

Reproduction and Genetics

Glossary

Abortion—A premature expulsion of the fetus.

Ejaculation—Discharge of semen from the male.

Embryo—Name given to the egg after fertilization during early development of the fetus.

Estrous cycle—Period of time from the end of one heat period to the start of the next.

Estrus—Period that the female will allow the male to mate with her. Also called heat.

Fertility—The degree of success or failure to reproduce.

Fertilization—Union of the sperm and the egg.

Fetus—The unborn lamb from the embryo period to birth.

Gestation (pregnancy)—The length of the period between fertilization and lambing, about 148 days in sheep.

Gonad—Germ cell producing tissue, an ovary or testis.

Heat—Another name for estrus.

Hormone—Specific chemical messengers secreted from endocrine glands that influence the bodily function of other organs.

Lambing—The parturition or birth of lambs.

Mate—Breeding a ram to a ewe.

Ovulation—Release of mature egg from the follicle of an ovary.

Ovum—Egg produced by the ovary that contains one-half of the number of chromosomes until fertilized.

Parturition—Act of giving birth to young.

Prolific—Reproducing regularly and numerously.

Puberty—Period in growth and development during which the reproductive system acquires mature form and function.

Sperm—The male sex cell.

Male Reproductive Organs and Their Functions

Accessory sex glands—Glands that add fluid that nourishes and transports sperm through the urethra.

Epididymis—Duct that collects and stores sperm while they undergo a maturation.

Penis—Organ used to place semen in the female reproductive system during mating.

Scrotum—An external pouch of skin that encloses the testicles and aids in regulating their temperature.

Testes—Sex glands where sperm originate.

Urethra—Duct through which semen and urine travel through penis to be discharged from the body.

Vas deferens—Duct that carries sperm from the epididymis to the accessory sex glands area.

Female Reproductive Organs and Their Functions

Cervix—Muscle that closes off uterus separating it from the vagina.

Ovaries—Glands where eggs originate and site of production of the hormones estrogen and progesterone.

Oviduct or fallopian tubes—Tubes that eggs travel through to enter the uterus.

Uterus—Organ that contains and nourishes the embryo throughout gestation until the fetus is born.

Vagina—Canal leading from the uterus to external part of the system, sometimes called birth canal. Also the site where semen is deposited during mating.

Vulva—The external part of the reproductive system.

