Proceedings, Applied Reproductive Strategies in Beef Cattle
September 11 and 12, 2007, Billings, Montana

ESTRUS SYNCHRONIZATION PROTOCOLS FOR COWS

G. Cliff Lamb, Jamie E. Larson, and Carl R. Dahlen
North Central Research and Outreach Center, University of Minnesota, Grand Rapids

Introduction

Estrous synchronization and artificial insemination (AI) are reproductive management tools available to beef producers for over 30 years. Synchronization of the estrous cycle has the potential to shorten the calving season, increase calf uniformity, and enhance the possibilities for utilizing AI. Artificial insemination allows producers the opportunity to infuse superior genetics into their operations at costs far below purchasing a herd sire of similar standards. These tools remain the most important and widely applicable reproductive biotechnologies available for beef cattle operations (Seidel, 1995). However, beef producers have been slow to utilize or adopt these technologies into their production systems.

Several factors, especially during early development of estrous synchronization programs, may have contributed to poor adoption rates. Initial programs failed to address the primary obstacle in estrous synchronization, which was to overcome puberty or postpartum anestrus. Additionally, these programs failed to manage follicular waves, resulting in more days during the synchronized period in which estrus detection was necessary. This ultimately precluded fixed-time AI with acceptable pregnancy rates. More recent developments focused on both corpus luteum and follicle control in convenient and economical protocols to synchronize ovulation. These developments facilitated fixed-time AI (TAI) use, and should result in increased adoption of these important management practices (Patterson et al., 2003). Current research has focused on the development of methods effectively synchronizing estrous in postpartum beef cows and replacement beef heifers by decreasing estrous detection time required, thus facilitating the use of TAI (Lamb et al., 2001, 2006, Larson et al., 2006). This new generation of estrous synchronization protocols uses two strategies which are key factors for implementation by producers because they minimize the number and frequency of handling cattle through a cattle-handling facility and eliminate detection of estrus by employing TAI.

High priority needs to be placed on transferring these current reproductive management tools and technology to producers, veterinarians and industry personnel to ensure they are adopted at the producer level and to provide the necessary technical support to achieve optimum results. Because current management, breed, economic, location, and marketing options are producer specific, it is essential to ensure transfer of this technology is not presented in blanket recommendations. Producers receiving all the necessary, applicable information packaged to include, but not limited to, protocol administration, economic implications, and genetic improvements to the cowherd are more apt to implement these tools into their management systems and achieve positive outcomes as a result. Without timely transfer of this technology within the United States, our research products and technology will be more effectively utilized in foreign countries competing with the United States to produce and market high quality, uniform beef products. The recent development of estrous synchronization protocols for TAI in beef cows has the potential to alter reproductive performance in numerous herds.

Abbreviations, Terms and Protocol Definitions

Abbreviations

AI: Artificial insemination
CIDR: controlled internal device release (vaginal implant containing 1.38 g progesterone)
CL: corpus luteum
GnRH: gonadotropin-releasing hormone (dose = 100 μg)
d: days
hr: hours
hCG: human chorionic gonadotropin
MGA: melengesterol acetate (fed at 0.5 mg/head/day)
PG: prostaglandin $F_{2\alpha}$ (dose = 25mg)
TAI: artificial insemination at a predetermined fixed-time

Terms

Synchronization rate: Proportion of females detected in estrus to total number treated.
Conception rate: Proportion of females becoming pregnant to those exhibiting estrus and inseminated during the synchronized period.
Pregnancy rate: Proportion of females becoming pregnant to total number treated.

Protocols Requiring Detection of Estrus

2 shot PG: Two injections of PG administered 11 to 14 d apart.
MGA-PG: MGA is fed for a period of 14 d with PG administered 19 d after MGA withdrawal.
Select Synch: GnRH followed in 7 d with an injection of PG.
CIDR-PG: CIDR inserted for 7 d with PG administered on d 7.
Select Synch + CIDR: CIDR inserted for 7 d with GnRH administered at CIDR insertion and PG administered on d 7 at CIDR removal.
7-11 Synch: MGA is fed for 7 d with PG administered on the last d of feeding, followed by Select Synch initiated 4 d later.

Protocols for TAI

MGA Select + fixed-time AI: MGA is fed for 14 d, GnRH is administered 12 d after MGA withdrawal, and PG is administered 7 d after GnRH. Insemination is performed 72 hr after PG with GnRH administered at AI.
Ovsynch: GnRH is administered followed in 7 d with the administration of PG. A second GnRH is administered at 48 hr with a TAI 16 hr later.
CO-Synch: GnRH is administered followed in 7 d with the administration of PG. Insemination is performed 48 to 72 hr after PG with GnRH administered at AI.

CO-Synch + CIDR: GnRH is administered at CIDR insertion followed 7 d later with the administration of PG at CIDR removal. Insemination is performed 66 hr after PG and CIDR removal with GnRH administered at AI.

Development of estrous synchronization method for TAI

Initial estrous synchronization systems focused on altering the estrous cycle by regressing the CL with an injection of PG followed by detecting estrus between 18 and 80 hr after the injection. Once systems involving a single injection of PG became successful, researchers focused on multiple injections of PG to further reduce days required for heat detection and AI (Lauderdale et al., 1974; Seguin et al., 1978). The next generation of estrous synchronization systems involved the use of exogenous progestins (MGA and CIDR), which (while administered) prevented estrus from occurring. Progestins were used to delay the time of estrus following a natural or induced luteolysis and extend the length of the estrous cycle (Brown et al., 1988; Lucy et al., 2001). Not until the discovery follicle growth in cattle occurs in distinct wave-like patterns (Fortune et al., 1988) were scientists able to embark on the third generation of estrous synchronization systems. Controlling follicular waves with a single injection of GnRH to cows at random stages of their estrous cycles causes release of luteinizing hormone leading to synchronized ovulation and luteinization of mostly large dominate follicles ($\geq$ 10 mm; Garverick et al., 1980; Bao and Garverick, 1998; Sartori et al., 2001). Consequently, a new follicular wave is initiated in all cows within 2 to 3 d of GnRH administration. Luteal tissue that forms after GnRH administration is capable of undergoing PG-induced luteolysis 6 or 7 d later (Twagiramungu et al., 1995). A drawback of this method, however, is approximately 5 to 15% of cows are detected in estrus on, or before, the day of PG injection, thus reducing the proportion of females detected in estrus and inseminated during the synchronized period (Kojima et al., 2000; Lamb et al., 2001). Based on this foundation, much of the current work has focused on three areas: 1) development of reliable protocols that rely solely on TAI; 2) development of systems that require a maximum of three animal handlings; and 3) research to ensure the systems are successful in both anestrus and estrous cycling females at any stage of the estrous cycle. This review is an update on these developments for synchronization of the estrous cycle in cows.

