Reproductive Tract Anatomy and Physiology of the Cow

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Understanding the anatomy and physiology of the cow's reproductive system is fundamental to good cattle management. Basic knowledge in this area will enable producers to do a better job in getting cows rebred, especially if artificial insemination and estrous synchronization are used. It will also enable producers to understand and cope with reproductive diseases and calving problems better.

ANATOMY

A sketch of the reproductive tract of the cow is presented in fig. 1. The female reproductive tracts of the various farm animals are similar to those shown for the cow, but with major differences in uterus shape.

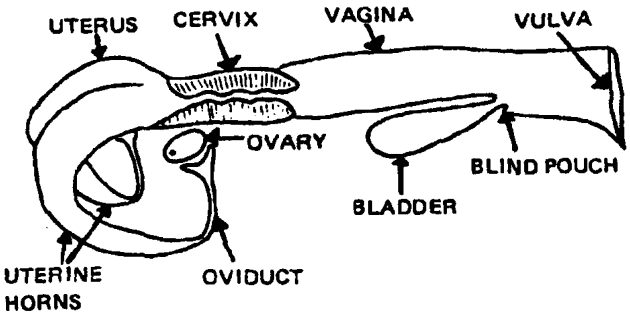

Fig. 1. The reproductive tract of a cow.

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

The secondary sex organs are, in effect, a series of tubes that receive semen, transport 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, which is continuous, oogenesis is cyclic. This cycle (called the *estrual cycle*) has a characteristic length, depending on the species, and consists of a definite sequence of events, both physiological and behavioral.

The ovary contains several thousand tiny structures, called *primary follicles,* that 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 develop. Rather, they die, are absorbed by the ovary, and are replaced by newly formed primary follicles.

The relatively few primary follicles that develop completely do so through a series of developmental 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 cavity grow larger, the egg is attached by a stalk of cells to the back side of the follicle opposite the ovulation site. 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*. At ovulation, the thin portion ruptures 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 uterus within the next 3–4 days. If it is fertilized, it

begins embryological development in the uterus. If it is not fertilized, 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 cows. In the mare, 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 because 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 that serves as a plug to protect the uterus from infection entering through the vagina.

The *vagina* serves as the receptacle for the male penis during service. In the cow, the semen is deposited in the vagina near the cervix, although in some other 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 posterior to 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 on hormones, which are 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 exert several specific effects.

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

Estrogen regulates several functions: 1) the development and functioning of the secondary sex organs; 2) the onset of heat, or *estrus*, the period of sexual receptivity; 3) rate and type of growth, especially fat deposition; and 4) primes or prepares the prepuberal heifer and postpartum cow for onset of sexual activity.

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

Estrogen and progesterone are not completely separate in their effects as both are necessary for complete development of some important organs. Uterine development 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 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 that might disturb pregnancy.

Complete development of the mammary gland also depends on 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.

In general, estrogen makes things happen and progesterone calms them down.

The *gonadotrophic hormones* of the anterior pituitary gland, which is located at the base of the brain, directly influence the production of ovarian hormones. The hormones are named *follicle stimulating hormone* (FSH) and *luteinizing hormone* (LH) because of their effects on the female. FSH stimulates the growth, development, and function of the follicle, while LH causes the follicle to rupture and the corpus luteum to develop.

A number of other hormones are known to have important roles in regulating the cow's reproductive system, and undoubtedly others will be identified or additional functions of known hormones will be identified as research efforts continue. The one other hormone group that merits discussion is the *prostaglandins*. Prostaglandins are secreted by many body tissues and perform a variety of functions in the body. The one most involved in the estrous cycle of a cow is prostaglandin F2α (PGF2α), produced by the uterus.

PGF2α is the natural luteolytic agent that, in the non-pregnant female, causes the corpus luteum to regress late in the estrous cycle and allows a new estrous cycle to be initiated. In a pregnant cow, a signal is sent from the developing embryo to the uterus, preventing PGF2α release, thus allowing the corpus luteum of the cycle to become the corpus luteum of pregnancy. Maternal recognition of pregnancy is believed to occur between days 16 and 17.

In the cow, injected prostaglandins will cause premature regression of the corpus luteum except during

the first five (1–5) and last five (17–21) days of the estrous cycle. This response allows the use of prostaglandins in estrus synchronization programs in cow herds and for initiating abortion in feedlot heifers.

THE ESTRUAL CYCLE

The reproductive cycle of the cow consists of a series of events that occur in a definite order over a period of days. The estrual cycle in the cow averages 21 days (range is 17–24). During this time, the reproductive tract is prepared for *estrus* or *heat* (the period of sexual receptivity) and *ovulation* (egg release). Figs. 2 and 3 outline the sequence of anatomical and hormonal changes that occur during a typical 21-day cycle in which pregnancy does not occur.

Day 0: The cow is in estrus (standing heat). Near the end of the standing heat, the mature Graafian follicle ovulates (ruptures) 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 the action of LH.

Days 2–5: The corpus luteum grows rapidly in both size and function. At this stage numerous follicles may be seen on the ovary 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 12. 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 high levels of progesterone.

Days 16–18: Increased follicular growth and accompanying estrogen secretion by the ovary stimulates prostaglandin secretion from the uterus, causing rapid regression of the corpus luteum.

