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The Genetics of Fertility
Existing and Developing Tools

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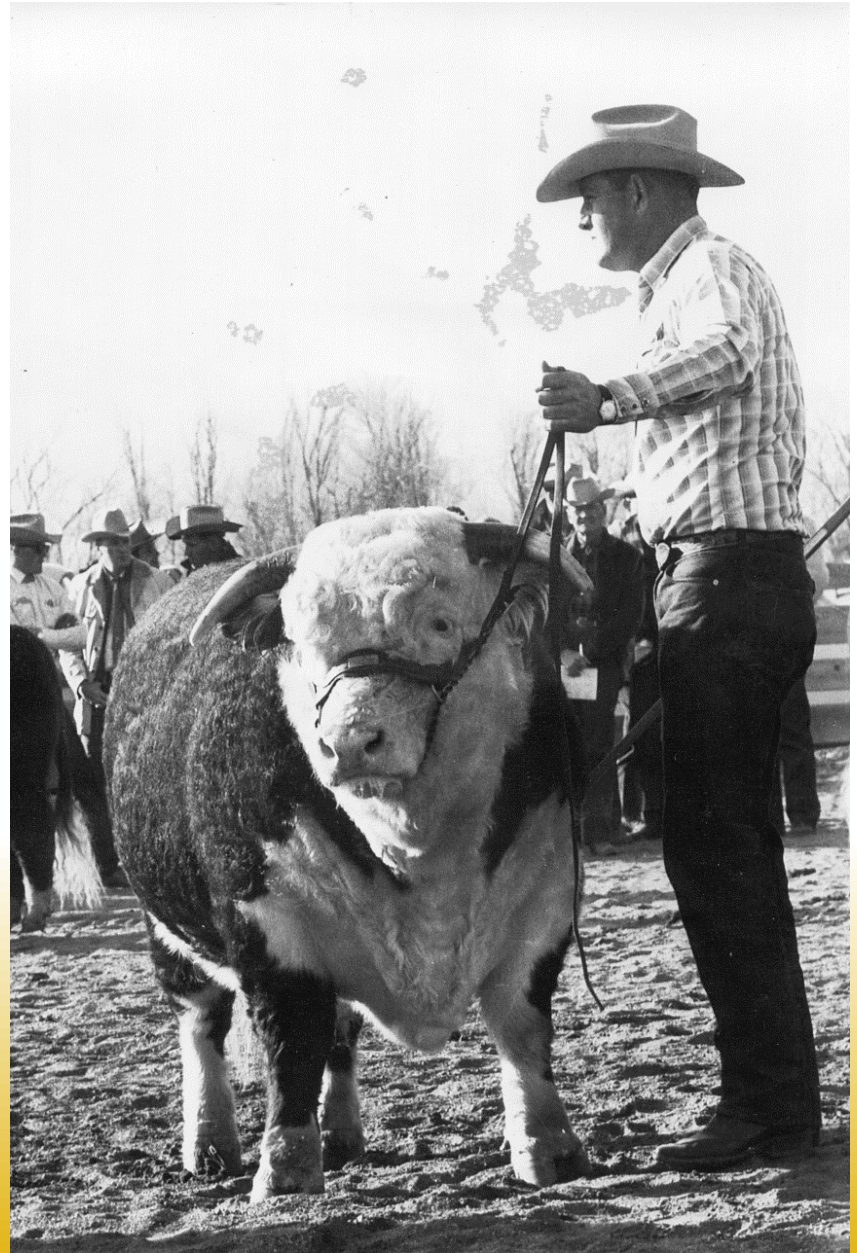
Tradition



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Legacy

How?

How?

