Lesson 1:
Importance of Reproduction in Livestock

How does livestock reproduction affect the average consumer? For producers to receive the optimum price for their products, they must improve the herd's quality through reproduction and genetics. This improvement influences the quality of products available in the store. In turn, consumers influence livestock quality through their buying power.

Careers Associated With Livestock Reproduction

There are many careers associated with livestock reproduction. Most of these occupations require an intense educational background with a strong science emphasis. This usually requires a baccalaureate college degree from a four-year institution, and some require additional educational experience.

Some of the careers associated with livestock reproduction are: veterinarian, breed association representative, breeding services technician, livestock scientist, Extension livestock specialist, sales representative, and livestock producer.

A veterinarian deals with a wide spectrum of livestock reproduction activities. Some of these activities are: AI programs, semen collecting, pregnancy testing, embryo transfer, cloning, and assisting with the birth process. Becoming a vet usually requires eight years of postsecondary education, in which the last four years are completed at specific institutions.

An occupation in a breed association is concerned with improving that particular breed through genetics. Breed associations compete with other associations to promote the superiority of their breed. This occupation usually requires four years of postsecondary education.

Breeding service companies, such as ABS, provide semen access and drugs associated with livestock reproduction. The educational requirement of breeding services is four years of postsecondary education.

Livestock scientists provide the latest research on livestock reproduction, such as genetic engineering, cloning, and embryo transfer. The educational requirement for this occupation is 7-8 years of postsecondary education.

An Extension livestock specialist provides information to the livestock producer on new and old methods and techniques in livestock reproduction. Extension specialists are available resources to any livestock producer in the U.S. The educational requirement for an Extension livestock specialist is usually at least four years of postsecondary education.

The main emphasis of a livestock producer is to produce quality livestock for his/her living. A livestock producer must have a strong experience background with livestock reproduction. Experience is more valuable than an educational background; however, gaining an educational background is becoming more and more valuable with all the new information bombarding the livestock industry.

A sales representative for livestock breeding products provides products used in purebred and commercial breeding programs. The educational requirement is usually four years of postsecondary education.

Economic Factors Associated With Reproduction

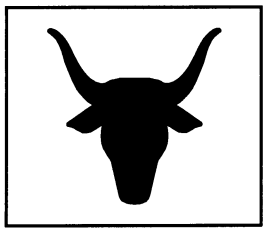
There many economically important reproductive traits that are influenced by inheritance. These traits determine profit or loss in a livestock operation.

Beef cattle - With beef, the first trait is calving interval. Cows which do not produce yearly calves are too costly to keep. Birth weight is an economic trait that is associated with calf survival rate. Low birth weight decreases the survival rate in calves.

Weaning weights are a good indication of milking ability and mothering ability. Gains before weaning are cheaper than after weaning, which result in increased profits for the producer. Maternal ability is important for calf survival and weaning weights.

Daily rate of gain becomes increasingly important in getting animals to market weight in a shorter period of time. Daily rate of gain is also highly correlated to efficiency gain. Pasture gain becomes extremely important when animals are raised on pastures, in backgrounding, and with cows on pasture.

Another economic trait influenced by livestock reproduction is efficiency of gain, which is the conversion of feed into muscling and rate of gain. More money can be made on animals that reach final feedlot weight at a faster rate. This weight is also influenced by birth weight, weaning weight, and rate of gain.



Conformation score is significant in relation to animal longevity (life span) and appearance. Finally, carcass traits measure the final product of the producer's efforts. Carcass traits are measured by the quality and quantity of the edible final product. More profit comes from a larger, quality carcass. Beef producers instill a breeding system that builds on these economic traits to improve their entire herd genetically.

Dairy cattle - In dairy, milk production is the essence of a dairy operation. The more milk that is produced, the more income received by the producer. Percent fat is considered icing on the cake; the higher the percentage of butterfat, the higher the price paid for a pound of milk. Percentage of protein in milk also increases the price paid for milk.

Soluble nitrogen-free extracts help animals take advantage of more nutrients in feed and convert nutrients into usable products. Feedlot gain is not as important in dairy cattle as it is in beef cattle, but it is vital for dairy steers on a feedlot.

Like beef cattle, stature becomes important to the longevity of animals. Stature is important in dairy cattle because of the length of time spent on hard surfaces such as concrete.

Legs and feet are strongly related to the animal's stature and are also influenced by reproduction. Correct legs and feet will influence the animal's production span.

To continue to produce milk, a dairy animal must have strong udder support. A strong udder will increase the longevity of the animal to continue to produce milk.

When considering economic traits, milking speed becomes important in a dairy operation. The quicker a cow milks, the quicker the milking procedure is completed, and the producer can move on to other projects.

Like other classes of livestock, birth weight is associated with survival rate and calving ease. Temperament becomes very important, especially in dairy cattle. An animal that becomes excited every time it enters the milking parlor will become extremely hard to milk and will be replaced soon.

As in any class of livestock, fertility is important. The longer it takes a female to become fertile, the longer it takes for that animal to come into her milking cycle; this is very costly for the producer. All dairy producers instill a breeding system that builds on these economic traits to improve their entire herd genetically.

Sheep - In sheep, multiple births are the first economic trait influenced by reproduction. Additional lambs produced by a single ewe will increase the amount of money that can be made by the producer. Like other classes of livestock, larger birth weights generally mean more vigorous lambs that have higher rates of gain.

Again, weaning weights reflect maternal ability and a cheaper rate of gain at weaning time. Rate of gain generally reflects milking ability of the mother and faster growth rate, which means more money in the pocket.

Type score in sheep determines market value and the ability to thrive under certain environmental conditions. Finish or condition at weaning is very important to the feeder lamb producer. The better the condition and finish at weaning weight, the better the price paid at market.

Wrinkles and skin folds become an economic factor because they determine shearing ease and

wool fiber uniformity. Face covering determines the ease of grazing for animals. Because of the wool hanging in their eyes, wool-blinded animals have decreased grazing ability and require extra labor for trimming. Fleece weight largely decides the price received for wool. Like fleece weight, staple length influences the price received for wool because it measures the length of fibers.

Finally, carcass quality largely influences profit or loss for the mutton producer. All sheep producers instill a breeding system that builds on these economic traits to improve their entire flock genetically.

Swine - For swine, a litter size at birth is an important economic trait related to reproduction. A high pig average is a desirable economic trait. Litter size at weaning is just as important as litter size at birth. Litter size at weaning reflects maternal ability. Heavier pigs at birth have more vigor and an increased survival rate. Like other classes of livestock, litter weight at weaning is an important economic trait for a swine producer. Remember, it is cheaper to put on pounds from birth to weaning than on post-weaning pounds.

An economic trait that is important for any swine producer is daily rate of gain from weaning to market weight. The more efficient the hogs, the quicker they go to market, which lowers feed costs for the producer. Like daily rate of gain, efficiency of feed reflects the conversion rate of pounds of feed to pounds gained. Every swine producer understands that efficiency of feed is an important economic trait influenced by inheritance.

Hard surfaces found in confinement facilities are very hard on hogs' legs and feet. Conformation score becomes important to swine producers who raise hogs in confinement facilities.

Finally, carcass quality is important to every swine producer. Buyers pay more for a quality swine carcass.

Parts and Functions of the Male Reproductive System

The scrotum is a heat-regulating structure that provides the proper temperature for sperm production. Sperm cannot be produced at normal body temperatures. The scrotum's function is to lower the testes when cooling is needed and contract them when warmth is needed. For sperm production to occur, the testes must be 4-7 degrees Celsius lower than normal body temperature.

All classes of male livestock are born with two testes, unless an abnormality occurs. The testes produce sperm and secrete male sex hormones. The testes are made up of several thousand feet of very small, tangled tubules called seminiferous tubules. These tubules are the actual structures that produce sperm within the testes.

