Linebreeding, inbreeding…
what's the difference?

By Alice G. Hall

A goat breeder, whether he or she is knowledgeable of the subject or not, is dabbling in the field of genetics (the science that deals with inherited characteristics). A little extra knowledge on the background of the science of breeding can go a long way toward improving future dairy goat characteristics and type.

The basic building blocks of genetics are genes. Genes are complex protein molecules made of DNA and RNA (acids that are templates or patterns for inherited characteristics.) Genes are lined on chromosomes (colored bodies) found in the nucleus of each cell in the body as beads on a string. Chromosomes, and therefore genes, are found in pairs in all the cells of the body except the sperm and eggs. The testicles and ovaries send the chromosomes through meiosis, a process whereby the pairs are split up so that each sperm and each egg carries only one half of a pair of chromosomes, and, therefore, genes. The sperm and eggs are called "gametes" because the number of genes and chromosomes in them are haploid (single) rather than diploid (double or paired) as they are in all other cells.

When two gametes, a sperm and an egg or ovum, unite, the haploid genes and chromosomes find partners and once again become diploid in the zygote (fertilized egg). As the zygote grows, divides itself, and multiplies in number of cells (in the process called mitosis), the cell retains its diploid state. Mitosis is the process by which a body grows and wounds are healed. Meiosis occurs only in the ovaries and testicles as sperms and eggs are manufactured. Each goat sperm and egg contains 30 chromosomes, so each normal body cell contains 60 chromosomes, or 30 pairs.

Genes come in two types, dominant and recessive. Dominant genes overshadow or modify recessive genes when the two are paired on a chromosome. In goats, the white color found in Saanens seems to be dominant over most other colors, so if a Saanen or mutant white gene is paired with a brown or black gene, the kid will probably be white. Such a mixed combination is called heterozygous. That means that a dominant gene and a recessive gene are paired in the genotype. If two dominant genes are paired together, or if two recessive genes are paired together, they are said to be homozygous. Recessive genes must be homozygous to show in the phenotype.

Phenotype is the product that is visible. For example, is the resulting kid black or white? Genotype is what the genes carry, i.e., are they paired homozygous or heterozygous? If a pair of genes is heterozygous, the breeder does not know what the genetics of the goat are. He only sees the dominant that shows in the phenotype. He does not know if that phenotype reveals heterozygosity or homozygosity of the dominant. A breeder who uses inbreeding increases his chances of homozygous recessives, and, therefore has a better chance of seeing recessives in the phenotype.

Horns are recessive, for example. For a goat to have horns, it must have received a gene for horns from both parents. If a horned animal is bred to a hornless one, the genes carried in the hornless kid are heterozygous for hornlessness if the hornless parent is homozygous. If the hornless parent is heterozygous, 50% of the kids will probably be homozygous horned, and the other half will be heterozygous hornless. Since hornlessness is dominant and so easily inherited, one might wonder why most goats seem to have the recessive trait for horns. That is because inbreeding among hornless animals often carries with it a “lethal” gene. Most lethal genes result in the outright death of the animal in a normal environment. The “lethal” associated with hornlessness is for hermaphrodism, so, although it is not lethal or deadly to the individual with the gene, it becomes deadly for the line in breeding inability.

One pair of chromosomes determines the sex of the kids. Females carry two “X” chromosomes, which are both the same length. Males carry a “Y” chromosome, a short or half chromosome, paired with the “X” they get from their mothers. Since only males manufacture “Y” gametes, it is the male that determines the sex of the offspring. Females can only produce females. Males can produce either sex.

Generally, what happens during breeding is that a randomly selected sperm penetrates an egg, also randomly selected, and the two produce a new individual. If the breeder is working with heterozygous parents, he might end up with any number of combinations in the kid. The results would be very unpredictable. This is what happens with outcrossing or cross-breeding. The kid would be a combination of all kinds of genes, only the dominant of which would show. The breeder would have no idea what recessive genes are masked in the genotype of the kid. A breeder can continue to keep the recessives masked and work with dominants as long as he continues to outcross, but he will continue to have unpredictable results unless he happens to hit on some lucky combinations of homozygous dominants.

