Utilising DNA Technology to Change Coat Colour

Coat colour is an easily recognisable trait and for many breeds a defining characteristic, so much so that many breeders include coat colour as an important part of their animal selection criteria. Coat colour shows a clear distinction between phenotypes and is a qualitative trait, controlled by only a few genes.

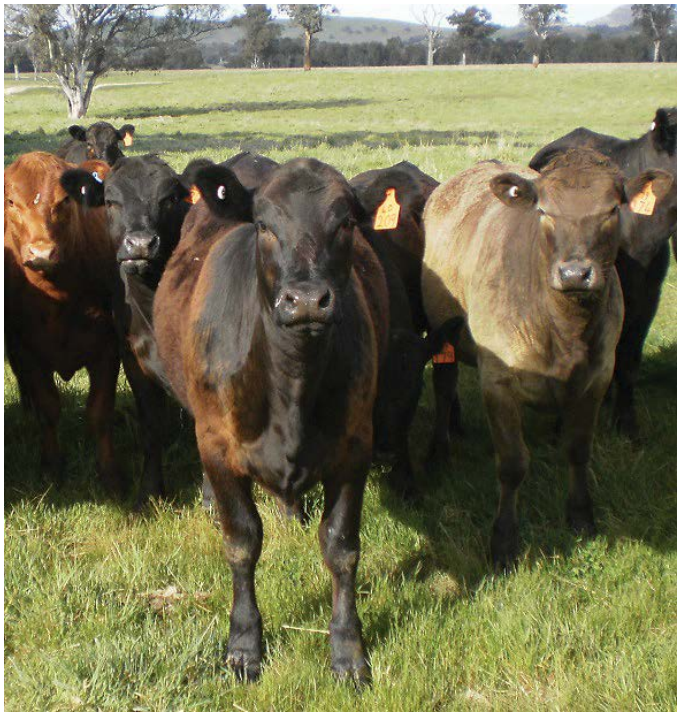
While a few different genes influence coat colour, all animals have one base coat colour, being either black or red. Other colours such as Spotting, Dilution, Roan and Brindle are caused by other genes acting on this base coat colour.

Importantly, breeding for a particular coat colour is not as simple as selecting animals which visually express that coat colour. Several DNA tests are available that identify the coat colour genetics of an animal, providing increased accuracy and the ability to change coat colour more rapidly than traditional visual selection on phenotype or progeny testing.

THE GENETICS OF COAT COLOUR

A gene called the melanocartin 1 receptor is involved in the production of red/black coat colour in cattle. The melanocartin 1 receptor controls the levels of an enzyme called tyrosinase in skin cells. High levels of tyrosinase in the skin cells cause a dark colour (brown or black) while low levels of tyrosinase result in a light coat colour (red or yellow).

The two main alleles for the melanocartin 1 receptor gene are Black (ED) or, Red (e), while another allele, Wild Type (E+) is also present in a small percentage of animals. Each animal will inherit two alleles for coat colour, one from each parent, with the Black allele being dominant over both the Red and Wild Type alleles. An animal can consequently be phenotypically Black but still carry one copy of either the Red or Wild Type allele, which can then be inherited and expressed by progeny. The Wild Type allele (E+) is considered to be neutral and can produce either a red or black coat colour depending on its interaction with other genes. The Red allele (e) is



recessive and an animal must carry two copies of the Red allele to have red coat colour.

All the possible genotypes and their corresponding phenotypic expressions of coat colour are shown in Table 1.

Table 1. Possible genotypes for coat colour and corresponding phenotypes

Genotype	Coat Colour (Phenotype)
ED ED	Black, or black & white
ED E+	Black, or black & white
E+ E+	Various
ED e	Black, or black & white
E+ e	Red, or red/black
e e	Red, or red & white

BREEDING FOR COAT COLOUR - THE THEORY

Because animals inherit two alleles for the base coat colour, it is possible that their phenotype does not reflect their underlying genotype. For example a phenotypically

Scenario 1. Homozygous Black Sire x Homozygous Black Dam

Black Dam \ Black Sire	ED	ED
ED		
ED		

Scenario 2. Homozygous Black Sire x Heterozygous Black Dam

Black Dam \ Black Sire	ED	ED
ED		
e		

Scenario 3. Heterozygous Black Sire x Heterozygous Black Dam

Black Dam \ Black Sire	ED	e
ED		
e		

Scenario 4. Heterozygous Black Sire x Homozygous Red Dam

Red Dam \ Black Sire	ED	e
e		
e		

black animal may be either homozygous Black and carrying two copies of the Black allele (ie. EDED), or heterozygous Black and carrying one copy of the Black allele and one copy of either the red or wild type allele (ie. EDe or EDE+).

Consider the four mating combinations shown above using only phenotypically black sires.

In the first scenario homozygous black dams (ED ED) are joined to a homozygous black sire (ED ED) with 100% of the resulting offspring being homozygous black (ED ED). In the second scenario heterozygous black dams carrying the Red allele (ED e), are joined to a homozygous black sire (ED ED). The resulting offspring will all be phenotypically black, but 50% will be heterozygous (ED e) and will carry one copy of the Red allele. In the third scenario heterozygous dams (ED e) are joined to a heterozygous sire (ED e), with 25% of the resulting offspring being homozygous black (ED ED), 50% being heterozygous black (ED e) and 25% being homozygous red (e e). In the final scenario homozygous red dams are joined to a heterozygous black sire. The resulting offspring will be 50% heterozygous black carriers and carrying one copy of the red allele, while the remaining 50% would be homozygous red.

DNA TESTS FOR COAT COLOUR

A number of DNA tests are now available that enable breeders to determine whether an animal with black coat colour is homozygous black or heterozygous black.

The tests currently available are predominantly available in Australia through the Animal Genetics Lab (AGL) at the University of Queensland and Zoetis Animal Genetics. A number of overseas DNA laboratories also offer tests for coat colour. Contact your Breed Society to find out if cost savings are available to members.

BREEDING FOR COAT COLOUR - THE PRACTICAL

Breeders wishing to increase the incidence of a particular coat colour within their herd can achieve the desired outcome a number of ways, however the pathway chosen will significantly affect the time taken and the cost that is incurred.

As with other traits, individual sires contribute proportionally more genetics to the herd and so careful selection of sires with the desired coat colour genetics results in the biggest gains. This may involve the use of sires of a particular base coat colour as a basic principle, but as the previous scenarios indicate, where available, sires that have been identified by a DNA test as being homozygous for coat colour will maximise genetic progress.

Breeders that are able to apply a level of selection pressure to their cow herd can also use the same philosophies that have been outlined for bulls above. Retaining only females of a particular coat colour will increase the frequency of those genes in the herd, while giving priority to dams which have been identified by DNA test as homozygous for coat colour will maximise the rate of genetic progress.

Importantly, breeding for coat colour should always be balanced with selection for other traits of economic and functional importance within the breeding objective. Simply selecting for coat colour without consideration for other economically important traits is not recommended as it may potentially compromise the genetics of animals for these other traits.

For further assistance in understanding the genetics of coat colour, or the use of DNA tests for coat colour, contact staff at Southern Beef Technology Services (SBTS) or Tropical Beef Technology Services (TBTS).

REFERENCES

Animal Genetics Laboratory (2013), 'Coat Colour – Dominant Black and Recessive Red', University of Queensland, accessed 20th January 2014 from:http://www.uq.edu.au/vetschool/content/animal-genetics-laboratory/coat-colour.pdf

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