Managing Inbreeding Within a Seedstock Beef Breeding Enterprise

The discussion of inbreeding in bull breeder circles can lead to a passionate debate, with thoughts ranging from "we must avoid inbreeding at all costs" to "linebreeding is the best thing since sliced bread".

Inbreeding is essentially the mating of animals that are related. Within the pedigree of the mated sire and dam, one or more animals will be in common; resulting in progeny with a certain level of inbreeding. The level of inbreeding will depend on the relationship between the two mated animals, with the closer the relationship, the greater the level of inbreeding that will occur in the resulting progeny.

Linebreeding is the deliberate mating of closely related animals with the perceived objective to concentrate desirable characteristics of the progeny and to breed "consistency".

THE MEASUREMENT OF INBREEDING

A common method of measuring the inbreeding level in a specific animal or from a planned mating is by way of an inbreeding coefficient. An inbreeding coefficient is calculated as the probability percentage (%) for any allele (i.e. pair of genes at a specific location on the chromosome) to be identical by descent.

Typical inbreeding coefficient percentages are as follows. This is assuming no previous inbreeding between any parents:

Relationship	Inbreeding Coefficient
Animal mated to its own parent (e.g. sire to daughter)	25%
Full siblings (e.g. sire to dam with a common sire and dam)	25%
Half siblings (sire to dam with a common sire or dam)	12.5%
Half cousins (sire to dam with a single common grandparent)	3.1%

One limitation when calculating the inbreeding coefficient value for an animal is the accuracy and depth of pedigree that is recorded. For example, the accuracy of the inbreeding coefficient that is calculated for an animal with little or no pedigree recorded may understate the true level of inbreeding, and be a lot lower than the inbreeding coefficient that would be calculated if 10 generations of pedigree had been recorded for the animal.

EFFECTS OF INBREEDING IN BEEF CATTLE

Inbreeding is an important consideration in breeding programs as it can potentially lead to three main negative outcomes being:

1) inbreeding depression in production traits
2) increase homozygosity of recessive genetic conditions
3) a reduction in genetic diversity

Inbreeding depression

Generally, animals with higher levels of inbreeding have depressed performance for a range of economically important traits when compared to animals with lower levels of inbreeding (with all other factors being equal).

The depression caused by inbreeding tends to negatively affect the traits which are positively affected by heterosis (i.e. crossbreeding - the opposite of inbreeding), with these being fertility, survival, growth, and to a lesser extent, carcase traits.

A literature review undertaken by Burrow (1993) investigated the effects of inbreeding in beef cattle. The review revealed that inbreeding of the individual has a consistent adverse effect on growth traits from birth to maturity and on maternal traits. More specifically, for every 1% increase in inbreeding coefficient a decrease of 0.06, 0.44, 0.69 and 1.30 kg in live weight at birth, weaning, yearling and maturity respectively was observed. Additionally, inbreeding in the dam decreased weaning and yearling weights by 0.30 and 0.21 kg respectively for every 1% increase in inbreeding coefficient, probably as a result of decreasing milk yield and reduced maternal value of the inbred dams.

The review also reported inbreeding as having a depressive effect (although the magnitudes of effect were small in some cases) on heifer conception rates, female fertility, conformation/structure, feed intake, feed conversion efficiency, carcase traits and male reproductive traits.
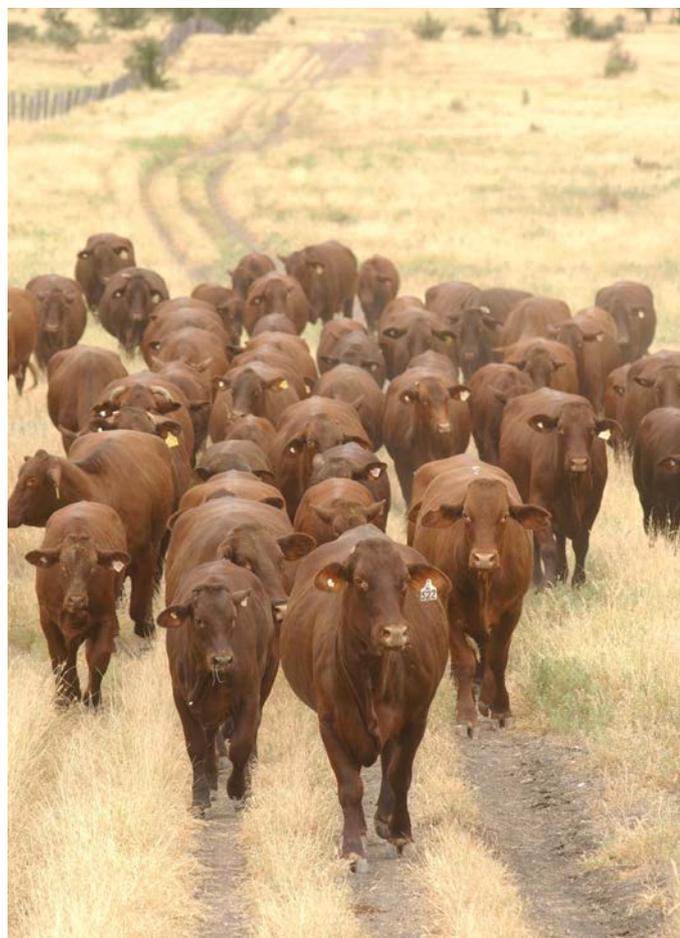
Recessive Genetic Conditions

Most breeds have at least one recognised recessive genetic condition. Examples of these are Arthrogryposis Multiplex (AM) in Angus or Angus derived cattle or Pompes Disease in Brahman or Brahman derived cattle. An animal must carry two copies (i.e. homozygote) of the recessive disease allele to be affected by the genetic condition. An animal that only carries one copy (heterozygote) will not show the affects, but is a "carrier".