Use of MGA in Cow Protocols

During the past 25 years numerous researchers have generated data to devise successful estrous synchronization protocols utilizing MGA in beef cows such as MGA-PG, MGA Select and 7-11 Synch (Kojima et al., 2000; Patterson et al., 1989, 2003). Melengestrol acetate is an orally active progestin. When consumed by cows on a daily basis, MGA will suppress estrus and prevent ovulation (Imwalle et al., 2002). Melengestrol acetate may be fed with a grain or a protein carrier and either top-dressed onto other feed or batch mixed with larger quantities of feed. Melengestrol acetate is fed at a rate of 0.5 mg/animal/day in a single daily feeding. The duration of feeding may vary between protocols, but the level of feeding is consistent and critical to success. Animals that fail to consume the required amount of MGA on a daily basis may prematurely return to estrus during the feeding period. This can be expected to reduce the estrous response during the synchronized period. Therefore, adequate bunk space (60 linear cm/head) must be available so all animals consume feed simultaneously (Patterson et al., 2003).

Animals should be observed for behavioral signs of estrus each day of the feeding period. This may be done as animals approach the feeding area and before feed distribution. This practice will ensure all females receive adequate intake. Cows will exhibit estrus beginning 48 hours after MGA withdrawal, and this will continue for 6 to 7 days. It is generally recommended females exhibiting estrus during this period not be inseminated or exposed for natural service because of reduced fertility females experience at the first heat after MGA withdrawal.

In spite of the success in development of the MGA protocols, the use of MGA as part of any estrus synchronization protocol in beef cows constitutes an extralabel use of medicated feed prohibited by the Animal Medicinal Drug Use and Clarification Act and regulation 21 CFR 530.11(b). The feeding of MGA is specifically approved for estrus suppression in heifers only. Although 35 years of feeding MGA to beef cows and beef heifers has demonstrated MGA is safe, effective and economical, the **feeding of MGA to adult cows is not an FDA approved label claim and therefore is strictly prohibited by the FDA**. It is unfortunate the MGA label does not include all reproductively mature beef cattle, but it does not.

Overview of the CIDR Device

The CIDR is an intravaginal progesterone insert, used in conjunction with other hormones to synchronize estrous in beef and dairy cows and heifers. The CIDR was developed in New Zealand and has been used for several years to advance the first pubertal estrus in heifers and the first postpartum estrus in cows. The CIDR is a “T” shaped device with flexible wings that collapse to form a rod that can be inserted into the vagina with an applicator. On the end opposite to the wings of the insert a tail is attached to facilitate removal with ease. The backbone of the CIDR is a nylon spine covered by progesterone (1.38g) impregnated silicone skin. Upon insertion blood progesterone concentrations rise rapidly, with maximal concentrations reached within an hour after insertion. Progesterone concentrations are maintained at a relatively constant level during the seven days the insert is in the vagina. Upon removal of the insert, progesterone concentrations are quickly eliminated.

Retention rate of the CIDR during a seven-day period exceeds 97%. In some cases, vaginal irritation occurs resulting in clear, cloudy or yellow mucus when the CIDR is removed. Cases of mucus are normal and do not have an impact on effectiveness of the CIDR. Caution should be taken when handling CIDRs. Individuals handling CIDRs should wear latex or nitrile gloves to prevent exposure to progesterone on the surface of the insert and to prevent the introduction of contaminants from the hands into the vagina of treated females. The inserts are developed for a one-time use only. Multiple uses may increase the incidence of vaginal infections.

Initial CIDR/$PGF_{2α}$ Protocols for Cows

During the seven days of CIDR insertion, progesterone diffusion from the CIDR does not affect spontaneous luteolysis. Assuming all cows have 21 day estrous cycles, there will be two populations of females after six days of CIDR treatment: females without corpora lutea and females with corpora lutea more than six days after ovulation. All females, therefore, have corpora lutea potentially responsive to an injection of $PGF_{2α}$. Although most research data indicates only about 90% of corpora lutea in cows more than six days after ovulation regress promptly to an injection $PGF_{2α}$, only about 60% of the females will have corpora lutea at the time of $PGF_{2α}$ treatment (assuming spontaneous corpora lutea regression beings about 18 days after ovulation). Therefore, about 95% of the females treated with the FDA approved CIDR/$PGF_{2α}$ protocol are synchronized to exhibit estrus within a few days of CIDR insert removal. However, more than 95% of the treated females will be synchronized to exhibit estrus if estrous behavior is monitored for five days after removal of the CIDR insert.

Table 1. Fertility rates in cycling or noncycling suckled beef cows treated with estrous synchronization protocols containing a CIDR.

