Dairy Repro 101: Anatomy and Function in a Dairy Cow

This resource provides a foundational understanding of how the reproductive system functions in a dairy heifer or cow, useful for anyone involved in reproductive management on a dairy farm.

Life of a Dairy Animal (Female)

To begin a conversation about reproductive management on dairy farms, there are three phases to consider in the dairy female: nonlactating heifer, lactation, and dry period. Efficient management during each phase will generally lead to greater economic returns by minimizing feed costs, maximizing milk production, and capitalizing on the supply of offspring (allowing for strategic marketing and culling practices).

The first phase is the nonlactating heifer phase. This is a long period of time, spanning approximately two years. During this phase, costs to the farm are significant for feed, housing, and labor. Unless a heifer is sold, there will not be any income generated from her until she calves and starts producing milk. General recommendations are to see heifers calve between 22 and 24 months of age to maximize production potential while also minimizing costs. If heifers are managed well, this is usually achievable.

The second phase will hopefully occur multiple times - lactation. During this phase, income should exceed expenses. Goals during this phase are to see a good peak in milk production early in the lactation and then sustained production at profitable levels. Minimizing the length of time a cow is milking for a particular lactation allows for higher average milk production in the herd, as well as a steady supply of offspring, which can be achieved with good reproductive management.

The third phase is the dry period, often lasting about 50 to 60 days between lactations and recurring after each lactation. This phase is similar to the nonlactating heifer phase in terms of no income being generated, but this phase is important for preparing a cow for the following lactation. Managing dry cows to minimize health disorders at the beginning of their upcoming lactation will positively impact future reproductive performance.

Reproductive Anatomy

Credit: photo from Dr. Michael O'Connor, Penn State University; modified by Andrew Sandeen, Penn State Extension

The reproductive tract of a heifer or cow is positioned at the back of the cow in the pelvic cavity just below the rectum, which allows for manual palpation of the tract. This “accessibility” allows for quick and easy artificial insemination (AI), pregnancy diagnosis, and other reproductive evaluations.

Starting from the outside, moving in…

The vulva is simply the genitalia that serves as the external opening into the reproductive tract.

The vagina is where copulation takes place. It is generally lubricated with mucus. It is also where the urethra discharges urine from the bladder.
The cervix serves as a barrier between the vagina (an environment subject to the presence of bacteria and "dirty" things) and the uterus, where a clean, protected environment is critical for embryo implantation and maintenance of pregnancy. The cervix produces mucus during estrus and closes down to serve as a seal during pregnancy.

The uterus provides an environment for an embryo to develop into a fetus and reside until the completion of pregnancy. In cattle, the uterus is composed of one main body connecting two horns.

The oviducts are small and difficult to find in a reproductive tract specimen, but they play an important role in fertilization and transportation of sperm cells and oocytes, both before and after fertilization.

The ovaries, of which there are two (one per uterine horn), are dynamic organs with constant growth and regression of two key types of structures - follicles and corpora lutea (plural for corpus luteum), often referred to as CL.

Uterus

Oviducts

Credit: photo from Dr. Adrian Barragan and Marcella Martinez, Penn State Extension, modified by Andrew Sandeen, Penn State Extension

Oviducts are the passageways between the two ovaries and the uterus. Though small in size, they are the critical for cow reproduction because they are where an oocyte (egg) may be fertilized by a sperm cell to form an embryo.

After ovulation of a follicle, an oocyte is release from the ovary and captured up into the oviduct. The oocyte migrates to an area in the middle of the oviduct where, if viable sperm cells are present, may be fertilized.

Ovaries

Credit: Dr. T.Y. Tanabe, Penn State University

Ovaries are always changing. At times they are small, not appearing as much more than a knot-like structure, and at other times they can double or triple in size. What causes the changes in size? Most commonly, an ovary will increase in size in response to reproductive hormones with the appearance of one or both of two main ovarian structures, a corpus luteum (CL) or a large, fluid-filled follicle. There is no other organ in the body that undergoes as much structural change as the ovaries. There is constant growth and constant regression, both of which sometimes occur at a rapid pace and can continue in a cyclic pattern.
Oocytes (eggs) are housed within follicles on the ovaries, and the total number of oocytes is in constant decline. A heifer’s ovaries have a full supply of oocytes when she is born, with no additional oocytes ever produced. The fate of those oocytes is either a natural death process, which happens to the majority of them, or ovulation.

**Follicles**

Credit: photo from Dr. Adrian Barragan and Marcela Martinez, Penn State Extension; modified by Andrew Sandeen, Penn State Extension

Ovaries are loaded with follicles, each of which houses a single oocyte (egg). The follicular cells around the oocyte produce key reproductive hormones while responding to hormones originating in other regions of the body.