SUSTAINABILITY:

STEWARDSHIP

RESPONSIBILITY

PROFITABILITY

Overview

- Selection on Performance
- Selection on Genetics
- New Research

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Phenotypic Selection

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Phenotypic Selection

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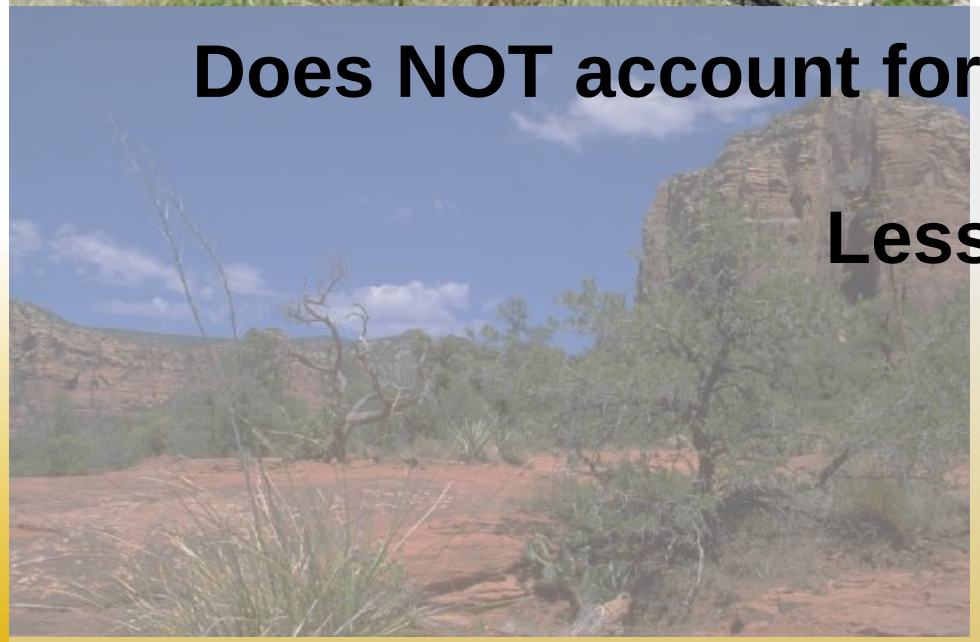
Phenotypic Selection

Does NOT account for environmental differences!

Less accurate



Limits of Phenotypic Selection

- Square Root of Heritability is the ceiling
- Birth Weight
  - h^2 = 0.46
  - Ceiling on selection accuracy = 0.68
- Marbling
  - h^2 = 0.48
  - Can’t use a carcass as a parent of the next generation
- Heifer Pregnancy
  - h^2 = 0.15
  - Ceiling on selection accuracy = 0.39
- No ceiling on EPD accuracy!

