SDSU Extension

BEEF

Chapter 24

The Estrous Cycle and Understanding Synchronization

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Chapter 24:

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Introduction

The percentage of cows exposed to bulls or artificially inseminated that become pregnant during a breeding season has a direct effect on the profitability of a ranch, and a basic understanding of the bovine estrous cycle can increase the effectiveness of many reproductive management practices. After heifers reach puberty (first ovulation) or following the postpartum anestrous period (a period of no estrous cycles) in cows, a period of estrous cycling begins. Estrous cycles give a heifer or cow a chance to become pregnant about every 21 days. During each estrous cycle, follicles develop in wave-like patterns, which are controlled by changes in hormone concentrations. In addition, the corpus luteum (CL) develops following ovulation of a dominant follicle and inhibits other follicles from ovulating while it is present. The length of each estrous cycle is measured by the number of days between each standing estrus.

The Anestrous Period

Anestrus occurs when an animal does not exhibit normal estrous cycles. This occurs in heifers before they reach puberty and in cows following parturition (calving). During an anestrous period, normal follicular waves occur, but standing estrus and ovulation do not occur. Therefore, during the anestrous period heifers/cows cannot become pregnant.

Standing Estrus and Ovulation

Standing estrus, also referred to as standing heat, is the most visual sign of each estrous cycle. It is the period of time when a female is sexually receptive. Estrus in cattle usually last about 15 hours but can range from less than 6 hours to close to 24 hours. In cattle, the period of time when a female will stand and allow mounting by other animals (Figure 1) is the sexually receptive period.

Females enter standing estrus gradually. Prior to standing estrus a cow may appear more nervous and restless (for example, walking a fence line in search of a bull or bawling more than usual). Prior to standing to be mounted by a bull or other cows, a cow will usually try to mount other animals.

Key Points

- Several hormones control the bovine estrous cycle.
- The first day of the estrous cycle is when standing estrus is observed.
- A normal estrous cycle has two or three follicular waves and one Corpus Luteum.
- Estrous synchronization utilizes hormones that occur in the body naturally to control both follicle waves and luteal regression to have resulting in cows exhibiting standing estrus at a predicted time.

Figure 1: Standing to be mounted by a bull or another cow is the only conclusive sign that a cow is in standing estrus and ready to be bred.

These signs will progress until standing estrus occurs. Other signs that a cow might be in standing estrus are a roughed up tail-head, a clear mucus discharge from the vagina, and a swollen vulva. However, the only conclusive sign that a cow is in estrus is standing to be mounted by other animals.

Following standing estrus, the dominant follicle that is present will ovulate, releasing the egg it contains. Rupture of the dominant follicle is referred to as ovulation and occurs between 24 and 32 hours after the onset of standing estrus. Following the release of an egg from a dominant follicle the egg will enter the female reproductive tract and be fertilized if the female has been mated.

Following each standing estrus, a new estrous cycle will be initiated. In a normal cycling animal the interval between each standing estrus should be about 21 days (Figure 2), but the range in normal estrous cycle length is from 17 to 24 days. When evaluating reproductive efficiency, it is important to realize that the interval between standing estrus can vary from 17 to 24 days.

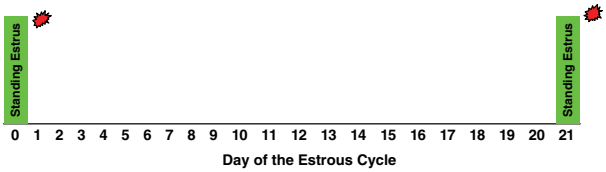

Figure 2: The interval between each standing estrus is about 21 days, but can range from 17 to 24 days. Ovulation occurs between 24 and 32 hours after the initiation of standing estrus (indicated by the red bursts).

