

Effect of Different Timing of PGF_{2α} Injection after CIDR Removal on Estrus Response and Pregnancy Rate in Nelore Cows

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Abstract: This research was conducted to evaluate the effect of estrus synchronization protocol on estrus response, follicular dynamics, corpus luteum function and pregnancy rate in Nelore cattle. Cows were selected and subdivided into four groups, namely the Control and Groups 1, 2 and 3. The Control (n=15 cows) were treated with CIDR inserts for 15 days. Cows in Groups 1 (n=14), 2 (n=12) and 3 (n=16) were treated with CIDR inserts for 15 days and given 500 µg of synthetic prostaglandin F_{2α} at 9, 14 and 19 days post CIDR removal, respectively. Estrus was observed for all cows and then artificially inseminated. Blood samples were collected twice per week during the research. The proportion of cows observed in estrus was higher in the Control group (80%) than the other groups. The pregnancy rate was higher in G2 (33.3 %) than the other groups. However, the difference was not significant. The interval from treatment to the onset of estrus and ovulation time (h) was highest (P<0.05) in G2 than other groups. Mean time from standing heat to ovulation (h) was not significant among groups. Normal progesterone profile was evident in G1, whereas the other groups showed delayed progesterone profile throughout the estrous cycle. In conclusion, the results indicated that CIDR inserted for 15 days alone resulted in a higher percentage of cows in estrus, but with lower pregnancy rate. However, the use of PGF_{2α} at different times after CIDR removal could improve fertility. In particular, cows in G2, given PGF_{2α} 14 days post CIDR removal had better fertility rates than cows in other groups. This study also indicated that animals treated with PGF_{2α} at 9 days after CIDR removal could give acceptable estrus response and a single timed insemination would give acceptable pregnancy rates.

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1. Introduction

Reproductive efficiency is a major factor affecting the production and economic efficiency of dairy and beef cow herds. The ideal calving interval of 1 year can only be achieved if the interval between parturition and successful natural service or AI is less than 85 days (Britt 1975). This ideal calving interval can only be attained with accurate detection of estrus and timing of insemination relative to ovulation (Stagg *et al.* 1995). Therefore, one of the reasons for the long calving interval in cows is poor estrus detection.

In Malaysia, most of the beef herds are pasture-fed and mating is done naturally by mixing bulls with cows at a ratio of 1: 10. Since estrus detection is not widely practiced. One of the reproductive challenges encountered in pasture-based cattle is repeat breeders. Improvement in fertility must first come from improved breeding management and only then from the use of assisted reproductive technology (ART) such as estrus synchronization. Estrus synchronization facilitates the use of genetically superior sires through artificial insemination (AI). It may also enhance reproductive efficiency by shortening the breeding and calving

seasons. There are two principles of controlling estrus and ovulation in cattle. The first principle is to prolong the life of the CL, thus delaying estrus. This can be advanced by administering progestin such as Controlled Internal Drug Release (CIDR) that mimics the function of the CL. The second principle is to shorten the life of the CL. Thus hastens the onset of estrus. This is attained by administering exogenous luteolytic agents such as prostaglandin F_{2α}. However, prostaglandin F_{2α} (PGF_{2α}) is effective only when a fully developed CL is present approximately beyond Day 5 and Day 7 of the oestrous cycle (Hafez and Hafez 2000).

Cows that have had their cycle extended by progestin administration showed reduced fertility (Beal, 1996). However, a longer duration of progestin treatment (more than 14 days) is necessary to allow for the spontaneous occurrence of luteolysis before treatment withdrawal. It is noteworthy that, this treatment regime gained the reputation as producing a highly synchronized, but infertile estrus (Fields *et al.* 2002). Furthermore, it was noted that conception rate is reduced when synchronization with short-term progestin treatments (between 7 and 12 days), combined with PGF_{2α} were initiated in the last third

of the oestrous cycle. Therefore, future improvement in estrus synchronization procedure is most likely to come from achieving more synchrony between the development of a highly fertile ovulatory follicle and controlling of luteal function.

We hypothesized that cows with functional CL will response to PGF_{2α} treatment and thus there would be an increase in estrus response and thus, in pregnancy rate. Therefore, this study was carried out to determine the effect of estrus synchronization treatment on estrus response, corpus luteum function, follicular dynamics, and pregnancy rate. Eventually, to establish a new estrus synchronization protocol for artificial insemination in breeding Nelore cattle.

