Pakistan Veterinary Journal

ISSN: 0253-8318 (PRINT), 2074-7764 (ONLINE)
Accessible at: www.pvj.com.pk

RESEARCH ARTICLE

Corpora Lutea Diameter, Plasma Progesterone Concentration and Follicular Development in $PGF_{2\alpha}$ and CIDR Estrus Synchronized Goats

M. M. Bukar[1, 2], Y. Rosnina[1]*, O. M. Ariff[1], H. Wahid[1], G. K. Mohd Azam Khan[3], N. Yimer[1] and G. K. Dhaliwal[1]

[1]Department of Veterinary Clinical Studies, Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia; [2]Department of Veterinary Surgery and Theriogenology, Faculty of Veterinary Medicine, University of Maiduguri, Maiduguri, Nigeria; [3]Faculty of Veterinary Medicine, Universiti Malaysia Kelantan,16100 Kota Bharu, Kelantan, Malaysia

*Corresponding author: rosnina@vet.upm.edu.my; yrosnina@yahoo.com

ARTICLE HISTORY

Received: September 21, 2011
Revised: October 14, 2011
Accepted: October 29, 2011

Key words:
CIDR
Corpus luteum
Follicles
Goats
$PGF_{2\alpha}$
Ultrasonography

ABSTRACT

The current study compares the number and diameter of the corpora lutea (CL), plasma progesterone concentrations and follicular development in $PGF_{2\alpha}$ and CIDR synchronized estrus cycle, their subsequent estrus cycles, and in unsynchronized, naturally cycling Boer x Feral crossbred goats. The $PGF_{2\alpha}$ group was synchronized with a double intramuscular injection of 125 µg cloprostenol 11 days apart, the progesterone group was synchronized with CIDR left in place for 17 days, while the third group was not synchronized and served as control. All the estrus synchronized goats ovulated and formed normal CL while 25% in the subsequent estrus cycle and 50% of the naturally cycling goats did not ovulate and hence might be a cause of reduced fertility in the goats. The diameter of the CL, and the plasma progesterone concentration between the $PGF_{2\alpha}$ synchronized (11.9±0.5 mm; 3.51±0.19 ng/ml) and their subsequent estrus cycle (12.0±0.4 mm; 3.22±0.71 ng/ml), as well as between CIDR synchronized (12.3±0.4 mm; 5.98±1.11 ng/ml) and subsequent estrus cycle (12.5±0.8 mm; 4.25±1.37 ng/ml) were not significantly different (P>0.05) but were higher than in the unsynchronized goats (9.3±3.8 mm; 2.99±s1.64 ng/ml). The day of emergence and duration of follicular waves, as well as the maximum diameter attained by the largest follicle in the follicular waves was unaffected irrespective of whether $PGF_{2\alpha}$ or CIDR was used for estrus synchronization. This indicated that the morphology and function of the CL did not influence these aspects of follicular development in non-seasonally polyestrus Boer crossbred goats in the humid tropics.

To Cite This Article: Bukar MM, Y Rosnina, OM Ariff, H Wahid, GKMA Khan, N Yimer and GK Dhaliwal, 2012. Corpora lutea diameter, plasma progesterone concentration and follicular development in $PGF_{2\alpha}$ and CIDR estrus synchronized goats. Pak Vet J, 32(2): 216-220.

INTRODUCTION

The use of real-time ultrasonographic techniques to monitor the pattern of antral follicular development in cattle and goats has increased the understanding of the dynamics of follicular development, growth, dominance and atresia as well as the ovulatory process (Simoes *et al.*, 2006; Aerts and Bols, 2010). In goats, the first description on the pattern of antral follicular development during estrus cycle was reported by Ginther and Kot (1994). Later, the patterns of antral follicular development during interovulatory intervals were described in goats synchronized with either intravaginal progestagen sponges (Fernandez-Moro *et al.*, 2008) or two injections of prostaglandin ($PGF_{2\alpha}$) (Simoes *et al.*, 2006; Vazquez *et al.*, 2010). These previous studies showed that the methods of estrus synchronization (synch) resulted in morphological and functional changes in the induced CL, thus affected the subsequent follicular development during the interovulatory interval.

