Small Ruminant Research 88 (2010) 38–43

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

The ovarian response and embryo recovery rate in Boer goat does following different superovulation protocols, during the breeding season

K.C. Lehloenya[a,*], J.P.C. Greyling[b]

[a] Department of Animal Sciences, Tshwane University of Technology, Private Bag X 680, Pretoria 0001, South Africa
[b] Department of Animal, Wildlife and Grassland Sciences, University of the Free State, P.O. Box 339, Bloemfontein 9300, South Africa

ARTICLE INFO

Article history:
Received 9 March 2009
Received in revised form 6 November 2009
Accepted 16 November 2009

Keywords:
Boer goats
Superovulation protocols
Progesterone concentration

ABSTRACT

Twenty-four Boer goat does were used to compare three superovulation protocols, with 8 does allocated per treatment during the natural breeding season. In Group 1 (Day 0 protocol), the oestrous cycles of does were synchronised for 7 days with CIDR's and injected PGF2α at CIDR insertion. Does were then superovulated with pFSH in 7 dosages at 12 h intervals, starting 88 h following CIDR removal. Concurrently with the 6th dosage, does were injected PGF2α. Cervical inseminations were performed 24 h and 36 h following the last superovulatory treatment. For Groups 2 and 3, the oestrous cycles of the does were also synchronised for 17 days using CIDR's. On day 14 of CIDR insertion, Group 2 does were injected with PGF2α. A superovulation treatment similar to Group 1 was administered in Groups 2 and 3, starting 48 h before CIDR removal. All does in these groups were also cervically inseminated with fresh undiluted Boer goat semen 24 h and 36 h following CIDR withdrawal. Embryos from all 3 treatment groups were flushed on day 6 following AI. Does in Group 1 responded to the short oestrous synchronisation protocol before the administration of a superovulation treatment (71.4% response), with time to onset of oestrus of 37.2 ± 0.7 h and duration of an induced oestrous period of 36.4 ± 0.5 h being recorded. Following superovulation only two does exhibited signs of oestrus in Group 1, while Groups 2 and 3 exhibited a 100% oestrous response. Groups 1 and 2 recorded similar intervals to the onset and durations of the induced oestrous period. The number of ovulations per donor was significantly lower in Group 1 (4.0 ± 0.7), compared to Groups 2 and 3 (14.5 ± 0.6 and 16.5 ± 0.8, respectively), with no significant difference between Groups 2 and 3. The Day 0 protocol (Group 1) also resulted into a significantly lower total number of structures recovered, compared to Group 3. Groups 2 and 3 recorded a relatively similar number of structures recovered. The number of embryos recovered was significantly lower ($P < 0.01$) in Group 1 (0.2 ± 0.1) than in Group 2 (13.2 ± 0.5) and Group 3 (11.5 ± 1.1), with the mean number of unfertilised ova and degenerated embryos being similar for all 3 treatment groups. Groups 2 and 3 also produced a similar number of transferable embryos. The blood progesterone concentrations followed a similar trend in the 3 treated groups, from CIDR insertion to embryo flushing. However, the mean serum progesterone concentration was significantly lower on day 4 in the Day 0 group, compared to Groups 2 and 3. The inclusion of PGF2α treatment in the superovulation protocol for Boer goats had no beneficial effect, while the Day 0 protocol engaged in this trial, resulted in a lower superovulation response. Further research is warranted, focusing on synchronisation, time when initiating superovulatory treatment and AI to improve the embryo yield in goats.

* Corresponding author. Tel.: +27 12 3825983; fax: +27 12 3824224.
E-mail address: lehloenyakc@tut.ac.za (K.C. Lehloenya).

0921-4488/$ – see front matter
doi:10.1016/j.smallrumres.2009.11.007

1. Introduction

The variation in response to superovulation and relatively low embryo survival rates after transfer are major factors limiting the successful use of a MOET programme in goats and other farm animals. The superovulatory protocol in goats traditionally includes the administration of an intravaginal progestagen pre-treatment over an 11–21-day period, followed by the superovulatory treatment with gonadotrophins, which start 72–48 h before progestagen removal (McNatty et al., 1989; Selgrath et al., 1990; Gonzalez-Bulnes et al., 2003). When intravaginal progestagen treatment is performed over a short period of time (9–11 days), a prostaglandin-F2α (PGF2α) injection is generally administered, coinciding with the first superovulatory treatment – 24–48 h prior to or at progestagen withdrawal, in order to allow for the precise timing of the onset of oestrus (Krisher et al., 1994; Senthil Kumar et al., 2003).

