Synchronization of Estrus in Cattle

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Introduction

Estrous synchronization is a reproductive management tool in which the estrous cycle is intentionally manipulated so that breeding females enter into estrus simultaneously at a time chosen by the producer. Although estrous synchronization is most commonly used with other reproductive programs such as artificial insemination (AI) and embryo transfer (ET), it can be used with natural mating as well.

Benefits of estrous synchronization

Additional chance to become pregnant

Failure of cows to calve is a major source of economic loss for cattle producers, projected to cost a minimum of $6.25 per cow exposed for every 1% decrease in pregnancy rate (Table 1). This reproductive failure may occur for a variety of reasons including poor body condition, disease, prepubertal females, anestrus females or pregnancy loss during the breeding season. In fact, 28.4% of embryos will not develop past Day 7, and 47.9% of exposed cows will lose their embryos within the first month of gestation. Providing animals with an additional opportunity to become pregnant within the defined breeding season can alleviate reproductive losses. The length of an estrous cycle is approximately 21 days, meaning a female only has one opportunity to become pregnant every 21 days. A synchronization protocol can be implemented before the breeding season so that the enrolled females express estrus on the first day of the breeding season. This gives them an extra opportunity to become pregnant before the breeding season ends (Figure 1).

Number of cows exposed	End-of-season pregnancy rate	Economic loss
100	99%	$625
100	95%	$3,125
100	90%	$6,250
100	85%	$9,375

Table 1. Economic losses due to reproductive failure assuming a loss of $6.25 per cow exposed for every 1% decrease in pregnancy rate. Adapted from Mercadante et al., 2020.

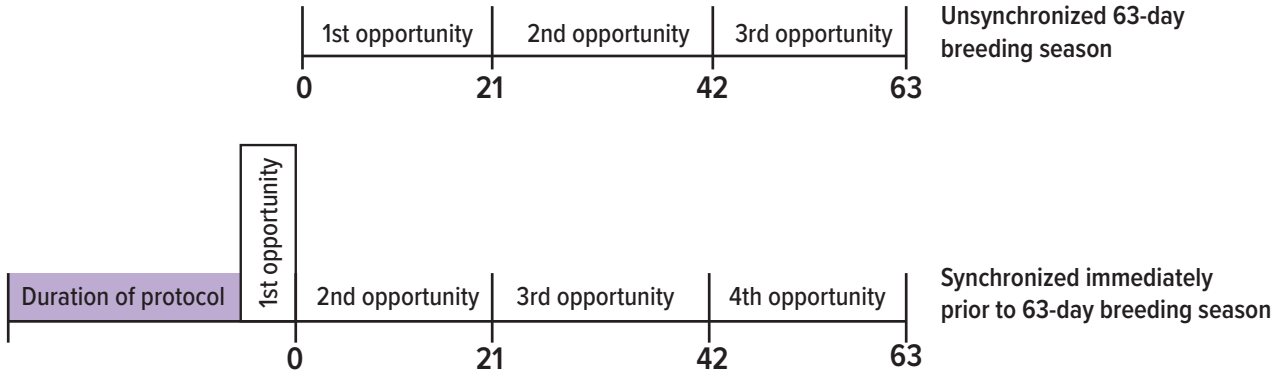


Figure 1. Initiating a synchronization protocol prior to a defined breeding season (in this example, a 63-day breeding season) provides an additional opportunity for a female to become pregnant, because the synchronization protocol is inducing the breeding herd to come into heat at the start of the breeding season.

Induce cyclicity in anestrous females

Scientists have reported 17% to 67% of postpartum cows to be anestrus, and 35% to 88% of heifers to be prepubertal at the start of the breeding season. Females, whether prepubertal or postpartum, that are anestrus at the start of the breeding season will have fewer opportunities to become pregnant. The anestrous period can be shortened with estrous synchronization protocols that incorporate progestins and/or gonadotropin-releasing hormone that simulate the hormonal changes that occur prior to ovulation.

Improved management of herd

Females that respond to synchronization will be bred at a similar time. An increase in the number of females at the same stage of pregnancy makes it easier to feed and vaccinate them for their appropriate stage of gestation. Calves will also be closer in age and older at weaning, which can improve calf management as well.

Heavier calves at weaning

Synchronizing estrus results in more calves being born earlier in the calving season due to an increased number of females in estrus at the start of the breeding season (Figure 2). Beef calves today are capable of gaining approximately 2 pounds per day, so older calves will be heavier at weaning than their later-born counterparts. Additionally, it's been demonstrated that heifers that calve in the first 21 days of their first calving season will wean heavier calves in their first six calving seasons (Figure 3).

