



Early Pregnancy Diagnosis and Fetometry by Real Time Ultrasonography in Teddy Goat

Faiz Muhammad Khand¹, Allah Bux Kachiwal², Zubair Ahmed Laghari²,
Shakeel Ahmed Lakho¹, Pershotam Khattri², Saeed Ahmed Soomro²,
Nazar Ali Korejo² and Ambreen Leghari^{1*}

¹Shaheed Benazir Bhutto University of Veterinary and Animal Sciences Sakrand, Sindh, Pakistan

²Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University Tandojam, Sindh, Pakistan

ABSTRACT

The main objective of present study was to estimate gestational age of teddy goat by B-mode ultrasound measurement of embryonic or fetal parts and uterine diameter throughout pregnancy by transrectal approach. Three parameters crown rump length (CRL), trunk diameter (TD), and uterine diameter (UD) were selected for measurement of gestational age with the weekly interval from 3rd week to 15 weeks of gestation of 12 pregnant teddy goats, all three parameters were significantly ($P < 0.01$) correlated with gestational age. The CRL was strongly positively correlated with gestational age ($r^2 = 0.98$) followed by the TD ($r^2 = 0.98$) and the UD ($r^2 = 0.97$). The fetal numbers were estimated 19 (five single and seven twines) by transrectal approach in twelve pregnant teddy goats. The earliest day of pregnancy diagnosis was 19 day after mating, while trunk was best parameter for determination of gestational age throughout gestational period and fetal sexing can be diagnosed at 7th week of gestation period in teddy goats.

Article Information

Received 15 March 2019

Revised 26 July 2019

Accepted 28 January 2020

Available online 17 July 2020

Authors' Contribution

ABK and SAS presented the concept. FMK suggested the methodology, provided resources, analysed the data and wrote the manuscript. ZAL provided technical support. SAL and PK validated the results. AL collected and processed the data. ABK reviewed the final manuscript.

Key words

Teddy goat, Pregnancy diagnosis, Ultrasonography, Fetometry

INTRODUCTION

Goats are the small ruminants playing leading role in developing the national economy and meeting the basic requirements of people. Economic losses in milk and kid production can be minimized or avoided through early diagnosis of pregnancy in goats as it aids for culling or rebreeding for food allotment, and for clinical and research purposes (Buckrell, 1988). Early pregnancy diagnosis has been increasing awareness to commercial farmers to increase their worth and minimize their extra uses of feed supplements. Accurate pregnancy diagnosis may provide essential information for effective herd management practices (Doize *et al.* 1997). A variety of approaches has been explored for the early detection of pregnancy in mammalian species. However recently many techniques have been used to detect the early pregnancy like radiography, estrone sulphate (Refsal *et al.*, 1991), progesterone assay (Murray and Newstead, 1988), vaginal biopsy (Richardson, 1972), palpation of uterus via laparotomy (Ishwar, 1995), pregnancy specific antigen (Humboldt *et al.*, 1990). These all are used in late pregnancy, time consuming and are very difficult to perform for early diagnosis of pregnancy. Real time B

mode ultrasonography is a non-invasive, accurate and rapid alternate for diagnosing of pregnancy and studying the development of the conceptus in livestock. B-mode real time ultrasound has been used for early pregnancy diagnosis and counting fetal numbers in goats (Dawson, 1999). Determination of fetal sexing and number of fetuses through ultrasonography can improve the reproductive management of farms. Especially the identification of gender of goat is much diffused as compared to cattle (Curran, 1992; Stroud, 1996). Measuring the embryo or fetal parts provides information on the growth status of the embryo or the fetus. Some parameters of fetus and uterus of female are used to measure the fetal age in different goats, CRL in saanen goat (Abdelghafar *et al.*, 2010; Amer, 2008) and TD was measured by Lee *et al.* (2005) and (Singh *et al.*, 2004) but these all are species specific. Information of these parameters of teddy goat is lacking. Teddy goat is the one of the famous goat breeds of Pakistan, his reproductive performance is very fast growing, low input and better efficiency (Kuthu *et al.*, 2013).

