Fertility Factors

Factors that influence fertility in natural and synchronized breeding programs.

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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.

This review will focus on the factors that affect pregnancy rates during specific days of the breeding season in both natural-service and synchronized breeding programs. Since pregnancy rates are a product of both estrus detection rates and conception rates, comparisons will be made between synchronized and non-synchronized cows bred by natural service or by artificial insemination (AI).

AI 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 AI.

With natural service, herd bulls are also selected for economically relevant traits but are limited as to the number of females they can service during the breeding season. During the breeding season, a herd bull's job is to detect cows and heifers in standing estrus (also referred to as standing heat) and breed them at the appropriate time. For successful AI to occur, the producer must take the place of the herd bull in detecting the females that are ready to be inseminated.

Synchronizing estrus is an effective way to minimize the time and labor required to detect standing heat in cattle that are going to be AIed. However, estrus synchronization can also benefit overall herd management.

Cows that respond and conceive to a synchronized estrus:

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 at weaning.

In addition, some estrus 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 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 (lb.) heavier than cows that were not synchronized.

Estrus synchronization simply implies the estrous cycles of a group of heifers/cows are manipulated to cause them to exhibit standing heat around the same time. However, the question is often asked, "Do estrus synchronization protocols increase or decrease fertility?" To answer this question, fertility must be compared between non-synchronized and synchronized females bred by natural service or AI.

Fertility with natural service

Non-synchronized 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. However, 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-to-10 to 1-to-60. This range depends on the age, experience and semen quality of the

Table 1: 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: Anestrual	Pregnancy rate: Unknown	Pregnancy rate: 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]	
Lamb et al., 2006	Cows	10 days	CIDR		43%[a]	
			Not synchronized		35%[c]	
Landivar et al., 1985	Cows	80 hours	1 shot PG		19%	
		21 days	Not synchronized		33%	
Whittier et al., 1991	Cows	25 days	1 shot PG	59.1%		86.1%
			Not synchronized	59.1%		76.3%
Lamb et al., 2006	Cows	30 days	CIDR		64.4%	
			Not synchronized		64.7%	

[a,b,c]Pregnancy rates within a study and estrous cycling status having different superscripts are different ([a,b]$P < 0.01$; [a,c]$P < 0.05$).

Table 2: Comparison between synchronized and non-synchronized pregnancy rates when bred by AI during the synchronized period

Study	Cows/ heifers	Period of time	Synchronization method	Pregnancy rate: Anestrual	Pregnancy rate: Unknown	Pregnancy rate: 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]
Landivar et al., 1985	Cows	80 hours	1 shot PG		19%	
		21 days	Not synchronized		30%	
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%[a b]	
			Progesterone + PG		49%[a]	
			Not synchronized		10%[c]	
Miksch et al., 1978	Heifers	5 days	Syncro-Mate B		36%[b]	
			Not synchronized		17%[c]	
Miksch et al., 1978	Heifers	5 days	Syncro-Mate B		39%	
			Not synchronized		28%	
Miksch et al., 1978	Cows	5 days	Syncro-Mate B	48%[a]		64%[a]
			Not synchronized	8%[b]		20%[b]
King et al., 1988	Cows	5 days	Syncro-Mate B		50%[a]	
			Not synchronized		16%[b]	

[a,b,c]Pregnancy rates within a study and estrous cycling status having different superscripts are different ([a,b; a,c]$P < 0.01$; [b,c]$P < 0.05$).

bull, as well as size and terrain of the breeding pasture. No differences were detected between a bull-to-female ratio of 1-to-25 and 1-to-60 for estrus 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-to-50 (77%) was used compared to a bull-to-female ratio of 1-to-16 (84%); however, no difference was detected between a bull-to-female ratio of 1-to-16 and 1-to-25 (84% and 83%, respectively).

In the following studies, a bull-to-female ratio of up to 1-to-25 was used.

A single injection of prostaglandin $F_{2\alpha}$ (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).

The greatest benefit of estrus synchronization with natural service is the ability to get more cows pregnant during the first five to seven days of the breeding season.