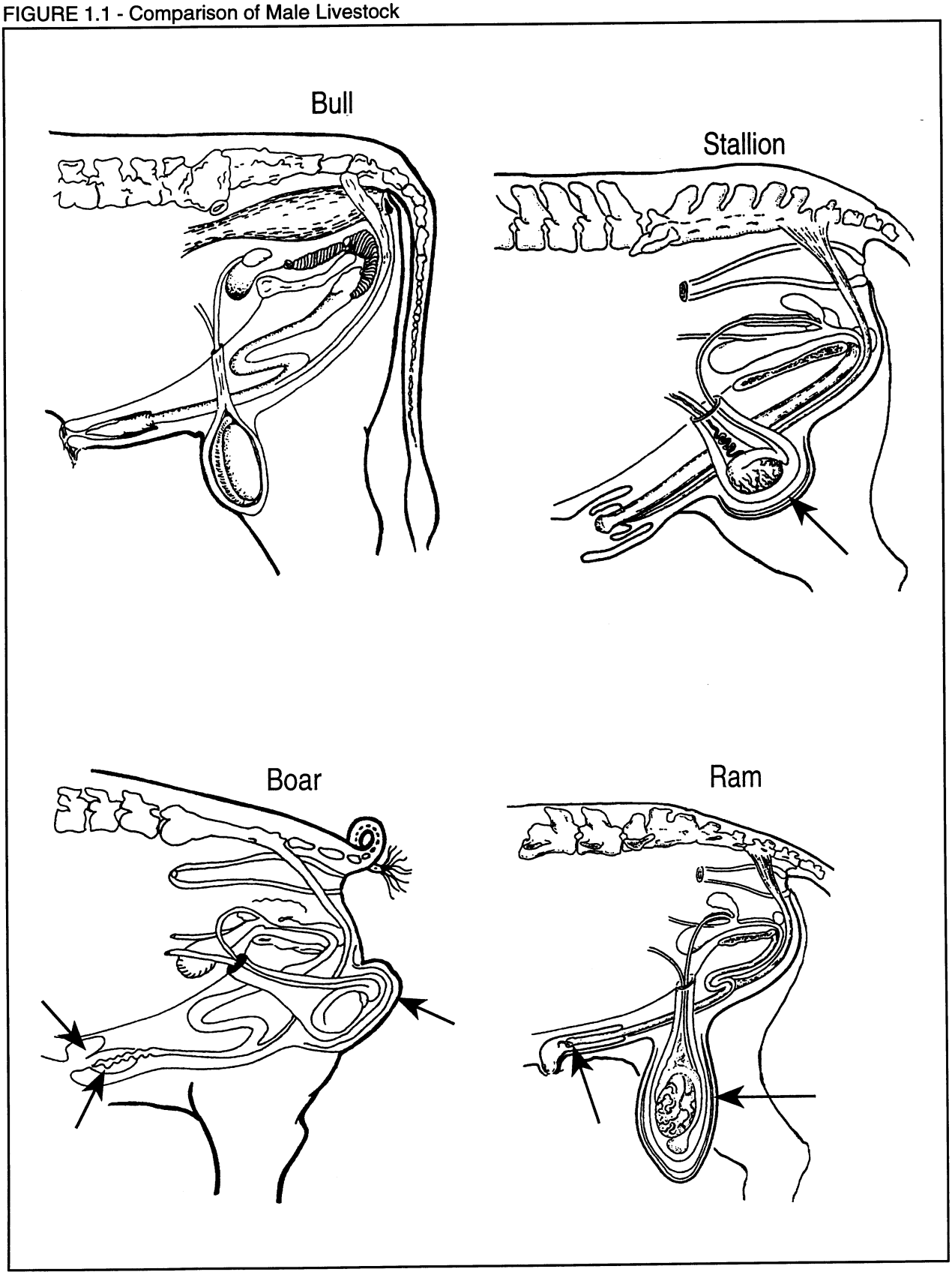
The epididymis is an elongated body close to the testes. It consists of three parts: the head, the body, and the tail. The epididymis has four functions: to store, mature, transport, and concentrate sperm. Sperm storage occurs in the tail of the epididymis. Sperm maturation is achieved through secretions from the epithelial cells. The epididymis transports sperm produced by the seminiferous tubules to the tail of the epididymis. Water absorption aids in this transportation.

The vas deferens transports sperm from the tail of the epididymis to the penis. The sperm passes by accessory glands like the seminal vesicles, prostate gland, and the Cowper's gland to produce the fluid called semen. Seminal vesicles are located posteriorly under the prostate gland and empty into the urethra. Secretions produced by the seminal vesicles make up 50 percent of the fluid in semen. This yellow fluid consists of high concentrations of proteins, potassium, citric acid, fructose, and several enzymes. It usually has a pH of 5.7-6.2.

Surrounding the urethra, the prostate gland's secretions pass into the urethra through small ducts along the urethra. Prostate secretions are similar to secretions produced by the Cowper's gland. Prostate secretions usually have a pH of 7.5-8.2.

The Cowper's gland is located above the urethra and near the rectum. The Cowper's gland is about the size of a walnut; like the prostate gland, it produces secretions to flush the urethra before mounting. The secretions are clear, watery, and

FIGURE 1.1 - Comparison of Male Livestock



sperm-free in nature. These secretions have the same pH as those found in the prostate gland.

The urethra is a jointed canal used for both semen and urine transportation. The urethra uses the length of the penis to carry urine from the bladder, or semen from the accessory sex glands, to the head of the penis.

In a dual role, the penis excretes urine from the body or deposits semen into the reproductive tract of the female. The length of the penis begins at the bladder and accessory glands and ends at the free part located in the sheath. Blood is pumped into the chambers of the penis during sexual excitement, which causes the straightening of the sigmoid flexure. When the sigmoid flexure straightens, it causes an erection and aids copulation. After copulation, the sigmoid flexure contracts and the retractor muscle pulls the penis back into the sheath. The sheath is the protective opening where the retracted penis is kept in a fixed position when relaxed.

Differences in male reproductive systems - The ram's scrotum is shorter than the scrotum found on a bull. The ram's scrotum is also covered with wool. In a ram, the urethra opening extends out further than the head of the penis, which rotates and sprays semen during ejaculation. (See Figure 1.1.)

The boar's scrotum is located just below the rectum, not hanging from the bottom of the animal as in other species. In the boar, the free part of the penis is shaped like a corkscrew. The boar has a preputial pouch above the opening to the sheath, which is responsible for the strong sex odor in boars. This pouch contains a mixture of decomposing urine and macerated epithelial cells, which permeates their meat and gives it a bad taste. This is why boar carcasses are seldom used for human consumption.

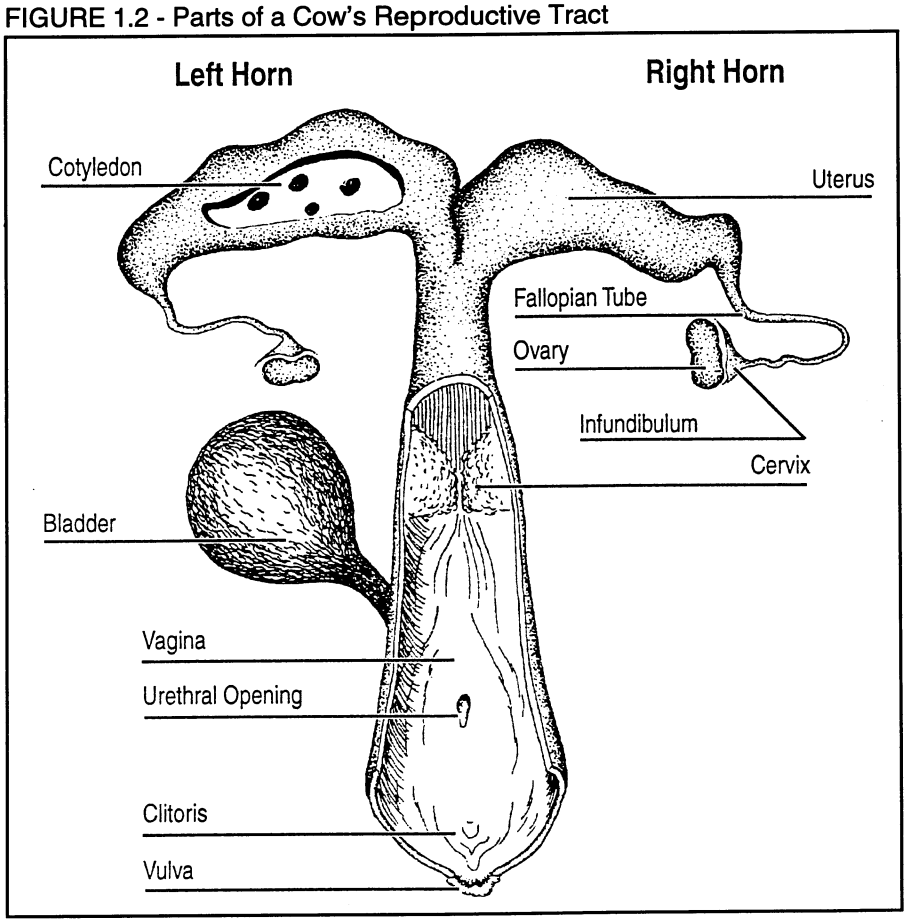
On a stallion, the scrotum is less pendulous than a bull's. In a relaxed state, the stallion's testes lie horizontally, but in an excited state, the testes become almost vertical in nature. A stallion is without a sigmoid flexure.