Even when long progestagen treatment protocols are used, it has become the norm to administer an injection of PGF2α (especially during the breeding season), before or at the initiation of superovulatory treatment to ensure complete luteolysis and removal of any possible CL's. In past studies with Boer goats, the superovulation protocol involved the utilisation of a long synchronisation programme (17 days) during and outside the natural breeding season, without any PGF2α treatment (Lehloenya et al., 2006a, 2008). Currently there is limited information on how Boer goats would respond if PGF2α is included in the superovulatory protocol and whether it has any benefit to be included.

In a superovulation programme, synchronisation is however not the only factor always under review. The physiological status of the ovary at the initiation of a superovulation treatment has also called for more attention recently. It is hypothesised that if the superovulatory treatment is initiated at an emergence of a follicular wave, the variation exhibited in ovarian response to superovulation could be reduced (Ginther and Kot, 1994; De Castro et al., 1998; Cognie et al., 2003; Gonzalez-Bulnes et al., 2004). In goats the emergence of a first follicular wave has been found to occur on Day 0 (ovulation) of the inter-ovulatory interval. Therefore, if a superovulatory treatment could be initiated during this period, it is hypothesised that the variation in ovarian response may be reduced and the ovarian response be increased. In goats the so-called Day 0 protocol in which superovulation is initiated just after ovulation – Day 0 being the day of ovulation – has been performed with promising results, measured by the number of ovulations induced, without the evaluation of embryo recovery rate (Menchaca et al., 2002). This protocol however, requires the use of an ultrasonographic scanner to visually confirm ovulation and limits the utilisation of the Day 0 protocol, especially in a commercial situation where an extensive MOET programme is to be performed. A limiting factor when utilising this protocol is that not every farmer owns a scanner or has the knowledge to utilise this type of sophisticated equipment for ovarian evaluations. If this protocol was to be utilised without the use of this ultrasonographic means, it would require an estimation of the occurrence of ovulation (hormonal assay), following oestrous synchronisation termination. The aim of this study was therefore to evaluate the efficiency of superovulation following a long progestagen synchronisation protocol, with or without the use of PGF2α and compare these protocols to a Day 0 protocol, using a predetermined time of ovulation, without the use of a sonographic scanner as previously used in superovulatory regimes.

2. Materials and methods

This study was conducted during the natural breeding season (autumn, 2007) at the University of the Free State's experimental farm. This farm is situated approximately 20 km south of Bloemfontein, South Africa – located at 28.57° south latitude and 25.89° east longitude, at an altitude of 1304 m above sea level. All does were allowed to graze on natural pastures during the day, initially improved by the hand sowing of Smuts Finger grass (*Digitaria eriantha*). The pasture composition also included red grass (*Themeda triandra*) as the dominant specie, weeping grass (*Eragrostis lehmanniana*), drop seed grass (*Sporobolas fimbriatus*) and prickle grass (*Aristida congesta*). At night all the animals were supplemented with milled lucerne, while housed in covered pens. For the entire period of the trial water and a mineral lick was available *ad libitum*.

Twenty-four Boer goat donor does were allocated to the 3 treatment groups. The does had 2–8 permanent incisors (1–4 years of age) and this was used as an indicator of the age of the experimental animals. The body weight of the does ranged between 28.7 kg and 68.6 kg. The groups were stratified based on age, previous superovulation treatments and body weight – so that each group consisted of an equal number of young and adult does, as well as having a similar average body weight per group of approximately 48.4 kg. In the first group of does (Group 1; $n = 8$; the so-called Day 0 protocol group), the oestrous cycles were synchronised with the aid of controlled internal drug release dispensers (CIDR; Phamacica & Upjohn, Auckland, New Zealand) for 7 days. At CIDR insertion does were also treated (i.m.) with 0.05 mg/doe PGF2α (Estrumate: cloprostenol). For the purpose of determining Day 0 (day of ovulation) in this specific group the ovulation time was estimated based on previous findings and predetermined to occur at approximately 72–80 h following progestagen withdrawal (Greyling and Van Der Nest, 2000).

