CONTROL OF ESTRUS WITH NATURAL SERVICE

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Introduction

The United States beef industry is dominated by herds that rely solely on bull breeding. The percentage of operations that relied only on bull breeding was 95.7% and of beef cows maintained, 98.3% were at least exposed to a bull during the breeding season (Figure 1; NAHMS, 2009). In addition, herds in the Eastern region of the United States reported lower use of technologies such as artificial insemination and estrous synchronization compared with herds in the Western and Central regions (NAHMS, 2009).

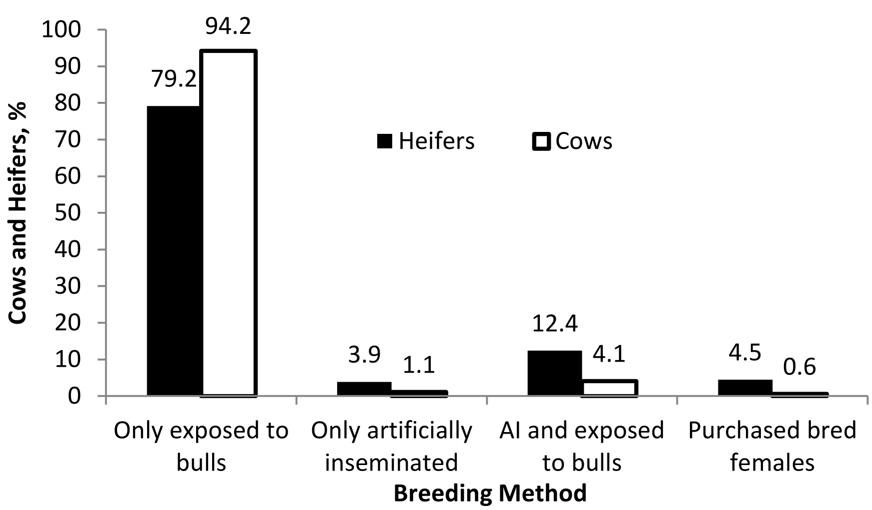

Figure 1. Percentage of heifers and cows bred by breeding method for calving in 2007. Adapted from NAHMS, 2009.

Breeding systems that utilize natural service bulls to breed estrus synchronized females may offer opportunities for cattlemen in terms of greater season-ending pregnancy rates (Whittier et al., 1991). In addition, females may conceive earlier in the breeding season (Lamb et al., 2008) resulting in calves born earlier in the calving season and greater subsequent weaning weights (Larson et al., 2010).

Moreover, in circumstances where synchronization products have been administered to cattle and a planned artificial insemination date is no longer a possibility (semen not delivered, semen tank ran dry, injured technician, etc.), breeding synchronized cows with bulls may be the only way to capitalize on the labor and financial resources already invested to achieve a synchronized estrus. In these instances it would be useful to know about the protocols used for synchronizing females for natural service breeding and note that these protocols can be quite different than those used to synchronize females for AI.

This review will focus on bull factors and cow factors that contribute to the success of synchronization with natural service, along with protocol options for synchronization with natural service and several other important considerations.

Bull Factors that Influence Success

Not all bulls are suitable for breeding groups of synchronized females. Age, breeding soundness, and libido need to be evaluated to determine whether individual bulls are suitable candidates for natural service synchronization protocols. After appropriate bulls are identified, one of the most frequent questions received is the question of stocking rates; how many synchronized cows should one bull be expected to breed?

Age. When different ages of bulls were evaluated for breeding success and behavior in single-sire pastures notable differences were observed (Table 1; Pexton et al., 1990). As bulls become older the overall number of times the bulls mounted cows was reduced. No differences were present, however, in the number of services (mount + intromission + ejaculation) among bulls of different ages. The greater number of mounts by yearling bulls reflects the fact that breeding is a learned behavior (Chenoweth, 1983) which bulls perfect with successive years of experience.

Table1. Breeding behavior and fertility of bulls of different ages.