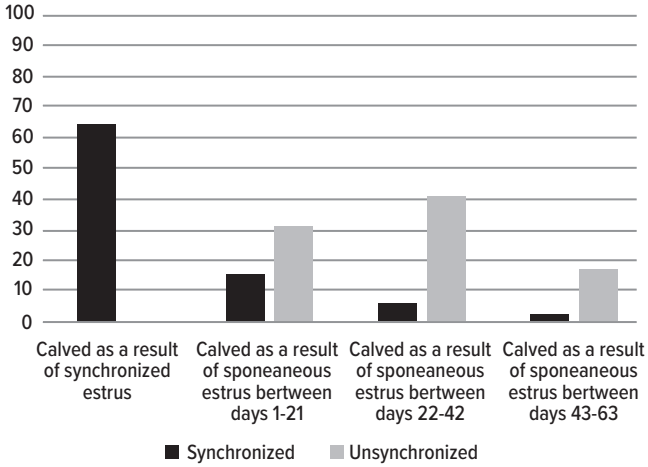


Figure 2. A depiction of calving distribution over a 63-day breeding season in a synchronized or unsynchronized herd. In both herds, a final calving rate of 90% is assumed.

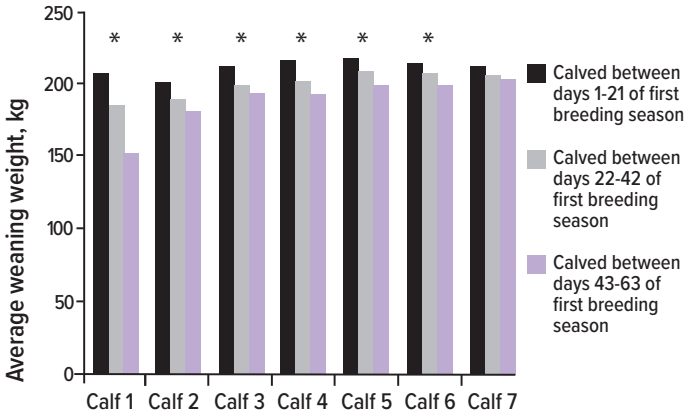


Figure 3. Heifers that calved in the first 21 days of their first breeding season weaned a heavier calf in their first six calving seasons. Adapted from Cushman et al., 2013.

Longer postpartum recovery period and herd longevity

Heifers (and cows) that calve earlier in the calving season have a longer postpartum period for uterine involution, recovery of lost body condition and resumption of cyclicity prior to the start of the breeding season (Figure 4). After the first month of the calving season, for every 10-day interval from the start of the calving season, the number of cows that begin to cycle increases 7%.

There is an increased amount of pressure placed on first-calf heifers. They are ideally bred at 60% to 65% of their mature size and should be around 80% of their mature size at calving (Figure 5). Not only are they themselves in the process of growing, they are also expected to grow a calf, lactate sufficiently for that calf once born and resume cyclicity for rebreeding. If feasible, heifers should be bred 2 to 4 weeks prior to the cows to provide them a longer first postpartum recovery and maximize their percent rebred at the next breeding season.

Figure 4. Illustration of length of postpartum recovery length based on time of conception.

Benefits of estrous synchronization (cont.)

Facilitates the use of artificial insemination and embryo transfer

Artificial insemination and embryo transfer provide producers the opportunity to incorporate superior genetics into their herd without the hefty price tag associated with purchasing genetically superior animals. These reproductive technologies can be quite labor intensive due to the need to properly observe animals for detection of heat, bringing estrus females up to the working facility for insemination/transfer and pushing them back to pasture over the entire breeding season. There is also increased labor due to an evenly spread calving distribution over the calving season. Synchronizing estrus brings a majority of females into heat within a shortened timeframe so that labor associated with synchronization and AI/ET can be concentrated to a shorter period of time at the beginning of the breeding season. There are also several synchronization protocols in which all females are bred at a fixed time so that heat detection isn't a component of labor needs.

