TALKING GENOMICS

with **Andrew Byrne**, Senior Technical Product Specialist, Neogen Australasia

Breeding for Polledness in Beef Cattle

Polledness, or the absence of horns, is an important trait being actively selected for within many beef breeding programs.

Polled animals are considered more desirable in many beef enterprises due to easier handling of stock, reduced bruising, reduced risk of injury to stock handlers, reduced labour costs and reduced concerns regarding the animal welfare issues associated with dehorning.

In this edition of 'Talking Genomics' we discuss the genetics of polledness, how breeding for polledness is not as simple as just selecting visually polled animals, and how DNA technologies can be used to fast track the introgression of polled genetics into a beef herd.

The Genetics of Polledness

Polledness is a qualitative trait controlled by genetics. Animals can either be horned, scurred or polled (Table 1), although considerable variation in expression is observed within these three different phenotypes.

The inheritance of polledness has long been recognised, with polledness being the first cattle trait to be shown to have Mendelian inheritance in 1902, and the trait soon became a classic Mendelian trait cited in many textbooks.

While the underlying genes and causal mutations remain to be fully elucidated, the visual expression of polledness suggests that the trait is controlled by only one, or a relatively small number of genes.

In simplistic terms, the polled gene exists in two different forms, referred to as alleles, being the polled allele and the horned allele. Animals inherit two copies of the polled gene, one coming from each parent, and so animals may inherit either a) two copies of the polled allele, b) two copies of the horned allele, or c) one copy of the horned allele and one copy of the polled allele.

The polled allele is dominant over the horned allele, meaning that animals which inherit two polled alleles (referred to as being homozygous polled, or PP) will be predominantly polled, animals that

Table 1: Phenotypes of Cattle for Polledness

Polled	There is a complete absence of horns and scurs
Scurs	Rudimentary horns are present that are loosely attached to the skin rather than the skull
Horns	Keratin coated permanent pointy protrusions are anchored to the skull

inherit one polled and one horned allele (referred to as being heterozygous polled, or PH) will be predominantly polled or scurred, while animals that inherit two horned allele (referred to as being horned, or HH) will be predominantly horned. (Table 2).

Table 2: Genotypes of Cattle for Polledness

Homozygous Polled (PP)	Animals will be predominantly polled
Heterozygous Polled (PH)	Animals will be predominantly polled and scurred
Horned (HH)	Animals will be predominantly horned

Mating Outcomes

The manner in which polledness is inherited means that the visual appearance of animals (i.e. whether they are visually horned, polled or scurred), may not reflect their underlying genotype.

Specifically, in scenarios where polled animals are heterozygous polled (HP), they will possess one polled and one horned allele, and their progeny will, on average, inherit a horned allele, rather than a polled allele, 50% of the time.

The effect of this when breeding for polledness is illustrated in the different mating outcomes outlined below.

