MATING SYSTEMS
DIFFERENT APPROACHES TO SUPERIOR PERFORMANCE

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There are various mating systems used, each with different objectives, advantages and disadvantages and some sparking great controversy and debate.

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Some breeders mate randomly or select only on phenotype, which leads to slower improvement but requires less effort. Certain systems, such as rotational crossbreeding, require more camps, intensive management and substantially more labour. **But for any breeding system to truly be successful, complete pedigrees and performance recording are essential.** There is no valid excuse for any stud breeder not to keep these records. The mating systems discussed will be random mating, outbreeding, inbreeding, line breeding, line-crossing and crossbreeding.

RANDOM MATING

Random mating is, as described by the name, where there is no selection of animals that will become parents of the next generation and no planned matings for these animals. Unfortunately this is often applied, although mostly by commercial breeders. In this case males would be allowed to roam freely between all the females, leaving them to choose their own mates, regardless of relatedness or genetic progress that might or might not be obtained.

OUTBREEDING

Outbreeding is the mating of animals that are not closely related – technically less related than the average relationship in the breed or population, but generally accepted as animals that are unrelated within the last 4-6 generations. This of often the advised system and will prevent a decrease in performance due to inbreeding depression.

Animals must be selected on their performance, with most efficient practice being selection on breeding values, to best suit the breeding objective of the breeder, while mating takes place by taking pedigree information into account to avoid inbreeding.

INBREEDING

Inbreeding, by definition, is the mating of animals that are more closely related than the average relationship within the breed or population. It is one of the most controversial topics in breeding with some strongly opposed to it, some accepting it to a degree and some passionately advocating for it. Some are shunned and harshly criticised for applying it and some mocked for rejecting it. It is debatable and there is no denying that if used correctly and carefully it can deliver good results. Most breeds (apart from composite breeds) were developed in this way. However, its effect is not always understood by breeders. It is not uncommon for some breeders (most notably breeders of pets and game) to claim that mating brother and sister is unacceptable, but mating parents to their offspring is fine – the relationship between parent and offspring is 50% and on average between full-sibs also 50%, however, it might happen that a brother and sister inherit completely different components from both parents, giving them a relatedness of less than 50%, or that they inherit the same genetic components from both parents, giving them a relatedness much higher than 50%.

After personally examining some registration certificates of dogs and communicating with breeders, it is clear that it is often not understood and not avoided. While many livestock breeders are more aware of this problem and its consequences, a large proportion of breeders don't take care to avoid or control it and many apply it strongly. The main dangers of inbreeding are the expression of deleterious genes and inbreeding depression. The expression of deleterious genes is sometimes a reason why some apply inbreeding. It is important to note that inbreeding does not create genetic mutations, but simply allows the expression of genes that are usually masked by other genes. By uncovering these genes one can eliminate them, but in the process it is possible that various other traits have been negatively affected by inbreeding depression.

Inbreeding depression is the depression/decrease in traits such as fertility and survivability due to inbreeding. It can happen systematically and initially go undetected. It can even be observed at an inbreeding coefficient (the probability that both copies of a gene came from the same ancestor) as low as 6.25% (typically occurring in matings where there is a common grandfather). With this in mind it is very surprising that some breeders applying line breeding (a form of inbreeding) proudly announce to anyone willing to listen that their stud ram has an inbreeding coefficient of 25%!

There are two main reasons for applying inbreeding: to increase uniformity and to create the opportunity for heterosis (hybrid vigour) when two inbred lines are crossed. Animals in an inbred herd will be more uniform and, genetically, inbreeding is the way to achieve this. **But is overall genetic uniformity always good?** A genetically uniform population is more vulnerable to environmental effects and less adaptable to change (therefore often less resistant to disease). Inbreeding is not the only way to create phenotypically uniform herds for specific traits. **It can be better or just as effective to consistently select for specific traits instead of a relationship to a certain ancestor.**

By using this method, a herd can be phenotypically uniform while still maintaining genetic variation for other (often less observable) traits, such as fertility and disease resistance. An example to illustrate uniformity outside familial lines is to use people, since that is a common reference we all share.

People in a family may share common interests, some talents and body features, but they often differ too. Simply belonging to a family does not guarantee similarities (and often similarities are environmental, not genetic). When comparing people within a rugby team or a class for computer programming, it is clear that the individuals within those groups are more similar, not because of a family relationship, but purely out of a similar talent or interest.

LINE BREEDING AND LINE CROSSING

Line breeding is a mild form of inbreeding and is designed to increase the relationship of a herd or strain to a highly acclaimed ancestor or group of ancestors to retain superior performance **without leading to high levels of inbreeding.** The general guideline is not to mate animals more closely related than half-sibs, however many breeders ignore this guideline. There is a common saying that it is called line breeding when it works, and inbreeding if it doesn't.