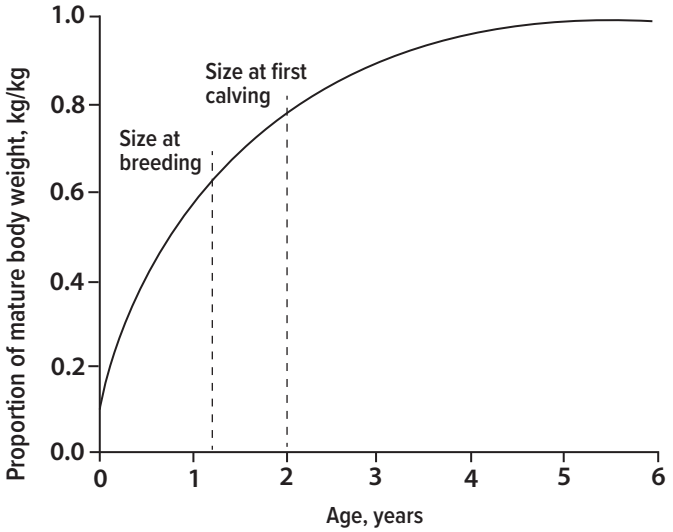


Figure 5. Growth curve of beef cattle. Heifers should be 55% to 60% of their mature body weight at breeding, approximately 80% at 2 years of age (age at first calving), approximately 90% of mature weight at age 3 and mature at approximately age 4.

Overview of the estrous cycle

The estrous cycle consists of a series of hormonal and structural changes that occur in a specific order within a specific timeframe. A detailed explanation of the estrous cycle can be found in LSU AgCenter Publication 3885 The bovine estrous cycle.

Figure 6 depicts the hormonal and ovarian changes that occur during the estrous cycle. Briefly, near the end of an estrous cycle, the ovulatory follicle grows and produces estradiol. Estradiol signals to the hypothalamus (an area of the brain) to secrete a hormone called gonadotropin-releasing hormone (GnRH). Gonadotropin-releasing hormone stimulates release of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) from the anterior pituitary (another area of the brain). Estradiol, GnRH and LH form a positive feedback loop and stimulate each other to increase. Eventually the concentration of estradiol is great enough to induce standing estrus in females. Standing estrus marks the start of a new cycle. Shortly after standing estrus, there is a surge of LH that induces ovulation. The released oocyte will enter the reproductive tract and the remnants of the follicle wall will transform into a corpus luteum (CL) which produces progesterone (P), the hormone responsible for maintaining pregnancy and suppressing any other ovulations during the cycle. If the oocyte does not become fertilized, the uterus secretes the hormone prostaglandin $F_{2\alpha}$ (PG or PGF), which travels to the ovary and destroys the CL (termed luteolysis). The destruction of the CL causes the concentration of progesterone to decline, which allows the ovulatory follicle to grow, produce estradiol, and eventually ovulate at the beginning of the subsequent estrous cycle.

Overview of the estrous cycle (cont.)