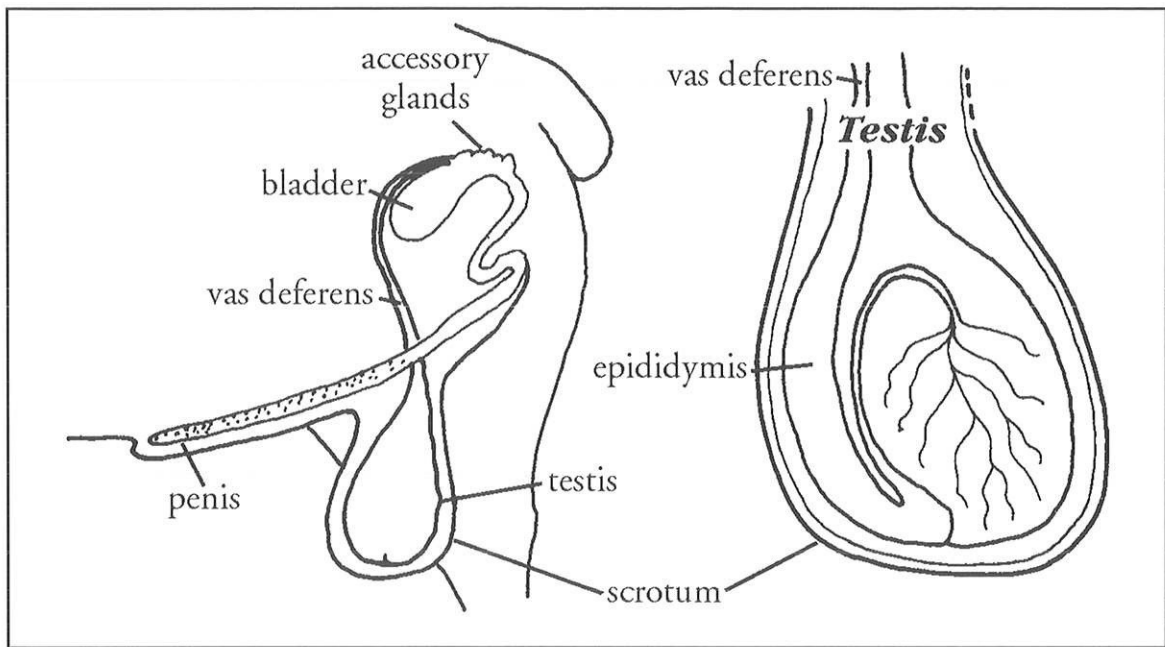


Figure 69
Ram's Reproductive System

Reproductive performance is of primary importance to the sheep industry. The success and profitability of any sheep enterprise is closely related to the level of lamb production. Production costs are nearly the same if a ewe produces no offspring or one, two or three lambs per year. The return to the producer varies greatly. Fertility not only affects the number of lambs born and the frequency of birth, but also the time. This is also of economic importance.

In the wild, sheep were seasonal breeders (breeding only during a certain season). Their offspring were born at the time most favorable for survival, usually in the spring. This has been slightly altered in domestic sheep for the convenience and profitability of producers.

Ewes and rams normally reach puberty at 5–8 months of age but this can be influenced by inheritance, nutrition, date of birth and breed.

Anestrus period (reproductive inactivity) is a period when ewes do not demonstrate estrus (heat). Three types of anestrus can be observed in ewes: seasonal, lactation, and post partum.

The time between estrus or heat periods is usually 14–19 days with the average being 16½ days. The length of estrus or heat period is usually 20–42

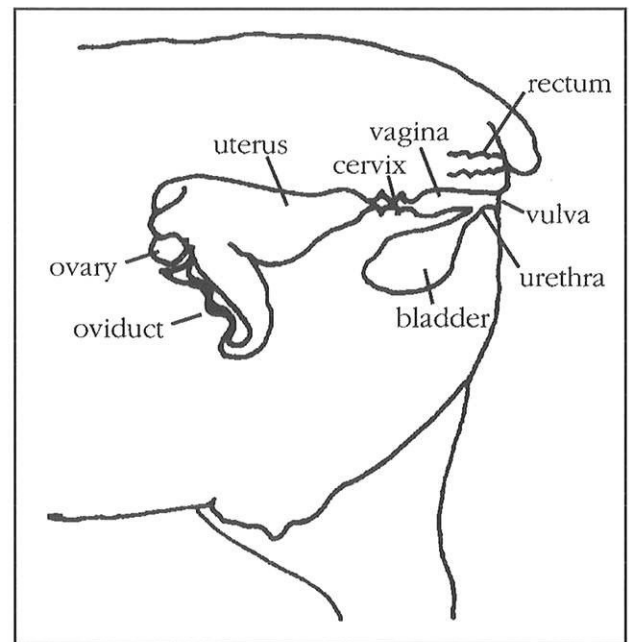


Figure 70
Ewes Reproductive System

hours with the average being 30–35 hours. Ovulation occurs late in the period.

The gestation period is 143–152 days with an average of 148 days. The medium wool breeds and meat breeds tend to have shorter gestation periods than the fine wool breeds. High

temperatures and high levels of nutrition may shorten the gestation by two to three days.

Many factors affect fertility in the ewe. These include heredity; age of puberty; age of the ewe; light, temperature, relative humidity and season; association with the ram; nutrition; parturition and lactation; disease and parasites; and the fertility of the ram.

Different breeds of sheep come into heat at different times of the year. The most popular times of the year for lambs to arrive are spring or fall. The ewe needs 148 days for the lambs to develop in her uterus. Breed her at least five months before you want the lambs to be born. (See *Breeding Chart*, Appendix II.)

