



## Sonographic Changes during Postpartum Uterine Involution in Sahel Goats (*Capra hircus*)

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### ABSTRACT

The use of ultrasonography as diagnostic tool is crucial in animal reproduction especially in pregnancy diagnosis and can be useful in the assessment of postpartum uterine involution. Uterine involution in does has been described using macroscopic and histological examination post-mortem. The present study was carried out to determine the time of uterine involution in live Sahel goats by measuring the uterine diameter using ultrasonography. A total of 35 non-pregnant does were estrus synchronized using 2 intramuscular injection cloprostenol (250µg/kg) at 11 days interval. All the does that came into estrus after the second treatment were allowed to run free with five bucks. Pregnancy was determined by ultrasonography and the does were monitored until successful parturition. It was found that the diameter of the uterus decreased from 88.6-118 mm on day 1 postpartum to 80.8-88.6 mm, 55.3-80.8, 45.6-55.3, 39.0-45.6 mm and 24.0-39.0 mm diameters on days 3, 7, 14, 21 and 28 postpartum respectively. In conclusion, postpartum uterine involution in Sahel does was completed by day 28 postpartum. This finding suggests that breeding of Sahel does can be considered after 28 days postpartum, particularly, in circumstances where suckling of the kids is not practicable or desired.

**Keywords:** Postpartum; Sahel goats; Ultrasonography; Uterine involution

### INTRODUCTION

The Sahel goat accounts for the third largest population of goats in Nigeria and is noted for its potential in promoting livestock development in the country (Igbokwe *et al.*, 1998; Maina *et al.*, 2006). The characteristic features of the Sahel goats are commonly found thriving well in the arid and semi-arid regions of the North East and some parts of the Sudan savannah in Nigeria. Amongst the Sahel goats, there are several ecotypes (Kwari, 2001), but the Borno white are typically recognized by their physical manifestations and productivity (Igbokwe *et al.*, 1998; Kwari *et al.*, 2004; Maina *et al.*, 2006). Their economic importance is increasing globally (Luikart *et al.*, 2001) because they are cheap and efficient sources of meat, milk, hide and skin (Morand-Fehr and Lebbie, 2004).

Postpartum period is one of the critical aspects of enhancing reproductive efficiency and breeding in animals. This period is characterized by uterine involution and restoration of ovarian activity, which are necessary for the establishment of subsequent pregnancy. Uterine involution has been defined as the process by which the postpartum uterine diameter is returned to its original non-pregnant size in a normally cycling

animal (Takayama *et al.*, 2010). Completion of uterine involution and resumption of sexual activity following parturition in ruminants normally depends on several factors such as nutrition, nursing of offspring and season of parturition (Delgadillo *et al.*, 1998; Yavas and Walton, 2000). However, evaluation of these changes in the uterus can be done by various techniques, one of which is ultrasonography. The ability of ultrasound to distinguish fluid from soft tissue and differentiate between soft tissues based on their composition makes it better option than radiography for examining soft tissue structures (Nyland and Mattoon, 2002).

The application of the ultrasound technique is generally acceptable in mammalian species, and it is a form of non-ionizing energy (Scott *et al.*, 2012, Steininger and Braun, 2012). It is different from X-rays, known to damage tissues because of their ionizing effect on living cells (Medan and Abd El-Aty, 2010)

The use of ultrasonography to study postpartum uterine involution in some goat breeds had been described previously (Hauser and Bostedt, 2002; Zdunczyk *et al.*, 2004; Ababneh and Degefa, 2005). Generally, two or three-dimensional

ultrasonography is performed to determine the length and width of the uterus (Sokol *et al.*, 2004), as well as uterine volume postpartum (Weissmann-Brenner *et al.*, 2013). Ultrasonography has thus been proven to be an excellent technique for the detection of early postpartum uterine involution as well as uterine involution complications in women, sows, dairy cows, Camel (Vyas and Sahani, 2000; Aslan *et al.*, 2002; Ferretti, 2000; Derar *et al.*, 2014; Meile *et al.*, 2020; Yuxin Lin *et al.*, 2020; Reshma *et al.*, 2020).

