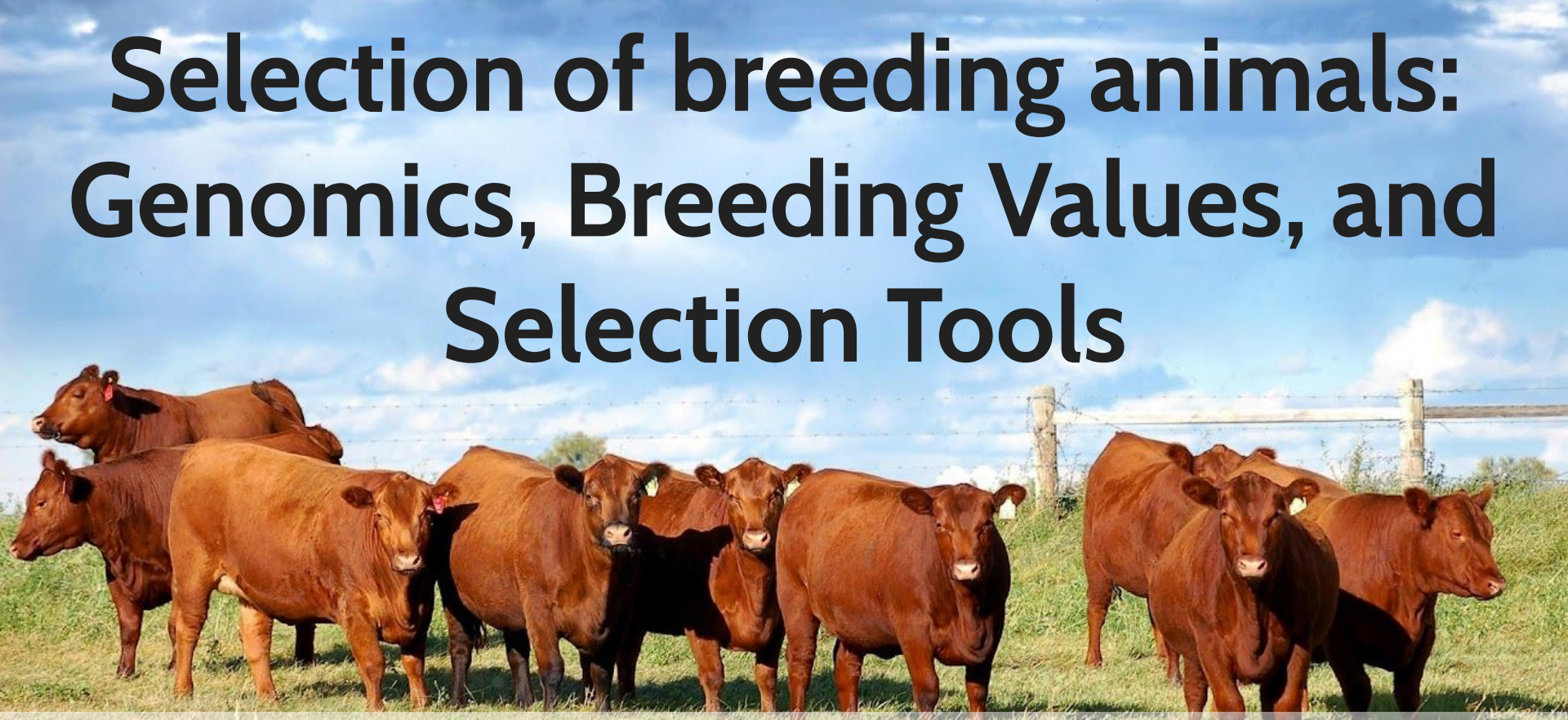
Selection of breeding animals: Genomics, Breeding Values, and Selection Tools



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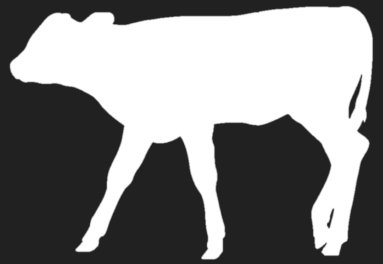
Dr. Troy Rowan

Estonian Cattle Breeders Training
November 27, 2023

Which traits matter for efficiency and profitability?

How does this influence our selection decisions?

"Revenue-generating" traits



Live calf

Weaned pounds

"Cost" (aka replacement female) traits

Bull selection tools for cow efficiency and fertility can help us achieve a more genetically efficient cow

Genetic Potential

Resource Needs

Cows need resources to reach their genetic potential

We need the type of cattle that fit our environment/ management

What is the most important decision that a commercial beef herd makes?

BULL SELECTION!

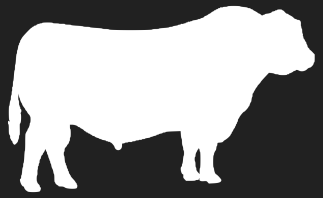
The bull purchase is one of the ***riskiest*** decisions that a commercial cattle operation makes

most important

most difficult

Wouldn't we like to know this before it happens?

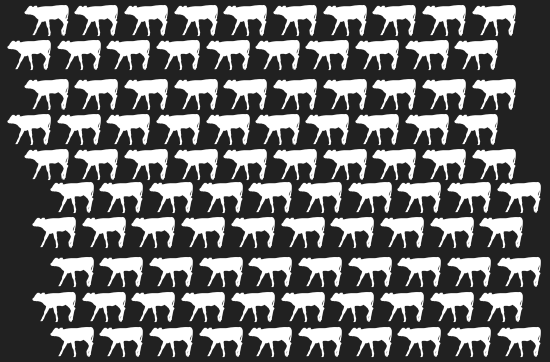
1 bull



Bull is more expensive

We save money on purchase

100 calves



Genetic potential to add 10 kg weaning weight per calf?
→ + $2800
20% of calves need pulled, losses to dystocia

