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FACTORS AFFECTING BREEDING SUCCESS

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INTRODUCTION

Reproductive failure is a major source of economic loss in the beef industry. The majority of this loss occurs because cows do not become pregnant during a defined breeding season. Therefore, the goal of any breeding program is to maximize the number of females that become pregnant. This means that fertility plays a major role in the success of any breeding program. There are several methods by which fertility can be measured: 1) conception rates (number of animals pregnant/number of animals inseminated), 2) pregnancy rates (number of animals pregnant/number of animals available for breeding), and 3) calving rates (number of animals calved/number of animals available for breeding). This review will focus on the factors that affect pregnancy rates during the breeding season in both natural service and artificial breeding programs.

Artificial insemination provides a method to inseminate a large number of females to a single sire that has been selected/proven to be an industry leader for economically relevant traits. Thus, genetic change in a herd can occur quickly through the use of artificial insemination. With natural service, herd bulls are also selected for economically relevant traits but are limited on the number of cows/heifers they can service during the breeding season. During the breeding season, a herd bull's job is to detect cows/heifers in standing estrus and breed them at the appropriate time. For successful artificial insemination of cattle to occur, the producer (herd manager) must take the place of the herd bull in detecting the cows/heifers that are ready to be inseminated. Since pregnancy rates are a product of both estrous detection rates and conception rates, comparisons must be made between synchronized and non-synchronized cows bred by natural service or by artificial insemination.

FERTILITY OF SYNCHORNIZED AND NON-SYNCHRONIZED FEMALES

Estrous Synchronization

Estrous synchronization simply implies the estrous cycles of a group of heifers/cows are manipulated to cause them to exhibit standing estrus around the same time. Synchronizing estrus is an effective way to minimize the time and labor required to detect standing estrus in cattle that are going to be artificially inseminated. However, estrous synchronization can be utilized with natural service and can benefit overall herd management. Cows that respond and conceive to a synchronized estrus have the following advantages: 1) exhibit standing estrus at a predicted time, 2) conceive earlier in the breeding season, 3) calve earlier in the calving season, and 4) wean calves that are older and heavier. In addition, some estrous synchronization protocols (progestin-based protocols) can induce a

proportion of anestrous cows to begin estrous cycles. This will decrease the anestrous postpartum interval and allow for more chances for cows to conceive during a defined breeding season. A study conducted at Colorado State University indicated cows that conceived to a synchronized estrus calved on average 13 days earlier and weaned calves 41 pounds heavier than cows that were not synchronized (Schafer et al., 1990).

Today's synchronization protocols produce pregnancy rates in the range of 45 to 60% with 1 to 5 days of breeding, and reports in the upper 60's are not uncommon. Many protocols are available today, but protocols that have been thoroughly tested by research and seem to be the most reliable for a wide range of production situations using artificial insemination in the United States are shown in **Figures 1 (cows) and 2 (heifers)**. Because heifers do not respond to all treatments in the same way as cows, different recommendations exist. These protocols can be grouped into three categories based on amount of estrus detection: 1) estrus detection and AI for 6 days; 2) estrus detection and AI up to the time point prescribed in schedule followed by mass insemination of animals not previously detected in heat (clean-up, fixed-timed AI); and 3) a strict fixed-time AI. Estrous synchronization can also be utilized with natural service. Protocols recommended for use with natural service are shown in **Figure 3**. These synchronization protocols distribute estrus out over several days, resulting in a more manageable breeding season for the herd bull.

