Functional Reproductive Physiology
Michigan State University Extension Service
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# MICHIGAN BEEF PRODUCTION

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# Functional Reproductive Physiology

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Sound reproductive management is fundamental to any cow-calf operation for only with the birth of a live, healthy calf can the benefits of even the most sophisticated breeding programs begin to be realized. Successful application of advanced reproductive management techniques such as artificial insemination, estrous synchronization and embryo transfer can only be achieved with a good understanding of the basic facts of reproductive physiology.

## BULLS

### Anatomy

Figure 1 shows the reproductive tract of a bull with the important organs indicated. The testicles have two

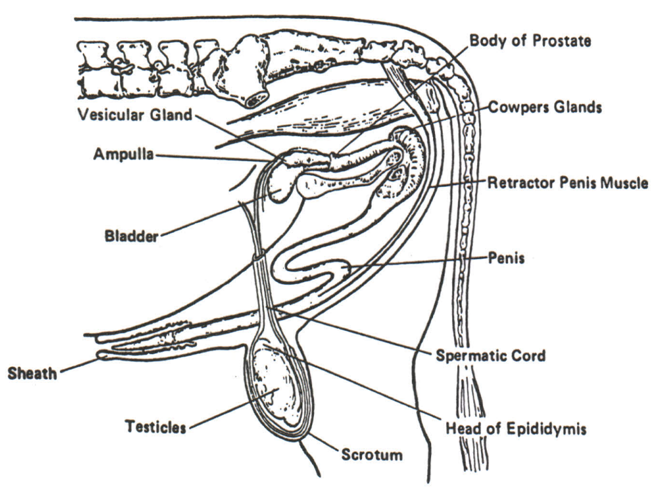


**Fig. 1. Reproductive anatomy of a bull.**

major functions, one of which is testosterone production. Testosterone is required for sperm maturation and is responsible for the masculine appearance and behavior of males. Further, testosterone acts as an agent to increase protein deposition which accounts for the more muscular conformation of bulls.

The second major function of the testicles is sperm production. One important point regarding sperm production is that from the time formation is initiated until sperm are fully mature, a time period of 45-50 days is required. That is why it is generally recommended that new bulls be acquired 60 days prior to the breeding season. This will allow ample time to overcome any detrimental effects which handling and transporting may have had on fertility.

While functioning to support and protect the testicles, the scrotum plays an important role in regulating their temperature. To maintain sperm production, the temperature of the testicles must be 2-4 degrees below that of body temperature. Under cold conditions, the supporting muscles contract to raise the testicles which thickens the scrotal wall and provides insulation. Under hot conditions the muscles relax, lowering the testicles, thereby stretching the scrotal wall.

The epididymus serves as a storage organ where final sperm maturation takes place. The accessory glands consist of the cowpers gland, prostate gland and seminal vesicles. They contribute fluid volume to semen which acts as a suspending medium necessary for transport and nutrition. However, the fluid is not involved in the fertilization process.

After maturation sperm must undergo a process known as capicitation before they are capable of fertilizing an egg. Capacitation takes place in the female reproductive tract following mating and requires several hours to complete.

## Puberty

The age at which a bull attains sexual maturity will vary widely both between breeds and within a breed. For most bulls this will be at 10-14 months of age but it is not at all uncommon for a 7 month-old-calf to be capable of mating. Generally the British breeds will reach puberty earlier than the larger European breeds. This can also vary with the nutritional status since underfeeding results in bulls that reach puberty later. One important point that needs to be stressed is that bulls do not reach their maximum reproductive capacity until 3-4 years of age. It is for this reason that care must be taken to see that yearling and two-year-old bulls do not get overused because it is possible for them to exhaust their semen reserves. The number of cows per bull will vary depending on the size and age of the bull. Under a 90-day pasture mating system the following can serve as a general guideline:

| Size or Age of Bull | No. of Cows per Bull |
|---|---|
| Small yearling | 0-10 |
| Large yearling | 10-20 |
| 2-year-old | 20-30 |
| 3-year-old and over | 30-40 |

If a breeder chooses to use a pen mating system where the cows in heat are brought to the bull, then these numbers can be approximately doubled.