Parts and Functions of the Female Reproductive System

The bladder's sole function is to store urine in the female. The urethral opening is the bladder's opening into the reproductive tract. The vulva is the external opening of the urinary tract and the female reproductive tract. (See Figure 1.2.)

The ovary is the structure that produces the egg or ovum. The ovary is connected to the Fallopian

FIGURE 1.2 - Parts of a Cow's Reproductive Tract



tube by the infundibulum. Then, the Fallopian tube carries the egg or ovum from the ovary to the horn of the uterus.

Twelve hours after the estrous cycle is completed, the ovary releases the ovum or egg into the upper third of the Fallopian tube, where fertilization occurs if the egg unites with sperm. The fertilized egg empties from the Fallopian tube into the uterus, where the fetus begins to develop. The cotyledon is used as an attachment point for connecting the placenta to the uterus.

When fertilization occurs, the cervix acts as a plug for the uterus. Once the fertilized egg empties into the uterus, the cervix closes, completely sealing the uterine cavity from the vagina. This closure protects the fetus from bacterial and foreign invasions. The cervix liquifies shortly before the birth, allowing the fetus to be expelled from the uterus.

The vagina is the female organ where semen is deposited at copulation. Semen is deposited at different places, depending on the class of livestock and the copulation process. Semen can be deposited as far in as the uterus. Like the cervix, the vagina dilates during the birth process to allow the fetus to be born.

Located in the vulva, the clitoris is the sensory organ allowing the penetration of the male penis. This sensory organ allows copulation to occur and is stimulated during the estrous cycle.

Summary

A good knowledge of animal reproduction helps people in livestock production and related occupations understand the complexity of this process. Knowing economically important reproductive traits is a necessity for a person in this field.

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Lesson 2:
Reproductive Hormones

The reproductive system of livestock is highly influenced by certain hormones. Therefore, to better understand the reproductive system, it is important to know the reproductive hormones and their functions.

Female Reproductive Hormones

Estrogen - The ovaries produce estrogen, which signals the rest of the reproductive system to prepare for ovulation. Estrogen is responsible for female sex characteristics. It causes uterine growth and contractions, as well as mammary duct system growth.

Estrogen's main role is to control the estrous cycle. When heat signs are especially obvious, the blood has a high level of estrogen. As the hormone's level decreases in the bloodstream, heat signs also decrease.

Progesterone - Progesterone is produced by the corpus luteum. The corpus luteum is a scar-like structure produced immediately after ovulation by an increase in follicular cells from the cavity left by the vacated egg. Progesterone prepares the uterus for pregnancy by reducing uterine movement and promoting nurturing secretions. Progesterone also blocks the release of the follicle-stimulating hormone from the pituitary gland. If pregnancy does not occur, the corpus luteum regresses (returns to its original form) and stops progesterone production. Progesterone is responsible for blocking the estrous cycle. It also stimulates alveolar growth in the mammary glands.

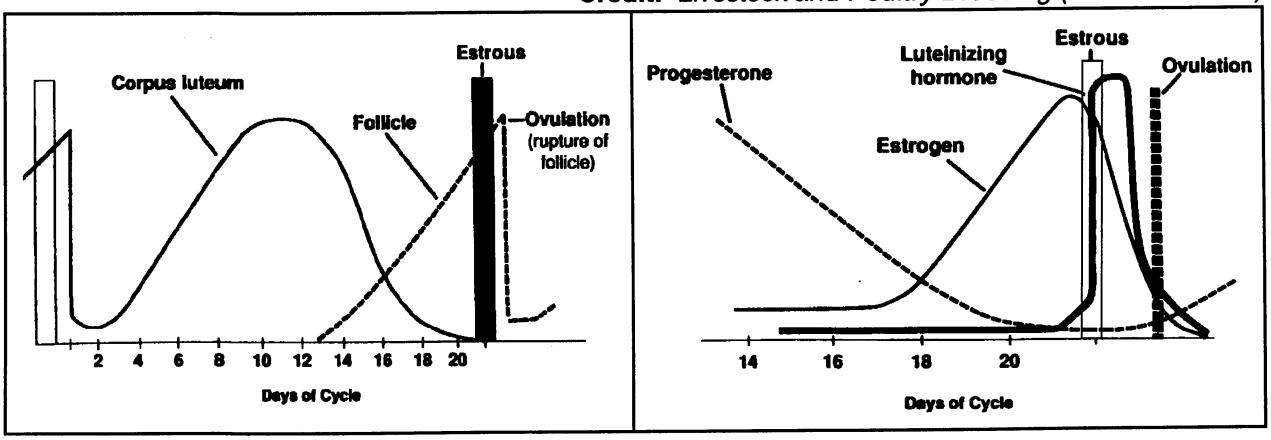
Follicle-Stimulating Hormone (FSH) - FSH is produced by the anterior pituitary gland. FSH causes growth of the follicle (part of the ovary that contains a mature egg). FSH is produced midway between the heat periods.

Luteinizing Hormone (LH) - When FSH production ceases, the anterior pituitary gland produces LH. LH travels to the ovary and causes the follicle to rupture, which causes the egg ovulation (release). After releasing the egg, the follicle collapses. LH continues to affect the ovary, and cells begin to grow in the void left by the ruptured follicle. The corpus luteum then takes the follicle's place, thus stimulating the production of progesterone.

Oxytocin - Oxytocin is produced by nerves in the brain and stored in the posterior pituitary gland. This hormone causes milk ejection and egg expulsion. It also causes uterine contractions. Oxytocin is often given to induce birth or to increase milk let-down in lactating mothers.

Relaxin - Relaxin is produced in the corpus luteum in most livestock, except for the mare, where it is produced by the placenta. This hormone causes the relaxation of ligaments and cartilage in the pelvis and dilation of the cervix, which assists in birth.

FIGURE 2.1 - Normal Estrous Cycle Development and Hormone Levels (Cattle)
Credit: *Livestock and Poultry Breeding (Student Manual)*



Prolactin - Prolactin is produced by the anterior pituitary gland. It initiates lactation and induces maternal behaviors.

Prostaglandin f-2-alpha - If fertilization does not occur, the uterine lining starts secreting the hormone prostaglandin. This hormone causes destruction of the corpus luteum, a reduction of progesterone secretion, and therefore an increase in FSH secretion. At this point, the estrous cycle begins again.

Male Reproductive Hormones

Testosterone - Testosterone is produced in the tissue of the testes. As the male matures, increased testosterone levels in the bloodstream trigger the development of the sex glands and secondary sex characteristics, including an aggressive nature and heavy muscling (especially around the neck and shoulders). Testosterone also controls the male's sex drive or libido. This hormone causes the maturation of sperm cells and the production of seminal plasma.

Follicle-Stimulating Hormone (FSH) - FSH is produced in the anterior pituitary gland. This hormone stimulates sperm production in the male (spermatogenesis).

Luteinizing Hormone (LH) - LH is also produced in the anterior pituitary gland. LH causes testosterone production in the tissues of the testes.

Summary

Hormones are chemical compounds that help regulate body functions. Hormones have a tremendous effect on the reproductive cycles of livestock. They control the development of sex characteristics, mating, and eventually fertilization. Therefore, hormones control the entire life cycle of livestock.

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Lesson 3:
Reproductive Cycles of Common Livestock

In humans, puberty occurs when male and female characteristics become more prominent than in the adolescent stage. Puberty begins with the release of hormones into the bloodstream. These hormones stimulate growth of the reproductive organs. Like humans, animals reach puberty in the same manner. Animals mature at a much faster rate than humans, however. Most production livestock species have reached puberty by the first year of life.

The Age of Puberty

In most classes of livestock, the initial sign of puberty in the female is the first estrous cycle. Puberty can be delayed by a poor nutritional diet or poor environmental conditions.

Cattle - A heifer's first estrous cycle can begin at 8-12 months old. The age difference depends on the breed, nutritional factors, and environmental factors. Smaller breeds usually mature faster than larger breeds.

The bull shows signs of puberty with the production of viable sperm and the desire to mount (about 8-12 months old). Both these indications are influenced by the hormone testosterone. The desire to mount can appear earlier in age, but usually viable sperm are not present.