	P	**P**
P	PP	PP
P	PP	PP

PP x PP

100% progeny will be PP

	P	**P**
P	PP	PP
H	PH	PH

PP x PH

50% progeny will be PP, 50% will be PH

	P	**H**
H	PH	HH
H	PH	HH

PH x HH

50% progeny will be PH, 50% will be HH

	P	**P**
H	PH	PH
H	PH	PH

PP x HH

100% progeny will be PH

	P	**H**
P	PP	PH
H	PH	HH

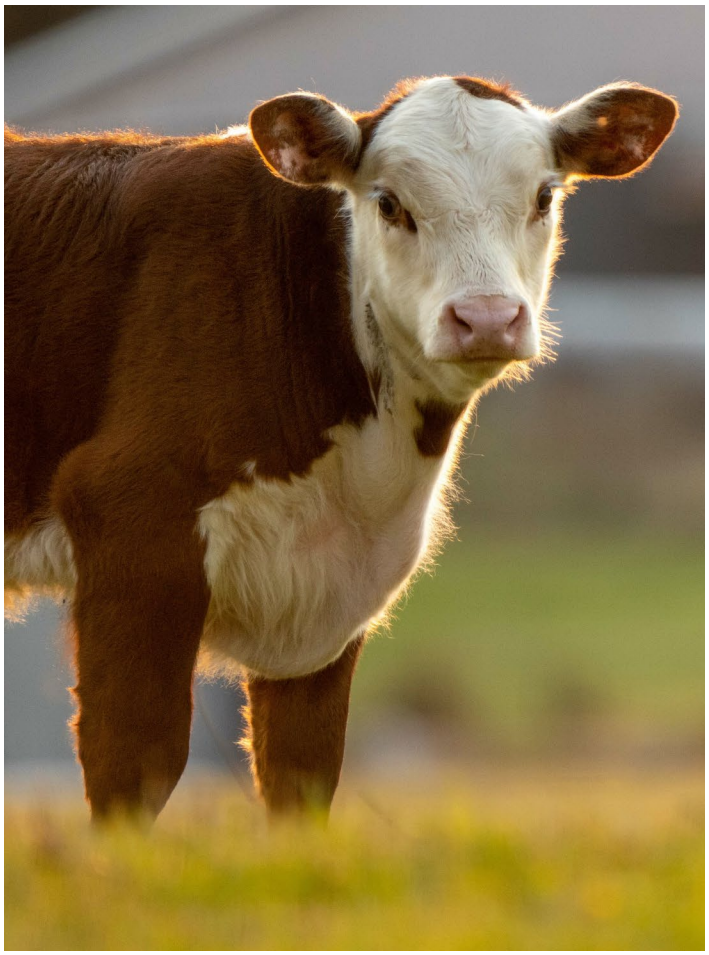
PH x PH

50% progeny will be PH, 25% will be PP, 25% will be HH

	H	**H**
H	HH	HH
H	HH	HH

HH x HH

100% progeny will be HH



The Bovine Horn-Poll Test

Neogen's Bovine Horn-Poll test is a predictive test that evaluates a DNA sample from animals that are visually polled, and identifies those that are predicted to be homozygous polled animals (i.e. will only pass polled genes onto their progeny), versus

those visually polled animals that are predicted to be carriers for the horned gene (i.e. will pass horned genes to 50% of their progeny).

Selection of homozygous polled animals, versus simply selecting visually polled animals, increases the proportion of polled progeny from a particular mating, which in turn increases the speed of transition from a horned to polled herd.

The Horn-Poll test is available for all beef breeds, and can be ordered as either a standalone test, or in association with one of Neogen Australasia's breed specific genomic test bundles.

Scientific Basis for the Bovine Horn-Poll Test

Analysis of the DNA sequence of animals has mapped the polled gene to a region on chromosome 1 (known as the poll locus). Within this region, 4 distinct variants of the polled allele have been identified, representing 4 different mutations of DNA sequence that have each been shown to be closely associated with the expression of polledness in different breeds of cattle. The different variants are known as the Celtic (Pc), Friesian (Pf), Mongolian (Pm) and Guarani (Pg) variants. Of these, the Celtic (Pc) and Fresian (Pf) variants are associated with polledness in most common breeds in Australia and New Zealand, with the Mongolian (Pm) and Guarani (Pg) variants being associated with the Mongolian Turano and Nelore breeds respectively. (Figure 1).

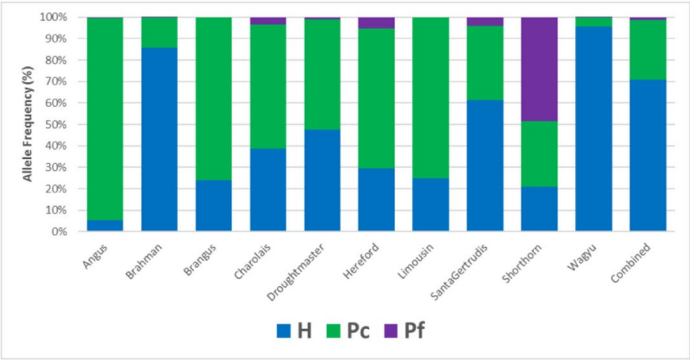


Figure 1 : Allele frequencies of Horn (H), Celtic Poll (Pc) and Fresian Poll (Pf) in various breeds (Source: University of Queensland)

The Bovine Horn-Poll test does not evaluate the poll allele directly, but relies on a number of genetic markers within the poll locus that are closely linked with the Celtic (Pc) and Fresian (Pf) variants of the polled allele.

Interpreting Bovine Horn-Poll Test Results

Results from the Bovine Horn-Poll test report the alleles that an animal is predicted to possess for the polled gene (Table 3).