To the best of our knowledge, this the first study to estimate the gestational age in teddy goats by using B-mode real time ultrasound. The present study aimed to determine the earliest day of pregnancy and to estimate the gestational age of teddy goats by B-mode ultrasound measurement of embryonic or fetal parts (CRL, TD and UD) of teddy goat. This study is also used to identify number and sex of fetuses.

* Corresponding author: drambreen.leghari@gmail.com
0030-9923/2021/0001-0001 \$ 9.00/0
Copyright 2021 Zoological Society of Pakistan

MATERIALS AND METHODS

Animals

The study was performed using 12 teddy goats (2.4 ± 0.347 years age; weighing 22 ± 3.47 kg) maintained at the research farm of Department of Surgery and Obstetrics, Sindh Agricultural University, Tandojam. The does were synchronized for estrus with injection of Lutalaze (Dinoprost tromethamine, Pfizer, Belgium) 1 ml/dose intramuscularly. The does were examined regularly for estrus sign. On the detection of estrus, a fertile buck was allowed for natural breeding and the day of breeding was considered as day 0 of gestation.

Ultrasound scanning

All does were subjected weekly to ultrasonographic scanning from day 17 onward after mating. Real time B mode scanner equipped with multi frequency (5-10 MHz) with transrectal probe was used (HS-2000, Honda Electronics Co., Ltd., Toyohashi, Japan). Animals were being kept off fed for 12 h prior to scanning. The does were tightly restrained by one person against railing in standing position. Using the transrectal approach, feces was removed from rectum (does usually defecate as soon as a finger or transducer enters the rectum) and a well lubricated 5 MHz with corboxymethyl-cellulose conducted gel was introduced into rectum.

Detection of conceptus

The first ultrasonographic signs of a possibly pregnant uterus were non-echogenic areas in the uterus which represent the fluid in the embryonic membranes with conceptus which was later confirmed as pregnancy.

Measurement of crown-rump length

The measurements were taken from the most upper

part of the skull to the end of the sacrum, when the fetus was fully extended. As the pregnancy progressed, the fetus adopted curved position, and the measurements were taken in two phases firstly from the head to the heart area and secondly from the heart area to the sacrum.

Measurement of trunk diameter

Fetal trunk diameter was measured from first thoracic vertebrae to lumbar vertebrae. The trunk measurements comprised the transversal diameter at the level of the last rib, the width of three vertebrae with their intervertebral spaces and the width of three ribs with its intercostal spaces were taken, since a single vertebra or rib was too short to be measured accurately.

Detection of fetal number

The single and twins were detected by number of fetal heads and independent movements of fetuses which was further confirmed after parturition for checking the accuracy of ultrasonographic machine.

Fetal sex determination

The sex of fetus was determined by the external genitalia (penis, prepuce scrotal bag, nipples and genital swelling) and localizing the genital tubercle (GT). The accuracy of the fetal sexing was determined by differentiation of GT from day 40 to 109 of gestation and then followed up to birth.

Statistical analysis

The ultrasonic measurements of CRL, TD, and UD were expressed as the mean \pm S.E.M. The paired t-test was used to compare the data within the group. Linear regressions analysis was used to determine relationship between gestational age and ultrasonic measurements (CRL, TD, and UD). The results were analyzed using the SPSS software (SPSS Inc., version 16.0, Chicago, IL, USA).