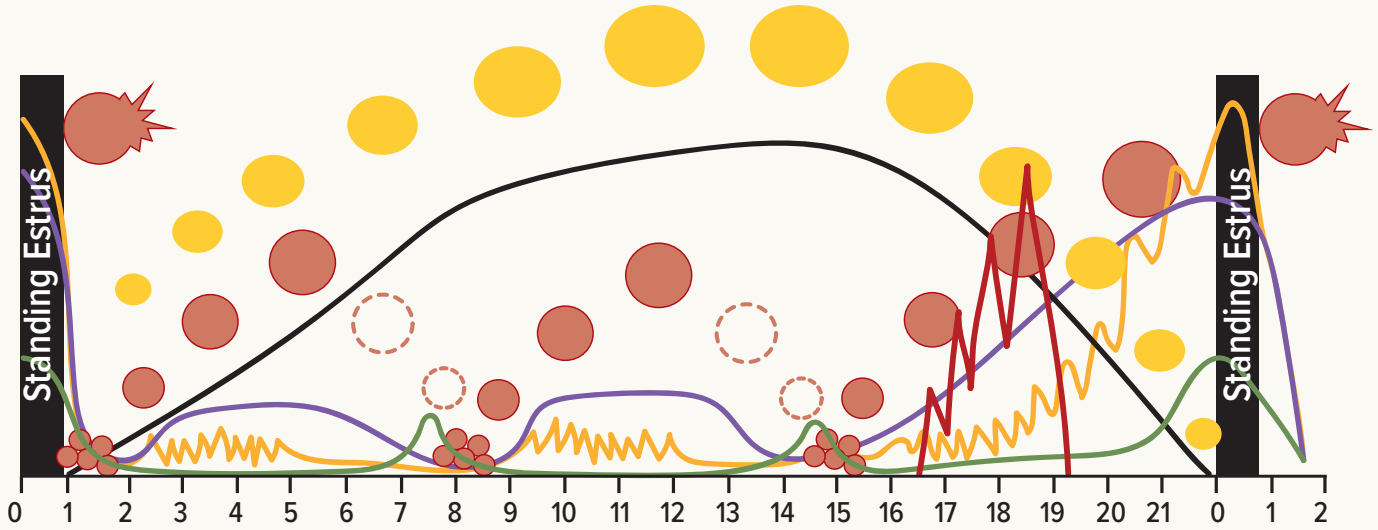


Figure 6. The hormonal and ovarian activity during the bovine estrous cycle. The dominant follicle produces an abundance of ***estradiol (purple line)*** *which results in standing estrus and a surge in* ***luteinizing hormone (orange line)*** *and ovulation of the dominant follicle 24 to 32 hours later (ruptured dark pink circle). An increase in* ***follicle-stimulating hormone (green line)*** *also occurs at this time which recruits the first wave of small follicles to begin growing. The follicular membrane transforms into a corpus luteum (yellow circle) and begins to produce* ***progesterone (black line).*** *A single follicle in that first wave responds to an increase in luteinizing hormone and continues to grow into the dominant follicle. That dominant follicle cannot ovulate due to the high concentration of progesterone so it dies and a new wave of follicles is recruited to begin growing. If the female is not pregnant, the uterus secretes* ***prostaglandin F_{2a} (red line)*** *at approximately Day 17 which destroys the corpus luteum and decreases progesterone. This decrease in progesterone allows the dominant follicle from the last wave to continue growing and producing estradiol, which stimulates estrus behavior, marking the start of the next estrous cycle. Note: Gonadotropin-releasing hormone is not depicted in this figure, but its concentration rises with estradiol, and its surge causes the surge in LH.*

Hormones to synchronize estrus

Estrus is synchronized by administering hormones that mimic the actions of naturally occurring hormones (Table 2). To reiterate, the estrous cycle consists of a sequential release of hormones in a specific order, so understanding the physiological effects of these hormones will reduce errors associated with their administration, such as giving them in an improper order.

Prostaglandins (PG)

After ovulation, the follicular wall transforms into a corpus luteum, which produces progesterone. Progesterone prepares the uterine environment for pregnancy, but it also suppresses any further ovulations from occurring. If the uterus does not receive a signal from an embryo, the uterus will produce prostaglandin F_{2a} which destroys the CL and allows another estrous cycle to begin.

A single injection of prostaglandin can be used on its own to synchronize estrus, however, it is only effective from Days 5 to 17 after the onset of standing estrus.

Hormone class	Action	Commercial products	
Gonadorelins – Gonadotropin-releasing hormone (GnRH)	Induces ovulation of the dominant follicle	Cystorelin®, Factrel®, Fertagyl®, GONAbreed®, OvaCyst®	
Prostaglandins – Prostaglandin F_{2a} (PG)	Lyses the corpus luteum	Synchsure®, Lutalyse® or Lutalyse®HighCon, Estrumate®, estroPLAN®, ProstaMate®	
Progestin – Progesterone (P)	Prevents ovulation	Intravaginal device	EAZI-BREED™ CIDR®
		Feed additive*	MGA® HeifermaX®

*Table 2. The hormone class, action, and commercial products FDA-approved for use in estrous synchronization protocols. *Feed additives require longer-term use and are recommended for use in heifers.*

Hormones to synchronize estrus (cont.)

Ovulation occurs approximately 30 hours after the onset of standing estrus and after ovulation, the follicular wall must transform itself into a functional CL, which takes approximately three and a half days after ovulation (five days after onset of standing estrus). Prior to this point, an injection of PGF will not induce luteolysis. As previously stated, the uterus naturally produces PGF on Day 17, so an injection of PGF would be redundant. If an injection of PGF is given at a time when the CL is responsive, standing estrus can be expected four to five days later. If the intention is to artificially inseminate these females, they must be observed for estrus behavior and inseminated 12 hours after standing estrus. For more information regarding heat detection, refer to LSU AgCenter Publication 3827 Standing estrus (heat) and heat detection aids in cattle.

Progestins (P)

Progesterone is produced by the corpus luteum and inhibits the increased production of GnRH. Without the increase in GnRH the LH surge cannot occur, and this prevents ovulation from occurring when the concentration of progesterone is high.

Progestins can also be used alone in order to synchronize estrus. The progestin melengestrol acetate (MGA) is a feed additive and needs to be fed for at least 14 days. Long-term feeding of MGA can produce a tight synchrony of estrus in breeding females however the dominant follicle becomes persistent during this time which greatly reduces fertility. Therefore, it is not recommended to breed to the first estrus after MGA withdrawal, but at the subsequent estrus 21 days later. Because of the length of time required for MGA protocols, they are only typically recommended for use in heifers. Short-term treatment with either MGA or progesterone from an intravaginal device (EAZI-BREED™ CIDR®; Figure 7) does not negatively affect the fertility of the resulting ovulation but the synchrony of estrus is not as tight as longer-term progestin treatments. Another benefit to using progestins in an estrus synchronization protocol is its ability to jump-start cyclicity in heifers approaching puberty and in postpartum anestrous cows.