The Corpus Luteum

Following ovulation, the different cells that make up the ovulatory follicle change function and become luteal cells that form the corpus luteum (CL). The CL is the main structure on the ovaries during the estrous cycle. The primary purpose of the CL is to produce progesterone, a hormone that regulates several physiological functions. Progesterone prepares the uterus for pregnancy, maintains the pregnancy if fertilization occurs, and also inhibits the cows from showing signs of standing estrus and ovulating. If a cow does not become pregnant, concentrations of progesterone will begin to decrease around day 17 of the estrous cycle. This allows the cow to show standing estrus again around day 21 (Figure 3).

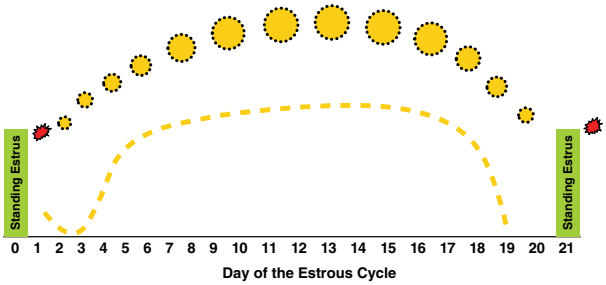

Figure 3: Demonstrates the growth and regression of the CL during the estrous cycle along with the changes in concentration of progesterone that occur. Following ovulation cells from the ovulatory follicle change function and become luteal cells forming the CL (indicated by the yellow circles). Concentrations of progesterone increase following the growth of the CL, and decrease with the regression of the CL (indicated by the yellow dotted line).

Follicular Waves

In cattle, follicles develop in wave like patterns, and follicular waves can be detected during most reproductive states including the prepubertal period in heifers, during estrous cycles, pregnancy (except the last 30 days), and even during the anestrous postpartum period. Following each ovulation, a new follicular wave is initiated. Several follicles are recruited from a pool of small growing follicles on the ovary and initiate a new follicular wave. Following recruitment of these follicles, a follicle is then selected to continue to grow. This selected follicle then becomes the dominant follicle and inhibits the growth of any other follicles. In the absence of progesterone, the dominant follicle will become the ovulatory follicle and will ovulate following standing estrus. In the presence of

progesterone the dominant follicle will not ovulate, but will undergo atresia (cell death), and a new follicular wave will be initiated. Cattle usually have 2 or 3 follicular waves during each estrous cycle (Figure 4).

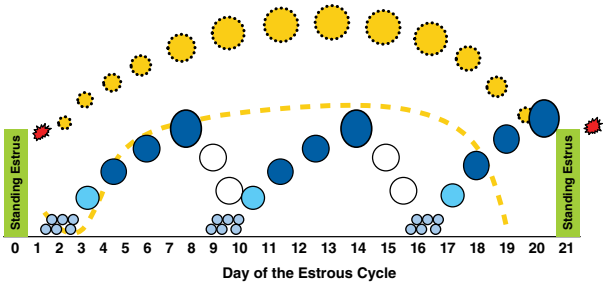

Figure 4: Demonstrates 3 follicular waves occuring during the estrous cycle along with the growth and regression of the CL and the changes in concentration of progesterone. A group of follicles is recruited from the growing pool of follicles on each ovary (indicated by the group of small light blue circles). A follicle from this recruited group is then selected to continue to grow (indicated by the medium light blue circles). Finally this follicle becomes the dominant follicle (indicated by the dark blue circles). The dominant follicle that is present after circulating concentrations of progesterone have decreased will become the ovulatory follicle and ovulate following standing estrus.

Hormonal Regulation of the Estrous Cycle

Several hormones regulate the bovine estrous cycle (Table 1). Changes in the concentrations of these different hormones regulate the recruitment and growth of the follicular waves, the timing of ovulation, and the length of the estrous cycle (Figure 5).

