

# The Physiology of Gestation and Parturition



IRM-3

## Dairy Integrated Reproductive Management

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### Fertilization and Gestation

Pregnancy is the period during which a cow carries a developing calf. The sequence of events leading to pregnancy are complex and multidimensional. The events include ovulation (release of ovum or egg from the ovary), ovum transport to the fertilization site, sperm deposition and sperm transport. A delicate balance of the hormonal environment of the cow controls these events.

Within 30 to 45 minutes of ovulation, the ovum passes one-third of the way through the oviduct to the site of fertilization. The transport of the ovum to this location is dependent on the balance of estrogen and progesterone.

After insemination either by natural service or artificial insemination (AI) some sperm reach the site of fertilization rapidly, within 10 to 15 minutes. However, these "early-birds" are not capable of fertilizing the ovum. The fertilizing ability of sperm is based upon a series of biochemical reactions that occur in the sperm, known as capacitation.

Although the number of sperm deposited in the reproductive tract by AI usually number 10 to 20 million, the number that reach the site of fertilization is significantly less, usually 10,000 to 20,000. When sperm encounter the ovum, they penetrate the outer cell layers of the ovum.

Although the process is poorly understood, a single sperm appears to burrow into the ovum, and the ovum becomes impenetrable to other sperm. In abnormal circumstances, more than one sperm may enter the ovum. However, these embryos die at a very early age.

After the sperm enters the ovum, the chromosomes of the ovum and sperm unfold and merge. The genetic information from the cow and bull determine the embryo's characteristics. Once merging of the ovum and sperm is completed, a new cell (zygote) is formed.

For optimum fertilization rates, the producer should be aware of a number of practical implications. Both the sperm and the ovum have finite lifespans; the ovum can survive unfertilized for 6 to 12 hours and the sperm can survive about 24 hours in the female reproductive tract. Therefore, having the sperm at the "right place at the right time" is of utmost importance.

In the dairy cow, ovulation occurs approximately 24-30 hours after the onset of estrus. When AI is used, acceptable conception rates are usually obtained if the cow is bred 10 to 20 hours after the onset of estrus. Consistent with this recommendation is the need for good estrous detection (Fact Sheet IRM-6).

After fertilization, the zygote divides many times without significant growth (cleavage). The first cleavage produces a 2-cell embryo, followed by 4-cell, 8-cell, 16-cell embryos and so forth. During the cleavage process, the embryo enters the uterus as a 16-cell embryo in 3-4 days. Peristaltic (wavelike) contractions transport the embryo to the uterus. These contractions appear to be controlled by a balance of estrogen and progesterone.

After the embryo enters the uterus, the cells become too numerous to accurately count. During the next several days, fluid collects inside the embryo, forming a cavity surrounded by cells. A mass of cells, destined to become the fetus, form on one side of the embryo. The embryo or blastocyst, as it is called at this point, begins to elongate ending the period of cleavage. The complete process of cleavage takes about 2 weeks in the dairy cow.

While the embryo undergoes cleavage, the uterus also changes in preparation for implantation. During this period, the uterus is primarily under the control of progesterone. Progesterone decreases the muscle tone of the uterus and increases the secretory capacity of the inner lining of the uterus (endometrium). This endometrium supplies the free-floating embryo with carbohydrates and proteins for nourishment during the life of the blastocyst.

The presence of the embryo in the uterus must be recognized by the cow to prevent the regression of the corpus luteum. The nature of the "luteal protective" signal is currently under debate. Whether the embryo produces a substance which prevents release of the luteolytic factor (prostaglandin F<sub>2α</sub>) or stimulates the corpus luteum directly or whether the endometrium produces a compound which prevents luteolysis is unknown. Irrespective of the mechanism, the dam recognizes that she is pregnant 16 to 17 days after breeding.

By day 16, the embryo enters a new stage of development known as differentiation. During this period, formation of extra-embryonic membranes and formation of all major organs and systems (circulatory system, muscular system, central nervous system, etc.) occurs.

Four extraembryonic membranes form during differentiation: the amnion, the allantois, the chorion, and the yolk sac. The yolk sac contains a source of nutrients but disappears by the end of this stage of development. The amnion (innermost layer) folds around the embryo and contains fluids which suspend the embryo, protecting it and permitting its free growth. During the period of differentiation, the fluid in the amnion becomes turgid, and can be palpated through the rectum between days 35 and 45. The allantois (middle layer) forms a pocket for waste products from the developing embryo. The chorion forms the outer membrane. Gradually, during differentiation, the allantois and chorion fuse forming a single membrane (the allantochorion). This membrane is the tissue which attaches to the endometrium. The process of differentiation occurs between days 16 and 45 of gestation.

During the process of differentiation, the embryo attaches to the wall of the uterus. In the dairy cow, this process begins about day 28 of gestation. The allantochorion adheres to the uterine wall in specific areas known as caruncles (buttons). Dairy cows have 80 to 100 of these specialized attachment organs. After the allantochorion attaches to the caruncle, a cotyledon (placentome) is formed.

The placenta is the fusion of the fetal membranes with the maternal membranes. The growing embryo derives its nourishment from the mother through the placenta via a "lifeline," the umbilical cord. Although the placenta serves as an interface for fetal and maternal blood and the exchange of nutrients, gasses and water, the blood of the fetus and mother never mix. Thus, the placenta substitutes for the fetal digestive tract, lungs, kidneys and liver, yet separates the maternal and fetal organisms to ensure separate development of the fetus. Complete attachment occurs by the 45th day of gestation.

