Introduction to
Animal Reproduction

Student Reference

10-4030-S

In cooperation with the Agricultural Education Department and the College of Agriculture, Food and Natural Resources University of Missouri-Columbia

Male Reproductive System

In order for a species to thrive, it must be able to reproduce itself. Producing offspring requires the proper functioning of both the male and female reproductive systems, each of which consists of several parts that have specific purposes in the reproductive system. Hormones also play an important role in reproduction. For example, in the male reproductive system, the parts and hormones work together to produce sperm and transfer it to the female.

Parts of the Reproductive System

The male animal possesses special reproductive organs. These organs are similar in all male mammals, although some differences in form and function do exist. The bull can be used to illustrate the male mammalian reproductive system.

Bull – A bull is a male bovine. Its reproductive system contains a number of different parts (Figure 1.1). A bull has two testicles, which are located in the scrotum beneath the animal. An epididymis is located in the scrotum next to each testicle. The epididymis is connected to the urethra by the vas deferens. The seminal vesicles, prostate gland, and Cowper's gland (also called the bulbourethral gland) are located next to the bladder where the vas deferens meets the urethra. The urethra extends from this point to the penis. The sigmoid flexure is located midway along the urethra, which also has a retractor muscle attached to it. The sheath provides an opening for the penis.

Boar – A boar is a male swine. The boar's reproductive parts are pictured in Figure 1.2. One difference between the boar and the bull is the positioning of the testicles and scrotum, which are located at the rear of the boar rather than at the bottom of the animal. The form of the penis, which is shaped like a corkscrew, also differs from the bull's.

Ram – A ram is a male sheep. The ram differs from the bull in that a filiform appendage extends from the head of the penis. In the ram, the sheath is also referred to as a prepuce.

Stallion – In horses, a male is called a stallion. In contrast to the bull, the stallion's scrotum is located further toward the rear of the animal and is less pendulous. The stallion also lacks a sigmoid flexure.

Dog – The Cowper's gland and seminal vesicles are absent in the male dog. The dog also does not have a sigmoid flexure. The sheath of the penis is referred to as a prepuce.

Figure 1.1 - Reproductive System of the Bull

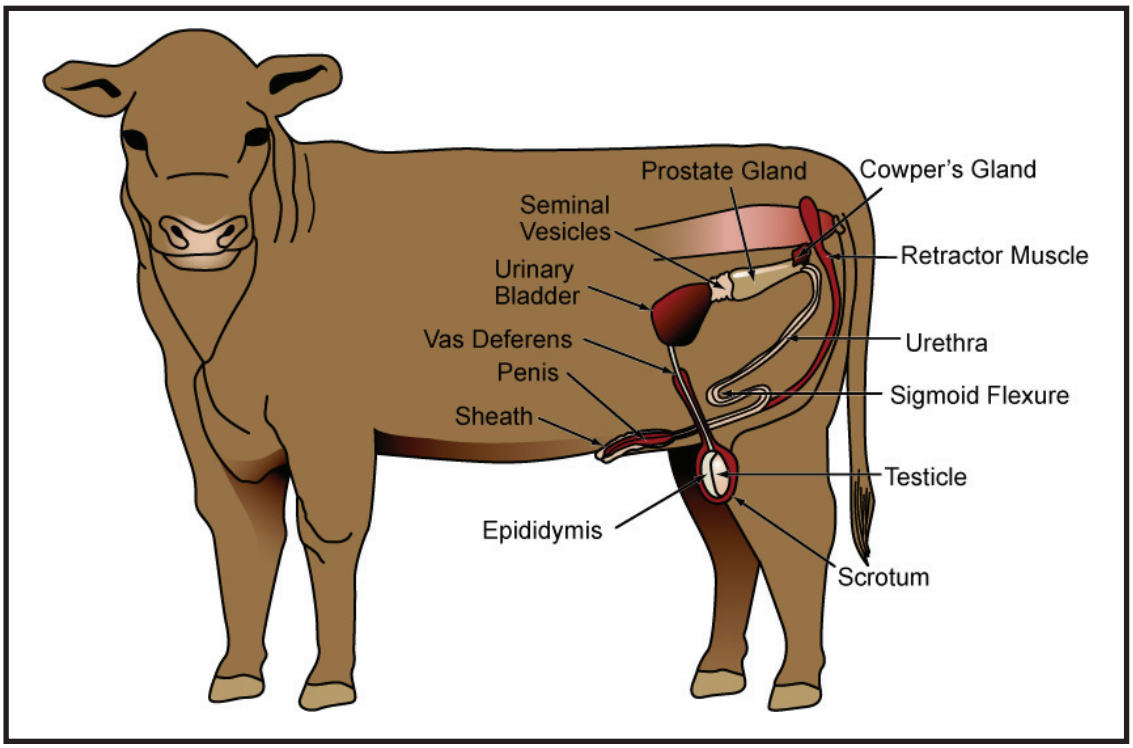
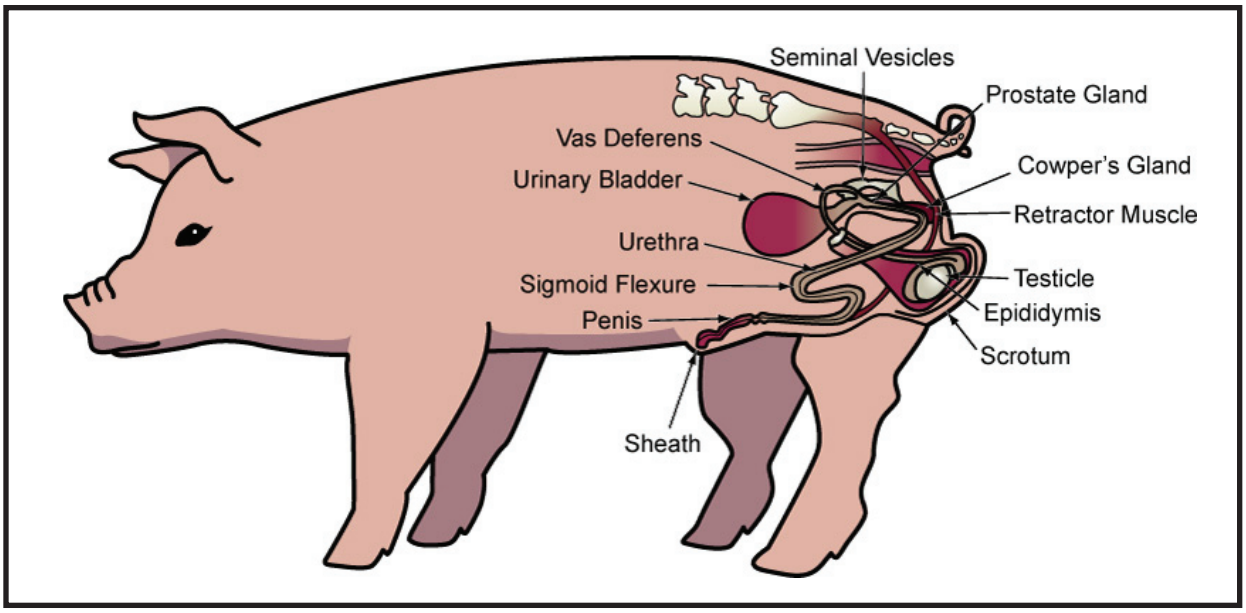


Figure 1.2 - Reproductive System of the Boar



Buck – The male rabbit is called a buck. Differences between the rabbit's reproductive system and the bull's include the name of the scrotum, which is referred to as the inguinal pouch, and that of the sheath, or prepuce. In the buck, the prostate gland is separated into three parts, and the Cowper's gland is absent. The buck also does not have a sigmoid flexure.

Fowl – Fowl include chickens, turkeys, and other birds. Unlike other animal species covered in this lesson, fowl are not mammals. Thus, they have a very different reproductive system from the others, as illustrated in Figure 1.3. Fowl do not have a scrotum. Instead, their testicles are located within the abdomen, next to the backbone. The vas deferens connects the testicles to the cloaca, papillae, and vent. The papillae are small, finger-like projections within the cloaca. Fowl do not have a urethra or urinary bladder.

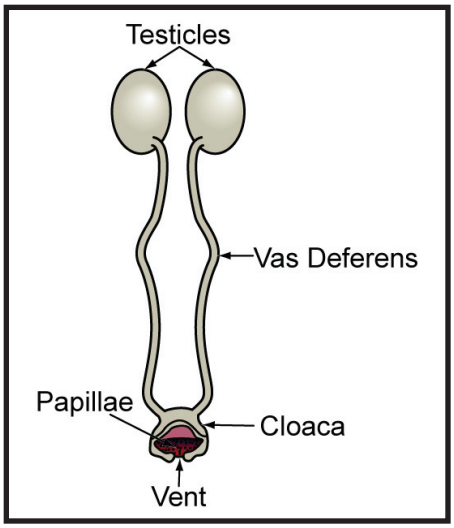
Functions of the Parts

Each part has a specific function in the reproductive system. If any of the parts do not function correctly, the animal may have difficulty with reproduction or be unable to reproduce. Following is a description of the functions of each of the reproductive parts of the bull.

Testicles – The testicles are the primary reproductive part. They produce hormones associated with reproduction as well as the male gametes, or sex cells, called sperm. The testicles are made up of seminiferous tubules, which are tiny coiled tubes that produce the sperm, as well as interstitial cells located between the tubules that secrete reproductive hormones.

Scrotum – The scrotum is a sac or pouch of skin that carries the testicles and regulates their temperature. When cold, the testicles are drawn close to the body for warmth. In hot weather, the testicles hang away from the body.

Figure 1.3 - Reproductive System of a Rooster



Epididymis – The epididymis is a tube with three parts: a head, body, and tail. Sperm is stored in the epididymis for maturation. It also concentrates the sperm and transports it from the testicles to the vas deferens.

Vas deferens – The vas deferens is a tube that transports sperm from the epididymis to the urethra.

Urethra – The urethra carries sperm and urine to the penis.

Urinary bladder – The bladder stores urine before it is released to the urethra. It has no reproductive function.

Seminal vesicles – The seminal vesicles produce the seminal fluid that transports and protects the sperm.

Prostate gland – The prostate gland releases fluid that mixes with the seminal fluid and nourishes the sperm. The combination of the sperm with the fluids from the seminal vesicles and prostate gland is referred to as semen.

Cowper's (bulbourethral) gland – This gland releases a fluid into the urethra that cleanses and neutralizes it to allow the sperm to survive the passage to the penis. The secretions pass through the urethra prior to the semen.

Sigmoid flexure – This S-curved muscle extends the penis outside the body during mating.

Retractor muscle – This muscle pulls the penis back into the body.

Penis – The penis is an organ that deposits semen into the female reproductive tract. It also excretes urine from the body.

Sheath – The sheath is a fold of skin that covers and protects the penis when it is relaxed.

The reproductive parts found in the boar, stallion, dog, and buck have functions similar to those of the bull. The filiform appendage found in the ram is actually the opening of the urethra, which extends beyond the head of the penis. It rotates and sprays semen during mating.

The reproductive system of the fowl, however, differs in form and function from the other domestic animals covered in this lesson.

Testicles – As in the other animals, sperm and hormones are produced in the testicles. In fowl, they also secrete the seminal fluid.

Vas deferens – Sperm and seminal fluid are transferred from the testicles to the cloaca through the vas deferens.

Cloaca – The reproductive and digestive systems meet at the cloaca. The male cloaca joins the female cloaca in the mating process.

Papillae – Attached to the inside wall of the cloaca, the papillae transport the sperm to the female reproductive tract during mating.

