The Bovine Estrous Cycle

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Introduction

Once a heifer has reached puberty, reproductive cyclicity begins. An estrous cycle starts at standing estrus (sexual receptivity) and ends at the following standing estrus approximately 21 days later, although a cycle can range from 17 to 24 days in length. During this interval, there are dynamic hormonal and ovarian changes occurring that, if successful, will result in pregnancy. An understanding of the estrous cycle can improve reproductive management of the herd and increase profitability.

Onset of cyclicity

When a heifer reaches puberty varies widely, from 6 to 24 months, but typically occurs by 11 to 12 months of age in *Bos taurus* breeds and around 18 months for *Bos indicus* breeds. Proportion of body weight is a much more accurate predictor of onset of cyclicity, regardless of breed, with heifers reaching puberty at 55% to 60% of their mature size.

Hormonal and ovarian activity during estrous cycle

There are two dominant structures of the ovary — the follicle which houses the oocyte, or egg, and the corpus luteum. These structures, and other organs in the body, secrete a variety of hormones (Table 1) that are responsible for the dynamic changes that occur within the ovary during the estrous cycle.

Hormone	Effect
Progesterone (P)	Prevents ovulation and prepares the uterus for pregnancy.
Prostaglandin (PGF)	Produced by the uterus to destroy the corpus luteum (CL) and begin a new cycle.
Follicle-stimulating hormone (FSH)	Recruits a group of small follicles to grow.
Luteinizing hormone (LH)	1. Supports the growth of the dominant follicle of each follicular wave. 2. LH surges and results in ovulation of the dominant follicle.
Estradiol (E)	Produced by the dominant follicle. When progesterone is low, estradiol promotes the female to exhibit signs of estrus.

Table 1. The major hormones that regulate the estrous cycle in cattle.

Standing estrus (heat) and ovulation

A female standing to be mounted is the definitive sign of sexual receptivity and marks the start of the estrous cycle, which can range 17 to 24 days in length. Approximately 24 to 32 hours after standing estrus, the preovulatory follicle will rupture and release the oocyte (Figure 1). That oocyte will travel down the oviduct (called the fallopian tube in women) where it will, ideally, be fertilized. The membrane of the dominant follicle remains on the ovary but transforms into a functionally different structure known as the corpus luteum (CL).

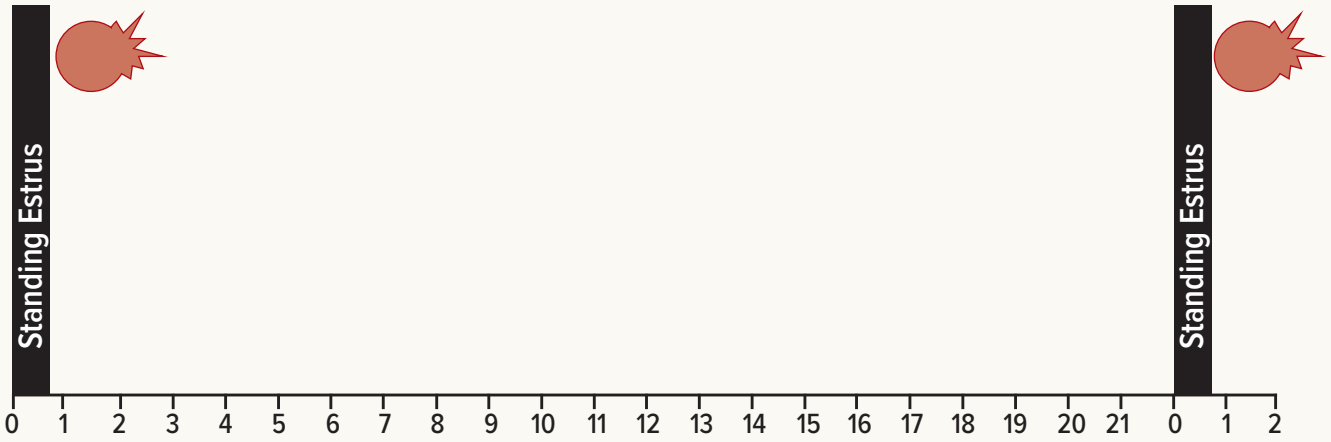

Figure 1. An estrous cycle begins at standing estrus and ends approximately 21 days later at the onset of the following standing estrus. The dominant follicle ruptures 24 to 32 hours after the onset of standing estrus (ruptured dark pink circle) and releases the oocyte (egg) into the reproductive tract to be fertilized.