During mating, the ram ejaculates semen into the vagina of the ewe. The semen consist of the sperm that is manufactured in the testicles and then mixed with fluids from glands in the reproductive tract. Ram semen is extremely concentrated when compared to boar and bull semen. The ram will normally ejaculate about 1cc. of semen. This normally contains 1–5 billion sperm cells. Only one sperm is needed to fertilize each egg produced by the ewe. Before a ram is used to breed ewes, you may want him to be evaluated for reproductive soundness. A veterinarian can collect a sample of semen and examine the sperm to make sure they are viable. This process of evaluating a ram for reproductive soundness is called a Breeding Soundness Exam (BSE).

Breeding Seasons

Some breeds used in the United States can be characterized as follows:

Breeds with long breeding season. Some individuals may breed during anestrus but the incidence is low.

- Rambouillet
- Merino
- Dorset
- Exotic types that had their development in a more equatorial region.

Breeds intermediate between these extremes.

- Hampshire
- Columbia
- Corriedale
- All crosses that involve Dorset or fine-wool ewes.

Breeds which remain largely restricted with little mating before September.

- Southdown
- Cheviot
- Shropshire
- The long-wool breeds which had their development in England or Scotland.

The Reproductive Process

At approximately 16–17 day intervals during the breeding season, the ovary produces one or more eggs. This coincides with estrus. The ewe then allows the ram to breed her and sperm are deposited through the penis into the vagina as a result of mating. Fertilization usually occurs in the upper third of the oviduct as the sperm that has traveled from the cervix area of the vagina encounters the eggs traveling toward the uterus. The fertilized egg begins cell division during its journey to the uterus. Within the uterus it attaches to the uterine wall, which is called

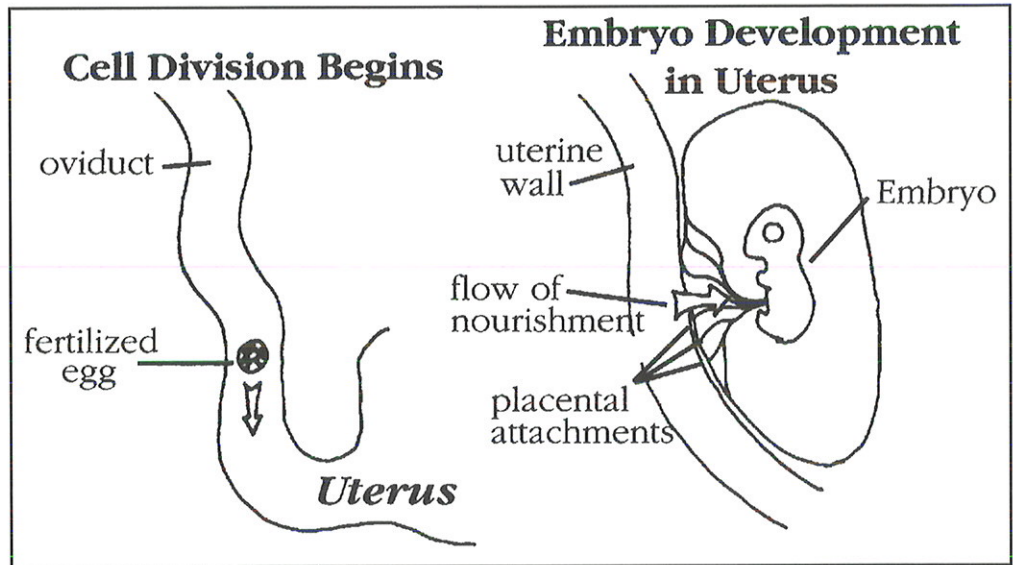


Figure 71

implantation. Tissues surrounding the embryo form the placenta through which the embryo receives nourishment from the ewe for development during gestation. The gestation period for ewes averages approximately 148 days.

