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Research Article

PRENATAL DEVELOPMENT OF FEMUR IN GOAT (*CAPRA HIRCUS*)

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ABSTRACT

The study was conducted on the femur of goat embryos/foetuses irrespective of sex and breed from 35 to 148 days of gestation, divided into three groups viz., Group I (d™ 50 days of gestation), Group II (> 50 days and d™ 100 days of gestation) and Group III (> 100 days of gestation till parturition) comprising of 8 foetuses in each group. The hindlimb of each foetus was stained with Alizarin Red-S stain or Alizarin Red-S and Alcian blue combined stain method to record the appearance of centers of ossification. At 44 days of gestation, the cartilaginous miniature of femur was formed in thigh region. It was cylindrical in structure with enlarged extremities. The first center of ossification for the diaphysis of femur appeared/formed on 46 days of gestation. Distinct but cartilaginous trochlear ridges and condyles were present at the distal extremity of femur on 52 days and 55 days of gestation, respectively. Well defined cartilaginous trochanter major and the head of femur were formed at the proximal extremity on 71 and 82 days of gestation, respectively. The centers of ossification for the head of femur and distal extremity appeared on 129 days of gestation. On 135 days of gestation, the center of ossification for trochanter major was observed.

Keywords: Femur, Goat, Prenatal development

The knowledge of first appearance of ossification centers is useful for age estimation of foetuses in domestic animals (Parmar *et al.*, 2009). Meager literatureis available on the development of ossification centers in the femur of goat (Parmar *et al.*, 2009), sheep (Harris, 1937) and buffalo (Lindsay, 1969 and Rao *et al.*, 2012). The detailed study on the development of femur is not available particularly in goat. Therefore, an efforts has been made to record the sequential development of femur in goat.

MATERIALS AND METHODS

The study was conducted on the femur of 24 apparently healthy goat embryos/foetuses irrespective of sex and breed from 35 to 148 days of gestation. The goat embryos/foetuses were collected from local slaughter houses of Mathura and aborted cases at clinics and farms of DUVASU, Mathura. The approximate age of foetuses was estimated by using the formula {W1/3=0.096 (t-30)} derived by Singh *et al.* (1979) in goat after interpolation of formula of Hugget and Widdas (1951). In addition to this, the gestational age estimation based on foetal measurements and phenotypic characteristics given by Njaa (2012) in goats was also used. The material was divided into three groups, viz., Group I (d™ 50 days of gestation), Group II (>50 days and d™ 100 days of gestation) and Group III (>100 days of gestation till parturition) comprising of 8 foetuses in each group.

The femur of each foetus (irrespective of side) of 44 days and above were dissected out and stained with either Alizarin Red-S stain or Alizarin Red-S Alcian Blue combined stain to study the appearance of centre of ossification. Biometry (total length of bone and ossified length of diaphysis) of femurs were recorded with the help of metric scale, Vernier Callipers and non-stretchable thread. The biometry of very small specimens was done under the stereo zoom microscope (Motic digital microscope DMW- 143- N2GG). Detailed morphology of femur was recorded under the stereo zoom microscope.

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RESULTS AND DISCUSSION

The trend of growth of femur from 46 days to 148 days of gestation is presented in Fig. 1. At 44 days of gestation, the cartilaginous model of femur was formed in the thigh region. It was a cylindrical structure with enlarged extremities. At the proximal extremity, a rounded smooth enlarged structure (future head of the femur) was recognised. The distal extremity was also enlarged and directed caudally, became much more enlarged to form the future condyles of the femur. Rao *et al.* (2012) observed the cartilaginous mass of femur at 57 days of gestation in buffalo. At 46 days of gestation, the first centre of