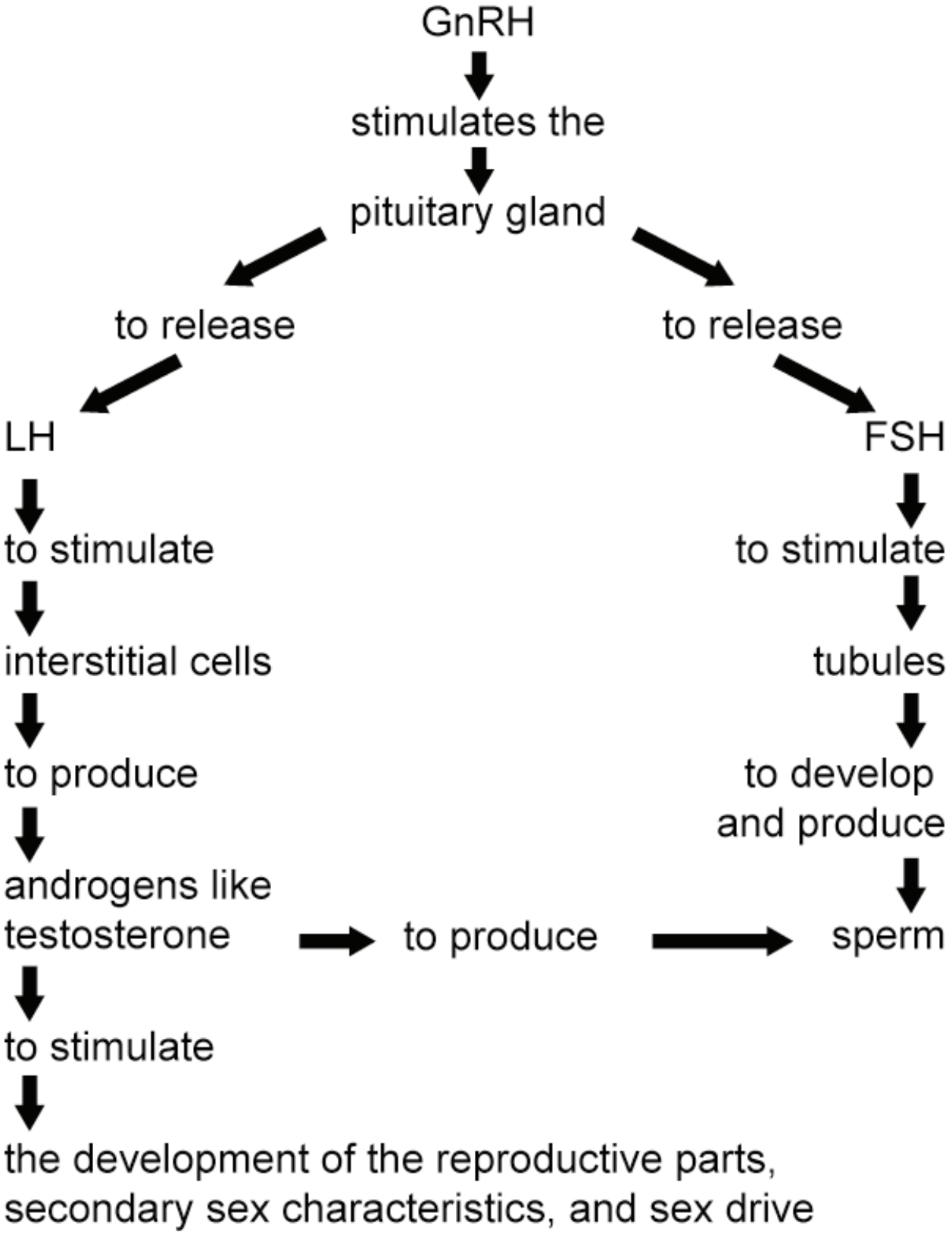
Vent – The vent is connected to the cloaca. It releases the reproductive and digestive products.

Hormones

A hormone is a chemical substance secreted by an organ of the body. When released into the bloodstream, it triggers a specific response in another organ. Reproductive hormones affect the activity of the parts of the reproductive system.

Gonadotrophin releasing hormone (GnRH) is a reproductive hormone produced by the hypothalamus gland, which is found in the brain; GnRH is not present in fowl. The anterior lobe of the pituitary gland secretes follicle stimulating hormone (FSH) as well as luteinizing hormone (LH). LH is also sometimes referred to as interstitial cell stimulating hormone (ICSH). The sex hormones that control male reproductive development and behavior are collectively called androgens. The androgen testosterone is produced in the testicles of all the species except rabbits, which produce another androgen.

Figure 1.4 - Hormones of the Male Reproductive System in Mammals



The Role of Hormones

Hormones play an important role in reproduction. A delicate balance exists among the various hormones. Figure 1.4 shows the connections between the different reproductive hormones and parts in mammals.

In mammals, GnRH stimulates the anterior pituitary gland in the brain to release both FSH and LH, which are essential to reproduction. In fowl, the release of FSH from the pituitary is stimulated by increased light. FSH affects the tubules in the testicles, causing them to produce sperm. LH causes the interstitial cells in the testicles to secrete androgens.

Androgens like testosterone stimulate the development, growth, and activity of reproductive parts. The production of androgens triggers a maturing stage called puberty, in which the reproductive parts mature as the ideal hormone level is reached. Testosterone and other androgens also trigger the development of male secondary sex characteristics. These characteristics may include a deep voice, heavy muscling, and aggressiveness; in fowl, sex characteristics may consist of plumage, a wattle and comb, and crowing. Sex drive, which is the desire and ability to mate, is similarly stimulated by androgens. They also function in the production of sperm.

Summary

Male animals have a reproductive system that includes specific parts and hormones. Each part has a function that is triggered by the hormones of the male reproductive system.

Credits

Allan, Eric, and Rowan Blogg. *Every Dog: The Complete Book of Dog Care*. Melbourne: Oxford, 1992.

Baker, Andy. *Animal Science*. University of Missouri-Columbia: Instructional Materials Laboratory, 1996.

Blakely, James, and David H. Bade. *The Science of Animal Husbandry*. 4th ed. Englewood Cliffs, N.J.: Prentice-Hall, 1985.

Cackler, William. *Livestock and Poultry Breeding (Student Reference)*. Rev. ed. Ohio State University: Ohio Agricultural Education Curriculum Materials Service, 1989.

Christiansen, Ib J. *Reproduction in the Dog and Cat*. London: Baillière Tindall, 1984.

Ensminger, M. E. *Poultry Science*. 3rd ed. Danville, Ill.: Interstate Publishers, Inc., 1992.

Gillespie, James R. Modern *Livestock and Poultry Production*. 3rd ed. Albany, N.Y.: Delmar Publishers, 1989.

Lee, Jasper S., et al. *Introduction to Livestock and Poultry Production.* Danville, Ill.: Interstate Publishers, Inc., 1996.

Rabbit Production Handbook. Rev. ed. Texas A&M University: Instructional Materials Service, 1993.

Reproductive Anatomy and Physiology of the Bull (G2016). University Extension agricultural publications, 1990.

Richards, Herbert. *Dog Breeding for Professionals*. Neptune City, N.J.: T.F.H. Publications, Inc., 1978.

Female Reproductive System

The female animal, like the male, has a reproductive system that consists of several different organs, as well as hormones that trigger the development and functioning of the various parts. The parts and hormones work together for the successful reproduction of healthy offspring.

Parts of the Reproductive System

The reproductive system of the female is very different from that of the male of the same species. However, all female mammals have a similar system. The reproductive system of the cow can therefore be used as a general example.

Cow – A cow is a female bovine. Its reproductive system is pictured in Figure 2.1. Two ovaries are found toward the rear of the abdominal cavity. Located next to each ovary is an infundibulum, which is the funnel-shaped portion of the oviduct. The oviducts, also known as the fallopian tubes, lead from the ovary to the uterus. The uterus consists of two branches, called uterine horns, and a body. The uterus is connected to the vagina by the cervix, the inner surface of which consists of folds of tissue. The contents of the bladder are emptied into the base of the vagina by the urethra. The external parts of the female reproductive tract are the clitoris and the vulva.

Figure 2.1 - Reproductive Parts of a Cow

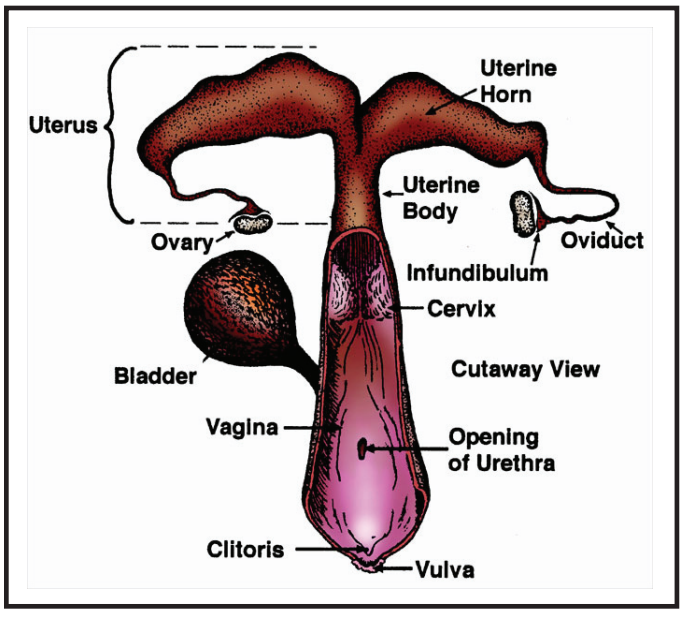
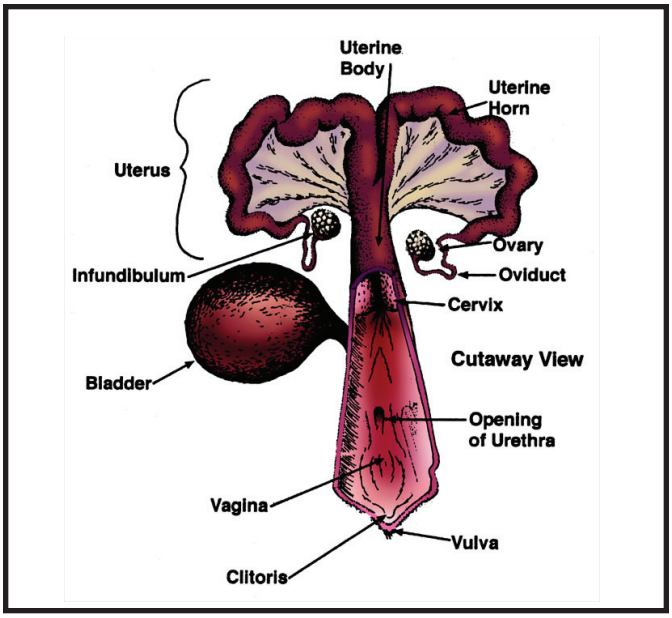


Figure 2.2 - Reproductive Parts of the Sow



Sow – A sow is a female swine. The sow's reproductive system (Figure 2.2) differs from the cow in that the uterine horns are more prominent in the sow. Also, the cervix is not folded but has protruding areas instead.

Ewe – The ewe is a female sheep. Its reproductive system is very much like the cow's.

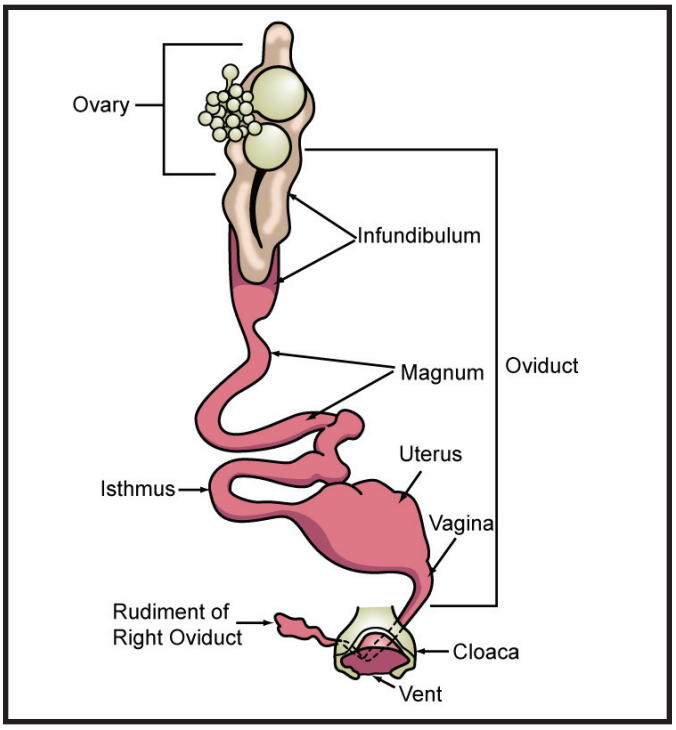
Mare – In horses, the female is called a mare. The mare has a smoother cervix, without folds like the cow's.