The ultrasonographic appearance of a corpus luteum is a reliable parameter that could be used to assess luteal function in goats (Orita *et al.*, 2000; Simoes *et al.*, 2007). Vazquez *et al.* (2010) compared the morphology and progesterone secretion of CL from spontaneous (natural) estrus cycle of Anglo-Nubian goats with CL from $PGF_{2\alpha}$ synchronized estrus cycle. It showed that the CL from $PGF_{2\alpha}$ synchronized goats were larger but secreted less progesterone than the CL from the natural cycles. Similarly, follicular development during interovulatory interval showed that the estrus synchronized goats had higher number of follicles, larger maximum diameter of the follicles during the first and second follicular waves than the spontaneous cycling goats (Vazquez *et al*., 2010). Fernandez-Moro *et al.* (2008) also reported that goats that were estrus synchronized with flugestone acetate (FGA) had a higher number of preovulatory follicles compared with $PGF_{2\alpha}$ synchronized goats. Furthermore, Baby and Bartlewski (2011) showed that progesterone from the CL is an important endocrine signal which regulates the periodicity of follicle stimulating hormone (FSH) peaks and the emergence of follicular waves in cyclic ewes. However, it is unclear if the number and diameter of the induced CL, plasma progesterone concentration and the pattern of follicular development are different between the $PGF_{2\alpha}$, and CIDR synchronized, and their subsequent estrus cycles compared with unsynchronized estrus cycles. Thus, this study was conducted to analyse and compare CL number, diameter, progesterone level, and follicular development during the interovulatory period of $PGF_{2\alpha}$ and CIDR synchronized estrus cycles, their subsequent estrus cycles, and unsynchronized, naturally cycling goats.

MATERIALS AND METHODS

Experimental design: This experiment was conducted on a private goat farm in Kuang, Malaysia (Lat: 3° 15N and Long: 101° 32' 60E) using a total of 24 Boer x Feral goats between 3 and 4 years old, and with average body weight of 35 ± 2.7 kg. Estrus behavior was observed in the goats throughout the year. The goats had a median body condition score (BCS) of 3 out of 5 (BCS 1=very thin, BCS 3=moderate, BCS 5=Obese) as the BCS of these goats were determined based on the amount of muscles and fats around the ribs and loins (Burkholder, 2000). Estrus behavior was observed in all the goats within one month that preceded the study (February 2009). The ambient temperature and relative humidity during the 3 months experimental duration (February to April, 2009) ranged from 20 to 35°C and 67 to 83%, respectively. The goats were fed with a mixed ration comprising soya bean meal and oil palm leaf silage based on 3% their body weight and supplemented with commercial ruminant pellets. The total feed given contained 16% crude protein and 10MJ/kg of metabolizable energy. Water and salt licks were provided *ad libitum*.

The goats were divided equally into three groups: $PGF_{2\alpha}$ synchronized group, the CIDR synchronized group, and an unsynchronized (control) group. In the $PGF_{2\alpha}$ group, estrus was synchronized with two intramuscular injections of 125 µg cloprostenol (Estrumate™, Schering-Plough, Australia) given 11 days apart (Cruz *et al*., 2005). In the CIDR group, the goats were synchronized with controlled internal drug release (CIDR, EAZI-BREED™, New Zealand), which contained 300 mg progesterone and inserted into the vagina and left in place for 17 days (Montlomelo *et al*., 2002).

Blood sampling and ultrasonography: Transrectal ultrasonographic examination of the ovaries was performed in all the goats once daily using a real-time B-mode ultrasound scanner (Aloka, 500 SSD, Japan), with a transrectal 7.5-MHz linear array probe (UST-660-7.5 model); until a complete estrus cycle of normal length (19-22 days) was recorded. Blood samples (5 ml) were collected from each goat prior to ultrasound scanning, twice a week at interval of 3-4 days via the jugular vein into heparinized vacutainer tubes. Blood samples were centrifuged at 1006 g for 15 min, plasma was aspirated and stored at -20°C until assay. Plasma progesterone concentration was measured using radioimmunoassay kit (PROG-CTK-4; DiaSorin, Italy). Inter- and intra assay coefficients of variation (CV) were 5.9 and 4.0% respectively, and analytical detectable limit (sensitivity) was 0.05 ng/ml.