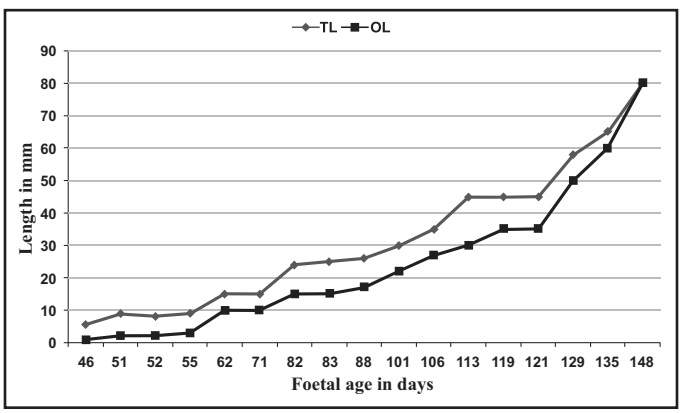
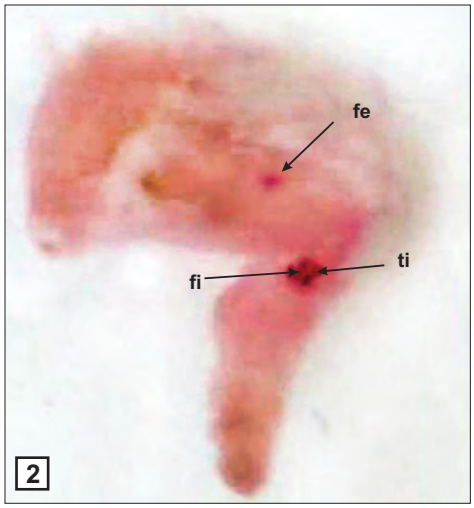
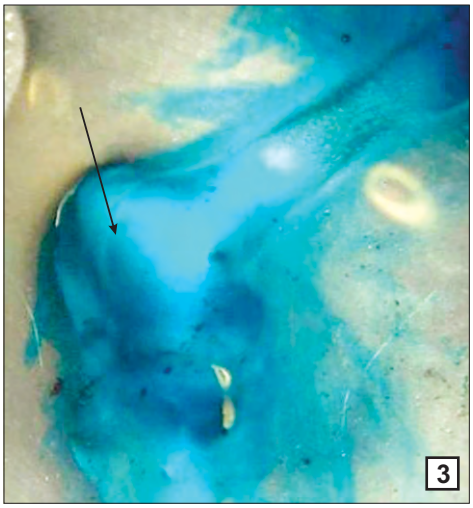


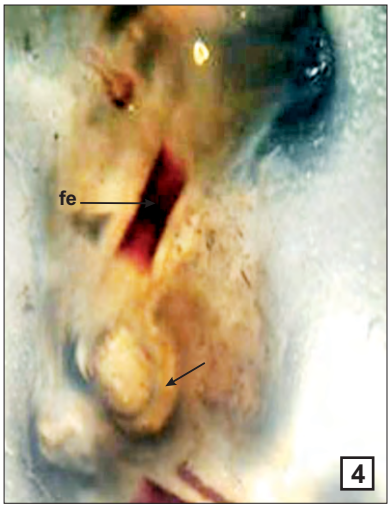
Fig. 1. Graph showing the trend of growth in total length (TL) and ossification length (OL) of femur with age