Bitch – In the female dog, or bitch, the uterine horns are more prominent, like those of the sow.

Doe – The female rabbit, called a doe, has prominent uterine horns, like the sow and bitch. In the doe, each uterine horn has a separate cervix connecting it to the vagina.

Fowl – The female reproductive system in fowl is quite different from that of the mammals. Figure 2.3 shows the reproductive organs of the chicken. Only the left ovary and oviduct of the hen are functional, although the right is found in an underdeveloped state. The oviduct has five parts—the infundibulum, magnum, isthmus, uterus, and the vagina. A cloaca and vent are located at the end of the oviduct.

Figure 2.3 - Reproductive Parts of the Hen



Functions of the Parts

Each part of the female reproductive system has a very specific function. If one of the organs in the reproductive system does not function correctly, reproduction may be impaired. It may become difficult or impossible for the animal to produce healthy offspring.

Ovary – The ovaries produce the female sex cells, called eggs or ova, and sex hormones. The ova are released from follicles on the ovary.

Infundibulum – The infundibulum receives the egg from the ovary.

Oviduct – The oviduct, or fallopian tube, is a tube-like structure that carries the egg from the ovary to the uterus. It is also the site where sperm and egg meet during fertilization.

Uterus – The fertilized egg develops in the uterus before birth.

Uterine horns – The fertilized egg attaches to the uterine wall and begins to develop in the uterine horns. The sow, dog, and rabbit have more pronounced uterine horns because they are litter-bearing animals.

Cervix – The cervix is a muscular structure that functions as a passageway for the sperm and keeps bacteria and foreign material out of the uterus during pregnancy by forming a waxy mucus plug. During the birthing process, the cervix acts as a part of the birth canal.

Vagina – Semen is deposited into the reproductive system through the vagina. The vagina is a part of the birth canal as well as part of the route by which urine passes out of the body.

Urinary bladder – The bladder stores urine before it is released through the urethra.

Urethra – Urine is passed from the bladder to the vagina through the urethra. It empties into the base of the vagina. The urethra and bladder have no reproductive function.

Clitoris – The clitoris, which is located inside the vulva, is a highly sensitive part corresponding to the penis that is stimulated during mating.

Vulva – The vulva is the external opening of the urinary and reproductive systems.

The functions of the various parts of the reproductive system described above are the same for all these species except fowl. In fowl, the reproductive parts and their functions are significantly different.

Ovary – As in other animals discussed in this lesson, the hen's single ovary produces ova. The nucleus of the egg is attached to a yolk sac.

Oviduct – The oviduct is a long tube that transports the mature yolk from the ovary to the cloaca. It also carries semen to the infundibulum.

Infundibulum – The infundibulum receives the mature yolk from the ovary. It is also the site where the egg is fertilized by the semen, which is stored in the infundibulum in the folds of the oviduct.

Female Reproductive System

Magnum – The magnum secretes albumen, which is the white of the egg. It surrounds the yolk.

Isthmus – Two shell membranes are added to the egg yolk and white in the isthmus.

Uterus – Also known as the shell gland, the uterus adds a thin white, shell, and pigment to the egg.

Vagina – The egg is temporarily stored in the vagina before it is laid. It also produces the cuticle, the exterior coating of the shell.

Cloaca – The cloaca, which is the junction of the digestive and reproductive systems, receives the male's semen. The egg passes through the cloaca during laying.

Vent – The vent is the opening through which the egg passes out of the body during laying.

Hormones

Hormones are vital to reproduction. They cause the organs of the reproductive system to develop and prepare the body of the female for producing offspring.

Some of the hormones produced by females are also found in males. For example, as in the male, gonadotrophin releasing hormone (GnRH) is produced by the hypothalamus. Follicle stimulating hormone (FSH) and luteinizing hormone (LH) are also secreted from the anterior pituitary gland. Other hormones, however, are unique to the female, such as estrogen, which is secreted by the follicles in the ovary. Another hormone produced in the ovary is progesterone, which is secreted by the corpus luteum, a body that develops from a follicle that has released an ovum. The hormone prostaglandin is released by the uterus.

Fowl differ not only in the parts of the reproductive system but also in the number of hormones produced. Their bodies secrete only four major sex hormones. FSH and LH are released by the anterior pituitary gland, and estrogen and progesterone are secreted by the ovary. While these hormones are found in the other species, their functions differ in fowl.

The Role of Hormones

Hormones regulate and develop the reproductive system. The hormones must interact in a balanced manner to ensure the proper development and functioning of the reproductive system. Figure 2.4 graphically illustrates the female hormone cycle.

As it does in the male, GnRH stimulates the pituitary to release FSH and LH. In the female, FSH stimulates the follicles in the ovaries to develop a mature ovum. FSH also triggers the secretion of estrogen.

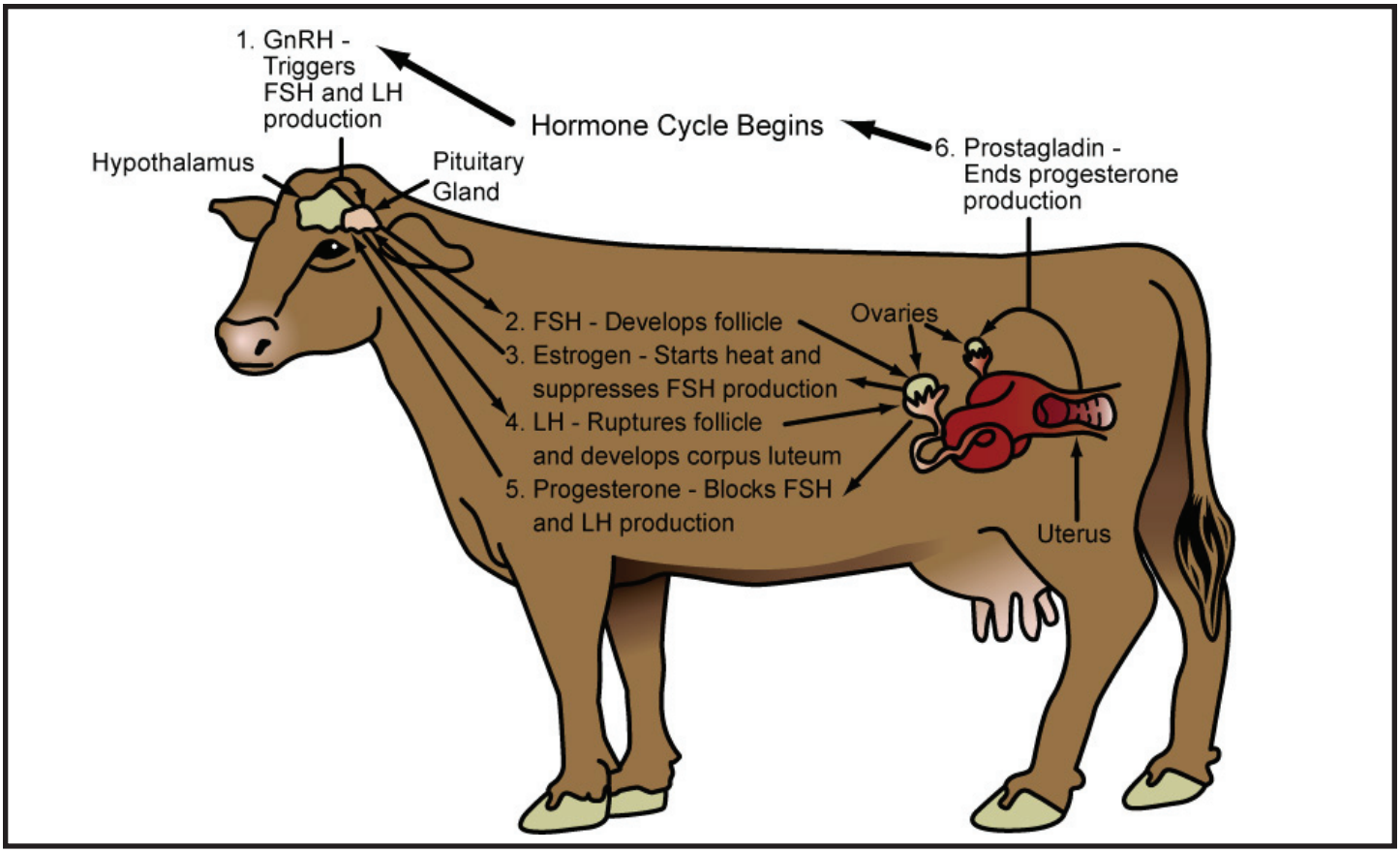
Estrogen causes the sex organs and secondary sex characteristics to develop and stimulates a desire to mate. Estrogen has an effect on other hormones as well; when estrogen is released, it suppresses the production of FSH and encourages the production of LH by the pituitary. Estrogen also causes uterine contractions that aid in transporting sperm to the oviduct to fertilize the egg.

LH causes the follicle to release the egg, a process referred to as ovulation. In addition, this hormone develops the corpus luteum, also known as the yellow body, from the follicle after the egg is released.

The hormone progesterone, secreted by the corpus luteum, stops the production of FSH and LH. It thus prevents follicle development and the secretion of estrogen.

The hormones then play different roles depending on whether the egg is fertilized or not. If the egg is fertilized, the corpus luteum stays in place, and progesterone is produced to maintain the pregnancy by preventing uterine contractions and triggering the release of secretions to nourish the fertilized egg. Progesterone also blocks ovarian activity by inhibiting the secretion of GnRH. If the egg is not fertilized, the corpus luteum deteriorates due to the secretion of prostaglandin in the uterus, ending progesterone production. When progesterone levels are low, GnRH is released and the cycle starts again.

Figure 2.4 - Female Hormone Cycle



In fowl, the hormones have different roles. FSH production is triggered by increased light; for example, lengthening spring days cause FSH to be produced in wild birds. FSH's main role is to develop yolks. It also stimulates the secretion of estrogen and progesterone. Estrogen increases blood calcium, protein, fats, vitamins, and other egg formation substances. The hormone also plays an important role in egg laying by prompting the separation of the pubic bones and the enlargement of the vent. Progesterone causes the hypothalamus to trigger LH production by the pituitary. When LH is added to the bloodstream, the follicle opens and releases the mature yolk into the infundibulum.

Summary

The various organs and hormones of the female reproductive system are important for producing healthy offspring. They work together to ensure successful reproduction.

Credits

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Blakely, James, and David H. Bade. *The Science of Animal Husbandry*. 4th ed. Englewood Cliffs, N.J.: Prentice-Hall, 1985.

Cackler, William. *Livestock and Poultry Breeding (Student Reference)*. Rev. ed. Ohio State University: Ohio Agricultural Education Curriculum Materials Service, 1989.

Ensminger, M. E. *The Complete Encyclopedia of Horses*. South Brunswick: A. S. Barnes and Company, 1977.

Evans, J. Warren. *Horse Breeding and Management*. New York: Elsevier, 1992.

Fielding, Denis. Rabbits. London: MacMillan, 1991.

Gillespie, J. R. *Modern Livestock and Poultry Production*. 5th ed. Albany, N.Y.: Delmar Publishers, 1997.

Goody, Peter C. *Horse Anatomy: A Pictorial Approach to Equine Structure*. London: J. A. Allen, 1976.

Lee, Jasper S., et al. *Introduction to Livestock and Poultry Production*. Danville, Ill.: Interstate Publishers, Inc., 1996.

Rabbit Production Handbook. Rev. ed. Texas A&M University: Instructional Materials Service, 1993.

Reproductive Anatomy and Physiology of the Cow (G2015). University Extension agricultural publications, 1988.

Richards, Herbert. *Dog Breeding for Professionals*. Neptune City, N.J.: T.F.H. Publications, Inc., 1978.

Stufflebeam, Charles E. *Principles of Animal Agriculture*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1983.