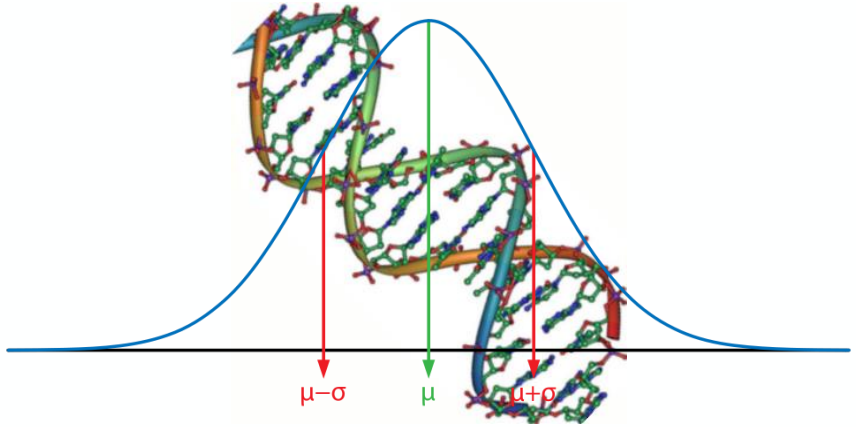
EPD

Expected
- Future, average, mean

Progeny
- Offspring

Difference
- Implies comparison between animals
- NOT phenotypic performance

Relatedness is the key



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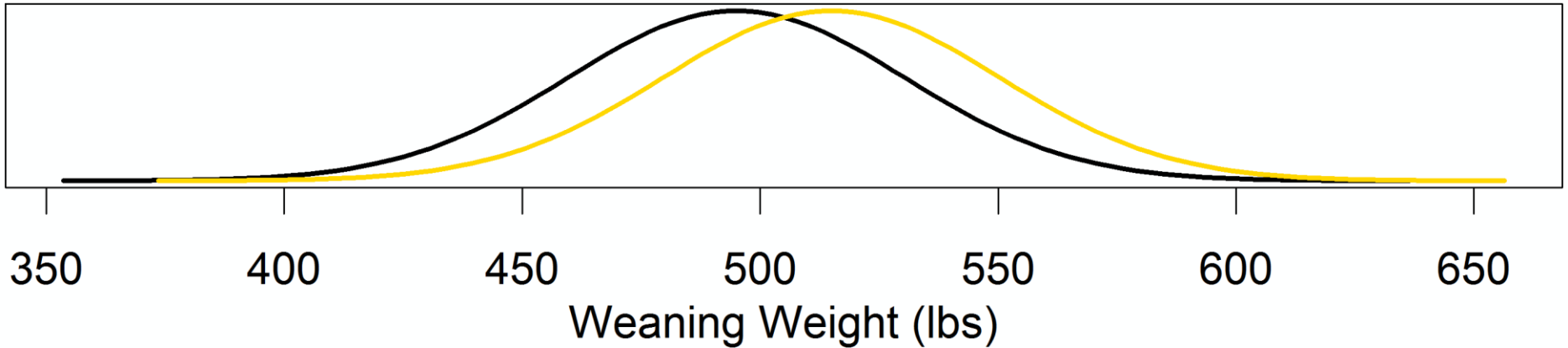
EPDs in Practice

Weaning Weight EPD = 50

Weaning Weight EPD = 70

Average Weaning Weight = 495

Average Weaning Weight = 515



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Genetic and Genomic Predictions Work!

New Results

Comment on this paper

Evaluation of Zoetis GeneMax Advantage genomic predictions in commercial *Bos taurus* Angus cattle

Brian. C. Arisman, Troy N. Rowan, Jordan M. Thomas, Harly J. Durbin, David J. Patterson, Jared E. Decker

doi: https://doi.org/10.1101/2020.10.23.353144

ABSTRACT

The GeneMax (GMX) Advantage test, developed by Zoetis, uses approximately 50,000 single nucleotide polymorphisms (SNP) to predict the genomic potential of a commercial Angus heifer. Genetic predictions are provided for Calving Ease Maternal, Weaning Weight, Heifer Pregnancy, Milk, Mature Weight, Dry Matter Intake, Carcass Weight, Marbling, and Yield. Indices of economically important traits are estimated on an index score (1-100 scale) and are divided into three indices; Cow Advantage index, Feeder Advantage index, and Total Advantage index. The indices provide a genomic prediction of the profitability of the cow's calves. Therefore, test results can inform selection and culling decisions made by commercial beef cattle producers. To measure the accuracy of the trait predictions, data from commercial Angus females and their progeny at the University of Missouri Thompson Research Center was utilized to analyze weaning weight, milk, marbling, fat, ribeye area, and carcass weight. Progeny phenotypic data was matched to the respective dam, then the cow's genomic predictions were compared to the calf's age-adjusted phenotypes using correlation