Figure 7. The EAZI-BREED™ CIDR® device (white T-shaped object) is impregnated with progesterone and is inserted into the vaginal cavity using the blue applicator. The device can be removed by gently pulling the blue plastic tail.

Gonadorelins (GnRH)

Follicular development occurs in a wave-like pattern and cows can exhibit two, three and even four follicular waves during an estrous cycle, with a dominant follicle present at each wave. During a natural cycle however, progesterone produced by the CL prevents all but the last dominant follicle from ovulating due to its suppressive effects on estradiol and GnRH. A dose of GnRH administered in the presence of a large, dominant follicle will induce ovulation, transformation of the follicular wall into a CL and initiation of a new follicular wave. Similar to progestin, treatment of anestrous females with a gonadorelin can hasten their start (heifers) or return (postpartum cows) to cyclicity.

Estrous synchronization protocols

Although PG and P can be used alone in order to synchronize estrus, their synchrony of estrus is not all that tight because these products are only manipulating one physiological process of the estrous cycle (PG: regression of the CL, P: suppression of ovulation). The more effective synchronization protocols use a combination of these hormones in order to manipulate several of these physiological processes and produce a tighter synchrony of estrus which is ideal for AI and ET programs. It is important to note that when several hormone products are used, they are only Food and Drug Administration-approved for use with their counterpart (Table 3). Using GnRH and PG products from different manufacturers is considered extra-label use and is illegal.

There are several estrous synchronization protocols that have been studied extensively and, based on their efficacy, are recommended by a group of scientists that specialize in beef cattle reproduction known as the Beef Reproduction Task Force. There are protocols geared towards heifers (Figures 8 to 11) and cows (Figures 12 to 15). Within these categories, they have also been further categorized by protocols requiring heat detection (Figures 8 and 12), AI following a detected heat and timed-AI of the females not yet expressing estrus (Figures 9 and 13), and protocols that do not require heat detection because all females are inseminated at a predetermined or fixed time (fixed-time AI protocols; Figures 10, 11, 14 and 15).

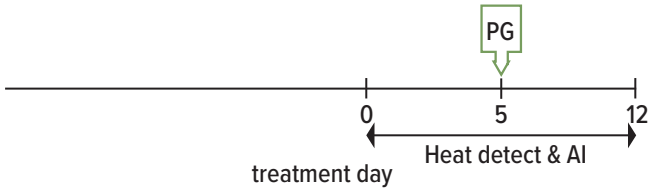
Estrous synchronization protocols (cont.)

Manufacturer	GnRH product	Dosage	Admin.	PG product	Dosage	Admin.
Merial, Inc.	Cystorelin®	2 mL	IM or IV	Synchsure®	2 mL	IM
Zoetis Inc.	Factrel®	2-4 mL	IM	Lutalyse® Lutalyse® HighCon	5 mL 2 mL	IM SQ or IM
Intervet, Inc.	Fertagyl®	2 mL	IM or IV	Estrumate®	2 mL	IM
Parnell Technologies Pty. Ltd.	GONAbreed®	1 mL	IM or IV	estroPLAN®	2 mL	IM
Bimeda Animal Health Limited	OvaCyst®	2 mL	IM	ProstaMate®	5 mL	IM

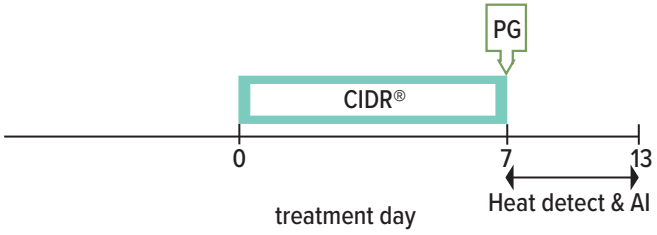
Table 3. The manufacturer and the commercial names of their GnRH and PG products, dosages and mode of administration. IM = intramuscular, IV = intravenous, SQ = subcutaneous. FDA-Approval is for the drugs produced by the same manufacturer. It is illegal to use any other GnRH-PG combination (e.g., it is illegal to use the GnRH product Cystorelin® with the PG product Lutalyse®).

