INBREEDING IN CATTLE: WHAT YOU NEED TO KNOW!

Inbreeding
Inbreeding is the mating of related animals. This simply means they have one or more ancestor in common. The closer the relationship between two animals, the greater the amount of inbreeding in the resulting progeny.

Linebreeding
Linebreeding is the mating of closely related animals in an attempt to concentrate desirable characteristics in the progeny. This is sometimes done with outstanding animals trying to fix or concentrate the genes of that superior animal in its progeny.

Related animals have more genes in common than unrelated animals. As well as having more favourable genes in common, related animals also have more undesirable genes in common.

Most animals carry undesirable genes that remain hidden and are not expressed in the phenotype. These genes are referred to as being recessive genes. There are many recessive genes which cause genetic disorders, or adversely affect reproduction, survival or overall functional fitness. Recessive genes only cause problems in animals that carry two copies of the gene (homozygous recessive animals).

Normally animals that express an undesirable trait are culled and therefore removed from the population. This causes the gene frequency for that trait (gene) in the breed to be lowered. Across a breed as a whole, there may be very few animals which are homozygous for a particular gene, but the genes are still there, undetected, in heterozygous or "carrier" animals.

As inbreeding results in an increase in the level of *homozygosity*, it will increase the risk of the appearance of undesirable effects in the phenotype. These undesirable effects (known as inbreeding depression) are generally associated with fertility and survival, and of lesser importance in growth and carcase traits. Inbreeding depression mainly tends to negatively affect the traits which are positively affected by *heterosis* (hybrid vigour) as a result of crossbreeding. So, it is helpful to think of inbreeding and inbreeding depression as being the opposite of crossbreeding and *heterosis* respectively.

Inbreeding depression can be particularly important if the level of inbreeding increases rapidly. Where the rate of inbreeding increases slowly, culling and strict selection criteria can be used to eliminate undesirable types and poor producers.

Outbreeding (or outcross)
Outbreeding is the mating of animals that are less related than the average degree of relationship within the population. It is the opposite of inbreeding, ie. it increases the number of *heterozygous* (i.e. different) gene pairs.

Is there a place for inbreeding?
Because inbreeding can bring desirable genes together, it can be used to produce superior individuals. Hence it can be beneficial. However, the risk of this approach is that inbreeding depression occurs or undesirable recessive genes being brought together. The wastage resulting from this strategy could be quite high, as when undesirable genes are expressed in the offspring high culling rates can occur.

Inbreeding may have a place where the aim is to produce a single superior individual (which might be the case in the horse industry if the breeder is solely focussed on producing a Melbourne Cup winner). However, for every superior animal produced there could be many inferior or even deformed offspring.

As the aim of most cattle breeders is more likely to be "to raise the average performance of the herd" rather than to produce a single superior individual, inbreeding offers little economic benefit to the commercial cattle breeder. Seedstock breeders contemplating the use of inbreeding techniques should have thoroughly researched and clearly identified objectives in mind before implementing such strategies.

Potential performance reduction through inbreeding.

Reports on inbreeding in cattle indicate that for each 10% increase in inbreeding, production of important traits can fall as shown in Table 1.

Table 1: Effect of inbreeding on important production traits

TRAIT	INBREEDING DEPRESSION
Growth	*5%*
Milk Yield	*3%*
Calves born	*4%*
Calves weaned	*10%*

In Holsteins a 10% increase in inbreeding has been shown to decrease milk production by about 270kg annually

It is important to realise that the level of inbreeding depression referred to in Table 1 relates to the first generation, not to the progeny of inbred animals. Thus there are no additional dangers associated with breeding from superior performing inbred animals, provided they are not mated to close relatives.

Genetic gain depends on the genetic variation within a population for that trait. Since inbreeding reduces genetic variation it can reduce the potential for future genetic progress.

Calculating the Inbreeding Percentage

The amount of inbreeding for a particular animal is measured by its inbreeding coefficient – which is the probability that any pair of specific genes have been inherited from a common ancestor. Computer programs can rapidly calculate inbreeding coefficients for individual animals from their pedigree information. Table 2 shows the inbreeding coefficients in progeny resulting from particular types of mating. In the case of a full brother-sister mating there is a 25% chance that a pair of specific genes are identical, because they were both inherited from a common parent.