In addition, pregnancy rates were similar ($P > 0.10$) for cows in which estrus was synchronized with a single injection of PG and exposed to a bull for 80 hours (19%) compared to non-synchronized cows exposed to a bull for 21 days (33%; Landivar et al., 1985). When cows were synchronized with a single injection of PG on Day 4 of the breeding season, there were no differences in pregnancy rates during the first 25 days of the breeding season (one cycle) between synchronized and non-synchronized cows (Whittier et al., 1991).

Therefore, the greatest benefit of estrus synchronization with natural service is the ability to get more cows pregnant during the first five to seven days of the breeding season (see Table 1). Cows that exhibit estrus early in the breeding season will also have additional chances 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 as many as four chances to conceive.

Some estrus synchronization protocols that utilize progesterone (CIDR®), norgestomet (Syncro-Mate B), or gonadatropin-releasing hormone (GnRH) can initiate estrous cycles resulting in a shorter anestrous postpartum period or

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Synchronization protocols capable of inducing puberty and shortening the anestrous postpartum period can result in an even greater percentage of cows having a chance to become pregnant during the first few days of the breeding season.

earlier onset of puberty (Yavas and Walton, 2000a; Lucy et al., 2001; Perry et al., 2004a).

In a small study, peripubertal heifers treated with melengestrol acetate (MGA, an orally active progestin) for 10 days resulted in a similar number of MGA-treated heifers and control heifers attaining puberty by Day 7 after MGA withdrawal. But, by Day 10 following MGA treatment, 50% more of the treated heifers attained puberty compared to the control animals (Imwalle et al., 1998).

Synchronization with a progestin [norgestomet or MGA] resulted in more ($P < 0.01$) heifers becoming pregnant (67% and 62%) during the first seven days of the breeding season compared to non-synchronized heifers (23%, Plugge et al., 1989). Furthermore, when a CIDR was inserted seven days before the start of the breeding season and removed the day the bull was introduced (no injections), more (43%; $P < 0.05$) CIDR-treated cows became pregnant by Day 10 compared to non-synchronized cows (35%; Lamb et al., 2006). However, when a single injection of PG was administered to a group of anestrous cows, no difference was detected between synchronized and non-synchronized cows (13.6% and 22.7%, respectively, Whittier et al., 1991).

Therefore, estrus synchronization protocols capable of inducing puberty and shortening the anestrous postpartum period can result in an even greater percentage of cows having a chance to become pregnant during the first few days of the breeding season.

Fertility with AI

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. Estrus synchronization makes AI more feasible due to the reduction in time and labor required for estrus detection. Therefore, it is also necessary to compare fertility between synchronized and non-synchronized females bred by AI (see tables 2 and 3).

When AI is combined with estrus 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. This can result in a more uniform calf crop that is older and heavier at weaning.

Cows synchronized with a single injection of PG and AIed for an 80-hour period had similar ($P > 0.10$) pregnancy rates (19%) compared to cows AIed for a 21-day period (30%; Landivar et al., 1985). However, when fertility is compared over the synchronized period, a single injection of PG two days before the start of the AI breeding season resulted in more ($P < 0.01$) cows pregnant during the first three days of the breeding season (22%) compared to non-

Table 3: Comparison between synchronized and non-synchronized pregnancy rates when bred by AI during the first cycle of the breeding season

Study	Cows/heifers	Period of time	Synchronization method	Pregnancy rate: Anestrual	Pregnancy rate: Unknown	Pregnancy rate: 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%	
Miksch et al., 1978	Heifers	27 days	Syncro-Mate B		64%	
			Not synchronized		62%	
Miksch et al., 1978	Heifers	27 days	Syncro-Mate B		74%	
			Not synchronized		67%	
Miksch et al., 1978	Cows	21 days	Syncro-Mate B	67%		79%
			Not synchronized	45%		76%
King et al., 1988	Cows	21 days	Syncro-Mate B		67%[a]	
			Not synchronized		56%[c]	
King et al., 1988	Cows	25 days	Syncro-Mate B		75%[a]	
			Not synchronized		61%[b]	

[a,b,c]Pregnancy rates within a study and estrous cycling status having different superscripts are different ($^{a,b}P < 0.01$; $^{a,c}P < 0.05$).

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 five days of the breeding season compared to non-synchronized cows (10%, Beal, 1983).