Heifer synchronization protocols

1 Shot PG



7-Day CIDR®–PG



MGA®–PG

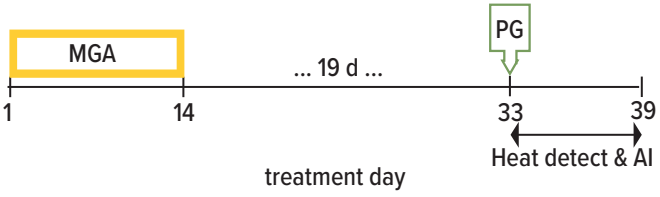
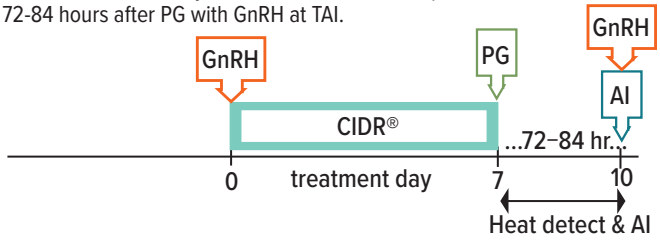


Figure 8. Heat detection protocols for heifers. Source: Beef Reproduction Task Force.

Heifer synchronization protocols

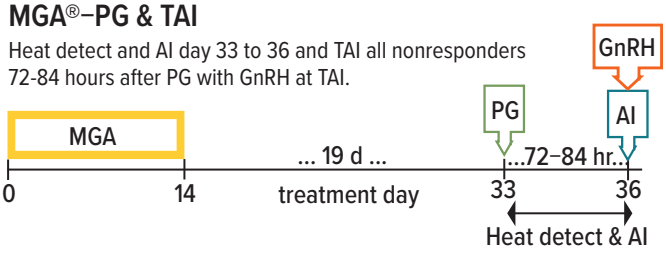
Select Synch + CIDR® & TAI

Heat detect and AI day 7 to 10 and TAI all nonresponders 72-84 hours after PG with GnRH at TAI.



MGA®–PG & TAI

Heat detect and AI day 33 to 36 and TAI all nonresponders 72-84 hours after PG with GnRH at TAI.



14-Day CIDR®–PG & TAI

Heat detect and AI day 30 to 33 and TAI all nonresponders 72 hours after PG with GnRH at TAI.

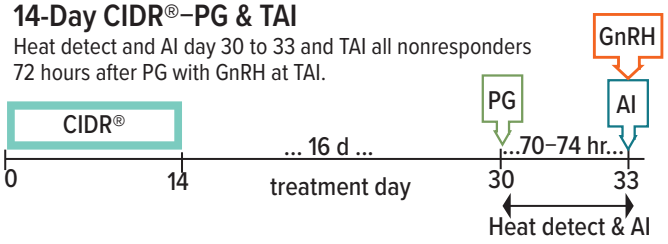
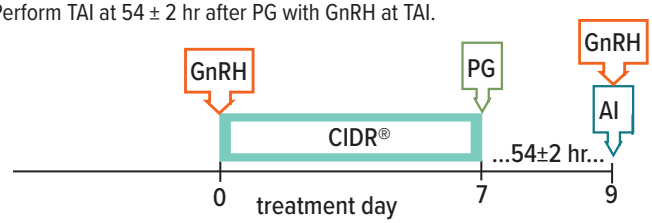


Figure 9. Heat detection and timed-AI protocols (TAI) for heifers. Source: Beef Reproduction Task Force.

Heifer synchronization protocols

7-day CO-Synch + CIDR®

Perform TAI at 54 ± 2 hr after PG with GnRH at TAI.



5-day CO-Synch + CIDR®

Perform TAI at 60 ± 4 hr after CIDR removal with GnRH at TAI.
Two injections of PG 8 ± 2 hr apart are required for this protocol.

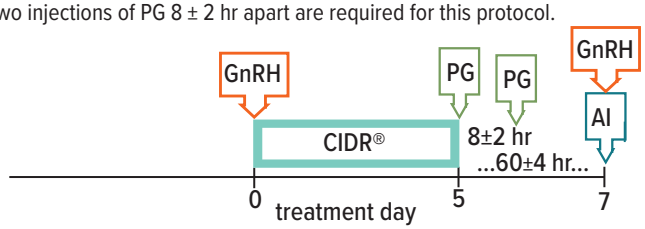
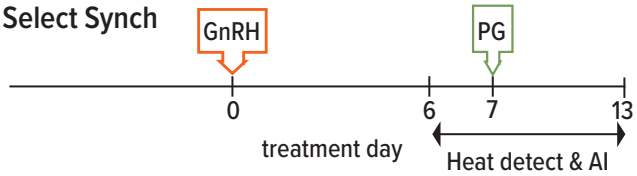


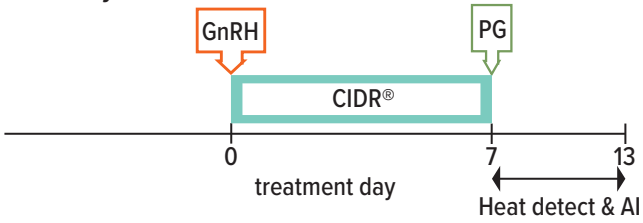
Figure 10. Short-term fixed-time AI protocols for heifers. The time interval listed should be considered the average time of insemination (i.e., the time when half of your females have been inseminated). Your starting time should be adjusted according to the number of females being inseminated, amount of labor present, and facilities. Source: Beef Reproduction Task Force.