Reference and treatment description	No. of cows	Conception rate[a], %	Pregnancy rate[b], %
Lamb et al., 2001			
CO-Synch – anestrous	56	-	22/56 (39)
CO-Synch - cyclic	172	-	91/172 (53)
CO-Synch + CIDR from d –7 to 0 - anestrous	61	-	36/61 (59)
CO-Synch + CIDR from d –7 to 0 - cyclic	161	-	102/161 (63)
Larson et al.., 2004a			
CIDR/$PGF_{2α}$ *(PG on d 0) - anestrous*	147	-	74/147 (50)
CIDR/$PGF_{2α}$ *(PG on d 0) - cyclic*	296	-	159/296 (54)
CO-Synch - anestrous	156	-	59/156 (38)
CO-Synch - cyclic	330	-	145/330 (44)
CO-Synch + CIDR - anestrous	180	-	85/180 (47)
CO-Synch + CIDR - cyclic	294	-	169/294 (57)
Hybrid Synch - anestrous	143	-	60/143 (42)
Hybrid Synch - cyclic	308	-	182/308 (59)
Hybrid Synch*+CIDR - anestrous*	136	-	72/136 (53)
Hybrid Synch*+CIDR - cyclic*	306	-	180/306 (59)
Lucy et al., 2001			
Control *- anestrous*	151	6/16 (38)	6/151 (4)
Control *- cyclic*	134	15/26 (58)	15/134 (11)
$PGF_{2α}$ *- anestrous*	154	17/30 (57)	17/154 (11)
$PGF_{2α}$ *- cyclic*	129	44/63 (70)	44/129 (34)
CIDR/$PGF_{2α}$ *(PG on d –1) - anestrous*	141	36/63 (57)	36/141 (26)
CIDR/$PGF_{2α}$ *(PG on d –1) - cyclic*	140	64/101 (63)	64/140 (46)

[a] Percentage of cows pregnant exposed to AI.
[b] Percentage of cows pregnant of all cows treated.

An advantage of a progestin-based estrous synchronization protocol is administration of progestins to prepubertal heifers and postpartum anestrous cows have been demonstrated to hasten cyclicity. When suckled beef cows were assigned randomly in replicates to one of three groups (Lucy et al., 2001): 1) untreated controls, 2) a single intramuscular (IM) injection of 25 mg $PGF_{2\alpha}$ ($PGF_{2\alpha}$ alone), or 3) administration of a CIDR insert for 7 d with an IM administration of $PGF_{2\alpha}$ on day 6 of the 7 d CIDR insert administration period (CIDR + $PGF_{2\alpha}$), no differences were detected between the CIDR + $PGF_{2\alpha}$ treatment group and either the $PGF_{2\alpha}$ alone or control groups for first-service conception rate for either the first 3 d of AI or the entire 31 d of AI. More cows were pregnant after either 3 d or 7 d of AI in the CIDR + $PGF_{2\alpha}$ group than in either the $PGF_{2\alpha}$ alone or the control group. No differences were detected in pregnancy rate to first services during the 31 d AI period between the CIDR + $PGF_{2\alpha}$ and either the $PGF_{2\alpha}$ alone or the control group. Therefore, insertion of the CIDR increased the synchronization rates within the first 3 d following $PGF_{2\alpha}$, resulting in enhanced pregnancy rates. A drawback of the current protocol is $PGF_{2\alpha}$ was administered on d 6 after CIDR insertion (a day before CIDR removal). For beef producers this tends to be impractical, because the cows need to be handled a minimum of four times including an AI. Therefore, a more practical modification of this protocol is to inject $PGF_{2\alpha}$ the on the day of CIDR removal.

Advances in Protocols Using the CIDR for Cows

Several alterations of the basic protocol are being evaluated; however, much work is yet to be done since field trials with CIDRs were limited during the FDA approval process. Inclusion of the CIDR in the CO-Synch procedure appears to be the most researched alternative method for synchronizing beef cows. We (Lamb et al., 2001) published data in which the CIDR was included in the CO-Synch estrous synchronization procedure (Table 1). The CIDR was inserted at the time of the first injection of GnRH and removed at the time of the injection of $PGF_{2\alpha}$. Overall, there was a positive effect of including the CIDR in the CO-Synch protocol; however, this positive effect was not consistent across all locations. Second, the positive effect of including the CIDR was absent in the cows cycling and had high progesterone concentrations at the time of $PGF_{2\alpha}$ treatment, which may explain why there was not a positive effect at each location. Along with parity, days postpartum, calf removal, and cow body condition (Table 2), our previous report (Lamb et al., 2001) also indicated location variables, which could include differences in pasture and diet, breed composition, body condition, postpartum interval, and geographic location, may affect the success of fixed-time AI protocols.

In a more recent study involving 14 locations in seven states we (Larson et al., 2006) evaluated both fixed-time AI protocols and detection of estrus protocols with a clean-up AI. These protocols were compared to GnRH/ $PGF_{2\alpha}$ protocols. Although the location accounted for the greatest variation in overall pregnancy rates the Select Synch + CIDR & TAI protocol (Figure 1) was the protocol that most consistently yielded the greatest pregnancy rates within each location. However, the CO-Synch protocol (Figure 1) was an effective Fixed-time AI protocol that yielded pregnancy rates of 54%.

Interestingly, the distribution of estrus among the Control, Select Synch & TAI, and the Select Synch + CIDR & TAI protocols was similar (Figure 2) as was the average interval from $PGF_{2\alpha}$ to estrus or AI was similar to among all three treatments (Figure 3). Since the estrus response was greater in the Select Synch + CIDR & TAI protocol overall pregnancy rates were greater.

Table 2. Pregnancy rates in suckled beef cows after treatment with Cosynch or Cosynch+CIDR (Lamb et al., 2001)

	Treatment[a]		
Item	Cosynch	Cosynch+P	Overall
	---------------- no. (%)	------------------	
Body condition[b]			
≤ 4.5	12/40 (30)	11/36 (31)	23/76[x] (30)
4.5 to 5.5	30/74 (41)	40/80 (50)	70/154[y] (45)
≥ 5.5	19/32 (59)	11/13 (85)	31/45[z] (69)
Days postpartum			
≤ 50	23/60 (38)	27/58 (47)	50/118[x] (42)
51-60	25/62 (47)	36/54 (67)	61/116[y] (53)
61-70	28/49 (62)	25/44 (57)	53/93[y] (57)
71-80	18/41 (44)	30/45 (67)	48/86[y] (56)
> 80	44/75 (59)	42/72 (58)	86/147[y] (59)
Parity[c]			
Multiparous	61/138 (44)	79/132 (60)	140/270 (52)
Primiparous	25/50 (50)	20/45 (44)	45/95 (47)

[a] See experimental design for treatments in Figure 1.
[b] Body condition scores from IL and MN only.
[c] Parity data from KS and MN only.
[xyz] Percentages within an item and column lacking a common superscript letter differ ($P < .05$).