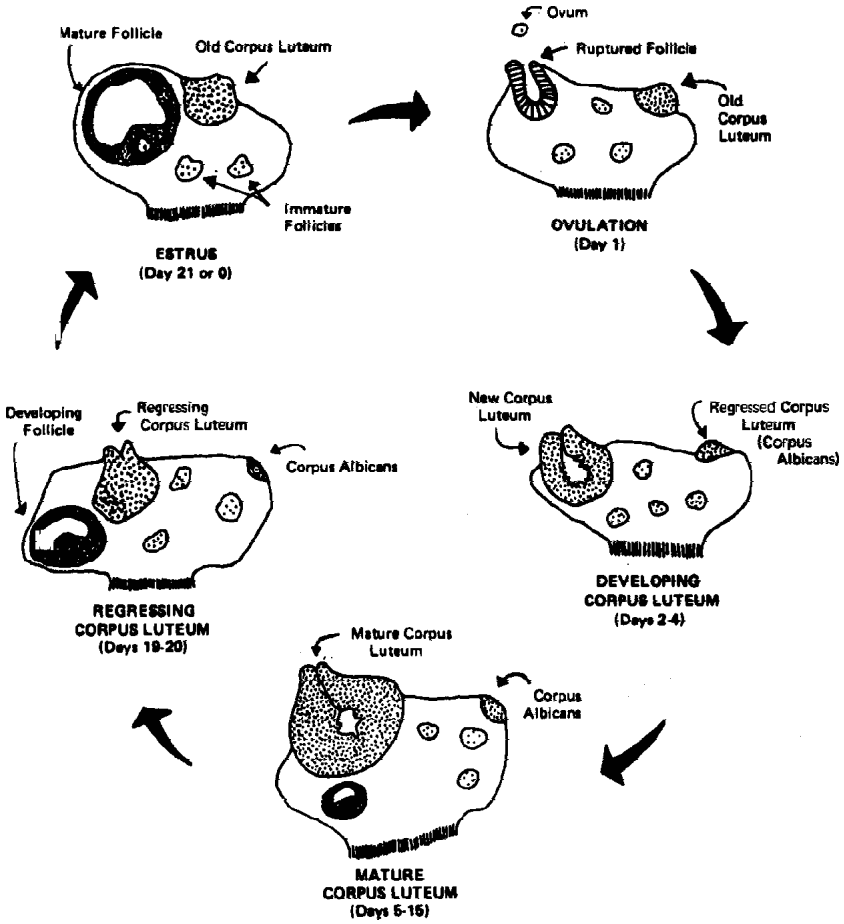

Fig. 2. The sequence of events in a typical 21-day estrual cycle in which pregnancy does not occur. Note that the development and regression of the corpus luteum and of follicles is a continuous process and that anatomically there is no clear break from one stage to the next.

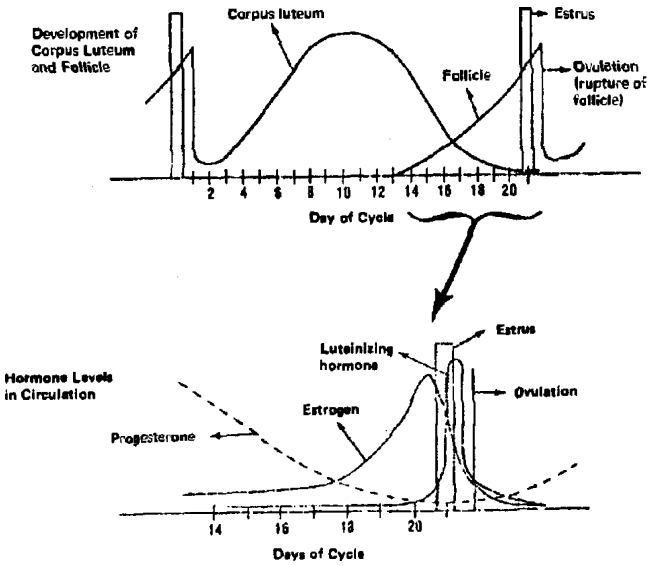

Fig. 3. The anatomical and hormonal changes that occur during a typical 21-day estrual cycle.

Days 18–19: 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 this Graafian follicle grows, it secretes increasing amounts of estrogen. The remainder of the follicles regress.

Days 19–20: 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 LH blood levels, 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 day 1–2). Progesterone again becomes the dominant hormone.

The timing given for the preceding events is only approximate and differs for different cycle lengths.

Also, the discussion of events occurring during the estrous cycle was based on a full cycle in which pregnancy does not occur. If the egg is fertilized and begins developing 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 when blood levels of progesterone remain high (such as implanting, injecting, or feeding progestin materials for estrus synchronization) will have the same effect as pregnancy. Occasionally the corpus luteum does not regress normally even though the animal does not become pregnant. This requires diagnosis and treatment by a veterinarian.

Occasionally, abnormally short estrous cycles (7–11 days) occur. This condition appears to be caused by either no corpus luteum being formed, or if one is formed, it is nonfunctional because progesterone levels remain low.

Species considered to be continuous breeders (such as the cow) are not without periods of *anestrus* when the estrous cycles stop. For example, an anestrus period is commonly observed in cows following calving. Low levels of nutrition are contributing causes of anestrus, especially in young cows nursing calves.

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 heats*) is not uncommon in cows, especially the first few weeks after calving. Such females will not accept service.

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