## Breeding Soundness Examination

Colorado State University conducted an extensive study of 10,940 breeder-owned bulls and found 20% either questionable or unsatisfactory for breeding purposes. Using semen evaluation, 11.2% of the bulls tested as questionable, 7.2% were rated unsatisfactory and 2.4% of the bulls semen checked okay, but a physical defect made them unable to mate. This example points out the importance of performing a breeding soundness exam prior to the breeding season.

There are three main areas of concern in conducting the exam. First the physical condition of the bull should be observed. Good feet and legs are essential and if foot trimming is needed this should be done prior to the breeding season. Body condition should be moderate since overfat bulls tend to be lazy and have lowered semen quality. The testicles should have a football shape, be equal in size and hang uniformly in the scrotum well away from the body. In young bulls the circumference of the scrotum can be used as a measure of sexual maturity. In general, if a yearling bull has a circumference greater than 32 centimeters he should be fertile. A circumference of 34 centimeters is preferred.

A second area of concern involves the accessory glands. An experienced veterinarian can perform a rectal exam to assure normal development and detect any evidence of infection.

The third area is the most critical and involves an examination of the bull's semen. Looking at semen under the microscope, an experienced technician can determine the concentration and numbers of sperm present, their motility and the number of abnormal or dead sperm. Based on this examination the potential fertility of a bull can be estimated.

# FEMALES

## Anatomy

The important organs in the reproductive tract of a cow are noted in Figure 2. During natural mating the vagina is the site of semen deposition. Sperm must then proceed through the cervix, uterus and into the oviduct where fertilization takes place. The cervix is a 2- to 4-in. long, sphincter-like muscle formed by interlocking rings. It serves in a protective capacity at the entrance to the uterus. Further, a plug forms in the anterior end during pregnancy which functions to prevent bacterial contamination of the uterus. With artificial insemination a pipette must be threaded thru the cervix so that semen may be deposited in the body of the uterus.

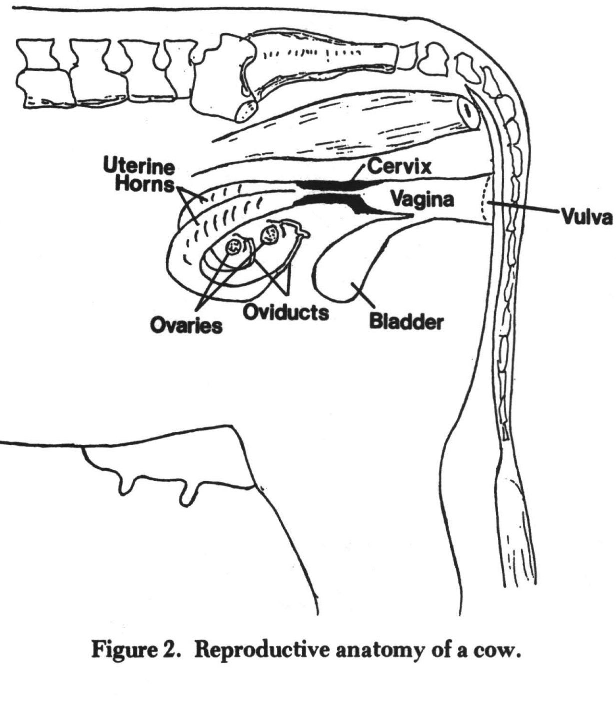


**Figure 2. Reproductive anatomy of a cow.**

The ovaries function as a storage organ for eggs and are responsible for production of estrogen and progesterone. In a normally cycling cow, one egg is released from a developing follicle approximately every 21 days. This egg, which has a life span of 6-10 hours, then moves into the oviduct where fertilization takes place. After a period of 2-3 days the developing embryo migrates to the uterus. It continues to grow, being nourished by uterine fluids, and eventually implants into the uterine wall at 30-40 days after conception.