For the two synchronized groups, ultrasonographic monitoring of ovarian follicular development commenced 24 hrs after the second $PGF_{2\alpha}$ injection or CIDR withdrawal, while goats in the control group were scanned from the beginning of the study until a complete natural cycle was recorded. The follicles >3 mm diameter were measured using the ultrasound scanner's built-in electronic caliper.

The CL were recorded and monitored as soon as they became distinguishable by day 4 after ovulation according to a previously described method (Chao *et al*., 2008). The mean maximum CL diameter and progesterone concentration was calculated as the average of 3 successive daily recordings on days 9, 10 and 11 after ovulation at maximum CL diameter and progesterone concentration. Follicular development parameters analyzed included day of follicular wave emergence from ovulation, duration of the follicular wave (days) and maximum diameter attained by the largest follicle in a wave. The follicular wave terminologies used were according to previously described methods; a follicular wave was defined as a cohort of two or more 3 mm diameter antral follicles that emerged within 48 hours and grew to at least 5 mm in diameter before regression or ovulation (Ginther and Kot, 1994; Simoes *et al*., 2006). Emergence of a wave was the day when 3-mm follicles were first detected, while the duration of a wave was the interval between wave emergence of a cohort of 3 mm diameter follicles and the regression of the follicles to 3 mm in diameter (Simoes *et al*., 2006).

Data analysis: The number and diameter of the CL were expressed as mean±SE. The mean diameter of the CL and plasma progesterone concentration between the synch and subsequent estrus cycles of the $PGF_{2\alpha}$ and of the CIDR synch groups were compared using paired t-test, while the synch, subsequent estrus cycles and the unsynchronized cycles were compared using analysis of variance (ANOVA). Kruskal-Wallis non-parametric analysis of variance (ANOVA) was used to analyze the mean time of emergence and duration of follicular waves, and maximum size attained by the largest follicles of sequential waves of the synch and unsynchronized groups. The SPSS statistical software version 17 (SPSS Inc.) was used for all data analyses.

RESULTS

The number of goats with one corpus luteum versus two CL and the number of non-cycling goats during the synchronized and subsequent estrus cycles are shown in Table 1. All the goats in the $PGF_{2\alpha}$ and CIDR synchronized groups ovulated and developed a CL during the interovulatory interval. However, two goats each (25%) from the subsequent natural cycle of the $PGF_{2\alpha}$ and CIDR synchronized groups did not ovulate (not cycling), while four goats (50%) in the unsynchronized (control) group were not cycling.

The mean CL diameter and progesterone concentration recorded during the inter-ovulatory intervals are shown in Table 2. The mean CL diameter and progesterone concentration of the synch groups were not different (P>0.05) from the mean CL diameter recorded during the subsequent natural estrus cycle but were significantly larger (P<0.05) than the mean CL diameter and progesterone concentration in the unsynchronized group.

Table 3 shows that the time of emergence and duration of the follicular waves from ovulation and duration of the follicular waves among the synchronized, subsequent estrus cycle and in the unsynchronized group were not significantly different (P>0.05). Similarly, Table 4 shows that the mean maximum diameter attained by the largest follicle in the follicular waves among the synch and in the unsynchronized groups was not significantly different (P>0.05).

DISCUSSION

In the current study, CL were formed in all the goats in synch groups, while in each of two synchronized groups two non-cycling goats (25%) were observed in the subsequent natural cycle and four goats in the unsynchronized groups (50%) were not cycling. This indicated that estrus synch either with $PGF_{2\alpha}$, or CIDR might contribute to improve regular cyclicity in these goats and that up to 50% of the spontaneously cycling goats studied might have failure of ovulation despite the observation of regular estrus behavior. The finding of the current study implies that abnormal ovarian cyclicity in the Boer goats and their crosses with other exotic goat breeds that have currently been introduced into many tropical countries such as Malaysia might be a significant cause of infertility and low success rates in the breeding programs of sheep and goat breeds (Kosgey *et al.*, 2006). In a previous report, approximately 30% of Boer goats in South Africa had long estrus cycles (40 to 60 days) except during the period of peak sexual activity in April and May (autumn) compared with the other months of the year, although there was no period of complete anestrus (Greyling, 2000). At present, there is no report of a period of reduced sexual activity or the prevalence of abnormal ovarian cyclicity among non-seasonal polyestrus goats in Malaysia.