When estrus synchronization protocols are used that will initiate estrous cycles (progesterone, norgestomet and GnRH protocols), an even greater benefit can be realized. Cows treated with a CIDR for seven 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 cycling cows becoming pregnant during the first three days of the breeding season compared to only 4% of anestrous and 11% of cycling control cows (Lucy et al., 2001).

Cows synchronized with Syncro-Mate B resulted in more cycling and anestrous cows pregnant (64% and 48%, respectively; $P < 0.01$) during the first five days of the breeding season compared to cycling and anestrous non-synchronized cows (20% and 8%, respectively, Miksch et al., 1978). Furthermore, when heifers were synchronized with Syncro-Mate B, a greater ($P < 0.05$) percentage became pregnant (36%) during the first five days of the breeding season compared to non-synchronized heifers (17%, Miksch et al., 1978).

Estrus synchronization protocols that utilize GnRH are also able to initiate estrous cycles in anestrous cows. When a GnRH-based protocol (Ovsynch; 100 µg GnRH administered intramuscularly on Day –9; 25 mg PG intramuscularly on Day –2; 100 µg GnRH intramuscularly on Day 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 anestrous cows (43% and 49%, respectively, Geary et al., 1998).

Therefore, estrus synchronization protocols capable of inducing puberty and shortening the anestrous postpartum period can result in anestrous 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.

Initiation of estrous cycles

The anestrous 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 anestrous postpartum cows (Yavas and Walton, 2000a; Lucy et al., 2001; Perry et al., 2004a), thereby shortening the anestrous postpartum interval. Consequently, many estrus synchronization protocols include progestin exposure.

By Day 5 after estrus synchronization, 95% of animals monitored 24 hours a day were detected in standing estrus, while only 56% of animals observed twice a day for 30 minutes were detected in standing estrus.

However, all progestins are not equally effective at inducing the initiation of estrous cycles in anestrous postpartum cows. Evidence for this difference is based on differences in the ability of progesterone and MGA to induce ovulation in anestrous cows (see Fig. 1). Fewer anestrous cows treated with MGA (0.5 mg MGA per cow per day for seven days) ovulated compared to progesterone-treated (1.9 g of progesterone contained in a CIDR for six days) cows (33% and 91%, respectively, Perry et al., 2004a). Fewer anestrous cows that spontaneously initiated estrous cycles (23%) or MGA-treated anestrous cows (46%) exhibited normal-length luteal phases compared to progesterone-treated cows (100% and 100%, Smith et al., 1987; Perry et al., 2004a). 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%, Fig. 1, Perry et al., 2004a).

These data indicate that following a CIDR protocol (progesterone exposure), a large percentage of cows should exhibit estrus, and following an MGA protocol (14 days 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 Syncro-Mate B 67%) during the first seven 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

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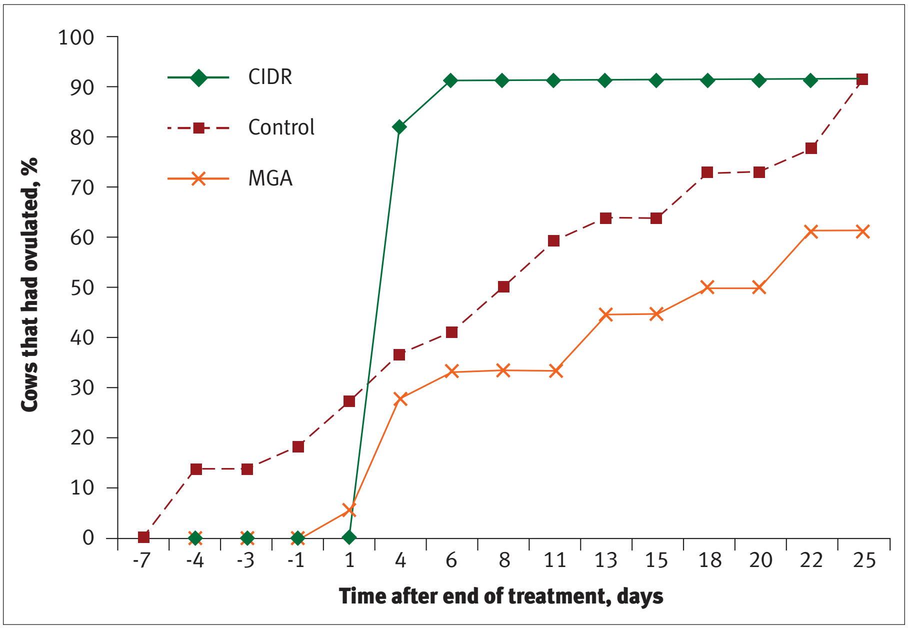
Fig. 1: Effect of treatment on the cumulative percent of animals that had ovulated
Ovulation is shown as having occurred four days before the first day. Circulating concentrations of progesterone were › 1 ng/mL by day of treatment (Day 0 = last day of feeding MGA and day of CIDR removal). Control animals received no treatment.