https://doi.org/10.1101/2020.10.23.353144

Genetics of Fertility

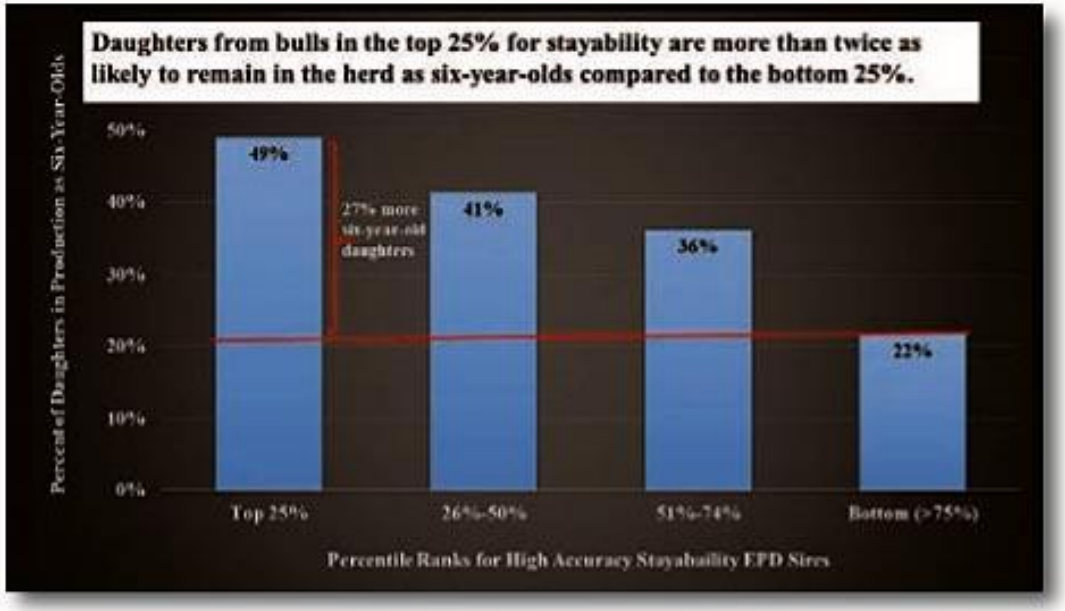
- Stayability
  - Breeds in IGS evaluation
- Sustained Cow Fertility
  - Hereford
- Heifer Pregnancy
  - Red Angus
  - Angus
  - Gelbvieh

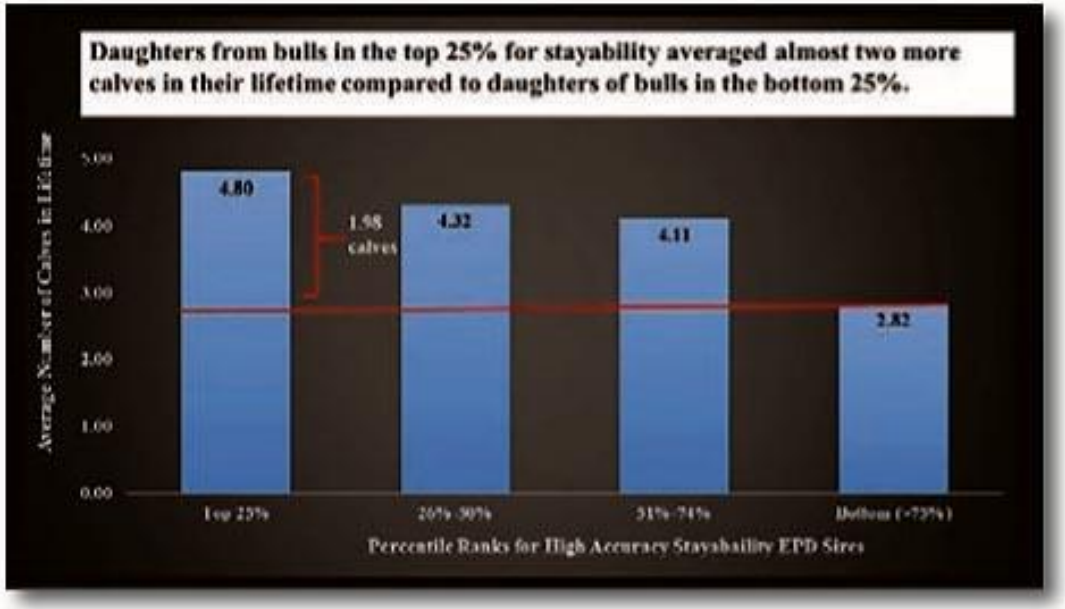
Stayability

- Percent probability that a bull's daughters will stay productive within a herd to at least six year of age