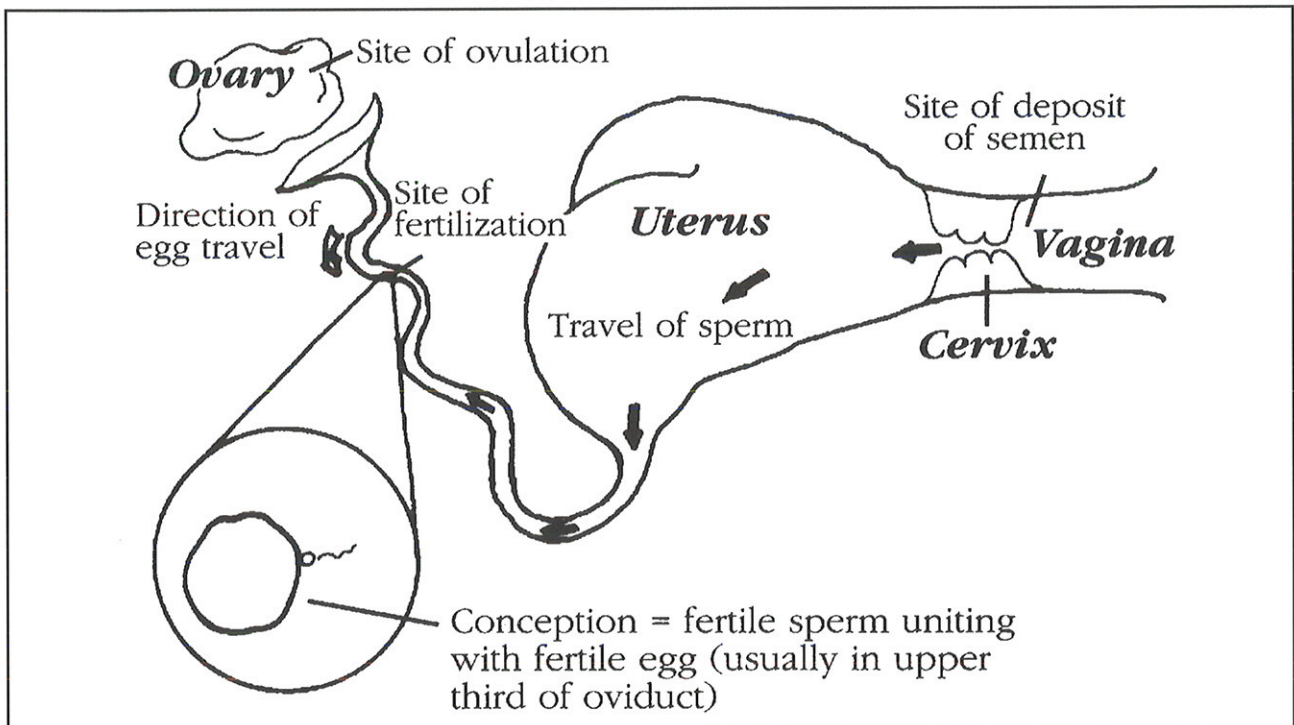


Figure 72

The Hormones of Reproduction

Hormones regulate the reproductive organs of the ram and ewe. Hormones are substances secreted from areas of the body like the brain, the ovaries and even the placenta.

Hormones in the Ewe

Estrogen causes the development of the sex organs and secondary sex characteristics in the ewe and causes her to exhibit estrus or heat.

FSH and LH (follicle stimulating hormone and luteinizing hormone) stimulate the development of the ova in the fluid filled gland on the ovary called a follicle.

GnRH (gonadotrophin releasing hormone) triggers the release of FSH and LH.

Progesterone is the hormone that maintains pregnancy.

Prostaglandin F-2 Alpha causes the regression of the Corpus Luteum (a follicle that has matured after the egg was ovulated) and allows the female to come into heat again.

Hormones in the Ram

FSH has a similar function in the ram as it has in the ewe. It stimulates the production and maturation of sperm.

GnRH triggers the release of FSH and LH in the ram, as it does in the ewe.

LH causes the secretion of the male sex hormone called testosterone.

Testosterone causes the development of sex organs and secondary sex characteristics in the ram.

Artificial Insemination of Sheep

Artificial insemination of sheep is an area of sheep reproduction which is growing at an increasing rate. Sheep producers are utilizing artificial insemination as a method to improve the genetics of their flocks. Artificial insemination can be used by the progressive producer to breed their ewes:

- To a variety of superior stud rams without purchasing those rams.
- To rams that are geographically inaccessible.
- To those “legendary” rams no longer with us.
- All to one ram or rams in one day to assist in the management of the lambing season.
- To the stud ram that is injured by a temporary disability.
- To prevent the transfer of disease or contagious infections.