2. Materials and methods

Fifty seven Nelore cows (beef cattle) of at least three years of age were selected for the study. These cows were healthy, primi- and multiparous and cycling normally. This herd was grazing on *Brachiaria decumbens* pasture and supplemented with commercial concentrates of palm kernel cake at the rate of 2 kg/cow/day. The ovaries were palpated per rectum for the presence of either follicles or an active CL. All cows were inserted with controlled internal drug release device (CIDR) for 15 days. This device is readily coated with 1.38 g of progestagen in a silicon rubber. After 15 days, the CIDR was removed and the cows were randomly divided into four groups; control, groups 1, 2 and 3. In group 1, 2 and 3, each cow was intramuscularly administered with 2 ml (equivalent of 500 µg) of cloprostenol (Estrumate[®], Schering-Plough Animal Health) on Days 9, 14, and 19 after CIDR removal, respectively.

The ovaries were examined by ultrasound (Aloka SSD-500, Japan) using a 5 MHz trans-rectal probe to determine the time of ovulation. Each ovary was scanned and the image of the largest follicle was recorded on a videotape. Ultrasound examinations of the ovaries were conducted (1) immediately after PGF_{2α} injection and (2) at standing estrus twice daily for the next 5 days. Ovulation is defined as the sudden disappearance of the follicle identified as a dominant follicle during the preceding examination. For confirmation that ovulation had occurred the cow was reexamined 12 hours later. Cows suspected pregnant were determined approximately 30 days following the second insemination.

For Control group, the estrus detection was performed twenty-four hours after removal of CIDR, however for groups 1, 2 and 3 estrus was observed immediately after PGF_{2α} injection. Cows were observed visually for behavioral estrus twice daily 1 hour at 0800h and 1600h until the end of the experiment. The signs observed for estrus were clear mucus discharge, congested vulva, mounting and

standing to be mounted. All cows that showed estrus were artificially inseminated with frozen-thawed Nelore semen. The first AI was done immediately after the first sign of estrus observation and a second AI was performed 12 hours later.

Blood samples were collected in EDTA tubes via a jugular venipuncture every 3-4 days beginning at day of CIDR insertion, until after A.I., and continued for the next 30 days. Following collection, labeled blood samples were immediately placed in ice and centrifuged for 15 min at 1340 Xg. The plasma was transferred into a 2 ml polypropylene tube and stored at -20 °C until assay. Plasma progesterone concentration was measured using a commercial radioimmunoassay (RIA) kit (Diagnostics Product Corporation, USA).

Data were analyzed using a statistical software SPSS release 12.0. Reproductive parameters in these two treatments were compared by a Kruskal-Wallis one-way ANOVA (non parametric statistical test), Mann-Whitney U test and Chi-square. Data are presented as arithmetic mean ± SEM.

3. Results

Estrus response, ovulatory response and pregnancy rates

Table 1 shows the estrus response and pregnancy rate after CIDR treatment in the Nelore cows. The percentage of cows observed in estrus was highest in the control group. However, estrus response was not statistically significant among groups except G3 (80.0%, 64.2 % and 58.3 % for control, G1 and G2, respectively). Contrariwise, control group, G1 and G 2 had significantly ($P < 0.05$) higher estrus response as compared to G3 (25.0 %). The average time taken from PGF_{2α} treatment to standing estrus is longest ($P < 0.05$) in G2 (108.0 ± 26.8 h). Similarly, G2 also showed a significant longer ($P < 0.05$) mean time from PGF_{2α} treatment to ovulation (112 ± 4.0 h). On the other hand, the mean time from standing heat to ovulation was longest in the control group (33.1 ± 7.5 h), but shortest in G3 (12.0 ± 0.0 h). However, there was no significant differences among the four groups. Ovulation of the dominant follicle after different estrous synchronization regimes occurred within about 120 hours (5 days) after PGF_{2α} treatment. The percentage of cows that ovulated was significantly highest in the G1 (100 %) when compared with the three other groups ($P < 0.05$). In addition, control cows ovulation rate (87.5 %) was higher ($P < 0.05$) than cows in G2 and G3. The highest pregnancy rate after AI was found in G2 (25.0 %), followed by G1 (21.4 %), control (20.0 %) and G 3 (12.5 %). However, the differences were not statistically significant among groups.

