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HOW ANGUS BREEDERS HAVE REDUCED THE FREQUENCY OF DELETERIOUS RECESSIVE GENETIC CONDITIONS

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SUMMARY

Undesirable genetic conditions are present in all species of livestock and could range from causing a reduction in performance or structural problems to being semi-lethal or lethal. Normally the frequency of genetic conditions is low and therefore not considered to be of significant economic importance. However, sometimes the frequency can increase, especially if the progeny of carrier animals perform for economically important traits. Through artificial breeding it is possible for one sire to generate thousands of progeny in a few years, increasing the population's co-ancestry and risk through inbreeding.

The Angus Society of Australia has adopted a policy of supporting the management of undesirable genetic conditions rather than vigorously pursuing their eradication. The development of highly accurate DNA tests and the implementation of GeneProb have made it possible to simultaneously reduce the carrier frequency for three recessive genetic conditions from approximately 7% to approximately 2% in less than four years.

INTRODUCTION

Mutations occur in the cells of living organisms and are a source of new genetic variation that is necessary for selection and genetic improvement. A mutation results in a change in genotype and when inherited by progeny, it can be beneficial or detrimental and can impact on fertility, performance or structural soundness. Some mutations result in a change in phenotype and in most cases this is how the mutation is eventually detected.

Artificial breeding has many advantages which have resulted in a steady increase in its popularity to the point where 40% of the registered Angus calves in Australia are now the product of artificial insemination while 10% are from embryo transplantation. Through artificial breeding thousands of progeny can be generated by a single sire which can spread genetic conditions through a herd or breed very quickly.

Over the past two decades Angus breeders have very effectively used Breedplan to identify genetically superior animals and then utilised artificial breeding to multiply desirable genetics at the breed level. This strategy (effectively low levels of breed-wide line breeding) has resulted in significant genetic gain in the breed and also the emergence of several very popular bulls that had a large influence on the breed's genetic composition.

THE MOST IMPORTANT GENETIC CONDITIONS IN ANGUS CATTLE

α-Mannosidosis. In the late 1970's it was estimated that about 5% (Peter Healy, personal communication) of Angus stud cattle in Australia could be carriers. The Angus Society decided to eradicate this genetic condition from the seedstock population by only allowing the registration of animals that were tested free, or progeny of free animals. It is still a requirement to test imported genetics to ensure they are not carriers.

Arthrogryposis Multiplex (AM). In 2008 this deleterious genetic condition was discovered in the USA with RITO 9J9 OF B156 7T26 (born in 1979) as the most probable progenitor. In late 2008, a diagnostic test was developed by Professor Beever from the University of Illinois in the USA and rapidly applied in Australia.

Neuropathic Hydrocephalus (NH). In 2009 this deleterious genetic condition was discovered in the USA with G A R PRECISION 1680 (born in 1990) as the most probable progenitor. A diagnostic test, also developed by Professor Beever, became available to Australian breeders in mid-2009.

Contractural Arachnodactyly (CA). In 1996 the first case of Fawn Calf Syndrome (the condition's initial name), was reported in Australia. Extensive pedigree analysis by Animal Genetics and Breeding Unit scientists identified FREESTATE BARBARA 871 OF KAF in 1999 as the most probable progenitor. In the absence of a DNA test, knowledge of known implicated bloodlines helped Angus breeders keep the frequency of carrier animals at a relatively low level until a DNA test was developed by Professor Beever in mid-2010.

ANGUS SOCIETY POLICY

Historically breed societies have been accused of ignoring the issue of genetic conditions and not informing and/or educating the broader beef industry about the proper management of genetic conditions. The discovery of three recessive genetic conditions and the realisation that some of the most widely used bloodlines in the breed were carriers posed a serious threat to the Angus breed.

As a result of the discovery of AM, the Board of the Angus Society of Australia focused their annual technical workshop in November 2008 on genetic conditions and how the breed should confront this issue. The breed had two options; the first was to attempt to eradicate any existing and future genetic conditions, or secondly use available DNA tests to reduce the gene frequency of AM and then manage it in the population.

The Angus Society Board agreed to develop a system to identify potential carrier animals, facilitate the testing of these animals, and report the results publicly to ensure seedstock and commercial producers were well informed. The focus was to manage genetic conditions rather than attempting to rapidly eradicate them from the population.

At the end of 2012, the Angus Society Board decided to assign a 12.5% probability of being a carrier to all animals in the Angus database with unknown pedigree. This was to reflect the risk associated with base animals of which the parents are unknown.

MANAGEMENT AT THE BREED AND HERD LEVEL

Compiling lists of carrier animals. The first step in managing genetic disorders at the herd level was to compile lists of potential carrier animals and make these lists available to seedstock breeders to help them ascertain their herd's exposure as well as identify animals that may need to be tested.