Way, Robert F., and Donald G. Lee. *The Anatomy of the Horse*. Philadelphia: J.B. Lippincott Company, 1965.

White, Kay. *Dog Breeding*. Edinburgh: John Bartholomew & Son Limited, 1980.

Wickham, G.A., and M.F. McDonald. *Breeding and Reproduction*. Auckland: Ray Richards Publisher in association with the New Zealand Institute of Agricultural Science, 1982.

Puberty and the Estrous Cycle

Animals must go through a process of sexual maturation before they are capable of producing offspring. It is important for the producer to be able to recognize when the animal has matured to the point that it is capable of reproduction. The producer also has to know when the female has entered a period of fertility and how long that period is likely to last. A lack of knowledge in these areas could be economically costly if productivity is lessened.

Puberty

Puberty is the stage of sexual maturation. In males, puberty is marked by a desire to mate and the ability to produce sperm capable of fertilizing an egg. Puberty in females involves the production of ova by the follicles, the development of the reproductive tract to give the animal the capacity to bear offspring, and a desire for mating.

While male animals are capable of breeding at any time after reaching puberty, female mammals are receptive to breeding only during specific periods, called estrus, or heat. Puberty in the female is marked by the first estrus. Therefore, it is important for breeding purposes to be able to recognize estrus.

Age of Puberty

Just as species differ in size and other characteristics, the age at which the female of each species reaches puberty varies. The age at puberty differs among individual animals within a particular species as well, dependent on factors such as nutrition, physical size, and breed. Chart 3.1 shows the age at which each species reaches puberty.

In cattle, a heifer reaches puberty between six and twelve months of age; in swine, the age at which a gilt reaches puberty ranges between four to eight months. A ewe lamb becomes sexually mature between five and nine months of age. Horses reach puberty at ten to twelve months. Sexual maturity commonly occurs in dogs at any time from six to twelve months of age but varies according to breed. Rabbits usually reach puberty at five to eight months.

In contrast to these other species, fowl do not mark puberty with estrus. They do, however, pass through a period of sexual maturation in order to reproduce. For example, chickens mature sexually at 17 to 26 weeks of age. Turkeys mature later, at 27 to 30 weeks.

Estrus

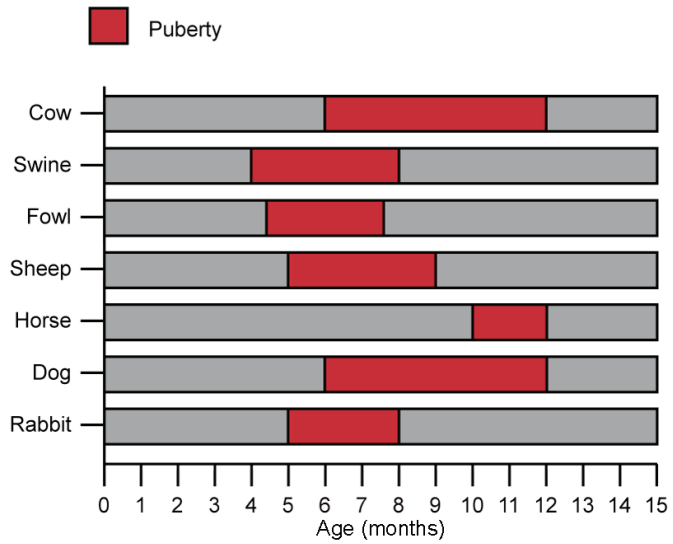
Estrus, or heat, is the period during which the female will accept the male for mating. Estrus begins at puberty and occurs at intervals during a female's life. Each interval is called an estrous cycle. The purpose of the estrous cycle is to prepare the female's reproductive tract for the release of the egg and receiving the embryo.

An estrous cycle has three phases—proestrus, estrus, and diestrus. During the proestrus phase, a follicle matures to release the egg. In the estrus phase, the female is sexually receptive to the male for mating. The egg is also released by the ovary during this phase. The last phase of the estrous cycle is diestrus. During diestrus, the reproductive tract becomes less active, until the cycle begins again with proestrus.

Variation in Estrous Cycles

Each species has a unique estrous cycle. They differ in how often estrus occurs in a year or breeding season, as well as in the length of the cycle.

Chart 3.1 - Age of Puberty in Various Species



A monoestrus animal has only one estrus in a breeding season or year. Dogs are monoestrus. They average one cycle every seven months.

Polyestrous animals are in estrus more than once a breeding season or year. Cattle, swine, sheep, horses, and rabbits are polyestrous, with estrus occurring a number of times throughout the year. Sheep and horses are different from the others in that they are seasonal breeders. In most breeds of sheep, the ewe cycles only during the fall. The time when the ewe is not cycling is called anestrus. During the breeding season, the ewe is in estrus several times. The mare usually experiences anestrus in the winter and cycles from around March until October or November. The variations in the estrous cycles of sheep and horses are triggered by changes in the length of days during the year. Decreasing daylight triggers FSH production in sheep, while increasing daylight stimulates the production of FSH in horses.

Estrous cycle lengths also differ. A cow, sow, and mare all have an average estrous cycle length of 21 days, although the ranges of possible estrous lengths vary. A cow's estrous cycle ranges between 17 and 24 days, a sow's between 18 and 24 days, and a mare's between 18 and 25 days. Sheep have an average estrous cycle length of 16 days, with a range of 14 to 20 days. Rabbits have an estrous cycle of 15 days with a range of 15 to 16 days. The length of a particular animal's estrous cycle may be altered by external factors such as the animal's environment and nutrition.

Since dogs are monoestrus, they do not have regular cycles. However, they do have reproductive events, passing through anestrus and then experiencing proestrus, estrus, and diestrus once each breeding season.

Estrus Length

Estrus is the window of opportunity for mating. The timing of breeding is important, so a knowledge of estrus length is crucial. A cow has an average estrus length of 18 hours, with a range of 10 to 30 hours. The sow has a longer estrus period. A sow is in estrus for an average of 3 days, although the period can range between 1 to 5 days. A ewe has an estrus length of 30 hours, with a possible range of 22 to 38 hours. Mares are in estrus for an average of 5 days, with a range of 1 to 10 days. Estrus in dogs lasts for an average of 9 days and a range of 5 to 19 days. Rabbits do not have a well-defined estrus period, since ovulation is stimulated by the act of mating.

A comparison of estrous cycle and estrus lengths is shown in Table 3.2.

Visual Signs of Estrus

The breeder can tell whether or not the female is in estrus by looking for visual signs, such as changes in physical appearance or behavior. These signs are triggered by the production of estrogen. The following are some of the common visual signs for each species.

Table 3.2 - Estrous Cycle and Estrus Lengths

Species	Estrous Cycle	Estrus
Cattle	21 days (17-24 days)	18 hours (10-30 hours)
Swine	21 days (18-24 days)	3 days (1-5 days)
Sheep	16 days (14-20 days)	30 hours (22-38 hours)
Fowl	-------	-------
Horses	21 days (18-25 days)	5 days (1-10 days)
Dogs	-------	9 days (5-19 days)
Rabbits	15 days (15-16 days)	not well defined

Cow – A cow in estrus may mount other females or be willing to be mounted. The cow may be nervous or become agitated. Another visual sign of estrus in a cow is frequent urination. Also, it may have a swollen, inflamed vulva from which vaginal discharges or mucus are secreted.

Sow – A sow may show all of the same visual signs as a cow when in estrus. In addition, the sow may occasionally grunt loudly. It may also assume an immobile stance, holding its ears erect.

Ewe – In contrast to the cow and the sow, the ewe shows few signs of estrus. The ewe's vulva may be slightly enlarged and secrete mucus. The best indicator is the ewe seeking the ram and standing to be mounted.

Mare – Mares exhibit visual signs such as a raised tail and a relaxed vulva with mucus discharges. The mare may also disturb other mares, be nervous, nicker, and urinate frequently. A visual sign of estrus that is unique to the mare is the winking of the vulva. Winking is when the mare lowers her pelvis and raises her tail in a submissive manner, signaling that she is ready to mate.

Bitch – The bitch will exhibit changes in behavior in the days preceding estrus. For example, appetite may decrease or increase. In addition to behavioral changes, the vulva becomes swollen. A bloody discharge that begins during the proestrus period will cease during estrus. Another sign of estrus in the bitch is a willingness to accept the male for mating.

Doe – A doe in estrus exhibits a reddish-purple, slightly swollen vulva. It also accepts the male to mate.

Factors in First Time Breeding

An important factor in successful first time breeding is choosing the appropriate time for the female to be bred. Although a female can be bred at the first estrus, doing so is not recommended because the animal may not be physically equipped for successful reproduction. The three basic factors to consider when deciding whether an animal should be bred are physical size, age, and breed.

The physical size of the animal is important. The female should have the weight and frame size to carry the offspring for an entire pregnancy. Age also plays a role in determining when to breed. An animal should be past puberty and fully sexually mature. The breed of a particular animal should also be considered. One breed may develop faster than another breed within the same species and can therefore be bred sooner.

Local feed dealers, veterinarians, and extension livestock specialists are good sources of information about how to weigh these factors to determine the correct breeding age for a specific animal.

Summary

Puberty is the period during which animals become sexually mature. In mammals, estrus is the first indication of puberty. Each species has a different puberty age, estrous cycle and estrous cycle length, and estrus length. The producer can determine whether a female is in estrus by looking for a number of visual signs. When breeding an animal for the first time, more than just the presence of estrus should be considered, however. Physical size, age, and breed are also important.

Credits

Blakely, James, and David H. Bade. *The Science of Animal Husbandry*. 4th ed. Englewood Cliffs, N.J.: Prentice-Hall, 1985.

Gillespie, J. R. *Modern Livestock and Poultry Production*. 5th ed. Albany, N.Y.: Delmar Publishers, 1997.

Leffert, Kenneth L. *Equine Science (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1995.

Rabbit Production Handbook. Rev. ed. Texas A&M University: Instructional Materials Service, 1993.

Robinson, Roy. *Genetics for Dog Breeders*. Elmsford, N.Y.: Pergamon Press, 1982.

University Extension agricultural publications, University of Missouri-Columbia.

G2015: *Reproductive Anatomy and Physiology of the Cow*
G9922: *Reproductive Management of the Brood Bitch*

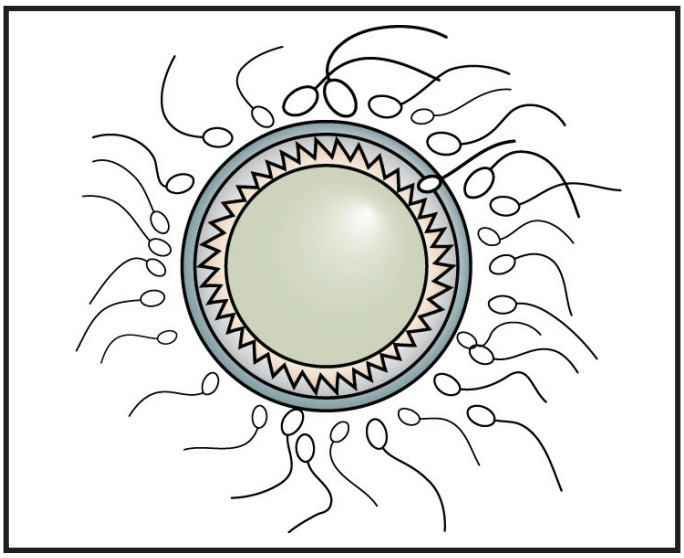
Warren, D. M. *Small Animal Care and Management.* Albany, N.Y.: Delmar Publishers, 1995.

After an animal goes through puberty, it is able to produce offspring. The process of producing a new life begins with conception and continues through gestation. This lesson will discuss conception and the gestation of the fetus.

Conception

During mating, the male mammal deposits semen in the female's vagina near the cervix. The sperm travels through the cervix and the uterus into the oviduct. If an egg is present, conception occurs when the head of the single sperm penetrates the egg, which usually takes place in the upper third of the oviduct. The union of the egg and sperm (pictured in Figure 4.1) creates a new life called an embryo.