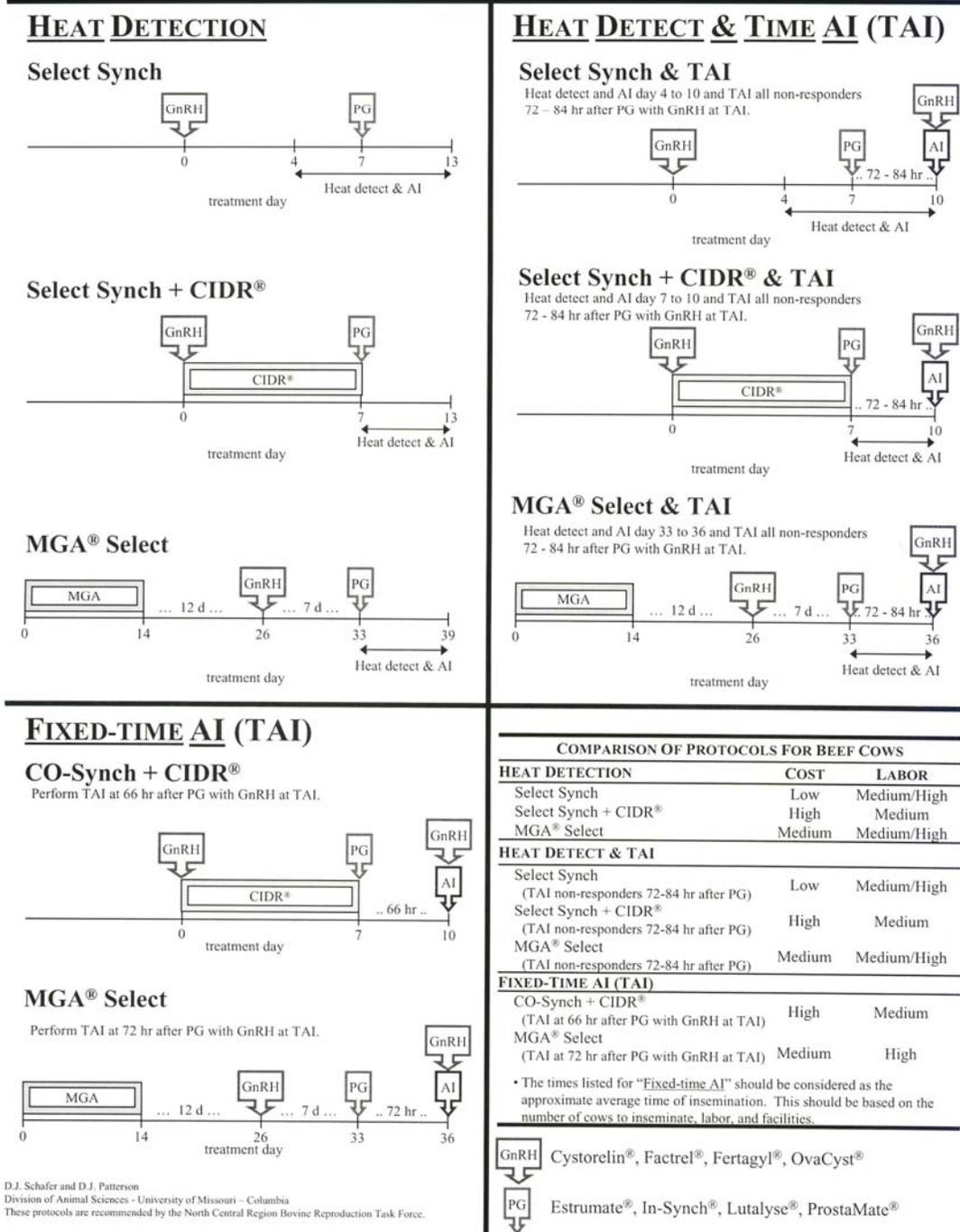
Artificial Insemination

Artificial insemination (**AI**) with semen collected from genetically superior sires is the most efficient and economical method for the genetic improvement of economically important traits in the beef industry. Estrous synchronization makes AI more feasible due to the reduction in time and labor required for estrous detection. When AI is combined with estrous synchronization, the limitation on serving capacity of a single bull is removed, and a large number of females can be bred to a single sire during the first few days of the breeding season. Therefore, there are specific estrous synchronization programs recommended for use with artificial insemination (**Figures 1 and 2**). It is also necessary to compare fertility between synchronized and non-synchronized females bred by AI (**Tables 1 and 2**).