Table 2: Level of inbreeding in the progeny arising from mating of related animals (in all these examples it is assumed that the parents are not already inbred).

Full brother-sister mating	***25%***
Half brother sister mating	***12.5%***
Father-daughter	***25%***
Grand dam-grandson	***12.5%***
Common grandparents (cousins)	***6.25%***

Conclusion

Pedigree analyses of the Australian Angus seedstock population (conducted by Dr. Peter Parnell) has shown that the average level of inbreeding is still relatively low, with an average inbreeding coefficient of only about 2% among current generation calves. However, due to the widespread use of popular AI sires across the breed in recent years there is the potential for rapid build up of inbreeding unless breeders actively avoid the mating of closely related animals. Breeders should be aware of the potential undesirable consequences of inbreeding and are encouraged to consider these consequences when making mating allocations.

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The following practical examples of inbreeding demonstrate the points above.

Case Study 1. **Using a Design Plus son over 323 grand-daughters** **Question:** Client A has a line of heifers by a son of B/R New Design 323 and is contemplating joining them to a PARB Design plus son from your sale catalogue. He is concerned that this might create inbreeding problems and asks you for advice. (NB. Both 323 and PARB Design Plus are by B/R New Design 036 but have different mothers.) **Reply**: *The level of inbreeding in the progeny would be 1.5625% (heifers have 036 as their great grandfather and the PARB Design Plus son has 036 as his grandfather). This is a relatively low level of inbreeding and is unlikely to cause any noticeable inbreeding depression provided you have not used other bulls with common ancestors in the last 3 generations.*	**Case Study 2.** **Using an 036 grand-son over 036 daughters** **Question:** Client B has been looking for a bull to join to a line of 036 daughters and has found one in your catalogue that she likes the look of. However, whilst he is by OB45 (a bull whose bloodlines she hasn't used previously) his dam is by 036. This means the calves she breeds will have a maternal sire and paternal grandsire in common. Should she be worried about this level of inbreeding? **Reply:** *The calves would have an inbreeding coefficient of 6.25%. This is usually regarded as a moderate level of inbreeding but still quite acceptable provided you have not used other bulls with common ancestors in the last 3 generations.*
Case Study 3. **Mating half brothers-sisters** **Question:** Client C a seedstock breeder seeking a high indexing sire to use over 036 daughters settles on B/R New Frontier 095 (an 036 son). What are the benefits or dangers associated with such a mating? **Reply**: *The progeny of such a half brother-sister mating would have an inbreeding coefficient of 12.25%. Inbreeding at this level is often referred to as Line Breeding and is usually only recommended if used as part of a well planned breeding program designed to increase prepotency by concentrating desirable genes in a particular family line. The danger however, is that there could be some loss of fertility and growth (up to 10% fewer calves weaned and a 5% reduction in growth rate have been reported from inbreeding at this level.) Put another way, 10% to 20% of the calves could suffer inbreeding depression to some extent so some economic loss is probable. A small percentage of the progeny might also exhibit genuinely superior performance.*	**Case Study 4.** **Using a bull from a father/daughter mating** **Question:** Client D is looking for a new stud sire and is keen on a high indexing son of OB45 that you have catalogued for sale. There has been widespread comment about the bull around the sale ring because, although he is an impressive individual, he is out of an OB45 daughter (ie. The result of a father/daughter mating). Is it safe to use an inbred bull like this as a stud sire? **Reply:** *This bull has an inbreeding coefficient of 25% (or to put it another way - there is a 25% chance that any specific pair of genes are identical). Hence some animals possessing this degree of inbreeding will have some deleterious recessive genes paired up and therefore be expressed phenotypically. This is most likely to manifest itself in the form of reduced fertility and survival attributes or through poorer growth.* *However, If the bull in question is structurally sound, has good growth relative to his contemporaries, and has been semen tested and seen to serve naturally, there should be no adverse inbreeding consequences from the use of this bull over unrelated females*