20 replacement females

Fertile daughters, 90% make it to 6 years old +

Horrible feet and legs for 3+ y/o cows

EBVs can be an essential tool for sire selection

EBVs are useful, but we still must evaluate bull phenotype

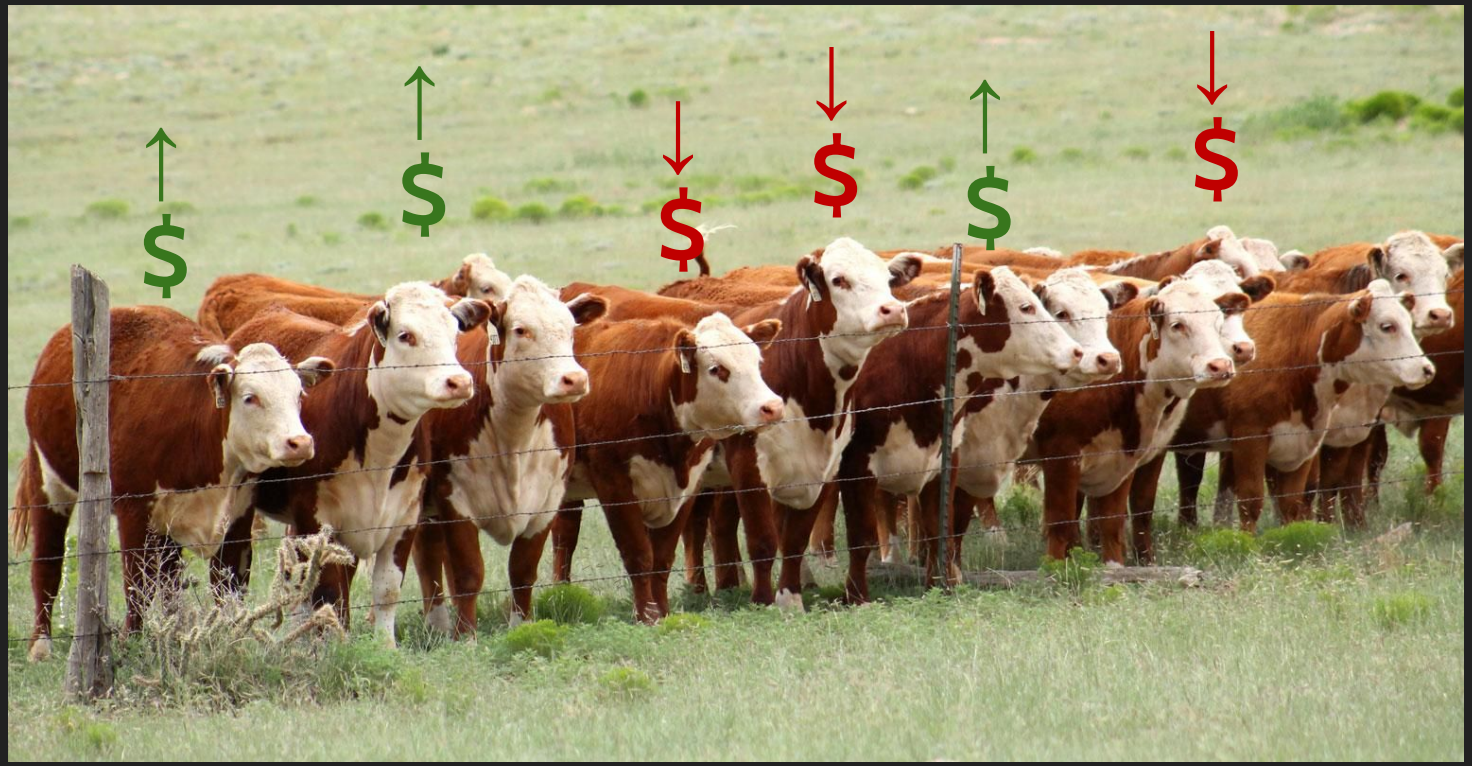
Disposition

Breeding Soundness

Foot and
Leg Structure

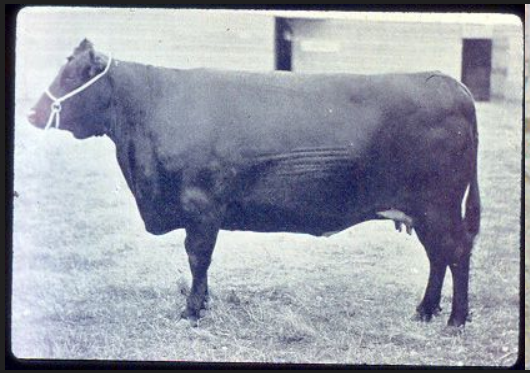
EBVs help to prevent trainwrecks

EBVs can accelerate genetic progress (and profitability)

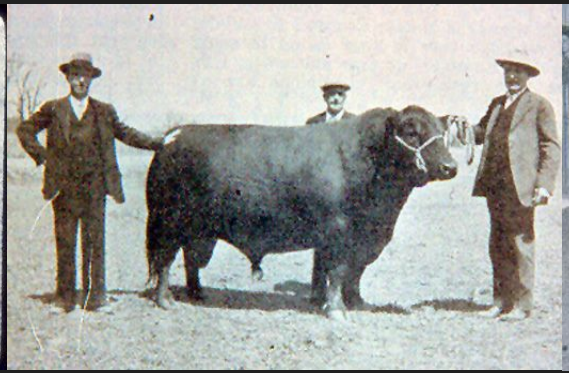


A Quick History on Selection Strategies

The power of selection



1890

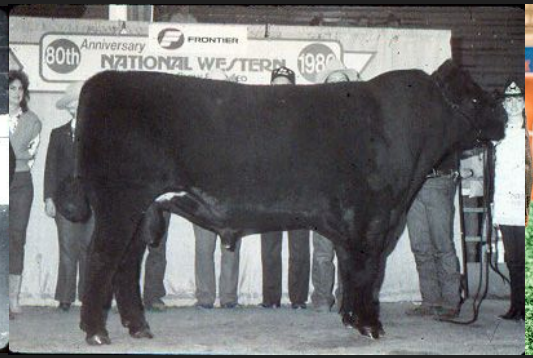


1932

1955

1964

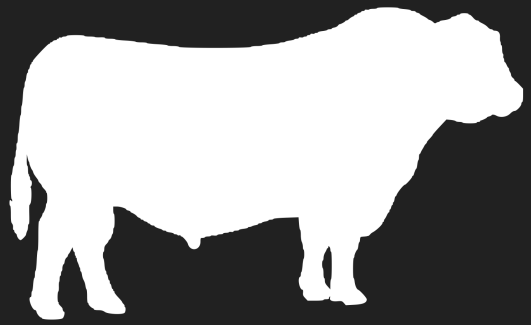
1969

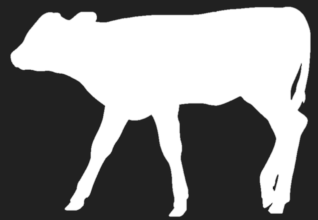


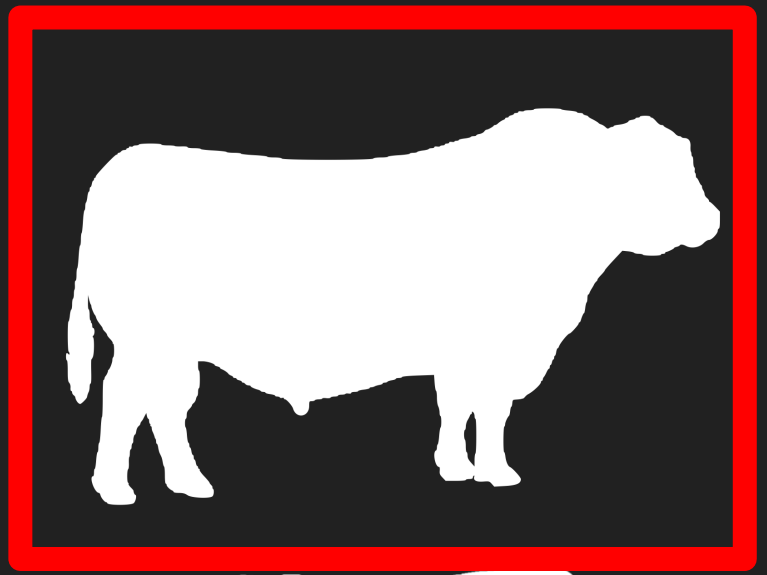
1985

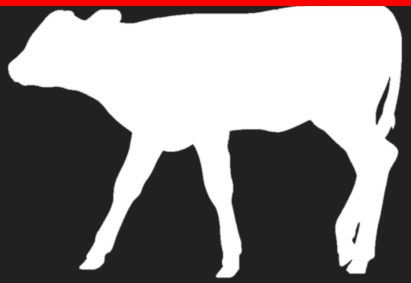
2020

Visual Selection



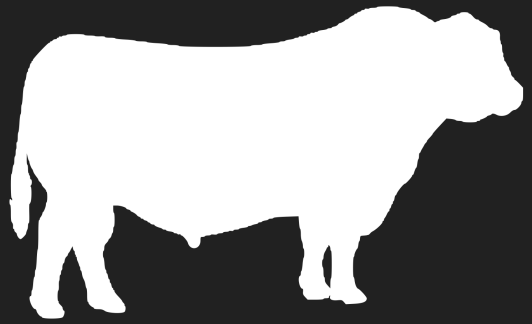






Phenotypic Selection (measured characteristics)

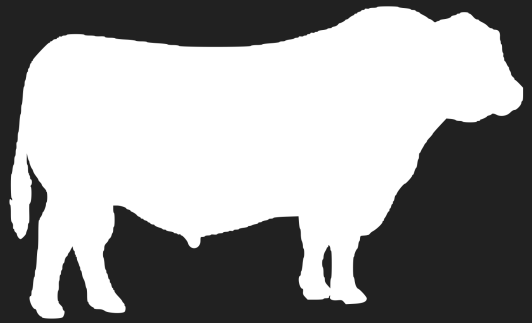
WW: 290 kg

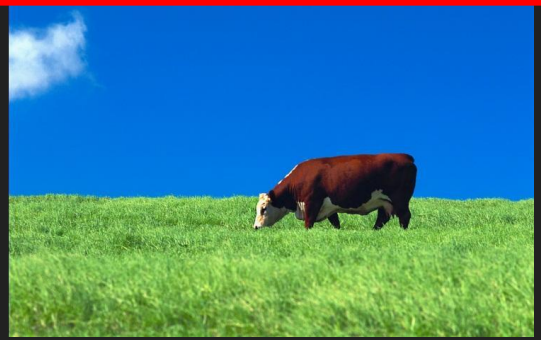


WW: 300 kg

Phenotypic Selection

WW: 290 kg





WW: 300 kg

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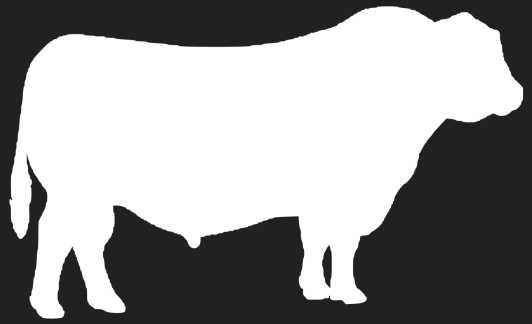
Phenotypic Selection (measured characteristics)

WW: 290 kg

???????