	Age of Bull		
	Yearling	Two	Three+
Number of bulls	29	36	27
Females per bull	20.1	26.2	27.8
Number of mounts	207[a]	120[b]	85.8[b]
Number of services	54.5	37.6	40.5
Estrus females serviced, %	69.4	73.8	72.0
Pregnancy rates of serviced females, %	39.6[a]	59.4[b]	62.2[b]
Overall pregnancy rate, %	30.9[a]	41.5[b]	49.9[c]

[a,c]Means within row lacking common superscript differ ($P < 0.05$; Adapted from Pexton et al., 1990).

A smaller proportion of females that were serviced by yearling bulls became pregnant compared with those serviced by 2 and 3 year old bulls, and overall pregnancy rate was increased when older bulls were used (Pexton et al., 1990). Taken together, these results highlight the fact that **experienced breeding bulls (2+ years of age**) are the best candidates to use for synchronization with natural service.

Breeding Soundness. Breeding soundness examinations (BSE) include a physical evaluation, measurement of scrotal circumference, and an evaluation of semen motility and morphology (Society for Theriogenology, 1993). Recommended timing of BSE is prior to the beginning of each breeding season with enough time in advance of turnout to find new bulls if several bulls are categorized as “unsatisfactory” during the exam. Bulls could also be classified as “deferred” and scheduled for a re-evaluation at a later time, or as “satisfactory” when no issues are noted according to the BSE criteria.

When cows were bred to bulls in either the satisfactory or deferred categories (termed “questionable” prior to 1993), a greater proportion of females bred to bulls classified as satisfactory breeders (46.6%) were pregnant at the end of the breeding season compared with females bred to bulls with classification deferred (36.5%; Farin et al., 1989). No differences, however, were observed among BSE classification in number of times bulls mounted females, number of services, or percentage of females serviced. Thus, a breeding soundness exam is an indication of potential fertility and not an indication of libido.

A measure not directly obtained in a routine breeding soundness exam is the concentration of sperm in the ejaculate. Questions about whether bulls breeding large groups of synchronized females would use all available sperm reserves and have no sperm remaining to impregnate cows are answered by a close look at sperm production. Production of semen in mature bulls is approximately 5×10^6 (5 million) spermatozoa per minute (Chenoweth, 1983). A commercial dose of AI semen may contain ~20 million sperm, which would only take a bull 4 minutes to produce. *Bos taurus* bulls in single- or multi- sire breeding pastures exposed to synchronized females bred on average 1 cow every 30 minutes over a 30 hour period of synchronized estrus (Farin et al., 1982). Based on the frequency of breeding and speed of natural sperm production it does not appear that the number of sperm present in ejaculates after heavy mating loads is limiting the number of cows a mature bull can successfully breed.

In addition, no differences in breeding soundness exam scores or individual components of scores (scrotal circumference, sperm morphology, and motility) were observed when exams performed prior to a 5 day synchronized breeding period were compared with those taken immediately after (Williams et al., 1988). This is evidence that the motility and morphology of semen, as measured by a BSE, were not impacted by the frequency of breeding.

Libido. High libido, or sex drive, is something that is certainly required of bulls that will be stocked with synchronized females. Service capacity tests place bulls in close proximity to immobilized females and evaluate sexual behavior over a fixed period of time (usually ~10 minutes). Bulls are classified as having high, medium, or low libido. Bulls with “high” libido performed a greater number of mounts and services, and serviced a greater proportion of females in estrus compared with “medium” libido bulls (Farin et al., 1989). The greater proportion of females serviced, however, did not translate to a greater proportion of cows becoming pregnant by the end of the breeding season. Service capacity tests, therefore, give an indication of libido but not necessarily fertility.

Bulls that would be ideally suited for use in situations where a synchronization program is used with natural service mating would be those that have the combination of **high libido** and current annual **BSE classification of “satisfactory”**. If producers find on-farm service capacity tests impractical on their operations, careful observation of bulls during the breeding season may give an indication of libido. Watch for yearling (and mature) bulls that aggressively seek and breed females as potential candidates for servicing synchronized females in upcoming years.

Concerns of bulls “falling in love” and spending too much time with a single female were not realized in many cases (Pexton et al., 1990). However, four general conditions were responsible for bulls breeding a single female a high number of times (Pexton et al., 1990): 1) few females were in estrus, 2) inexperienced bulls shortly after turnout, 3) bulls that were fatigued toward the end of the breeding season, and 4) permissive females present in pasture.