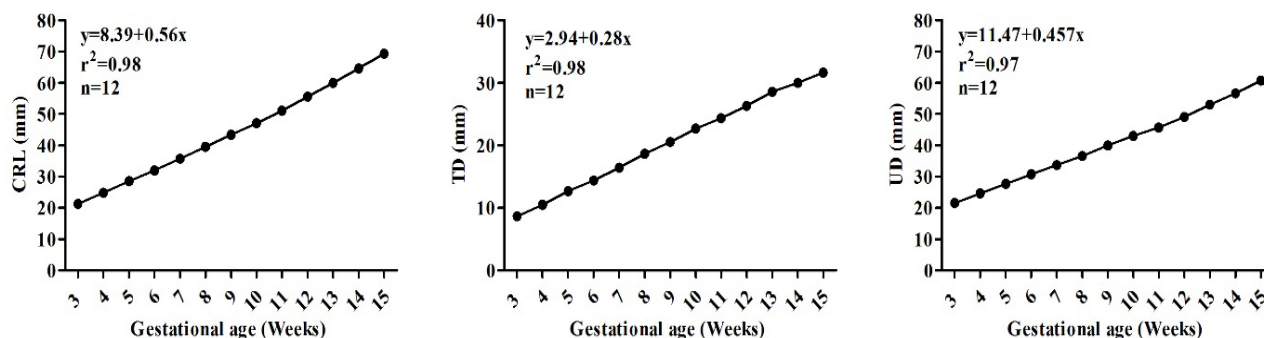


Fig. 1. Measurements of crown-rump length, trunk diameter, uterine diameter in relative to gestational age.

RESULTS

All the does were estrus synchronized and breed were detected positive for pregnancy which will final confirmed at delivery. The first sign of pregnancy was an elongated or somewhat circular anechoic area in uterus which was detected on day 19 of gestation, while proper embryo with echoic structure within uterine fluid was detected on day 21 and the CRL, TD and UD were measured afterwards.

The CRL, TD and UD of fetus by transrectal ultrasonography were measured from 3rd week to 15th week of gestation of teddy goat and results are presented in [Figure 1](#). It was observed that the average crown rump length in pregnant goat was 21.3 ± 0.24 , 8.64 ± 0.14 and 21.55 ± 0.32 mm on 3rd week of gestation, respectively. However, this trend smoothly increased up to 14th week of gestation.

Further analyses showed a wide variation in the weeks of gestation for CRL, TD and UD with a highest coefficient of correlation ($r^2=0.98$; $p<0.01$, $r^2=0.98$; $p<0.01$, $r^2=0.97$; $p<0.01$ respectively) was observed. The relationship between gestation age and the size of CRL from 3rd week up to 15th week was described by the following regression equation ($r^2=0.98$; $p<0.01$): $y=8.39+0.56x$. while, the relationship between gestation age and the TD from 3rd week up to 15th week was described by the following regression equation ($r^2=0.98$; $p<0.01$) $y=2.94+0.276x$. However, the relationship between gestation age and the UD from 3rd week upto 15th week was described by the following regression equation ($r^2=0.97$; $p<0.01$): $y=11.47+0.457x$. [Figure 1](#) shows a linear relationship between CRL, TD, UD and gestation age.

Furthermore, the result of analysis of variance showed that there was highly significant difference in CRL, TD, and UD, among different stages of pregnancy at 5% confidence interval. The images reveal that measurements of CRL of fetus were recorded during the gestation at weekly interval. The measurements were taken from the crown (most upper part of the skull) to the buttocks (end of the sacrum) when fetus was fully extended.

The fetal sex and numbers were determined by transrectal ultrasonography in pregnant goats. The fetal sex from first to twelve pregnant goats were recognized as 09 female and 10 males. Whereas, the fetal numbers from twelve goats were observed as single in five goats and twins in seven goats. No deference was detected in the accuracy of fetal sexing among different type of pregnancies.

The identification of fetal sex by location of the genital tubercle (GT) varied from 6th to 7th week of the gestation, for most of the fetuses (10/19), the GT migration was completed in the 7th week of gestation. For some

fetuses (9/19) the completion of GT migration accrued in the 6th week of the pregnancies.