When fertility is compared over the synchronized period, a single injection of prostaglandin F₂ (**PG**) 2 days before the start of the AI breeding season resulted in more ($P < 0.01$) cows pregnant during the first 3 days of the breeding season (22%) compared to non-synchronized females (7%, Lucy et al., 2001). Furthermore, cows synchronized with two injections of PG 11 days apart also resulted in more ($P < 0.01$) cows pregnant (28%) during the first 5 days of the breeding season compared to non-synchronized cows (10%, Beal, 1983). When estrous synchronization protocols are used that will initiate estrous cycles [progesterone (CIDR), norgestomet (Syncro-mate-B), and GnRH protocols], an even greater benefit can be realized (**Table 1**). Cows treated with a CIDR for 7 days before the start of the breeding season and an injection of PG at time of CIDR removal resulted in 26% of anestrous and 46% of estrous cycling cows becoming pregnant during the first 3 days of the breeding season compared to only 4% of anestrous and 11% of estrous cycling control cows (Lucy et al., 2001). Estrous synchronization protocols that utilize GnRH are also able to initiate estrous cycles in anestrous cows. When a GnRH-based protocol (Ovsynch; 100 µg GnRH, i.m. on d -9; 25 mg PG, i.m. on d -2; 100 µg GnRH, i.m. on d 0 and timed AI on day

1) was compared to Syncro-Mate B with timed-AI, similar pregnancy rates were obtained ($P > 0.10$) by both protocols among anestrus cows (43% and 49% respectively, Geary et al., 1998). Therefore, estrous synchronization protocols capable of inducing puberty and shortening the anestrus postpartum period can result in anestrus cows having a chance to become pregnant during the first few days of the breeding season and more opportunities to conceive during the breeding season.

Figure 1. BEEF COW PROTOCOLS

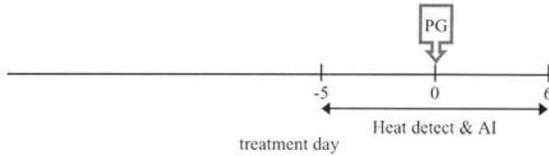


D.J. Schafer and D.J. Patterson
 Division of Animal Sciences - University of Missouri - Columbia
 These protocols are recommended by the North Central Region Bovine Reproduction Task Force.

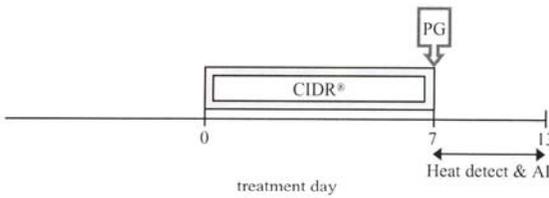
Figure 2. BEEF HEIFER PROTOCOLS

HEAT DETECTION

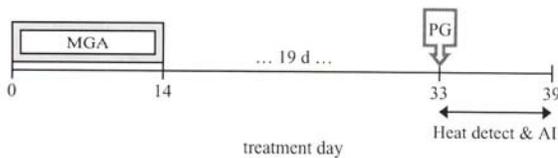
1 Shot PG



CIDR®-PG



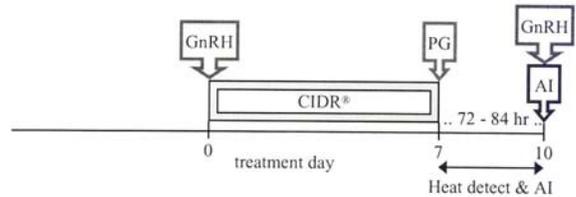
MGA®-PG



HEAT DETECT & TIME AI (TAI)

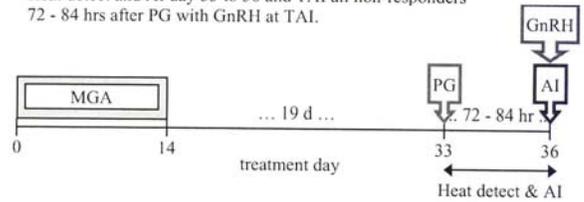
Select Synch + CIDR® & TAI

Heat detect and AI day 7 to 10 and TAI all non-responders 72 - 84 hr after PG with GnRH at TAI.



MGA®-PG & TAI

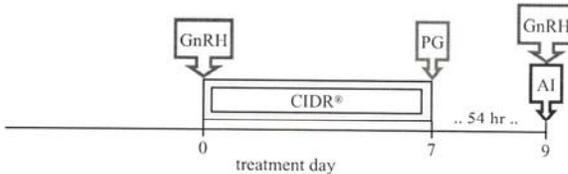
Heat detect and AI day 33 to 36 and TAI all non-responders 72 - 84 hrs after PG with GnRH at TAI.