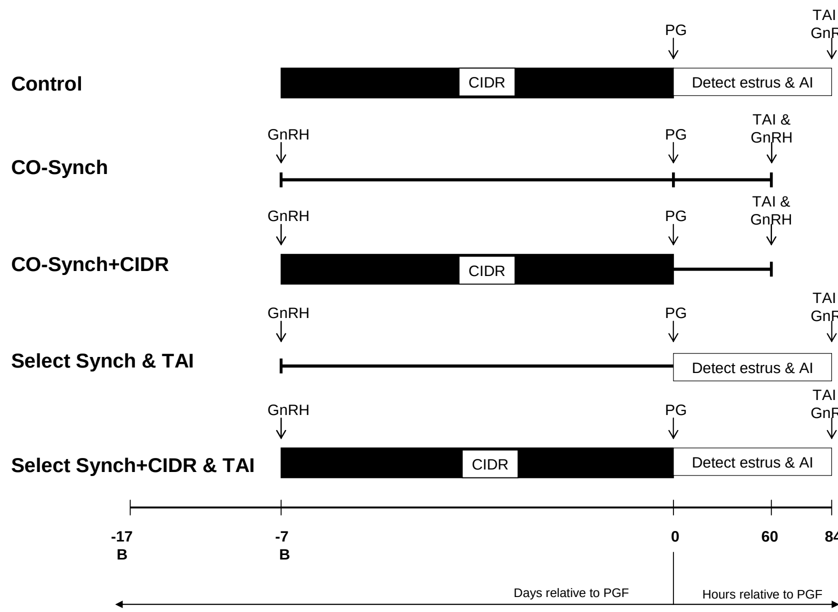

Figure 1. Estrous synchronization protocols using a CIDR (Larson et al., 2006).

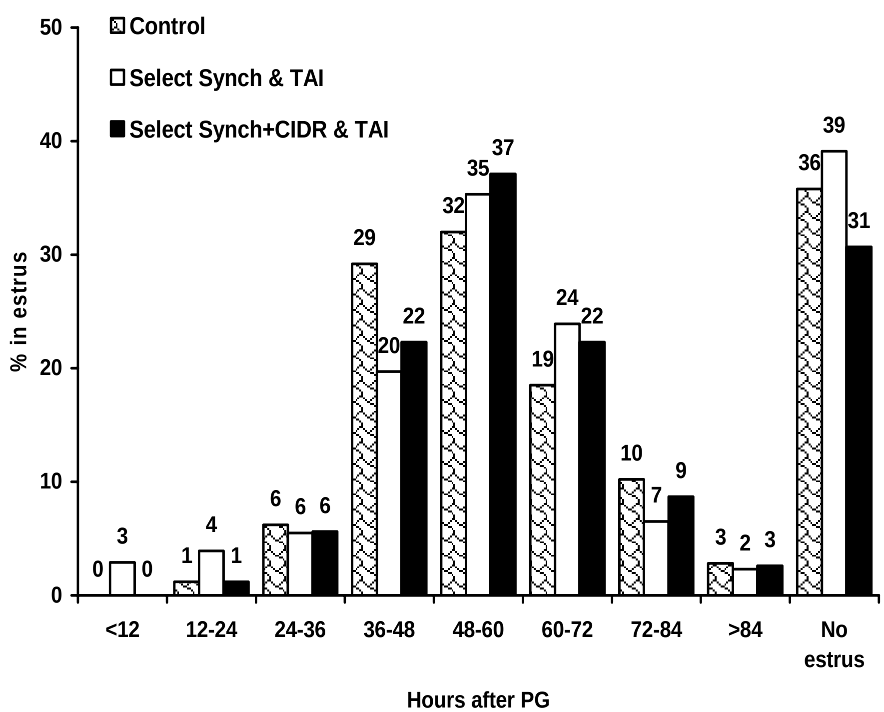

Figure 2. Percentage of cows treated with Control, Select Synch & TAI, Select Synch + CIDR & TAI observed in estrus, separated by hours from PG injection to AI (Larson et al., 2004a).

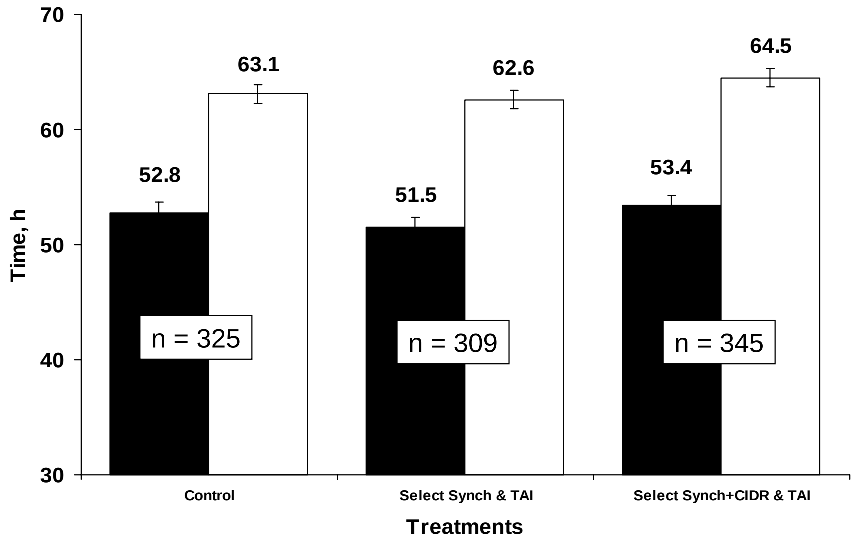

Figure 3. Time from PG injection to estrus (black bar) and time from PG injection to AI (white bar) for those cows exhibiting estrus in Control, Select Synch & TAI, Select Synch + CIDR & TAI treatments (Larson et al., 2006).