Figure 4.1 - Conception



Conception is the same in cattle, swine, sheep, dogs, and rabbits. In some of these species, however, more than one egg may be released and fertilized. The sow, bitch, and doe are all litter-bearing animals. They produce multiple ova when ovulating.

While conception is similar in fowl, some differences do exist. The male deposits semen in the cloaca. The semen then travels up the oviduct to the infundibulum, where the egg is fertilized. Fertilization takes place on the yolk at a point called the germinal disk, which contains the nucleus. In contrast to the other animals, sperm from fowl remain viable for weeks while stored in the folds of the infundibulum. Conception can therefore still occur quite some time after mating.

Methods of Impregnation

A female animal can be bred naturally or artificially. Natural breeding involves the copulation of the male and the female. Artificial methods of breeding involve human intervention in impregnation.

Two methods are used to artificially impregnate animals. One method is called artificial insemination (AI). In AI, semen is collected from the male and carefully stored to ensure the survival of the sperm. The stored semen is then ready to use when the female is in estrus. The semen is inserted into the reproductive tract using an inseminating tube (mammals) or syringe (fowl).

Another method used to artificially impregnate animals is embryo transfer (ET). In ET, injections of FSH are used to stimulate the female to ovulate many eggs. The induced eggs are fertilized either naturally or artificially. Once the eggs are fertilized, the embryos are collected from the female. Individual embryos are inserted into host females for the rest of the gestation period. ET cannot be used in fowl.

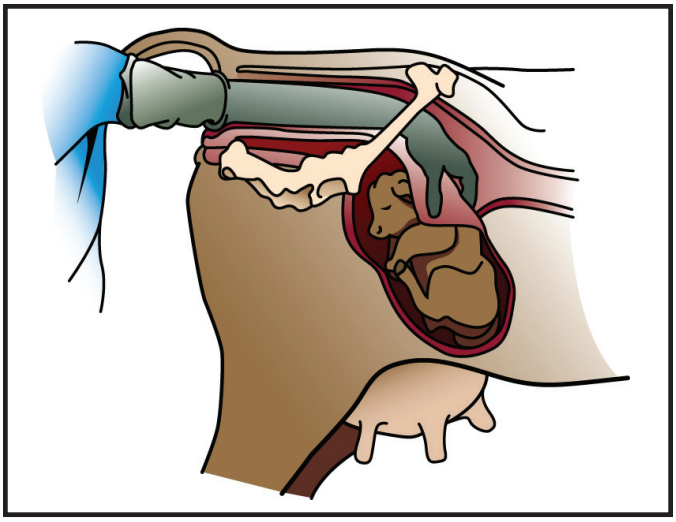
Pregnancy Determination Procedures

Being able to determine whether or not an animal is pregnant is very important. It allows the producer to make appropriate production decisions for his or her animals.

One way to determine pregnancy is by a visual inspection. If pregnant, a female will not have the visual signs of estrus. Also, the female may appear to have an enlarged abdomen later in the pregnancy.

Rectal palpation is another way to determine pregnancy. It is widely used for cattle and horses. The determination is made by feeling the uterus, as illustrated in Figure 4.2. After putting on a sterile glove to protect against infection, insert the hand into the female's rectum, which lies above the reproductive tract. Once the hand is inside the rectum and past the pelvic bones, feel for the cervix below. It should feel something like the neck of a soda bottle. After confirming the location of the cervix, extend the hand and arm to the uterus to feel for a fetus floating in the distended uterus. In the cow, button-like cotyledons, which are the points of attachment between

Figure 4.2 - Rectal Palpation in the Cow



the placenta and the uterus, may also be felt. A modified version of rectal palpitation is used in sheep; a rod is inserted in the rectum and used to move the fetus so that it can be felt through the abdomen.

Abdominal palpation can also be used to determine pregnancy. It is utilized for dogs and rabbits. Abdominal palpation is actually a routine physical check, in which the abdomen is examined externally with the hands. The person doing the palpation feels for an enlarged uterus, an indication that the female is pregnant. Care should be taken when using this method to determine pregnancy, because exerting too much pressure on the abdomen could damage the embryos.

Ultrasonic sound is used for pregnancy checks for many species. The equipment necessary includes a transducer, a machine unit, and some type of sealant. The sealant is placed between the transducer and the body to exclude air. When the transducer is correctly placed, ultrasonic sound waves are transmitted through the body. The sound waves are reflected by tissue. When the waves encounter a fetus, the unit will sound or light up, indicating that the female is pregnant. Figure 4.3 shows a sow being pregnancy checked with ultrasonic sound.

Pregnancy can be determined in other ways. A laboratory may provide pregnancy results from blood tests. X-rays can be used to reveal pregnancy as well.

Gestation

Gestation is the period of development of mammalian young that begins at conception and ends at birth. Another name for gestation is pregnancy. During gestation, the fetus receives nutrients and oxygen from the mother through the placenta, the membranous tissue that surrounds the fetus in the uterus. The fetus in turn gives off carbon dioxide and waste products that are absorbed by the placenta.

Gestation can be divided into three stages, which are referred to as the cell division, embryonic, and fetal stages. The cell division stage begins right after conception. The fertilized egg undergoes 16 or more divisions while moving through the oviduct to the uterus. The cell divisions are energized by substances within the egg called cytoplasm.

The next stage is the embryonic stage. During this stage, the embryo differentiates body parts, and organs are formed. The embryo gets nourishment from the mother's uterine secretions. When the embryonic stage is complete, the fetus has been formed.

The last stage is called the fetal period. During the fetal period, the fetus continues to grow until birth. This stage is also known as the time of growth.

Figure 4.3 - Determining Pregnancy Using Ultrasonic Sound

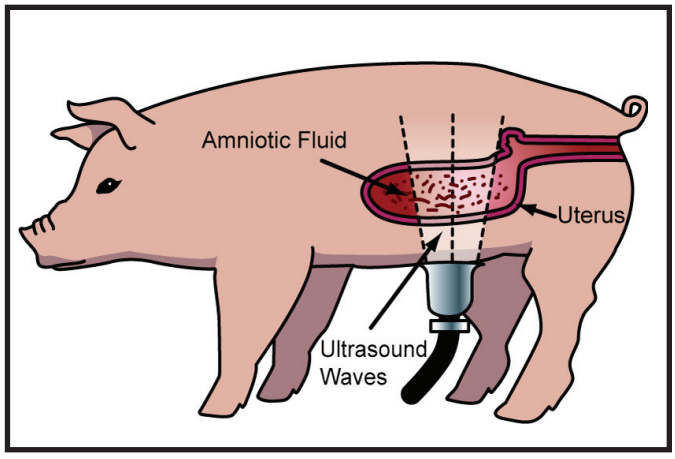
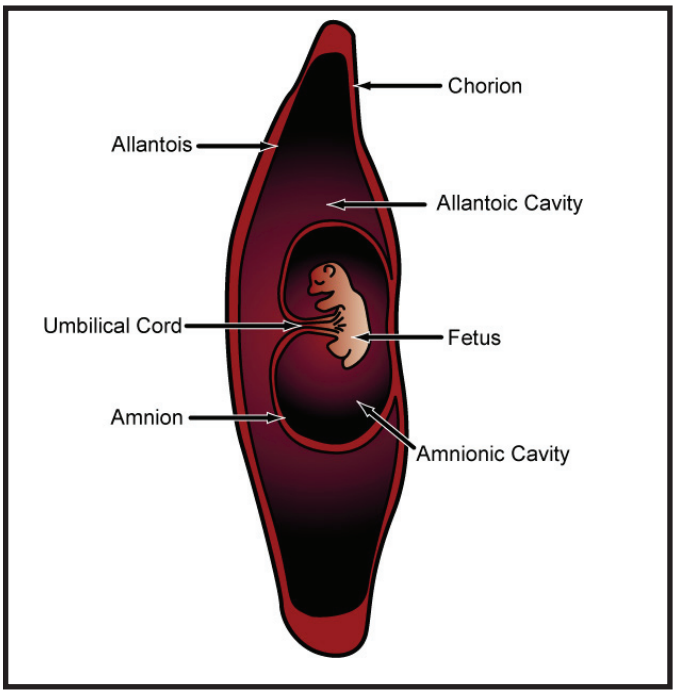


Figure 4.4 - Embryonic Membranes of a Pig



Embryonic Membranes

Three membranes form the placenta that surrounds the embryo in the uterus. These thin tissues protect and provide nourishment to the developing offspring. The embryonic membrane system is shown in Figure 4.4.

The outermost embryonic membrane is the chorion, and the innermost membrane is the amnion. The chorion is connected to the uterus. Nourishment from the mother as well as waste disposal is provided through the points where the membrane is attached to the uterus. The amnion is a sac that surrounds the embryo and contains fluid. The embryo floats within the amniotic fluid, which protects the embryo from shock. The amnion is connected to the embryo's navel by the umbilical cord, which has veins and arteries that provide nourishment for the embryo.

The third membrane is between the amnion and the chorion. This membrane is called the allantois. The allantois is an extension of the urinary system of the fetus that passes through the umbilical cord. As the pregnancy progresses, the allantois occupies more space than the other two membranes. The fluid contained within the allantoic cavity comes from the kidney of the fetus.

Factors Influencing Gestation Length

The length of gestation is often influenced by the mother's characteristics. The two most important characteristics are the mother's breed and age. Gestation length may be longer for one breed than another. The mother's age can also factor into the length of gestation; an older animal may have a shorter pregnancy. In addition, gestation length is very dependent on the individual animal. Two mothers may be of the same breed and age but still have gestation periods of different lengths.

Some other factors may also influence the length of gestation. The weather, for example, may have an effect on how long gestation lasts; extremely cold weather may trigger early delivery. The sire chosen for breeding has an effect on gestation length as well. A particular sire may consistently produce offspring with a longer or shorter gestation length than the offspring of another sire.

Incubation

Because fowl pass the fertilized egg out of the body surrounded by a protective shell, they do not experience a gestational period like that found in mammals. However, the embryo does go through a period of fetal growth called incubation that is similar to gestation. Incubation is the period from when a hen sits on an egg or it is placed in an incubator until the chick emerges at hatching. During incubation, the developing embryo is nourished by the yolk. The membranes that surround the embryo are the same as those found in mammals, although the chorion and allantois eventually merge to form the chorioallantoic membrane, which functions as a respiratory organ. Figure 4.5 is a picture of the embryo during incubation.

Figure 4.5 - Chick Embryo

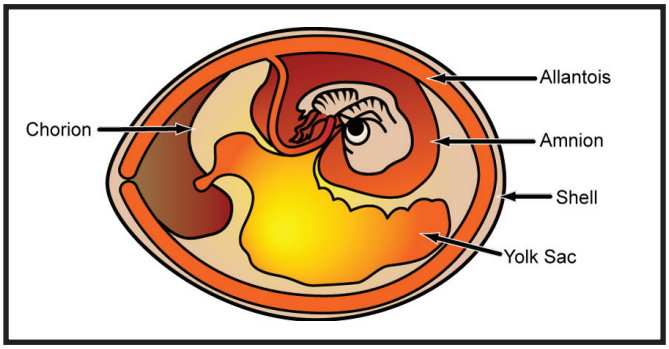


Table 4.1 - Gestation and Incubation Lengths

Species	Gestation Length	
	Average (days)	Range (days)
Cattle	281	274-290
Swine	114	112-116
Sheep	147	144-151
Horses	336	330-350
Dogs	63	56-70
Rabbits	31	30-32
Fowl (Incubation)	Chicken - 21	---
	Turkey - 28	---

Gestation and Incubation Lengths

Gestation lengths vary among species, as shown in Table 4.1. A cow has an average gestation length of 281 days, although it may range from 274 to 290 days. A sow averages 114 days, with a range of 112 to 116. The ewe's average gestation length is 147 days, with a range of 144 to 151 days. Gestation in a mare may range from 330 to 350 days, though the average is 336 days. A bitch may have a gestation length of anywhere from 56 to 70 days, with an average of 63 days. The average gestation length for a doe is 31 days, with a range of 30 to 32 days. The average length of incubation varies for different species of fowl, but the average is 21 days for chickens and 28 days for turkeys.