In the current study, the mean CL diameter and progesterone concentrations of the synch groups were not significantly different (P>0.05) with the mean CL diameter recorded during the subsequent estrus cycle, indicating that the CL diameter and progesterone concentration in the synchronized and subsequent estrus cycles were similar. However, the mean CL diameter and progesterone concentrations in the synch groups were significantly higher (P<0.05) than the mean CL diameter and the progesterone concentration in the unsynchronized group. Previous studies showed that a significant positive correlation existed between the diameter of CL and progesterone concentration in goats (Orita *et al.*, 2000;

Table 1: Number (%) of CL in synch, subsequent and unsynchronized estrus cycles in goats

Method of estrus synch	Synchronized estrus cycle			Subsequent estrus cycle		
	No CL	One CL	Two CL	No CL	One CL	Two CL
$PGF_{2\alpha}$	-	4 (50)	4 (50)	2 (25)	2 (25)	4 (50)
CIDR	-	3 (37.5)	5 (62.5)	2 (25)	4 (50)	2 (25)
Unsynchronized* (control)	-	-	-	4 (50)	2 (25)	2 (25)

*The unsynchronized goats were monitored for natural estrus cycle only.

Table 2: Mean±SE (mm) diameter of the corpora lutea and plasma progesterone concentrations (ng/ml) in $PGF_{2\alpha}$, CIDR synchronized and unsynchronized estrus cycles in goats

Method of estrus synch	Diameter of CL		Progesterone concentration	
	Synchronized	Subsequent estrus cycle	Synchronized	Subsequent estrus cycle
$PGF_{2\alpha}$	$11.9\pm0.5^{a,x}$	$12.0\pm0.4^{a,x}$	$3.51\pm0.19^{a,x}$	$3.22\pm0.71^{a,x}$
CIDR	$12.3\pm0.4^{a,x}$	$12.5\pm0.8^{a,x}$	$5.98\pm1.11^{a,x}$	$4.25\pm1.37^{a,x}$
Unsynchronized (control)*	9.3 ± 3.8^{b}		2.99 ± 1.64^{b}	

Values with different superscripts within rows (x, y) and between rows within columns (a, b) denote statistical significance (P<0.05); *The unsynchronized goats were monitored for natural estrus cycle only.

Table 3: Mean±SE day of emergence and duration of follicular waves in Boer crossbred goats synchronized with $PGF_{2\alpha}$, CIDR, their subsequent estrus cycles and in unsynchronized group

Wave Number	Follicular wave parameter (days)	Method of estrus synch: $PGF_{2\alpha}$ Synchronized estrus cycle	$PGF_{2\alpha}$ Subsequent estrus cycle	CIDR Synchronized estrus cycle	CIDR Subsequent estrus cycle	Unsynchronized Group	P-value
1	Day of emergence	1.7±0.4	2.5±0.7	1.3±0.3	1.5±0.4	1.5±0.3	P=0.59
	Duration	8.0±0.8	6.9±0.3	7.6±0.6	7.5±1.2	5.8±0.8	P=0.24
2	Day of emergence	9.6±1.0	8.6±0.3	8.5±0.8	8.4±1.3	6.0±1.4	P=0.08
	Duration	5.0±0.2	6.1±0.7	7.1±1.1	5.5±0.8	5.4±0.5	P=0.16
3	Day of emergence	14.3±0.9	14.4±0.7	14.4±0.3	12.0±2.1	10.1±1.5	P=0.07
	Duration	5.7±0.6	5.4±0.4	6.0±0.5	7.3±1.1	6.4±0.5	P=0.53

Table 4: Mean±SE maximum diameter (mm) attained by the largest follicle in the three follicular waves of $PGF_{2\alpha}$ or CIDR synchronized, and unsynchronized estrus cycles

Number of waves	Method of estrus synch			P-value
	$PGF_{2\alpha}$	CIDR	Unsynchronized	
1	7.3±0.5	8.7±0.9	7.0±0.3	0.27
2	5.9±0.5	6.8±0.3	6.7±0.3	0.24
3	7.0±0.4	7.4±0.5	6.7±0.5	0.24