Table 1. Estrus Response, Pregnancy Rate and Ovulatory Response Following Synchronization Treatment in the Nelore Cows

Item	Control	G 1	G 2	G 3
No. of treated cows (n)	15	14	12	16
Estrus exhibition (%)	80.0 ^a	64.2 ^a	58.3 ^a	25.0 ^b
Mean time from treatment to standing heat (h)	58.0 ± 3.5 ^b	64.0 ± 5.6 ^b	108.0 ± 26.8 ^a	72.0 ± 9.7 ^b
Mean time from treatment to ovulation (h)	90.8 ± 5.7 ^b	81.6 ± 4.4 ^b	112.0 ± 4.0 ^a	76.0 ± 4.0 ^b
Mean time from standing heat to ovulation (h)	33.1 ± 7.5 ^a	24.0 ± 0.0 ^a	18.0 ± 6.0 ^a	12.0 ± 0.0 ^a
Percentage of cows ovulated (%)	87.5 ^b	100 ^a	50.0 ^c	37.5 ^c
Pregnancy rate of cows in estrus (%)	20.0 ^a	21.4 ^a	33.3 ^a	12.5 ^a

^{a, b, c} values with different superscripts in the same row differ significantly at P<0.05; Chi-square and ANOVA.

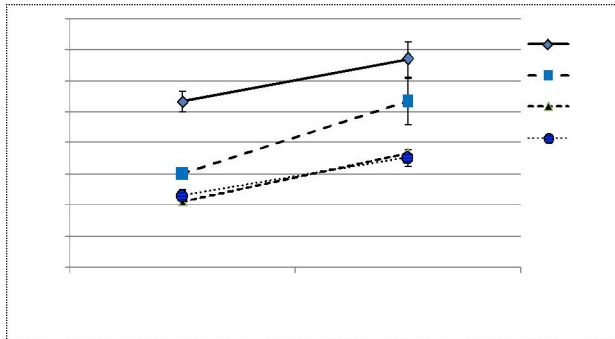


Figure 1. Mean Size of Dominant Follicle at Treatment and the Size of Follicle before Ovulation.

The size of the dominant follicle at treatment and before ovulation in various groups is shown in Figure 1. The mean diameter of follicle that was recorded a day after the removal of CIDR from cows in the control group was 16.0 ± 1.0 mm. For the other 3 groups; the follicular diameter was measured at PGF_{2α} injection. The mean diameters of dominant follicle for G1, G2, and G3 were 9.0 ± 0.2, 6.3 ± 0.4,

and 7.0 ± 0.5 mm, respectively. The mean follicular size in the control group after CIDR removal was significantly larger (P<0.05) when compared with the other three groups. The maximum size of the dominant follicle in the control group was not different than that in G 1. However, the maximum size of the dominant follicle in the control (20.1 ± 1.7 mm) and G1 (16.0 ± 2.2 mm) cows were statistically significant (P<0.05) as compared with G2 (11.0 ± 0.0 mm) and G3 (10.6 ± 0.8 mm) cows.

Figure 2 shows the distribution of cows exhibiting estrus over time following synchronization treatment. Twenty five out of the 32 cows (78.1 %) showed standing estrus within 72 h after treatment. The onset of estrus ranged between 36 and 96 hours post treatment in all groups. Only one cow from G2 displayed estrus at approximately >121 hours. Majority of the cows (90.0 %) showed estrus within 72 hours mark compared with other range of times and the difference was statistically significant (P<0.05).