WW: 300 kg

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Phenotypic Selection (measured characteristics)

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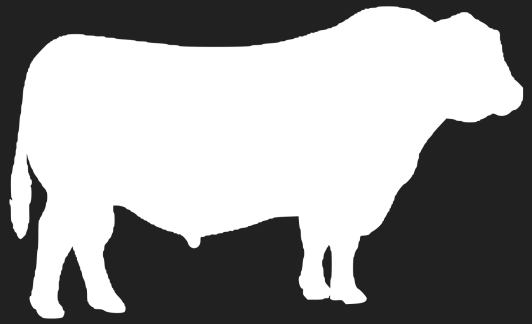


WW: 300 kg

Does NOT account for environmental differences!

Less accurate

Your calf crop:

Phenotype = Genotype + Environment

What we get paid for

Genetic potential of herd (bulls and cows)

Farm's management and environment

Bull Selection

Phenotype = Genotype + Environment

Bull's individual performance

What bull can pass on to his offspring

Management and environment where bull was raised

Dissecting phenotypes for more accurate selection

Phenotype = **Genotype** + **Environment**

Heritable Genetic Variation

Environmental Variation

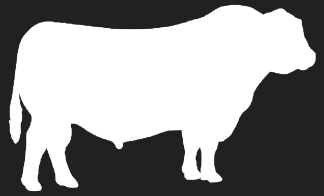
Dissecting phenotypes for more accurate selection

Phenotype = **Genotype** + **Environment**

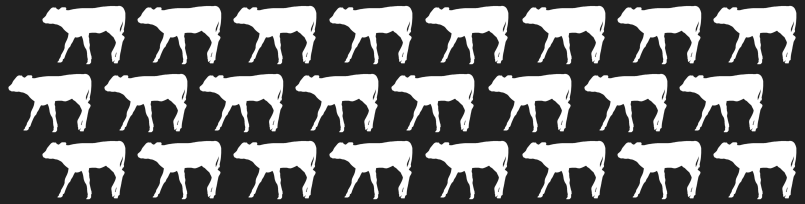
EBVs

Contemporary Groups

White Bull

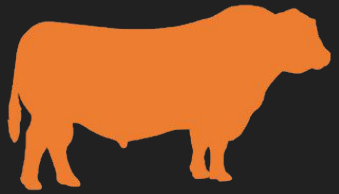


Weaning Weight EBV = 2

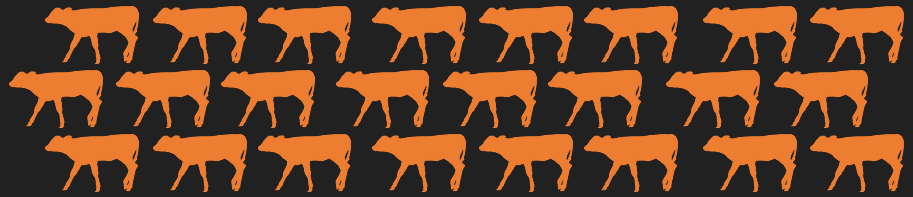


Average calf crop weaning weight = 290 kg

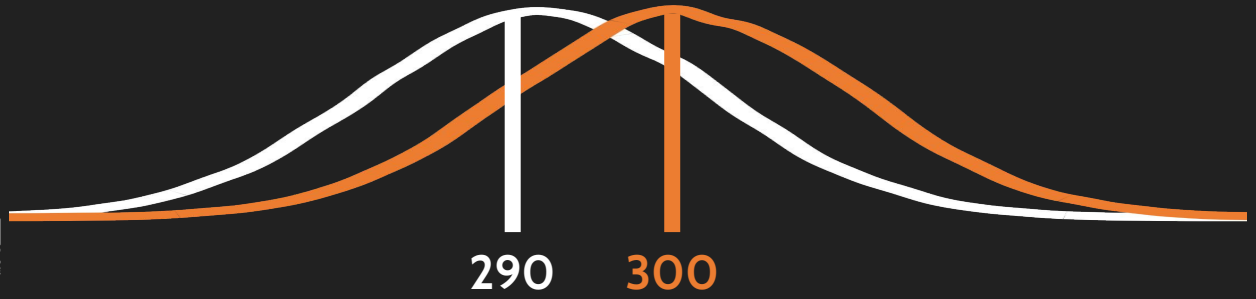
Orange Bull



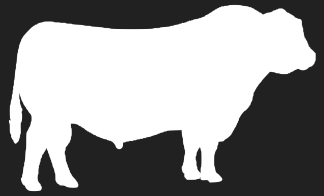
Weaning Weight EBV = 22



Average calf crop weaning weight = 300 kg

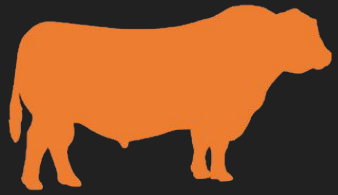


White Bull



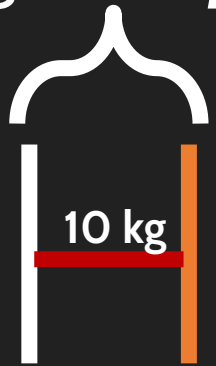
Weaning Weight EBV = 2

Orange Bull



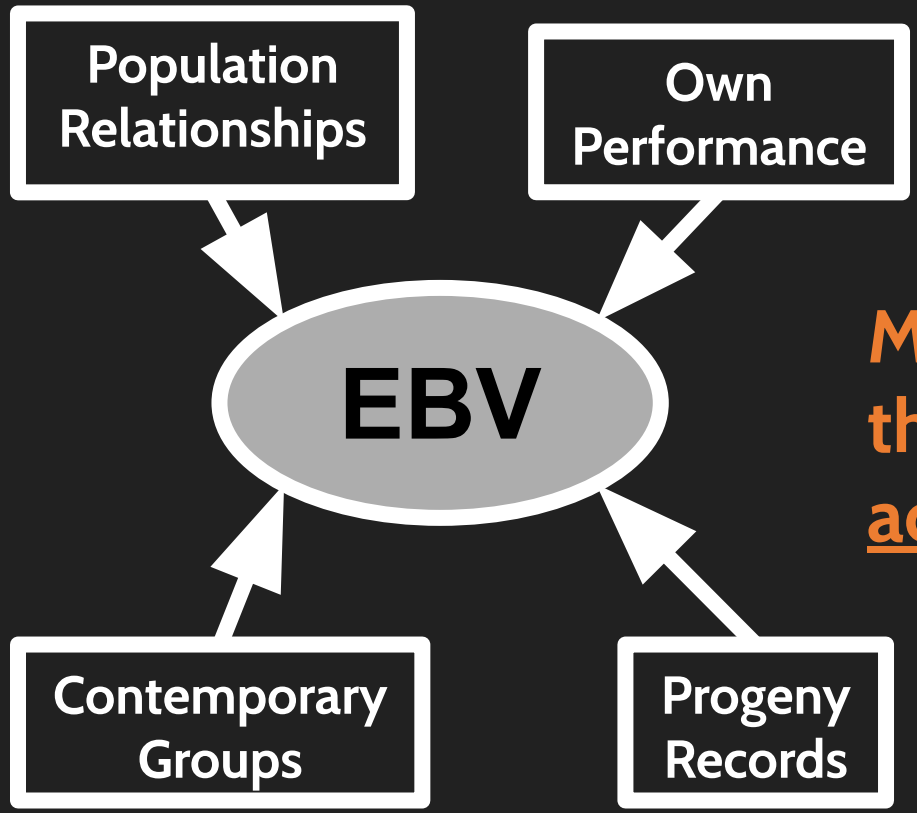
Weaning Weight EBV = 22

EBVs are our ***statistical estimate*** of bull's ***genetic potential***



How confident are we that these predictions represent the animal's actual genetic potential?