One phenomenon that is recurrent throughout the literature is that fact that bulls are naturally selective about which females they will breed. A great range in number of services per female bred during a period of receptivity exists (ranging from 1 to 27 services in one report; Pexton et al., 1990). The number of services a single bull performs is typically much greater than the number of females in a breeding group. In some cases bulls will return to a previously bred female rather than breed a non-bred female that is showing all signs of behavioral estrus with other females. The proportion of females observed in behavioral estrus that were actually bred ranges from 60 to 80% (Farin et al., 1989). The reason that 20 to 40% of females in heat are not bred remains unknown. As the breeding season progresses and fewer females are receptive, however, bulls will likely become less selective.

Age, breeding soundness, and libido all ultimately contribute to generate minimum recommendations for bulls to consider for breeding with synchronized females:

- Age of 2+ years with previous breeding experience
- Complete Breeding Soundness Exam rated as “satisfactory” including physical exam
- High libido

Stocking Rate. Once bulls that meet the minimum requirements are identified for use in synchronized breeding scenarios, a final decision on stocking rates must be made. Several studies that have looked at the question of stocking rates of bulls breeding synchronized cows can help us understand the options available.

When stocking rates ranging from 7 to 51 synchronized females per bull were evaluated a slight linear decrease in the proportion of estrus females serviced was observed (Pexton et al., 1990). This study, however, was not able to determine the optimal stocking rate for bulls breeding synchronized females.

A study comparing different bull stocking rates among groups of heifers synchronized with an MGA/prostaglandin $F_{2\alpha}$ (PGF) protocol highlighted several differences in reproductive performance among groups (Healy et al., 1993; Table 2). No differences in pregnancy rate within the first 6 days or the entire 28 day breeding season were observed among synchronized heifers stocked at a rate of 1 bull per 25 heifers or 1 bull per 16 heifers. The estimated days to conception (based on palpation per rectum), however, was less in heifer stocked at 1:16 (8 days into breeding season) compared with heifers stocked at 1:25 (11 days into breeding season).

Table 2. Effect of bull to heifer ratio on pregnancy status and date of conception.

	Bull:Heifer Ratio*			
	1:50	1:50	1:25	1:16
	Non-Synchronized	Synchronized		
Number of bulls in pasture*	2	2	4	6
Day 6 pregnancy rate, %	40	38	41	53
Day 28 pregnancy rate, %	82	77[a]	83	84[b]
Estimated day of conception after turnout	10[a]	10[a]	11[a]	8[b]

*Each pasture had 100 heifers with different number of bulls present to reach each respective stocking rate.

[a,b]Means within row lacking common superscript differ ($P < 0.05$; Adapted from Healy et al., 1993).

An economic analysis of the stocking rates tested revealed that a stocking rate of 1:25 was the optimal mating load of all the treatments studied and it was hypothesized that perhaps bulls in non-synchronized breeding scenarios could be stocked at rates greater than the traditional 1:25 or 1:30 (Healy et al., 1993). In addition, authors theorized that the greater opportunity for heifers in the 1:16 stocking rate pastures to be bred by a greater number of bulls compared with the 1:25 stocking rate pasture may be responsible for earlier date of conception in the 1:16 treatment compared with the 1:25 treatment. Indeed, we expect females stocked with multiple bulls to be bred by multiple bulls. Of the heifers that had been serviced in pastures containing two bulls, 50% had been serviced by both bulls present in the pasture (Farin et al., 1982).

Cow Factors that Influence Success

Many of the factors that contribute to the success of synchronized breeding systems that rely on the use of AI are just as important to consider when determining whether a synchronized natural service breeding system is appropriate for your operation. Cows must be far enough postpartum and females must be in sufficient body condition to achieve optimal benefit from synchronization. Days postpartum and body condition score are indicators that females may be in appropriate physiological status to initiate cyclicity, and estrus is essential to make bull breeding systems work.