Ram Semen Collection (Ram Semen Cryopreservation)

Ram semen collection is a technology that is being utilized by sheep producers to allow further use of “superior” stud rams. Ram semen collection is being used by the sheep producer to:

- Provide reproductive insurance—it allows usage of semen anytime in the future, anywhere.
- Provide protection of your investment at a minimal cost
- Provide for greater marketability of your ram.
- Provide for semen sales in the U.S. and in the international market.
- Eliminate the geographical inhibitors in partnership agreements.
- Provide for research and development of reproduction and genetics.
- Assist in spider gene research and other reproductive research.

Genetics

Genetics is the science that studies how animals inherit characteristics or traits from parents and pass these traits on to offspring. All living plants and animals are made up of tiny units called cells. Although cells vary considerably, they all have three common features. Each cell has a nucleus, cytoplasm and a cell membrane.

The nucleus is very important to genetics. The tiny threadlike materials from inside the nucleus

are called chromosomes. Chromosomes are carriers of small units called genes. The chromosomes and the genes within them determine the animal's genetic make-up or genotype. Genes occur in pairs—one inherited from each parent. Sheep have 27 pairs of chromosomes. Humans have only 23 pairs of chromosomes. The way the genes are expressed, or the physical appearance of the animal, is called the phenotype.

All cells of an individual have the same number of chromosomes and carry the same genes except the sex cells. Male sex cells are called sperm. Female sex cells are called eggs or ova. The sperm and egg only contain half the number of chromosomes that other body cells (autosomal chromosomes) have. This is because when the sperm and egg combine in fertilization the chromosomes also combine and add up to 54 (27 pairs).

Genes are responsible for many changes within a cell. Certain traits are controlled by only one gene pair. These traits are called qualitative traits. Qualitative traits fall into specific categories, such as wool color or the presence of horns. Many traits, such as growth and wool production involve several pairs of genes. These are called quantitative traits. Quantitative traits are easily influenced by the environment in which the animal lives, such as feed, shelter, medication, and weather. Because of the environmental portion of quantitative traits, there must be an estimate of how much a particular trait is because of genetic makeup. This estimate is heritability.

Heritability is the proportion of variation in a trait resulting from genetic effects, or the part of the trait that comes from the animal's ancestors, mother, father, etc. The greater the genetic influence on a trait, the higher the heritability value.

Heritability estimates below 20 percent are considered low; values above 40 percent are high. (See Table 15.) Those traits between 0.20 and 0.40 percent are medium in heritability. Birth weight, for example, is 15 percent heritable and is low in heritability. Fifteen percent of an animal's birth weight comes from its parents, the other 85 percent is a result of the environment. The environment includes: how the ewe was fed; if the lamb is a single, twin or triplet; the age of the

dam and other factors. The amount of progress that can be made through genetic influence is determined by heritability. A sound breeding program is based on improving traits that are heritable. Generally, more improvement is possible in traits with higher heritabilities than in traits with lower heritabilities. Selecting for too many traits, however, may result in reducing the amount of progress you can make in a short time.

Heritabilities of Various Traits*

Reproductive traits	Percent
Ewe fertility	5 ^a
Prolificacy ^b	10
Scrotal circumference	35
Age at puberty	25
Lamb survival	5
Ewe productivity ^c	20
Growth traits	
Birth weight	15
60-day weight	20
90-day weight	25
120-day weight	30
240-day weight	40
Preweaning gain: birth–60 days	20
Postweaning gain: 60–120 days	40
Carcass traits	
Carcass weight	35
Weight of trimmed retail cuts	45
Percent trimmed retail cuts	40
Loin eye area	35
12 th rib fat thickness	30
Dressing percent	10
Fleece traits	
Grease fleece weight	35
Clean fleece weight	25
Yield (%)	40
Staple length	55
Fiber diameter	40
Crimp	45
Color	45

^aMay increase to 10 percent in ewe lambs and in ewes bred in spring.

^bLambs born per ewe lambing.

^cPounds of lamb weaned per ewe exposed.