Ultrasonography plays a key role to differentiate the normal or abnormal postpartum uterus and in early diagnosis of any abnormal condition related to the uterus (Feldman and Nelson, 1996). Uterine evaluation such as in the case of involution or torsion is a challenging diagnosis in ruminants because vaginal examination is restricted by the narrow diameter of the reproductive tract and will not identify a detailed description of the body of the uterus cranial to the cervix (Wehrend *et al.*, 2002). Also, the application of transabdominal ultrasound examination of the uterine wall as close to the cervix as possible (ventral midline immediately cranial to the pelvic brim with the probe head directed vertically) as a non-invasive means of detecting uterine torsion in sheep has been described (Wehrend *et al.*, 2002). Macroscopic and microscopic evaluations of uterine involution in ewes was evaluated recently (Gazali *et al.*, 2023), but its major disadvantage is that the uterine and samples are collected and evaluated postmortem. Thus, this study was undertaken to evaluate the postpartum uterine involution using ultrasonography in Sahel goats

## METHODOLOGY

### Animals

A total of thirty-five healthy reproductive Sahel does and five bucks were purchased from the Kasuwan Shanu livestock market in Maiduguri. The animals weigh between 30-40kg, and aged between 2 to 3 ½ and 3 to 3 ½ respectively. They were kept at the large animal unit of the University of Maiduguri Veterinary Teaching Hospital. The animals were acclimatised for two weeks and managed intensively during which they were treated for haemo and gastrointestinal parasites. They were fed with wheat offal, bean husks, and groundnut hay, salt licks and water were provided ad libitum. The does were synchronized using cloprostenol (Estrumate®, Schering Trough Animal, Germany) at 250µg/kg intramuscularly at 11-day intervals. The second dose was given at day 11<sup>th</sup> and the does came on heat (estrus) after the second treatment and were allowed to be served naturally by the bucks of the proven fertility. Pregnancy was determined by ultrasonography according to method described by (Taverne and Willemse, 1989). The welfare of the does were managed adequately throughout the gestation period. At the end of the gestation period, the does were separated into groups by assigning them randomly on postpartum days 1, 3, 7, 14, 21 and 28 to undergo ultrasonographic examination of the uterus.

## Ultrasonography

Ultrasonographic examination of the uterus was performed in all does on days 1,3,7,14, 21 and 28 postpartum according to the method described by Taverne and Willemse (1989). This was carried out to measure the diameter of the involuting uterine lumen using a real-time B-mode ultrasound scanner Falco® 100 (Pic Medical; Holland) equipped with a linear-array transducer frequency of 7.5 MHz (Sony Sao Paulo, Brazil). The equipment also has a built-in caliper for measurements. The does were physically restrained in a standing position with the help of two assistants. Thereafter, probe was lubricated using carboxyl-methyl cellulose gel and gently placed on the abdomen. The transducer was moved medially and laterally for the best view of the specific uterus, where the maximum diameter (in millimeters) of the involuting uterus was measured. Uterine involution was considered to be completed when there was no further reduction in the uterine diameter with absence of lochia in the uterus (Zdunczyk *et al.* 2004).

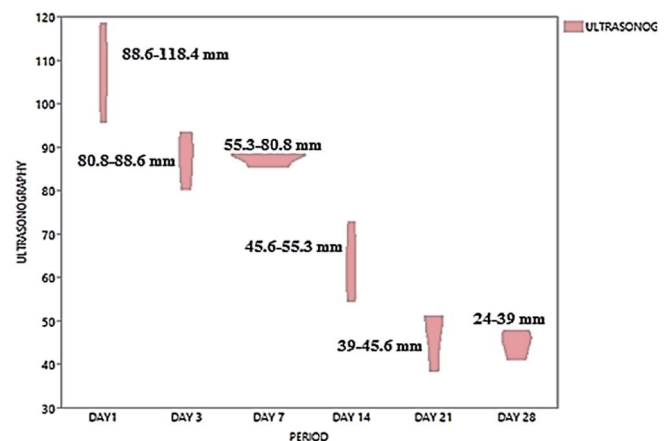
## Statistical Analysis

The data obtained were analysed using descriptive statistics (Graphs pad) and Analysis of variance (ANOVA) were used to differentiate between the variables, Turkey Kramer as post-hoc test with JMP version 11 software (SAS Institute Inc, Cary, NC) were also used,  $p < 0.05$  were considered statistically significant.