The superovulatory treatment with pFSH (Folltropin, Vetrepharm) was then initiated 88 h following CIDR withdrawal and treatment consisted of a total dose of 200 mg FSH/doe, administered i.m. in 7 dosages, at 12 h intervals per day (the first dose being 50 mg and all others being 25 mg). Concurrently with the 6th dosage, does were administered an i.m. injection of 0.05 mg/doe PGF2α. Fixed time AI, using 0.1 ml fresh undiluted Boer goat semen (sperm concentration approximately 350×10^6/ml) was performed 24 h and 36 h following the last superovulatory injection. Oestrous detection was performed with the aid of vasectomised bucks at 8 h intervals for a period of 172 h following CIDR removal.

In the second group (Group 2, $n = 8$), the oestrous cycles of the does were synchronised using intravaginal CIDR's for a period of 17 days. On day 14 (day 0 being the day of CIDR insertion) following CIDR insertion, all does in this group were injected with 0.05 mg/doe PGF2α and the superovulatory pFSH treatment initiated on day 15. In the last group (Group 3; $n = 8$), the synchronisation and superovulation treatments were performed using a similar approach as that in the second treatment group. However, does did not receive a PGF2α treatment. The superovulatory treatment for Groups 2 and 3 was similar to that of Group 1, however, starting 48 h prior to CIDR removal. Groups 2 and 3 does were cervically inseminated with 0.1 ml fresh undiluted Boer goat semen performed at a fixed time (24 h and 36 h) following CIDR withdrawal. Does from Groups 2 and 3 were also checked for oestrus at 8 h intervals for a total period of 96 h following CIDR removal with the aid of vasectomised bucks.

On day 6 following AI, embryos from all groups were flushed as described by Lehloenya et al. (2008). The flushing media recovered was scrutinized microscopically and evaluated under a stereomicroscope to identify and classify the structures (unfertilised ova and embryos) collected. The structures recovered were evaluated for the stage of development and quality using morphological criteria. The embryos were classified as unfertilised ova (no cleavage), degenerate embryos (embryos at 8-cell or earlier stage) or as transferable embryos Grade 1, 2 and 3 (morphologically intact compact morulae, early blastocysts or expanded blastocysts). Grade 1 embryos were morphologically intact and had an even granulation and cell distribution, Grade 2 were embryos with small deviations e.g. a few exuded blastomeres, while Grade 3 embryos demonstrated an uneven cell organisation, a loosened structure, with numerous free blastomeres (Lindner and Wright, 1983; Nuti et al., 1987).

Blood samples were collected from 5 animals in each group via jugular veni-puncture into 10 ml vacutainer tubes with no anti-coagulant. For Group 1, blood samples were collected on the day of CIDR insertion, then on day 4 and at CIDR withdrawal. The last blood sample for this group was taken on the day of embryo flushing. For Groups 2 and 3, blood samples during progestagen treatment were collected at 4-day intervals (from progestagen insertion to day 12). Further blood samples were then taken from CIDR removal and the last on the day of embryo collection. After blood sample collection, serum was aspirated following centrifugation at 1500 rpm for 15 min. The serum was stored at −20 °C, until assayed for serum progesterone concentrations.

The serum progesterone concentration was determined using an Automated Chemiluminescence System (Chiron Diagnostics ACS:180, USA). The Chiron Diagnostics ACS:180 progesterone assay is based on a competitive immunoassay, using direct chemiluminescent technology. Progesterone in the sample binds to an acridinium ester-labeled mouse monoclonal anti-progesterone antibody in the light reagent. Unbound antibody then binds to a progesterone derivative covalently coupled to paramagnetic particles in the solid phase. The concentration of progesterone present in the sample is inversely related to the amount of relative light units detected by the system. The ACS:180 progesterone assay sensitivity was 0.11 ng/ml with the inter- and intra-assay coefficients of variation being 9.1% and 14.6%, respectively. All data were analysed using the ANOVA procedures of SAS, except for data incorporating the occurrence of oestrus, pregnancy rate and fertilisation rate, which were analysed using the Chi square test (SAS, 2003).