Chao *et al*., 2008). Furthermore, Simoes *et al*. (2007) reported that plasma progesterone concentration was higher in goats with two CL (6.4±3.7 ng/ml) compared with goats having only one CL (5.4±3.0 ng/ml). These findings might explain the lower progesterone concentration in the naturally cycling goats with lower mean CL diameter found in the current study compared with the synch groups. Our findings are also in agreement with Letelier *et al*. (2011), who reported that in ewes, secretion of progesterone was significantly higher in cloprostenol synchronized ewes compared with FGA synchronized or naturally cycling ewes. Vazquez *et al*. (2010) also reported that there were more double ovulations and the CL of the goats were larger in the $PGF_{2\alpha}$ synch goats compared with the naturally cycling goats. However, in contrast with our findings, Vazquez *et al*. (2010) reported that the CL from the naturally cycling goats secreted higher progesterone than the $PGF_{2\alpha}$ treated goats due to defective preovulatory follicular development. This resulted in reduced functionality and progesterone secretion from the induced CL of the $PGF_{2\alpha}$ synch goats compared with the naturally cycling goats. Thus, the finding of the current study infers that the reduced functionality did not influence the CL diameter and progesterone concentration in the $PGF_{2\alpha}$ synch goats. Furthermore, the fewer number of CL in the unsynchronized group found in the current study might also have contributed to the lower mean CL diameter and progesterone concentration compared with the synch group.

In the current study, the mean day of emergence of the follicular waves, the duration of the follicular waves and the maximum diameter of the follicles among the synch groups and in the unsynchronized group were not significantly different. Previous studies have shown that in cattle (Adams *et al*., 1992), ewes (Leyva *et al*., 1998) and goats (Gonzalez-Bulnes *et al*., 2005; Cueto *et al*., 2006), exposure of the developing follicles to low progesterone concentration during the follicular growth increased the maximum diameter attained by the follicles. However, in the current study, the lower mean CL diameter and progesterone concentration in the unsynchronized group did not result in significant differences in the pattern of follicular development. Cueto *et al*. (2006) had reported that the day of follicular wave emergence was not significantly different between and within Anglo-Nubian and Saanen breeds. Similarly, there were non significant differences in day of follicular wave emergence between two natural estrus cycles of Anglo-Nubian goats (Filho *et al*., 2007).

The implication of the current finding on the pattern of follicular development is that estrus synch with $PGF_{2\alpha}$ or CIDR in goats could be successfully followed up by estrus re-synch immediately afterwards with either hormone and with comparable percentage estrus response, ovulation and pregnancy rates as was recorded in cows (Sani *et al*., 2011). Thus, with the increased interest and application of artificial reproductive technology such as AI in goat production, we anticipate that a successful outcome could result from re-synch of estrus in unmated goats or those that returned to estrus after timed artificial insemination (TAI) as is practiced in cows.

In conclusion, estrus synchronization increased the number of cycling goats. The diameter of the CL, plasma progesterone concentration and follicular wave pattern during the interovulatory period of synchronized estrus cycles and their subsequent estrus cycles were not significantly different irrespective of whether $PGF_{2\alpha}$ or CIDR is used. On the other hand, the CL diameter and progesterone concentration was lowest in the unsynchronized goats. However, the day of emergence and duration of follicular waves, as well as the maximum diameter attained by the largest follicle in the follicular waves was unaffected, indicating that the morphology and progesterone secreted from the CL did not influence these aspects of follicular development in non-seasonally polyestrus goats in the humid tropics.

Acknowledgements: The authors wish to thank the Universiti Putra Malaysia for graduate research fellowship for the first author and to ar-Raudhah Biotech Farm Sdn Bhd, Malaysia for providing animals for this study. We also wish to acknowledge Mr. P. Ganesamurthi and Mr. M. Fahmi for their technical assistance and to Mr K. C. Yap for the hormonal analysis.

REFERENCES

Adams GP, RL Matteri and OJ Ginther, 1992. Effect of progesterone on ovarian follicles, emergence of follicular waves and circulating follicle stimulating hormone in heifers. J Reprod Fertil, 95: 627-640.

Aerts JMJ and PEJ Bols, 2010. Ovarian follicular dynamics. A review with emphasis on the bovine species. Part II: Antral development, exogenous influence and future prospects. Reprod Dom Anim, 45: 180-187.

Baby TE and PM Bartlewski, 2011. Circulating concentrations of ovarian steroids and follicle-stimulating hormone (FSH) in ewes with 3 or 4 waves of antral follicle emergence per estrus cycle. Reprod Biol, 11: 19-36.