Heifers are usually mated at 13-14 months or when they weigh 600-650 pounds. The age at which to breed is usually based on the producer's preference. The heifer's condition influences the time to breed. An older bull can service more females than a yearling bull.

Sheep - The first sign of puberty in the female is the estrous cycle, which can begin at 8-10 months. The beginning of the estrous cycle depends on the type of breed, nutritional requirements, and environmental conditions. In general, mutton breed ewes usually have their initial estrous cycle in the fall of their first year. Ewe lambs are somewhat slower reaching their sexual maturity than ram lambs.

The first signs of puberty in the ram are the production of viable sperm and the desire to mount. Testosterone released into the bloodstream influences sexual maturity in the male. These signs of puberty generally occur at 5-7 months.

Generally, young ewes are bred after they are 12 months old so that they lamb before 24 months of age. As in cattle, producer preference and the condition of ewe lambs determine the breeding schedule. Rams used for service before they are yearlings usually service a small number of females. After the rams have reached yearling age, they can service larger numbers of ewes.

Swine - A similarity between swine and other classes of livestock is that the first sign of puberty in the female is the first estrous cycle at 4-8 months of age. The wide age range depends on the type of breed, environmental conditions, and especially nutrition. All these differences can lead to a delay in puberty in swine. Nutrition is important in swine sexual maturity. If gilts receive a poor nutritional diet, puberty can be delayed dramatically. Gilts should reach 180 lbs. before 8 months of age. Most gilts do not begin their first estrous cycle until they weigh 180 pounds or more.

The first signs of puberty in the boar are the production of viable sperm and the desire to mount. Again, the desire to mount usually comes before the production of viable sperm. The first signs of puberty generally begin at 4-8 months. In general, boars reach their sexual maturity later than gilts. Gilts are usually bred to farrow at 11-12 months. In swine, breeding gilts largely depends on development, not age. A general rule is to breed gilts when they reach a weight of 225 lbs., instead of when they reach a certain age. Boars can begin service at 8-12 months. Younger boars service a smaller number of females in the earlier stages of their sexual maturity.

Horses - The ages of sexual maturity are very similar in horses. Both the male and female reach puberty at 12-15 months. As in other classes of livestock, the first signs of puberty in horses are the first estrous cycle and the production of viable sperm with the desire to mount.

Mares are bred based on their maturity level. Well-developed mares have been bred as early as 2 years old to foal when they are 3 years old. The best time to breed mares is when they are 3 years old so they foal when they are 4 years old. Stallions are ready for service when they have reached sexual maturity.

Estrous Cycle

Before puberty occurs, the female reproductive tract and ovaries grow slowly and show no functional activity. The growth of the reproductive tract seems to parallel the increase in body weight as the animal gets older. As puberty nears, the anterior pituitary gland releases FSH (follicle-stimulating hormones) into the bloodstream. FSH stimulates follicle growth in the ovary. As follicle growth occurs, ovarian weight increases and estrogen (a female sex hormone) is released. This release is triggered by a hormone called LH (luteinizing hormone), which is also produced by the anterior pituitary gland. The LH ruptures the follicle and releases the egg, which is called ovulation. Once this has occurred, the animal has reached puberty.

Puberty is reached at different ages, depending on the species. The estrous cycle or heat period begins when the female is willing to accept the male for mating. The cycle begins with release of estrogen from the ovaries, and the egg is ovulated. The length of the heat period, distance between heat periods, and release of the egg are different in each class of livestock. Table 3.1 shows the differences for each class of livestock.

Outward signs of heat - Successful, practical artificial insemination requires that a person's judgment be substituted for a sire's instinct. This is difficult, but not impossible if one is diligent. Similar conditions to some of those described below for finding cows in heat are often observed in other classes of livestock.

Cows in heat are affected by a sudden, high-level presence of the female or "heat" hormone (estrogen). The egg-containing follicle which produces the hormone is at the height of its growth.

The cow's nervous system is greatly affected; she is excitable and may bawl excessively. She is restless and often walks the fences. The producer who knows the cows well can often recognize heat by the alert, bright-eyed, nervous appearance shown by cows during this period.

Cows in heat attempt to ride other cows and stand to be mounted by other cows. Under natural conditions, they would stand and accept service by a bull. Standing is the only reliable, practical test for heat. When a cow stands, she is in heat and is ready for service.

Ruffled hair over the tail head suggests that a cow has recently been ridden; she may or may not have been in heat. Many heifers and cows in heat flatten themselves down in the loin region. This presents a "sway back" and "high tail head" appearance.

The sex hormone from the ovary also has an effect upon the genital organs. Genital mucous may flow from the vulva in long strings. Wet mucous smears are often seen on the buttocks, over the pin bones and under the tail. Also, the

TABLE 3.1 - Differences in Estrous Cycles

Type of stock	*Length of heat period*		*Interval of heat period*		*When egg is released*
	Range	*Average*	*Range*	*Average*	*Time*
Cattle	6-30 hrs.	16-20 hrs.	19-23 days	21 days	12 hrs. after estrous is completed
Sheep	20-42 hrs.	30 hrs.	14-20 days	16-17 days	24-30 hrs. after estrous cycle is completed
Swine	1-5 days	2-3 days	18-24 days	21 days	36-40 hrs. after onset of heat
Horses	2-10 days	4-6 days	10-37 days	21 days	In latter part of the estrous cycle

vulva of a cow in heat appears somewhat swollen.

On the second or third day after heat (or earlier), bloody mucous passes from the cow's vulva. This may be smeared on the buttocks, on the tail, or in a pool behind the cow after lying down. Bleeding from the cow means that she has been in heat (ovulated) 2-3 days before.

To ensure accurate results for an artificial breeding program, check for heat at least twice each day.

Spermatogenesis in Livestock

Spermatogenesis is the production of sperm within the seminiferous tubules in the male testes. This process occurs through meiosis, mitosis, and metamorphosis. Spermatogenesis starts with spermatogonia, which carry both sets of chromosomes (XY). Spermatogonia are sex cells in the form of immature sperm. Spermatogonia become mature sperm through spermatogenesis.

Mitosis is a form of cell division in which one cell divides into two separate cells, both containing two complete sets of chromosomes. In meiosis, sex cells divide and split the chromosome number in half. The spermatogonia have two X chromosomes and two Y chromosomes. Spermatogonia first divide during mitosis and make an identical cell with two X chromosomes and two Y chromosomes. A cell having two X chromosomes and two Y chromosomes is called a diploid. In the first meiotic division, the diploid is split in half, creating a haploid. A haploid has only one X chromosome and one Y chromosome.

The spermatogonium goes through a second meiotic division where the first haploid divides into a second haploid. Once this division occurs, the new haploid is left with either an X chromosome or a Y chromosome. The new haploid has either an X chromosome or a Y chromosome, not both. This is important because it determines the sex of the offspring.

Before the second haploid becomes a mature sperm, it must go through a metamorphosis (change). Then, the haploid receives a head and a tail to move through the female reproductive tract. Once this metamorphosis occurs, the haploid is a mature sperm. An X chromosome sperm that reaches the egg first determines a female offspring, while a Y chromosome sperm determines a male offspring. The whole process of spermatogenesis takes about 46-49 days to occur.

Gestation Lengths

Gestation or pregnancy period is the length of time between fertilization and the birth of the offspring (parturition). To understand gestation, begin with the ruptured follicle that released the egg. This ruptured follicle develops into an endocrine gland called the corpus luteum. The endocrine gland produces hormones for the reproductive system, while the corpus luteum produces a hormone called progesterone, which maintains pregnancy in livestock.

Once the egg is fertilized, it floats freely in the uterus for a short time. Then, the fertilized egg begins development of the placenta. The placenta is attached to the uterus by the cotyledons, which hold the placenta in place for the remainder of the gestation period. Gestation lengths vary from one class of livestock to another. Table 3.2 shows the differences of gestation lengths in each class of livestock.

TABLE 3.2 - Gestation Length

Livestock class	*Range (days)*	*Average (days)*
Cattle	240-330	283
Swine	111-115	114
Sheep	144-152	148
Horses	315-350	336

Summary

It is especially vital for a livestock producer to understand the reproductive cycles of livestock. This understanding helps in AI programs, hand or pasture mating, determining the number of females per male, the age at which to breed young stock, and record keeping.