Options for Synchronization with Natural Service

Before we begin to talk about the impact synchronization can have on date of pregnancy attainment, it is important to review what we expect without any intervention. We anticipate cyclic females to have a random distribution of estrus over a 21 day period and, thus, every day we would expect 4.8% of cyclic females (1 day ÷ 21 days in an estrous cycle) to be in standing estrus. Following this logic, within the first 5 days of the breeding season 24% of cyclic females will have been in estrus (5 days ÷ 21 days in an estrous cycle), and 48% of cyclic females would show estrus within the first 10 days of a breeding season (10 days ÷ 21 days in an estrous cycle). Females would be bred and become pregnant throughout the days of the breeding season but the average date of conception for cyclic females pregnant during the first estrous cycle of the breeding season would be day 10 (mid-point between d 1 and 21).

With the proportion of females in estrus and anticipated date of conception in mind for a system with no intervention, we can now evaluate both theoretical responses and experimental outcomes of different synchronization strategies for natural service breeding. Theoretical outcomes will be mentioned under the assumption that all females with a CL responsive to PGF responded to administration.

1×PGF. In a 21 day estrous cycle, cattle will respond to administration of PGF from roughly days 6 to 17 of the cycle by killing, or lysing, a mature *corpus luteum* (CL) present in their ovaries which will subsequently allow them to come into heat over the next 5 day period. In addition females that were from day 18 to 21 in their estrous cycle would also come into heat within the next 5 days. Thus, 76.2 % of cyclic females would be in heat over a 5 day period. Females that were originally on d 1 to 5 of their estrous cycle would be in heat from roughly day 17 to 21 after the start of the breeding season. In this scenario the average days to conception would be day 6.8 of the estrous cycle (3.2 d advantage compared with no synchronization).

When a single injection of PGF was compared with two injections of PGF 13 days apart for synchronizing natural service bull breeding no differences were observed in proportion of heifers pregnancy within 5 days of the breeding season (average of 53% of heifers; Chenoweth and Lennon, 1984). Thus, a single injection of PGF is likely favorable due to the reduced cost and labor associated with protocol implementation. In addition, both treatments receiving PGF had a greater proportion of heifers pregnant in the first 5 days of the breeding season compared with the proportion of untreated heifers that became pregnant in the first 5 days of the breeding season (33.7%). Overall pregnancy rates, however, were not different among untreated heifers and those that received either PGF treatment, and days to conception or calving data were not reported (Chenoweth and Lennon, 1984).

day 4 or 5 PGF. This method allows bulls to acclimate to breeding pastures and breed roughly 19-20% of cyclic females before the synchronization protocol is initiated. An injection of PGF is administered 4 or 5 days after bull turnout and females show heat over the next 5 days (days 6 to 10 of the breeding season). Using this method 100% of cyclic females would theoretically be in heat within the first 10 days of the breeding season with a majority of breeding activity occurring around day 8 of the breeding season. Interestingly, average day of conception in females responding to synchronization (day 6.8 of the breeding season) would be that same as for the 1×PGF protocol administered just prior to or in concert with bull turnout. A potential advantage of the day 4 or 5 PGF protocol compared with the 1×PGF protocol, however, is the additional biostimulatory effect breeding bulls have on hastening non-cyclic females' return to estrus (Berardinelli and Joshi, 2005) that would occur prior to the time of PGF administration.

A greater proportion of suckled beef cows given PGF **4** days after bull turnout were in heat and became pregnant from days 4 to 9 of the breeding season compared with cows in a control group (treated with saline; Whittier et al., 1991). In addition, 6.5% more cows calved that had been given PGF 4 days after bull turnout compared with control cows (Whittier et al., 1991). It was hypothesized that cows that did not conceive to the synchronized estrus may have had more opportunities to become pregnant during the breeding season compared with control cows. Whereas the proportion of cows calving in the first 21 days of the calving season was greater in suckled beef cows treated with PGF 108 hours (4.5 days) after bull turn out compared with untreated cows, no differences were observed in season ending pregnancy rates (Larson et al., 2009).

In contrast, the overall pregnancy rates at the end of the 25 day breeding season were reduced in heifers treated with PGF **5** days after bull turnout (73.1%) compared with untreated heifers (78.3%; Larson et al., 2010). However, a greater proportion of calves were born in the first 21 days of the breeding season for PGF treated heifers (87.1% of calves born) compared with untreated heifers (77.4% of calves born) which resulted in steer calves that were heavier at weaning for heifers treated with PGF compared with untreated heifers (Larson et al., 2010).