If a dairy goat breeder is working with homozygous parents, either dominant or recessive, his results will be fairly predictable. Homozygous dominant parents will both pass on to the offspring dominant characteristics, so the kid will much resemble his parents. Homozygous recessive parents, if both are homozygous recessive, will also pass on predictability by passing on recessive traits that will be homozygous in offspring phenotypes.

Homozygosity, and therefore, predictability, is the aim and advantage of inbreeding. Inbreeding is the breeding together of closely related animals in the same line. Breeders who choose to inbreed must be willing to cull heavily at the beginning because, according to research done with Holstein cattle, it’s much easier to inherit many undesirable traits than a positive trait. For instance, tall stature (a positive trait in all breeds of goats except Pygmies and Nigerians) is 47% heritable, while short stature is 51% heritable. Pygmy and Nigerian breeders would have an advantage here, and others would have to be very sure to cull out short-statured animals early in the program or be stuck with them forever, since it seems to be somewhat dominant.

Pygmy goat breeders might also have an advantage in breeding for head, as short head is 44% heritable in Holsteins, while the ideal Holstein head is only 17% heritable. According to Holstein research, a sloping rump is far easier to get than an ideal rump, a good fore udder is much easier to breed for than a good rear udder, posty hind legs are more common than ideal hind legs, and a topline that slopes toward the withers is easier to get in breeding than an ideal topline. Since so many “negative” traits are dominant, a breeder interested in inbreeding has to be willing to cull what is undesirable. Cull in this case, means to kill! It does not mean sell to a 4-H member.

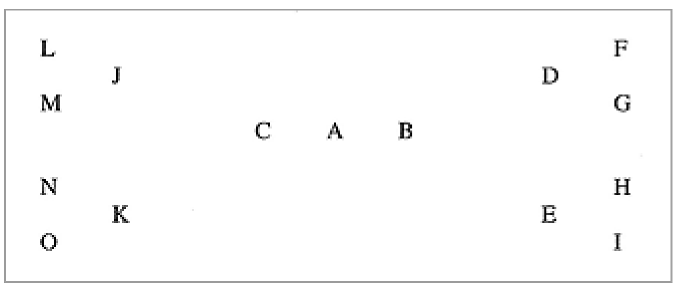
If a breeder starts with hybrids-outcrossed or crossbred animals, his first step toward inbreeding is called backcrossing. This is the same as up-grading, breeding a crossbred kid back to one of its purebred parents. Line- breeding is often used by breeders who hesitate to breed extremely close but want to tie into some common relatives. Linebreeding involves the breeding of animals in the same line, like cousins. As a breeder becomes more and more inbred with his herd, his results become more and more predictable-unless he hits a mutation.

A mutation is a sudden, unexpected change that is heritable. Mutations are very often dominant and are passed on easily to the offspring. Mutations are also often lethal, so their heritability is a moot point.

So, if a breeder enjoys working with the unknown and unexpected results, he will enjoy outcrossing. If a breeder would prefer a more definite direction, he would rather use linebreeding. If a breeder knows exactly what he wants, has animals that promise to give that, and if he is willing to cull heavily to retain it, inbreeding might pay for him.

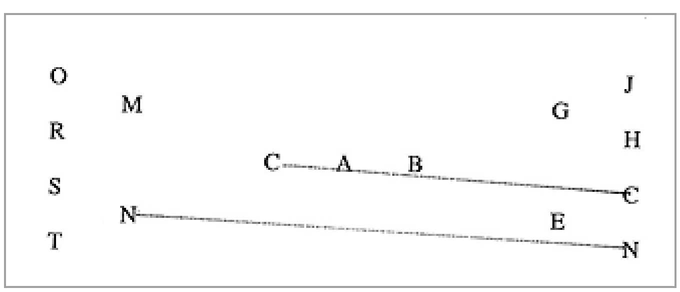
Breeders who enjoy linebreeding and inbreeding can “do all their breeding on paper” before they ever match a doe to a buck. Not only are the results somewhat scientific, they are also artistic.