It can be very successful in producing lines of superior performance in desirable traits, but when it fails it can be a disaster! A study in Montana, USA, established 11 Hereford lines by line breeding, of which only 2 survived (the others eliminated themselves through undesirable genes that were uncovered). Of these 2, one had average performance and the other was superior and made a major contribution to the breed. Establishing lines, particularly good lines, is time consuming and large herds are needed to allow strict, accurate selection and extensive culling.

The other advantage of line breeding, as mentioned above, is to get heterosis when lines are crossed. Line crossing is like crossbreeding but within breed instead of between breeds. The resulting offspring have qualities of both lines and will perform better than the average of their parents. The effect is greater when the difference between lines is greater.

The chicken industry has been very successful in producing lines, both to promote certain characteristics, such as egg colour, age at puberty and hatchability, and to apply line-crossing to have more fertile hens (from a line dedicated to fertility) to hatch chicks that grow faster (from a sire line dedicated to growth and carcass traits). Chickens have the advantages of a short generation interval, the ability to produce many offspring within a short time and a lower financial value per animal, which makes culling easier.

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CROSSBREEDING

Crossbreeding is the mating of animals from different breeds. There are 2 main reasons for crossbreeding: **heterosis** and complementarity. **Heterosis** is defined as the increase in performance of the offspring over the **average** of the **parents** and is due to an increase in heterozygosity (different forms of the same gene in a population opposed to homozygosity as a result of inbreeding).

The effect of heterosis is greater on traits that are lowly heritable, such as fertility, survivability and maternal traits, than on traits that are highly heritable (with no effect for carcass traits). The effect is also cumulative, in other words crossing a crossbred with another breed can deliver even better results. There are three different types of heterosis, namely individual (offspring) heterosis, maternal heterosis (crossbred dam) and paternal heterosis (crossbred sires). The latter has received very little attention, but should not be completely ignored. Studies have shown an improvement in semen quality, libido and mating ability in crossbred males. **Maternal heterosis** increases the ability of a dam to conceive and raise heavier calves (through increased milk production). **Individual heterosis** is the effect on the offspring – heavier weights, faster growth, better fertility… It is important to note that heterosis refers to performance better than the average of the parents and therefore the selection of breeds and individual animals for mating is extremely important. **It is better to have a productive purebred herd with superior genetics than a crossbreeding program based on inferior animals.** There are various systems of crossbreeding, including terminal crossbreeding, rotational crossbreeding, grading up and composites.

Terminal crossbreeding: **All crossbred offspring are sold and none kept as replacements. This system takes advantage of individual heterosis.** However, the problem of replacements arises. Replacements will either have to be bought or a separate purebred system must exist on the farm.

Rotational crossbreeding: **The resulting crossbreds are kept and mated to a sire from another breed.** This takes advantage of maternal heterosis, which will further increase the performance of the offspring. The cycle can continue by alternating between the sires, or even include more breeds. The cumulative effect of heterosis can therefore be utilised.

This system requires intense management, many camps and large herds.
A combination of rotational and terminal systems can also be used, where the best cross-breds are kept as replacements and the rest mated to a terminal sire to produce offspring for slaughter.

Grading up: **This is the repeated crossing of a female and her female progeny to sires of a single breed.** The ultimate goal is to create a herd/population that is indistinguishable from the breed of the sire.

Composites: **A composite breed was established from two or more breeds, but is seen and managed as a pure breed. This is done to retain some heterosis and utilise breed complementarity.** Complementarity is when breeds are crossed with the purpose of complementing the weakness in one breed with the strength of another and to take advantage of different strengths overall.

One occasionally hears that breeds were combined to obtain only the best qualities of both breeds, which is not a valid statement. All qualities will combine, not only the best. Breeds used to produce composites must be selected carefully as to create a final product that is highly adaptable to its environment, performs well and meets market specifications. The development of composites require very large populations (500-750 females and 25 or more sires per generation), the correct choice of breeds, time to make the initial crosses over a few generations, a lot of money and patience.

It is **important** to realise that **heterosis can only be retained** if there is **no inbreeding** within the composite breed. It has been said that composites will never take over because selection within breed will lead to inbreeding and consequently decrease heterosis, **herds must be large to minimise or avoid inbreeding, maximum heterosis is never obtained,** breeders take pride in pure breeds, and purebreds will be needed to produce more base animals. However, composites have been very well received in South Africa and perform well. About 59% of stud cattle herds in South Africa are composites, of which the Bonsmara is most popular.

CONCLUSION

There is no single mating system that will work best for everyone and each has its own advantages and disadvantages. Careful consideration should go into choosing a system and it is essential that a breeder understands his/her choice and whether it will aid in the ultimate goal. Some systems require more labour and intensive management. The importance of pedigree records to be more successful cannot be emphasised enough. One cannot plan to use line breeding and claim not to breed closely related animals when there are no pedigree records. **After all, how can you know where you're going if you don't know where you are?** ■