FIXED-TIME AI (TAI)

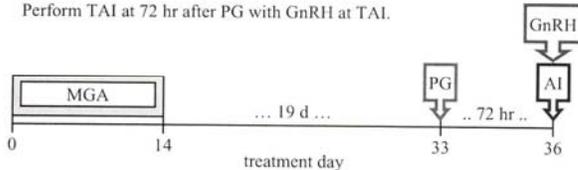
CO-Synch + CIDR®

Perform TAI at 54 hr after PG with GnRH at TAI.



MGA®-PG

Perform TAI at 72 hr after PG with GnRH at TAI.



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COMPARISON OF PROTOCOLS FOR BEEF HEIFERS

HEAT DETECTION	COST	LABOR
1 Shot PG	Low	High
CIDR®-PG	Medium	Medium
MGA®-PG	Low	Low/Medium

HEAT DETECT & TAI

Select Synch + CIDR® (TAI non-responders 72-84 hr after PG)	High	Medium
MGA®-PG (TAI non-responders 72-84 hr after PG)	Medium	Medium

FIXED-TIME AI (TAI)

CO-Synch + CIDR® (TAI at 54 hr after PG with GnRH at TAI)	High	Medium
MGA®-PG (TAI at 72 hr after PG with GnRH at TAI)	Medium	Medium

• The times listed for "Fixed-time AI" should be considered as the approximate average time of insemination. This should be based on the number of heifers to inseminate, labor, and facilities.

GnRH Cystorelin®, Factrel®, Fertagyl®, OvaCyst®

PG Estrumate®, In-Synch®, Lutalyse®, ProstaMate®

Figure 3. PROTOCOLS FOR USE WITH NATURAL SERVICE

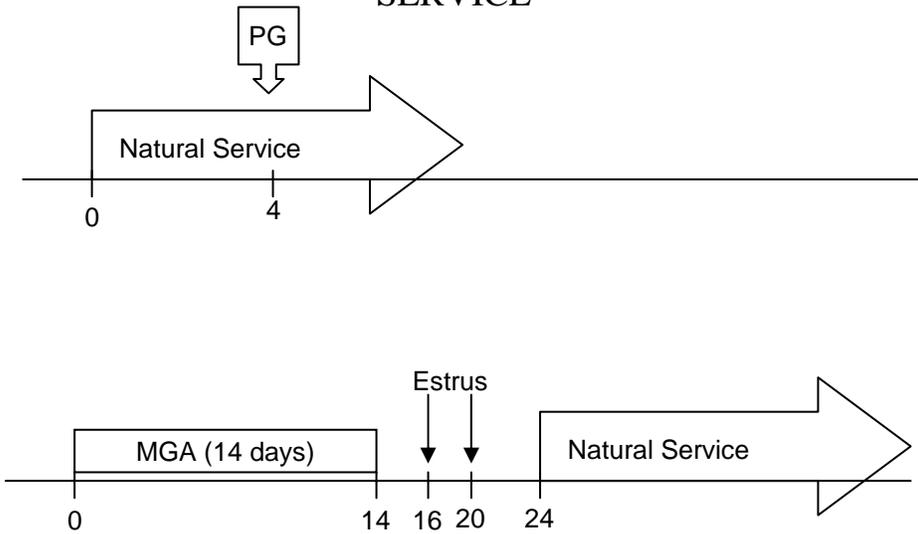


Table 1. Comparison between synchronized and non-synchronized pregnancy rates when bred by artificial insemination during the synchronized period

Study	Cows/ Heifers	Period of Time	Synchronization Method	Pregnancy Rate	
				Anestrual Unknown	Estrual
(Lucy et al., 2001)	Cows	3 days	1 shot PG	11% ^b	34% ^c
			Progesterone + PG	26% ^a	46% ^b
			Not synchronized	4% ^c	11% ^a
(Lucy et al., 2001)	Heifers	3 days	1 shot PG	6% ^b	19% ^b
			Progesterone + PG	28% ^a	49% ^a
			Not synchronized	6% ^b	9% ^c
(Heersche et al., 1979)	Heifers	5 days	Norgestomet + PG	60%	
		21 days	Not synchronized	61%	
(Beal et al., 1988)	Cows/ Heifers	7 days	MGA-PG	40% ^a	
			Not synchronized	24% ^b	
(Beal, 1983)	Cows	5 days	2 shots PG	28% ^{ab}	
			Progesterone + PG	49% ^a	
			Not synchronized	10% ^c	

Pregnancy rates within a study and estrous cycling status having different superscripts are different ^{ab; ac} $P < 0.01$ ^{bc} $P < 0.05$.