Burkholder WJ, 2000. Use of body condition scores in clinical assessment of the provision of optimal nutrition. J Am Vet Med Assoc, 217: 650-654.

Chao LM, K Takayama, Y Nakanishi, K Hamana, M Takagi, C Kubota and T Kojima, 2008. Luteal lifespan and fertility after estrus synchronization in goats. J Vet Sci, 9: 95-101.

Cruz JF, D Rondina and VJ Freitas 2005. Ovarian follicular dynamics during anestrus in Anglo-Nubian and Saanen goats raised in tropical climate. Trop Anim Hlth Prod, 37: 395-402.

Cueto M, A Gibbons, R Alberio, H Taddeo and A Gonzalez-Bulnes 2006. Timing of emergence of ovulatory follicles in polyovulatory goats. Anim Reprod Sci, 91: 275-284.

Fernandez-Moro D, A Veiga-Lopez, C Ariznavarreta, JA Tresguerres, T Encinas and A Gonzalez-Bulnes 2008. Preovulatory follicle development in goats following estrus synchronization with progestagens or prostaglandins. Reprod Dom Anim, 43: 9-14.

Filho TF, MHB Santos, PG Carrazzoni, FF Paula-Lopes, JP Neves, CC Bartolomeu, PF Limaa and MAL Oliveira 2007. Follicular dynamics in Anglo-Nubian goats using transrectal and transvaginal ultrasound. Small Rumin Res, 72: 51-56.

Ginther OJ and K Kot 1994. Follicular dynamics during the ovulatory season in goats. Theriogenology, 42: 987-1001.

Gonzalez-Bulnes A, C Dıaz-Delfa, RM Garcia-Garcia, B Urrutia, JA Carrizosa and A Lopez-Sebastian 2005. Origin and fate of pre-ovulatory follicles after induced luteolysis at different stages of the luteal phase of the estrus cycle in goats. Anim Reprod Sci, 86: 237-245.

Greyling J, 2000. Reproduction traits in the Boer goat doe. Small Rumin Res, 36: 171-177.

Kosgey IS, RL Baker, HMJ Udo and JAM Van Arendonk, 2006. Successes and failures of small ruminant breeding programmes in the tropics: a review. Small Rumin Res, 61: 13-28.

Letelier CA, I Contreras-Solis, RA Garcia-Fernandez, MA Sanchez, P Garcia-Palencia, B Sanchez, C Ariznavarreta, JAF Tresguerres, JM Flores and A Gonzalez-Bulnes, 2011. Effects of estrus induction with progestagens or prostaglandin analogues on ovarian and pituitary function in sheep. Anim Reprod Sci, 126: 61-69.

Leyva V, BC Buckrell and JS Walton, 1998. Regulation of follicular activity and ovulation in ewes by exogenous progestagen. Theriogenology, 50: 395-416.

Montlomelo KC, JPC Greyling and LMJ Schwalbach, 2002. Synchronisation of estrus in goats: the use of different progestagen treatments. Small Rumin Res, 45: 45-49.

Orita J, T Tanaka, H Kamomae and Y Kaneda, 2000. Ultrasonographic observation of follicular and luteal dynamics during the estrus cycle in Shiba goats. J Reprod Dev, 46: 31-37.

Sani RN, N Farzaneh, M Moezifar, HA Seifi and AA Tabatabei, 2011. Evaluation of five resynchronization methods using different combinations of $PGF_{2\alpha}$, GnRH, estradiol and an intravaginal progesterone device for insemination in Holstein cows. Anim Reprod Sci, 124: 1-6.

Simoes J, JC Almeida, R Valentim, G Baril, J Azevedo, P Fontes and R Mascarenhas, 2006. Follicular dynamics in Serrana goats. Anim Reprod Sci, 95: 16-25.

Simoes J, JC Almeida, G Baril, J Azevedo, P Fontes and R Mascarenhas, 2007. Assessment of luteal function by ultrasonographic appearance and measurement of corpora lutea in goats. Anim Reprod Sci, 97: 36-46.

Vazquez MI, MS Blanch, GA Alanis, MA Chaves and A Gonzalez-Bulnes, 2010. Effects of treatment with a prostaglandin analogue on developmental dynamics and functionality of induced corpora lutea in goats. Anim Reprod Sci, 118: 42-47.