3. Results

From the Day 0 group (Group 1) one Boer goat doe became ill and was removed from the trial. Of the remaining 7 does, only 5 (71.4%) exhibited overt signs of oestrus following CIDR removal after the 7-day progestagen treatment prior to the administration of the superovulatory treatment. The time to the onset of oestrus recorded in this first induced oestrus following CIDR (Group 1) removal was 37.2 ± 0.7 h and the oestrous period lasted for 36.4 ± 0.5 h. One doe from the Group 3 developed an abscess and was also removed from the trial. The oestrous response was 100% following oestrous synchronisation and superovulation in Groups 2 and 3, while only two does exhibited signs of oestrus in the Day 0 (Group 1) following the superovulation treatment. The time to the onset of oestrus (33.0 ± 1.0 h vs 28.6 ± 0.5 h) and duration of the induced oestrous period (26.0 ± 0.9 h vs 21.7 ± 1.6 h) for Groups 2 and 3, respectively, did not differ significantly.

The superovulation response of the Boer goat does following the 3 different superovulatory regimes are set out in Table 1. The Day 0 protocol (Group 1) resulted in a significantly (P < 0.01) lower total number of CL's (4.0 ± 0.7) being induced per doe, compared to Groups 2 and 3. The difference in the mean number of CL's between Group 2 (14.5 ± 0.6) and Group 3 (16.5 ± 0.8) were not statistically different. The mean total number of structures (fertilised and unfertilised ova) recovered from Group 2 (8.4 ± 1.0) and Group 3 (11.4 ± 1.0) were also relatively similar. The mean total number of structures recovered from Group 1 (1.4 ± 0.1) was significantly (P < 0.05) lower, compared to Group 3 (11.4 ± 1.0), but did not differ significantly, when compared to Group 2 (8.4 ± 1.0).

Concerning the total number of embryos recovered, the Day 0 protocol resulted in a significantly (P < 0.01) lower mean number of embryos being recovered, compared to Groups 2 and 3. Although the Group 1 does demonstrated a lower response to superovulation treatment, the mean number of unfertilised ova was similar for all the treatment groups. Group 1 did not show any occurrence of degenerating embryos, and all 3 treatment groups were similar for this parameter. Regarding the fertilisation rate and the number of transferable embryos recorded, the Day 0 (Group 1) group resulted in the collection of only one embryo, which was also transferable, but due to the single value, no statistical analysis was performed. There was no significance difference regarding the fertilisation rate and the mean number of transferable embryos recorded between Groups 2 and 3.

The mean serum progesterone concentrations following the 3 different superovulation protocols from synchronisation to flushing are set out in Fig. 1. The mean serum progesterone concentration for all 3 groups followed a similar trend from CIDR insertion to embryo flushing. The mean serum progesterone concentration for the 3 groups increased after CIDR insertion and was significantly (P < 0.01) lower in the Day 0-treated does (Group 1) on day 4 following CIDR insertion, compared to the other 2 treatments. At CIDR removal (day 7 in the Day 0 group and day 17 in Groups 2 and 3 following CIDR insertion) the mean serum progesterone concentration was similar for all treatment groups. The mean progesterone concentrations increased in the 3 groups post oestrus and were highest on the day of flushing (day 6 following AI).

4. Discussion

The progestagen synchronisation treatment preceding superovulation in Group 1 (Day 0) was performed for a

Table 1
The mean (±s.e.) ovarian response in Boer goat does following different superovulatory regimes.

Parameters	Day 0 (Group 1)	CIDR/PGF2α/FSH (Group 2)	CIDR/FSH (Group 3)
No. of does flushed	5	8	7
No. of ovulations (total CL's/donor)	4.0 ± 0.7^{a}	14.5 ± 0.6^{b}	16.5 ± 0.8^{b}
Total number of structures recovered per doe flushed (unfertilised ova and embryos)	1.4 ± 0.1^{c}	8.4 ± 1.0^{cd}	11.4 ± 1.0^{d}
Total number of embryos recovered/donor	0.2 ± 0.1^{a}	13.2 ± 0.5^{b}	11.5 ± 1.1^{b}
Fertilisation rate (%)	–	98.9 ± 0.3^{a}	83.3 ± 5.8^{a}
Total number of unfertilised ova/donor	1.2 ± 0.2^{a}	0.2 ± 0.1^{a}	1.8 ± 0.6^{a}
Total number of degenerate embryos/donor	0^{a}	1.2 ± 0.2^{a}	2.3 ± 0.5^{a}
Total number of transferable embryos/donor	1.0	12.0 ± 0.4^{a}	9.2 ± 1.0^{a}

^{ab}Values within the same row with different superscripts differ significantly (P < 0.01). ^{cd}Values within the same row with different superscripts differ significantly (P < 0.05).