Corpus luteum

The corpus luteum forms from the remnants of the follicular wall and becomes fully functional around Day 5 of the estrous cycle (Day 0 is the onset of standing estrus) although it continues to increase in size and function until midcycle. Its purpose is to produce the hormone progesterone (P). Progesterone inhibits ovulation and prepares the uterus to sustain a pregnancy should fertilization of the oocyte occur. If fertilization does not occur, the uterus produces prostaglandin $F_{2\alpha}$ (PGF), a hormone that destroys the CL (termed luteolysis) around Day 17, which decreases progesterone (Figure 2). The fall in progesterone allows the preovulatory follicle to continue to grow and produce estradiol (E) which induces the female to enter into standing estrus which marks the start of another cycle (Figure 3).

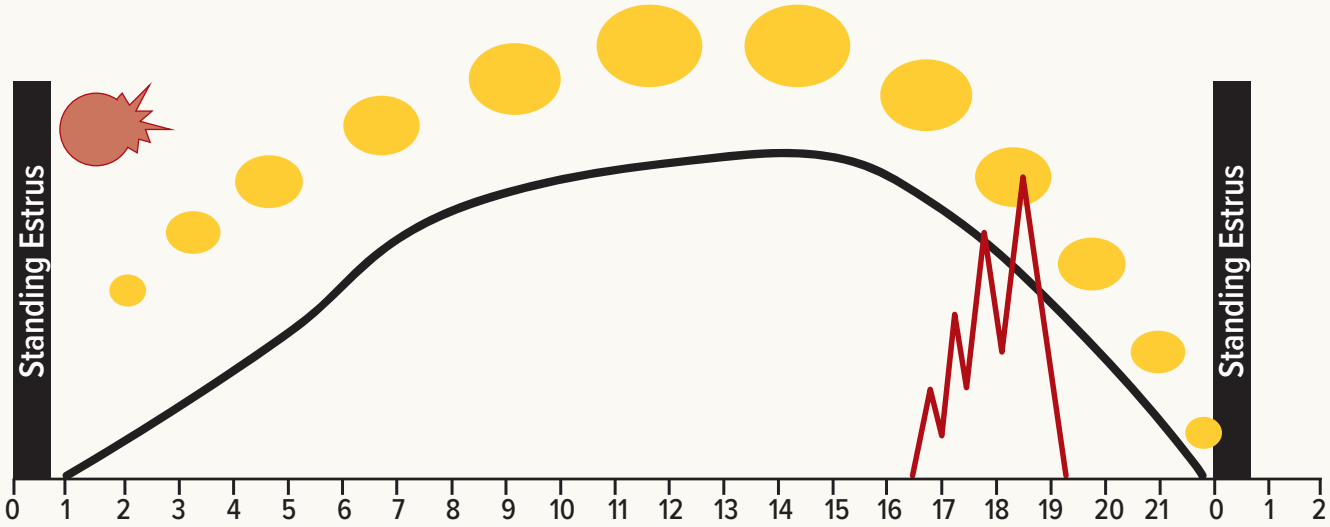

Figure 2. The follicular wall quickly transforms into the corpus luteum (yellow circle) and secretes **progesterone (black line)**, to inhibit ovulation of any more follicles and prepare the uterus for pregnancy. If the female is not pregnant, the uterus secretes **prostaglandin $F_{2\alpha}$ (red line)**, to destroy the CL and allow the next cycle to begin.