Table 3 : Bovine Horn-Poll Test Results

Result	Interpretation
PcPc **PcPf** **PfPf**	Homozygous Poll (PP)
HPc **HPf**	Heterozygous Poll (PH)
HH	Horned (HH)

In a small proportion of cases, one or more of the genetic markers may fail testing, or the combination of genetic markers may fail to produce a result, in which case the result will be reported as 'NR', meaning 'no result'. Research has indicated that a result can be expected in greater than 99% of cases.

Accuracy of Results

The Bovine-Horn Poll test is a predictive test, and while it is highly informative and can significantly reduce the time taken to transition to a polled beef herd, it is important to recognise that there is no perfect DNA test for polledness that will deliver the correct result 100% of the time.

In particular, while closely associated with the polled allele, the genetic markers utilised in the Bovine Horn-Poll test have not been confirmed as the cause of polledness in beef cattle, meaning in a small percentage of cases, Bovine Horn-Poll test results may not align with the underlying genotype of the animal for the polled gene, or the visual appearance of the animal (i.e. whether the animal is visually horned, polled or scurred).

A major research study undertaken by the University of Queensland, in collaboration with Meat & Livestock Australia, reviewed the concordance between Bovine Horn-Poll test results and the visual appearance recorded with their respective breed association for 18,417 animals across 16 breeds. The study revealed the Bovine Horn-Poll test result was concordant with the visual appearance recorded for the animal in 97.5% of cases (Table 4).

Table 4 : Concordance of Bovine Horn-Poll Test Results with Visual Appearance Recorded with Breed Associations for Animals

Bovine Horn-Poll Test Result		Visual Appearance and Concordance (%)			
		Horn	Scur	Poll	Total
Horned	**HH**	11528 (97.4%)	84 (12.2%)	60 (1%)	11672
Heterozygous Polled	**HPc**	286 (2.4%)	579 (84.2%)	1852 (31.4%)	2717
	HPf	2 (0.016%)	20 (2.9%)	114 (1.9%)	136
Homozygous Polled	**PcPc**	16 (0.1%)	4 (0.6%)	3531 (59.9%)	3551
	PcPf	1 (0.008%)	1 (0.1%)	311 (5.3%)	313
	PfPf	1 (0.008%)	0 (0.0%)	27 (0.5%)	28
	Total	11834	688	5895	18417

Key learnings from this research study include:

- in a small number of cases (0.9%), animals predicted to be homozygous polled may visually have scurs or horns.
- in a small number of cases (1%), visually polled animals may return a result of HH (horned).

The accuracy of the Bovine Horn-Poll test is expected to further improve in the future with scientific advances, such as the inclusion of genetic markers associated with the Guarani (Pg) variant of the polled allele.

The Genetics of Scurs

Knowledge of the genetics underpinning scurs development remains limited, although it is considered likely that scurs is controlled by separate genes to polledness. Research suggests the expression of scurs is likely to influenced by a complex pathway involving the presence and interaction between many genes, combined with non-genetic factors such as the sex and age of animals.

At this stage, a DNA test is not available for scurs, however selection for homozygous polled bulls is expected to reduce the incidence of scurred animals over time.

Further Information

To further discuss the utilisation of genomic testing to increase the proportion of polled cattle in a beef herd, contact your local Neogen Genomics Territory Manager.

Additional Reading

Detailed information about the Bovine Horn-Poll test can be found at: https://www.mla.com.au/contentassets/6835af7a3d344af-c9a50cf341d98f776/l.gen.1713_final_report.pdf

References

Nicholas, F. W., Tammen, I., & Sydney Informatics Hub. (2023). OMIA:000483-9913: Online Mendelian Inheritance in Animals (OMIA) [dataset]. https://omia.org/. https://doi.org/10.25910/2AMR-PV70

Meat & Livestock Australia (2020), 'Improving the Australian Poll Gene Marker Test' MLA Final Report, Accessed September 2024 https://www.mla.com.au/contentassets/6835af7a3d344af-c9a50cf341d98f776/l.gen.1713_final_report.pdf

Southern/Tropical Beef Technology Services (2016), 'Breeding for Polledness' Fact Sheet, Accessed September 2024 https://breedplan.une.edu.au/media/4i1nz1jt/breedpoll.pdf