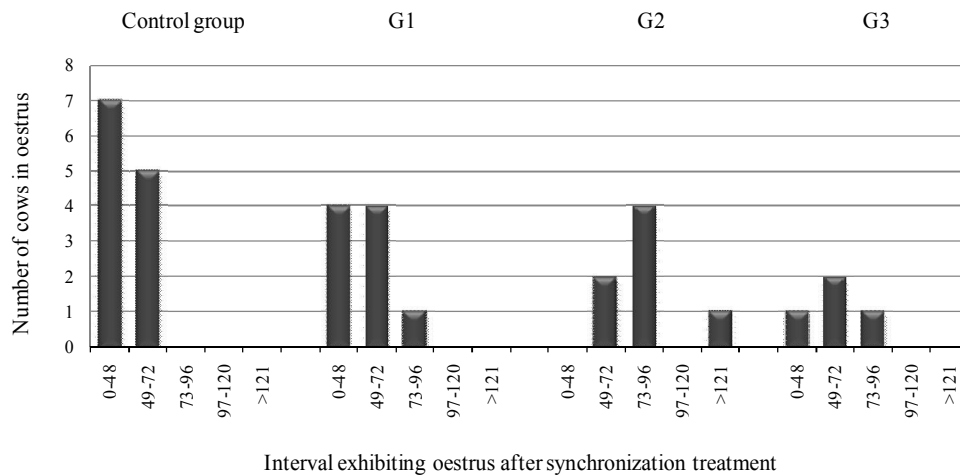


Figure 2. Distribution of Cows Exhibiting Estrus over time Following Synchronization Treatment.

Effect of CIDR insert and various timing of prostaglandin $F_{2\alpha}$ injection on plasma concentration of progesterone

Cows from the control group showed estrus after CIDR removal and immediately artificially inseminated. Initially at estrus the progesterone (P_4) concentration was at 0.4 ± 0.1 ng/ml and then increased to 1.5 ± 0.4 ng/ml 7 days later, and remained high (3.6 ± 0.8 ng/ml) for 11 days. The average P_4 concentration was 2.1 ± 0.3 ng/ml in the estrous cycle (Figure 3). In G1, CIDR was inserted for 15 days and $PGF_{2\alpha}$ was given 9 days after CIDR removal. On Day 9, $PGF_{2\alpha}$ was injected and the first estrus occurred within 64.0 ± 5.6 hours. Mean progesterone concentration was initially 0.2 ± 0.04 ng/ml at estrus, then increased to 1.7 ± 0.8 ng/ml on

Day 4, peaked at 3.2 ± 1.0 ng/ml on day 11 and began to decrease thereafter. In G2, progesterone concentration was also initially at 0.2 ± 0.1 ng/ml, then increased to 2.0 ± 1.7 ng/ml 7 days later and peaked at 1.4 ± 0.7 ng/ml on Day 17. The average P_4 concentration was 2.3 ± 0.4 ng/ml within the estrous cycle (Figure 3). In G3, CIDR was inserted for 15 days and $PGF_{2\alpha}$ was given 19 days later after CIDR removal. On Day 19 after CIDR removal, $PGF_{2\alpha}$ was injected and the estrus occurred within 72.0 ± 9.7 hours. The mean progesterone concentration dropped to 0.4 ± 0.3 ng/ml at estrus after $PGF_{2\alpha}$ injection, which then increased to 2.0 ± 0.8 ng/ml 11 days later, and remained high until Day 17 (1.0 ± 0.5 ng/ml). The average P_4 concentration was 1.2 ± 0.2 ng/ml in the oestrous cycle (Figure 3).

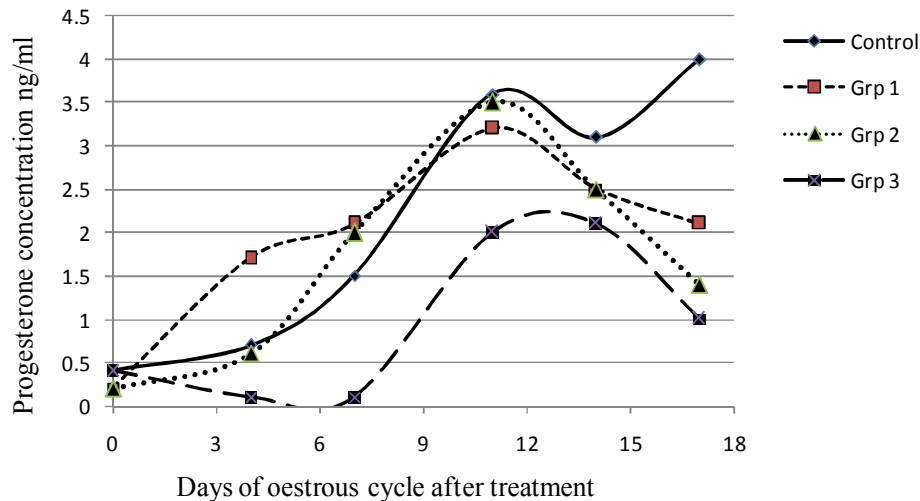


Figure 3. Mean Progesterone Concentration from the Day of Estrus to Day 18 after Estrus Synchronization Treatment in Four Groups.