Treatment (P ‹ 0.01); Day (P ‹ 0.01); Treatment x Day (P ‹ 0.01).

Source: Perry et al., 2004a.

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during the first seven days of the breeding season (Plugge et al., 1989). Furthermore, when a group of cycling cows and heifers were synchronized with a seven-day MGA protocol (MGA-PG), pregnancy rates after seven days (40%) of AI were greater in synchronized animals compared to non-synchronized animals (24%, Beal et al., 1988).

Estrus detection

When pregnancy rates from 13,942 first-service AI breedings were compared to 6,310 first-service natural matings, no difference ($P > 0.10$) was detected between AI 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).

However, for successful AI 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 heat is simply looking for the changes in animal behavior associated with a cow or heifer standing to be mounted by a bull or another cow or heifer. Accurate detection of animals in standing estrus is the goal of good estrus detection and plays a vital role in the success of any AI program.

In a study conducted at CSU, animals were administered an estrus synchronization protocol, then monitored for standing heat either 24 hours a day or twice a day for 30 minutes. By Day 5 after estrus synchronization, 95% of animals monitored 24 hours a day were detected in standing estrus, while only 56% of animals observed twice a day for 30 minutes were detected in standing estrus (Downing et al., 1998).

With a 95% estrus detection rate and a 70% conception rate, 67% of the animals will be pregnant (95% × 70% = 67%); whereas, only a 39% pregnancy rate will occur with a 55% estrus detection rate (55% × 70% = 39%; see Table 4).

The success of any AI program requires detecting the animals that are ready to be bred and inseminating them at the correct time. Failing to detect estrus and misdetection of estrus can result in significant economic losses (Heersche and

Detection of standing estrus can be one of the most time-consuming chores related to AI.

Nebel, 1994). Accurate estrus detection can be a difficult and time-consuming activity. When estrus was detected in 500 Angus cows with Heat Watch estrus-detection aids, the length of estrus averaged 10 hours (range: 0.5 hours to 24 hours), and 26% of cows exhibited estrus for less than seven hours and had fewer than 1.5 mounts per hour (Rorie et al., 2002).

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 more than 500 animals exhibiting natural estrus in three separate studies indicated 55.9% of cows initiated standing estrus from 6 p.m. to 6 a.m. (see Table 5).

Furthermore, when cows were observed for standing estrus every six hours (at 6 a.m., noon, 6 p.m. and midnight), estrus detection increased by 10% with the addition of a mid-day observation and by 19% when observed four times daily (every six 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 AI.

Several estrus detection aids have been developed to assist with this time-consuming chore. These aids can effectively determine which cows are or have been in standing estrus, therefore relieving some of the time required to visually observe cattle. A comparison between visual estrus detection every three hours (eight times daily), a marker animal and Estrus Alert patches resulted in a similar ($P > 0.79$) percentage of animals correctly identified in standing estrus (92%, 92% and 91%, respectively; Perry, 2005). However, increased visual observation, in addition to the use of estrus detection aids, could improve fertility by detecting the most possible number of animals ready to be inseminated and the most appropriate time for insemination.

Fixed-time insemination

To expand the use of AI and to increase the adoption rate of other emerging reproductive technologies, precise methods of controlling ovulation must be developed. Numerous studies have been conducted to induce ovulation in cattle at a specific time, thereby eliminating the time and labor required to detect estrus.