The ovaries possess two structures at different stages of the estrous cycle which are responsible for hormone production. The follicle from which the egg is released is responsible for production and secretion of estrogen. Estrogen will cause a cow to come in "heat" when levels are at their peak. Estrogen also increases the muscle tone of the reproductive tract. This is important since muscular contractions are responsible for moving both egg and sperm to the site of fertilization.

Following rupture of the follicle and release of an egg, the cavity formed is filled by a structure known as a corpus luteum. The corpus luteum functions in production and secretion of progesterone. Progesterone is necessary for the maintenance of pregnancy. High levels of progesterone prevent cows from coming into heat which is the basis for one method of synchronization of estrous. The decrease in progesterone and increase in estrogen at the time of estrus also signals the cervix to dilate. This allows movement of semen during natural mating and facilitates passage of a pipette for artificial insemination.

## Puberty

Normally, heifers reach sexual maturity by 10-14 months of age. It is possible for some heifers to reach puberty as early as 7 months of age and to be bred by early-maturing bull calves. For this reason it may be advisable to separate bull and heifer calves to avoid unwanted pregnancies.

The age at which a heifer reaches puberty is influenced by several factors including: level of nutrition, breed, growth rate and heterosis. Inadequate rations for growing heifers result in reduced growth rates and delayed puberty. This effect can be clearly seen in Table 1.

**Table 1. Influence of breed and level of nutrition on age and weight at puberty in beef heifers.[a]**

| | Breed of Heifer | | |
|---|---|---|---|
| Nutriton | Hereford | Angus | Angus x Hereford Crossbreds |
| | | Age of Puberty (days) | |
| High | 387 | 374 | 381 |
| Low | 660 | 483 | 424 |
| | | Wt. at puberty (lbs.) | |
| High | 647 | 671 | 726 |
| Low | 614 | 565 | 559 |

[a]Adapted from Wiltbank *et al.*, 1969, J. Anim. Sci. 29:602.

Straightbred heifers on the high level of feed reached puberty an average of 191 days earlier than straightbred heifers on a low level of feed. The difference between the crossbred heifers on the two levels of feed was only 43 days.

Crossbreeding reduced the age at puberty by 148 days for heifers on the low level of nutrition but had no effect on age at puberty of heifers fed the high nutrition level.

## The Estrous Cycle

Once a heifer has reached puberty she will exhibit estrous cycles ranging in length from 17-24 days. An average estrous cycle is assumed to be 21 days. The duration of estrus or the "heat" period can vary from 4-30 hours with an average period lasting 12-18 hours. Heifers will often have shorter heat periods than older cows. Ovulation or rupture of the follicle occurs from 2-26 hours after the end of the heat period with an average time being 10-14 hours. The egg will tend to remain viable for a period of 6-10 hours.

Basically, the estrous cycle can be divided into two stages. The 5-6 day period when a female is coming into or going out of heat is termed the estrual stage. This is the time period when the hormone estrogen, secreted by the developing follicle, is predominant. The stimulus for the follicle to begin development comes from two hormones: (1) follicle stimulating hormone (FSH), and (2) luteinizing hormone (LH). These two hormones are secreted from the anterior pituitary gland located at the base of the brain. As the follicle develops it continues to secrete more estrogen. When the estrogen level reaches its peak the animal will come into heat. A surge of LH follows after the estrogen peak which causes final maturation of the follicle. Ovulation occurs shortly thereafter.

The second stage known as the luteal phase of the cycle then begins. The cells in the cavity where ovulation occurred begin to divide to form the corpus luteum (CL). The CL secretes progesterone which reaches a peak about 6 days following estrus and remains high for about ten days. It is during this time that the uterus prepares for the impending pregnancy. If pregnancy does not occur, the uterus secretes prostaglandin $F_{2\alpha}$ which acts on the CL to cause its regression. This initiates the start of another estrual phase. If conception has occurred, then the CL is maintained which suppresses further estrous cycles and allows the pregnancy to continue.

