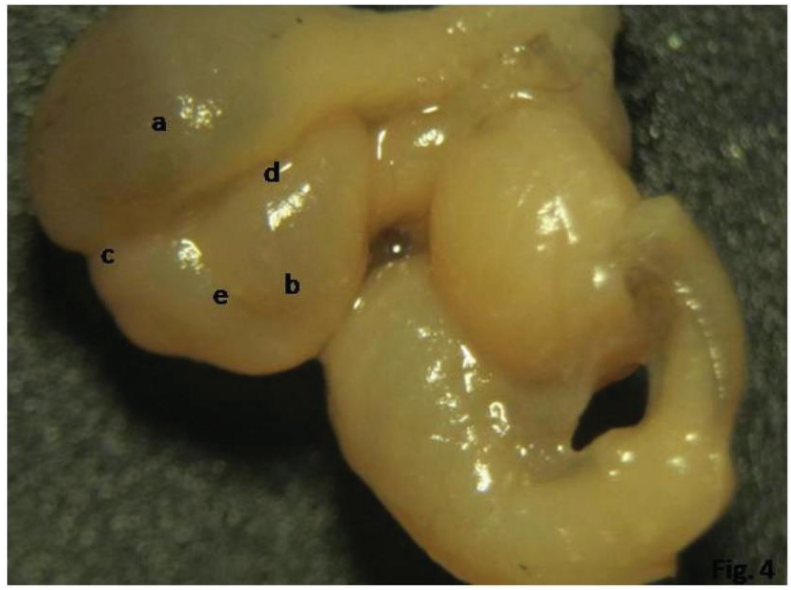

Fig (4): A photograph of 53 rd day of gestation of goat fetus showing rumen (right view) a dorsal sac; b ventral sac; c caudal transverse groove; d right longitudinal groove; e caudo-ventral coronary groove.

Fig (5): A photograph of 53 rd day of gestation of goat fetus showing rumen (left view) a dorsal sac; b ventral sac; c caudal transverse groove; d left longitudinal groove; e caudo- ventral coronary groove.

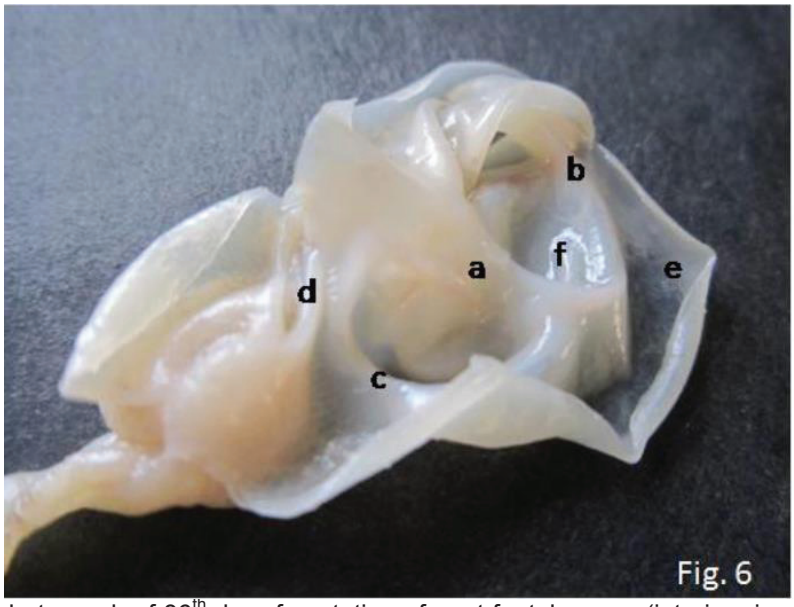

Fig (6): A photograph of 86th day of gestation of goat foetal rumen (interior view) showing a cranial pillar; b caudal pillar; c rumino-reticular fold caudal transverse groove; d reticular groove; e dorsal sac, f ventral sac.