Calving data during the subsequent calving season was also assessed. Of the 1,752 calves, 994 (56.7%) were the result of AI after estrus synchronization. Average duration of gestation among all AI sired calves was 281.9 ± 5.2 d (× ± SD), and the range was 258 to 296 d. Duration of gestation was similar among treatments, but a location effect (P < 0.0001) was detected, which may have included breed, sire and management differences. Period of gestation was greater (P < 0.001) for male (282.9 ± 0.2 d) than female calves (280.9 ± 0.2 d), and single calves were carried 3.0 d longer (P < 0.05) than multiple calves. For those cows from which calving data was recorded, the average interval from the $PGF_{2\alpha}$ injection (Day 0 of the study) to calving among all cows was 297.3 ± 17.7 d (× ± SD) with a range of 258 to 373 d (Figure 4). Although average calving interval was similar among treatments, a (P < 0.001) location effect was detected.

At calving, gender was recorded in 1,490 calves, with 770 (52.2%) male calves compared with 704 females. In addition, 15 sets of twins and a single set of triplets were recorded. Gender ratio of calves conceived to AI at estrus synchronization favored (P < 0.01) bulls (i.e., 52.7% of 841 calves born were male). Similarly, of the 635 calves conceived to clean-up bulls, 51.7% were male. No difference was detected in gender ratio for AI compared with natural-sired calves. Multiple birth rates for AI-sired calves [1.1% (9 of 850)] were similar to calves sired by clean-up bulls [0.9% (6 of 641)].

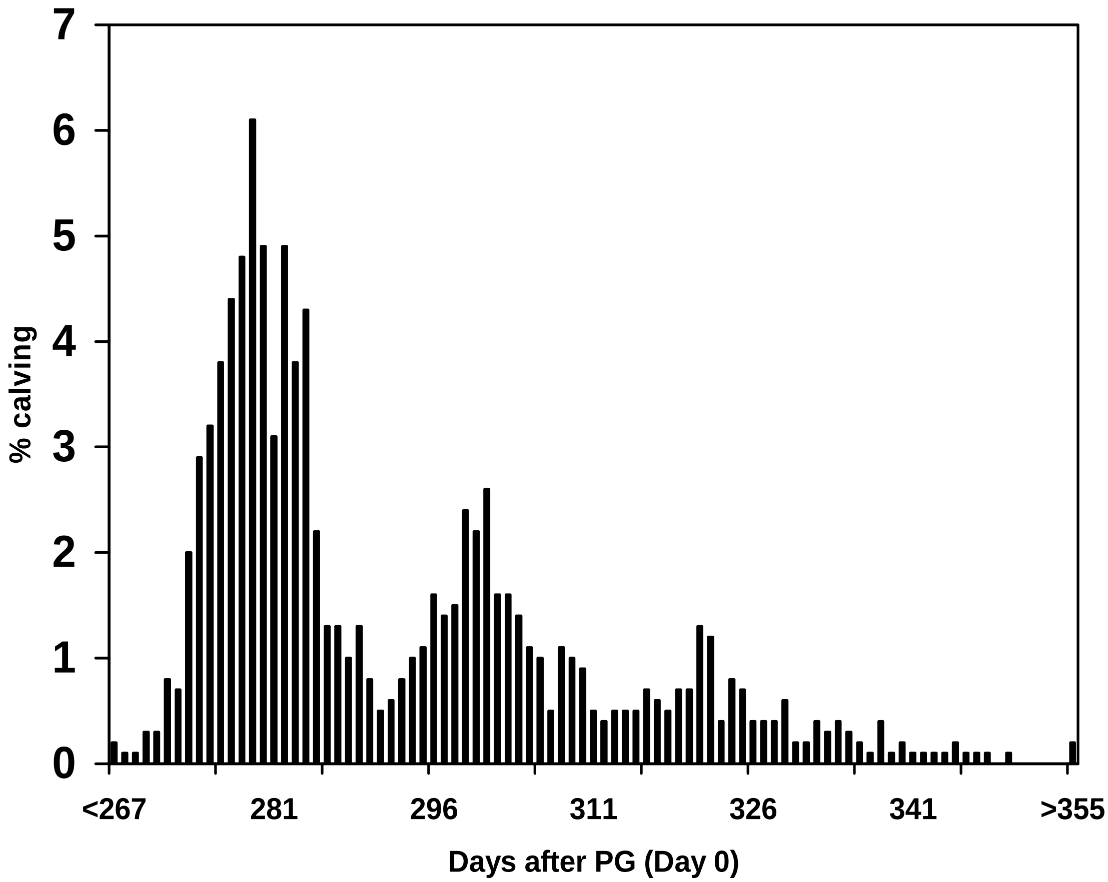

Figure 4. Distribution of calving during the subsequent calving season after synchronization of estrous with GnRH, $PGF_{2\alpha}$, and (or) a CIDR.

Today the CO-Synch + CIDR protocol is the primary TAI protocol recommended for use in beef cows by the Beef Reproduction Task Force. Table 3 summarizes results from field trials conducted in Missouri involving 34 herds and 3,015 cows (Patterson et al., 2006). The pregnancy rates shown in Table 3 represent results from fixed-time AI using the CO-Synch + CIDR protocol with insemination performed 66 hours after CIDR removal and PG administration. Careful evaluation of these results indicate under proper management conditions pregnancy rates ranged from a low of 60% to a high of 86% with an overall average of 65%. Keep in mind no estrus detection was performed on these farms, cows were inseminated at the predetermined fixed-times without estrus detection.