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Lesson 4:
Fetal Developmental Stages

The livestock industry relies on the production of quality animals to ensure a quality product for the consumer. The production of such animals begins with proper care of the developing fetus and its mother. Understanding developmental stages of livestock enables the producer to ensure the delivery of healthy young.

TABLE 4.1 - Timetable of Calf Development

Time (days)	Development
	First trimester
0	Fertilization in oviduct
4	Embryo (in eight- to 16-cell stage) reaches uterus.
8-11	Embryo transfer possible
12	Embryo forms weak attachment to uterine wall.
18	Amnion encloses embryo.
21	Heart begins to beat; reproductive tract begins to develop.
23	Head region is recognizable.
25	Forelimb buds appear.
30	First placental plates appear.
33	Fragile cotyledonary attachment forms.
37	Facial features appear.
46	Developing animal is now a fetus.
60	Eyelids can close.
	Second trimester
100	Horn pits appear.
110	Tooth development begins.
	Third trimester
230	Hair covers the body.
283	Birth

Developmental Stages of the Livestock Fetus

Animal life begins as a single cell (the fertilized egg). Through the processes of cell division, the cell multiplies and develops into a mature animal. Growth includes all of the physiological processes that allow the fertilized egg to develop into a many-celled animal.

Growth - Animal growth occurs because of an increase in both the size and number of body cells. The increase in the number of cells is called hyperplasia, while the increase in size of cells is hypertrophy.

During embryonic growth, all cells increase in size and number. However, in the adult animal, there are three different types of cells. Permanent cells, which include muscle and nerve cells, stop dividing or increasing in number early in prenatal life. Stable cells continue to increase in number and size throughout most of the postnatal growth stage and until the animal reaches maturity.

Prenatal growth - Growth/development before birth or hatching is one of two types of growth in livestock. This period involves the time between the fertilization of the ovum by the sperm (the formation of a zygote) and birth. The embryonic growth period includes early stages of prenatal growth and development. After fertilization, the zygote begins as one cell that contains chromosome pairs, one each from the mother and father. The zygote's single cell then begins a series of divisions into two cells, then four, then eight, etc. The cell division rate varies with different species of animals.

In the first stages of its life, the newly fertilized egg free-floats in its mother's reproductive tract. This embryo spends the first few days traveling in the oviduct toward the uterus. By the time it reaches the uterus, 16 or more cell divisions have taken place within the cell wall of the egg. Also, the hormone progesterone has prepared the uterus to care for the new animal. The egg's cytoplasm provides the necessary energy for cell division until the egg reaches the uterus.

After reaching the uterus, the egg continues to free-float and absorb nourishment from fluids in the uterus. This free-floating period lasts as long

as 30 days in the dairy cow and the mare, but is somewhat shorter in other mammalian livestock.

During this time, the embryo surrounds itself with a set of membranes. These membranes form a sac of fluid to keep the embryo moist and act as a shock absorber. These extra membranes and fluid (known as the placenta or afterbirth) attach to the rich uterine lining.

In hogs, the entire placenta attaches to the entire surface of the uterus. In sheep, horses, and cattle, there are cotyledons (button-like spots on the placenta) that attach to caruncles (spots) on the uterus. These points of attachment, along with arteries and veins in the umbilical cord, provide the calf with nourishment from the mother and waste disposal. Until birth, the embryo has its own blood circulation system plus the external (mother's) system, which passes through the umbilical cord.

Swine also have another reproductive characteristic that is unique compared to cattle, sheep, and horses. Swine are polytocous (litter bearing) animals producing multiple ova, which can all be fertilized to produce multiple births. It is not unusual for sows to ovulate 15-20 ova during an estrous period. This is the main reason why the entire placenta is attached to the entire surface of the uterus in swine.

Morphogenesis - The cells in the developing embryo go through a process of differentiation in which the cells organize into specific structures.

TABLE 4.2 - Timetable of Chick Development

Time (days)	Development
3	Blood circulation between embryo and yolk is established.
5	Sex can be determined.
8	General outline is recognizable.
8-9	Lungs, nervous, muscular, and sensory systems are in place.
10-11	Embryo is covered with down and first feathers.
21	Hatching occurs.

This differentiation of cells into organs and tissues with a specific purpose is called morphogenesis. It begins with the cells dividing into three basic layers: the ectoderm (outer) layer, the mesoderm or middle layer, and the endoderm (inner) layer.

The ectoderm develops into the brain and other parts of the central nervous system, skin, hair, wool, hooves, and certain endocrine glands. The mesoderm develops into both voluntary and involuntary muscle tissue; the heart and other parts of the circulatory system; and connective tissue, such as bone, cartilage, ligaments, and tendons. The endoderm develops into the liver, digestive system, and other endocrine glands.

Body organs and tissues are formed in a specific sequence. For example, the head forms before the tail, and the beginning of the spinal chord forms before other organs. This process continues until all body organs and tissues are formed.

Highly differentiated cells, such as the brain, cannot be replaced if destroyed after the original number is fixed during the fetal stage (second stage of prenatal growth and development). Therefore, seriously damaged nerve cells are not replaced and usually remain damaged. Muscle cell numbers are also fixed during the fetal stage and increase only in size after birth. Bone tissue grows both before and after birth.

The rate of prenatal growth in livestock varies among species. For example, the length of gestation in pigs is 111-115 days, while in horses it is 315-350 days. Although the rate of prenatal growth varies, most livestock are born with a fairly equal degree of maturity.

Development of Embryo During Incubation

In birds, the process of incubation (causing something to develop or take form) corresponds to gestation in mammals.

Terminology - The amnion is the sac that surrounds the embryo. The chorion is the lining between the egg shell and the internal portion of the egg. Allantois refers to the part of an egg that stores excretory wastes; it fills the space between the amnion and the chorion.

Incubation - When fertilization occurs in poultry, the embryo begins development around a well-defined germinal disk. This area is clearly visible to the naked eye when a freshly laid, fertilized egg is broken. Within 48 hours after fertilization, a chick embryo establishes an intricate blood circulation system between itself and the life-sustaining yolk. (See Table 4.2.) Since there is no placenta, as in mammals, the poultry embryo has to develop on this circulation network to provide nutrients and remove waste products.

By the end of the third day, the embryo has a full set of membranes. The allantois, which stores excretory wastes, fills the space between the amnion and the chorion. Later, the allantois merges with the chorion to form the chorio-allantois, which expands and contacts the shell membrane. The chorio-allantois serves as the respiratory organ for the developing embryo until the pulmonary organ takes over about 24 hours after hatching. The shell and the membranes also protect the developing embryo from harmful microorganisms or molds.

As in mammals, the embryo floats within fluid in the amniotic cavity. The developing embryo is protected by this floating movement, and it must continue until the last 3-4 days before hatching. Without this movement, malformations can occur that endanger the life of the newly hatched chick. In an incubator, the egg must be turned several times a day to prevent adhering of the embryo to the chorio-allantois membrane. Under natural conditions, the hen instinctively shifts the egg several times a day.

Physical factors - Several physical factors are critical for adequate levels of egg incubation and hatching.

1. Temperature - To have most of the chick embryos survive, store the eggs for a maximum of seven days at 60°F outside the incubator. This allows for development processes to continue without adverse effects after the eggs are placed in the incubator. With some minor differences between breeds, a temperature range of 98-104°F within the incubator is best.
2. Humidity - Since the egg is approximately 70 percent water, it is important to maintain a certain humidity level to prevent water loss. Pre-incubation storage of hatching eggs should be at 85 percent relative humidity; during incubation, store eggs at 60-65 percent humidity. This water allows for excretion of the embryo's metabolic wastes and serves as a heat regulator, much like a car radiator transfers heat through water.
3. Air velocity - Although the rate of moving air in an incubator does not appear to have much influence on hatchability, a constant supply of fresh air is necessary for the developing embryo.
4. Energy supply - The egg represents a highly concentrated form of energy provided by the hen. This stored energy is extremely important for the developing embryo during incubation *and* in later stages. Embryo development uses 25 percent of the egg's energy; the rest is incorporated into the developing chick.

Nutritional Requirements During Pregnancy and Lactation

Cattle - The period during which the calf crop is affected most by nutrition extends from 30 days before calving until 70 days after calving. The nutritional needs of nursing cows are higher and more critical than those of pregnant cows. After a cow has calved, her energy needs jump about 50 percent; her protein needs double; her calcium and phosphorus needs triple. Compared to during pregnancy, she needs approximately 50 percent more feed for milk production.

During the last trimester, the nutritional requirements are higher than in an open female because of the requirements of the growing fetus.