Table 2. Comparison of Progesterone Concentration between Groups after Treatment

Day of estrous cycle	Control group	G 1	G 2	G 3
0	0.4 ± 0.1^a	0.2 ± 0.04^a	0.2 ± 0.1^a	0.4 ± 0.3^a
4	0.7 ± 0.08^b	1.7 ± 0.8^a	0.6 ± 0.1^b	0.1 ± 0.05^b
7	1.5 ± 0.4^a	2.1 ± 1.1^a	2.0 ± 1.7^a	0.1 ± 0.07^b
11	3.6 ± 0.8^a	3.2 ± 1.0^a	3.5 ± 1.4^a	2.0 ± 0.8^a
14	3.1 ± 0.6^a	2.5 ± 1.2^a	2.5 ± 1.3^a	2.1 ± 1.0^a
17	4.0 ± 1.0^a	2.1 ± 1.1^b	1.4 ± 0.7^b	1.0 ± 0.5^b
Average P_4 level	2.1 ± 0.3^a	2.3 ± 0.3^a	2.3 ± 0.4^a	1.2 ± 0.2^b

^{a, b, c} values with different superscripts in the same row differ significantly at $P < 0.05$.

Table 2 shows the comparison of the mean P_4 concentration in all groups. Progesterone concentration on Day 0 (AI) was highest in the Control group (0.4 ± 0.1 ng/ml) and G 3 (0.4 ± 0.3 ng/ml) than G 1 (0.2 ± 0.04 ng/ml) and G 2 (0.2 ± 0.1

ng/ml). The P_4 concentration increased significantly ($P < 0.05$) at Day 4 after AI in G 1 (1.7 ± 0.8 ng/ml) than other groups. While, P_4 concentration on Day 7 was significantly higher ($P < 0.05$) in the Control group, G1, and G2 (1.5 ± 0.4 , 2.1 ± 1.1 , and 2.0 ± 1.7

ng/ml, respectively) than G3 (0.1 ± 0.07 ng/ml). On the other hand, the P_4 concentration on Day 11 and 14 post AI was not significantly different among the groups. On Day 17, P_4 concentration was significantly higher in the Control group (4.0 ± 1.0 ng/ml) than in other groups. The average P_4 concentration from the day of AI/estrus to 17 days post-AI was significantly higher in the Control group, G1, and G2 (2.1 ± 0.3 , 2.3 ± 0.3 , and 2.3 ± 0.4 ng/ml, respectively) than G3 (1.2 ± 0.2 ng/ml; $P < 0.05$).

4. Discussion

Results from this study showed that the proportion of cows observed in estrus was higher in the Control group (80.0 %). This result was similar to that reported by Beal (1996), whereby in his long term study which involved exogenous treatment for a period of more than 14 days. In his report synchronized estrus reach 100 % after 18 days of the P_4 treatment, which resulted in the delay of estrus, thus leading to synchronization by exogenous administration of progesterone.

The results of our study demonstrated that $PGF_{2\alpha}$ injections at Days 9, 14, and 19, were effective in luteolysis as evidenced from the marked decrease in the progesterone level. In normal cycling cow, the oestrous cycle is divided into 4 stages: preestrus, estrus, metestrus, and diestrus. Diestrus is characterized by the presence of a corpus luteum which produces progesterone. Furthermore, diestrus can be divided into 3 substages: the early (day 5 to 9), mid (day 10 to 13), and late diestrus (day 14 to 18). It is well-established that the exogenous administration of $PGF_{2\alpha}$ after Day 5 of the bovine oestrous cycle causes luteolysis and a rapid decline in the peripheral serum progesterone concentrations. However, the proportion of cows observed in estrus was variable. It was observed that, in early diestrus (G1) a higher percentage of cows displayed estrus. This effect, in turn, induces estrus and subsequent ovulation (Berardinelli and Adair 1989; Lucy *et al.* 2004). In another study by Berardinelli and Adair (1989), it was reported that synchronization was the most precise when cows were injected in the early diestrus or in the late diestrus. It is noted also that the most varied response among cows was in mid diestrus (Days 12 and 13). On the other hand, cows injected with during early diestrus were least likely to be detected in estrus in the 10 days following treatment (81 % and 85 % on Days 7 and 8, respectively) and most likely to be detected with injections in the late diestrus (98% on Days 14 and 15) (Macmillan *et al.* 2003).