Stayability

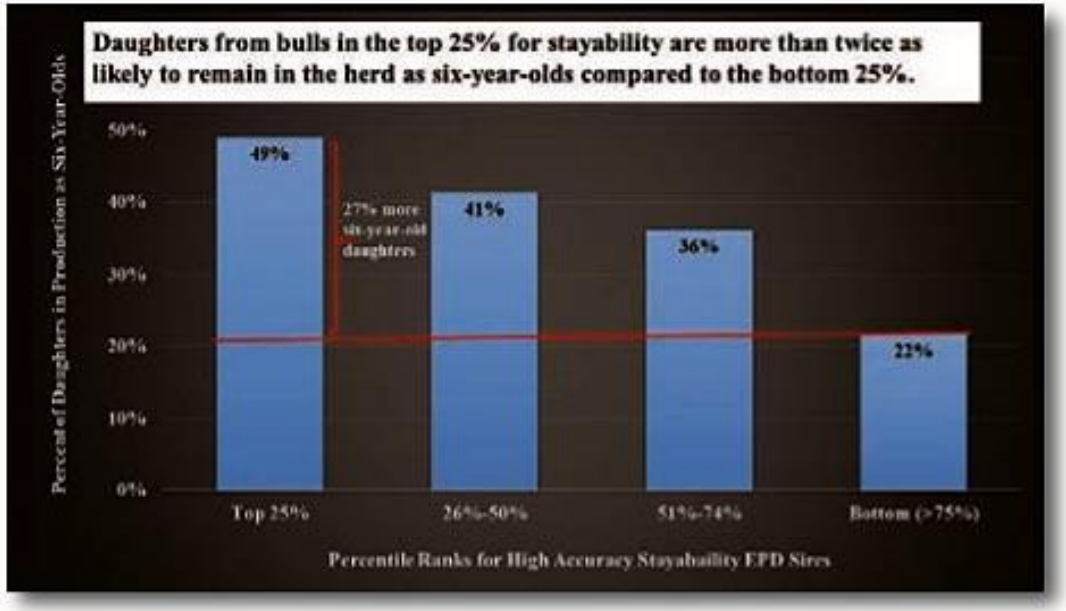
- Observation is success or failure
- Percent probability that a bull's daughters will stay productive within a herd to at least six year of age
- "Stayability EPD. Does it Work?"
  - Drs. Culbertson and Atkins at IGS
- https://simmental.org/site/index.php/pub/article-topics/industry-events/245-stayability-epd-does-it-work