Regulation of Follicular Waves: Following ovulation, circulating concentrations of Follicle Stimulating Hormone (FSH) increase. This increase in FSH causes the recruitment of a group (cohort) of follicles at the beginning of each follicular wave. After the group (cohort) of follicles has been recruited, circulating concentrations of FSH decrease. Beginning around the time of selection, the continued growth and development of the selected follicle is regulated by Luteinizing Hormone (LH). Luteinizing hormone also regulates the growth and development of the dominant follicle. While a dominant follicle is present, circulating

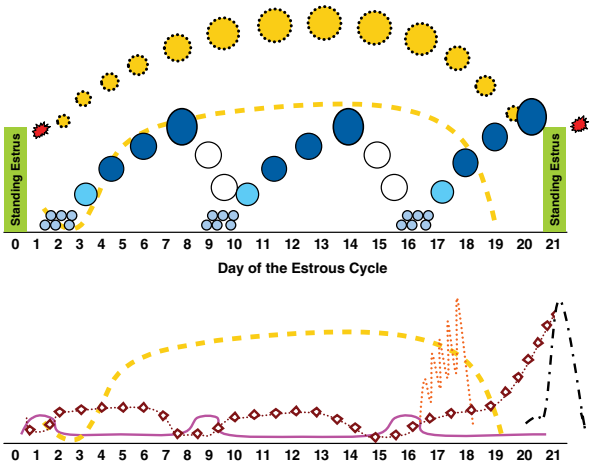

Figure 5: Demonstrates the changes in concentrations of different hormones that regulate the bovine estrous cycle along with the growth and regression of the CL and 3 follicular waves. While a dominant follicle is present, circulating concentrations of FSH (solid purple line) are low, but following ovulation or atresia of a dominant follicle, circulating concentration of FSH rise and initiate a new follicular wave. As follicles grow they produce increasing concentrations of estradiol, but when progesterone (dotted yellow line) is present, dominant follicles undergo atresia. When progesterone is not present, concentrations of estradiol (dotted and diamond red line) increase with follicle size and induces a surge of LH (dashed single dotted black line), which causes ovulation to occur. When no embryo is present, the uterus releases PG (dotted orange line), resulting in luteolysis and allowing standing estrus to occur within a few days.

Table 1: Hormones that regulate the bovine estrous cycle.

Hormone Name	Abbreviation	Role in the estrous Cycle
Follicle Stimulating Hormone	FSH	Recruitment of the group of small follicles from the pool of growing follicles on each ovary
Luteinizing Hormone	LH	1) Stimulation of the continued growth of follicles following selection 2) A preovulatory surge of LH results in the ovulation of the ovulatory follicle
Progesterone	P4	Inhibits ovulation
Estradiol	E2	Elevated concentrations in the absence of progesterone cause behavioral changes associated with standing estrus and cause the release of a surge of GnRH
Gonadotropin Releasing Hormone	GnRH	Causes the preovulatory surge of LH to occur, resulting in ovulation of an ovulatory follicle
Prostaglandin F_{2a}	PG	Induces the destruction of the CL

concentrations of FSH remain low, which inhibits the initiation of a new follicular wave. However, after a dominant follicle ovulates or undergoes atresia, a rise in circulating concentrations of FSH occurs and a new follicular wave is initiated.

Regulation of Estrous Cycle Length: Maternal recognition of pregnancy occurs around day 15 of the estrous cycle, when the embryo sends a signal to the dam that it is present and developing in the uterus. When a cow does not become pregnant, no signal is received from a developing embryo, and the estrous cycle must be repeated to allow for another opportunity to become pregnant. When maternal recognition of pregnancy does not occur, the uterus releases prostaglandin F_{2a} (PG) to induce luteolysis (luteolysis means destroying the CL). If luteolysis does not occur, the cow will not be able to return to standing estrus, and therefore will not have another opportunity to become pregnant during the breeding season.

Regulation of Ovulation: As follicles grow they produce increasing amounts of estradiol. During the estrous cycle, when progesterone is present, circulating concentrations of estradiol increase and decrease as follicular waves grow and regress. When progesterone is not present, high concentrations of estradiol cause standing estrus and the behavioral changes associated with standing estrus. High concentrations of estradiol, in the absence of progesterone, stimulates the release of a surge of Gonadotropin Releasing Hormone (GnRH). This surge of GnRH results in a surge of LH causing ovulation of the ovulatory follicle.