Table 3. Results from field trials conducted in Missouri involving the CO-Synch + CIDR protocol with fixed-time AI performed 66 hours after CIDR removal and PG administration (Patterson et al., 2006).

Herd	No. pregnant	No. inseminated	Pregnancy rate (%)
1	41	51	80
2	67	104	64
3	56	78	72
4	29	43	67
5	62	98	63
6	60	90	67
7	31	48	65
8	87	143	61
9	61	100	61
10	44	69	63
11	68	111	61
12	47	60	78
13	143	224	64
14	62	100	62
15	66	101	65
16	106	164	65
17	60	96	63
18	104	163	64
19	110	169	65
20	10	13	77
21	19	22	86
22	18	21	86
23	8	10	80
24	28	45	62
25	71	115	62
26	89	142	63
27	20	25	80
28	73	106	69
29	67	96	70
30	69	105	66
31	68	113	60
32	56	93	60
33	32	48	67
34	31	49	63
Totals	**1,963**	**3,015**	**65**

Utilization of the CIDR for bull breeding

To many producers artificial insemination is too technical or time consuming, yet many producers feel with the development of fixed-time AI (TAI) protocols AI might be a technology that can be utilized to generate a greater proportion of genetically superior beef cattle. The primary reason U.S. beef producers cite for the lack of widespread AI use to breed heifers and cows is limited time and labor (NAHMS, 1998). However, the step from using natural service without estrous synchronization to using TAI is a large jump few producers are willing to take. Therefore, there is reason to believe estrous synchronization for bull breeding herds is a suitable step towards altering the calving season, decreasing the breeding season length, and initiating noncycling cows to start cycling. Estrous synchronization in bull breeding herds has the potential to impact a greater number of producers, because greater than 90% of producers do not utilize AI in their current management systems. In fact, only 8.1% of beef cattle operations in the U.S. use AI management procedures regularly on replacement beef heifers or postpartum beef cows to improve reproductive management of their herds and ultimately improve profitability (NAHMS, 1997).

When estrous was synchronized for bull breeding with a single injection of PG administered at initiation of the breeding season the percentage of females detected in estrus and pregnancy rates were greater than saline treated controls (Whittier et al., 1991). In addition, when heifers were estrous synchronized with melengestrol acetate and $PGF_{2\alpha}$ and exposed to bulls, the desirable bull:heifer ratio was 1:25 or less (Healy et al., 1993). Under this premise, we (Dahlen et al., 2006) designed a study to determine whether insertion of a CIDR for 7 d prior to the breeding season and removing the CIDR on the day bulls were introduced to the cowherd would alter the overall pregnancy rates, average days to conception, and the subsequent calving distribution.

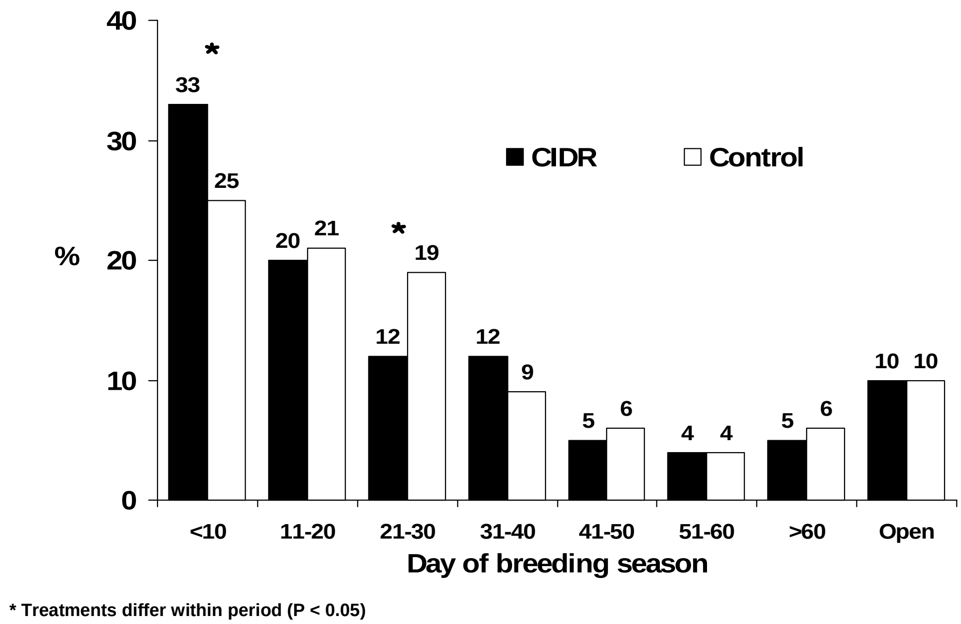

Figure 8. Proportion of cows conceiving at various intervals of the breeding season for cows in Control or CIDR treatments.

Overall pregnancy rates ranged from 59.3 to 98.9% among the 13 locations. Pregnancy rates within the first 30 days of the breeding season were similar between CIDR (64.4%) and Control (64.7%), and overall pregnancy rates were similar between CIDR (89.7%) and Control (89.6%). The average day of conception after initiation of the breeding season was shorter ($P < 0.05$) for CIDR (20.1 ± 0.8 d) compared to Control cows (23.2 ± 0.8 d). Of cows conceiving during the breeding season, more ($P < 0.05$) CIDR cows (43%) conceived during the first ten days of the breeding season than Control cows (35%; Figure 8). Therefore, insertion of a CIDR prior to the breeding season failed to increase overall pregnancy rates, but did influence the average day of conception in earlier calving cows.

Postinsemination Utilization of CIDR

Previous reports have demonstrated post-insemination progesterone supplementation on d 5 after AI enhanced pregnancy rates in Holstein cows, but suppressed fertility when administered within 2 d of first insemination (Van Cleeff et al., 1996). In addition, heifers receiving a CIDR insert on d 2 after AI had shorter estrous cycles than controls (Lynch et al., 1999).