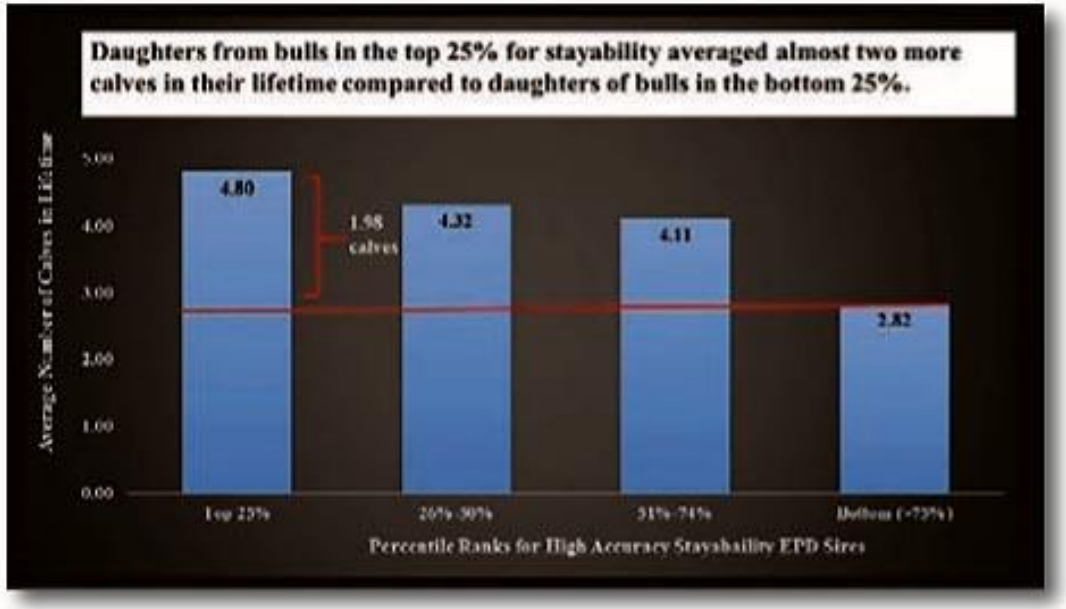




Stayability

- Staybility EPD works.
- Are you using it?





Sustained Cow Fertility

- Observation is success or failure
- “Sustained Cow Fertility EPD (SCF) is a prediction of a cow’s ability to continue to calve from three years of age through 12 years of age, given she calved as a two-year-old.”

Heifer Pregnancy

- Observation is success or failure
- Breeding season begin date, breeding season end date, contemporary group, was heifer exposed, was heifer pregnant, calf date of birth
- “Ability of their daughters to conceive and calve at two years of age.” BIF Guidelines

Crossbreeding!

- Crossbred cow is 25% more productive in her lifetime
  - Fertility

- If you are going to straight bred, need to use fertility EPDs!

Future Directions

- Existing tools work!

Future Directions

- Existing tools work!
- Can we do better?

Embryonic Lethals

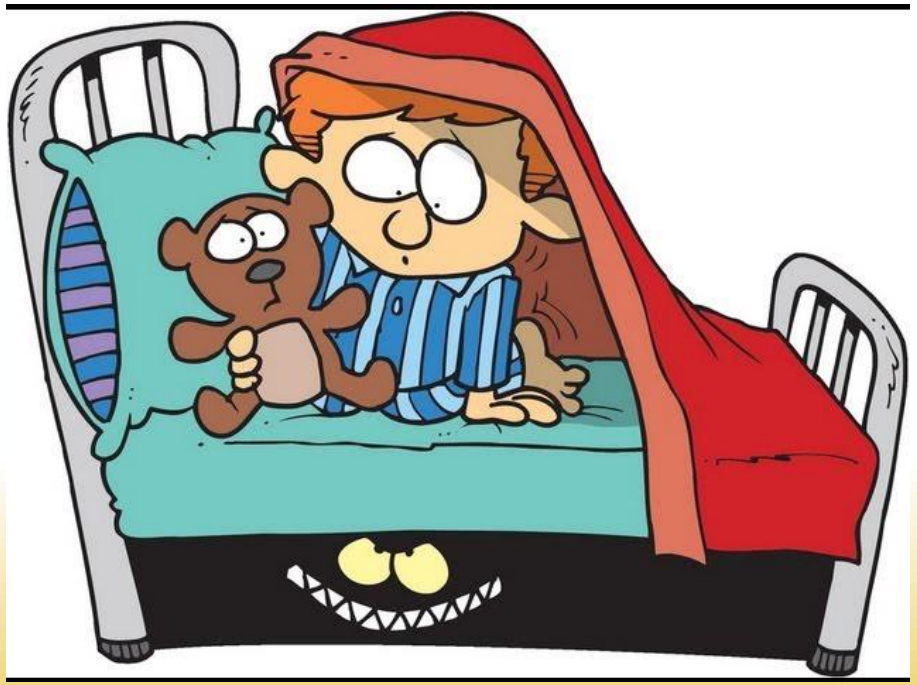
- Recessive DNA variants
- Inherit one copy, fetus, and eventually calf, is fine
- Inherit two copies, embryo or fetus is aborted