DISCUSSION

Early pregnancy diagnosis in goats is needed for culling or rebreeding of barren does with minimum necessary delay and it provides a valuable tool in selection of animals for increased fecundity ([Singh et al., 2004](#)). The present study was carried out to determine the accuracy of early pregnancy diagnoses, number of fetuses, gender of fetuses and the gestational age of fetus utilizing measurement of CRL, TD and UD through ultrasonography. The result of present investigations showed that the early pregnancy was detected at the 3rd week (day 19) of gestation of goat through B-mode real time ultrasonography using a 5-10 MHz transducer probe in teddy goats. While in many other studies diagnosed the pregnancy between 4 and 5 weeks after mating of goat through real time ultrasonography by the use of 5.5 MHz trans abdominal transducer ([Taverne, 1984](#); [Baronet and Vaillancourt, 1989](#); [Lavoie and Taverne, 1989](#); [Haibel 1990](#); [Kahn et al., 1992](#); [Hesselink and Taverne, 1994](#)). In present investigation the average CRL of fetus from 21.3 to 69.34 mm was measured in between 3rd to 15th week of gestation by trans-rectal ultrasonography. The results are in agreement with findings reported by [Martinez et al. \(1998\)](#) who found CRL on day 40 as 34.2 ± 0.6 mm. While [Schrick and Inskip \(1993\)](#) reported the CRL as 17.0 ± 2.0 , 25.0 ± 2.0 and 36.0 ± 4.0 mm on day 30, 35 and 40 day, respectively. The difference in ultrasonographic measurements of fetal CRL might be due to different goat breeds, nutritional status and management because previous studies were conducted on large Egyptian native dairy goat ([Amer, 2008](#)) and medium size goat breeds.

In the present study strong positive correlation ($r^2=0.98$; $p<0.01$) between CRL and the gestational age was observed from 3rd (21 days) week to 15th week (105 days) week of gestation. Similar observations ($r^2=0.98$) were also reported by [Kahn et al. \(1992\)](#). However, in another study, [Karen et al. \(2009\)](#) reported that CRL was highly significant correlated ($P \leq 0.0000$; $r^2 0.94$) with the gestational age from 25 to 70 days.

The results of present findings showed that the TD of fetus was in the range of 8.64 to 31.65 from 3rd week (21 days) to 15th week (105 days) of gestation of teddy goat. Further, it was observed that 14.4 mm TD at 41 days of gestation, 18.65 mm at 55 day and 20.54 mm at 61 day of gestation of teddy goats. [Singh et al. \(2004\)](#) reported the TD as 15.2 mm, 21.9 mm and 19.8 mm on day 50, 61 and 64 day, respectively. The difference in TD of fetus might be due to different goat breed. In the present study

strong positive correlation ($r^2=0.98$; $p<0.01$) between TD and the gestational age was observed from 3rd (21 days) week to 15th week (105 days) week of gestation. Similar observations ($r^2=0.98$) were also reported in Merino ewes by [Sergeev *et al.* \(1990\)](#). However, in another study [Gonzalez *et al.* \(1998\)](#) also reported that TD was highly significant correlated ($P\leq 0.0000$; $r^2 0.94$) with the gestational age from 6 weeks to 20 weeks of gestation. Only the study by [Lee *et al.* \(2005\)](#) has evaluated the correlation coefficient ($r^2= 0.89$) between TD and the gestational age in goats between Days 60 to 135 was lower than that obtained in the present study. The difference in intervals of examination (15 vs. 3–5 days, respectively) in the two studies might be the reason.

The results of present findings showed that the UD of fetus was in the range 21.55 ± 0.32 to 60.76 ± 1.41 from 3rd week (21 days) to 15th week (105 days) of gestation of teddy goat. Further, it was observed that 36.65 mm UD at 56 days of gestation, 39.94 mm at 63 day and 53.02 mm at 82 day of gestation of teddy goats. The results are in followed by [Singh *et al.* \(2004\)](#) who found that UD on day 56 as 36.65 mm. While, [Singh *et al.* \(2004\)](#) reported the UD as 39.94, 43.02 and 53.02 mm on day 56, 63 and 82 day, respectively in Jamuna pari goats which are little bit different as compared to present findings which may be due to breed difference, health status or nutrition. In the present study strong positive correlation ($r^2=0.98$) between UD and the gestational age was observed from 3rd (21 days) week to 15th week (105 days) week of gestation.

