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G80-537-A

NebGuide

Published by Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln

Reproductive Tract Anatomy and Physiology of the Cow[1]

Knowledge of basic reproduction will help a producer to obtain higher conception rates when using estrous synchronization and/or artificial insemination.

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The reproductive performance of a cow herd has a great influence on the income and profit realized. A good understanding of the anatomy and physiology of the cow's reproductive system is, therefore, beneficial for successful management. Knowledge of basic reproduction will help a producer to obtain higher conception rates when using estrous synchronization and/or artificial insemination. It will also allow for a better understanding of pregnancy examinations, reproductive diseases and calving difficulty problems.

Anatomy

A diagrammatic sketch of the reproductive tract of the cow is shown in *Figure I*. The female reproductive tracts of the various farm animals have similar parts to those shown for the cow, but differ primarily in the shape of the uterus.

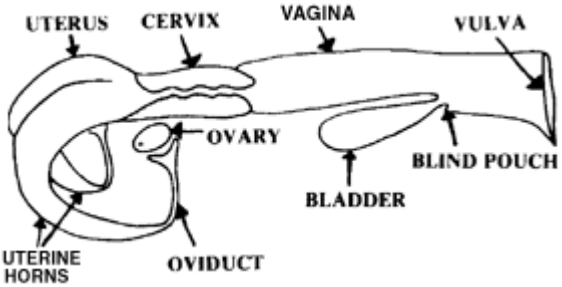

Figure 1. Diagrammatic sketch of the reproductive tract of the cow.

The *ovary* is the primary reproductive organ of the female and has two important functions: 1) production of the female reproductive cell, the egg or ovum, and 2) production of two hormones, estrogen and progesterone. Each of the cow's two ovaries are oval to bean-shaped organs 1 to 1 1/2 inches long, located in the abdominal cavity.

The secondary sex organs are, in effect, a series of tubes which receive the semen of the male, transport the sperm to the egg so it can be fertilized, nourish the fertilized egg (embryo), and expel the offspring. These organs include the vagina, cervix, uterus, uterine horns, and oviducts (also called Fallopian tubes) which have a funnel shaped opening called the infundibulum.

The ovary produces the egg by a process called *oogenesis*. In contrast to spermatogenesis in the bull which is continuous, oogenesis is cyclic. This cycle, (called the estrous cycle), is of a characteristic length, depending on the species, and consists of a definite sequence of events, both of physiological and of behavioral nature.

The ovary contains several thousand tiny structures, called *primary follicles*, which consist of a germ cell surrounded by a layer of cells. This germ cell has the potential to mature into an egg if the follicle completes development. However, most of the primary follicles never complete development, but rather die, are absorbed by the ovary and replaced by newly formed primarily follicles.

The relatively few primary follicles which complete development do so through a series of phases. Many layers of cells are added to the single layer of cells surrounding the egg in the primary follicle, and a central cavity forms. As the follicle and the cavity grow larger, the egg is attached by a stalk of cells to the back side of the follicle opposite the site of ovulation. As the follicle continues to grow rapidly, the side opposite the egg bulges from the surface of the ovary and becomes very thin. This follicle is then mature and called a Graafian follicle. The thin portion ruptures at ovulation to release the contents of the follicle, including the egg.

Following ovulation, the cells that developed within the follicle differentiate to form the *corpus luteum*, which has the very important function of producing progesterone.

The released egg is caught by the *infundibulum* and moves into the *oviduct* where fertilization occurs if viable sperm are present. The egg remains capable of fertilization for only a few hours; thus, it is very important that fertile sperm be present near the time of ovulation. The egg moves through the oviduct into the uterine horn within the next 3 to 4 days. If it is fertilized, it begins embryological development; if not, it degenerates and disappears.