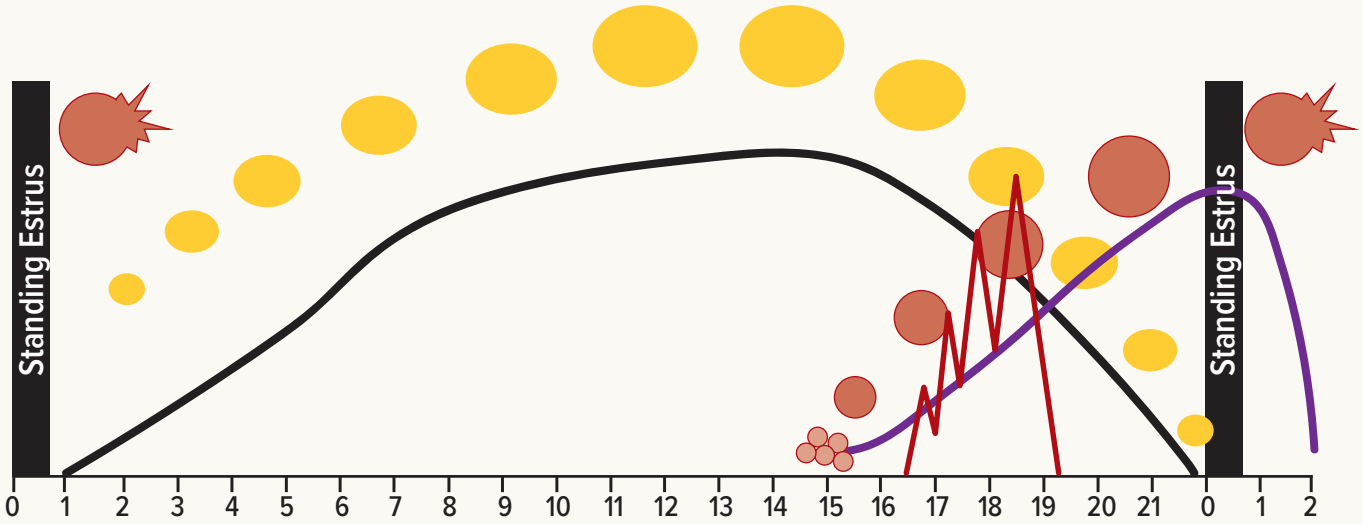

Figure 3. If the female is not pregnant, the uterus secretes **prostaglandin $F_{2\alpha}$ (red line)**, to destroy the CL (yellow circle) and decrease the concentration of **progesterone (black line)**. The decrease in progesterone allows the dominant follicle of the last wave (ovulatory wave; dark pink circle) to continue growing and producing **estradiol (purple line)**, the hormone responsible for estrus behavior.

Follicular development

The estrous cycle is approximately 21 days in length, but it does not take that long for a follicle to grow and develop. During an estrous cycle, two or three waves of follicles develop, but only the dominant follicle of the last wave of the cycle ovulates (Figure 4). Progesterone secreted by the CL prevents the dominant follicles from ovulating. Instead, they undergo atresia (cell death) allowing the next follicular wave to begin. The fall in progesterone allows the dominant follicle to continue to grow and eventually ovulate 24 to 32 hours after the start of the next estrous cycle (Figure 5).