In this study the period of fetal sexing based on final position of GT (genital tubercle) and the migration of genital tubercle stated that maximum migration was done in 6th and 7th week of gestation and the result of this study was found similar to findings of [Santos *et al.* \(2006\)](#). The sexing of goat fetuses begins only after 7th week of gestation due to wide range of time to completion of genital tubercle migration these observations are supported by [Santos *et al.* \(2006\)](#). In this study the first embryo was detected on day 20 and all embryos were counted accurately until day 23, whereas at least one embryo was identified in day 19 of post breeding but not all embryos counted accurately until day 26 ([Kaulfuss *et al.*, 1996](#); [Schrick and Inskeep, 1993](#)). While another study ([Medan *et al.*, 2004](#)) stated that at 60 days of gestation the fetal number were detected by real-time B-mode ultrasonography which was 91.7% accurate in diagnosis. Overall accuracy of ultrasonography for pregnancy diagnosis of does in the whole experiment, total of 12 does was scanned through ultrasonography for pregnancy diagnosis. All 12 does diagnosed as pregnant and kidded. The sensitivity of the whole experiment reached 100% and the specificity also reached to 100%. More than 95% accuracy of diagnosing pregnant were

reported in ewe ([Grace *et al.*, 1989](#); [Logue *et al.*, 1987](#)) and accuracy of 100% in diagnosing pregnant status was also reported by [White *et al.* \(1985\)](#) in ewe between 50 to 100 days of gestation by using real time ultrasonography.

CONCLUSION

Early diagnosis of pregnancy was detected on 19 day of gestation through transrectal ultrasonography after breeding and all embryos were detected on 23 day, among all the parameters recorded, the trunk was best parameter for determination of gestational age throughout gestational period and fetal sexing was 7th week of gestation period in teddy goats.

ACKNOWLEDGEMENTS

The authors are grateful to the Department of Surgery and Obstetrics, Sindh Agriculture University, Pakistan for providing ultrasound machine for smoothly conducting research and their collaboration in methodological issues and was supported by research fund of Sindh Agriculture University, Pakistan.

Conflict of interest statement

There is no conflict of interest among authors regarding publication of this article.

REFERENCES

- Abdelghafar, R., Ibrhim, M., Abdelrahim, S. and Ahmed, B., 2010. *Sensitivity and specificity of real-time ultrasonography for pregnancy diagnosis and litter size determination in Saanen goats (Capra hircus)*. Proceeding of the 14 th scientific congress. Faculty of Veterinary Medicine, Assuit University, Egypt.
- Amer, H.A., 2008. Determination of first pregnancy and foetal measurements in Egyptian Baladi goats (*Capra hircus*). *Vet. Ital.*, **44**: 429-437.
- Baronet, D. and Vaillancourt, D., 1989. Diagnostic de gestation par échotomographie chez la chèvre. *Méd. Vét. Québec*, **19**: 67-72.
- Buckrell, B., 1988. Applications of ultrasonography in reproduction in sheep and goats. *Theriogenology*, **29**: 71-84. [https://doi.org/10.1016/0093-691X\(88\)90032-5](https://doi.org/10.1016/0093-691X(88)90032-5)
- Curran, S., 1992. Fetal sex determination in cattle and horses by ultrasonography. *Theriogenology*, **37**: 17-21. [https://doi.org/10.1016/0093-691X\(92\)90244-L](https://doi.org/10.1016/0093-691X(92)90244-L)
- Dawson, L.J., 1999. *Pregnancy diagnosis in goats*. Goat FieldDay, Langston University, Langston, United