Summary

Conception occurs when the egg and sperm unite. This act begins the gestation or incubation period, which continues until birth or hatching. During gestation and incubation, the fertilized egg goes through several stages of development while it is protected and nourished through a system of membranes. The length of gestation varies among species as well as within a particular species.

Credits

Blakely, James, and David H. Bade. *The Science of Animal Husbandry.* 4th ed. Englewood Cliffs, N.J.: Prentice-Hall, 1985.

Cackler, William. *Livestock and Poultry Breeding (Student Reference).* Rev. ed. Ohio State University: Ohio Agricultural Education Curriculum Materials Service, 1989.

Rabbit Production Handbook. Rev. ed. Texas A&M University: Instructional Materials Service, 1993.

Taylor, R. E. *Scientific Farm Animal Production*. 4th ed. New York: Macmillan Publishing Company, 1992.

University Extension agricultural publications, University of Missouri-Columbia.

G2299: *Swine Pregnancy Checking by Ultrasonic Sound*
G2610: *Sheep Pregnancy Checking by Ultrasonic Sound*
G9923: *Pregnancy Determination in the Bitch*

Warren, D. M. *Small Animal Care and Management.* Albany, N.Y.: Delmar Publishers, 1995.

Gestation ends with parturition, or birth. Because both the mother and the newborn may experience a number of complications associated with parturition, it is important for a producer to be able to recognize the signs that signal birth will soon take place, as well as problems associated with parturition. He or she will then be able to see that appropriate care is taken during and after the birth to maintain the health of both the mother and her offspring.

Parturition

Parturition is the act of giving birth. It begins after gestation has ended and is the final stage in reproduction. Hormones and mechanical factors are both at work during the birthing process.

During parturition, contractions occur to move the fetus out of the female's body. Labor involves the dilation of the cervix and the passage of the fetus and the placenta, or afterbirth. The contractions force the fetus and then the afterbirth from the uterus through the birth canal, which consists of the cervix and vagina, and then out of the body through the vulva.

Parturition is given special names when referring to different species. In cattle, for example, parturition is referred to as calving. It is called farrowing in swine, lambing in sheep, foaling in horses, whelping in dogs, and kindling in rabbits.

Physical Signs of Parturition

Certain physical signs will allow the observant producer to determine when parturition will soon occur. Some signs are common to many species, while others are unique to a particular species.

Cow – An early physical sign of parturition in the cow is a swollen udder. The hips or tail head of the cow may have a sunken appearance, and the abdominal area may be enlarged or dropped. The vulva will be swollen and reddened. As birth approaches, the female will separate from the herd and locate a place to give birth. Very close to birth, the teats will swell and leak milk. Increased mucus discharge will appear from the vulva. The cow may become restless and nervously switch back and forth from a standing to a resting position. The time of birth is near when a portion of the embryonic membranes called the water bag appears from the vulva.

Sow – Signs of approaching parturition in the sow include an enlarged abdominal area, restlessness, and attempts to build a nest. A swollen vulva and teats indicate that the sow will farrow soon.

Ewe – The first physical sign of parturition that may be observed in sheep is that the teats are swollen with milk. The vulva will swell and become slack. As lambing approaches, a mucus discharge will appear from the vulva, and the ewe will become restless, changing position by standing, lying down, and then standing again.

Mare – As in the cow, early physical signs of parturition in the mare include a swollen udder and sunken hips with a dropped abdomen. The teats will swell and a waxy substance will appear in the nipples; closer to birth the wax will disappear and milk will leak from the teats. The vulva will become swollen and relaxed. The mare will seek a spot away from other horses if possible. It may exhibit a raised tail, urinate frequently, and sweat excessively. The mare will restlessly shift from a standing to a lying position. Birth should occur soon after the water bag breaks, discharging its fluid.

Bitch – One physical sign of whelping in dogs is that the bitch will refuse meals within 24 hours of the birth. As birth approaches, the dog's body temperature will fall slightly below normal. Vomiting may also occur before whelping. A few hours before the birth, a mucus discharge will appear from the vulva.

Doe – The doe signals that birth is approaching by pulling out its fur to line its nest. It will exhibit a loss of appetite before kindling. The doe will also become nervous and excitable a few days before the birth.

Hormones and Parturition

Hormones trigger parturition. Toward the end of gestation, the corpus luteum reduces its production of progesterone. As progesterone levels in the blood decrease, the levels of the hormones estrogen, oxytocin, and relaxin increase. Relaxin is produced by the corpus luteum in most species. It relaxes the pelvic muscles, cartilage, and ligaments. The birth canal then opens due to

increased levels of estrogen from the ovary. The estrogen acts together with oxytocin from the pituitary to cause contractions in the uterus.

The hormone prolactin is also produced before birth by the anterior pituitary gland. It stimulates the production of milk for the newborn.

Problems During Parturition

Because successful parturition depends on many factors, problems sometimes arise during the birthing process. These problems may be associated with either the mother or the fetus.

Some of the problems associated with parturition are due to the size of the fetus in relation to the mother's birth canal and pelvic opening. For example, a very large fetus may be too big to pass through the female's birth canal. A similar problem may occur with a normal-sized fetus if the female's pelvic opening is smaller than average. Problems with size arise due to the selection of animals for breeding. Parturition may be difficult if a large male of a particular breed is bred to a small female of the same breed. Similar problems occur if a male of a larger breed is bred to a female of a smaller breed.

A young mother may also have difficulty with the passage of the fetus. The lack of both birthing experience and physical development is the source of the difficulty.

During the birth, damage may be done to the reproductive system. The mother can tear the cervix, vagina, and vulva. After the birth, a prolapse may occur, with the organs of the reproductive system being pulled out of the mother's body.

Other complications may also arise. The fetus may be positioned abnormally, or malpresented, which can create birthing problems. Uncontrollable fetal bleeding can be a problem if the fetus is injured during parturition. The mother or newborn may also become infected from the actual birthing process.

Malpresentations

The fetus should be positioned in the uterus in order to pass through the birth canal with the least resistance. The normal presentation for cattle, sheep, horses, dogs, and rabbits is with the head positioned between the front legs to leave the birth canal first. Fetal pigs, however, do not orient themselves in any one position for birth.

Any variation from the normal position is called a malpresentation. For example, one malpresentation occurs when the fetus is positioned backward with both hind legs extended to pass into the birth canal first. While birth may proceed without assistance and occur without difficulty, the birth process must go quickly or the fetus may suffocate if the umbilical cord breaks. See Figure 5.1 for illustrations of the ideal presentation and malpresentations.

Other malpresentations require intervention in order for the birth to proceed. Often the fetus can be straightened to exit the birth canal and pulled from the mother. While some malpresentations can be corrected by the producer, many require the assistance of a veterinarian. Some of the common types of malpresentations and ways to assist with each are listed below.

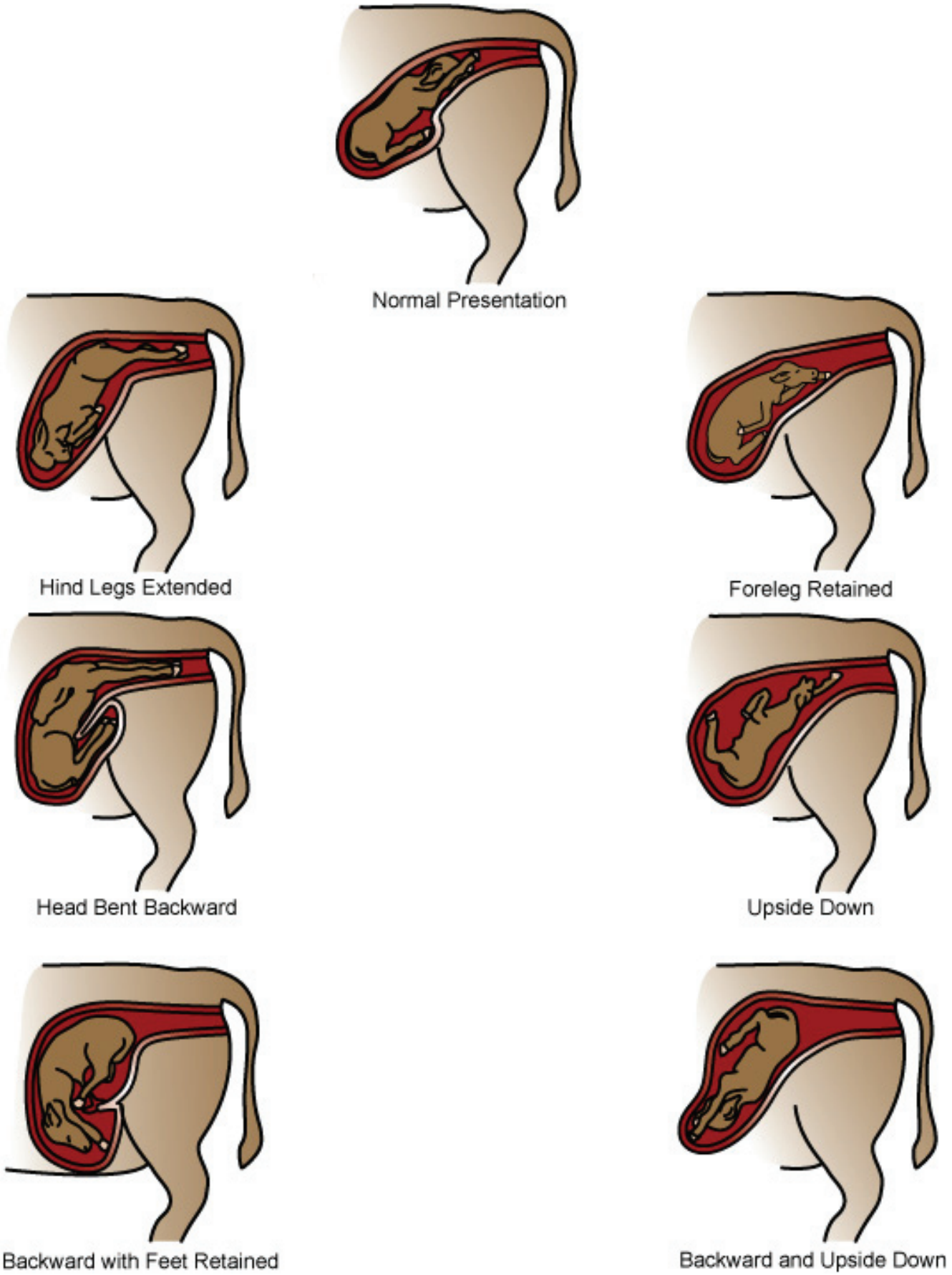
1. The fetus may be turned backward with its legs retained, or bent back into the uterus. If this malpresentation occurs, straighten the hind legs to enter the birth canal. The fetus must then be delivered quickly to avoid suffocation, as explained above.

2. The fetus may be positioned to leave the birth canal headfirst but have one or both forefeet retained. If a foot is retained, pull it forward in order for the calf to exit the birth canal in the normal position.

3. The head of the fetus may be bent backward. To assist with the birth, reposition the fetus by pushing it back into the uterus and bringing the head forward between the legs. Pull the legs forward to allow the fetus to exit the birth canal.

4. The fetus may be presented abnormally by being turned upside down. Turn the fetus to the normal position or deliver it upside down.

Figure 5.1 - Parturition Presentations of a Calf



5. The fetus may be turned upside down and backward. Turn it to the normal position.

Occasionally, some births are so problematic that the fetus may require additional assistance. If pulling the fetus is not appropriate, a cesarean may be performed. In this procedure, a veterinarian makes an incision in the mother's abdomen to deliver the fetus.

If the fetus is no longer alive, dismemberment of the dead fetus by a veterinarian may be an alternative to remove it from the mother. Dismemberment is done to provide the least resistance for the mother.

Postpartum Management Factors

Once the birth process has been completed, the producer still has work to do. In the postpartum period, or the period that follows immediately after parturition, both the mother and the newborn need to receive care in order to ensure that they are healthy.