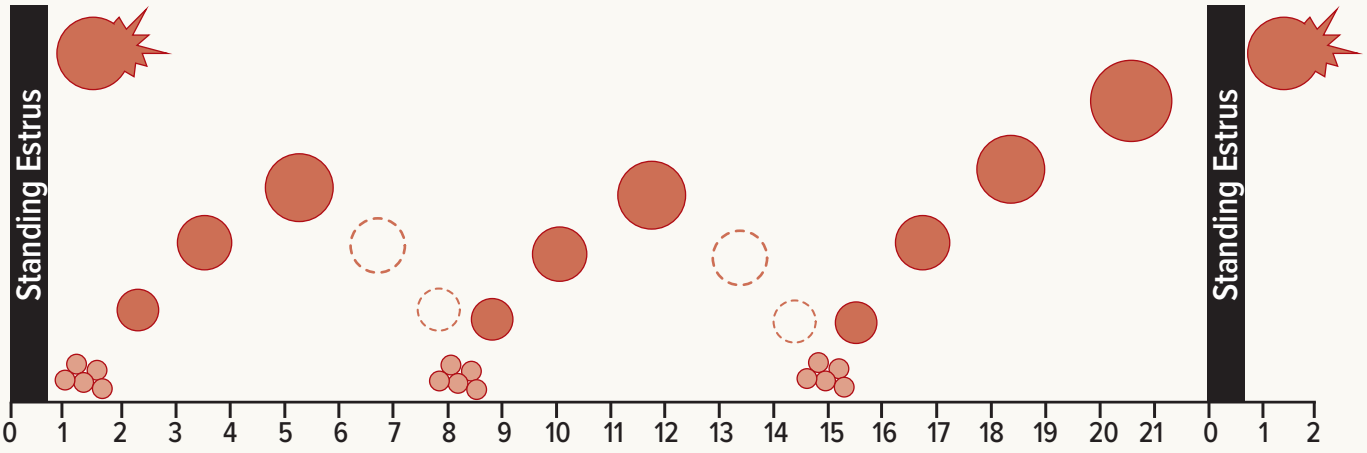

Figure 4. Follicles grow throughout the estrous cycle in patterns known as waves. Each wave begins with a group of small follicles (small, light pink circles). From that group, one is selected to continue growing and become dominant (darker pink circle). Depicted is an estrous cycle with three waves of follicular development. Females can also exhibit two- and four-wave patterns of follicular development.

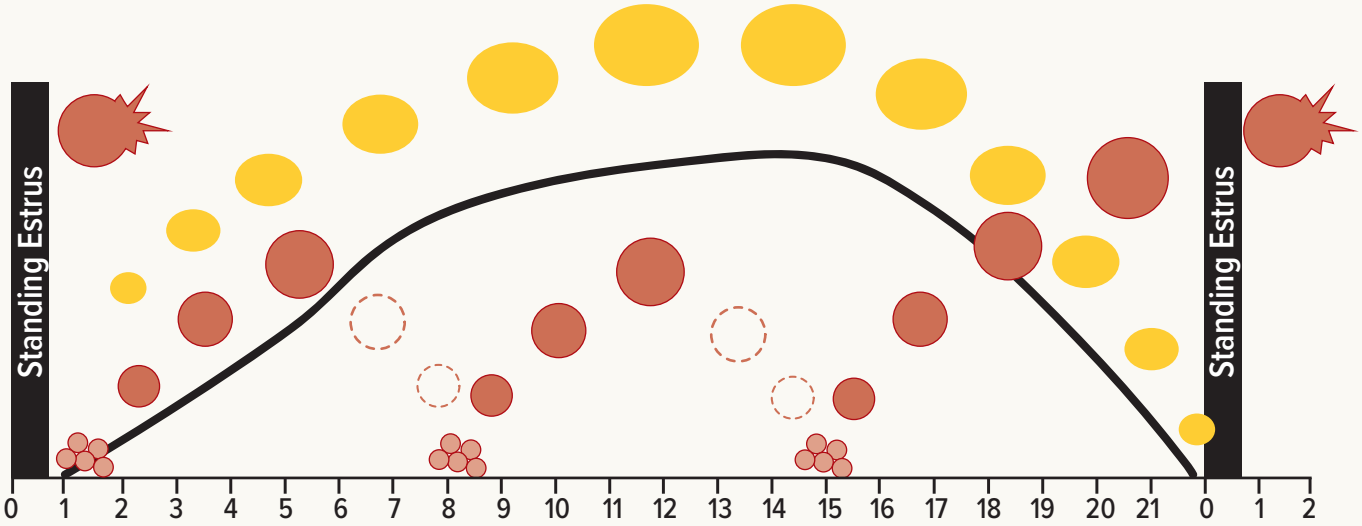

Figure 5. Follicles grow throughout the estrous cycle in patterns known as waves. Each wave begins with a group of small follicles (small, light pink circles). From that group, one is selected to continue growing and become dominant (darker pink circle). The production of **progesterone (black line)** by the CL (yellow circle) prevents the dominant follicle from ovulating so it undergoes cell death (dashed circle), and another group of small follicles is selected to begin growing. The dominant follicle that is growing at the time when the CL is destroyed continues to grow and will ovulate at the start of the next estrous cycle.