Table 4: Effect of estrus detection rate on increasing pregnancy rate

Estrus 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%

Table 5: Time of day when cows exhibit standing estrus

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

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

The uterine environment is likely a major factor in decreased fertility following induced ovulation of small dominant follicles.

Methods of inseminating cattle at a fixed-time with consistently high pregnancy rates may be a reality in the near future. Stevenson et al. (2000) reported higher pregnancy rates ($P < 0.05$) for cattle AIed following detection of standing estrus (44%; Select Synch — GnRH on Day –9, PG on Day –2 and detect estrus) compared to cattle bred by timed-AI (33%; Co-Synch — Select Synch with timed-insemination and a second injection of GnRH on Day 0). However, Lemaster et al. (2001) reported higher ($P < 0.05$) pregnancy rates for timed-AI following the Co-Synch protocol (31%) compared to AI following estrus detection with the Select Synch protocol (21%).

Currently, most fixed-time insemination protocols (ovulation synchronization protocols) utilize GnRH to ovulate a dominant follicle around the time of insemination. The Ovsynch (Pursley et al., 1998) and Co-Synch (Geary and Whittier, 1998) protocols include the same hormonal treatments to synchronize ovulation [GnRH is administered on Day –9; PG is administered on Day –2; and 48 hours later (Day 0) GnRH is administered to induce ovulation around the time of insemination].

The MGA-select timed-AI protocol (MGA is fed for 14 days, GnRH is administered on Day 26, PG is administered on Day 33, and GnRH is administered 72 hours later to induce ovulation around the time of insemination; Perry et al., 2002b) also utilizes GnRH to induce ovulation around the time of insemination.

The use of GnRH at the time of insemination resulted in a wide range of follicle sizes being induced to ovulate (Perry et al., 2005), and although dominant bovine follicles (10 mm) have the ability to ovulate in response to a GnRH-induced gonadotropin surge, a larger dose of luteinizing hormone (LH) was required to induce ovulation of a 10 mm follicle compared to larger follicles (Sartori et al., 2001).

A decrease in pregnancy rates occurred when small follicles were induced to ovulate following fixed-time AI in both heifers and cows (CIDR protocol: Lamb et al., 2001; T.W. Geary, unpublished data; Co-Synch protocol: Perry et al., 2004b; Perry et al., 2005; see Fig. 2). In addition, when the length of proestrus was varied to induce ovulation of small (< 12 mm) or large (≥ 12 mm) follicles, pregnancy rates were decreased in animals induced to ovulate small follicles compared to animals induced to ovulate large follicles (Mussard et al., 2003).

The ovulatory follicle may affect fertility through the preparation of the oocyte for embryonic development, preparation of follicular cells for luteinization, and/or preparation of the uterine environment for the establishment and maintenance of pregnancy. However, when embryos of similar quality were transferred into cows induced to ovulate small (< 12 mm) or large (> 12 mm) follicles, cows induced to ovulate small follicles had significantly lower pregnancy rates compared to cows induced to ovulate large follicles (Mussard et al., 2003).

The preceding study indicates the uterine environment is likely a major factor in decreased fertility following induced ovulation of small dominant follicles.

Variation does exist in the proportion of animals induced to ovulate small follicles by different fixed-time insemination protocols. Following the Co-Synch protocol, 30% of cows and 52% of heifers (G.A. Perry, unpublished data) were induced to ovulate follicles < 11.5 mm in diameter. However, when fixed-timed AI was performed in cows with or without a CIDR from Day –9 to Day –2 [on Day –9, GnRH was administered, on Day –2, PG was administered, and 48 hours later (Day 0) GnRH was administered and animals were inseminated], the percentage of cows that ovulated follicles < 11.5 mm was 7% for CIDR-treated cows and 15% for cows not receiving a CIDR (T.W. Geary, unpublished data).

Therefore, different timed-insemination protocols are more effective at reducing the percentage of small follicles induced to ovulate. However, regardless of synchronization protocol, reduced fertility does appear to occur whenever small follicles are induced to ovulate.

Furthermore, pregnancy rates were increased when animals were detected in standing estrus within 24 hours of fixed-time insemination regardless of follicle size induced to ovulate (Perry et al., 2004; Perry et al., 2005). Cows that initiate standing estrus around the time of fixed-time insemination had elevated preovulatory concentrations of estradiol compared to cows that do not exhibit standing estrus and similar concentrations to cows that spontaneously initiate estrus and ovulation (Perry and Busch, 2005).