Embryonic Lethals

- Dairy industry has been using these for years
  - Don’t give them a name – simply an acronym
- Jerry Taylor and David Patterson are wrapping up a grant on this in beef cattle
- Angus Genetics Inc is working to validate candidates they have found
- https://blog.steakgenomics.org/2020/10/angus-university-focusing-on-fertility.html

Embryonic Lethals

- Avoid mating carriers to carriers, pregnancy rates and calving distribution improve
- Benefit of crossbreeding?
- https://blog.steakgenomics.org/2020/10/angus-university-focusing-on-fertility.html



Future Directions

- No predictions of early puberty
- Few records are turned in
- Low information content
  - Binary success or failure
  - Quantitative measures have more information
- No credit given to females who conceive early in the breeding season

How have we handled other difficult traits???

How have we handled other difficult traits???

- Multiple trait models!
- Calving ease
  - Success/failure with many contemporary groups with no variation
  - Use birth weight as a quantitative indicator!
- Carcass traits
  - Ultrasound data used as an indicator
  - Weaning weights to account for incomplete/biased sampling

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United States Department of Agriculture

National Institute of Food and Agriculture

Genomics of puberty and fertility in heifers focusing on functional variants

June 1, 2020 to May 31, 2024

https://blog.steakgenomics.org/2020/02/HeiferRecruitment.html

https://blog.steakgenomics.org/2020/07/heifer-puberty-and-fertility-project.html

Improved prediction of Heifer Puberty and Fertility

- Reproductive tract score is a direct measurement of a heifer's puberty status
- Pelvis grows rapidly during puberty, thus pelvic measures have genetic correlations with puberty
- Days Open is a quantitative measure of Heifer Pregnancy
- How do predictions improve when we fit multiple traits in the evaluation?

Participation Overview

- https://blog.steakgenomics.org/2020/07/heifer-puberty-and-fertility-project.html
- Pre-breeding exam 30 to 45 days prior to start of breeding season
  - DNA sample
  - Pelvic Measurement
  - Reproductive Tract Score
- Ultrasound Fetal Age
  - 90 days after start of the breeding season
- Must do whole herd reporting, i.e. entire group of heifers being developed