The body of the uterus of the cow, as well as that of the ewe and sow, is short and poorly developed while the *uterine horns* are relatively long and well developed. The embryo develops in the uterine horns in these species. In the mare the uterine horns are poorly developed and embryological development occurs in the body of the uterus. Wherever it occurs, the fetus develops within a layer of membranes called the *placenta*, through which nourishment from the mother diffuses since there is no direct blood connection between fetus and mother.

The *cervix* is, in effect, the neck of the uterus. It has thick walls and a small opening that is difficult to penetrate in the cow because of overlapping or interlocking folds. It serves as a passageway for sperm deposited in the vagina and for the fetus at the time of birth. During pregnancy it is usually filled with a thick secretion which serves as a plug to protect the uterus from infection entering from the vagina. The *vagina* serves as the receptacle for the male's penis during service. In the cow, the semen is deposited in the vagina near the cervix, although in some species the cervix may be penetrated. The urinary bladder

opens to the exterior through the urethra which opens into the vagina. This region of the cow's vagina is restricted in size because of sphincter muscles associated with the urethral opening. The region behind the external urethral orifice is called the vestibule and is a common passageway for both the urinary and the reproductive systems. The external opening of the vagina is called the vulva.

Hormonal Regulation of the Female Reproductive Tract

Normal reproduction in the female depends upon hormones--specific chemical substances produced by specialized glands called endocrine glands. These secretions pass into the body fluids (blood and lymph) and are transported to various parts of the body where they produce several specific effects.

The female hormone, *estrogen*, is produced by the Graafian follicle. A second ovarian hormone, *progesterone*, is produced by the corpus luteum. Each has an important role in the female reproductive process.

Estrogen has varied effects: 1) the development and functioning of the secondary sex organs, 2) the onset of heat, or *estrus*, the period of sexual receptivity, 3) it affects rate and type of growth, especially the deposition of fat, and 4) it primes or prepares the prepuberal heifer and post-partum cow for onset of sexual activity.

Progesterone, the hormone of pregnancy, suppresses the further development of follicles and secretion of estrogen. The female does not come into heat while progesterone is being produced. It is also necessary for preparing the uterus to receive the fertilized egg, and maintains the proper uterine environment for the continuation of pregnancy.

Estrogen and progesterone are not completely separate in their effects since both are necessary for complete development of some important organs. The development of the uterus is initiated by estrogen and completed by progesterone. The fertilized egg will not implant and survive in the uterus unless that tissue has been properly prepared by the action of estrogen and then by that of progesterone. Estrogen causes rhythmic contractions of the uterus. Progesterone, on the other hand, has a quieting effect on the uterus so there are no contractions which might disturb pregnancy.

Complete development of the mammary gland also depends upon both hormones. Estrogen promotes the growth of the duct system and progesterone is necessary for the development of the clusters of milk-secreting alveoli on the ducts.

Thus, it can be seen in general that estrogen makes things happen and progesterone calms them down.

The production of the ovarian hormones is under the direct influence of the *gonadotrophic hormones* produced by the anterior pituitary gland which is located at the base of the brain. The names *follicle stimulating hormone* (FSH) and *lutenizing hormone* (LH) were given because of the effects of these hormones on the female. FSH stimulates the growth, development and function of the follicle, while LH causes the rupture of the follicle and development of the corpus luteum.

The Estrous Cycle

The reproductive cycle of the cow consists of a series of events which occur in a definite order over a period of days. In the cow, this cycle averages 21 days in length (range is 17 to 24 days) and is concerned with preparing the reproductive tract for *estrus* or heat (the period of sexual receptivity) and *ovulation* (the release of the egg). *Figures 2* and *3* show the ovarian changes and sequence of events in a

typical 21-day cycle in which pregnancy does not occur.