The findings of this study demonstrated that the percentage of cows that failed to display estrus was highest in G3 (75 %) than in other groups. All

cows in this group showed a decrease in P_4 after $PGF_{2\alpha}$ injection. These cows were heavily handled since blood sampling was done twice a week and ultrasound examination of the ovary was done once daily for 5 days depending on the time of ovulation. It has been shown that stress can shorten or inhibit estrus (Orihuela, 2000). Hormones like adrenocorticotrophic hormone (ACTH), cortisol and/or dexamethasone are often used to induce stress. Intramuscular (IM) injections of 320 IU of ACTH during pro-estrus delayed the onset and shortened the duration of estrus in heifers (Hein and Allrich 1992). It was reported by Stoebel and Moberg (1982) that the infusion of high cortisol during the preovulatory period prevented the LH surge and also estrus behavior in three of four heifers studied. However, ovarian function may have been altered by the infusion of cortisol and the stimulus responsible for estrus behavior (estrogen) may have been absent. In addition, one injection of 4 mg of dexamethasone (a synthetic glucocorticoid) to estradiol-treated ovariectomised heifers cause a decrease in the percentage of heifers in estrus, but the behavior of those heifers that displayed estrus was not altered (Cook *et al.* 1987; Allrich *et al.* 1989). Synthetic glucocorticoids hormone has the ability to inhibit estrus in intact and estradiol-treated animals. Therefore, we can assume that the natural glucocorticoids like cortisol that were produced from the stressed Nelore cows in our study could also inhibit estrus behavior, thus resulting in a low percentage of estrus response.

The mean time from standing heat to ovulation was longest in the Control group (33.1 ± 7.5 h) but when compared with the other groups, it was not statistically significant. This is probably because stressors like restraining, doing ultrasonography, and handling during blood collection incurred on the cows may have affected the time of ovulation after standing estrus in the control group. In several studies, stressors can disrupt the correct functioning of each part of the hypothalamus-pituitary-ovarian axis and this include disruption of the pulsatile pattern and timing of the LH surge (Dobson *et al.*, 2001; Saifullizam *et al.*, 2010; Fergani *et al.*, 2012), lower than normal oestradiol secretion (Saifullizam *et al.*, 2010; Fergani *et al.*, 2012) and thus resulting in late ovulation.

In the current results, injection with $PGF_{2\alpha}$ at the mid stage of the luteal phase (G2) led to a higher pregnancy rate when compared with the other three groups, although the estrus response was the lowest but not statistically significant. On the contrary, Diskin *et al.*, (2002) reported that both heifers and cows, injected with prostaglandin at the late stage of the luteal phase have a greater estrus response and a

higher conception rate than animals treated in the early or mid-luteal stage. Although the cows were raised freely on pasture, it was evident that fertility can be affected by handling as shown in our study. We believe that this effect on fertility is produced by contact stressor, in particular, the rough handling at the beginning of estrus synchronization treatment. This could lead to one or more of the following results: high incidence of post-insemination luteal sub-function (Hommeida *et al.*, 2004); high incidence of embryo deaths correlating with the sub-function of corpus luteum (Taponen *et al.*, 2003); ovulation without estrus (Leyva-Ocariz *et al.*, 1996); and anovulatory follicle (Stevenson *et al.*, 1997; Wiltbank *et al.*, 2002).

The maximum size of ovulatory follicle in the Control group was larger (20.1 ± 1.7 mm) and statistically significant ($P < 0.05$) when compared with those in the G2 and G3. In a study by Pierson and Ginther (1988), it was reported that the long term treatment with progestagen (> 14 days) to cows, would have an older dominant follicle at the end of the progestagen treatment, and thus, the follicle had completed its maturation process and was able to produce enough estradiol to promote estrus behavior shortly after the CIDR removal. The sequential relationship of the low progesterone increased the frequency of LH pulses. Therefore, long time of frequency of LH pulses will cause a persistent largest follicle and reduced fertility which is widely accepted as one of the causes and effects (Inskeep, 2004). In cows of G1, the dominant follicle of wave 1 increased in diameter in which became the ovulatory follicle after $\text{PGF}_{2\alpha}$ treatment. However, the results in our study confirmed that the static-phase dominant follicle of wave 1 was capable of further growth after induction with luteolytic agent even though it had apparently reached its maximum diameter before the $\text{PGF}_{2\alpha}$ treatment. In addition, the diameter of the ovulatory follicle on the day prior to ovulation was smaller in cows of G2 and G3, which ovulated from wave 2 than in those of G1 which ovulated from wave 1. This is consistent with a previous study which indicated that the ovulatory follicle of wave 1 was larger in diameter than the ovulatory follicle of wave 2 (Kastelic and Ginther 1991).