*Adapted from SiD Sheep Production Handbook, 1996

Table 15

Glossary

Chromosomes—Carriers of the basic units of heredity.

Gene—Basic unit of heredity that is located on chromosomes and affects a specific trait.

Genotype—The genetic make-up of the animal.

Heritability—The amount of variation in a trait resulting from genetic differences.

Heterosis—The increase in performance associated with the crossbred animal when compared to the average of the purebred parents.

Heterozygous—A gene pair with different genes for the same trait.

Homozygous—A gene pair where both genes are identical.

Phenotype—The expression of genetic traits.

Prepotency—The ability of an animal to make its offspring resemble it and each other more closely than usual.

Qualitative traits—Traits that are controlled by only one gene pair.

Quantitative traits—Traits that are controlled by multiple gene pairs.

Trait—An animal characteristic that can be selected for.

The Way Genes are Inherited

The parents each donate one gene to the offspring, giving the animal a pair. The genes can be either dominant or recessive.

A dominant gene is expressed regardless of the other gene in the pair. Dominant genes are written in a capital letter (P).

A recessive gene is one that is not expressed unless there are two recessives in the pair. Recessive genes are written in lower case letters (p).

When two dominant or recessive genes occur together (PP or pp), the animal is called homozygous for that trait. If the animal has one dominant and one recessive gene, the animal is heterozygous for that trait (Pp). A very simple example of this is the presence of horns. P=the dominant, polled condition. p=the recessive horned condition. (See Table 16.)

PP=homozygous, dominant polled

Pp=heterozygous, dominant polled

pp=homozygous, recessive horned

Another example is a single pair of chromosomes that determine the sex of the offspring. The chromosome pair for females is XX. The chromosome pair for males is XY. All eggs produced by the female contain an X (female) chromosome, but the sperm contain both female (X) and male (Y) chromosomes. Because the sperm contain half male and half female chromosomes, approximately half the lambs born are male and half are female. The sperm determines the sex of the lamb because it can give a female (X) or male (Y) to the egg (X). (See Table 17.)

Genes

A.

If the sire and dam are both homozygous polled:

All offspring would be polled.

		P	Dam	p
Sire	P	PP	PP	
	p	PP	PP	

B.

Sire and dam both horned:

All offspring will be horned

		p	Dam	p
Sire	p	pp	pp	
	P	pp	pp	

C.

Both sire and dam heterozygous polled:

Offspring will be:
 $\frac{3}{4}$ polled
 $\frac{1}{4}$ horned

		P	Dam	p
Sire	P	PP	Pp	
	p	Pp	pp	

D.

Sire homozygous polled, dam heterozygous polled:

All offspring would be polled.

		P	Dam	p
Sire	P	PP	Pp	
	p	PP	Pp	

E.

Sire homozygous polled, dam horned:

All offspring will be polled

		p	Dam	p
Sire	P	Pp	Pp	
	p	Pp	Pp	

Table 16

How Sex is Determined

$\frac{1}{2}$ female
 $\frac{1}{2}$ male
 offspring

		X	Dam	X
Sire	X	XX	XX	
	Y	XY	XY	

Table 17

Applying Genetic Principles To Your Flock

- Set a goal. Decide what you want to achieve genetically with your flock.
- Select a breed that will allow you to meet your goals. Discuss this with your advisor and other producers.
- Choose good animals within the breed for your flock. Decide which traits are most important to you in meeting your goals.
- Keep accurate records of each ewe's production and each lamb's growth performance.

To be successful in genetic selection, develop a clear idea about the merits of individual traits.

For selection to be effective the traits must be:

- **Heritable.** The traits must be capable of being transmitted from parents to offspring.
- **Variable.** Differences must exist between sheep for that trait.
- **Measurable.** The traits must be able to be measured so you can evaluate performance and progress.

Traits of Major Economic Importance

Reproduction

These are traits, such as lambs weaned per ewe and out of season breeding, which are lowly heritable. But, these are still important in economical sheep production.

Growth

This is a moderately heritable trait that can be selected for with good response. Examples of this are birth weight and weaning weight.

Carcass Merit

Carcass traits are fat thickness or loin eye area. These traits are moderately to highly heritable.