Efficient transportation of sperm through the female reproductive tract requires that the female be in estrus or under the influence of estrogen (Hawk, 1983). In a recent review by Santos et al., (2004) fertilization failure in lactating beef cows ranged from 0% to 25% and in lactating dairy cows from 12% to 45%.

Fig. 2: Regression analysis of the effect of ovulatory follicle size at time of GnRH injection/insemination on pregnancy rates 27 and 68 days after insemination
Follicle sizes at which pregnancy rates were decreased ($P < 0.05$) below the maximal pregnancy rates are indicated with vertical lines. (Perry et al., 2005)

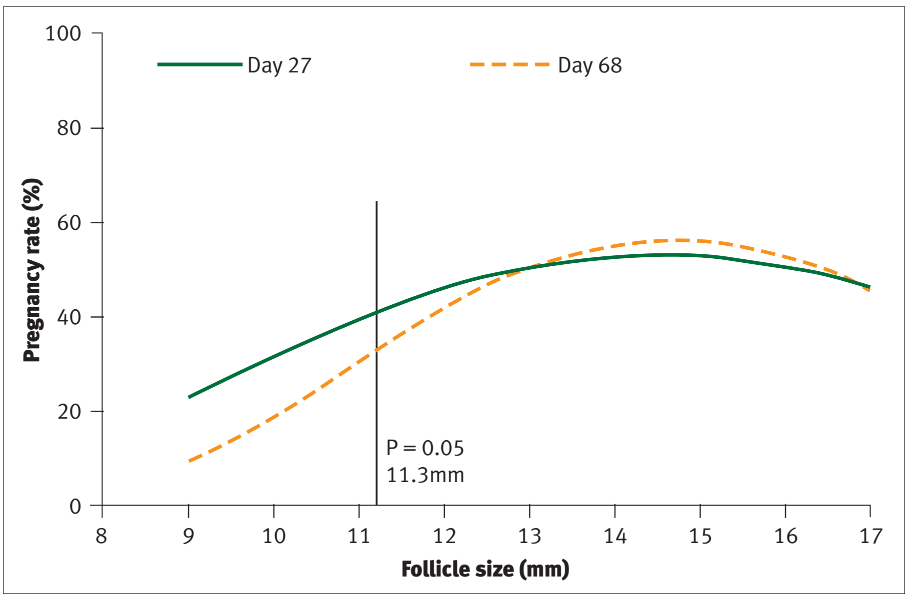

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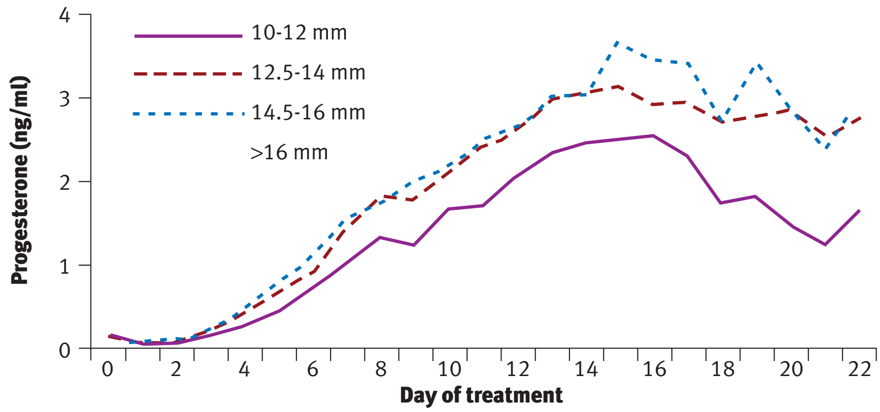
Fig. 3: Effect of ovulatory follicle size, across both anestrous and cycling cows, on mean serum concentrations of progesterone from Day 0 (second GnRH injection) through Day 22, and rate of progesterone increase from Day 0 to peak progesterone concentration. Progesterone (ng/mL)



Rate of progesterone rise:

10.0-12 vs. 12.5-14 (P ‹0.01)
10.0-12 vs. 14.5-16 (P ‹0.01)
10.0-12 vs. >16 (P ‹0.01)

Progesterone concentration

Follicle size group (P <0.04); Day (P <0.01)

Source: Perry et al., 2005.