An increase in inbreeding can inadvertently lead to an increase in the likelihood of animals being affected by recessive genetic conditions. This is primarily through the increase in allele homozygosity as explained earlier.

Reduction in Genetic Diversity

Over time, higher levels of inbreeding will result in a loss of genetic diversity within the population. This can impact in both the potential loss of favourable alleles that may have existed for some traits, plus a decrease in the amount of genetic variation that exists between the animals on which future selection decisions can be made.

INBREEDING CONSIDERATIONS

Some breeders may argue that "structured" inbreeding programs can be used to produce a single "superior" individual through the stacking of desirable genes for certain production or functional traits (i.e. linebreeding). This is common practice in the thoroughbred horse industry. For example, Black Caviar has common ancestry in its pedigree through the stallion, Vain. This stallion is both Black Caviar's paternal great grandsire and maternal great-great-grandsire. She also has a second sire, Silly Season, further back in the pedigree that appears on both the maternal and paternal side.

Of course, aiming to produce one superior individual will also result in many more inferior animals through inbreeding depression or appearance of recessive genetic conditions. The aim of beef cattle breeders should be to improve the average performance of the herd. This can be achieved through objective selection and allocation of matings of breeding animals on performance traits (EBVs and selection indexes) in conjunction with visual appraisal, while managing inbreeding levels. This will ensure the average performance of a herd (or breed) is

improved while the inbreeding level (or genetic diversity) is maintained.

ACCEPTABLE LEVELS OF INBREEDING

There is no magic level that is considered an acceptable level of inbreeding within a breeding program, with the goal in most breeding programs being to manage inbreeding rather than totally avoid it. Breeding programs that simply avoid inbreeding without considering the genetic merit of the animals used within the mating program are not likely to be economically sustainable in the long term.

Ultimately, the most beneficial breeding program will be the one that results in the progeny with the highest overall genetic merit once the negative effects of inbreeding have been adjusted for.

Average inbreeding coefficient levels of less than 5% within a breeding program are considered low, with inbreeding levels of 5 – 10% generally considered more moderate levels of inbreeding and warranting more careful management. However, managing the increase in inbreeding level over time is as important, if not more important than managing the overall level of inbreeding within the breeding herd. Ensuring inbreeding levels do not increase by 1% per generation is generally considered to be a good rule of thumb.

TOOLS TO MANAGE INBREEDING

Bull breeders have a range of tools available to assist them with genetically improving the average of their herd for production traits while monitoring and managing inbreeding. These include:

1. Online Mating Predictor

The online animal search facility (colloquially know as Internet Solutions) includes an "enhanced" mating predictor option which has been implemented by many Breed Societies. This facility includes the calculation of an inbreeding coefficient, plus details on the depth of pedigree as a pseudo "accuracy" measure, for progeny from a specified mating (see Figure 1 below).

2. Mate Allocation Tools (e.g. MateSel)

A number of computer based breeding tools are available that enable breeders to optimise breeding outcomes for their herd by creating a mating list based on a list of candidate sires and dams. These provide beef cattle seedstock producers with a mechanism for objectively optimising mating allocations to reflect their breeding goals and creating long term, sustainable genetic gains. The genetic gains are based on a nominated breeding objective, while constraints are applied on inbreeding to ensure genetic diversity is maintained or improved. More information is provided regarding one such tool, MateSel, on the BREEDPLAN website.

For further information regarding the management of inbreeding within a seedstock beef breeding enterprise, please contact staff at Southern Beef Technology Services (SBTS) or Tropical Beef Technology Services (TBTS).

REFERENCES
1. Burrow H.M (1993). The Effects of Inbreeding in Beef Cattle, Animal Breeding Abstracts Vol. 61 No. 11.

Name	Calving Ease Dir (%)	Calving Ease Dtrs (%)	Gestation Length (days)	Birth Wt. (kg)	200 Day Wt. (kg)	400 Day Wt. (kg)	600 Day Wt. (kg)	Mat. Cow Wt. (kg)	Milk (kg)	Scrotal Size (cm)	Days to Calving (days)	Carcase Wt. (kg)	Eye Muscle Area (sq.cm)	Rib Fat (mm)	Rump Fat (mm)	Retail Beef Yield (%)	IMF (%)	Docility (Trial)
SIRE: MURRAY REGENT G368(APR)(AI) - NURG368	+1.6	+0.5	-5.1	+4.9	+49	+85	+107	+89	+14	+2.1	-5.6	+62	+6.1	+1.6	+1.0	-0.3	+3.0	+3
DAM: MURRAY REGENT G098 G98(ET) - NURG98	+2.0	+1.2	-1.8	+5.3	+41	+78	+102	+90	+15	+1.8	-4.4	+59	+7.5	+0.5	+0.4	+0.4	-	0
Expected Average Progeny Value	+1.8	+0.9	-3.5	+5.1	+45	+82	+105	+90	+15	+2.0	-5.0	+61	+6.8	+1.1	+0.7	+0.1	-	+2

Inbreeding Coefficient: **16%.**   Min./(Avg.) generation: **7/(11.0)**   Pedigree display of this mating

Figure 1. Example outcome from the mating predictor from a half-sib mating

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