Understanding Estrous Synchronization of Cattle

Synchronizing estrus is simply manipulating the bovine estrous cycle to cause the majority of cows to show standing estrus around the same time. Because a cow's estrous cycle is 21 days, she only has one chance to become pregnant every 21 days of the breeding season (3 chances during a 66-day breeding season). However, cows that are synchronized to cycle at the start of the breeding season have an additional opportunity (4 chances) to become pregnant during that same 66-day breeding season (Figure 6).

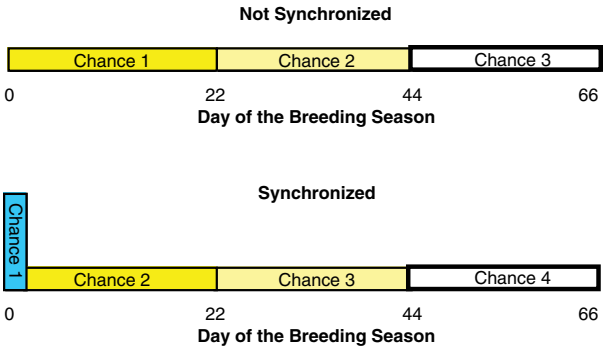

Figure 6: Comparison of the number of chances a nonsynchronized and a synchronized cow has to become pregnant during a 66 day breeding season. Nonsynchronized animals have one chance every 21 days to become pregnant. Animals that are synchronized will show estrus in the first few days of the breeding season and will therefore gain an extra opportunity to become pregnant during a similar length breeding season.

Types of Synchronization Protocols

Successful synchronization of estrus requires control of both the luteal (the time period when a corpus luteum is present on the ovaries) and follicular phases of the estrous cycle. Estrous synchronization protocols can be grouped into four main classes: 1) prostaglandin F_{2a} (PG) based, 2) gonadotropin releasing hormone (GnRH) based, 3) progestin based, and 4) combination.

A. Prostaglandin F_{2a} (PG)-Based Protocols

Prostaglandin F_{2a} (PG) is a naturally occurring hormone that regresses the CL, allowing cows to return to standing estrus. Giving an injection of PG will cause the regression of a CL before it would normally regress on its own. Using PG allows for control of the luteal phase of the estrous cycle.

During the first 5 days of luteal development and during natural CL regression (after day 17 of the estrous cycle), the CL is not responsive to PG. Therefore, PG will only work to regress the CL from days 5 to 17 of the estrous cycle (Figure 7). When an injection of PG is given during the responsive period (days 5 to 17), the CL will regress and cause the animal to exhibit standing estrus 48 to 120 hours after the injection. If an animal does not have a CL present (cows in the postpartum anestrus period or heifers that have not reached puberty), they will not respond to an injection of PG. Therefore, animals must be cycling and be between days 5-17 of the estrous cycle to respond to an injection of PG.

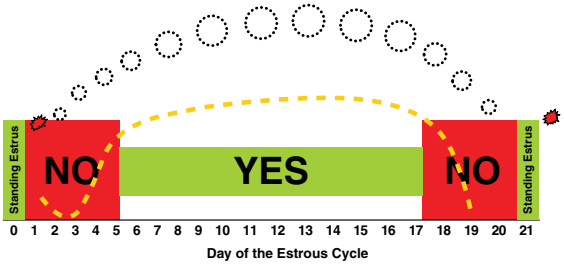

Figure 7: Normal growth and regression of the CL (indicated by the dotted circles) during the estrous cycle along with the changes in concentration of progesterone (yellow dotted line) that occur. From day 0 to 5 and from 17 to 21 (indicated with the NO) the CL will not respond to an injection of PG. From days 5 to 17 (indicated with a YES) the CL will regress following an injection of PG.