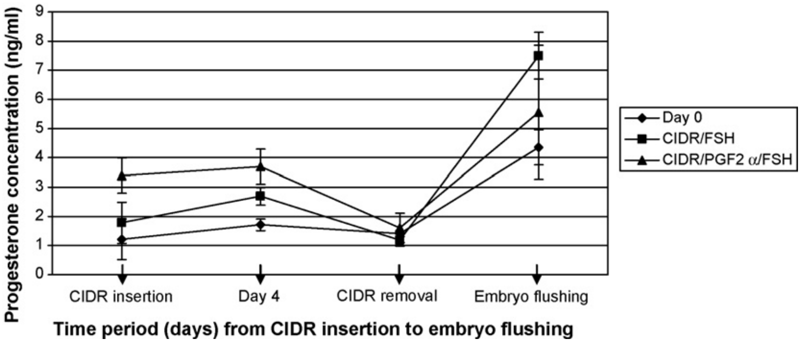

Fig. 1. Mean (±s.e.) serum progesterone concentration following 3 superovulation protocols in goats.

short period of time (7 days), with efficient synchronisation of the does – as indicated by the occurrence of oestrus. It has previously been observed that when goats are primed with progesterone for a shorter period of time they generally exhibit a more compact oestrus (Oliveira et al., 2001). The oestrous response has been reported to be even higher following short progestagen priming when PGF2α was administrated at the time of intravaginal progestagen device insertion (Rubianes and Menchaca, 2003).

In the current trial the oestrous response in the Day 0 (Group 1) donors was 71.4%, which was lower than in protocols (short and long oestrous synchronisation periods) previously recorded for goats (Oliveira et al., 2001; Motlomelo et al., 2002; Romano, 2004). Thus, for a short synchronisation treatment to result in a high oestrous response, it would require the administration of PGF2α to ensure luteolysis. The lower oestrous response obtained in this trial may be ascribed to also the omission of an eCG treatment at progestagen removal in this short progestagen treatment protocol. It was assumed that exogenous eCG treatment would be an extra superovulatory stimulus inside the natural breeding season – as generally Boer goats are highly receptive at that time of the year.

The time interval from CIDR removal to the onset of oestrus recorded in the Day 0 (Group 1) group preceding superovulation treatment, was in line with the 39.8 ± 6.3 h and 40.2 ± 10.5 h following a short progesterone priming treatment reported when also using CIDR's (Menchaca et al., 2002; Romano, 2004). These observations demonstrate that short progestagen priming does not really affect the duration of the induced oestrous period.

The oestrous response recorded in Groups 2 and 3 was similar to that previously reported following oestrous synchronisation and superovulation in goats (Selvaraju et al., 2003; Espinosa-Marquez et al., 2004). The oestrous response, the time interval from CIDR withdrawal to the onset of oestrus and the duration of the induced oestrous period were not affected by the treatment with a PGF2α. Results also indicate no beneficial advantage regarding the inclusion of prostaglandin in a superovulation protocol when implementing a long progestagen synchronisation treatment in Boer goat does, during the natural breeding season. The time from CIDR withdrawal to the onset of oestrus for Group 2 was longer, compared to the 27.6 ± 3.5 h reported in Alpine goats (Baril and Vallet, 1990). The longer time from CIDR removal to the onset of oestrus in Group 2 may be ascribed to the long progestagen synchronisation programme. However, the effect of breed and nutritional status of the animals are factors to be borne in mind. The time interval from CIDR removal to the onset of oestrus in Group 3 (17 day CIDR + pFSH treatment) was also longer, compared to the 24–25.3 h reported in Alpine goats (Selgrath et al., 1990). These differences may be attributed to breed and seasonal differences. The duration of the induced oestrous period in the does of Groups 2 and 3 on the other hand, was shorter, when compared to the 38.0 ± 17.0 h reported in Boer goats following oestrous synchronisation with progestagens and superovulated with pFSH, without the addition of PGF2α (Greyling et al., 2002). The shorter duration of the induced oestrous period in this study may be attributed to the utilisation of a number of young does used in the trial.

The lower ovulation rate obtained following the Day 0 superovulation protocol may be ascribed to the poor recruitment and development of ovarian follicles to the ovulatory stage, or insufficient ovarian stimulation. This poor recruitment or stimulation of ovarian follicles usually occurs when a dominant follicle is present at the time of superovulation initiation – the dominant follicle being known to suppress growth and recruitment of new ovarian follicles (Driancourt, 2001; Senger, 2003). This observation may therefore, mean that the superovulatory treatment in this trial may have started prior to the estimated time of ovulation.