Sheep and goats - In general, feeding a suitable, well-balanced ration with necessary minerals and vitamins will ensure a strong, healthy lamb crop. During the last 4-5 weeks before lambing, the fetus develops rapidly and demands on the ewe are heavy. Ewes should be fed 0.5-1.0 pounds of grain per head daily during this time.

Following lambing, the feed allowance of the ewe should be increased according to her capacity and needs. Though varying somewhat with size and condition of the ewe (and whether she is raising

twins or a single lamb), an adequate ration can consist of 4 pounds of high-quality alfalfa hay plus 1-2 pounds of grain daily.

Swine - About two-thirds of the fetal growth occurs in the last month. During gestation, it is important that body reserves be stored for lactation. Feed should be increased to 4-5 pounds daily. However, sows should not be overfed because fat sows have farrowing difficulties. Four to five days before farrowing, it is a good practice to decrease feed intake and feed a bulky, laxative feed.

Nutrient requirements of a lactating sow are more rigorous than requirements during gestation. The lactating sow should be fed 2.5-4.5 pounds daily for each 100 pounds of body weight.

Summary

Although gestation periods of various species of livestock differ, the stages of fetal growth and the effects of gestation on the mother are very similar. The growth of the fetus is just more rapid when the length of gestation is shorter. To ensure a safe pregnancy and healthy offspring, it is important to make management changes that relieve stresses placed on the mother during gestation.

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Lesson 5:
Effects of the Environment on Reproduction

Plant *and* animal growth are affected by the photo period, environmental conditions, and fertilization requirements. Both plants and animals are affected by the length of daylight hours. Like plants, animals that do not receive the correct amount of nutrients have reproductive (growth) problems. Like plants, livestock reproductive difficulties become more apparent during extreme environmental conditions. If animals cycle naturally and receive adequate nutrition and temperature, they will also reproduce abundantly.

Effects of Nutrition and Body Condition

Nutritional diet - Nutrition is related to several reproductive difficulties in female livestock. These difficulties seem more prominent in younger females than mature females. Older females have built up reserves within their bodies to pull from, but younger females do not.

Longer breeding and calving seasons can occur from poor nutritional diets. Because of deficiencies in their diet, a smaller percentage of females come into their heat period in the first 21 days after calving. Frequently, nutrient-deficient females will be less synchronized in their heats. This disturbance could result in a longer breeding and calving season. A low percentage of females conceive on the first service by the sire. Nutrient-deficient females have lower conception rates on the first estrous cycle.

Worse yet, poor nutrition can cause more calving deaths at birth (parturition) and in the first two weeks after birth, which results in extreme losses for that year. Since all these difficulties can be prevented through a proper nutritional diet, producers can control their own destiny.

Livestock producers must be aware of nutritional requirements for females during lactation, gestation, and the pre-breeding period. Most reproductive failures are caused by deficiencies in one or more nutrients during the 100-day period before birth and the days immediately following birth. Critical nutritional deficiencies during this 100-day period will determine the conception rate and calving difficulties during the next breeding season.

Flushing is a nutritional technique used by swine and sheep producers to prepare breeding stock for the breeding season. Flushing keeps sows and ewes on a full feed ration to allow the body and reproductive tract to build back up before the next breeding. If this method is used, reproductive problems associated with nutrition will be reduced.

Energy is more important than protein when it comes to reducing reproductive problems. Livestock receiving inadequate levels of energy have more reproductive difficulties. Diets containing low levels of phosphorus have a reduction in the calf crop. Low phosphorus diets usually occur in the range land in the western states, where forages have lower levels of phosphorus. Heifers on a dry forage diet benefit from supplements of vitamin A.

The amount and type of feedstuffs fed before and after calving determine conception rate and proper timing of heat periods for the next breeding season. Feed requirements increase after calving, so feeding allowances must parallel this need. If not met, the female will have severe weight loss, which will delay the heat cycle and decrease conception rates.

Body condition - The female's condition also affects reproductive difficulties. During gestation, the female's condition determines reproductive difficulties for the next breeding season. An average conditioned cow should have a minimum gain of 100 lbs. during gestation. After calving, an average conditioned cow should gain $^1/_2$ to $^3/_4$ lb. daily to build up reserves for the next breeding season. A cow in thin condition should also have a 100 lb. minimum gain during gestation, but it should gain $1^1/_2$ to 2 lbs. daily after calving to build up reserves for next breeding season.

In reality, the condition of the female body during gestation and after birth applies to all classes of livestock. Adequate gains can be achieved through a proper diet and quality feedstuffs. A proper diet during these periods will produce healthier offspring, lower mortality rates, quicker breed back, and longer female productive life. The

principles of nutrition apply to all classes of livestock; only the numbers will be different.

In females that have not reached puberty yet (prepubertal), a restricted or nutrient-lacking diet can delay puberty or cause hypoplasia. Hypoplasia is the defective or incomplete development of reproductive organs; it is usually the reason reproductive organs remain below normal size. Nutritional disorders can be detected in females by the lack of an estrous cycle. A proper diet can solve prepubertal disorders if the problem is caught in time.

Effects on sires - Nutritional deficiencies also affect the reproductive efficiency of the male. Younger sires are affected more than more mature sires. Older sires can go many months on a poor or deficient diet without reducing sperm numbers. These mature sires use body reserves to maintain proper sperm production.

A poor nutritional diet can delay puberty and can be fatal if the nutrient deficiency is extreme enough. A nutritional deficiency in younger sires can cause irreparable damage over prolonged periods of time. This damage results in reduced testes size, low sperm production, and sperm replenishment.

Effects of the Photo Period

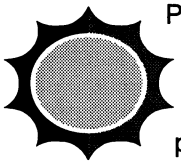

Photo period refers to the length of daylight. Corn, for example, needs a certain number of daylight hours to grow normally. Like plants, animals' reproductive cycles are influenced by daylight. Imported livestock breeds had to adjust to new environments, as did their reproductive cycles. Sometimes, these new breeds never adjusted to the new environment and they could not reproduce in this country. All classes of livestock are influenced by the photo period, although some are affected more than others.

Beef - Cattle are considered continuous breeders. Most beef producers aim for calving during September, October, and November, so the breeding season is during the months of January, February, and March.

Hogs - Swine are also continuous breeders. For this reason, most confinement pork producers plan breeding systems to keep their farrowing houses full year-round. For producers farrowing twice a year, breeding systems are more influenced by heat, funds available, and available feeds, not by photo period. Feed costs aren't significant in breeding swine since they are continually fed.

Horses - Sometimes, horses are considered continuous breeders. The breed usually has a greater influence on the reproductive cycle than the photo period. Since most equine breeds originated overseas, environmental conditions influence the timing of the reproductive cycle. Horses tend to show more sexual activity during the spring months.

Sheep - Although not considered continuous breeders, some sheep breeds can produce more than one lamb crop per year. Generally, sheep have a set breeding season stimulated by the photo period. Estrous cycles in sheep usually begin in September and end in March. The Dorset breed has the longest breeding season (June through April). If managed correctly, Dorsets can have two lambing seasons. Sheep are heavily influenced by the shortening of day hours.

Poultry - The early ancestors of poultry only laid eggs in the spring months. Through selection and improved management techniques, poultry now lay eggs continuously. Photo period has the greatest influence on poultry than on any class of livestock because the bird's eye is sensitive to light intensity. The optic nerve is responsible for detecting light intensity. When light intensity increases, activity in the pituitary gland increases. This pituitary gland activity continues hormone production, which stimulates the reproductive cycle. Continuous light in hen houses is the sole reason for continual laying by hens.

Temperature's Effects

Females - Environmental temperatures affect the reproductive cycle in livestock in many ways. Heat stress causes several problems in the female reproductive cycle. Extreme heat can delay the estrous cycle in many classes of livestock, especially in sheep. Remember, most sheep have a limited breeding season. Sheep do not begin

showing signs of heat until late summer and early fall. Ewe lambs show the first signs of puberty in the fall of their first year.

Extreme heat influences offspring weights at birth by causing the female to expel more energy to cool her body than she provides to the offspring. Also, extreme heat causes a loss of appetite in animals, which decreases the amount of feed intake. This reduced feed intake lowers the amount of nutrients supplied to the offspring.

During the last trimester, extreme heat conditions can be detrimental. Extreme heat conditions contribute to abortions, fetal deaths, low birth weights and litter sizes, and abnormalities in offspring. The size of the placenta is reduced under extreme heat conditions, which can cause birthing difficulties.