EBVs are our best statistical guesses



More of any of these = more accurate EBVs

EBV Reliability

- EBVs are statistical estimates of an animal's true genetic merit that they can pass down to their offspring
- More information = better prediction of genetic merit
- Better prediction → better chance of choosing the "correct" animal as a sire (or dam) → more rapid genetic progress

Combining data for increased EBV accuracy

- Pedigree connections exist between animals of breeds in different countries
- This can allow an increased accuracy of genetic predictions
- More records and more pedigree connections = more reliable EBVs

Interbeef and Estonia

Analyzed Aberdeen Angus and Limousin breeds and the quality of prediction for their breeding values.

Adjusted weaning weight prediction

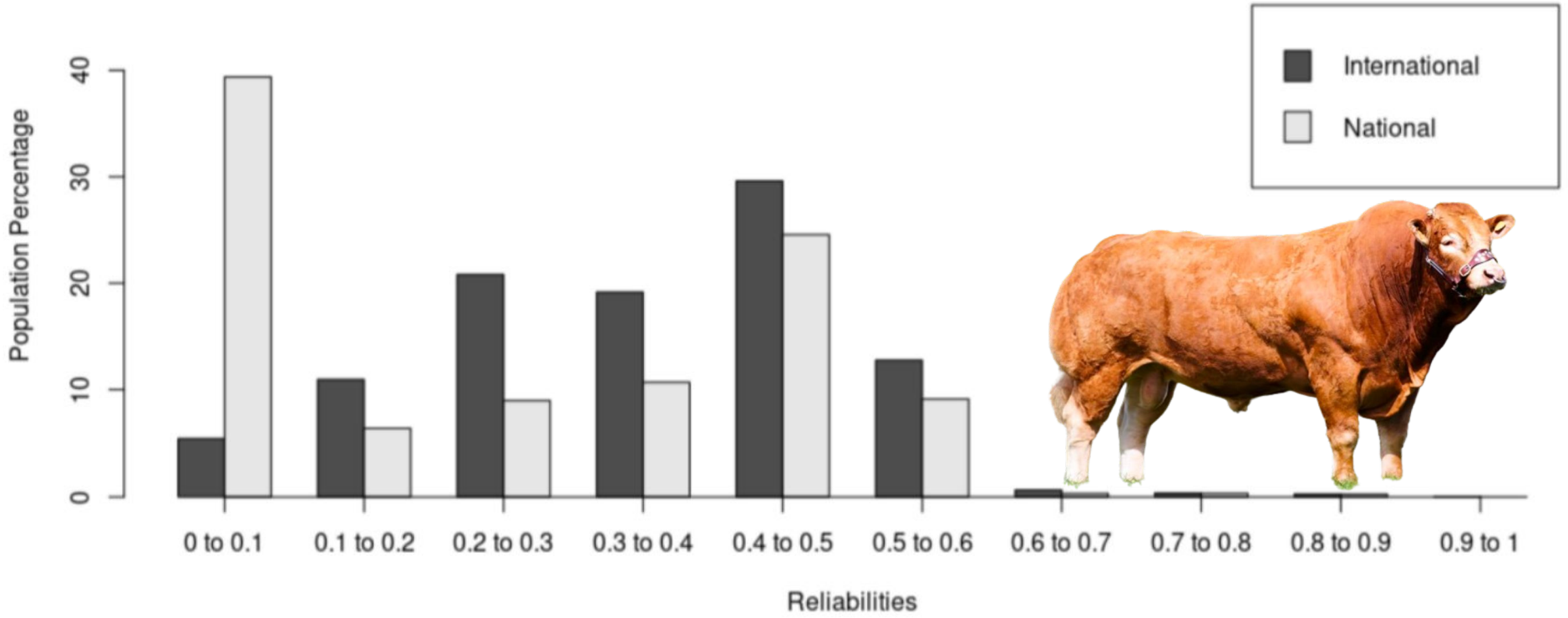
<

Assessing the benefits from joining the International beef cattle genetic evaluation (Interbeef) at SLU's Interbull Centre

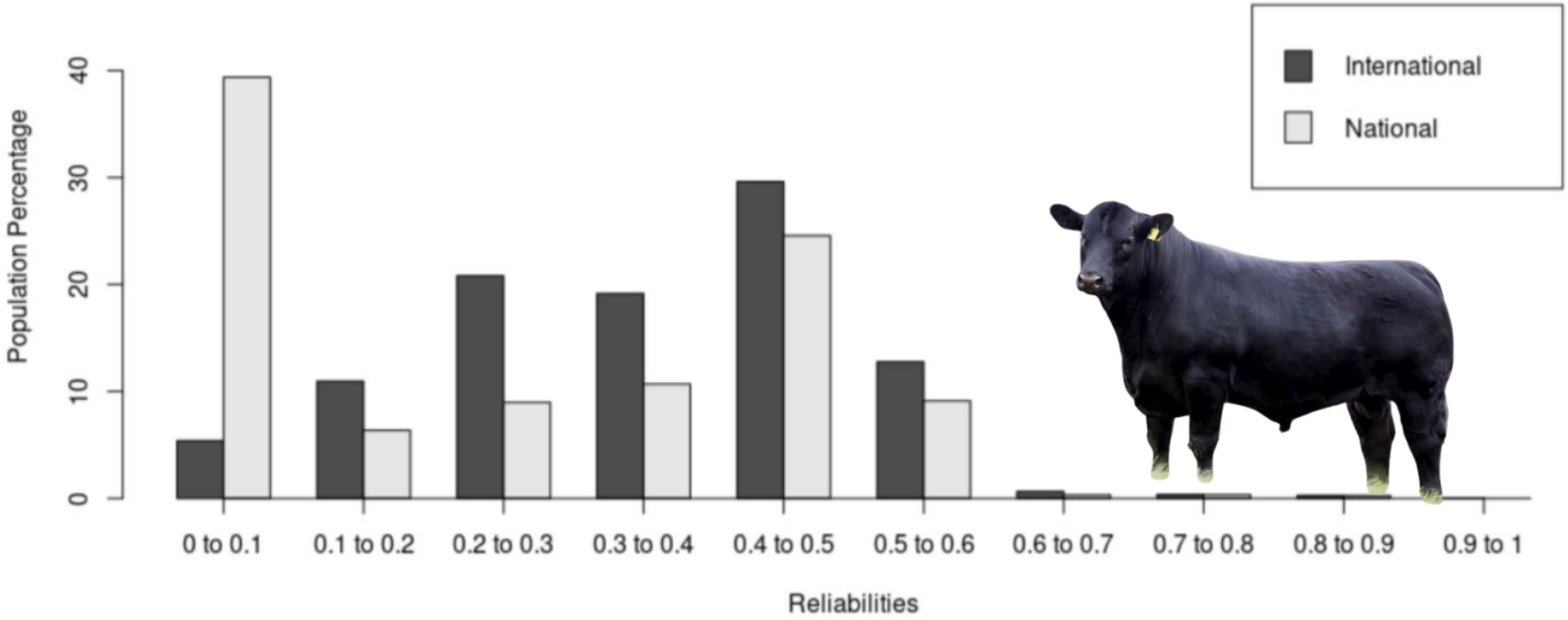
– Estonia as a case study

Tzayhri Osorio Gallardo

Limousin Reliabilities: International vs National



Angus Reliabilities: International vs National

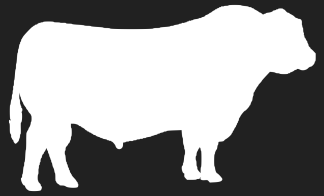


How can we increase EBV accuracy?