The difference among studies in the impact of season ending pregnancy rates is unclear. Perhaps cows and heifers react differently to administration of PGF 4 or 5 days after bull turnout. Alternatively, administration of PGF on day 5 of the cycle may result in abortions in a portion of females that became pregnant very early in the breeding season and subsequent difficulty becoming pregnant during the remainder of the breeding season. A fixed time insemination protocol in suckled beef cows that included administration of PGF 5 days after administration of GnRH and a CIDR resulted in 89% of females undergoing luteolysis (Bridges et al., 2012). Perhaps day 4 PGF administration is a more appropriate timing of PGF delivery as the CL is younger and less responsive to PGF (Louis et al., 1973).

7 day CIDR. In cyclic females administration of a CIDR will stop estrus from occurring over the duration of CIDR insertion. Upon CIDR removal females that would have naturally been in heat during the interval of CIDR insertion would show estrus within a few days and the remaining females would continue the natural course of their estrus cycle. Thus, within the first 5 days after a 7 day CIDR protocol, 57% of cyclic females would be expected to show heat ([7 days of delayed natural estrus from CIDR + 5 days of natural estrus] ÷ 21 days in an estrous cycle), and 80% of females would show estrus within the first 10 days of the breeding season. The average days to conception in this scenario would be day 6 of the breeding season (4 day advantage compared with no synchronization).

We (Lamb et al., 2008) explored a method of synchronizing suckled cows with only a CIDR for several reasons. The first reason was that withholding PGF from a synchronization protocol would allow a synchronized estrus with a more gradual distribution of estrus compared with the peak in estrus activity observed when PGF is administered at CIDR removal (Lamb et al., 2006). The second reason for using a CIDR in a natural service synchronization protocol is to attempt to initiate cyclicity in a portion of non-cyclic females (Stevenson et al., 2003) and subsequently get them pregnant earlier in the breeding season.

Fifteen locations were used in the study and overall pregnancy rates varied from 59.3 to 98.9%. No differences in overall pregnancy rates were observed among treatment for either pregnancy rates up to day 30 of the breeding season or in season ending pregnancy rates (68.2 and 88.9% for CIDR and 66.7 and 88.6% for control, respectively; Lamb et al., 2008). The average days to conception, however, was shorter for cows in the CIDR treatment (20.1 days) compared with cows in the control treatment (23.2 days). In addition, there was an interaction among treatment and days postpartum which revealed that the CIDR-treated cows that benefited most from the CIDR insertion were those that were further postpartum (Figure 2). Based on these data, though no direct measures of cyclic status were taken, our interpretation was that cows that are likely cyclic at the time of CIDR insertion are most likely to respond to synchronization with the 7 day CIDR method.

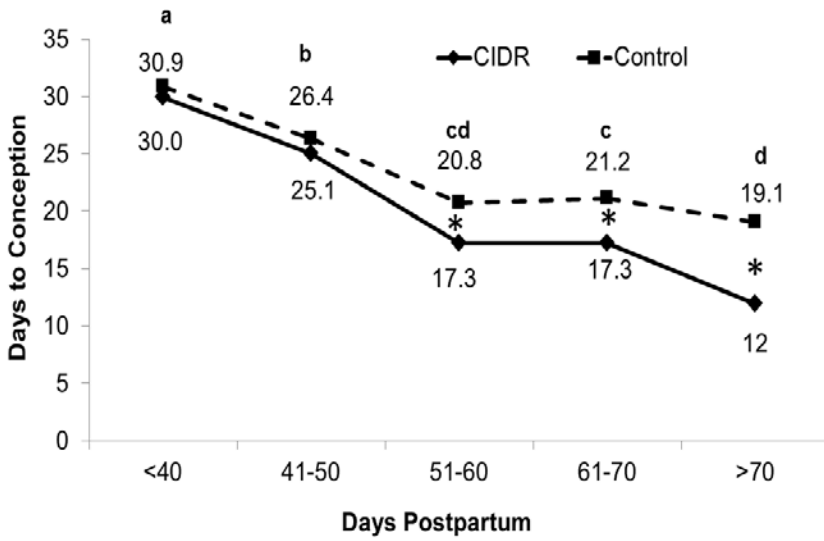

Figure 2. Interval to conception from initiation of the breeding season at various days postpartum. Days postpartum×treatment ($P < 0.05$). *Treatments within days postpartum differ ($P < 0.05$). [a-d]Days postpartum differ ($P < 0.05$; Adapted from Lamb et al., 2008).