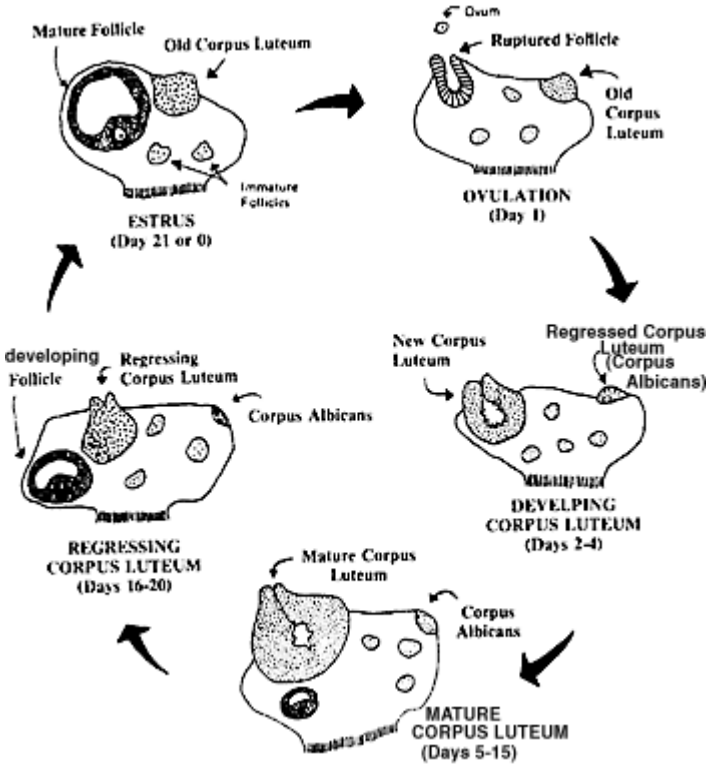

Figure 2. The ovarian changes during a typical 21-day estrous cycle in which pregnancy does not occur. Note that the development and regression of the corpus luteum and of the follicles are continuous processes.

Days 0-1. The cow is in for estrus (standing heat) on *Day 0* for an average of 18 hours (range 12 to 24 hours). Approximately 12 hours after the end of the standing heat, the mature Graafian follicle ruptures (ovulates) in response to a surge of LH released by the pituitary gland.

Days 1-2. The cells that formerly lined the follicle change and become the lutein cells of the corpus luteum. This change in cell form is caused by hormonal action, primarily that of LH.

Days 2-5. The corpus luteum grows rapidly in both size and function. Numerous follicles may be seen on the ovary at this stage, but by *Day 5* they have begun to regress.

Days 5-16. The corpus luteum continues to develop and reaches its maximum growth and function about *Day 10*. It secretes the hormone progesterone which inhibits (blocks) LH release by the pituitary gland. During this period, the ovaries are relatively inactive except for the functional corpus luteum. No follicles reach maturity and/or ovulate because of the existence of the high levels of progesterone.

Days 16-18. The corpus luteum regresses rapidly due to some luteolytic activity of the uterus. Evidence is increasing that this may be a prostaglandin.

Days 18-20. The corpus luteum is almost nonfunctional and this releases the blocking action of progesterone. Of the several follicles that commence growth, one becomes more prominent by a surge in rapid growth and activity. As the Graafian follicle grows, it secretes increasing amounts of estrogen. The

remainder of the follicles regress.

Day 21 or 0. With the increase in estrogen release by the Graafian follicle and a corresponding decrease in progesterone by the regressing corpus luteum, estrus or heat will occur (cycle has now returned to Day 0). The high estrogen level in the blood.triggers a release of LH near the end of heat. Following this surge in blood levels of LH, the mature follicle ruptures to release the egg and the cellular tissue left behind becomes luteinized in response to the stimulation of a hormonal complex to form a new corpus luteum (cycle has now returned to *Days 1-2*). Progesterone again becomes the dominant hormone.

It must be noted that the timing given for the preceding events is only approximate, and differs for different cycle lengths.