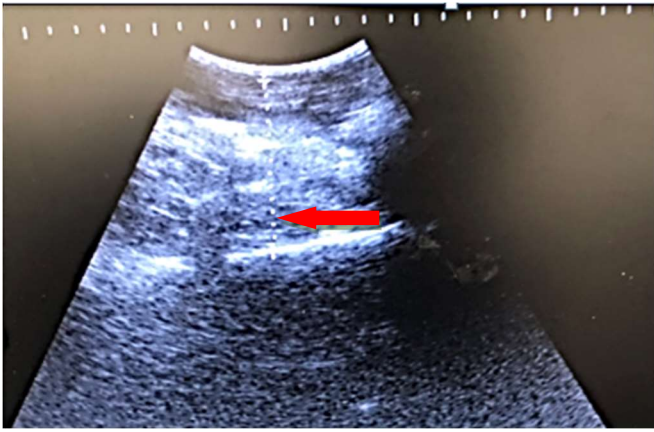
## RESULTS

Postpartum uterine involution using ultrasonography during days 1, 3, 7, 14, 21, and 28 in Sahel goats is presented in Figure 1. The does showed decrease in the uterine diameter. The diameter ranged from 88.6-118.4 mm, 80.8-88.6 mm, 55.3-80.8 mm, 45.6-55.3 mm, 39-45.6 mm and 24-39 mm on days 1, 3, 7, 14, 21 and 28 postpartum respectively.

There was a significant ( $p < 0.05$ ) decrease in the uterus from day 1-7 postpartum with a gradual decrease during days 14 and 21 and a complete decrease on day 28 postpartum to a non-pregnant size (Figure 1).



**Figure 1:** Diameter of the uterus during days 1, 3, 7, 14, 21, and 28 postpartum uterine involutions in Sahel goats



**Plate 1:** Sonogram of uterus of Sahel goat showing built-in caliper-measurement of diameter postpartum uterine involution (arrow).

## DISCUSSION

The uterus experiences considerable enlargement and distortion of tissues and intensive glandular development to accommodate and nourish the developing fetus to term. For breeding and pregnancy to occur, the uterus must undergo gross anatomical changes together with extensive remodelling and changes in tissue mass and function during the postpartum period (Hunter, 1980; Sanchez *et al.*, 2002). During uterine involution, uterine contractions, and weight loss in the uterus, reduction in size, and loss of tissue fluid occur more rapidly and these processes start to slow down afterward (Hunter, 1980; Baru *et al.*, 1983; Mwaanga and Janowski, 2000; Sanchez *et al.*, 2002). Similarly, ultrasonography has been used to monitor uterine involution post-partum, which was delayed in ewes after manual correction of dystocia and cesarean section (Hauser and Bostedt, 2002). Uterine evaluation such as in the case of involution or torsion is a challenging diagnosis in ruminants because vaginal examination is restricted by the narrow diameter of the reproductive tract and will not identify a detailed description of the body of the uterus cranial to the cervix (Wehrend *et al.*, 2002).

In the present study, the overall interval for complete uterine involution using ultrasonography was 28 days. The diameter of the uterine lumen decreased gradually from day 1 until day 28 postpartum. Therefore, ultrasonographic uterine involution in the Sahel does was completed at 28 days postpartum. The regression was rapid between days 1-14 postpartum but steadier from days 21-28 postpartum. This agrees with the report of Badawi *et al.* (2014) who reported a rapid decline in uterine diameter from day 3-14 postpartum but more steadily from day 17-27 postpartum stating that, more than 50% of the size of the uterus was regressed in Nubian goats. A similar observation was also reported in sows (Meile *et al.*, 2020). However, the two reports are in disagreement with Hayder and Ali (2008) who reported an enormous decrease in the uterine diameter (more than 50%) during the first week of parturition in Farafra sheep. Though, the findings of Hauser and Bostedt (2002) was in close agreement with the present study that reported more than 80% uterine involution occurred during the first 11 days postpartum in German sheep. Ababneh and Degefa (2005) reported that the majority of uterine involution occurred during first week of parturition in Balady goats. Lochia was observed during the 1-14 days postpartum in the endometrium and this is in agreement with

the report of Hauser and Bostedt (2002), and Zdunczyk *et al.* (2004) as well as Ababneh and Degefa (2005) in sheep. The fast reduction in the diameter of the uterus during the early postpartum is associated with a response to myometrial contraction which plays a major role in clearing lochial debris after parturition.