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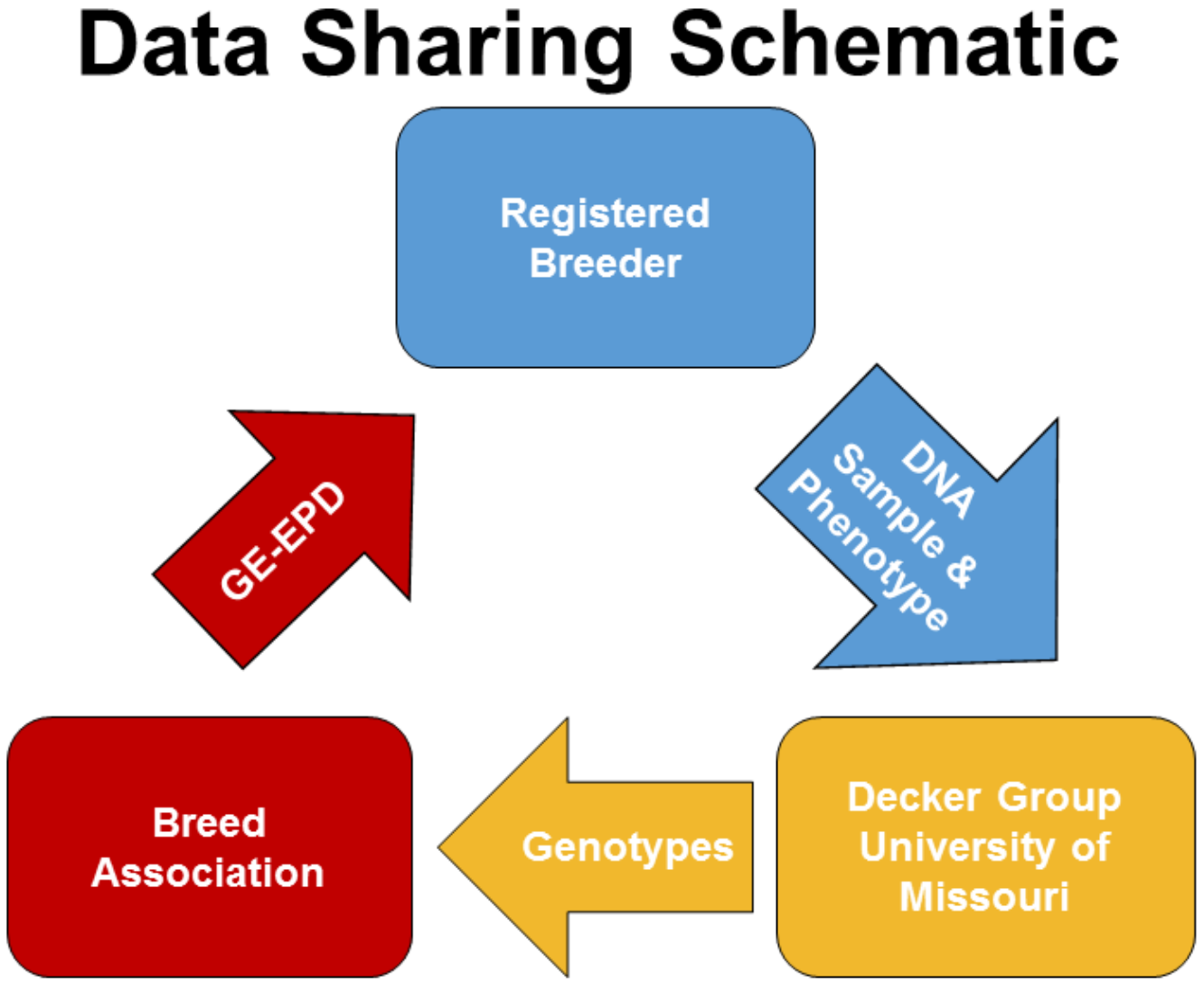
"FREE" GE-EPDs

- Producer pays veterinarian for cost to collect:
  - Reproductive Tract Score
  - Pelvic Measurements
  - Ultrasound Fetal Age
- Grant pays for blood card and DNA testing, which is shared with RAAA and AHA for free GE-EPDs



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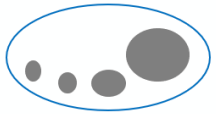
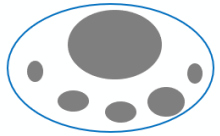
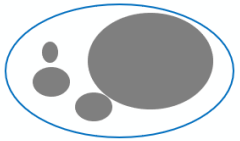
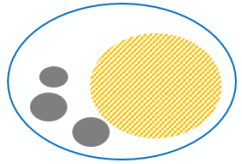
Reproductive Tract Scores

	Pre-Pubertal		Peri-pubertal	Pubertal	
Reproductive Tract Score	**1**	**2**	**3**	**4**	**5**
Ovary & Follicle Size					
Pregnancy Rate from Fixed-Time AI	**8%**	**32%**	**46%**	**49%**	**52%**

Early Results

- Days Open has higher heritability than Heifer Pregnancy
  - More information content
- Mild genetic correlation between Reproductive Tract Score and Days Open
  - Bulk of this data was synchronized using 14-Day CIDR
- Moderate genetic correlation between Reproductive Tract Score and pelvic measurements

NCARG Seminar Series

- Carcass ultrasound professionals get paid to collect phenotypes for genetic evaluations
- Feed intake systems get paid to collect phenotypes for genetic evaluations

- Opportunity for veterinary practices with reproduction focus?

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Recruiting Heifers!

- 2,500 Red Angus
- 2,500 Hereford
- Red baldies, commercial heifers accepted
- Please contact us if you are interested in participating!

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Conclusions

- Use EPDs over phenotypes at every possible chance
  - Especially for low heritability traits
  - Caveat: phenotypes drive the bus for EPDs
- Fertility trait EPDs work
  - Use them!
- Help is on the way!