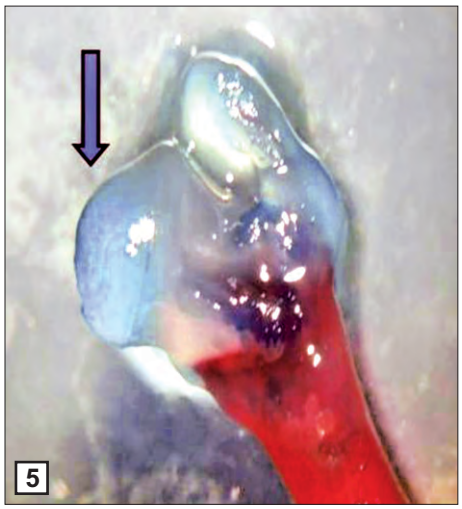
ossification was seen in the middle of the shaft of femur as red stained area in Alizarin Red-S preparation (Fig. 2). The total length of femur was 5.5 mm, out of which the length of ossified shaft was 1.0 mm (18.18%). In contrast to this, Parmar *et al.* (2009) reported the appearance of ossification centre for the shaft of femur at 49 days of gestation through radiographic study in the same species. Harris (1937), Wenham (1977 and 1981) and Supriya *et al.* (2017) reported the appearance of ossification centre for the diaphysis of femur at 42 days, 50 days, 42 days and 45 days of gestation, respectively, in sheep. Lindsay (1969) in bovine observed the same at 50 days of gestation. Rao *et al.* (2012) reported that in buffalo, the centre of ossification for the diaphysis of femur developed in the form of a small nodule at 59 days of gestation. At 51 days of gestation, the total length of femur was 9.0 mm, out of which the central 2.0 mm (22.22%) part of diaphysis was ossified. In the cortical area, the staining was darker than in the central area. At 52 days, the femur became more elongated. It was 8.0 mm long, out of which the central 2.0 mm part (25.00%) of diaphysis was ossified. Extremities were completely cartilaginous. The proximal extremity of femur became much enlarged. Distal extremity was showing distinct trochlear ridges (Fig. 3). The medial ridge was larger than the lateral one. At 55 days, the shaft of femur was progressively ossified (Fig. 4). The total length of femur was 9.0 mm long out of which 3.0 mm of shaft (33.33%) was ossified. Distal extremity of femur although cartilaginous, was showing a pair of condyles. At 62 and 71 days of gestation, the femur was 15.0 mm, long out of which 10.0 mm of shaft (66.67%) was ossified. At 71 days, the ossification in diaphysis of femur was more progressive towards its proximal extremity. At the proximal extremity, the contour of trochanter major was formed in the form of an enlargement. The distal extremity was also enlarged. At 82 days, the femur was 24.0 mm long, out of which 15.0 mm of shaft (62.50%) was ossified. A well formed head of the femur was present (Fig. 5). At 83 days, the femur was 25.0 mm long, out of which 15.0 mm (60%) of shaft was ossified. At 88 days, the femur was 26.0 mm long and length of ossified shaft was 17.0 mm (65.38%). The trochanteric ridge of femur became more prominent. The trochanter minor was seen as a cartilaginous prominence at the medial surface of proximal 1/3 of shaft of femur. The average length of femur during mid prenatal period was 16.38±2.70 mm and ossified length was 09.25±2.20 mm. The average percentage of ossification was 50.22±6.97.

