REPRO TRACKS

by Cliff Lamb, Texas A&M University

Understanding Hormonal Patterns

Over the years, we have written multiple articles and reports on how to best manipulate the estrus cycle of cattle, but have not focused on the hormonal patterns that allow us to use various products in combination to actually ensure that a female comes into estrus. Therefore, we will focus on the hormonal patterns during the estrus cycle.

The estrus cycle is divided into three stages: follicular phase, estrus and luteal phase. It is regulated by hormones secreted by the hypothalamus (GnRH), anterior pituitary gland (follicle stimulating hormone [FSH] and luteinizing hormone [LH]), ovary (estradiol and progesterone), and uterus (prostaglandin F2α [PGF2α]). These hormones serve as chemical messengers that travel in the blood to target tissues which contain receptors that are hormone specific and regulate the phases of the estrus cycle.

The combination of hormone secretion and metabolism (liver, kidneys and lungs) maintains the correct hormonal balance during the follicular phase, estrus and luteal phase of the cycle. Table 1 provides a list of hormones, their biological functions, and action as a reference.

Follicular phase

The follicular phase (proestrus) begins with the initiation of corpus luteum regression (luteolysis) and ends with the onset of estrus. Luteolysis is accompanied by a rapid decrease in progesterone, resulting in a decrease in the negative feedback on pituitary LH secretion. As circulating concentrations of progesterone decrease, LH pulse frequency increases followed by a rapid increase in follicular estradiol secretion.

The production of follicular estradiol results from the coordinated actions of LH and FSH on theca and granulosa cells of the follicle. As a result, there is an increase in circulating concentrations of estradiol that initiates estrus behavior and induces surge in LH.

The bovine estrus cycle usually consists of two to three follicular waves, and each wave begins with the recruitment of a cohort of antral follicles from a pool of growing small follicles. One follicle is subsequently selected from this cohort for continued growth and becomes dominant. The remaining follicles in the cohort become atretic.

The estrus cycle length of cows that have three follicular waves is generally longer (20-24 days) compared to cows with two follicular waves (18-20 days).

Estrus phase

Increasing circulating concentrations of estradiol following luteolysis initiates estrus behavior, increases uterine contractions (to facilitate sperm transport), and induces the preovulatory gonadotropin surge.

That surge coordinates the following events that are critical to the establishment of pregnancy: resumption of meiosis within the oocyte, follicular rupture, and luteinization of follicular cells. LH is generally considered the primary gonadotropin that controls the preceding events; however, FSH also causes ovulation and luteal tissue formation. The end of the estrus phase of the cycle is marked by follicular rupture or ovulation.

Luteal phase

The luteal phase spans the time of corpus luteum formation and maintenance, which begins with ovulation and ends with luteolysis.

Progesterone is the primary secretory product of the corpus luteum and is regulated by secretions

Table 1: ***Reproductive hormones, the endocrine gland from which they originate, and their functions during the estrus cycle.***

Hormone	Endocrine gland	Function of hormone	Biological action in estrus synchronization
Progesterone	Corpus luteum	Inhibit estrus Inhibit ovulation Prepares animal for pregnancy Maintenance of pregnancy	Inhibit estrus Inhibit ovulation Induce cyclicity Dominant follicle turnover
Prostaglandin F2a	Uterus	Induce luteal regression	Induce premature regression
Gonadotropin releasing hormone (GnRH)	Hypothalamus	Controls secretion of LH Induces gonadotropin surge	Synchronize follicle wave Induce ovulation
Follicle stimulating hormone (FSH)	Anterior pituitary gland	Initiation of a follicular wave	Superovulation
Luteinizing hormone (LH)	Anterior pituitary gland	Stimulated by GnRH Induction of ovulation Oocyte maturation Luteal tissue formation	Synchronize follicular wave Induction of ovulation
Estradiol	Ovarian follicle	Estrus behavior Induction of gonadotropin surge Sperm transport	Dominant follicle turnover Estrus behavior

Adapted from Smith et al., 2018

of the anterior pituitary, uterus, ovary, and embryo. In cattle, PGF2α is the uterine luteolysin (causes death to the corpus luteum) and is commonly used to synchronize estrus in cattle.

In the absence of an embryo, the uterine concentrations of PGF2α increase during the late luteal phase and PGF2α is secreted and pulses into the uterine veins on days 17 to 20 following estrus.

In the presence of an embryo, pulsatile secretion of PGF2α is reduced and the corpus luteum does not regress. Maintenance of high circulating concentrations of progesterone in pregnant animals prevents the expression of estrus and ovulation.

In general, understanding how these various hormones and glands communicate will provide some valuable information when using products to synchronize estrus for artificial insemination (AI). Hopefully the information presented in Table 1 will serve as a useful reference guide. AJ

Editor's note: Cliff Lamb is the animal science department head and a professor at Texas A&M University in College Station, Texas.