Cattle – Make sure that the calf is breathing properly. It may be necessary to remove mucus from the respiratory tract or provide some form of stimulation to trigger breathing. Make sure the calf has been licked dry by the mother, or dry it by rubbing it with a cloth. The newborn calf should nurse soon after birth in order to receive colostrum, a special milk secreted for only a short while after birth that passes vitamins, minerals, and antibodies to the calf; it may be necessary to hand or force feed the calf. The navel should be dipped in iodine to reduce navel infections. The calf should be identified with an ear tag. Check to make sure that the cow has expelled the afterbirth. If the placenta has been retained, serious infections can result. The cow should also be checked for signs of milk fever. Milk fever is associated with low levels of calcium in the blood and causes partial paralysis of muscles. It may appear shortly before calving and make it difficult for the cow to give birth; it may also appear after calving. Signs of milk fever are a limp tail and dragging hind feet. A veterinarian must be contacted to treat the animal with calcium injections. If untreated, the cow may become paralyzed, collapse, and die in a relatively short period of time.

Swine – Check the newborn piglet's breathing and remove mucus or provide stimulation if necessary. Dry the piglet with a cloth. Make sure that the pig nurses to receive colostrum. Remove the umbilical cord, and treat the navel with iodine. Clip the needle teeth with side cutters to protect the sow's udder. Dock the piglet's tail, and then notch the ears for identification. Make sure that the afterbirth is expelled by the sow.

Sheep – Observe the lamb's respiration. Place the lamb and its mother in a clean pen. Dry the lamb with a cloth, and make sure it is warm. It may be necessary to use heat lamps or warm water to warm the lamb, since lambs may die from becoming chilled. Check that the lamb nurses to get colostrum, and force feed if necessary. Cut the umbilical cord and treat it with iodine. Monitor the ewe to make sure the afterbirth is not retained. Check for signs of milk fever.

Horses – Check the foal's breathing. Make sure the foal nurses in order to obtain colostrum. The umbilical cord should break by itself, but if it has not broken after five minutes, it may be necessary to cut it with a pair of clean, dull scissors. However, cutting the cord may cause excessive bleeding. Once the umbilical cord has been broken or cut, dip the navel in iodine. Make sure the afterbirth is expelled within three hours; if not, call a veterinarian. The afterbirth should be closely examined to make sure the entire placenta is expelled by the mare due to the high risk of infection. Check to make sure that the foal has a bowel movement in the first 24 hours; if not, an enema may need to be administered.

Dogs – Monitor the whelp's breathing. Dry the whelp and make sure that it nurses for colostrum. Dip its navel in iodine. Make sure that the afterbirth is not retained by the bitch. The bitch also needs to be observed for a condition called eclampsis, which is caused by a calcium deficiency and occurs mostly when large litters requiring a high level of milk production are produced. If left untreated, the bitch may experience convulsions and die. Physical signs of eclampsis are panting, restlessness, whining, trembling, weakness, and fever. If these signs are observed, consult a veterinarian to obtain calcium injections.

Rabbits – Examine the new litter for 24 hours after the birth. Check the doe's nest for any dead newborns and remove them to keep the nest clean and free of infection. Also remove any afterbirth. Make sure that the newborn rabbits are nursing by examining their stomachs. Check that the nest is warm, well-drained, and well-ventilated.

Fowl and the Hatching Process

Fowl do not experience parturition, since they lay eggs instead of giving birth to young. Birds go through their own birthing process called hatching, which involves breaking through the egg's shell. In order for an egg to hatch properly, temperature, humidity, and air velocity around the egg all need to be monitored during incubation. Cool or hot temperatures, low humidity, and too low or too high a velocity of fresh air may also impair hatchability.

Like mammals, the fowl fetus may be malpresented. In fowl, the normal hatching position is with the fetus lying on its side along the longest axis of the egg. The head, which is turned to the egg's larger end, is tucked under the right wing. A malpresentation is any variation from this position.

As in the case of the young of other species, newly hatched fowl need special attention. The temperature of the brooder, which houses the young chicks, needs to be highest right after hatching. A brooder guard should be placed around the brooder for the first few days to ensure that the young birds remain where they can receive enough warmth for health and growth. Humidity and space need to be adequate, and the amount of lighting should be carefully controlled. Make sure the new fowl have proper and sufficient feed and water and are eating and drinking.

Summary

Parturition is the birth process. It is a mechanical process that occurs under the influence of hormones and is signaled by observable physical signs. A number of problems connected with the birth process may occur, including those arising from abnormal fetal presentation. After the newborn enters the world, proper postpartum management must be carried out for the mother and her young to ensure their health. Parturition does not occur in fowl, which go through the process of hatching instead, but the newly hatched chicks also need special care to remain healthy.

Credits

Blakely, James, and David H. Bade. *The Science of Animal Husbandry*. 4th ed. Englewood Cliffs, N.J.: Prentice-Hall, 1985.

Cackler, William. *Livestock and Poultry Breeding (Student Reference)*. Rev. ed. Ohio State University: Ohio Agricultural Education Curriculum Materials Service, 1989.

Calving Difficulty in Beef Cattle (G2035). University Extension agricultural publications, 1986.

Lee, Jasper S., et al. *Introduction to Livestock and Poultry Production*. Danville, IL: Interstate Publishers, Inc., 1996.

Rabbit Production Handbook. Rev. ed. Texas A&M University: Instructional Materials Service, 1993.

Taylor, R. E. *Scientific Farm Animal Production*. 4th ed. New York: Macmillan Publishing Company, 1992.

Warren, D. M. *Small Animal Care and Management*. Albany, N.Y.: Delmar Publishers, 1995.

Introduction to Animal Reproduction

Genetics is the science of inheritance, the study of the passage of traits from one generation to its offspring. A knowledge of genetics can help the producer determine the characteristics that will likely be passed on through breeding.

Genes and Their Function

A gene is the unit of inheritance. Inheritable traits are carried to offspring during reproduction by the genes of its parents. The genes found in a particular cell determine what that cell will be like, and thus what the body made up of those cells will look like. The component of the gene that controls inheritance is deoxyribonucleic acid (DNA).

Chromosomes and Their Function

Chromosomes are long, slender, threadlike structures found in the nucleus of a cell. The chromosome carries the genes responsible for the inherited traits of the animal. Each chromosome carries hundreds of genes, which are found at a fixed location. Chromosomes occur in pairs, and thus so do genes. The genes appear side by side on the paired chromosomes. Figure 6.1 illustrates the pairing of genes and chromosomes.

Figure 6.1 - Chromosomes and Genes

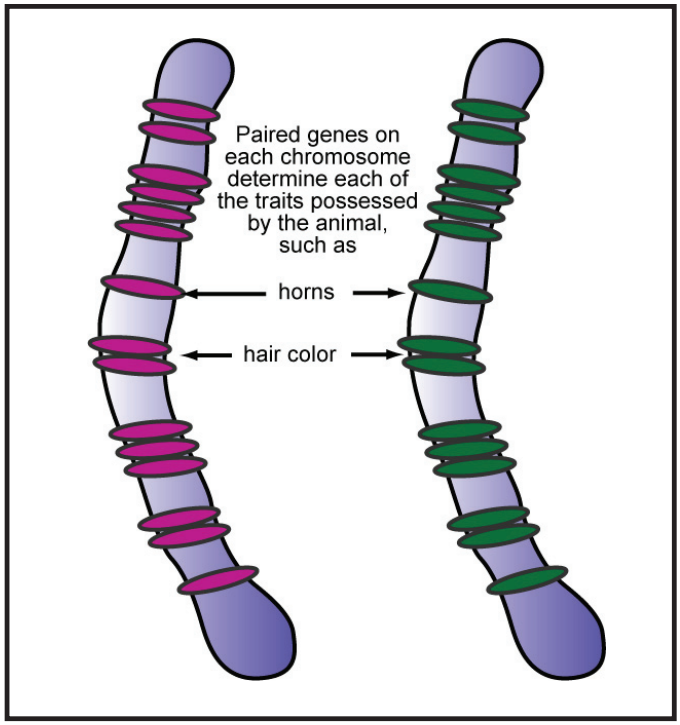


Table 6.1 - Chromosome Numbers

Species	Chromosomes	Pairs
Cattle	60	30
Swine	38	19
Fowl (poultry)	78	39
Sheep	54	27
Horses	64	32
Dogs	78	39
Rabbits	44	22

The reproductive cells (sperm and ova) are different from other cells in that they possess single rather than paired chromosomes. In human beings, for example, reproductive cells have 23 chromosomes, while other cells have 23 pairs of chromosomes. When the sperm and egg unite at conception, the fertilized egg has 23 pairs of chromosomes combining genetic material from the mother and father.

Different animal species have different numbers of chromosomes. Look at Table 6.1 to compare species. Cattle have 60 chromosomes, while swine have 38 chromosomes. The numbers of chromosomes found in fowl vary, but poultry have 78 chromosomes. Sheep have 54 chromosomes. A horse has 64 chromosomes, and a dog has 78. Rabbits have 44 chromosomes. To find the number of pairs, divide the number of chromosomes by two.

Dominant and Recessive Genes

Most of the traits that are expressed in offspring are determined by the combination of several gene pairs. However, some characteristics are determined by only a single pair. In that case, the interaction of the genes making up the pair can be traced, and the likelihood of whether or not an unborn animal will possess the associated trait can be calculated.

Not all of the genes inherited from its parents have a visible effect on the offspring. Some genes, called dominant genes, hide a paired gene's characteristic. The gene of the suppressed or hidden trait is called a recessive gene. The way in which the dominant and recessive genes match up at conception determines the trait that will be found in the offspring. Even if the gene pair has only one dominant

gene, the newborn will exhibit that trait. The recessive trait will only be exhibited if the gene pair is composed of two recessive genes.

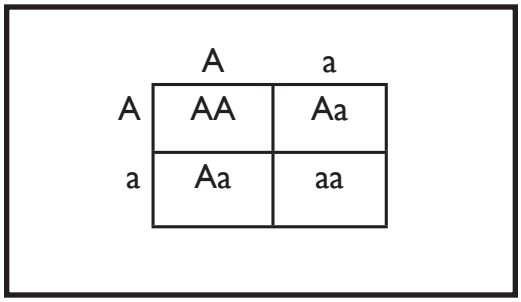
Sometimes neither of the genes in a gene pair is dominant. Incomplete dominance is the result of the joint action of the genes, both of which have an effect on the characteristic controlled by that gene pair. For example, in shorthorn cattle, the coat color may be red, white, or roan, which results from the interaction of the genes for red and white coat color.

The possible combinations of dominant and recessive gene pairs found in offspring can be predicted with a checkerboard system, which makes use of a set of boxes that form what is referred to as a Punnet square. As an example, suppose that a polled cow is to be mated to a polled bull. Horns are a recessive trait, while the polled characteristic is dominant. It is known that both cow and bull possess the recessive gene as well as the dominant one.

When recording the genetic makeup of each animal, a capital letter is used to indicate the dominant gene and a lowercase letter is used to indicate the recessive gene. In the example, a large A is used to represent the dominant polled gene and a small a indicates the recessive horned gene. The cow and bull thus each have a gene pair of Aa.

The bull's gene pair is placed on top of the Punnet square and the cow's placed on the side, one gene for each box on that side of the square. For the bull, the large A is placed over the first column and the small a over the second column, while the cow's large A is written next to the first row with the small a next to the second. Each of the boxes in the square represents a possible gene pair for the offspring. For each column and row the gene's letter is brought down or across. For example, the male has an A in the first column that is carried down the two boxes in the column. The result is four possible gene pairs of AA, Aa, Aa, and aa, as shown in Figure 6.2.

Figure 6.2 - Aa x Aa Cross



According to the Punnet square, two of the offspring are heterozygous, and two are homozygous. A heterozygous animal is one that carries two different genes for a particular characteristic (Aa). A homozygous animal is one that carries identical genes for a characteristic (AA, aa).

The outward physical appearance of the animal is called the phenotype. Of the four possibilities for offspring, three will be polled, because they possess the dominant A gene. Only one of the possibilities will be horned. So the phenotypic ratio is 3:1, with three polled and one horned.