It must also be pointed out that the occurrence of the first follicular wave may differ in breeds, as these can be determined by the duration of the oestrous cycle. Based on this information and the fact that ovulation as such was not synchronised and the application of eCG at CIDR removal was not performed, these results may have been attributed to the poor timing of ovulation and hence the lower induction of superovulation. It is assumed that if the superovulatory treatment could be initiated 24 h following the expected time of ovulation, it would be possible to capture all the animals immediately after ovulation. Thus coinciding with the period during which there are a higher number of small follicles present. Nonetheless, the number of CL's following the Day 0 protocol (Group 1) was comparable to the 5.6 ± 0.8 per animal recorded following a similar Day 0 protocol in sheep (Rubianes et al., 1997).

The number of ovulations recorded in Groups 2 and 3 did not differ much and was lower, than in previous experiments following a superovulatory protocol and similar to the one used for Group 3 of this trial (Lehloenya et al., 2006b). These differences may be attributed to the age of the donor does used in the different trials. In the current trial more young maiden does were mated for the first time, compared to previous trials (where multiparous Boer goat does were generally used). This phenomenon has been confirmed by a similar superovulatory response of 15.0 ± 6.2 reported in a previous trial during the natural breeding season (Lehloenya et al., 2006a – where the majority of donors were in their 2nd parity). However, the mean overall ovulation rate obtained in these two protocols (Groups 2 and 3) are in line with the ovulation rate obtained in most goat breeds and is highly acceptable (Armstrong et al., 1983; Mahmood et al., 1991; Cognie et al., 2003; Gonzalez-Bulnes et al., 2003).

The Day 0 protocol resulted in a lower number of structures being recovered, although the mean (2.1 ± 0.6) was in line with that obtained per sheep donor (Rubianes et al., 1997). In goats there are limited trials reporting the embryo recovery success rates following a Day 0 protocol. More research is warranted to further perfect this particular aspect of superovulation at a time just after ovulation. Even though the number of structures recovered in Group 1 was lower (than e.g. in Group 3), it was relatively similar to Group 2. Evident was the high variation in the number of structures recorded for the individual animals within Groups 2 and 3. This tends to indicate the importance of monitoring the follicular waves when administering gonadotrophins for the purpose of superovulation. The high variation recorded could imply that the animals within a treatment group being at different stages of their oestrous cycles. With regard to the high variation observed in the number of structures recorded, a superovulation protocol with an additional PGF2α (Group 2) to a long synchronisation progestagen treatment in goats seemed to have no distinct advantage. This is in contrast to cattle where PGF2α is included in all protocols as it is known to improve the recovery rate (Mapletoft et al., 2002). However, the time of prostaglandin administration and the dosage used could also facilitate and affect the response induced.

The low number of embryos recovered in Group 1 was as expected, as only two doe exhibited oestrus following superovulation. This observation also demonstrated a need for further studies to be done to perfect this Day 0 protocol, especially where ultrasonography equipment is not available. On the other hand, the mean number of embryos per donor recovered from the Groups 2 and 3 were very similar with a mean number of embryos reported (14.7 ± 2.5, 14.3 ± 0.5 and 11.8 ± 2.9), following superovulation in dairy goats, Murciano-Granadina and Jakhrana goats, respectively (Pendleton et al., 1992; Gonzalez-Bulnes et al., 2003; Goel and Agrawal, 2005). The mean number of embryos recovered in the current trial in Group 2 and Group 3 was lower, when compared to other trials (Lehloenya et al., 2008). These differences may be due to a higher number of young does utilised in this trial and thus weaker ovarian response obtained.

The mean number of transferable embryos of acceptable quality in Group 2 and Group 3 was higher, when compared to that reported in other goat breeds, with or without an injection of PGF2α in the FSH superovulation regime (McNatty et al., 1989; Pendleton et al., 1992; Gonzalez-Bulnes et al., 2003). These differences in embryo quality may be ascribed to differences in the response to superovulation and the hormonal environment created in the different breeds. It could also indicate that the Boer goat does respond better than other goat breeds following exogenous hormonal superovulation treatments. When considering the ovarian response induced by superovulatory treatment, the Day 0 protocol performed poorly. However, it should be pointed out that this trial was aimed at evaluating if this Day 0 protocol could be used without prior visual ovarian inspection using the ultrasound. The time of ovulation was assumed to begin at superovulatory treatment. In order to be able to utilise this protocol without the use of ultrasonography, more frequent time intervals of initiating superovulation treatment need to be evaluated for an accurate estimate of the ovulation time for a specific goat breed. Moreover, the ovulation time needs to be synchronised more precise to allow a better prediction of ovulation and hence the time to start superovulatory treatment. Here the treatment with GnRH to induce ovulation could be an alternative, with or without the use of ultrasonography.