Conformation

This refers to the structural make up of the animal and is moderately to highly heritable.

Wool

Wool characteristics like fleece weight and grade are highly heritable.

Methods of Selection

Single Traits

Individual or Mass Selection—This is selecting animals on their physical appearance or performance record. Use of this method is most successful when the heritability of the trait is high.

Family Selection—Replacements are chosen on the average performance of the whole family. This is best used when heritability of the trait is low.

Pedigree Selection—The breeding value of the ancestor is considered when selecting replacements. This should be used when the trait is expressed by only one sex or is not expressed until later in life.

Progeny Test—This is a form of pedigree selection. The breeding value is estimated by the performance of the offspring.

Multiple Traits

As the number of traits being selected for increases, the progress made is smaller.

Tandem Selection—This focuses on one trait at a time, gets it to the desired level and then considers the next trait.

Independent Culling Levels—A minimum standard is set for each trait and all individuals below the standard for any trait are culled.

Selection Index—This ranks each animal for economic importance of the trait, how heritable the trait is and how it is related to the other traits being selected.

Genetic Evaluation Programs—Examples of these are “on-farm testing,” NSIP* and Central ram test programs.

*NSIP (National Sheep Improvement Program) is a performance recording and genetic evaluation program. Contact your county Extension agent or state sheep specialist for more information.

Mating Systems

Mating systems involve mating or breeding the sheep in your flock to obtain certain results. Pure breeding, or straight breeding, is the mating of two animals of the same breed. This is done to maintain a certain breed and its characteristics. Crossbreeding is mating two different breeds to combine desirable traits of two or more different breeds and produce superior offspring.

Straight Breeding

There are several different types of straight breeding:

Outbreeding is the continuous use of unrelated rams. This allows you to get the maximum amount of heterozygosity in a flock.

Inbreeding is the mating of a ram and ewe that have one (or more) common ancestor(s). Examples of this are daughter/sire matings and dam/son matings. Inbreeding increases the number of dominant and recessive genes (homozygosity) and may result in lowered reproductive performance and decreased fleece weights.

Linebreeding is a special kind of inbreeding, which concentrates on continued matings of descendants of a certain animal.

Crossbreeding

This is done because crossbred offspring are superior in some traits when compared with available purebred breeds. The superiority of the offspring is known as heterosis or “hybrid vigor.”

Grading up is the repeated use of rams of a single breed on a set of ewes and their daughters.

New breed formation is the development of a new breed of sheep from crossbreeding existing breeds.

Systematic crossbreeding involves crossing rams and ewes of certain breeds or crosses to get a specific type of offspring. Examples are: two-breed terminal crossing, three-breed rotational cross, roto-terminal cross, etc. The purpose of crossbreeding is to increase both individual and maternal heterosis.

Inherited Defects

A defect is any characteristic that reduces the possibility of survival or decreases the productivity of the animal. The following defects are transmitted from parents to offspring by genetics. Animals and their relatives who exhibit these should be culled and not used for breeding.

Color—Spots or dark patches in the wool.

Cryptorchidism—One or both testes of the ram may be retained in the abdomen. This greatly reduces fertility.

Dwarfism—A very serious defect that results in abnormally short legs, decreased fertility and a short life span.

Entropion (inverted eyelids)—The lower eyelid rolls in and causes eye irritation.

Face covering—Too much wool on the face causes problems with the sheep's vision and reduces production.



Fleece defects—Imperfections such as high belly wool, hairiness and fuzzies should be avoided because they reduce fleece value.

Horns and scurs—These are a defect in polled breeds.

Jaw defects—Undershot and overshot jaws where the teeth do not meet the pad.

Rectal prolapse—A weakness that causes the sheep to push out part of the rectal tissue.

Skin folds—These wrinkles make the sheep very hard to shear.

Spider lamb syndrome—This is a recessive trait that results in lambs with deformed legs and spines. These lambs die early in life and rarely reproduce. This is a very serious defect that is currently appearing in some breeds of sheep. (See Figures 73 and 74.) DNA testing is currently available to assist in the elimination of this syndrome.



Figures 73 and 74

The crooked back and legs are symptoms of spider lamb syndrome.

