

Genomic Selection for Reproductive Traits

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Overview

- Quantitative inheritance
- Response to selection
- Heritability
- Genomic selection
- Measures of reproduction
- Questions

<https://ag.ethz.ch/>

Trait types

- **Simple** – ~100% genetic control
 - Single (few) genes control trait
 - black/red, horned/polled, etc...
- **Complex or quantitative** – varying degree of genetic control
 - Controlled by many genes
 - Subject to environmental effects
 - Most measured traits that are associated with production or performance

What makes a phenotype?

- **Genetics**
 - The genetic makeup of an individual
 - Genetic contribution from father and mother
- **Environment**
 - Outside influences
 - nutrition, climate

The art (science) of animal breeding

- Choosing the most appropriate parents to produce the best offspring
- Tools for selection
 - Phenotype
 - measured performance
 - complimentary, uniformity
 - Breeding values (EPDs)
 - targeted performance
 - DNA genotype

<https://ag.ethz.ch/>

Why is it difficult to make genetic progress?

$h^2 = \frac{\text{response}}{\text{selection differential}}$

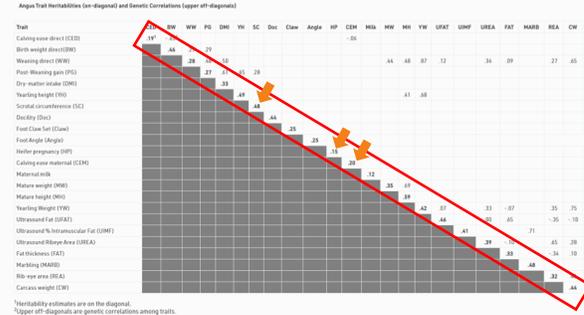
Heritability

- The relative proportion of variation that is due to genetics
 - Heritability (h^2)
 - Genetic variance / phenotypic variance
- Can be observed/estimated from population data
 - Phenotype correlations between relatives





Angus Trait Heritabilities (see diagonal) and Genetic Correlations (upper off-diagonal)



Heritability estimates are on the diagonal.
Upper off-diagonal are genetic correlations among traits.

<https://www.angus.org/Nce/Heritabilities.aspx>





Improving accuracy of selection

- Increase accuracy of genotype prediction
 - The higher the correlation between the phenotype collected and the actual genotype, the higher the accuracy
- Is there an opportunity for direct selection on genotype?





Expected Progeny Differences (EPDs) and Genomic Selection

- EPDs are an estimation of an animal's relative genetic merit based on phenotypes and pedigree
 - Performance data collected on large numbers of animals in many environments
- Genomic selection uses direct genotype information to enhance EPD estimate
 - Trait variance directly associated with specific DNA marker genotypes
 - Improved estimation of genetic relationships

Background image courtesy of Dan Minor, American Angus Association





Measures of Reproductive Merit

- Scrotal Circumference (SC)** – predicts the difference in transmitting ability for scrotal size compared to that of other sires.
- Heifer Pregnancy (HP)** – is a selection tool to increase the probability or chance of a sire's daughters becoming pregnant as first-calf heifers during a normal breeding season.

<https://www.angus.org/Nce/Definitions.aspx>





- Stayability (STAY)** – predicts the probability of a bull's daughters remaining productive until at least six years of age.
- Sustained Cow Fertility EPD (SCF)** – predicts a cow's ability to continue to calve from three years of age through twelve years of age, given she calved as a two-year old.

<https://redangus.org/genetics/ranchers-guide-to-epds/>
https://hereford.org/wp-content/uploads/2017/02/issue-archive/0811_PerformanceMatters.pdf





Measures that may indirectly impact reproductive success

- **Calving Ease Maternal (CEM)** – predicts the average ease with which a sire's daughters will calve as first-calf heifers when compared to daughters of other sires.
- **Maintenance Energy (ME)** – predicts differences in daughters' maintenance energy requirements
- **Cow Energy Value (SEN)** – differences in cow energy requirements and includes lactation energy requirements and energy costs associated with differences in mature cow size.

<https://redangus.org/genetics/ranchers-guide-to-epds/>
<https://www.angus.org/Nce/Definitions.aspx>



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Summary

- Due to the complex inheritance patterns of reproductive traits, genetic progress can be difficult
 - Most measures of reproductive merit are only indirect
 - Future opportunities may exist for more direct measures
 - Optimization of the production environment has a higher relative importance
- Genomic Selection via enhanced EPDs is the best tool for genetic improvement
 - Expect further improvements as more data and potential direct measures of reproduction are identified



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