Estrogen may influence fertilization rates through both sperm transport and fertilization efficiency by altering the uterine environment around the time of fertilization. Uterine pH decreased at the initiation of standing estrus (Elrod and Butler, 1993) to a pH similar to seminal plasma (Acott and Carr, 1984). Furthermore, uterine pH was decreased in animals that exhibited standing estrus at the time of fixed-time AI compared to animals not in standing estrus (Perry and Perry, 2006; Nelson et al., 2006).

During final maturation, sperm lose their ability to biosynthesize, repair, grow and divide, and they become very simple in their metabolic function (Hammerstedt, 1993). This results in sperm becoming completely dependent on their external environment.

While in the epididymis, sperm are stored for a long period of time in a relatively quiescent state, but upon ejaculation or dilution of caudal epididymis fluid, motility is increased (Acott and Carr, 1984; Carr and Acott, 1984). However, a consequence of the increased motility is a reduction in viability from several weeks to only several hours in the female tract (Austin, 1975).

The pH of the medium influenced the motility of sperm collected from the caudal epididymis (Acott and Carr, 1984). Goltz et al., (1988) showed the motility of demembraned bull sperm increased as the pH of the medium was raised from 6.6 to 7.1.

An increase in sperm motility above basal levels appears to be necessary to assist the sperm in penetrating the viscous oviductal mucus and the cumulus matrix that surrounds the oocyte (Suarez and Dai, 1992) as well as the oocyte so fertilization can occur (Stauss et al, 1995). Therefore, changes in uterine pH from initiation of standing estrus (low pH) until ovulation may play a vital role in fertilization.

Following fertilization, luteal secretion of progesterone during the subsequent estrous cycle is required for the survival of the embryo/fetus (McDonald et al., 1952), and has been associated with fertility in cattle by stimulating both uterine secretions (Geisert et al., 1992) and embryonic growth and development (Garrett et al., 1988; Mann et al., 1996). Uterine secretions including nutrients, growth factors, immunosuppressive agents, enzymes, ions and steroids contribute to early conceptus growth/survival (Geisert et al., 1992; Gray et al., 2001).

Cows with normal developing embryos had higher concentrations of progesterone on days 3 and 6 after insemination compared to cows with degenerating embryos (Maurer and Echternkemp, 1982). Following timed-AI protocols, serum concentrations of progesterone were affected ($P < 0.04$) by the size of the dominant follicle induced to ovulate (see Fig. 3). More specifically, the rise of progesterone following GnRH-induced ovulation was decreased ($P < 0.01$) in cows that ovulated ≤ 12 mm follicles compared to cows that ovulated larger follicles. Furthermore, cows induced to ovulate ≤ 12 mm follicles had decreased ($P < 0.05$) pregnancy rates compared to cows induced to ovulate larger follicles (29% vs. 71%, respectively, Perry et al., 2002a).

Implications

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 estrus synchronization, more cows can conceive and become pregnant early in the breeding season with no decrease in fertility.

Some estrus synchronization protocols can even induce estrous cycles and shorten the anestrous postpartum period, allowing cows to conceive earlier in the breeding season. However, when estrus synchronization is used together with AI, one of the largest factors that influences fertility is efficiency and accuracy of estrus detection.

With fixed-timed insemination protocols, fertility can be reduced in a proportion of animals (cows induced to ovulate follicles < 11.5 mm). However, if the appropriate amount of time and effort cannot be spent detecting estrus, fixed timed-insemination protocols may result in overall greater pregnancy rates.

In conclusion, when fertility is defined as the percentage of cows that conceive in the first few days of the breeding season, synchronized cows will have increased fertility compared to non-synchronized cows. When fertility is defined as the percentage of cows that conceive during the first cycle (first 21-25 days) of the breeding season, estrus-synchronized females will have similar or better fertility than non-synchronized females, depending on the percent of animals that are anestrous or prepubertal and the synchronization protocol used. Therefore, estrus synchronization can be a tremendous management tool to get more cows pregnant early in the breeding season with no decrease in fertility.

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