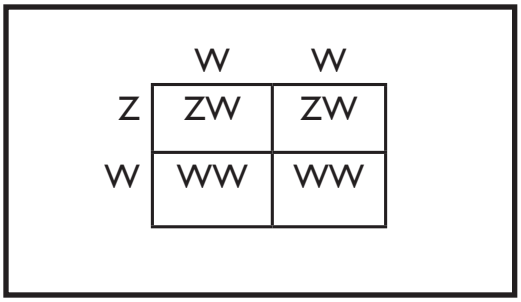
The gene pair possibilities can also be analyzed according to the actual genes found in each pair. The genetic makeup of an individual is referred to as the genotype. In the example, there are three different genotypes, with one AA, two Aa, and one aa. The genotypic ratio is 1:2:1.

Sex Determination in Offspring

Genetic inheritance also determines the sex of offspring. In most species, the X and Y chromosomes determine sex, with X being the female chromosome and Y the male chromosome. A female has a chromosome pair of XX and so can only give offspring an X chromosome. The male's chromosome pair is XY. The male therefore determines the sex of offspring, since he can contribute an X or a Y chromosome. The sex of the offspring depends on whether the X or the Y chromosome is present in the sperm that joins with the egg at conception.

In contrast, the female determines the sex in fowl. The process is the same, but the female and male roles are switched, since the female has two different

Figure 6.3 - Sex Determination in Fowl



chromosomes while both of the male's are the same. Figure 6.3 illustrates sex determination in fowl, with WW standing for the male chromosome pair and ZW for the female pair.

Summary

A gene is a unit of inheritance that is located on a chromosome. Each animal species has a specific number of chromosomes, which are found in pairs. The gene pairs on these paired chromosomes determine the characteristics of the animal, which can be passed on to its offspring through the reproductive cells. A Punnet square can be used to predict the relationship of dominant and recessive genes in offspring when the male and female are mated. Genetic inheritance determines not only the traits but also the sex of the offspring.

Credits

Cackler, William. *Livestock and Poultry Breeding (Student Reference)*. Rev. ed. Ohio State University: Ohio Agricultural Education Curriculum Materials Service, 1989.

Gillespie, James R. *Modern Livestock and Poultry Production*. 5th ed. Albany, N.Y.: Delmar Publishers, 1997.

Lee, Jasper S., et al. *Introduction to Livestock and Poultry Production*. Danville, IL: Interstate Publishers, Inc., 1996.

University Extension agricultural publications, University of Missouri-Columbia.

G3000: *Fundamentals of Inheritance*
G2791: *Genetics of Coat Color of Horses*

Warren, D. M. *Small Animal Care and Management*. Albany, N.Y.: Delmar Publishers, 1995.

Genetic Improvement Management Practices

Genetic improvement management practices are used to improve the genetic makeup of offspring, which leads to better quality animals. Developing a superior animal through these management practices allows the producer to achieve greater efficiency in production, since he or she has a higher quality animal.

Management Practices

Management practices that will improve a producer's stock genetically require the careful selection of animals for breeding by the producer. Genetic selection, evaluating the animal, and artificial methods of breeding are general management practices.

Genetic selection is a major management practice used to improve genetics in a breeding program. Genetic selection can be achieved using several different techniques, such as tandem selection, culling, and selection indexing.

Tandem selection involves breeding for one or two traits at a time. The selection process becomes limited and ineffective when selecting for more than two traits, because the desired traits will have less of an impact on the breeding program as more are selected. When using this technique, an individual identifies a desired trait and selects an animal possessing that trait for breeding.

Culling is a management practice that is widely used for many species. Culling eliminates less desirable traits by removing individuals possessing those traits from the breeding program. Unlike tandem selection, culling involves the removal rather than the addition of traits from the stock.

Another management practice involves using a selection index, which is a type of scoring system. Criteria are developed reflecting the desired qualities for the breeding animal. Animals are ranked for each quality, with a low score being best. The animal that has the lowest overall score based on the criteria of the index is used for the breeding program. In contrast to tandem selection, this practice considers all of the traits of the animal when selecting the best animal for the breeding program.

Evaluating animals by comparing the pedigrees (lists of an animal's ancestors), individual appearances, performance records, and progeny tests of different animals can help an individual select the proper animal for use in a breeding program. This type of management practice does not involve trying to analyze the genetics of an animal but rather evaluates its heritage and performance. For example, performance records include data on the measurable aspects of an animal's performance through its life stage that can be consulted when deciding whether or not to include it in a breeding program. Progeny tests compare sires based on the estimated performance of their offspring; they cannot be used for a young sire that has not yet produced a large number of offspring. When making improvements to a breeding program, items such as these should be considered to achieve a balanced program.

Other management practices that can be used to improve the genetic makeup of a producer's stock include artificial breeding methods. The use of these breeding methods can broaden the choices available to the producer when he or she is trying to select an animal for a breeding program. Management practices like artificial insemination (AI) and embryo transfer (ET) can be utilized after the right animal has been selected for breeding. With these techniques, the genes of exceptional males and females can be spread more extensively than they would if natural mating was used. Genetic improvement is achieved by selecting a genetically superior sire for AI or a genetically superior female for ET.

Breeding Systems

A breeding system is a system that determines the offspring's breed and its relationship to other offspring and to its parents. The two types of breeding systems are straight breeding and crossbreeding. These two systems are used in a breeding program to improve the genetic makeup of animals and the desired outcome of that program.

Straight breeding is a system that involves the mating of two animals from the same breed. Straight breeding helps to maintain a purebred stock for commercial producers, who use them in their operations to produce high quality animals. Several types of straight breeding may be utilized.

Purebred breeding is one type of straight breeding. The male and female are both purebred animals and are of the same breed. Purebred breeding results in a greater standardization of genetic material, which may at times have the negative effect of causing less desirable recessive traits to appear in the offspring.

Another type of straight breeding is inbreeding, the mating of animals that are more closely related than the average of the population. Inbreeding is used to improve genetic purity in a breeding program by further selecting for a desirable characteristic of that breed. This type of breeding is further broken down into two categories. The term close breeding is used if the relationship is a close one and the animals share more than one ancestor, such as a sire and daughter or brother and sister. In another type of inbreeding, line breeding, the mating of related animals is used to maintain a close genetic relationship to an outstanding ancestor. Examples of line breeding include the mating of cousins or a female and her grandsire. This breeding system requires a careful use of selection and culling for best results.

Outcrossing involves breeding a male and female that are of the same breed but different pedigrees. The purpose of outcrossing is to bring new desirable traits into the stock.

Another method that can be used to improve genetic stock is called grading up or upgrading. In upgrading, a purebred male is bred to a grade female, which has one purebred parent and one of a mixed or unknown breed and so cannot be registered with a breed association. Grading up results in slower overall improvement, but a marked genetic improvement is present after the first breeding, clearly demonstrating the enhancements that have been made.

Crossbreeding is the other type of breeding system. It involves the breeding of two animals from different breeds; the animals may both be purebred, or a purebred male and a grade female may be bred. The major benefit of crossbreeding is hybrid vigor. Hybrid vigor is evident when the offspring displays superior qualities in comparison to the average of its parents, such as an increase in size, rate of growth, and vitality. Crossbreeding also results in animals that combine desirable traits not found in any one breed. Several different crosses may be made when using the crossbreeding system.

One type of crossbreeding system is the two-breed cross. This cross involves mating a female and male from different breeds. An example of a two-breed cross is the breeding of a Hereford cow to an Angus bull.

A three-breed cross involves the mating of a crossbreed female to a male of a different breed. For example, if a crossbreed Angus-Hereford cow were produced by the first cross described above and bred to a Simmental bull, it would be a three-breed cross.

A rotational cross is another type of breeding system. A rotational cross involves using males of different breeds for several succeeding generations of females, ending with a male of the same breed as the female used in the first cross and then repeating the series. If the offspring of the Angus-Hereford cow from the first example and a Simmental bull was bred back to a Hereford sire, it would be a three-breed rotational cross.

Another type of crossbreeding is called backcrossing. Backcrossing involves the crossbred female being bred to a male that is of the same breed as one of the parents of the female. In the case of a backcross, the crossbred Angus-Hereford cow would be bred to an Angus or Hereford bull.

Artificial Insemination

Once a breeding system and the appropriate animals for breeding have been selected, the female can be bred either naturally or by using artificial insemination (AI). As discussed in Lesson 4, artificial insemination involves depositing semen that has been previously collected from the male in the female reproductive tract. Genetic improvement is achieved through AI by selecting the sire that best complements the breeding program.

Using AI for genetic improvement has a number of advantages.

- The biggest advantage to AI is that it allows an outstanding sire to be used more widely to improve genetics, since the sire does not need to be present for the breeding. The male can therefore produce a greater number of genetically superior animals. The rate of genetic improvement for a producer's stock is increased.

- Another advantage is that AI allows the collected semen to be frozen and stored so that more offspring can be produced from one semen collection. Using AI, the offspring can even be produced after the sire is dead.

- Injured sires can still produce offspring in a breeding program with the help of AI.

- AI can also be used to control diseases.

- Traditional sire ownership becomes unnecessary, eliminating associated costs.

- Sire costs may be lowered, since the producer no longer has to pay for service. However, he or she still has to pay for the services of the technician.

Artificial insemination also has some disadvantages when used as a way of improving genetic stock.

- The collected semen requires careful handling and storage. If a mistake is made when storing the semen for later use, it cannot be used to produce offspring.

- Another disadvantage concerns the thawing of semen. Once semen is thawed, it cannot be refrozen and used again, since the sperm cells are destroyed.

- AI also requires additional management practices and facilities and more time and labor to ensure pregnancy. Each use of AI requires special handling of the animal. Also, estrous cycles must be carefully monitored. Conception depends on breeding at the right time, and if insemination occurs at the wrong time, the female will not conceive and the producer will have to wait through another estrous cycle to try again.

- Since the use of proper technique is vital or conception may not occur, the person doing the procedure must be specially trained.

- A final disadvantage of using AI is that it may overly stress females.

Embryo Transfer

Embryo transfer (ET), as explained in Lesson 4, is the transferring of embryos from one female to others for the rest of the gestational period. It improves the genetic stock by allowing for the best use of the superior female that has been selected for the breeding program. ET, like AI, has its own advantages and disadvantages that should be taken into consideration when determining whether or not to use it.

Embryo transfer has several advantages for the producer.

- The greatest advantage of ET is that it allows an exceptional animal to produce a larger number of genetically superior offspring since the female yields a large number of ova for implantation. Because the female does not have to bear all her offspring herself, she can produce many more offspring during her lifetime. The rate of genetic improvement is therefore increased.

- Another advantage of ET is that the collected embryos can be frozen and remain dormant for months or years to be implanted whenever it best suits the plans of the producer.

- An embryo can be mechanically divided to produce identical twins to increase the number of superior animals.

- Superior females that cannot produce offspring themselves due to some condition may be used in a breeding program.

Disadvantages of using ET also exist.

- Extensive management is required for successful embryo transfer, since the procedure may involve the use of AI as well as the process to recover the embryos after fertilization.

- Special management is also required for estrous synchronization, or matching the estrous cycles of the donor and the host female, which is necessary in order to transfer the embryo to the host at the best time for gestation. If the timing is off, the desired offspring will not be produced.

- In order to have enough recipient females available to carry the eggs harvested from the donor female, the producer will have to keep more stock, with several recipients for every donor. Keeping more animals increases costs for the producer, with no return if the animal is unused.

- In addition to the cost of keeping additional females, ET is itself a costly process.

- Another disadvantage is the low pregnancy rate for frozen embryos implanted in surrogate mothers.

- If the procedure to remove the embryos from the donor female does not work, surgery may be required.

Summary

Genetic improvements are made through a variety of management practices. Proper management practices for breeding involve the selection of the appropriate animals and the use of a particular breeding system. When the animals to be bred and the breeding system to be used are determined, either artificial insemination or embryo transfer can be used to improve the genetic makeup of the stock owned by a producer.

Credits

Baker, Andy. *Animal Science (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1996.

Crossbreeding Systems for Small Herds of Beef Cattle (G2040). University Extension agricultural publications, 1993.

Gillespie, J. R. *Modern Livestock and Poultry Production*. 5th ed. Albany, N.Y.: Delmar Publishers, 1997.

Taylor, R. E. *Scientific Farm Animal Production.* 4th ed. New York: Macmillan Publishing Company, 1992.