- Adding an animal's own record to evaluation
- Accurate pedigrees
- Progeny records
- Genomics (in some cases)

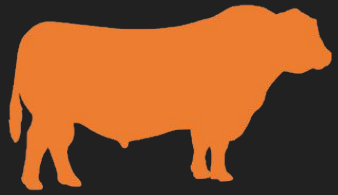
Once we have removed environmental variation from a phenotype, then we can start to figure out **WHICH** genetics an animal inherited from its parents.

White Bull



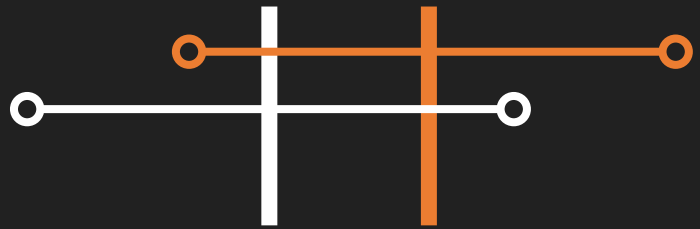
Weaning Weight EBV = 2

Orange Bull



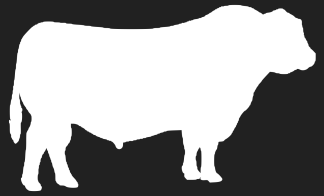
Weaning Weight EBV = 22

With low amounts of information (i.e. no progeny records), EBV reliability is relatively low. Our confidence that EBV represents animal's true genetic merit is low.



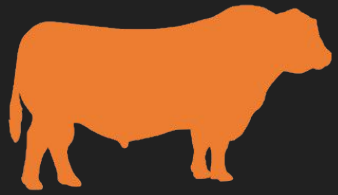
Where true genetic merit might actually be