Our study also showed that the time lapsed from $\text{PGF}_{2\alpha}$ until showing estrus was longest in G2 compared to other groups. Therefore, cows treated during the mid stage of luteal phase (G2) tended to have longer intervals between estrus than those treated during the early (G1) or late (G3) stage. Our findings were similar to the findings of Berardinelli and Adair (1989). They reported that a greater proportion of heifers ($P < 0.05$) showed estrus by 60 h after $\text{PGF}_{2\alpha}$ when treated during the early (5 – 9 days)

and late (14 – 19 days) luteal stages (75.5 %) than for heifers treated during the mid luteal stage (30.4 %). The average interval to estrus in heifers treated during the mid luteal stage was 67 h, which is longer than in heifers treated in the early and late luteal stages (56 h). Similar results were also presented in numerous studies for both dairy and beef heifers (King *et al.* 1982; Tanabe and Hann 1984; Etherington *et al.* 1986). Also, we can't ignore the nutritional status differences between the Berardinelli and Adair cows with good feeding strategy and the current Nelore cows, that might caused the delay for displaying estrus in Nelore cows.

Different progesterone profiles were observed in the different treatment groups. In G1, the progesterone concentration peaked at day 4 after estrus. In these animals, estrus was observed at 64 hours after treatment and the development of corpus luteum occurred at approximately the same time. Therefore, the progesterone peak occurred on the same day. However, the progesterone peak for the Control group, G2 and G3 was only observed 7 days after estrus. In these animals, estrus was observed from 58 to 108 hours after treatment. Five out of 16 cows in the G3 have basal progesterone level after treatment. In addition, 9 cows in this group showed abnormal progesterone profile. Therefore, in these nine animals the development of corpus luteum was probably delayed as indicated by the delay of the progesterone peak.

Delayed progesterone productions were recorded in the Control group, G2 and G3. Delayed P_4 profile is defined as progesterone concentrations of ≥ 1.0 ng/ml on Day 7 post AI. The luteotrophic hormone as LH support the corpus luteum for secretion of progesterone (Baird, 1992). Therefore, partial withdrawal of luteotrophic support during the luteal phase resulted in inadequate corpora lutea secreting subnormal amounts of progesterone (Southee *et al.* 1988). In addition, ovulation of immature follicles (Hunter, 1991) may also cause subnormal amounts of progesterone. Delayed progesterone profile can cause a stronger luteolytic signal and also predispose to a higher incidence of embryo loss (Lonergan, 2011). These abnormal progesterone profiles were also associated with decline in pregnancy rate due to the asynchrony between the uterus and the embryo (Hommeida *et al.* 2004). In cows with normal gestation there is an increase in the progesterone in the early postovulatory 15-17 days after AI with a high progesterone concentration during the luteal phase. In addition, the embryos of these cows produced larger amounts of interferon tau ($\text{INF-}\tau$) that would alter the dynamics of $\text{PGF}_{2\alpha}$ secretion, and therefore the

pregnancy was more likely to be maintained (Mann and Lamming 2001).

In conclusion, luteal phase of the estrous cycle and follicular development during the luteal phase may be considered as major factors affecting the rate of estrus synchronization in Nelore cattle. Variability in the interval to estrus and the distribution of the estrus response in cows that exhibited estrus was due primarily to treating cows during the mid stage of the luteal phase (G2). The cause of this variability appears to be related to the manner in which progesterone decreased in cows during the mid stage of the luteal phase after PGF_{2α} treatment and may also be related to ovarian follicular development. However, the greater degree of synchronization among animals was due to treatment with CIDR alone or together with administration of PGF_{2α} 9 days after CIDR removal (G1). The results in the present study indicated that animals treated with PGF_{2α} 9 days after CIDR treatment resulted in acceptable estrus response and a single timed insemination gave acceptable pregnancy rates.

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