The end of the uterine involution in Sahel goats was determined at approximately 28 days postpartum in the present study. This agrees with Hayder and Ali (2008) in Farafra ewes that lambed in October, and involution occurred at  $28.72 \pm 1.0$  days postpartum which is slightly shorter than ewes that lambed in February ( $29.42 \pm 1.2$ ) and in June ( $33.85 \pm 1.1$  days). According to Van Niekerk (1976), complete uterine involution occurred in ewes mostly between 28 and 35 days after parturition. It is also in agreement with the report of Greyling (2000) and Enginler *et al.* (2017) whom stated that complete uterine involution in slaughtered animals is 28 days, the mean involution period in single and twin saturated does to be  $27.10 \pm 0.43$  and  $28.29 \pm 0.54$  days respectively, and complete uterine involution in goats occurred within 28 days postpartum. The current study is also in close agreement with previous reports (Baru *et al.*, 1983; Tian and Noakes, 1991; Sanchez *et al.*, 2002; Ababneh and Degefa, 2005; Takayama *et al.*, 2010; Zongo *et al.*, 2014; Medan and El-Daek, 2015) but is in contrast with the report of others (Rubianes *et al.*, 1996; Zdunczyk *et al.*, 2004; Fernandes *et al.*, 2013; Fasulkov, 2014; Ahmed *et al.*, 2016; Souhayla *et al.*, 2016) who observed the end of uterine involution after 30 days. Shorter days postpartum (16 days) period was also reported by Sanchez *et al.* (2002) in does, Lin *et al.*, 2021 in Chinese Holstein dairy cow for all the parity and Samir *et al.* (2023) in Egyptian Balady goats. However, El-Hassan *et al.* (2009) reported a much longer duration (148 days) of the postpartum period in the Nubian breed, likewise, Greyling (2000) also reported that in Boer goats, Freitas *et al.* (2004) in Anglo-Nubian Saanen, and Atta *et al.* (2012) in Nilotic goats. The difference in time required for a complete uterine involution, may be attributed to breed, season of parturition, reproductive status, and methods used in collecting the samples.

## Conclusion

The use of ultrasonography to monitor uterine involution in Sahel goats showed that the uterine involution was completed by day 28 postpartum. This is usually around the period of first postpartum estrus in the goats. It is therefore recommended that breeding of Sahel the does can be considered after 28 days postpartum, particularly, in circumstances where suckling of the goat kids is not practicable or desired.

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## Author's Contributions

YM conceptualized and interpreted the result, HDK, MZ and SOA read and reviewed the manuscript. KAS analyzed the result. MMB carried out the ultrasonography.

**Conflict of Interest**

The authors have no conflict of interest to declare.