- Kingdom.
- Doize, F., Vaillancourt, D., Carabin, H. and Belanger, D., 1997. Determination of gestational age in sheep and goats using transrectal ultrasonographic measurement of placentomes. *Theriogenology*, **48**: 449-460. [https://doi.org/10.1016/S0093-691X\(97\)00254-9](https://doi.org/10.1016/S0093-691X(97)00254-9)
- Gonzalez, B.A., Santiago, M.J. and Lopez, S.A., 1998. Estimation of fetal development in Manchega dairy ewes by transrectal ultrasonographic measurements. *Small Rumin. Res.*, **27**: 243-250.
- Grace, N., Beach, A., Quinlivan, T. and Ward, B., 1989. *Multiple pregnancy diagnosis of ewes using real time ultrasonic body scanner and video-fluoroscopy systems*. Proceedings of the New Zealand Society of Animal Production.
- Haibel, G.K., 1990. Use of ultrasonography in reproductive management of sheep and goat herds. The veterinary clinics of North America. *Fd. Anim. Pract.*, **6**: 597-613. [https://doi.org/10.1016/S0749-0720\(15\)30835-5](https://doi.org/10.1016/S0749-0720(15)30835-5)
- Hesselink, J. and Taverne, M., 1994. Ultrasonography of the uterus of the goat. *Vet. Quart.*, **16**: 41-45. <https://doi.org/10.1080/01652176.1994.9694415>
- Humblot, P., De Montigny, G., Jeanguyot, N., Tetedoie, F., Payen, B., Thibier, M. and Sasser, R., 1990. Pregnancy-specific protein B and progesterone concentrations in French alpine goats throughout gestation. *J. Reprod. Fertil.*, **89**: 205-212. <https://doi.org/10.1530/jrf.0.0890205>
- Ishwar, A., 1995. Pregnancy diagnosis in sheep and goats: A review. *Small Rumin. Res.*, **17**: 37-44. [https://doi.org/10.1016/0921-4488\(95\)00644-Z](https://doi.org/10.1016/0921-4488(95)00644-Z)
- Kähn, W., Kähn, B., Richter, A., Schulz, J. and Wolf, M., 1992. Sonography during the pregnancy of sheep. I. Fetometry for the determination of the stage of gestation and prediction of the time of parturition. *DTW. Deut. Tierarztl. Wochensh.*, **99**: 449-452.
- Karen, A.M., Fattouh, E.-S.M. and Abu-Zeid, S.S., 2009. Estimation of gestational age in Egyptian native goats by ultrasonographic fetometry. *Anim. Reprod. Sci.*, **114**: 167-174. <https://doi.org/10.1016/j.anireprosci.2008.08.016>
- Kaulfuss, K., Zipper, N., May, J. and Suess, R., 1996. Pregnancy diagnosis by B-mode ultrasonography in sheep. Part 2: Comparison of transcutaneous and transrectal diagnosis. *Tieraerztl. Praxis.*, **24**: 559-566.
- Kuthu, Z., Javed, K., Babar, M., Sattar, A. and Abdullah, M., 2013. Environmental effects on growth traits of Teddy goats. *JAPS, J. Anim. Pl. Sci.*, **23**: 692-698.
- Lavoir, M. and Taverne, M., 1989. *The diagnosis of pregnancy and pseudopregnancy and the determination of foetal numbers of goats, by means of real-time ultrasound scanning: Diagnostic ultrasound and animal reproduction*. Springer. pp. 89-96. https://doi.org/10.1007/978-94-017-1249-1_8
- Lee, Y., Lee, O., Cho, J., Shin, H., Choi, Y., Shim, Y., Choi, W., Shin, H., Lee, D. and Lee, G., 2005. Ultrasonic measurement of fetal parameters for estimation of gestational age in Korean black goats. *J. Vet. med. Sci.*, **67**: 497-502. <https://doi.org/10.1292/jvms.67.497>
- Logue, D., Hall, J., McRoberts, S. and Waterhouse, A., 1987. Real-time ultrasonic scanning in sheep: The results of the first year of its application on farms in south-west Scotland. *Vet. Rec.*, **121**: 146-149. <https://doi.org/10.1136/vr.121.7.146>
- Martinez, M., Bosch, P. and Bosch, R., 1998. Determination of early pregnancy and embryonic growth in goats by transrectal ultrasound scanning. *Theriogenology*, **49**: 1555-1565. [https://doi.org/10.1016/S0093-691X\(98\)00101-0](https://doi.org/10.1016/S0093-691X(98)00101-0)
- Medan, M., Watanabe, G., Absy, G., Sasaki, K., Sharawy, S. and Taya, K., 2004. Early pregnancy diagnosis by means of ultrasonography as a method of improving reproductive efficiency in goats. *J. Reprod. Dev.*, **50**: 391-397. <https://doi.org/10.1262/jrd.50.391>
- Murray, R. and Newstead, R., 1988. Determination of steroid hormones in goats' milk and plasma as an aid to pregnancy diagnosis using an ELISA. *Vet. Rec.*, **122**: 158-161. <https://doi.org/10.1136/vr.122.7.158>
- Refsal, K., Marteniuk, J., Williams, C. and Nachreiner, R., 1991. Concentrations of estrone sulfate in peripheral serum of pregnant goats: relationships with gestation length, fetal number and the occurrence of fetal death in utero. *Theriogenology*, **36**: 449-461. [https://doi.org/10.1016/0093-691X\(91\)90474-R](https://doi.org/10.1016/0093-691X(91)90474-R)
- Richardson, C., 1972. Diagnosis of pregnancy in the ewe by vaginal biopsy. *Br. Vet. J.*, **128**: 316-330. [https://doi.org/10.1016/S0007-1935\(17\)36937-3](https://doi.org/10.1016/S0007-1935(17)36937-3)
- Santos, M., Moura, R., Chaves, R., Soares, A., Neves, J., Reichenbach, H., Lima, P. and Oliveira, M., 2006. Sexing of Boer goat fetuses using transrectal ultrasonography. *Anim. Reprod.*, **3**: 359-363.
- Santos, M., Rabelo, M., Guido, S., Torreão, J., Júnior, E.L., Freitas, V., de Lima, P. and Oliveira, M., 2006. *Determination of the genital tubercle migration in Morada Nova sheep fetuses by real time ultrasonography*. Diagnóstico precoce do sexo