Figure 3 shows a graphic presentation of the development of the corpus luteum and follicle as it occurs during a normal 21 day cycle. The figure also shows the hormone levels present during the estrous cycle and their timing in relationship to estrus and ovulation.

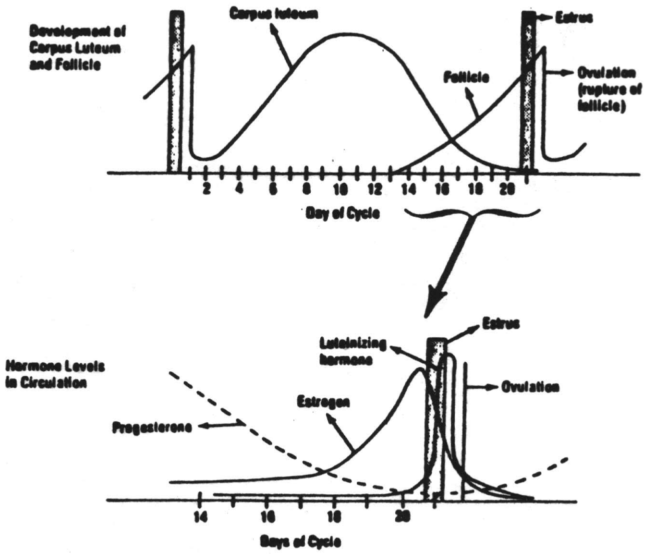


**Figure 3. Follicle development and hormone levels during normal estrous cycle.**

At the time of estrus, the muscle tone and vascular supply of the uterus increase. In the 2-3 day period following estrus the uterus relaxes, quite often producing a bloody secretion due to breakdown of arteries lining the uterus. This bleeding in no way relates to whether a pregnancy has occurred. It can often be useful in heat detection since it indicates the cow was in heat several days earlier and aids in predicting when the next heat will occur.

If estrus ceases after breeding this is a good indication that pregnancy has occurred although estrus does continue in 3-5% of pregnancies for periods of up to 3 months. Positive pregnancy diagnosis can be made by rectal palpation as early as 42 days following insemination but is more reliable if performed at 60-90 days.

The breed of sire and dam play an important role in determining gestation length. Cattle can range from 270-300 days with an average gestation length of 283-285 days. In general, first-calf heifers tend to have shorter gestation periods than mature cows. Furthermore, the gestation period for twins will be about one week shorter than normal.

Following calving, the uterus must return to its normal size and position (known as involution) in order to prepare for the next pregnancy. The time required for complete involution normally ranges between 30 and 50 days. The interval from calving to first estrus averages between 45 and 60 days but this can be highly variable. Inadequate nutrition can prolong this interval dramatically. Furthermore, calving difficulty, disease and uterine infection can also delay the interval to first estrus.

**Table 2. Summary of sequence and timing of events in female reproduction.**

| | Average | Normal Range |
|---|---|---|
| Puberty | 10-14 mos. | 6-15 mos. |
| Estrous cycle length | 21 days | 17-24 days |
| Estrus "heat" period length | 12-18 hours | 4-30 hours |
| Ovulation (time after end of "heat" period) | 10-14 hours | 2-26 hours |
| Egg life | 6-10 hours | |
| Capacitation of sperm (time required in uterus) | 6-10 hours | |
| Sperm life (in female reproductive tract) | up to 24 hours | |
| Implantation of embryo | 30-40 days after conception | |
| Positive pregnancy diagnosis (by rectal palpation) | after 60 days | |
| Gestation period | 283-285 days | 270-300 days |
| Uterine involution following calving | 30-50 days | |
| Interval from calving to 1st estrus (ideal conditions) | 45-60 days | |



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