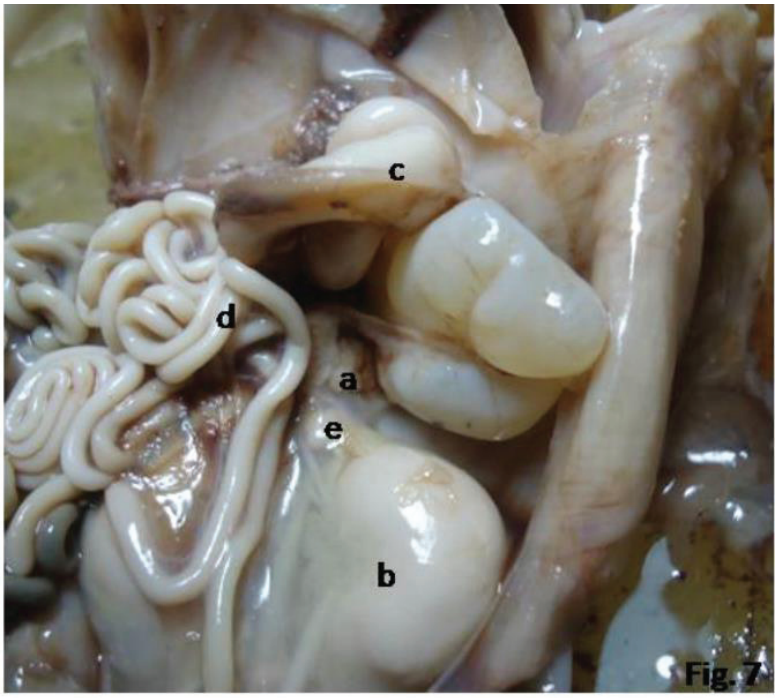

Fig (7): A photograph of 106th day of gestation of goat foetal rumen (in situ position) showing its relation with developing a pancreas; b metanephros; c abomasum; d small intestine, e left adrenal.

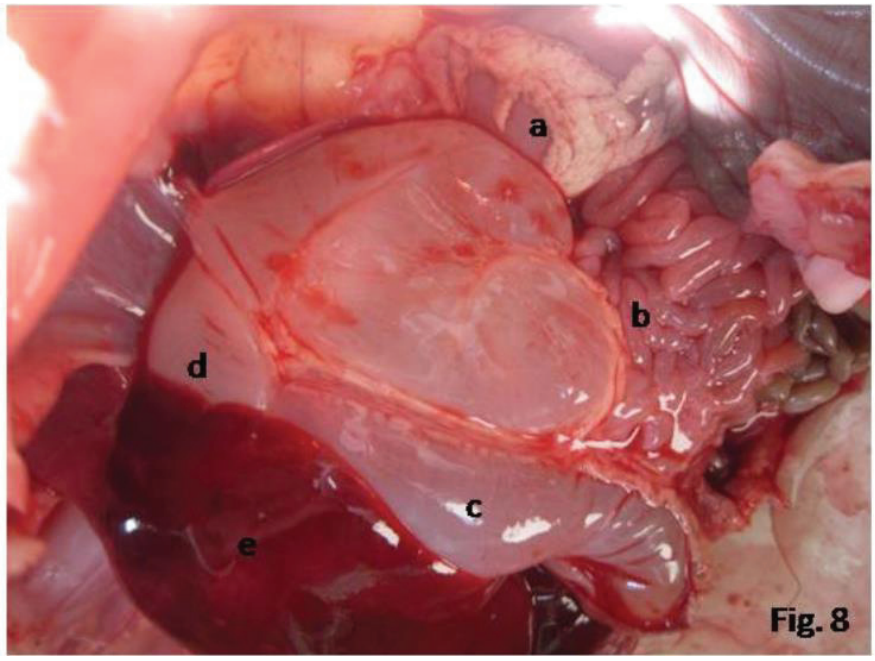

Fig (8): A photograph of 121st day of gestation of goat foetal rumen (in situ position) showing its relation with developing a metanephros; b small intestine; c abomasum; d reticulum, e liver.

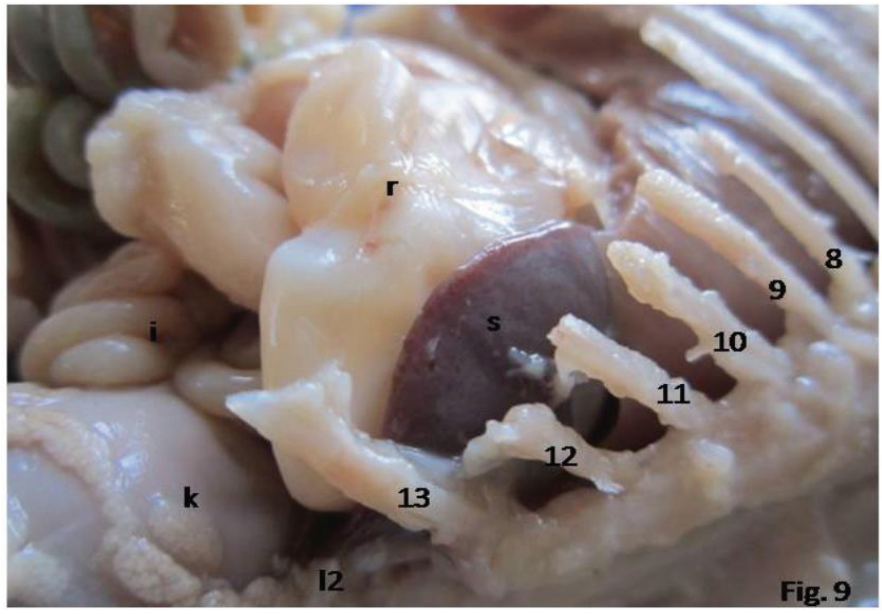

Fig (9): A photograph of 134th day of gestation of goat foetal rumen (in situ position) showing its location developing. r rumen; s spleen; k kidney.