

Genetic Effects on the Productivity of Beef Cattle

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INTRODUCTION

The physical features we observe and performance characteristics we can measure in cattle are called traits. Both the animal's genes, and the environment in which it lives, shape its traits. Economically important traits in beef cattle include fertility, growth rate and carcass characteristics. Genes influence all of them.

Three factors determine the productive performance of cattle:

- a) their genes
- b) their environment
- c) the interaction between their genes and their environment.

This *Agnote* explains some of the principles of the inheritance of productive traits and gives practical examples. The extent of genetic effects on many important traits in beef cattle is explained. **Understanding the extent of genetic effects on important traits puts both the genetic and environmental influences of those traits in perspective. This enables beef producers to target their productivity improvement efforts more effectively.**

BACKGROUND AND SOME IMPORTANT DEFINITIONS

Under normal circumstances all animals inherit two copies of each gene, one from each parent. Genes can have different forms, called **alleles**.

Some traits are influenced by a single gene or very few genes. These are called **major genes**. Horns, coat colour and double muscling are examples of traits controlled by major genes in cattle. All animals inherit alleles for major genes and express a distinct form. The environment can have some influence on traits controlled by major genes. An example is red coated cattle that are phosphorus deficient take on a "washed out" appearance and become a lighter shade of red.

Two important definitions are those of genotype and phenotype. **Genotype** refers to the genetic makeup of an animal, whereas **phenotype** refers to different forms of traits we can observe e.g. horned or polled; or differences we can measure e.g. growth rates and mature weights. The distinction is important because:



Phenotype evaluation should include structure, breed character, muscling and disposition.

- Animals with different genotypes can express the same phenotype (see the example for horns below). Another example would be if a Brahman steer and a Santa Gertrudis steer had the same growth rate. They have expressed the same phenotype for growth rate but clearly have different genotypes.
- Animals with the same genotype can express different phenotypes. An example is identical twins raised under different conditions. One fed grain will obviously grow faster than the other fed roughage despite having identical genotypes.

Hundreds or thousands of genes contribute to most of the important productive traits. These are called **quantitative traits**. Unlike traits controlled by major genes these traits do not have distinct forms but fit into a range. An example is growth rates, which vary from extremely low, right through to extremely high. Traits influenced by multiple genes are more influenced by the environment than traits controlled by major genes.

Heritability is the amount of transmission of a trait from parents to offspring. When the genetic effect on a trait is strong, the trait is highly her-

itable. The reverse is also true. When the genetic effect on a trait is weak, it is lowly heritable and the environment has the greatest influence on that trait.

Sometimes some genes act on more than one trait. Such traits are called **correlated traits** as they go hand in hand with each other. An example is high growth rates are correlated with high birth weights. Another example is scrotal circumference. Scrotal circumference on its own is of no importance; however it is a very useful trait because it is correlated with both male and female fertility.

As noted earlier, there is interaction between the genes of animals and the environment. The importance to beef producers is that different genotypes (different breeds or sometimes strains within breeds) will perform differently in different environments. For example, with similar feed, in hot, humid tropical areas *Bos indicus* cattle will outperform *Bos taurus* cattle, whilst the reverse is true in cool climates with good pasture.

EXAMPLES OF MAJOR GENES

An example of a major gene is horns in British and European breeds, where there are only two alleles of the one gene, horned and polled. If a

beast inherits two copies of the polled allele, it will be polled. If it inherits two copies of the horned allele it will have horns.

The polled allele is **dominant** to the horned allele. This means that if a beast inherits one allele for horns and one for being polled it will be polled. The horned allele is termed **recessive**. Recessive genes lead to “throwbacks”. A long line of polled cattle will quite often produce some horned offspring.

Alleles can also be of “equal strength”. This is called **co-dominance**. An example is coat colour in Shorthorn cattle where there are two alleles - red and white. If a Shorthorn has two copies of the red allele it will be red; if it has two copies of the white allele, it will be white. Roans result when they inherit one copy each of the red and white alleles. A similar pattern is observed when grey and red Brahmins are crossed to produce honey colored offspring.

TRAITS INFLUENCED BY MULTIPLE GENES

The environment has the greatest influence on lowly heritable traits. The environment is more than climate and type of country. It also includes parasites, diseases, seasons, pregnancy status, lactation status, castration status, water quality, forage quality, management groups etc. The list goes on and on.

Some environmental factors have permanent effects on cattle while others are only of a temporary nature. For example, poor nutrition and calving young commonly combine to permanently stunt cows. Lactation status on the other hand is temporary, once a cow dries up her chances of going in calf increase greatly.

Management can influence some environmental factors. Nutrition is often the most important environmental factor influencing the productivity of beef cattle. Nutrition is affected by the type of country, pasture type and seasonal conditions. Management can influence the quality and quantity of nutrition available by techniques such as manipulating stocking rates and use of supplements.

The heritability of a number of important production and adaptation traits for beef cattle is listed in Table 1.

The least heritable trait in Table 1 is calving interval. This means that environmental factors have overwhelming influence on the calving interval of cows, with the main influence usually being nutrition.

The genes in cattle have a greater effect on traits of medium heritability such as growth rate than on calving interval.

Genes have a much greater effect (and consequently environmental factors have much less influence) on highly heritable traits such as mature weight than they do on calving interval.

PUTTING GENETIC EFFECTS ON TRAITS IN PERSPECTIVE

Traits controlled by major genes are the most heritable of all traits. Cattle breeders can select for or against different forms (phenotypes) for traits controlled by major genes very quickly. However, many genes influence most of the important traits in beef cattle. Genetic improvement can be made rapidly by selecting for or against highly heritable traits. On the other hand, genetic improvement is slow if selecting for or against traits of low heritability. Because environmental factors have overwhelming influence on traits of low heritability, efforts to improve performance for such traits should primarily focus on management inputs that modify the conditions under which the cattle are expected to perform.

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Table 1. The extent of heritability of some important traits in beef cattle.

| TRAIT | Range | HERITABILITY* | |
|-----------------------------------|-------------|------------------|-----------------|
| | | Temperate Breeds | Tropical Breeds |
| Fertility | | | |
| Calving Interval | Low | 10% | 15% |
| Scrotal Circumference (18 months) | Medium-High | 35-50% | 30-35% |
| Growth | | | |
| Birth Weight | High | 40% | 40% |
| Weaning Weight | Medium | 30% | 30% |
| Yearling Weight | Medium-High | 40% | NA |
| Mature Cow Weight | High | 50% | > 50% |
| Growth Rate | Medium | 30% | 30% |
| Carcass | | | |
| Dressing % | Medium-High | 40% | NA |
| Rump Fat Depth | Medium-High | 35% | 20-45% |
| Eye Muscle Area | Medium | 20% | 30-40% |
| Adaptation | | | |
| Eye Cancer Susceptibility | Medium | 30% | NA |
| Tick Resistance | Medium | NA | 20-35% |
| Worm Resistance | Medium | NA | 25-30% |
| Buffalo Fly Resistance | Medium | NA | 20-30% |

*Heritability estimates sourced from various publications

NA - either not available or not applicable

Table 1 shows that there is a wide range in the heritability of important traits in beef cattle. The heritability of important traits puts both the genetic and environmental influences on these traits in perspective.