White Bull



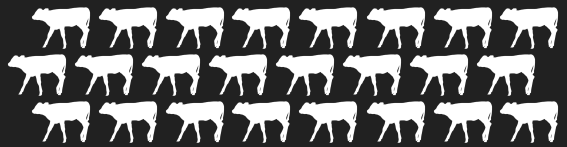
Weaning Weight EBV = 2

Orange Bull



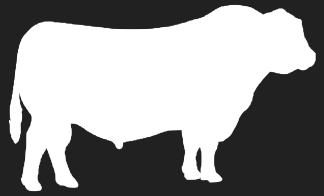
Weaning Weight EBV = 22

More progeny increases our confidence in EBV



Genomics allow us to directly observe the genetics that an animal inherited

White Bull

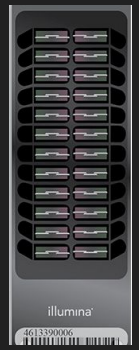


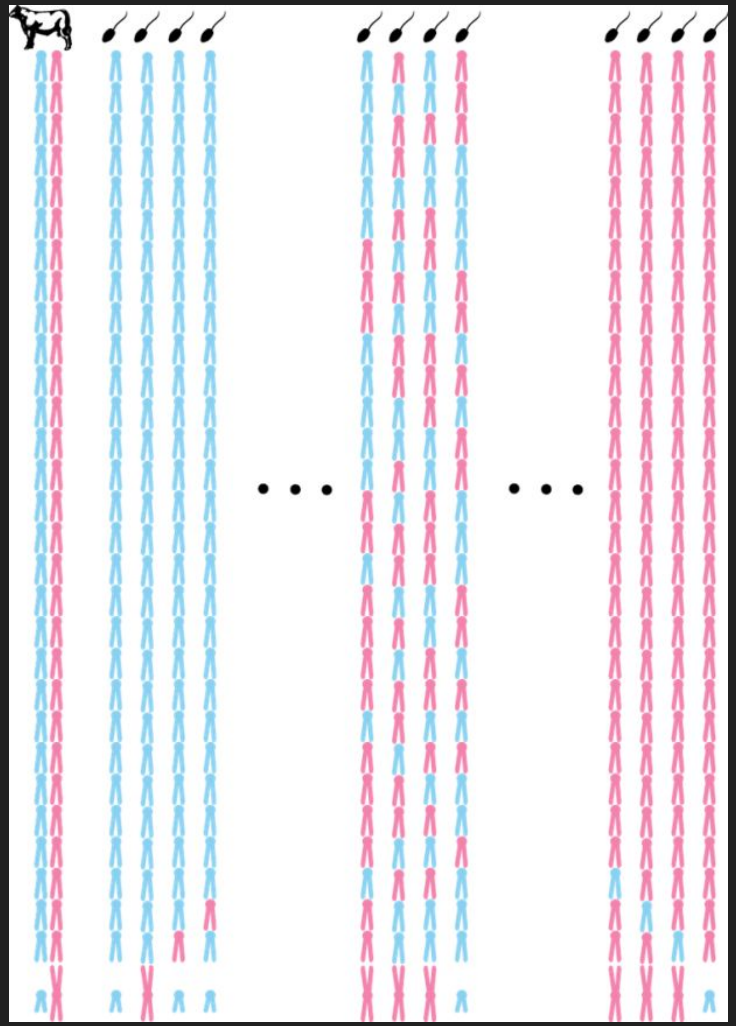
Weaning Weight EBV = 2

Orange Bull

Weaning Weight EBV = 22

Genomic tests can increase EBV accuracy in *unproven animals*

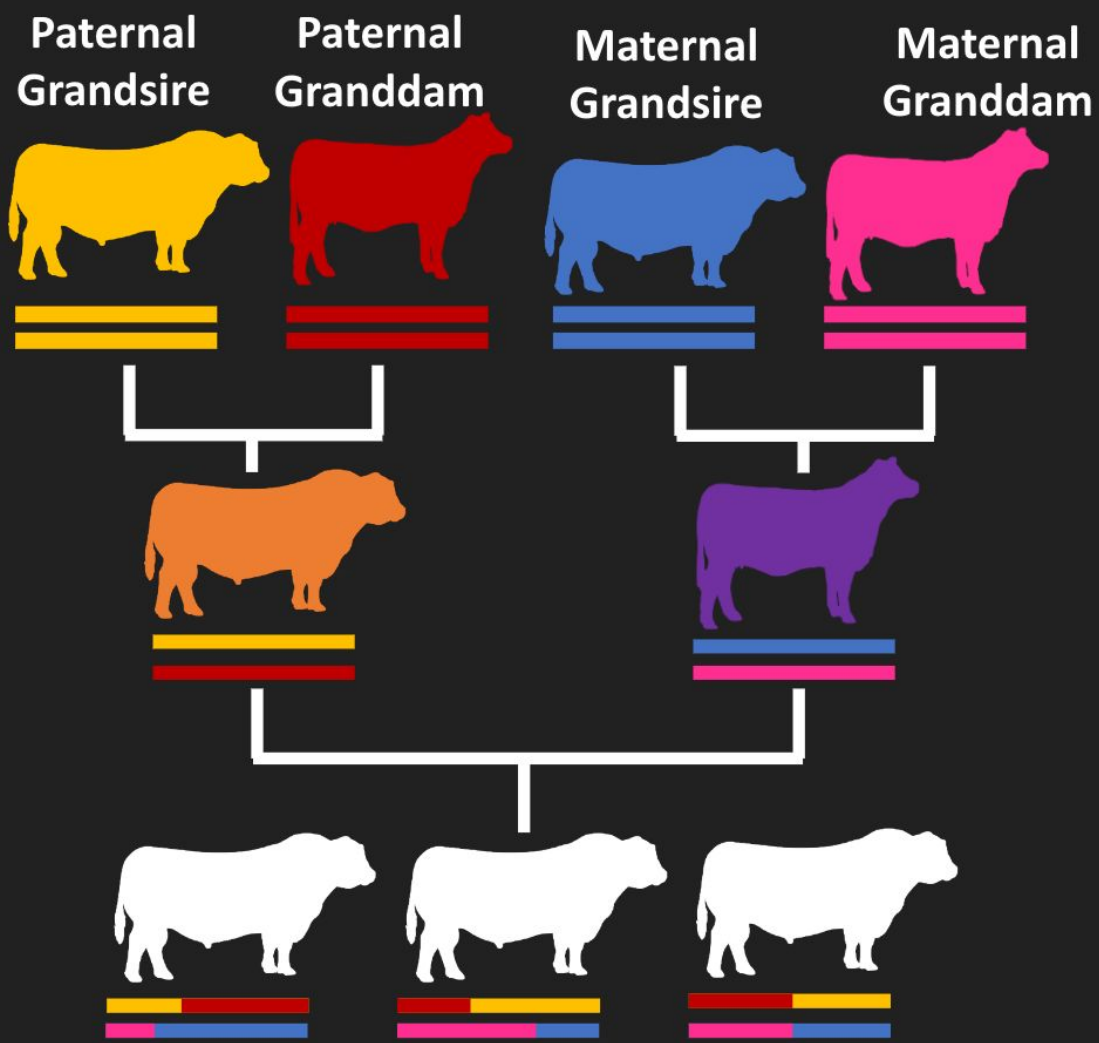




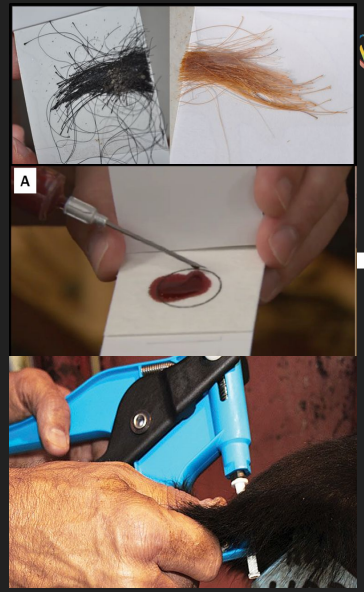
Billions of possibilities! All due to the random shuffle of genes!

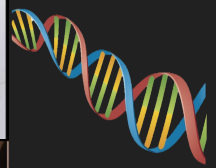
Figure c/o Jared Decker

Genomics allow us to directly observe the genetics that an animal has inherited



DNA Sample/Extraction

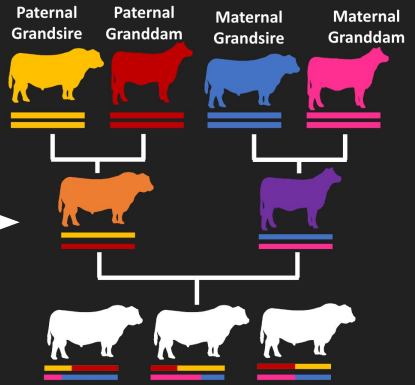




Observe genetic polymorphisms

$$
\begin{array}{c} \\ h_1^1 \\ h_1^2 \\ h_2^1 \\ h_2^2 \\ h_3^1 \\ h_3^2 \\ h_4^1 \\ h_4^2 \end{array}
\begin{array}{c}
\begin{array}{cccccccc} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \end{array} \\
\left[\begin{array}{cccccccc}
0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\
0 & 1 & 1 & 0 & 0 & 1 & 1 & 1 \\
0 & 0 & 0 & 1 & 1 & 0 & 0 & 1 \\
1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\
1 & 1 & 1 & 0 & 0 & 1 & 0 & 0
\end{array}\right]
\end{array}
$$

Represent relationships between animals better



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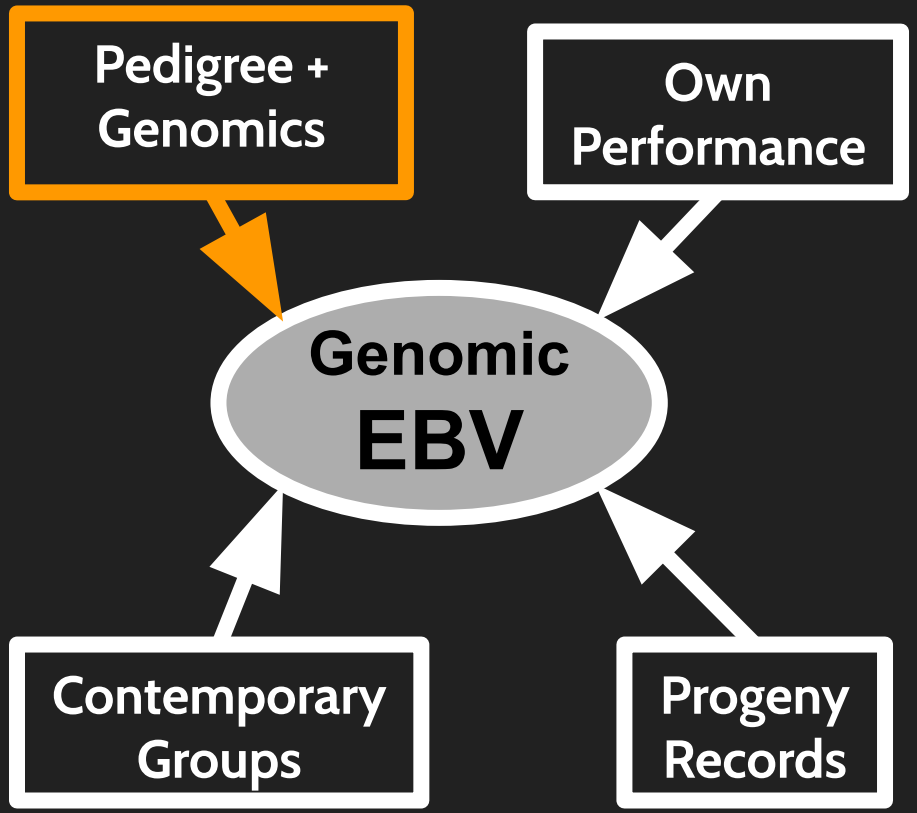
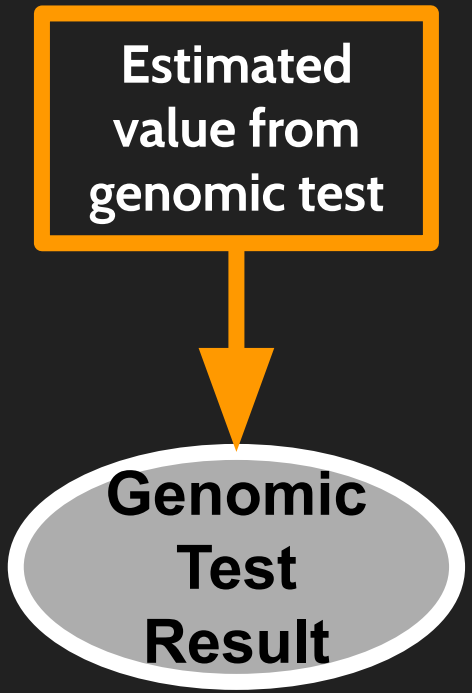
DNA Sample Collection with Tissue Sampling Unit (TSU)

DNA doesn't change! Genotypes will remain the same over time

Putting Genomic Tests (e.g. Neogen) to work

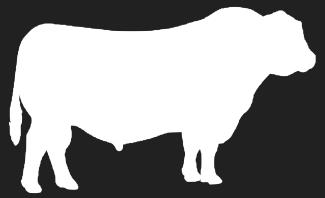
Genomic-EBVs vs. Genomic Test Results





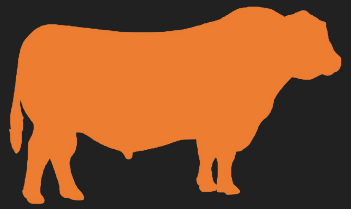
Molecular Breeding Values

Estimate effect of genotype at each marker → Sum effects across genome



0.5	0	0	-0.15	0	0.6	-0.6	0	1.1	0	0.8	0.4	0	0	0.1
B	A	A	B	A	B	B	A	B	A	B	B	A	A	B
0.5	0.4	0.8	-0.3	0	0.6	-0.6	0	2.2	-0.5	0.8	0.8	0	-0.5	0.2
A	B	B	B	A	A	A	A	B	B	A	B	A	B	B
0	0.4	0.8	-0.15	0	0	0	0	1.1	-0.5	0	0.4	0	-0.5	0.1