No matter when a new genetic condition is discovered and a DNA test becomes available, it will always be inconvenient to at least some breeders as it will be too close to their bull sale to allow sufficient time to test sale bulls prior to sale.

To minimise the lag time between when the genetic condition was initially identified and when the test became available in Australia, the ability to send urgent samples to Professor Beever's lab was negotiated. Several batches of urgent samples were couriered to the USA with some results being available 30 days after sample collection.

Development and implementation of GeneProb. GeneProb is a software program developed by Kinghorn (2000) for the analysis of large datasets to calculate the probability of each animal being a carrier of a specified recessive genetic condition.

The Angus Society worked with their database service provider, the Agricultural Business Research Institute, to implement GeneProb to enable weekly analysis of new results and their publication for each animal on the Society's website.

DNA Testing. With the availability of GeneProb results, Angus members were able to efficiently identify potential carrier animals and focus on testing those animals. Immediately after a diagnostic test became available for each newly defined recessive genetic condition, a large amount of testing followed to determine potential carrier animals. After initial testing and identification of potential carrier animals, testing has become cyclic with a drop-off in the first quarter of each year. Interestingly, this is also the time of the year when the least number of bull sales occur.

Table 1 illustrates the number of animals tested for one, two or all three genetic conditions for each of the Angus breed registers. The percentage of animals downgraded (or culled from the breeding herd) was also investigated, and it was found that almost 50% of all animals downgraded were carriers of at least one genetic condition. This indicated the carrier status of an animal was not the only deciding factor determining whether an animal gets downgraded or not.

Table 1. Number of animals in each Angus register tested and found to be carriers of one, two or all three genetic conditions.

Register	No. animals tested				No. carriers			
	1 Cond.	2 Cond.	3 Cond.	Total	1 Cond.	2 Cond.	3 Cond.	Total
HBR/RAR	22,630	7,313	1,986	31,929	10,956	700	8	11,664
APR	6,905	2,504	599	10,008	3,209	230	1	3,440
MBR	182	35	15	232	34	0	0	34
ACR	36	53	13	102	24	5	0	29

Reduction in carrier frequencies. As soon as a new genetic condition was discovered and bloodlines involved were announced, members adjusted their breeding decisions by changing sires selected for the next year's calves. Figure 1 illustrates that the initial reduction in carrier frequency of calves (based on GeneProb results) was closely associated with the timing of the first announcements concerning the discovery of the genetic condition and subsequent development and release of the DNA test.

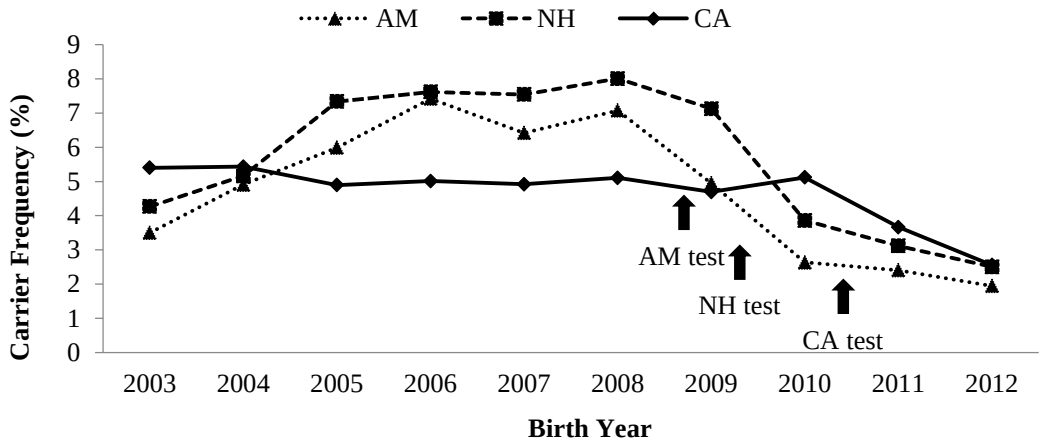

Figure 1. Frequency of carrier calves relative to birth years and the reductions in carrier frequency when DNA tests were made commercially available.

CONCLUSIONS

The initial reduction in the carrier frequency of calves was mainly achieved by using sires that were tested and found to be free of the genetic condition or were expected to be free through pedigree analysis.

Many breeders could not afford to cull all carrier cows and therefore had no option but to continue to breed with some carrier cows. It is expected that the carrier frequencies of calves will continue to decrease as carrier cows are being replaced with cows tested or expected to be free.

The decision of the Angus Society Board to manage, rather than eradicate, recessive genetic conditions has allowed members to respond to this challenge in a financially responsible way. Simultaneously reducing the carrier frequency for three genetic conditions from approximately 7% to approximately 2% in less than four years is a very significant achievement.

ACKNOWLEDGEMENTS

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