Table 2. Comparison between synchronized and non-synchronized pregnancy rates when bred by artificial insemination during the first cycle of the breeding season

Study	Cows/ Heifers	Period of Time	Synchronization Method	Pregnancy Rate	
				Anestrual	Estrual
(Lucy et al., 2001)	Cows	31 days	1 shot PG	47%	65% ^a
			Progesterone + PG	46%	71% ^a
			Not synchronized	42%	58% ^c
(Lucy et al., 2001)	Heifers	31 days	1 shot PG	25% ^b	56% ^c
			Progesterone + PG	50% ^a	69% ^a
			Not synchronized	31% ^b	64% ^c
(Beal et al., 1988)	Cows/ Heifers	30 days	MGA-PG		72%
			Not synchronized		69%
(Beal, 1983)	Cows	24 days	2 shots PG		52%
			Progesterone		53%
			Not synchronized		56%

Pregnancy rates within a study and estrous cycling status having different superscripts are different ^{ab} $P < 0.01$; ^{ac} $P < 0.05$.

Natural Service

Role of the herd bull: In a natural service breeding program the herd bull plays a tremendous role in overall herd fertility. The herd bull provides half the genetics to all the calves sired, and loss of fertility can result in loss of an entire calf crop. Therefore, it is important that a breeding soundness evaluation (BSE) be performed each year before the breeding season. A BSE includes a physical examination, measurement of scrotal circumference, and evaluation of semen quality. A BSE is not good for the life of the bulls. Sperm production is a continuous process; therefore a BSE only provides a snapshot of what is there that day. There are also many factors not tested in a BSE that can influence a herd bull's fertility. These include: libido, mating ability, serving capacity, and social dominance. These factors are only evaluated by watching the herd bull during the breeding season.

Nonsynchronized females: When cows are bred by natural service, the time required to detect estrus is not a concern since the bull will be detecting the cows that exhibit standing estrus, but the serving capacity of the bull becomes a critical management consideration. Recommendations for the bull to female ratio in non-synchronized cows range from 1:10 to 1:60. No differences were detected between a bull to female ratio of 1:25 and 1:60 for estrous detection or pregnancy rates in the first 21 days of the breeding season provided the bulls were highly fertile and had large scrotal circumferences (Rupp et al., 1977).

Synchronized females: When cows are synchronized and bred by natural service, management considerations should be made for the serving capacity of the bull. Healy et al., (1993) reported a tendency ($P < 0.10$) for pregnancy rates over a 28-day synchronized breeding season to be reduced when a bull to female ratio of 1:50 (77%) was used compared

to a bull to female ratio of 1:16 (84%); however, no difference was detected between a bull to female ratio of 1:16 and 1:25 (84% and 83%, respectively). Therefore, specific estrous synchronization protocols are recommended for use with natural service (**Figure 3**).

In the following studies, a bull to female ratio of up to 1:25 was used. A single injection of prostaglandin F₂ (PG) on day 4 of the breeding season (bulls introduced on day 1) resulted in more cycling cows becoming pregnant during days 5 to 9 of the breeding season compared to cycling cows not injected with PG (55.7 vs. 25.0%, respectively; Whittier et al., 1991). However, when cows were synchronized with a single injection of PG on day 4 of the breeding season, there were no differences in pregnancy rates over the first 25 days of the breeding season (1 cycle) between synchronized and non-synchronized cows (Whittier et al., 1991). Therefore, the greatest benefit of estrous synchronization (PG) with natural service is the ability to get more cows pregnant during the first 5 to 7 days of the breeding season (**Table 3**). Some estrous synchronization protocols that utilize progesterone (CIDR) or GnRH can initiate estrous cycles resulting in a shorter anestrous postpartum period or earlier onset of puberty in heifers (Yavas and Walton, 2000a; Lucy et al., 2001; Perry et al., 2004). The influence of estrous cycling will be discussed later in this review, but cows that exhibit estrus early in the breeding season have an additional chance to conceive during a defined breeding season. The average estrous cycle is 21 days (range 18 to 23 days), allowing one chance every 21 days for a cow to conceive. During a 65-day breeding season, cows that cycle naturally have only three chances to conceive, but cows that are synchronized and show estrus the first few days of the breeding season have up to four chances to conceive.