Resynchronization of estrous in nonpregnant cows after an initial AI reduces the period required for detection of estrus and AI of nonpregnant females. When cows were resynchronized with a progestin the synchronized return rates of nonpregnant females was greater than controls (Stevenson et al., 2003). Therefore, we conducted a study to determine whether resynchronization of an estrus could be accomplished in nonpregnant cows without compromising pregnancy in cows pregnant from a previous synchronized estrus or to those inseminated to the resynchronized estrus. Ovulation was synchronized in 937 suckled beef cows at 6 locations using a CO-Synch + CIDR protocol. After initial TAI cows were assigned randomly to 4 treatments; 1) untreated (control; n = 237); 2) CIDR inserted 5 d after TAI and removed 14 d after TAI (CIDR5-14; n = 234); 3) CIDR inserted 14 d after TAI and removed 21 d after TAI (CIDR14-21; n = 232); or 4) CIDR inserted 5 d after TAI and removed 14 d after TAI and then a new CIDR inserted at 14 d and removed 21 d after TAI (CIDR5-21; n = 234). After TAI, cows were observed twice daily until 25 d after TAI for estrus and inseminated according to the AM-PM rule. Pregnancy was determined at 29 and 59 d after TAI to determine conception to first- and second-service AI.

Pregnancy rates to TAI were similar for control (55%), CIDR5-14 (54%), CIDR14-21 (48%), and CIDR5-21 (53%; Table 4). A greater proportion of nonpregnant cows were resynchronized during a 2-d peak period in the CIDR5-21 (76/109, 70%) and CIDR14-21 (77/119, 65%) than controls (44/106, 42%) and CIDR5-14 (39/109, 36%) cows. Although overall pregnancy rates after second AI service were similar, conception rates of nonpregnant cows detected in estrus and inseminated seemed to be compromised ($P < 0.05$) in CIDR5-21 (41/76, 54%) and CIDR14-21 (71/77, 53%) compared with CIDR5-14 (28/39, 72%) cows, whereas controls (29/44, 66%) were intermediate. Insertion of a CIDR 5 d after a TAI did not compromise or enhance pregnancy rates to TAI, however, conception rates were compromised in nonpregnant cows resynchronized with a CIDR from d 5 or 14 until 21 d after TAI.

Supplementation of progesterone to postpartum suckled beef cows on d 5 after AI does not appear to enhance fertility. In addition, resynchronization of estrus in nonpregnant cows with a CIDR until d 21 after TAI improves synchronized return rates, but decreases conception rates at the resynchronized estrus.

Table 4. Fertility rates and estrous response to cows resyncronized with a CIDR after an initial fixed-time AI (Thielen et al., 2006).

Item	Treatments			
	Control	CIDR5-14	CIDR14-21	CIDR5-21
1st service pregnancy rates, no./no. (%)[a]	130/237 (55)	126/234 (54)	111/232 (48)	124/234 (53)
2nd service pregnancy rates, no./no. (%)[b]	159/237 (67)	159/234 (68)	155/232 (67)	161/234 (69)
Non-pregnant cows exhibiting estrus, no./no. (%)[c]	44/106 (42)[x]	39/109 (36)[x]	77/119 (65)[y]	76/109 (70)[y]
Conception rates, no./no. (%)[d]	29/44 (66)[xy]	28/39 (72)[x]	41/77 (53)[y]	41/76 (54)[y]

[a] Percentage of cows pregnant to fixed-time AI compared to all cows treated.
[b] Percentage of cows pregnant to fixed-time AI and resynchronized estrus compared to all cows treated.
[c] Percentage of non-pregnant cows that exhibited estrus between d 5 and 26 after fixed-time AI.
[xyz] Percentages within a row lacking a common superscript letter differ ($P < .05$).

Summary

To achieve optimal pregnancy rates with estrous synchronization, cows should be in good body condition (BCS ≥5) and treatments should be initiated only when cows are at least 50 days postpartum. Treatment of suckled cows with a CIDR and GnRH will yield industry accepted pregnancy rates. Results of the most recent CIDR based studies indicate for a fixed-timed AI protocol the CO-Synch + CIDR protocol yields the most impressive pregnancy rates for a fixed-time AI protocol, whereas the Select Synch + CIDR & TAI treatment yields the best overall pregnancy rates. In addition, cows can be resynchronized successfully with a CIDR, but caution should be taken to ensure that the CIDR is removed before day 20 after TAI to ensure conception rates are acceptable.

Literature Cited

Bao, B. and H.A. Garverick. 1998. Expression of steroidogenic enzyme and Gonadotropin receptor genes in bovine follicles during ovarian follicular waves: A review. J. Anim. Sci. 76:1903-1921.

Brown, L.N., K.G. Odde, D.G. LeFever, M.E. King, and C.J. Neubauer. 1988. Comparison of MGA-$PGF_{2\alpha}$ to Syncro-Mate B for estrous synchronization in beef heifers. Theriogenology 30:1.

Fortune, J.E., J. Sirois, and S.M. Quirk. 1988. The growth and differentiation of ovarian follicles during the bovine estrous cycle. Theriogenology 29:95-109.

Garverick, H.A., R.G. Elmore, D.H. Vaillancourt, and A.J. Sharp. 1980. Ovarian response to Gonadotropin-releasing hormone in postpartum dairy cows. Amer. J. Vet. Res. 41:1582-1585.

Healy, V.M, G.W. Boyd, P.H. Gutierrez, R.G. Mortimer, J.R. Piotrowski. 1993. Investigating optimal bull:heifer ratios required for estrus-synchronized heifers. J. Anim. Sci. 71:291-297.

Imwalle, D. B., D. L. Fernandez, and K. K. Schillo. 2002. Melengestrol acetate blocks the preovulatory surge of luteinizing hormone, the expression of behavioral estrus and ovulation in beef heifers. J. Anim. Sci. 80:1280-1284.