Extremely cold temperatures usually do not have as much impact on reproduction as extreme heat. When extremely cold conditions do arise, the only factor that usually develops is a lower birth weight, since the female uses more energy to control body temperatures than it contributes to the offspring.

Males - The male's reproductive ability is affected by environmental conditions to a smaller degree. The production of testosterone is not influenced by extreme environmental conditions, but there can be some fluctuations in sperm production and abnormalities due to extreme heat periods.

There are seasonal variations in sperm production in males, but they have little effect on the reproductive efficiency of sires like extreme heat conditions do. The number of females serviced during extreme heat conditions is reduced because sires become exhausted more quickly. The testosterone levels are there, but the desire to mate is greatly reduced because of the extreme heat conditions.

Extremely cold temperatures do not have an affect on male reproduction because breeding seasons usually do not occur during these months.

Summary

For people associated with livestock production, it is vital to have a solid knowledge base of factors influencing the reproductive cycle. One must produce the greatest number of offspring to sustain a profit in the operation. Knowing that photo period, nutrition, and environmental conditions influence livestock reproduction will greatly improve monetary success for a producer.

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Lesson 6:
Management and Technology in Reproduction

The advancement of the livestock industry is due largely to the great strides made in improving the management and technology available in reproduction. Understanding these techniques and their effects greatly increases the success of livestock producers.

Artificial Insemination

Artificial insemination (AI) is the introduction of male reproductive cells (sperm) into the reproductive tract of a female by artificial means. The origin of AI is unclear, but an Arabian legend dating to 1322 maintains that the method was first used by a chieftain who had stolen the "seed" of an enemy's stallion to deposit into his own mare.

The first scientific research about AI of domestic animals was conducted on dogs by the Italian physiologist, Lazarro Spallanzani, in 1780. By the late 1800s, American veterinarians used it to get mares in foal that consistently did not settle by natural methods. AI has been in practical use successfully in the U.S. since the 1950s. In 1988, more than 65 percent of the nation's dairy cattle were artificially inseminated. AI is becoming increasingly popular in other classes of livestock, as well.

Benefits from AI - There are several advantages of using artificial insemination.

1. Through the use of AI, many more animals are bred to superior males selected on the basis of similar traits. These traits are often economically important or considered to be aesthetically pleasing. This provides greater uniformity in a breeding program.
2. With reasonably priced semen, the value of progeny produced exceeds the costs of semen and service. The offspring of outstanding sires are usually higher and more efficient producers--more profitable than other offspring.
3. It helps control disease. AI is a valuable tool in preventing and controlling the spread of venereal diseases. Also, reproductive problems in females are more easily detected.
4. AI improves herd records. The sires and breeding dates of each offspring are known. Thus, improved culling and management result from closer herd records and observations.
5. AI allows the development of genetically superior animals in a more timely manner. For example, in the cattle industry, the semen from a superior bull can be used through AI to service as many as 20,000 cows per year. Using natural service, this same bull would only be able to service approximately 60 cows per year.

Limitations of AI - Although there are many advantages to using AI, there are also some limitations.

1. Successful AI requires a skilled and conscientious technician. Adequate training is a must for any person performing this technique.
2. Just as superior genetics are passed to the next generation in a more timely manner, inferior genetic traits are perpetuated, as well. Often, selection *for* one trait can lead to selection *against* another.
3. There is some potential for abuse (e.g., improperly labeled semen).
4. AI requires more time and management knowledge. Proper heat detection of the female takes a great deal of time and knowledge. Also, because of the extra handling for palpation and insemination of each individual, extra labor and facilities are needed.

Semen collection - The most popular means of semen collection is through the use of an artificial vagina (AV). An AV is constructed to mimic natural copulation. It consists of an outer tube with a thin rubber lining. Water that is warmed to body temperature is used to fill the space between the lining and the outer tube. The liner is often lubricated, and one end of the AV is left open for entry of the penis. The other end has a small collection vesicle, usually a test tube, for the ejaculated semen.

Most sires can be trained to use cows, steers, or dummy mounts. The artificial vagina is forced over the erect penis when it tries to penetrate the dummy (or other mount). When filled, the test tube is removed and taken to a processing lab, where the semen is processed.

Electrical stimulation in conjunction with the artificial vagina is the second most common way to collect semen. The electro-ejaculator produces an electrical impulse to stimulate the nervous system, causing erection and ejaculation. Electrodes are placed in the bull's rectum, and low-power stimulations are given until semen is produced. This method is generally used to obtain semen samples for fertility testing or when a mounting dummy is not available.

Semen testing - Semen density is tested to estimate the number of sperm in the semen. Next, the semen is examined under a microscope. A drop of fresh semen is placed on a glass slide. The observer notes what percentage of the sperm move. If 80 percent or more of the sperm move, the "percent motility" is excellent; 70 percent is good; 50-60 percent is fair. Rapid forward movement is desirable.

Extending semen - Millions of sperm are ejaculated by the male at the time of mating. In natural mating, all these sperm are used to breed one female, although only one sperm of the millions fertilizes the egg. With AI, a male's ejaculation can be extended or diluted so that many more females can be bred with it. This is accomplished by adding materials to the semen that help keep it alive and give the sample more volume.

See Table 6.1 for some common extenders and the classes of livestock for which they are used.

TABLE 6.1 - Semen Extenders

Type of diluent	Animals used for
Egg-yolk citrate	Bull, ram
Egg-yolk phosphate	Bull, ram, stallion
Homogenized milk	Bull, ram, boar
Glycine-containing diluents	Boar

Antibacterial agents are added to the extenders to help control bacterial growth. To keep sperm alive, it is important that the extenders be added a few minutes after the semen is collected from the male. It is also important that sperm never be cooled suddenly. Thus, the semen and extender should always be near the same temperature.

Undiluted semen will not live much longer than 24 hours at room temperature. By adding diluents and slowly cooling the semen to refrigerator temperature (41°F), the sperm can be kept fertile for nearly a week.

Storage of semen - After special treatment of semen with extenders, the sperm can withstand freezing to extremely low temperatures. Bull semen is often stored frozen, while boar semen does not withstand freezing well and is used fresh.

The basic unit for semen storage and shipment is an individual plastic straw containing enough semen for a single insemination. Each straw is identified with the sire's name and registration number. If the semen can withstand freezing using liquid nitrogen or dry ice in an alcohol bath, the diluted semen with the glycerol added is slowly frozen. When maintained at -320°F until needed for breeding, semen will stay fertile and can be stored for months or perhaps years. Most of the semen is stored in a liquid nitrogen container (semen tank).

General management practices - Some general management practices will increase AI conception rates if they are followed properly.

1. Avoid breeding diseased or infected females.
2. Have females that have been bred 2+ times without conception checked by a veterinarian.
3. Wait at least 60 days after calving to breed cows back.
4. Sows should be bred back 35-50 days after farrowing.
5. All semen collection equipment should be clean and sterile.

Timing of cattle insemination - The rule of thumb that generally provides good conception rates for cattle herds is: Inseminate approximately 12 hours after estrous is completed. Ovulation occurs 12-16 hours after standing heat.

Insemination techniques - To inseminate a cow properly, the inseminating gun must be inserted into the vagina and directed through the cervix before releasing the semen. Learning the proper technique of artificial insemination usually takes three days of concentrated practice on several cows. Following is a brief outline of the AI technique to give a better understanding of the procedure used.

1. Insert the gun with tip pointed upward at a 30° angle into the vagina. This angle keeps the gun from entering the urethra.
2. After the gun tip is inserted into the vagina, place a gloved hand into the anus of the cow to direct the inseminating gun. Next, direct the gun tip through the vagina and into the cervix. Inserting the gun into and through the cervix can be difficult. If the opening of the cervix is difficult to locate, straddle the cervix with the first two fingers of the gloved hand. Pin the cervix to the floor of the pelvis, and locate the opening of the cervix with the thumb.
3. Next, bring the gun tip up until it strikes the thumb. Insert the gun into and through the cervix by using light but steady forward pressure.
4. The cervical channel consists of three cartilage-type rings. Hold the cervix with the gloved hand until the insemination gun is worked through the three rings.
5. After passing through the three rings, the gun will slip forward with little resistance. When this happens, the tip of the gun will be in the uterine body. Since the uterine wall is thin, you should be able to feel the gun tip with the gloved hand. Next, slowly pull back the gun until it is even with the cervical opening. This ensures that the gun tip is inserted only 2" into the cervix. Otherwise, all the semen will be deposited into one uterine horn instead of both.
6. Take about five seconds to deposit the semen slowly.
7. After properly depositing the semen, slowly pull the gun from the reproductive tract. Clean the equipment.