**REFERENCES**

- Ababneh, M.M. and Degefa, T. (2005). Ultrasonic assessment of puerperal uterine involution in Balady goats. *Journal of Veterinary Medicine. A, Physiology, Pathology, Clinical Medicine*: 52(5):244-8. doi: 10.1111/j.1439-0442.2005.00718.x. PMID: 15943609.
- Ahmed, M., Ynzeel, J. and Majeed, A. (2016). Ultrasonographic study of uterine involution in Awassi ewes in Iraq. *Al-Anbar Journal of Veterinary Sciences*, 9(1), 16-21.
- Aslan, S., Findik, M., Erunal-Maral, N., Kalender, H. and Celebi, M.S.E. (2000). Comparison of Various examination methods used in ovarian diagnostics in cattle. *Journal of Reproduction and Fertilization.*, 54: 483-493. PMID: 10916937.
- Atta, M., Zeinelabdeen, W., El Khidir, O. and Adam, A. (2012). Reproductive performance of Sudan Nilotic does fed pelleted molasses and mash sorghum based diets. *Small Ruminant Research*, 104(1-3), 99-103. <https://doi.org/10.1016/j.smallrumres.2011.10.010>
- Badawi, M. E., Makawi, S. E. A., Abdelghafar, R. M. and Ibrahim, M. T. (2014). Assessment of postpartum uterine involution and progesterone profile in Nubian goats (*Capra hircus*). *Journal of Advanced Veterinary and Animal Research*, 1(2), 36-41. DOI: 10.5455
- Baru, P., Khar, S., Gupta, R. and Luthra, R. (1983). Uterine involution in goats. *Veterinary Medicine & Small Animal Clinician*, 78(11), 1773-1776.
- Delgadillo, J.A, Flores, J.A, Villarreal, O., Flores, M.J, Hoyos, G., Chemineau, P., Malpoux, B. (1998). Length of postpartum anestrus in goats in subtropical Mexico: effect of season of parturition and duration of nursing. *Theriogenology*.15; 49(6):1209-18. doi: 10.1016/s0093-691x(98)00068-5. PMID: 10732058.
- El-Hassan, K., El-Abid, K. E., and Abu Nikhaila, A. M. A. (2009). A study on some non-genetic factors and their impact on some reproductive traits of Sudanese Nubian goats. *International Journal of Dairy Science*, 4, 152-158. Doi: 10.3923/ijds.2009.152.158
- Enginler, S. Ö., Sandal, A. İ., Erzençin, Ö. M., Yüksel, H., Ertürk, E., Doğan, N., Özdaş, Ö. B., Gündüz, M. C. and Baran, A. (2017). Effects of Gestation Type and Parity on Uterus Involution in Saanen Does. *Animal Health Production and Hygiene*, 3(1), 288-293.
- Fasulkov, I. (2014). Ultrasonography of uterine involution in goats. *Journal of the Faculty of Veterinary Medicine Istanbul University*, 40(1): 63-69.
- Fernandes, C. E., Cigerza, C. F., Pinto, G., Miazzi, C., Barbosa-Ferreira, M., and Martins, C. F. (2013). Parturition characteristics and uterine involution in native sheep from Brazilian pantanal. *Ciência Animal Brasileira*, 14(2): 245-252. DOI: 10.5216/cab.v14i2.17926
- Freitas, V., Rondina, D., Nogueira, D. and Simplicio, A. (2004). Post-partum anoestrus in Anglo-Nubian and Saanen goats raised in semi-arid of North-eastern Brazil. *Livestock Production Science*, 90(2-3), 219-226. <https://doi.org/10.1016/j.livprodsci.2004.06.005>
- Gazali, Y. A., Gambo, B. G., Zakariah, M., and Sonfada, M. L. (2023). Morphological characteristics of the placenta of Balami and Yankasa ewes at different stages of gestation in Maiduguri, Nigeria. *Sokoto Journal of Veterinary Sciences*, 21(1), 11-20.
- Greyling, J. (2000). Reproduction traits in the Boer goat doe. *Small Ruminant Research*, 36(2), 171-177. [https://doi.org/10.1016/S0921-4488\(99\)00161-3](https://doi.org/10.1016/S0921-4488(99)00161-3)
- Hauser, B. and Bostedt, H. (2002). Ultrasonographic observations of the uterine regression in the ewe under different obstetrical conditions. *Journal of Veterinary Medicine Series A*, 49(10), 511-516. <https://doi.org/10.1046/j.1439-0442.2002.00496.x>
- Hayder, M. and Ali, A. (2008). Factors affecting the postpartum uterine involution and luteal function of sheep in the subtropics. *Small Ruminant Research*, 79, 174-178. <https://doi.org/10.1016/j.smallrumres.2008.07.023>
- Hunter, R. H. (1980). *Physiology and technology of reproduction in female domestic animals*: Academic Press. <https://doi.org/10.1016/j.smallrumres.2008.07.023>
- Hussain, S.O., Hussain, K.A. and Al-Ani, A.A. (2016). Study on post-partum uterine involution by Ultrasonography and progesterone profile in local goats in Iraq. *The Iraqi Journal of Veterinary Medicine*, 40(1), 151-156.
- Igbokwe, I. O., Ribadu, A. Y. and Bukar, M. M. (1998). Erythrocyte glutathione concentrations in Nigerian Sahel goats. *Small Ruminant Research*, 30, 1-6. [https://doi.org/10.1016/S0921-4488\(98\)00089-3](https://doi.org/10.1016/S0921-4488(98)00089-3)
- Igbokwe, N., Sandabe U. K., Sanni, S., Wampana, B., Wiam, I.M. and Igbokwe, I.O. (2018). Aqueous stem-bark extract of *Ficus viciifolia* increases sperm production and pH of sperm microenvironment in growing albino rat. *Animal Reproduction*, 6(4), 509-515.
- Kwari, H. (2001). A morphological Study of the Ecotypes of Sahel Goats in Borno State with special reference to Sexual Dimorphism. *A PhD Thesis, Department of Veterinary Anatomy, Faculty of Medicine, University of Maiduguri, Borno State Nigeria.*
- Kwari, H. D., Sivachelvan, M.N. and G.A., C. (2004). Characterization of Sahel goats in Borno State, Nigeria for certain qualitative traits *Nigerian Journal of Experimental Applied Biology*, 5, 151-154.
- Lin, Y., Yang, H., Ahmad, M.J., Yang, Y., Yang, W., Riaz, H., Abulaiti, A., Zhang, S., Yang, L. and Hua, G. (2021). Postpartum uterine involution and embryonic development pattern in Chinese Holstein dairy cows. *Frontiers in Veterinary Science*, 7, 604729. <https://doi.org/10.3389/fvets.2020.604729>
- Luikart, G., Gielly, L., Excoffier, L., Vigne, J.-D., Bouvet, J. and Taberlet, P. (2001). Multiple maternal origins and weak phylogeographic structure in domestic goats. *Proceedings of the National Academy of Sciences*, 98(10), 5927-5932. <https://doi.org/10.1073/pnas.091591198>