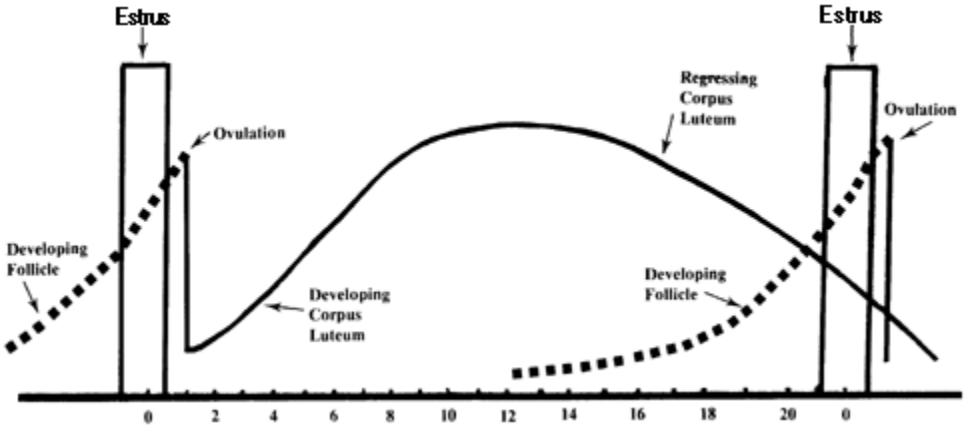

Figure 3. A graphic sketch of the sequence of events in a typical 21-day estrous cycle.

The discussion of events occurring during the previous cycle was based on a full cycle in which pregnancy does not occur. If the egg is fertilized and begins development in the uterus, the corpus luteum does not regress but continues to function by secreting progesterone. No follicles develop to maturity and heat does not occur. Progesterone keeps the uterus quiet and thus provides the most favorable conditions for the developing fetus.

Any condition that prolongs the period of time that blood levels of progesterone remain high will have the same effect as does pregnancy. Occasionally, the corpus luteum does not regress normally (persistent CL) even though the animal does not become pregnant. This requires the diagnosis and treatment of a veterinarian.

Abnormally short estrous cycles (7 to 11 days) can occur, and this condition appears to be caused by either no corpus luteum being formed, or if one is formed, it is nonfunctional as progesterone levels remain low. An estrous cycle can be shortened intentionally by injecting a prostaglandin which causes a regression of the corpus luteum and can be used in estrous synchronization.

Most animal species, including all farm livestock, are spontaneous ovulators--ovulation occurs at a certain time during the estrous cycle whether mating occurs or not. However, some species are induced ovulators, with ovulation occurring only following the stimulus of mating. Included in this group are the rabbit, cat, and mink. It has been established that ovulation in these species is the result of LH secretion in response to nerve impulses resulting from the mating act. Thus, both hormonal and nerve pathways are important factors in the reproductive process.

There are wide differences between the species of mammals in the various characteristics of the estrous cycle. Some species have only one heat period each year and are called monoestrous. The cow is in a group that exhibits heat more than one time per year and is called polyestrous. There is considerable variation in the latter group, however, from those having estrus continuously throughout the year to those that have only a few cycles during a restricted season (seasonal breeders). The nonbreeding period is called anestrus.

Species that are considered to be continuous breeders (such as the cow) are not without periods of anestrus during which the estrous cycles stop. For example, anestrus is commonly observed in cows (especially young ones) when nursing calves and subsisting on low planes of nutrition. Therefore, cows should be fed on a high level of nutrition for rapid breeding.

Estrus is not always accompanied by ovulation, nor ovulation by estrus. Heat without ovulation (anovulatory heat) will not result in pregnancy even though the female is bred. Ovulation without the external signs of heat (quiet or silent heat) is not uncommon in cows, especially the first few weeks after calving. Such females will not accept service.

[1]Adapted from Great Plains Beef Cattle Handbook Fact Sheet GPE-8454 by T.D. Rich and E.J. Turman, Oklahoma State University.

File G537 under: BEEF
B-10, Breeding & Reproduction
Issued December 1980; 15,000 printed.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.

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