During late stages of development, follicles grow and fill with follicular fluid. During these later stages they also produce high levels of estrogen.

Towards the end of the estrous cycle, one or more follicles are able to reach the point of ovulation. After ovulation, the remaining cells of the ovulated follicle are collectively transformed into luteal cells and form a corpus luteum (CL).

**Corpus Luteum**

Credit: Dr. Adrian Barragan and Marcela Martinez, Penn State Extension

The corpus luteum (CL) is a distinct but temporary structure on an ovary which is formed from an ovulated follicle. In the image above of a bisected ovary, the CL is the round, orange structure at the bottom of the picture.

If pregnancy is established after ovulation, a corpus luteum will remain for the duration of the pregnancy, producing progesterone, an important hormone for maintaining pregnancy.

If pregnancy is not established, hormonal signals from the uterus towards the end of the estrous cycle cause a rapid decline in progesterone production and complete disappearance of the CL within a few days.

**Ovarian Hormones**

Credit: image from Dr. Rob Lofstedt, Library of Reproduction Illustrations; modified by Andrew Sandeen, Penn State Extension

The image above is an ultrasound image of a cow ovary. On the right (red dashed line), is a large CL. To the immediate left of the CL is a black circle, which is a large fluid-filled follicle. The less distinct line that encases both of these structures defines the edge of the ovary.

These two key structures, follicles and CL, produce important reproductive hormones. Large, fluid-filled follicles secrete high concentrations of estrogen, a hormone important for causing estrous behavior and playing a key role in the process of ovulation. With a function almost opposite of follicles and estrogen, CL produce progesterone. Progesterone is commonly known as the hormone essential for establishing and maintaining pregnancy. It also has a controlling effect on follicle activity, preventing ovulation and estrus behavior.
Pituitary Hormones

The pituitary gland releases several hormones important for reproductive function. Two important ones to highlight are called follicle stimulating hormone (FSH) and luteinizing hormone (LH).

Follicle stimulating hormone stimulates follicular growth on the ovaries. It is not commonly used for reproductive management protocols, except for embryo transfer protocols to stimulate development of multiple follicles.

A large surge of LH is the critical event that triggers ovulation of a large follicle on an ovary. This event typically corresponds with larger follicles that are ready to ovulate. Luteinizing hormone also stimulates development and maintenance of a CL.

Another important hormone secreted by the hypothalamus, known as gonadotropin-releasing hormone (GnRH), controls the secretion of both FSH and LH. Treatments with GnRH are common in various reproductive management protocols, especially timed AI protocols, causing a surge of LH and subsequent ovulation.

Prostaglandin F2α (PGF) is released from the nonpregnant uterus towards the end of the estrous cycle and directly impacts any developed CL on the ovaries. It causes regression of the CL, which is a structural breakdown of the tissue and leads to a rapid decline in circulating progesterone.

Prostaglandin F2α is commonly used in estrous synchronization and timed AI protocols. Two important things to understand are that administration of PGF during the first few days of the estrous cycle when a new CL is developing (or after GnRH-induced ovulation) will not cause complete regressions of the CL, and treatment of a pregnant animal can cause a loss of pregnancy.

Estrous Cycle

The estrous cycle of a cow, on average, is 21 days long, though it can typically fall anywhere between 18 and 24 days in length. After calving, it usually takes a few weeks for normal cyclicity to be re-established, but from that point a healthy cow should continue cycling until becoming pregnant again.

Follicles, colored yellow (growing) and red (regressing) in the image above, grow throughout the estrous cycle. As the follicles get larger, they produce more estrogen. At the end of the cycle, one or more follicles reach a peak in both size and estrogen production.

The CL that forms from an ovulated follicle, shown as the orange structure in the image above, secretes progesterone, represented as the lighter orange area under the curve. Progesterone, which is high in the middle of the estrous cycle, limits follicle growth and natural ovulation, but once the CL regresses and progesterone declines, the end of the cycle is near and a follicle will likely ovulate within the next few days, starting the cycle over again.

Follicular Waves

The ovaries have their full supply of follicles at birth, each one containing a single oocyte. Over time, that supply is diminished as follicles grow and either die off (the fate of most of them, represented by red circles in the figure above) or ovulate (the fate of just a select few).
Looking at the cyclical pattern of follicle growth in a mature heifer or cow, a group of small follicles grow over a period of several days, with gradual loss of some follicles and growth to a significant size for a few. Under conditions of high progesterone, all of the follicles eventually die off and a new group begins to grow. This growth has been described to have a wave-like pattern; thus it is common to refer to a heifer or cow as having follicular waves. Interestingly, the number of waves per cycle can vary. There are typically either two or three follicular waves during each estrous cycle.