4.4



0	0.4	0.8	0	0	0.6	-0.6	0.5	0	0	0.8	0	0	-0.5	0
A	B	B	A	A	B	B	B	A	A	B	A	A	B	A
0.5	0.8	1.6	0	0.7	0.6	-1.2	1.0	1.1	0	0.8	0	0.9	-1.0	0.1
B	B	B	A	B	A	B	B	B	A	A	A	B	B	B
0.5	0.4	0.8	0	0.7	0	-0.6	0.5	1.1	0	0	0	0.9	-0.5	0.1

4.9

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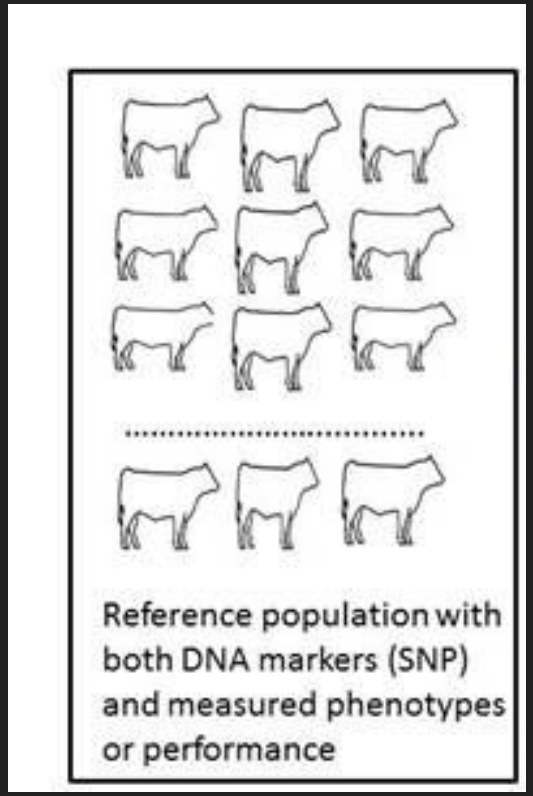
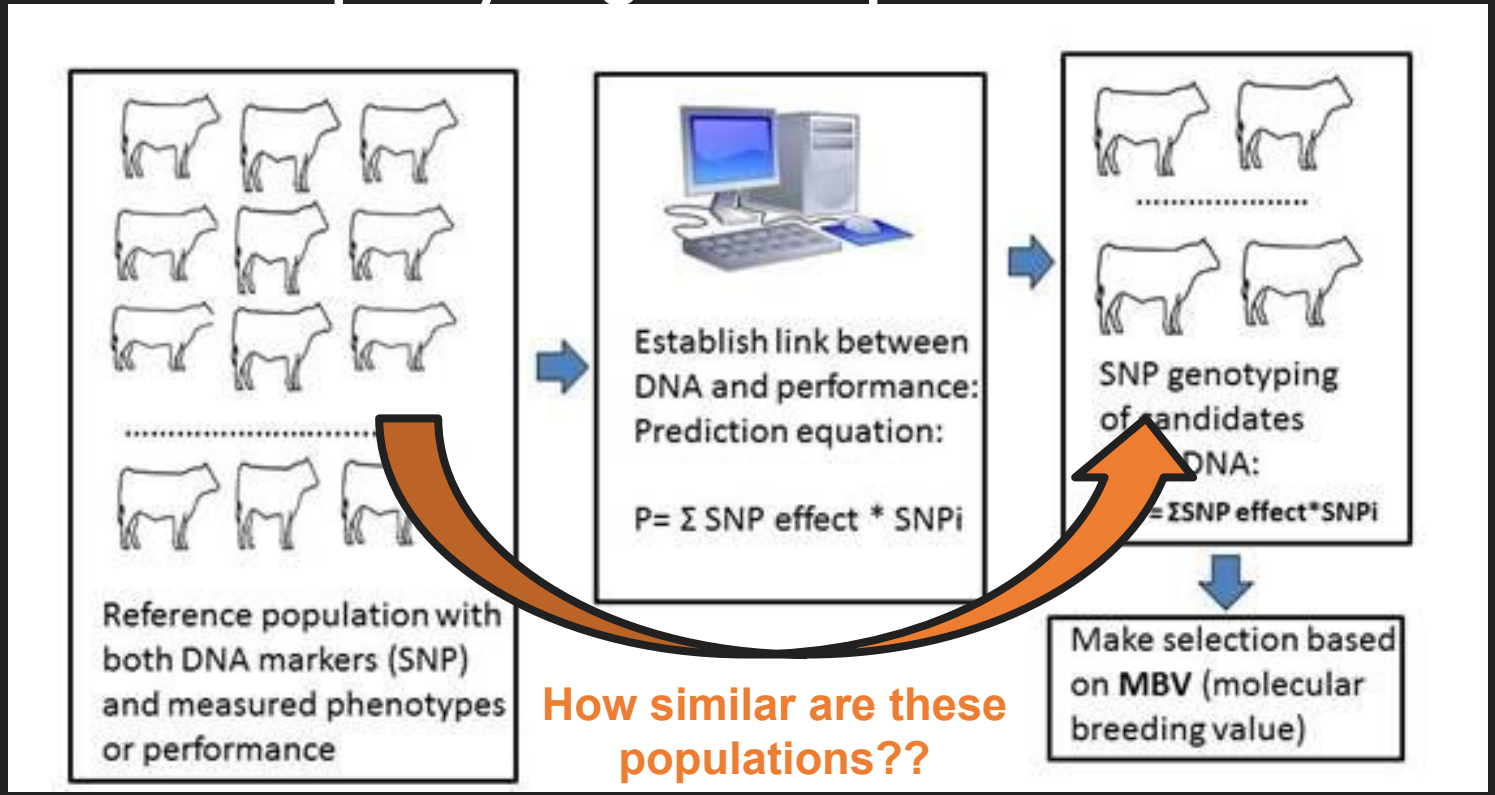
How genomic test values are calculated



https://beefgenomicprediction.ca/html/What-is-genomic-prediction.html

Relationship to training population is important for the quality of genomic predictions



https://beefgenomicprediction.ca/html/What-is-genomic-prediction.html

What commercial genomic tests don't take account to

- Own performance does not influence prediction
- These tests do not borrow information from pedigree relatives of genotyped animal
- Quality of predictions relies heavily on the tested animal's relationship to the training population

Why use these genomic tests?

- Tests offer additional traits and indexes not yet reported
- Results can be evaluated alongside InterBull EBVs
- Allow us to make selection decisions on animals earlier in the process → Devote resources to replacements

Which traits do these tests predict?

- Birth Weight
- Calving Ease (Direct & Maternal)
- Stayability
- Heifer Pregnancy Rate
- Docility
- Milk

- Residual Feed Intake
- Average Daily Gain
- Scrotal Circumference
- Weaning Weight
- Yearling Weight
- Tenderness
- Marbling
- Ribeye Area
- Fat Thickness
- Carcass Weight

Igenity Test Scoring

Values are reported as 1-10 scores for each trait

Not interpreted the same as an EBV

Tables for determining genetic effects:

https://www.neogen.com/globalassets/pim/assets/original/10019/official_igenity-beef-handbook_brochure.pdf

Heifer Pregnancy Rate (HPR)	Igenity Score	Genetic Effect	Description
Animal A	8	9.5%	Animal A will produce daughters with a 6.8% higher probability of conceiving during a normal breeding season compared to daughters of Animal B.
Animal B	3	2.7%	
		6.8%	

Stayability (STAY)	Igenity Score	Genetic Effect	Description
Animal A	8	41.7%	Daughters of Animal A have a 29.8% greater probability of staying in the herd until six years of age than daughters of Animal B.
Animal B	3	11.9%	
		29.8%	

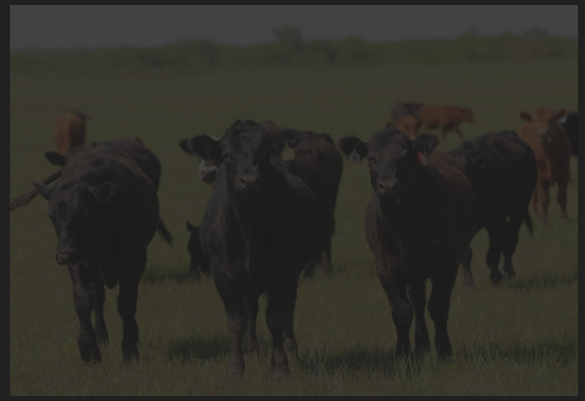
Average Daily Gain (ADG)	Igenity Score	Genetic Effect	Description
Animal A	8	0.21 lbs.	Animal A is expected to produce progeny that will gain 0.15 pounds more per day than progeny of Animal B, and therefore weigh 22.5 pounds more after 150 days on feed.
Animal B	3	0.06 lbs.	
		0.15 lbs. per day	

Residual Feed Intake (RFI)	Igenity Score	Genetic Effect	Description
Animal A	8	0.54 lbs.	Progeny of Animal B are predicted to consume 0.39 pounds less feed per day than progeny of Animal A to achieve the same daily gain.
Animal B	3	0.15 lbs.	
		0.39 lbs.	