- Maina, V., Chaudhari, S. and Mshelia, G. (2006). Spermogram of the white ecotype of Sahel bucks in Maiduguri Metropolis. *Pakistan Journal of Biological Sciences*, 9(2), 307-309.
- Medan, M. S. and Abd El-Aty, A. M. (2010). Advances in ultrasonography and its applications in domestic ruminants and other farm animals reproduction. *Journal of Advanced Research*, 1(2), 123-128. <https://doi.org/10.1016/j.jare.2010.03.003>
- Meile, A., Nathues, H., Kauffold, J. and Grahofner, A. (2020). Ultrasonographic examination of postpartum uterine involution in sows. *Animal Reproduction Science*, 219, 106540. <https://doi.org/10.1016/j.anireprosci.2020.106540>
- Morand-Fehr, P. and Lebbie, S. (2004). Proposals for improving the research efficiency in goats. *Small Ruminant Research*, 51(2), 145-153., 35(5), <https://doi.org/10.1016/j.smallrumres.2003.08.012>
- Mwaanga, E.S. and Janowski, T., 2000. Anoestrus in dairy cows: causes, prevalence and clinical forms. *Reproduction in domestic animals*, 35(5), pp.193-200. <https://doi.org/10.1046/j.1439-0531.2000.00211.x>
- Nyland T.G. and Mattoon J.S. (2002) Small Animal Diagnostic Ultrasound. 2nd ed. Philadelphia: WB Saunders
- Mwaanga, E. and Janowski, T. (2000). Anoestrus in dairy cows: causes, prevalence and clinical forms. *Reproduction in Domestic Animals*
- O'shea, J. D. and Wright, P. J. (1984). Involution and regeneration of the endometrium following parturition in the ewe. *Cell and Tissue Research*, 236, 477-485. <https://doi.org/10.1007/BF00214253>
- Reshma, A., Sathiamoorthy, T., Sridevi, P., Tirumurugaan, KG and Balagangatharathilagar, M. (2020). Ultrasonography of Uterine Involution in normal and metritis affected postpartum cows. *Journal of Entomology and Zoology Studies*, 8(3): 1823-1826.
- Rubianes, E., Ungerfeld, R., Vinales, C., Carbajal, B., Castro, T. D. and Ibarra, D. (1996). Uterine involution time and ovarian activity in weaned and suckling ewes. *Canadian Journal of Animal Science*, 76(1), 153-155. <https://doi.org/10.4141/cjas96-022>
- Samir, H., Radwan, F., El-Khawagah, A.R., Kandiel, M., El Sayed, M.A., Elfadany, A., Karen, A. and El-Sherbiny, H.R. (2023). Ultrasonography and computer-assisted assessment of postpartum uterine echotexture and its relationship with peripheral oxidative stress biomarkers in goats. *Small Ruminant Research*, 221, p.106947. <https://doi.org/10.1016/j.smallrumres.2023.106947>
- Sanchez, M., Garcia, P., Menendez, S., Sanchez, B., Gonzalez, M. and Flores, J. (2002). Fibroblastic growth factor receptor (FGF-R) expression during uterine involution in goat. *Animal Reproduction Science*, 69(1-2), 25-35. [https://doi.org/10.1016/S0378-4320\(01\)00169-5](https://doi.org/10.1016/S0378-4320(01)00169-5)
- Scott, P. R. (2012). Applications of diagnostic ultrasonography in small ruminant reproductive management. *Animal Reproduction Science*, 130(3-4), 184-186. <https://doi.org/10.1016/j.anireprosci.2012.01.013>