5. Conclusions

All parameters measured following superovulation were similar between Groups 2 and 3 and therefore, it can be concluded that the addition of a PGF2α treatment in the superovulatory protocol following a long progestagen synchronisation treatment in Boer goat does had no advantage. The Day 0 protocol engaged in this trial resulted in a poor superovulatory response (based on the ovulation rate, total number of structures and embryos recovered), compared to the other superovulatory treatments. It could thus also be concluded that the poor ovarian response to the superovulatory treatment in Group 1 (Day 0) warrants further research, which will have to focus on the synchronisation of ovulation and the appropriate time of initiating superovulatory treatment in this protocol.

Acknowledgements

Authors wish to thank the National Research Foundation and the University of the Free State for financial support of this research.

References

Armstrong, D.T., Pfitzner, A.P., Warnes, G.M., Ralph, M.M., Seamark, R.F., 1983. Endocrine responses of goats after induction of superovulation with PMSG and FSH. J. Reprod. Fertil. 67, 395–401.

Baril, G., Vallet, J.C., 1990. Time of ovulations in dairy goats induced to superovulate with porcine follicle stimulating hormone during and out of the breeding season. Theriogenology 34, 303–311.

Cognie, Y., Baril, G., Poulin, N., Mermillod, P., 2003. Current status of embryo technologies in sheep and goat. Theriogenology 59, 171–188.

De Castro, T., Rubianes, E., Menchaca, A., Rivero, A., 1998. Ultrasonic study of follicular dynamics during the estrous cycle in goats. Theriogenology 49, 399 (Abstr.).

Driancourt, M.A., 2001. Regulation of ovarian follicular dynamics in farm animals. Implications for manipulation of reproduction. Theriogenology 55, 1211–1239.

Espinosa-Marquez, M.C., Valencia, J., Escobar-Medina, F.J., Colina-Flores, F., Arechiga-Flores, C.F., 2004. Effect of fluorogestone acetate on embryo recovery and quality in eCG-superovulated goats with premature luteal regression. Theriogenology 62, 624–630.

Ginther, O.J., Kot, K., 1994. Follicular dynamics during the ovulatory season in goats. Theriogenology 42, 987–1001.

Goel, A.K., Agrawal, K.P., 2005. Ovulatory response and embryo yield in Jakhrana goats following treatments with PMSG and FSH. Trop. Anim. Health Prod. 37, 549–558.

Gonzalez-Bulnes, A., Carrizosa, J.A., Diaz-Delfa, C., Garcia-Garcia, R.M., Urrutia, B., Santiago-Moreno, J., Cocero, M.J., Lopez-Sebastian, A., 2003. Effects of ovarian follicular status on superovulatory response of dairy goats to FSH treatment. Small Rumin. Res. 48, 9–14.

Gonzalez-Bulnes, A., Baird, D.T., Campbell, B.K., Cocero, M.J., Garcia-Garcia, R.M., Inskeep, E.K., Lopez-Sebastian, A., McNeilly, A.S., Santiago-Moreno, J., Souza, C.J.H., Veiga-Lopez, A., 2004. Multiple factors affecting efficiency of multiple ovulation and embryo transfer in sheep and goats. Reprod. Fertil. Dev. 16, 421–435.

Greyling, J.P.C., Van Der Nest, M., 2000. Synchronisation of oestrous in goats: dose effect of progestagen. Small Rumin. Res. 36, 201–207.

Greyling, J.P.C., Van Der Nest, M., Schwalbach, L.M.J., Muller, T., 2002. Superovulation and embryo transfer in South African Boer and indigenous feral goats. Small Rumin. Res. 43, 45–51.

Krisher, R.L., Gwazdauskas, F.C., Page, R.L., Russell, C.G., Canseco, R.S., Sparks, A.E.T., Velander, W.H., Johnson, J.L., Pearson, R.E., 1994. Ovulation rate, zygote recovery and follicular populations in FSH-superovulated goats treated with PGF_2 and/or GnRH. Theriogenology 41, 491–498.