Table 3. Comparison between synchronized and non-synchronized pregnancy rates when bred by natural service in cows and heifers

Study	Cows/ Heifers	Period of Time	Synchronization Method	Pregnancy Rate	
				Anestrous Unknown	Estrual
(Whittier et al., 1991)	Cows	4 days	1 shot PG	13.6%	55.7% ^a
			Not synchronized	22.7%	25.0% ^b
(Plugge et al., 1989)	Heifers	7 days	MGA + PG		62% ^a
			Syncro-Mate B		67% ^a
			Not synchronized		23% ^b
(Whittier et al., 1991)	Cows	25 days	1 shot PG	59.1%	86.1%
			Not synchronized	59.1%	76.3%

Pregnancy rates within a study and estrous cycling status having different superscripts are different ^{ab} $P < 0.01$.

AI vs. Natural Service

When pregnancy rates from 13,942 first service artificial inseminations were compared to 6,310 first services by natural service, no difference ($P > 0.10$) was detected between artificial insemination and natural service (Williamson et al., 1978). Furthermore,

no differences were detected between synchronized pregnancy rates when cows were bred by AI or natural service (Plugge et al., 1989). Therefore, other factors that can have a significant influence on the success of a breeding season must be evaluated. These include: 1) estrous detection efficiency and 2) estrous cycling status.

ESTROUS DETECTION

For successful artificial insemination of cattle to occur, the producer (herd manager) must take the place of the herd bull in detecting the cows/heifers ready to be inseminated. Detecting standing estrus (also referred to as heat detection or detecting standing heat) is simply looking for the changes in animal behavior associated with a cow/heifer standing to be mounted by a bull or another cow/heifer. Detecting animals in standing estrus is the goal of good estrous detection and plays a vital role in the success of any artificial insemination program. However, when estrus was detected in 500 Angus cows with Heat Watch estrus-detection aids (24 hour a day estrus detection), the length of estrus averaged around 10 hours (ranged from 0.5 hours to 24 hours), and 26% of cows exhibited estrus for less than 7 hours and had fewer than 1.5 mounts per hour (Rorie et al., 2002).

In a study conducted at Colorado State University, animals were administered an estrous synchronization protocol, then monitored for standing estrus 24 hours a day or twice a day for 30 minutes. By day 5 after estrous synchronization, 95% of animals monitored 24 hours a day were detected in standing estrous, while only 56% of animals observed twice a day for 30 minutes were detected in standing estrus (Downing et al., 1998). With a 95% estrous detection rate and a 70% conception rate ($95\% \times 70\% = 67\%$), 67% of the animals will be pregnant; whereas, only a 39% ($55\% \times 70\% = 39\%$) pregnancy rate will occur with a 55% estrus detection rate (**Table 4**). Therefore, a successful artificial insemination program requires good estrous detection.

Table 4. Effect of estrous detection rate on increasing pregnancy rate

Estrous Detection Rate	55%	60%	65%	70%	75%	80%	85%	90%	95%
Conception Rate	70%	70%	70%	70%	70%	70%	70%	70%	70%
Pregnancy Rate	39%	42%	46%	49%	53%	56%	60%	63%	67%

To maximize detection of standing estrus, it is extremely important to visually monitor cattle as much as possible. Observations should occur as early and as late as possible, as well as during the middle of the day. Continuous observation of over 500 animals exhibiting natural estrus in 3 separate studies indicated 55.9% of cows initiated standing estrus from 6 p.m. to 6 a.m. (**Table 5**). Furthermore, when cows were observed for standing estrus every 6 hours (6 a.m., noon, 6 p.m., and midnight), estrous detection increased by 10% with the addition of a mid-day observation and by 19% when observed four times daily (every 6 hours) compared to detecting standing estrus at 6 a.m. and 6 p.m. alone (Hall et al., 1959). Therefore, detection of standing estrus can be one of the most time-consuming chores related to artificial insemination. However, the success of any artificial insemination program requires detecting the animals that are ready to be bred (standing estrus) and inseminating them at the correct time. Failing to detect estrus and mis-detection

of estrus can result in significant economic losses (Heersche and Nebel, 1994). Several estrous detection aids have been developed to assist with this time-consuming chore. These estrus-detection aids can effectively determine which cows are or have been in standing estrus, therefore relieving some of the time required to visually observe cattle for standing estrus. However, increased visual observation, in addition to the use of estrous-detection aids, could improve fertility by detecting the most possible number of animals ready to be inseminated and indicating the most appropriate time for insemination.