Kojima, F. N., B. E. Salfen, J. F. Bader, W. A. Ricke, M. C. Lucy, M. F. Smith, and D. J.Patterson. 2000. Development of an estrus synchronization protocol for beef cattle with short-term feeding of melengestrol acetate: 7-11 Synch. J. Anim. Sci. 78:2186-2191.

Lamb, G.C., C.R. Dahlen, K.A. Vonnahme, G.R. Hansen, J.D. Arseneau, G.A. Perry, J. Clement, J.D. Arthington. 2006. Effects of estrous synchronization with a CIDR prior to the breeding in bull-breeding herds on pregnancy rates J. Anim. Sci. 84(Suppl. 1):433.

Lamb, G.C., J.S. Stevenson, D.J. Kesler, H.A. Garverick, D.R. Brown, and B.E. Salfen. 2001. Inclusion of an intravaginal progesterone insert plus GnRH and prostaglandin $F_{2\alpha}$ for ovulation control in postpartum suckled beef cows. J. Anim. Sci. 79:2253-2259.

Lamb, G.C., J.E. Larson, T.W. Geary, J.S. Stevenson, S.K. Johnson, M.L. Day, R. P. Ansotegui, D. J. Kesler, J.M. DeJarnette, and D. Landblom. 2004. Synchronization of estrus and artificial insemination in replacement beef heifers using GnRH, PGF_{2}□ and progesterone. J. Anim. Sci. (84: In press).

Larson, J. E., G. C. Lamb, J. S. Stevenson, S. K. Johnson, M. L. Day, T. W. Geary, D. J. Kesler, J. M. DeJarnette, F. N. Schrick, A. DiCostanzo, and J. D. Arseneau. 2006. Synchronization of estrus in suckled beef cows for detected estrus and artificial insemination and timed artificial insemination using gonadotropin-releasing hormone, prostaglandin F2alpha, and progesterone. J. Anim. Sci. 2006 Feb;84(2):332-342.

Lauderdale, J.W., B.E. Seguin, J.N. Stellflung, J. R. Chenault, W.W. Thatcher, C.K. Vincent, and A. F. Loyancano. 1974. Fertility of cattle following $PGF_{2\alpha}$ injection. J. Anim. Sci. 38:964-967.

Lynch, P.R., K.L. Macmillan, V.K. Taufa. 1999. Treating cattle with progesterone as well as a GnRH analogue affects oestrous cycle length and fertility. Anim. Reprod. Sci. 56:189-200.

Lucy, M. C., H. J. Billings, W. R. Butler, L. R. Ehnes, M. J. Fields, D. J. Kesler, J. E. Kinder, R. C. Mattos, R. E. Short, W. W. Thatcher, R. P. Wettemann, J. V. Yelich, and H. D. Hafs. 2001. Efficacy of an Intravaginal Progesterone Insert and an Injection of PGF2a Synchronizing Estrus and Shortening the Interval to Pregnancy in Postpartum Beef cows, Peripubertal Beef Heifers, and Dairy Heifers. J. Anim. Sci. 79: 982-995.

NAHMS 1997. Part 1: National Animal Health Montiroing Service, USDA, APHIS. Beef Cow-Calf Management Practices. USDA-APHIS Center for Epidemiology and Animal Health, Fort Collins, CO. Pp. 1-55.

NAHMS. 1998. Part IV. National Animal Health Monitoring Service, USDA, APHIS. Changes in U.S. beef cow-calf producers. USDA-APHIS Center for Epidemiology and Animal Health, Fort Collins, CO. Pp. 1-48.

Patterson, D. J., G. H. Kiracofe, J. S. Stevenson, and L. R. Corah. 1989. Control of the bovine estrous cycle with melengesrol acetate (MGA): A review. J. Anim. Sci. 67:1895-1906.

Patterson, D.J., F.N. Kojima, and M.F. Smith. 2003. A review of methods to synchronize estrus in replacement heifers and postpartum beef cows. J. Anim. Sci. 81(E. Suppl. 2):E166-E177.

Sartori, R., P.M. Fricke, J.C. Ferreira, O.J. Ginther, and M.C. Wiltbank. 2001. Follicular deviation and acquisition of ovulatory capacity in bovine follicles. Biol. Reprod. 65:1403-1409.

Seguin, B.E., B.K. Gustafson, J..P. Hurtgen, E.C. Mather, K.R. Refsal, R.A. Wescott, and H. L. Withmore. 1978. Use of the prostaglandin $F_{2\alpha}$ analog cloprostenal (ICI 80,996) in dairy cattle with unobserved estrus. Theriogenology 10:55-64.

Seidel, G.E. Jr. 1995. Reproductive biotechnologies for profitable beef production. Proc. Beef Improvement Federation. Sheridan, WY. Pp. 28-39.

Thielen, K.N., J.E. Larson, B.J. Lovaas, D.J. Kesler, J.S. Stevenson, T.T. Marston, and G.C. Lamb. 2006. Influence of a CIDR insert after a fixed-time AI on pregnancy rates and return to estrus of nonpregnant cows. J. Anim. Sci. 84 (Suppl. 1):432.

Twagiramungu, H.L., A. Guilbault, and J.J. Dufour. 1995. Synchronization of ovarian follicular waves with a Gonadotropin-releasing hormone agonist to increase the precision of estrus in cattle: A review. J. Anim. Sci. 73:3141-3151.

Van Cleeff, J., K.L. Macmillan, M. Drost, M.C. Lucy, W.W. Thatcher. 1996. Effects of administering progesterone at selected intervals after insemination of synchronized heifers on pregnancy rates and resynchronization of returns to service. Theriogenology 46:1117-30.

Whittier, J.C., R.W. Caldwell, R.V. Anthony, M.F. Smith, and R.E. Morrow. 1991. Effect of a prostaglandin F2 alpha injection 96 hours after introduction of intact bulls on estrus and calving distribution of beef cows. J. Anim. Sci. 69:4670-4677.