For the remainder of gestation, 45 to 280 days, the fetus grows increasingly in weight, from 1/8 ounce (smaller than a mouse) to about 100 lbs. Several landmarks in the development of the calf occur during this period. Tooth formation begins around 110 days and extensive bone formation by 180 days. By 230 days, the body of the calf is covered entirely by hair. During the period of fetal growth, the pregnant animal gains weight due to an increase in the weight of the fetus, an increase in the weight of the placenta and nutrient retention.

Genetic factors and environmental factors affect fetal development during growth. For instance, Holstein calves at birth can weigh up to 35% more than Jersey calves. Major environmental factors which affect growth of the calf include size of the dam, parity (how many calves the dam has had), nutrition of the dam, and climate.

Heifers that have not reached adult size continue to grow during pregnancy and compete with the fetus for available nutrients. Therefore, nutrition of the dam plays an important role. This is especially vital during the final three months of pregnancy. During this time, the fetus increases in weight from 10 to about 100 lbs. (final weight varies depending upon the breed). As the size of the fetus increases, so does the demand for nutrients. Increasing the plane of nutrition of the dam during the final third of pregnancy helps to ensure birth of healthy, non-stunted calves.

Additionally, heat stress during the final trimester of pregnancy has been shown to have a deleterious effect on reproductive performance. Researchers in the southeastern part of the United States have shown that heat stress reduces the birth weight of calves. Availability of shaded areas during gestation also might be important in some areas. Although these findings may have limited application in some parts of the country, producers should be aware of climatic effects.

The reproductive organs of the cow also undergo discrete changes during gestation. The vulva enlarges, which becomes notable around the seventh month of gestation. The cervix remains tightly closed and is sealed by a mucus plug. Relaxation of the pelvic ligaments occurs gradually during gestation and becomes more noticeable with approaching parturition due to the hormone relaxin.

Maintenance of pregnancy is largely dependent upon the proper balance of hormones maintained by interactions between the cow, the placenta and the fetus. Progesterone has the dominant role for the maintenance of pregnancy. Hence, the corpus luteum of the cow persists throughout gestation.

## Pregnancy Diagnosis

The presence of the embryo in the uterus interrupts the estrous cycle. During this interruption the corpus luteum persists, releasing progesterone into both the blood and milk. The presence of progesterone in the milk 21 to 23 days after breeding is 85% efficient in diagnosing pregnancy and even more accurate for diagnosing open cows (Fact Sheet IRM-9).

Pregnancy also can be detected by rectal palpation. Most veterinarians prefer to palpate for pregnancy 45 to 60 days after breeding. At this time, the veterinarian determines pregnancy by the size of the "fluid filled" horns and "slips membranes" or allows the fetal membranes to slip through his or her fingers as the diagnosis for pregnancy. Irrespective of the pregnancy exam used, a pregnancy check is of great importance for successful reproductive management. Open cows should be diagnosed as rapidly as possible so an optimum calving interval can be maintained (Fact Sheet IRM-5).

## Parturition

Parturition is the birth process and signifies the end of gestation. Although the length of gestation varies among dairy breeds (Ayrshire—278 days; Jerseys—278 days; Holstein—279 days; Guernsey—284 days; Brown Swiss—290 days), the events leading to parturition are similar.

As parturition approaches, the fetus rotates into the birth position. After rotation, the fetus rests on its abdomen with its forefeet positioned at the uterine end of the cervix with its nose resting between the forefeet. Abnormal presentation of the fetus occurs in 5 out of every 100 dairy cows. Abnormal presentation may range from one or both forelegs turned back to one of the several breach positions (Fact Sheet IRM-20). In these cases, producer or veterinary assistance is usually required for delivery.

The hormone pattern established during the latter portion of gestation triggers parturition. During the last three weeks of gestation, the fetus begins to release hormones from the adrenal cortex (predominantly cortisol). Cortisol from the fetus stimulates estrogen production by the placenta. The placental estrogen stimulates uterine secretion of the luteolytic factor,  $\text{PGF}_{2\alpha}$ , which interrupts progesterone secretion. The hormonal environment of the dam stimulates dilation of the cervix (which permits the fetus to pass through the birth canal) and uterine contractions (which expel both the fetus and placental membranes). Therefore, a combination of hormones from the fetus, placenta and dam induce a series of events leading to parturition.

The birth process can be divided into three stages. The first stage of parturition ends with dilation of the cervix and entry of the fetus into the cervical canal. This stage usually takes 2 to 6 hours in the cow. The second stage is more rapid than the first and begins with the breaking of the allantochorionic sac. This is typically noted as the "water bag" breaking. This phase is characterized by the expulsion of the fetus and usually takes no more than 2 hours. Expulsion of the placenta occurs during the third stage and may take up to 2 hours.

## Appointment Calving

Induction of parturition can be induced by injection of dexamethasone (a synthetic adrenal cortex hormone similar to cortisol), estrogen and  $\text{PGF}_{2\alpha}$ . However, at present, hormonal induction of calving results in a high incidence of retained placenta (Fact Sheet IRM-21). Further refinement of the hormonal treatment will be required to make appointment calving a realistic tool.

## Summary

The process of fertilization, gestation and parturition requires the precise synchrony of the physiology of the cow. The producer should have a program for pregnancy determination as well as a health program for dystocia and retained placenta. Although calving is a stressful period in the lifetime of a cow, development of a plan by the producer for reducing the degree of stress during parturition will reduce losses and ultimately increase production capabilities.

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