Lehloenya, K.C., Greyling, J.P.C., Schwalbach, L.M.J., Grobler, S., 2006a. Superovulatory response in Boer goats pre-treated with a GnRH-agonist during the natural breeding season. S. A. J. Anim. Sci. 36 (Suppl.), 63–66.

Lehloenya, K.C., Greyling, J.P.C., Schwalbach, L.M.J., Grobler, S., 2006b. Superovulatory response in Boer goats pre-treated with a GnRH-agonist outside the natural breeding season. S. A. J. Anim. Sci. 36 (Suppl.), 30–33.

Lehloenya, K., Greyling, J., Grobler, S., 2008. Effect of season on the superovulatory response in Boer goats does. Small Rumin. Res. 78, 74–79.

Lindner, G.M., Wright, R.W., 1983. Bovine embryo morphology and evaluation. Theriogenology 20, 407–416.

Mahmood, S., Koul, G.L., Biswas, J.C., 1991. Comparative efficacy of FSH-P & PMSG on superovulation in Pashmina goats. Theriogenology 35, 1191–1196.

Mapletoft, R.J., Bennett Steward, K., Adams, G.P., 2002. Recent advances in the superovulation in cattle. Reprod. Nutr. Dev. 42, 601–611.

McNatty, K.P., Hudson, N.L., Ball, K., Mason, A., Simons, M.H., 1989. Superovulation and embryo recovery in goats treated with Ovagen and Folltropin. N. Z. Vet. J. 37, 27–29.

Menchaca, A., Pinczak, A., Rubianes, E., 2002. Follicular recruitment and ovulatory response to FSH treatment initiated on Day 0 or Day 3 postovulation in goats. Theriogenology 58, 1713–1721.

Motlomelo, K.C., Greyling, J.P.C., Schwalbach, L.M.J., 2002. Synchronisation of oestrus in goats: the use of different progestagen treatments. Small Rumin. Res. 45, 45–49.

Nuti, L.C., Minhas, B.S., Baker, W.C., Capehart, J.S., Marrack, P., 1987. Superovulation and recovery of zygotes from Nubian and Alpine dairy goats. Theriogenology 28, 481–488.

Oliveira, M.A.I., Guido, S.I., Lima, P.F., 2001. Comparison of different protocols used to induce and synchronize estrus cycle of Saanen goats. Small Rumin. Res. 40, 149–153.

Pendleton, R.J., Youngs, C.R., Rorie, R.W., Pool, S.H., Memon, M.A., Godke, R.A., 1992. Follicle stimulating hormone versus pregnant mare serum gonadotropin for superovulation of dairy goats. Small Rumin. Res. 8, 217–224.

Romano, J.E., 2004. Synchronization of estrus using CIDR, FGA or MAP intravaginal pessaries during the breeding season in Nubian goats. Small Rumin. Res. 55, 15–19.

Rubianes, E., Ungerfeld, R., Vinoles, C., Rivero, A., Adams, G.P., 1997. Ovarian response to gonadotropin treatment initiated relative to wave emergence in ultrasonographically monitored ewes. Theriogenology 47, 1479–1488.

Rubianes, E., Menchaca, A., 2003. The pattern and manipulation of ovarian follicular growth in goats. Anim. Reprod. Sci. 78, 271–287.

SAS, 2003. SAS Institute Inc. Cary, NC 27513, USA.

Selgrath, J.P., Memon, M.A., Smith, T.E., Ebert, K.M., 1990. Collection and transfer of microinjectable embryos from dairy goats. Theriogenology 34, 1195–1205.

Selvaraju, S., Agarwal, S.K., Karche, S.D., Majumdar, A.C., 2003. Ovarian response, embryo production and hormonal profile in superovulated goats treated with insulin. Theriogenology 59, 1459–1468.

Senger, P.L., 2003. Pathways to Pregnancy and Parturition. Current Conceptions, Inc., WA, 373 pp.

Senthil Kumar, P., Saravanan, D., Rajasundaram, R.C., Selvaraju, M., Kathiresan, D., 2003. Serum oestrdiol and progesterone profiles and their relationship with superovulatory responses in Tellicherry goats treated with eCG and FSH. Small Rumin. Res. 49, 69–77.