Table 5. Time of day when cows exhibit standing estrus

Time of day	Cows exhibiting standing estrus
6 a.m. to 12 noon	26.0 %
12 noon to 6 p.m.	18.1 %
6 p.m. to midnight	26.9 %
Midnight to 6 a.m.	29.0 %

Data adapted from (Hurnik and King, 1987; Xu et al., 1998, G.A. Perry unpublished data).

INITIATION OF ESTROUS CYCLES

The anestrus postpartum interval is a major contributing factor to cows failing to become pregnant and calving on a yearly interval (Short et al., 1990; Yavas and Walton, 2000b). However, treatment with some progestins can induce ovulation in anestrus postpartum cows (Yavas and Walton, 2000a; Lucy et al., 2001; Perry et al., 2004), thereby shortening the anestrus postpartum interval. Consequently, many estrous synchronization protocols include progestin exposure. However, all progestins are not equally effective at inducing the initiation of estrous cycles in anestrus postpartum cows. Evidence for this difference is based on differences in the ability of progesterone (CIDR) and MGA to induce ovulation in anestrus cows. Fewer anestrus cows treated with MGA ($0.5 \text{ mg MGA} \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$ for 7 days) ovulated compared to progesterone-treated [1.9 g of progesterone contained in a controlled internal drug releasing device (CIDR) for 6 days] cows (33% and 91%, respectively, Perry et al., 2004), and fewer anestrus cows that spontaneously initiated estrous cycles (23%) or MGA-treated anestrus cows (46%) exhibited normal length luteal phases compared to progesterone-treated cows (100% and 100%, Smith et al., 1987; Perry et al., 2004). However, by day 22 after treatment withdrawal there was no difference ($P > 0.05$) between the percentage of CIDR-treated cows that had ovulated (91%) and the percentage of MGA-treated cows that had ovulated (61%, Perry et al., 2004). These data indicate that following a CIDR protocol (progesterone exposure), a large percentage of cows should exhibit estrus, and following a MGA protocol (14 day of MGA and an injection of PG on day 33) an equally large percentage of cows should exhibit estrus. For example, when heifers were synchronized by progestin exposure (MGA or norgestomet), more heifers became pregnant ($P < 0.01$, MGA 62% and SMB 67%) during the first 7 days of the breeding season compared to non-synchronized heifers (23%), but there was no difference between MGA and norgestomet in the percentage of heifers pregnant during the first 7 days of the breeding season (Plugge et al., 1989). Furthermore, when a group of cycling cows and heifers were synchronized with a 7-day MGA protocol (MGA-PG), pregnancy rates after 7 days (40%) of

artificial insemination were greater in synchronized animals compared to non-synchronized animals (24%, Beal et al., 1988).

IMPLICATIONS

There are several factors that influence the fertility of a breeding program. Proper reproductive management of your herd can maximize fertility. Synchronizing estrus in cows and heifers is an effective way to maximize the use of time and labor required to detect standing estrus in cattle. In addition, by using estrous synchronization, more cows can conceive and become pregnant early in the breeding season with no decrease in fertility. Some estrous synchronization protocols can even induce estrous cycles and shorten the anestrus postpartum period, allowing cows to conceive earlier in the breeding season. However, when estrous synchronization is used together with artificial insemination, one of the largest factors that influences fertility is efficiency and accuracy of estrous detection. When fertility is defined as the percentage of cows that conceive in the first few days of the breeding season, synchronized cows have increased fertility compared to non-synchronized cows. When fertility is defined as the percentage of cows that conceive during the first cycle (first 21 to 25 days) of the breeding season, estrous-synchronized females will have similar or better fertility than non-synchronized females depending on the percent of animals that are anestrus or prepubertal and the synchronization protocol used. Therefore, estrous synchronization can be a tremendous management tool to get more cows pregnant early in the breeding season.

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