B. Gonadotropin Releasing Hormone-Based Protocols

Gonadotropin releasing hormone (GnRH) is a naturally occurring hormone that induces a luteinizing hormone (LH) surge which causes ovulation of the dominant follicle even in the presence of progesterone. During an estrous cycle with 3 follicular waves, there are 3 time periods when a dominant follicle is present and can be induced to ovulate with an injection of GnRH. When a follicular wave is developing and a dominant follicle is not present an injection of GnRH will have no effect (Figure 8). Following the induced ovulation of a dominant follicle by an injection of GnRH, a CL will form and a new follicular wave will be initiated.

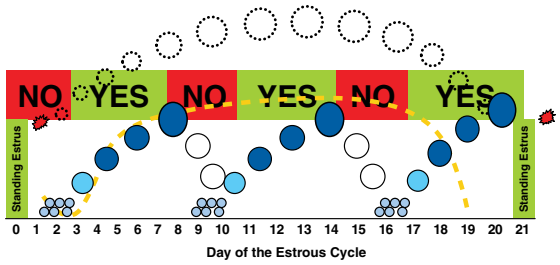

Figure 8: Three follicular waves (indicated by the group of small circles, the medium circles, and the large circles) occurring during the estrous cycle along with the growth and regression of the CL (indicated by the dotted circles) and the changes in concentration of progesterone (yellow dotted line). When a dominant follicle is present, an injection of GnRH is capable of inducing ovulation and initiating a new follicular wave (indicated with a YES). When a follicular wave is developing and a dominant follicle is not present, an injection of GnRH will have no effect (indicated with the NO).

C. Progestin-Based Protocols

Progestins mimic the progesterone produced by the CL and inhibit ovulation. Progestins control the estrous cycle by extending the luteal phase of the cycle. Instead of the animal exhibiting standing estrus and ovulating after natural regression of the CL, the introduced progestin will inhibit ovulation (Figure 9). Following the removal of the progestin, progesterone concentrations will be low and standing estrus and ovulation will occur. However, when a CL regresses and cows are exposed to a progestin to inhibit ovulation of the dominant follicle, the follicle will continue to grow and will become a persistent follicle. Breeding animals at the first estrus after exposure for more than 7 days to a progestin will have decreased fertility, but subsequent ovulations will have normal fertility.

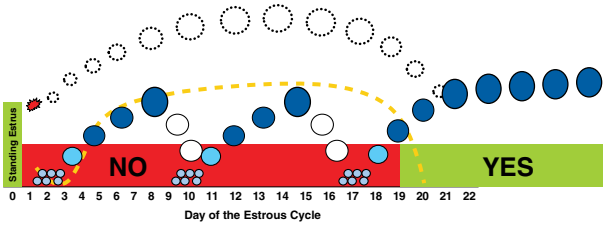

Figure 9: Three follicular waves (indicated by the group of small circles, the medium circles, and the large circles) occurring during the estrous cycle along with the growth and regression of the CL (dotted circles) and the changes in concentration of progesterone (yellow dotted line). While a CL is present and progesterone concentrations are high, a progestin will have no influence, but when a CL regresses and progesterone concentrations are low, a progestin will inhibit standing estrus and ovulation.

D. Combination Protocols

When PG, GnRH, or progestins are used alone, they will only synchronize either the luteal or follicular phases of the estrous cycle. Therefore, most estrous synchronization protocols combine the above methods to control both phases of the estrous cycle.

Summary

Each year a list of recommended synchronization protocols to be used with artificial insemination (AI) is established based on research conducted across the country the previous year. The list of recommended protocols can be found in any current semen catalog or at beefrepro.org/ (protocols).

Estrous synchronization is a very effective method to increase the proportion of animals that are bred at the beginning of the breeding season. By understanding the changes that occur during the bovine estrous cycle, and how the hormones that are available to be used for estrous synchronization affect

the estrous cycle, protocols can be successfully used to increase the number of animals that conceive early in the breeding season. Any one of many estrous synchronization protocols can be used to achieve good synchrony of estrus in your herd. To determine which synchronization protocol will work the best in your operation contact your local cattle reproduction specialist.

For Further Reading

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Adams, G. P. 1999. Comparative patterns of follicular development and selection in ruminants. Journal of Reproduction and Fertility. Supplement 54:17-32.