A complete outcross would look something like this-where “A” is the new or proposed kid, B and C are its parents, and the others are grands and great grands:

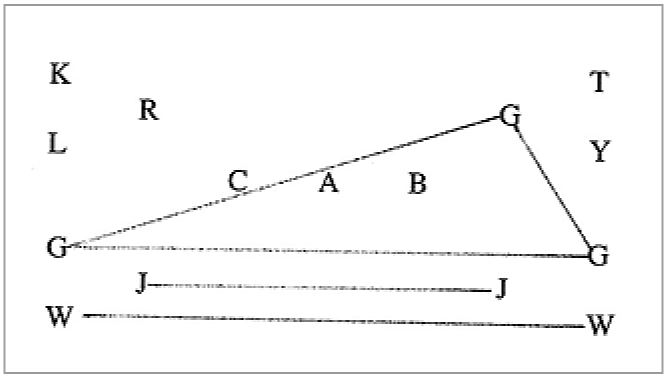


The pedigree of an out-crossed animal between two line-bred parents would look a little bit different.

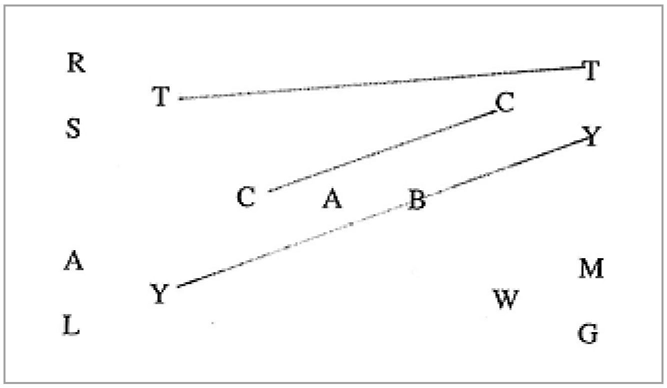
A nicely linebred animal’s pedigree might look like this:



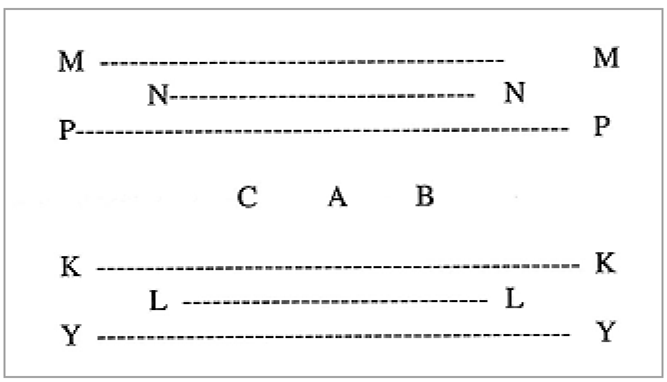
A half-brother, half-sister inbreeding might resemble this pedigree if parent B also had the same sire as its dam:



A sire/daughter or dam/son breeding would result in the following pedigree pattern:



Full sibling breedings are a risky form of inbreeding. It's the closest a person can go in inbreeding. It can work if the sire and dam were the products of outcrosses, and sometimes it can even work if they're more inbred. But if inbreeding problems such as lack of stature, fertility, or productivity are to occur, it would be here:



All these pedigrees are actual pedigrees of purebred animals. The experience of some breeders who have used the "patterns on paper" program indicate that the most successful breedings are the ones in which the pedigrees show triangular patterns. The half-sibling pedigree shows a good triangle. More triangles become apparent as the pedigree is extended to further generations. Straight-line tie-ins don't seem to be as satisfactory in inbreeding. No matter what kind of breeding program a person decides to follow, it is wise to remember that genes determine potentials of the offspring, but the environment determines how much of that potential is reached. A kid could be bred for outstanding stature and production, but if his environment doesn't support him properly, his genetic potential will never be reached.