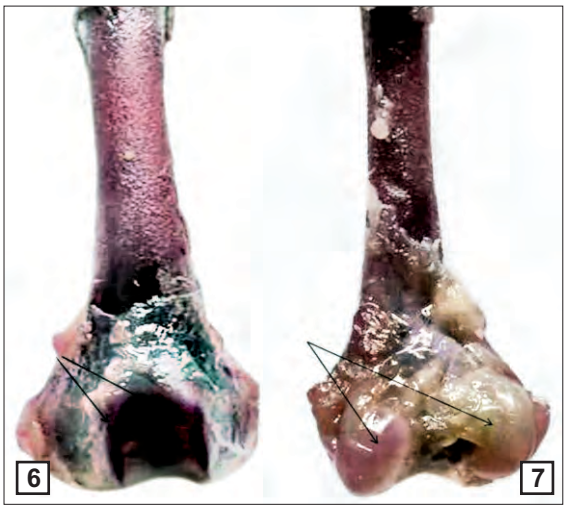
At 101 days of gestation, the femur was 30.0 mm long and the length of ossified shaft was 22.0 mm (73.33%). A cartilaginous trochanter minor was formed as a prominence on the medial surface of the femur in the proximal 1/3rd of the shaft. At 106 days, the femur was 35.0 mm long and the length of ossified shaft was 27.0 mm (77.14%). At 113 days, the cartilaginous trochlea became more prominent. At 119 and 121 days of gestation, the femur was 45.0 mm long and the length of ossified shaft was 35.0 mm (77.78%). Trochanteric fossa was formed at the proximal extremity of the femur. At 129 days, the femur was 58.0 mm long and the length of ossified shaft was 50.0 mm (86.21%). The centres of ossification for head of femur at the proximal extremity and for distal extremity were exhibited on 129 days of gestation. At 135 days of gestation, the shaft of femur was elongated cylindrical in shape with two extremities. The length of bone was 65 mm and the ossified length of diaphysis was 60 mm (92.31%). It showed centre of ossification for trochanter major. Parmar *et al.* (2009) in goat reported the appearance of ossification centre for distal epiphysis at 103 to 113 days, the head at 117 days and trochanter major at full term by radiographic method. Harris (1937) in sheep foetuses reported that the centre of ossification appeared for the head of femur at 131 day and for great trochanter and lesser trochanter, it appeared at 138 days of gestation. Wenham (1977) reported that in sheep, the condyles were the first of the secondary centres to appear between 93 and 105 days. The head was discernible in some foetus after 126 days and were normally present after 135 days and quickly followed by trochanter minor. Rao *et al.* (2012) stated that in buffalo, the secondary centre for the distal epiphysis of femur appeared at 170 days and third ossification for head appeared at 252 days of gestation. Lindsay (1969) reported secondary ossification centres for distal epiphysis, head and trochanter major at 163 days, 203 days and 238 days of gestation in bovine foetuses. The femur was 80 mm long by 148 days of gestation in goat, and it was completely (100%) ossified. Its proximal extremity consisted of head and trochanter major. The head was rounded in shape. At the medial surface of the head, round ligament was attached in the fovea capitis which was distinctly formed. The trochanter major was present laterally and was separated from head by groove. The trochanter major lay slightly higher than the level of head. Caudally, a trochantric ridge was formed which joined the trochanter major with the trochanter minor. The trochanter minor was present at the caudo-medial surface of the proximal 1/3rd of the shaft of the femur in the form of a tubercle. Trochanteric fossa was also present. Neck was well defined. The distal extremity was comprised of trochlea cranially showing the centre of ossification as evidenced in Alizarin Red-S stain. Medial trochlear ridge was longer and higher than the lateral one. Caudally two condyles were present, with a groove in between. Centre of ossification for the trochanter major which was seen on 135 days became darker in colour in Alizarin red-S staining. Medial trochlear ridge was larger and more superiorly placed than the lateral one. Both the trochlear ridges were showing the centres of ossification and stained











Figures. **2.** Photograph showing centres of ossification for femur (fe), tibia (ti) and fibula (fi) of hind limb in 46 days old goat foetus. **3.** Photograph under stereo zoom microscope showing trochlear ridges (arrow) at distal extremity in 52 days old goat foetus. **4.** Photograph under stereo zoom microscope showing centre of ossification in the diaphysis (fe) and cartilagenous distal extremity of femur in 55 days old goat foetus. **5.** Photograph under stereo zoom microscope snowing head of femur (arrow) at proximal extremity in 82 days old goat foetus. **6.** Photograph showing ossified trochlear ridges (arrow) at distal extremity of femur in 148 days old goat foetus. **7.** Photograph showing ossified condyles of femur at distal extremity in 148 days old goat foetus.

very well with the Alizarin red-S (Fig. 6). Caudally, the distal extremity was consisted of two femoral condyles (Fig. 7). The average total length, ossified length and ossification percent of femur during late prenatal period was 50.38± 5.80, 42.38±6.94 mm and 81.40±3.81%, respectively.

It is concluded that the center of ossification for the shaft of femur was exhibited on 46 days (I trimester) of gestation. During mid trimester of gestation, progressive ossification of shaft of femur occurred. The centers of ossification for the extremities were exhibited in the later part of the III trimester of gestation.

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