Hormonal control of follicular waves

Follicle-stimulating hormone (FSH) is produced in the absence of a dominant follicle (after ovulation or death of the dominant follicles) and recruits a group of small follicles to begin growing (Figure 6). Several days later, a single follicle that is able to respond to the secretion of luteinizing hormone (LH) is selected to continue growing, becoming the dominant follicle capable of producing estradiol (Figure 7). If that dominant follicle reaches a preovulatory size in the presence of a CL it will die off, FSH will be produced, and another group of small follicles will be recruited to grow. Near the end of the cycle, when the CL is destroyed and progesterone falls, the dominant follicle is stimulated by LH to produce more estradiol. The increase in estradiol causes more LH to be released and this pattern continues until the concentration of LH is great enough to induce ovulation of the dominant follicle (Figure 8).

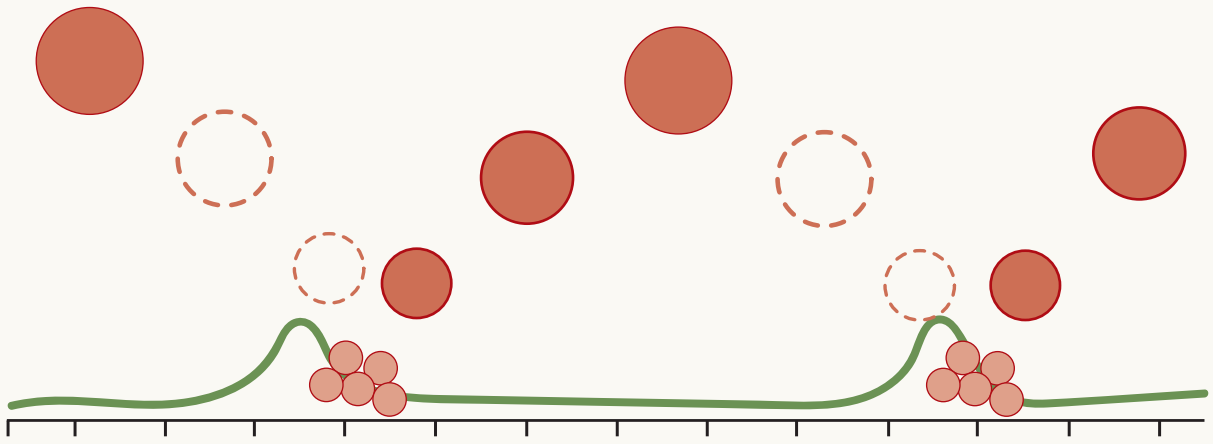

Figure 6. An increase in **follicle-stimulating hormone (green line)** results in a small group of follicles (small, light pink circles) to begin growing.