Cow synchronization protocols

Select Synch



Select Synch + CIDR®



PG 6-day CIDR®

Heat detect and AI days 0 to 3. Administer CIDR to nonresponders and heat detect and AI days 9 to 12. Protocol may be used in heifers.

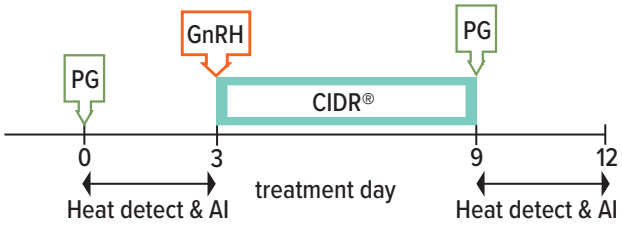
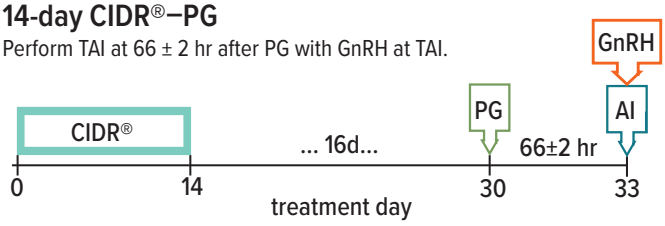


Figure 12. Heat detection protocols for cows. Source: Beef Reproduction Task Force.

Heifer synchronization protocols

14-day CIDR®–PG

Perform TAI at 66 ± 2 hr after PG with GnRH at TAI.



MGA®-PG

Perform TAI at 72 ± 2 hr after PG with GnRH at TAI.

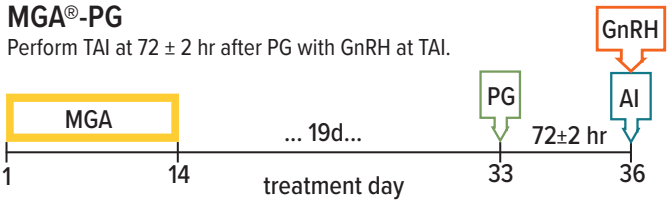
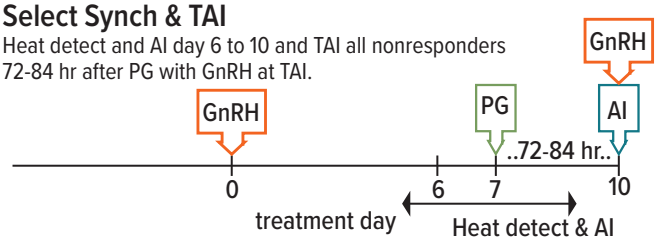


Figure 11. Long-term fixed-time AI protocols for heifers. The time interval listed should be considered the average time of insemination (i.e., the time when half of your females have been inseminated). Your starting time should be adjusted according to the number of females being inseminated, amount of labor present, and facilities. Source: Beef Reproduction Task Force.

Cow synchronization protocols

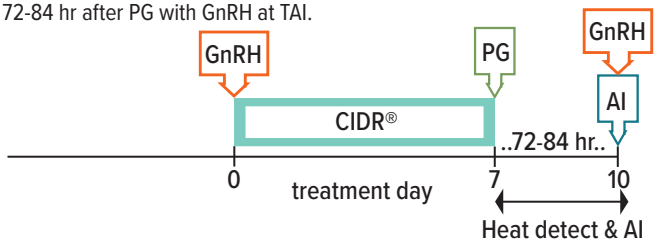
Select Synch & TAI

Heat detect and AI day 6 to 10 and TAI all nonresponders 72-84 hr after PG with GnRH at TAI.



Select Synch + CIDR® & TAI

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



PG 6-day CIDR® & TAI

Heat detect and AI days 0 to 3. Administer CIDR to nonresponders & heat detect and AI days 9 to 12. TAI nonresponders 72-84 hr after CIDR removal with GnRH at AI. Protocol may be used in heifers.