- fetal de caprinos e ovinos pela ultra-sonografia. pp. 70.
- Schrick, F. and Inskip, E., 1993. Determination of early pregnancy in ewes utilizing transrectal ultrasonography. *Theriogenology*, **40**: 295-306. [https://doi.org/10.1016/0093-691X\(93\)90267-9](https://doi.org/10.1016/0093-691X(93)90267-9)
- Sergeev, L., Klemann, D., Walker, S., Smith, D., Grosser, T., Mann, T. and Seamark, R., 1990. Real-time ultrasound imaging for predicting ovine fetal age. *Theriogenology*, **34**: 593-601. [https://doi.org/10.1016/0093-691X\(90\)90014-K](https://doi.org/10.1016/0093-691X(90)90014-K)
- Singh, N., Gawande, P., Mishra, O., Nema, R., Mishra, U. and Singh, M., 2004. Accuracy of ultrasonography in early pregnancy diagnosis in doe. *Asian Aust. J. Anim. Sci.*, **17**: 760-768. <https://doi.org/10.5713/ajas.2004.760>
- Stroud, B., 1996. Using ultrasonography to determine bovine fetal sex. *Vet. Med.*, **91**:663-672.
- Taverne, M., 1984. *Gebruik van linear-array real-time echografie in de veterinaire verloskunde en gynaecologie*. Tijdschrift voor diergeneeskunde.
- White, I., Russel, A., Wright, I. and Whyte, T., 1985. Real-time ultrasonic scanning in the diagnosis of pregnancy and the estimation of gestational age in cattle. *Vet. Rec.*, **117**: 5-8. <https://doi.org/10.1136/vr.117.1.5>

Online First Article