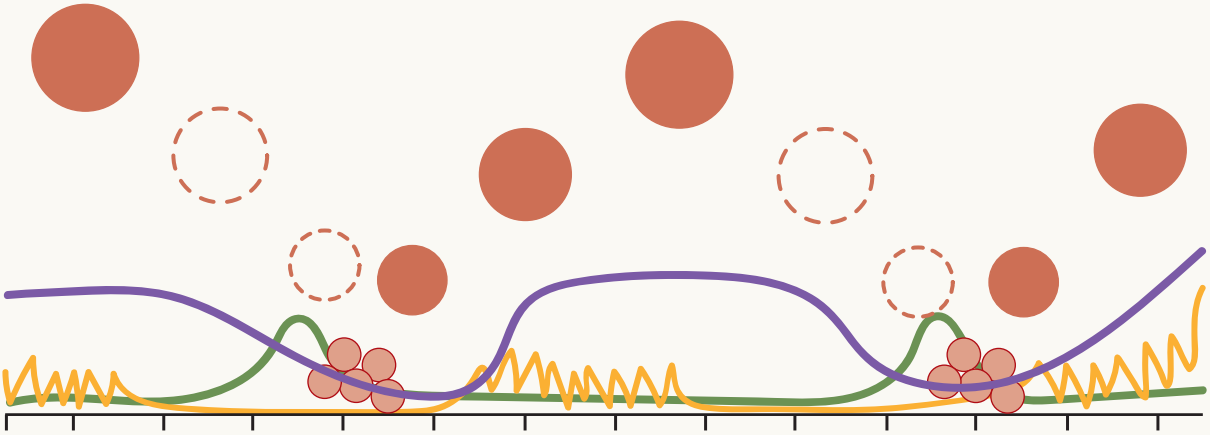

Figure 7. Follicle-stimulating hormone (green line) recruits a small group of follicles (small, light pink circles) to begin growing. The follicle capable of responding to the secretion of **luteinizing hormone (orange line)** continues growing and becomes the dominant follicle (dark pink circle) capable of producing **estradiol (purple line)**.