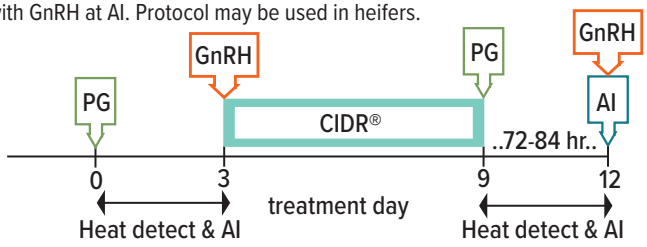


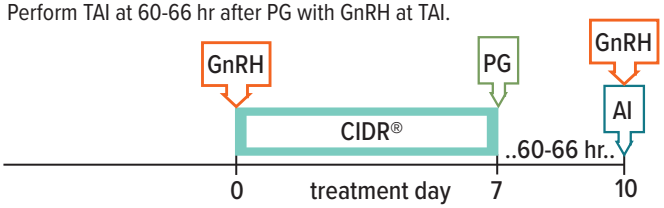
Figure 13. Heat detection and timed-AI protocols for cows. Source: Beef Reproduction Task Force.

Benefits of estrous synchronization (cont.)

Cow synchronization protocols

7-day CO-Synch + CIDR®

Perform TAI at 60-66 hr after PG with GnRH at TAI.



5-day CO-Synch +CIDR®

Perform TAI at 72 ± 2 hr after CIDR removal with GnRH at TAI.
Two injections of PG 8 ± 2 hr apart are required for this protocol.

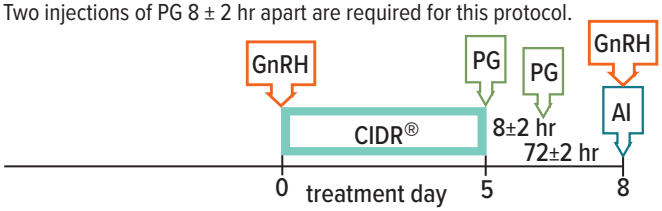


Figure 14. Fixed-time AI protocols for cows. The time interval listed should be considered the average time of insemination (i.e., the time when half of your females have been inseminated). Your starting time should be adjusted according to the number of females being inseminated, amount of labor present, and facilities. Source: Beef Reproduction Task Force.

Cow synchronization protocols

Bos Indicus PG 5-day + CIDR®

Perform TAI at 66 ± 2 hr after CIDR removal with GnRH at TAI.

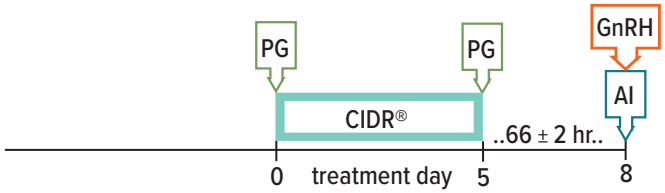


Figure 15. Fixed-time AI protocol for Bos indicus cows. The time interval listed should be considered the average time of insemination (i.e., the time when half of your females have been inseminated). Your starting time should be adjusted according to the number of females being inseminated, amount of labor present, and facilities. Source: Beef Reproduction Task Force.

Considerations before implementing an estrous synchronization protocol

Reproduction is not a vital physiological process, so animals that are undernourished are less fertile and estrous synchronization (with natural mating or AI) will be less successful. Females will also be administered hormones at the same time so it is necessary to have holding and handling facilities that can accommodate the number of animals that are being synchronized. If facilities are a bit too small and access to labor allows it, consider forming groups of animals and staggering their synchronization schedules so they will not all need to be worked at once. This can be especially useful if artificial insemination is used. Smaller groups ensure that all females will be inseminated within the allotted timeframe.

If using a heat detection and timed-AI protocol, effective heat detection is necessary to optimize success. Detailed information on heat detection can be found in LSU AgCenter Publication 3827 Standing estrus (heat) and heat detection aids in cattle.

Proper planning also ensures successful implementation of estrous synchronization programs. The injected hormones require a veterinary prescription in order to purchase, so it is necessary to discuss your plans with your veterinarian prior to purchase. Calculate the amount of hormone needed to ensure that the proper number of vials are ordered and check the expiration date on any hormones already on-hand before incorporating those doses into your count. Read label instructions of all hormones and be sure to store them accordingly as some hormones require refrigeration. Additionally, ensure that there are an adequate number of needles and syringes. If AI will be used with estrous synchronization, check that there is a correct number of semen straws from the desired bull(s), as well as any AI necessities (shoulder length sleeves, AI rod sheaths, paper towels, etc.).

Summary

Estrous synchronization, even without the use of AI, can be beneficial to a cattle operation. There are a variety of protocols with varying degrees of involvement and cost that suit a number of different operations and management considerations. Proper planning will ensure successful implementation of an estrous synchronization program.

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