**Ovulation**

If a large follicle is present at the time of a surge of LH from the pituitary gland, typically occurring after progesterone has declined, ovulation of that follicle will usually occur. The wall of the follicle bursts open, allowing fluid and the oocyte (egg) to be released. The oocyte enters the oviduct, where it migrates to the site of potential fertilization.

Back at the ovary, the cells of an ovulated follicle quickly transform into a CL.

**Fertilization**

After ovulation of a follicle and migration of an oocyte into the oviduct, fertilization can take place if viable sperm cells are present.

With natural service by a live bull, semen is deposited in the vagina near the opening to the cervix. With artificial insemination, it is recommended that semen be deposited on the other side of the cervix in the body of the uterus. Either way, sperm cells make their way into the oviduct and to the specific, central region where fertilization occurs. If viable sperm cells don’t arrive at the right time, fertilization will not occur, since an oocyte only remains viable for a few hours.

Timing of insemination is critical for maximizing the odds for fertilization and pregnancy. Ideally, artificial insemination should be performed 4 to 16 hours after the onset of estrus.

After fertilization, muscle contractions in the oviduct aid transport of the developing embryo into the uterus within a few days, where it will reside for the duration of the pregnancy.
Pregnancy

The length of gestation (pregnancy) in a cow is approximately nine months, typically ranging between 277 and 286 days.

There are several key steps in the early stages of pregnancy.

Around Day 17 after ovulation, a viable embryo secretes a protein called interferon-tau that causes the reproductive system to recognize the pregnancy and stops the release of PGF from the uterus that would occur during a normal estrous cycle, thus saving the CL from regression and allowing sustained progesterone.

An embryo begins the process of implantation into the uterus about three weeks after ovulation and is well established by Day 40 of pregnancy.

A placenta develops that has a different style of attachment than is found in most other species. The placenta attaches to the uterus at numerous locations through structures called cotyledons which create an appearance of many buttons. Cotyledons have abundant blood flow and connective tissue. The umbilical cord starts forming about one month after conception from small vessels at these sites of attachment and is where the exchange of blood between the mother and her fetus occurs.

Twinning

Though the majority of bovine pregnancies involve a single fetus, twin pregnancies are not entirely uncommon (commonly around 5%). Twins are typically undesirable because of calving difficulties, effects on cow health, and an issue called freemartinism. A freemartin is a sterile heifer that was born twin to a bull. The reason most heifers born twin to a bull are infertile is because they are exposed to the male reproductive hormones during pregnancy, causing incomplete development of their reproductive tract.
Calving

Calving, also referred to as parturition, is initiated by the fetus. Hormonal changes eventually cause regression of the CL, pelvic ligament dilation, cervical secretions, and muscle contractions. After delivery of the calf, expulsion of the placenta may take several hours, but is an important final stage to allow for recovery of the tract and a healthy start into lactation.

The calving process has three stages: dilation, expulsion of the calf (also known as labor), and expulsion of the placenta.

During the first stage of calving, the cow’s cervix dilates, the uterus begins to contract, and the calf rotates into position for expulsion. This stage is thought to last up to 24 hours. Cues include an engorged udder, leaking of colostrum, and discharge from the vulva.

The second stage begins with the breaking of the amniotic sac and abdominal contractions in the cow as the calf moves into the birth canal. This stage ends with expulsion of the calf. Intervention is needed only if there is a lack of noticeable progress every 15 to 20 minutes, if the cow or calf are showing significant signs of distress, or if the calf is in an abnormal position.

The final stage is expulsion of the placenta. It is a critical step that must be completed before the uterus can begin to recover. When the placenta does not completely detach and is not expelled within 12 to 24 hours, this is a condition commonly called retained placenta and considered a health disorder.

For more details on calving, see our article "Maternity Management Practices in Dairy Farms".

Conclusion

The ovary is a busy, important place in the dairy cow, playing a big role in reproductive function. It is the starting place for oocytes, which are housed in follicles that grow in a wave-like pattern throughout the female’s lifetime. Corpora lutea come and go after ovulation.

Within a week after fertilization, the uterus becomes home to a developing embryo. What eventually becomes referred to as a fetus develops a placenta that has a cotyledonary attachment to the uterus and spends nine months developing into a calf.

Hormones play a critical role in many aspects of reproductive function. Many of the important ones are produced by the ovaries, the uterus, and the pituitary gland. They control follicle development, ovulation, maintenance of pregnancy, estrous behavior, and many other things.

Photos and educational content were contributed by Dr. Adrian Barragan, Extension Veterinarian.

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