Theoretical Comparisons

The previous paragraphs contained an overview of theoretical scenarios for cyclic females and a summary of actual results of research efforts aimed at determining the effects of synchronization on natural service mating systems. Theoretical comparisons are prudent in the discussion of natural service synchronization systems because extensive research comparing all protocols simultaneously is lacking. Table 3 compares the theoretical response to synchronization among protocols mentioned above. In addition to measures of estrus response and days to conception of cyclic females, the potential advantage in days to conception for each synchronization protocol compared with no intervention and potential calf weight gains advantages are listed for each protocol. Also included is the theoretical response for a 7 day CIDR-PG protocol because research data highlighting the actual response do not exist.

Table 3. Theoretical comparisons of synchronization protocols for natural service breeding in cyclic females[1]

	Synchronization Protocol				
	No Intervention	*1×PGF*	*day 4 PGF*	*7 day CIDR*	*7 day CIDR-PG*
Estrus within first 5 days, %	24	76	24	57	100
Estrus within first 10 days, %	48	76	100	80	100
Day of conception after turnout	10	6.8	6.8	6	3
Advantage in conception date, days[2]	--	3.2	3.2	4	7
Potential calf weight advantage, lbs.[3]	--	6.4	6.4	8	14

[1]All scenarios highlight response in cyclic females. Individual protocols may increase the proportion of cyclic females compared with no intervention.
[2]Calculated by subtracting days to conception for each respective protocol from days to conception for a system with no intervention.
[3]Additional weight possible at weaning based on age differences of calves from dams receiving each synchronization protocol compared with no intervention and assuming calf growth of 2 lbs. per day.

Producers can use this table to evaluate potential responses in their herds but caution must be used as the comparisons are only for cyclic females. The importance of cycling status in systems of natural service synchronization cannot be understated. As the number of non-cyclic females in a herd increases the overall estrus response within given window will decrease along with the coincident demands on breeding bulls. Therefore the theoretical comparisons likely give a **maximal** response and the realized response will likely be diluted based on the proportion of noncyclic females present in each respective herd.

Other Considerations

In addition to those protocols listed above, Select Synch, Synchro-Mate B, and 14 day MGA/PGF protocols have all been successful methods of synchronizing cows and heifers for natural service breeding. Producers wishing to use long-term progestin-based protocols (14 day MGA/PGF, 14 day CIDR, etc.) need to be aware of the impact long-term exposure to progestins can have on fertility of breeding to the estrus immediately after progestin removal. For example, a persistent follicle is a follicle that did not ovulate during the progestin exposure that subsequently contains an egg that is no longer capable of becoming fertilized or dividing and gestating to term (Ahmad et al., 1995). Based on our current knowledge, if long term progestin-based protocols are used for synchronizing estrus with natural service it is imperative that a window of 17 to 19 days passes prior to administration of PGF to ensure absence of persistent follicles.

Much research with modern estrus synchronization protocols has focused on making the window of time over which cows ovulate as small as possible. This small window of ovulation time in a group of cattle is essential for optimization of fixed-time artificial insemination pregnancy rates. Many of these protocols include GnRH administered two to three days after PGF to facilitate fixed-time AI (see Lauderdale, 2009 for review). In the case of bull breeding it is imperative that

GnRH is **NOT** administered near breeding as cows may subsequently not show estrus and therefore not be bred via natural service

On a final note: Breeding synchronized females with natural service bulls is a strategy that will work for some people and not for others. In either case (synchronized or non-synchronized bull breeding) producers are encouraged to closely monitor pastures for breeding activity and injuries throughout the breeding season. Though not all problems will be seen (such as the case with changes in semen quality after the yearly BSE), identifying issues early in the breeding season will allow time to replace bulls that need to be replaced and salvage the remainder of the breeding season.

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