- Sokol, E.R., Casele, H., and Haney, E.I. (2004). Ultrasound examination of the postpartum uterus: what is normal? *Journal of Maternal, Fetal and Neonatal Medicine*. 15(2), 95-99. <https://doi.org/10.1080/14767050310001650798>
- Steininger, K. and Braun, U. (2012). Ultrasonography of the urinary tract in 29 female Saanen goats. *Schweiz Arch Tierheilkd*, 154(2), 67-74.
- Takayama, H., Tanaka, T. and Kamomae, H. (2010). Postpartum Ovarian activity and Uterine Involution in non-seasonal Shiba goats, with or without nursing. *Small Ruminant Research*, 88(1), 62-86. <https://doi.org/10.1016/j.smallrumres.2009.11.001>
- Taverne, M. A. and Willemsse, A. H. (Eds.). (1989). *Diagnostic ultrasound and animal reproduction*. Kluwer Academic. <https://doi.org/10.1007/978-94-017-1249-1>
- Tian, W. and Noakes, D. (1991). A radiographic method for measuring the effect of exogenous hormone therapy on uterine involution in ewes. *The Veterinary Record*, 129(21), 463-466. <https://doi.org/10.1136/vr.129.21.463> PMID: 1763467
- Van Niekerk, C. H. (1976). Limitations to female reproductive efficiency. *Sheep Breeding, West Australian Institute of Technology*, 303-314.
- Vyas, S. and Sahani, M. S. (2000). Real-time ultrasonography of ovaries and breeding of the one-humped camel (*Camelus dromedarius*) during the early postpartum period. *Animal Reproduction Science*, 59(3-4), 179-184. [https://doi.org/10.1016/S0378-4320\(00\)00118-4](https://doi.org/10.1016/S0378-4320(00)00118-4)
- Watanagana, T., Phithakwatchara, N., Komoltri, C., Tantisirin, P., Pooliam, J., Titapant, V. (2015). Functional three-dimensional sonographic study of the postpartum uterus. *Journal of Maternal, Fetal and Neonatal Medicine*. 28, 2221-2227. <https://doi.org/10.3109/14767058.2014.983063>
- Weissmann-Brenner, A., Haas, J., Barzilay, E., Gilboa, Y., Gat, I., Gindes, L., Mashlach, R., Achiron, R. and Dulitski, M. (2013). Added value of 3-dimensional sonography for endometrial evaluation in early puerperium. *Journal of Ultrasound Medicine*. 32(4), 587-592. <https://doi.org/10.7863/jum.2013.32.4.587>
- Wehrend, A., Bostedt, H. and Burkhardt, E. (2002). The use of trans-Abdominal B mode ultrasonography to diagnose intra-partum uterine torsion in the ewe. *Veterinary Journal*. 164(1), 69-70. [doi:10.1053/tvj.2002.073](https://doi.org/10.1053/tvj.2002.073)
- Yotov, S. (2007). *Early pregnancy diagnostics and determination of offspring number and gender in sheep*. (Doctoral dissertation, PhD thesis, Stara Zagora.
- Zdunczyk, S., Milewski, S., Baranski, W., Janowski, T., Szczepanski, W., Jurczak, A., Ras, A. and Lesnik, M. (2004). Postpartum uterine involution in primiparous and pluriparous polish longwool sheep monitored by ultrasonography. *Bulletin-Veterinary Institute in Pulawy*, 48(3), 255-258.
- Zongo, M., Traoré, B., Ababneh, M. M., Hanzen, C. and Sawadago, L. (2014). Ultrasonographic assessment of uterine involution and ovarian activity in West African Sahelian goats. *Journal of Veterinary Medicine and Animal Health*, 7(2), 71-76. DOI: 10.5897/JVMAH2014.0322