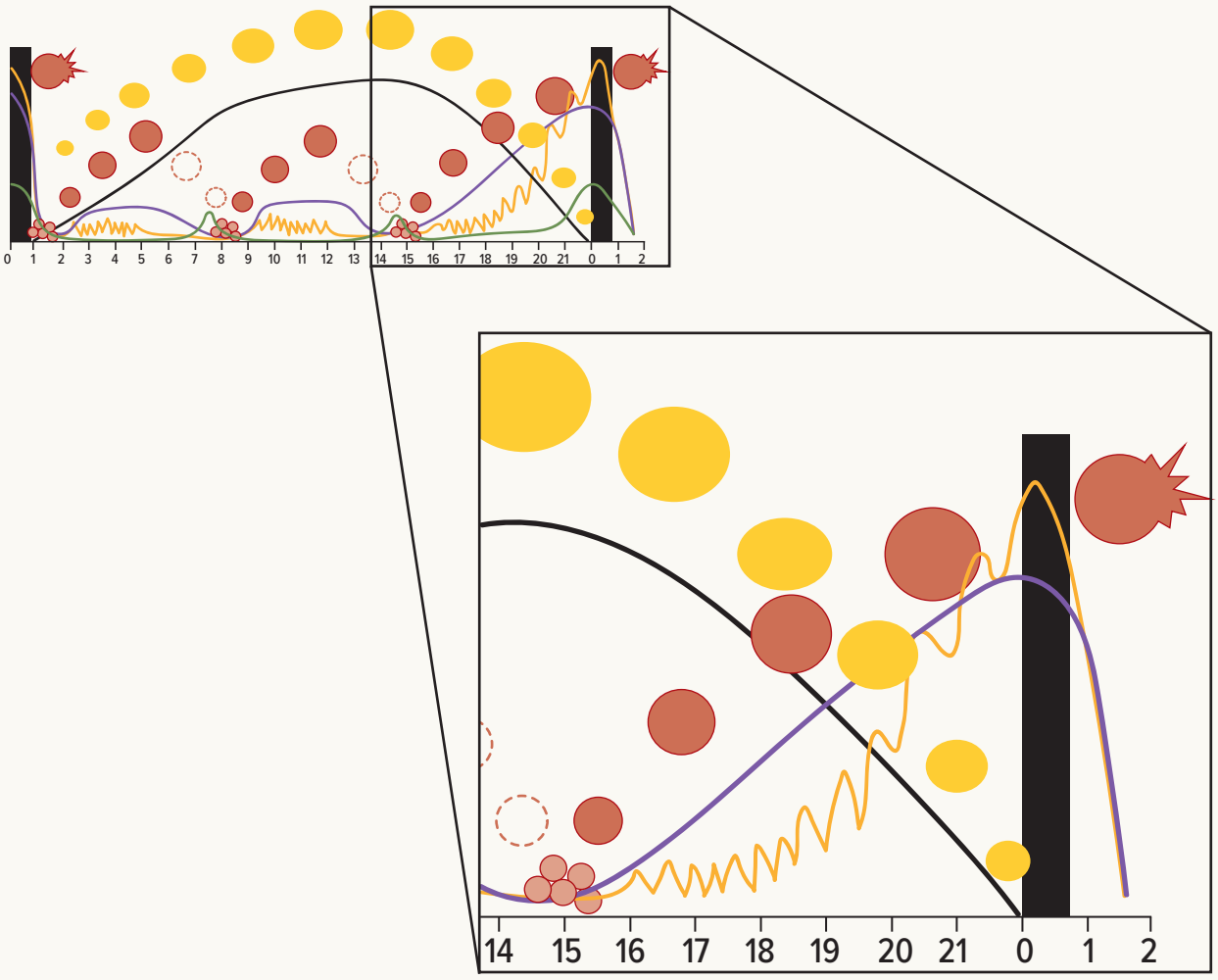

Figure 8. When the CL is destroyed and progesterone declines, **luteinizing hormone (orange line)** increases which stimulates the dominant follicle to produce more **estradiol (purple line)**. This cycle continues until a surge of luteinizing hormone is released that induces ovulation of the dominant follicle.

Interruptions to Cyclicity

The dynamic structural and hormonal activity throughout the estrous cycle is depicted in its entirety in Figure 9. Once a female reaches sexual maturity and begins cycling, she will continue to cycle throughout most of her life. There are normal interruptions to cyclicity (termed anestrous periods) that occur during pregnancy and lactation (postpartum), however a female can also stop cycling (or have the onset of cyclicity delayed) if their nutritional needs are not being met, if they are under excessive amounts of stress, have an injury or infection of the reproductive tract, or an inadequate production of hormones.

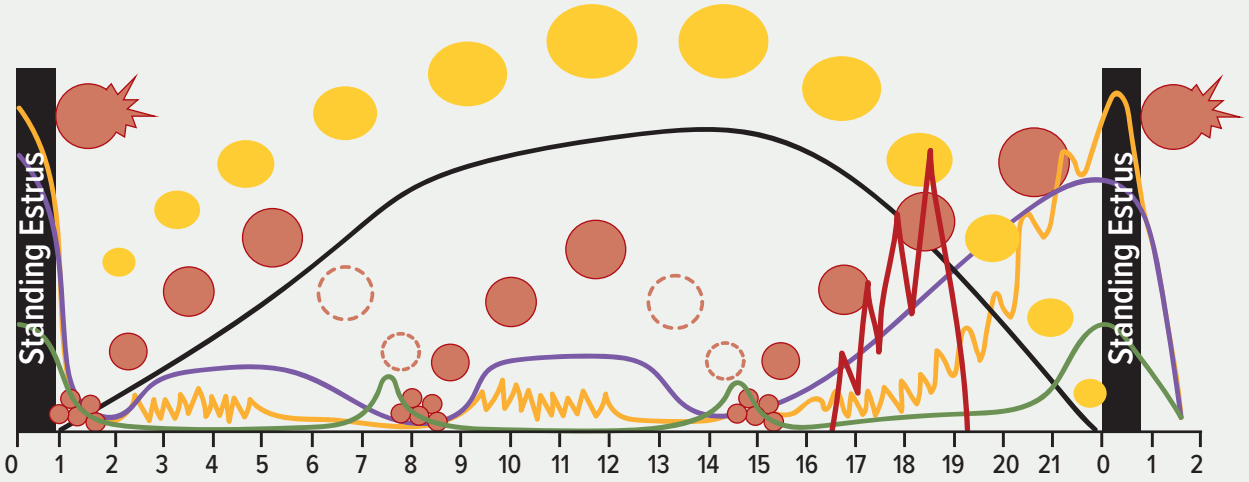

Figure 9. The hormonal and ovarian activity during the bovine estrous cycle. The dominant follicle produces an abundance of **estradiol (purple line)** which results in standing estrus and a surge in **luteinizing hormone (orange line)** and ovulation of the dominant follicle 24 to 32 hours later (ruptured 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 $F_{2\alpha}$ (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.

Summary

An understanding of the estrous cycle and its normal interruptions allows for more effective management of a breeding herd. Knowledge of the reproductive hormones and their effect is also beneficial when estrous synchronization is being used. Information on estrous synchronization and methods of heat detection are available in LSU AgCenter Publications P3866 Synchronization of Estrus in Cattle and P3827 Standing Estrus (Heat) and Heat Detection Aids in Cattle.

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