Timing of insemination in horses - The mare's heat period lasts 2-10 days. The egg is ovulated 1-2 days before the end of the heat period.

Artificial insemination techniques in horses - AI has become popular for use in some breeds of horses. AI is not permitted by some horse breed registry associations. If AI is permitted, fresh semen is required by many breed associations. Normally, breed associations will not accept registration for foals conceived from frozen semen. When AI is used, a syringe is attached by a rubber adapter to a disposable insemination tube. Using a sterile sleeve glove, the inseminating tube is inserted directly into the vagina. Then the gloved fingers open the cervix and pass the rod into the uterus to place the semen directly into it.

Sheep - For many reasons, AI in sheep is not widely used in the U.S. outside of research. There are no reliable indicators of the onset of heat in ewes. The ewe has a small and highly folded cervix, making it difficult to deposit semen directly into the uterus. No suitable long-term storage method has been developed for ram semen. No method has been developed for identifying superior sires. The conception rates from a single insemination are not high enough to produce an adequate lamb crop. Most importantly, the additional labor requirements for AI economically outweigh the benefits.

Timing of swine insemination - In swine, the average length of the heat period is 2-3 days, but gilts' heat periods are usually slightly shorter than those of sows. Ovulation occurs about 40 hours after the onset of heat. However, even with daily observation, it is difficult to know precisely when first standing heat occurs. As a rule of thumb, breeding should take place about 12 hours after observing heat and at 24-hour intervals for as long as the female will stand. Allow at least 2-3 services to provide higher conception rates and larger litters.

Artificial insemination techniques in swine - To inseminate swine correctly, follow these steps.

1. Confine the female in a small pen.
2. Put about 100cc of extended semen in a 4 oz. squeeze bottle with a cone-shaped tip. A large syringe can be used, but it is more difficult.
3. Place a few drops of lubricant on the tip of the rubber spirette. Insert the tip into the vulva, pointing it toward the backbone at a 45° to

avoid the opening of the urethra. The cervix is usually 8-10" inside the vulva, but it can be deeper in larger females.

4. When the cervix is located, start rotating the rubber spirette counterclockwise until it becomes "locked" into the cervix.
5. When the spirette is in place, connect the semen container and begin squeezing the semen through the spirette. If the semen starts to run out of the vulva, release pressure, wait a few moments, and start again.
6. When finished, remove the catheter and clean the equipment.

Problems of using frozen semen - On the average, conception rates with frozen semen are 10-20 percent lower than those obtained with freshly collected semen. Also, litter sizes show a reduction of one pig per litter with frozen semen. When freshly collected semen is used, the results are very close to those of natural breeding.

Poultry - Natural mating in broad-breasted turkeys generally results in low fertility rates. For this reason, more than 90 percent of U.S. turkey breeders use artificial insemination in combination with natural mating. The insemination is done with a syringe.

Estrous Synchronization

For AI and embryo transfer, it is important to have a large number of females in estrous at the same time--hence the term estrous synchronization.

There are different advantages to the use of estrous synchronization, depending on the species. For example, horse breeders often strive to breed their mares so that they foal shortly after January 1. The reason for this is that the racing industry considers all foals a year old on January 1, regardless of when they were born during the preceding year. In the dairy industry, estrous synchronization is used frequently to facilitate the use of AI in heifers.

For all species, synchronizing estrous and (ultimately) breeding times shortens the period from birth to conception of the next offspring. For use with an AI program, it increases the number of females to breed at one time, cutting down on time and handling.

TABLE 6.2 - Optimum Breeding Times

Live-stock	Heat length (ave.)	Best time to breed after start of heat
Cattle	18 hours	12-19 hours
Horses	5 days	Third day
Sheep	30 hours	20 hours
Swine	3 days	End of first day

Products Used for Estrous Synchronization

Progestogens - These compounds mimic the hormone progesterone, which is produced by a structure on the ovary called the corpus luteum (CL). Progesterone from the CL controls the timing of estrous by preventing the release of other hormones needed for estrous to occur.

Administering progestogens in oral, injectable, or implant form mimics the action of the CL. Long-term administration (14-21 days) causes the CL on the ovary of the cow to disappear. When the progestogen is withdrawn, the female will typically come into estrous.

In mares, progesterone is effective in suppressing heat in mares that have long and erratic estrous cycles. It has also been used (with less consistent results) to maintain pregnancy in mares with history of abortions.

Prostaglandins - These hormone-like substances are administered to the female to induce the disappearance of the CL, also called CL regression. Regression of the CL causes blood levels of progesterone to fall. This induces estrous within 2-4 days. In all species, the CL is not responsive to prostaglandins early in an estrous cycle; therefore, not all animals would be expected to respond to a single injection.

In 1979, the Upjohn Company of Kalamazoo, Mich., received FDA approval on the use of Lutalyse®, a prostaglandin product, for synchronization of estrous in beef cows, beef heifers, and nonlactating dairy heifers.

Human Chorionic Gonadotropin (HCG) - This hormone, which has been used with some success in horse breeding, stimulates follicles to ovulate. It is most often given when the mare is bred. HCG will normally lead to ovulation of a mature follicle within 48 hours, aiding in appointment breeding (when a stud is being brought in from another farm at a specific date) and helping mares that fail to ovulate.

Syncro-Mate B® - This is the trade name for an estrous synchronization product approved by FDA in 1982. It contains Norgestomet®, a patented, potent, synthetic progestin, and estradiol valerate, a synthetic estrogen. SMB, which is used as an ear implant, is designed to cause cows or heifers to ovulate in a predictable period of time.

Melengestrol acetate (MGA) - This synthetic progesterone suppresses heat in feedlot heifers. A drawback of MGA is that FDA approval is pending. Research has shown that a combination of MGA and prostaglandins can make estrous synchronization practical for cattle producers. Feeding MGA to heifers for 14 days and then following up 16-18 days later with an injection of prostaglandin has resulted in a majority of the heifers coming into heat within five days.

Embryo Transfer

Embryo transfer (ET) is the placing of an embryo into the oviduct or uterus. ET in cattle was developed as a result of research done by Jim Rowson at Cambridge, England, in the early 1950s. The earliest work was done with sheep, then cattle and hogs. The first commercial embryo transfers in the U.S. were done in the early 1970s.

The steps of ET in cattle are:

1. Synchronize estrous in cows that will be used as *donors* of embryos and those that will be used as *recipients* of embryos.
2. Superovulation uses a drug that increases the number of embryos that can be collected from a single female by increasing the number of ova or eggs that she ovulates.
3. Breed the donor cow either through artificial insemination or natural service.
4. Recover the embryos from the donor cow (through a non-surgical method) 6-10 days after breeding.
5. Isolate and characterize each embryo to make sure it is normal.
6. Transfer healthy embryos to the recipient cows, which act as foster mothers.

Pregnancy can be confirmed in the recipient cows by rectal palpation of the uterus approximately 35 days after the transfer. Recipient cows with successful pregnancies from the embryo transfers will give birth to calves that are full siblings. Recipient cows have no genetic influence on the calves they carry. Producers often use recipient cows that are less desirable, grade animals because they make no genetic contribution to the calves that they carry.

The greatest advantage of ET is that it increases the reproductive potential of superior females in much the same way that AI increases the impact of superior males. Both of these reproductive techniques increase the number of offspring from a single valuable animal and the rate of genetic improvement in a herd.

Sexing Semen

Sexing semen determines if the semen contains the X or Y sex chromosome. If the semen contains the X chromosome, it will produce a female; if the semen contains the Y chromosome, it will produce a male.

Being able to obtain semen that has been sexed has great economic importance. Because the dairy producer has little use for bull calves, the use of sexed semen to produce only females would make milk production more efficient. Swine producers could market more pork if they could only produce females because females grow faster than males. The opposite is true in beef cattle and sheep, where males would be desired unless trying to produce replacement females.

Semen is sexed by the amount of DNA present on the X and Y chromosomes. The DNA content of the Y chromosome can be monitored because it contains less DNA than the X chromosome.

Cloning

Cloning of an animal is the production of an exact genetic copy. Cloning usually results from the

splitting of embryos, which produces genetically identical twins.

Summary

There are many management and technological techniques to control or synchronize an animal's reproductive cycle. All of the techniques need to be carefully analyzed before a producer decides whether to use any of them.

Credits

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