Opportunities with genomics

Improved replacement heifer selection

Optimize sire selection decisions



Add value to feeder calves

We MUST test more heifers than we plan to keep

Testing only heifers we already know we'll keep is just expensive confirmation bias

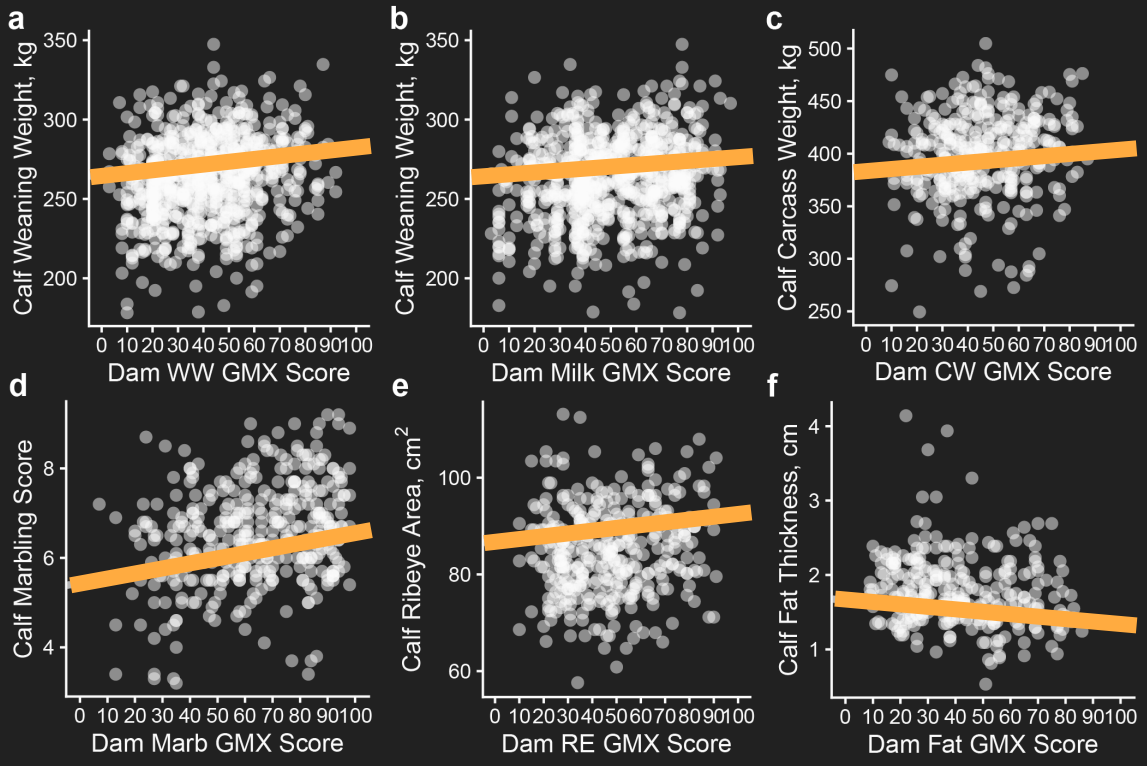
When should I genotype?

Before decision-making time! (weaning?)

Commercial genomic tests work!

Multi-year commercial genomic test validation

Dam genomic scores vs. actual calf phenotypes



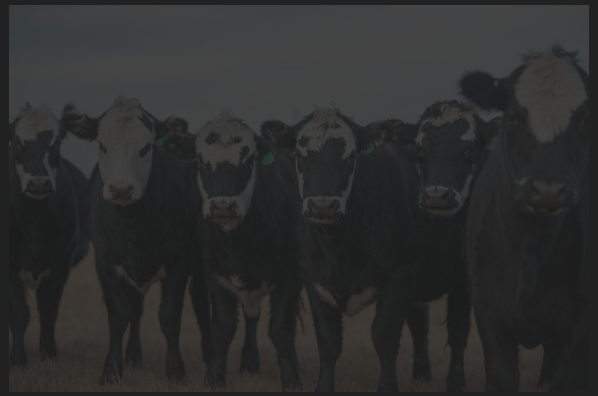
GMX GENEMAX Advantage

UTAGRESEARCH INSTITUTE OF AGRICULTURE THE UNIVERSITY OF TENNESSEE

Arisman et al. 2022

UTCVM INSTITUTE OF AGRICULTURE THE UNIVERSITY OF TENNESSEE

Opportunities with genomics



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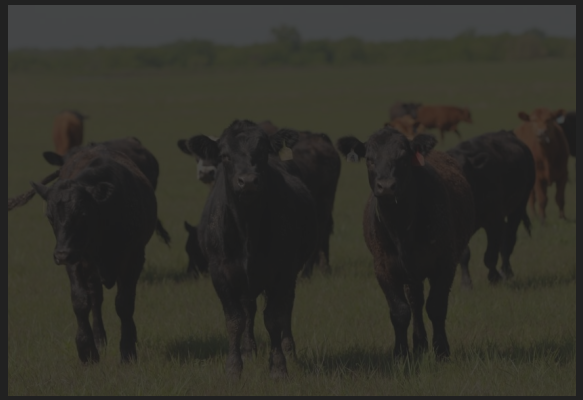


Add value to feeder calves

Which bull would you choose?

Group 1 Heifers – Average Weaning Weight: 525 lbs.

Act. BW	Adj. WW	Adj. YW	Adj. SC	Adj. IMF	Adj. REA
72	732	1266	40.16	6.12	17.0

BULL #1

CED	BW	WW	YW	DMI	SC	DOC	MW	MILK
+12	-.7	+72	+139	+1.59	+1.05	+19	+88	+20
10%	15%	25%	15%	85%	40%	50%	25%	90%

CLAW	ANGLE	HP	CEM	PAP	CW	MARB	RE	FAT
+.50	+.49	+10.5	+14	-3.34	+74	+1.85	+.93	+.055
55%	55%	70%	5%	1%	5%	1%	15%	95%

$M	$W	$F	$G	$B	$C
+53	+61	+131	+115	+246	+372
80%	45%	1%	1%	1%	1%

Act. BW	Adj. WW	Adj. YW	Adj. SC	Adj. IMF	Adj. REA
40	505	1051	34.05	7.25	12.5

BULL #2

CED	BW	WW	YW	DMI	SC	DOC	MW	MILK
+13	+0	+63	+117	+.76	+1.33	+18	+89	+23
10%	25%	50%	40%	35%	20%	50%	20%	70%

CLAW	ANGLE	HP	CEM	PAP	CW	MARB	RE	FAT
+.50	+.48	+8.3	+16	-1.53	+64	+2.21	+1.14	+.038
55%	50%	85%	2%	4%	15%	1%	2%	85%

$M	$W	$F	$G	$B	$C
+43	+57	+123	+137	+260	+380
90%	55%	3%	1%	1%	1%

Act. BW	Adj. WW	Adj. YW	Adj. SC	Adj. IMF	Adj. REA
70	818	1375	37.70	4.25	14.2

BULL #3

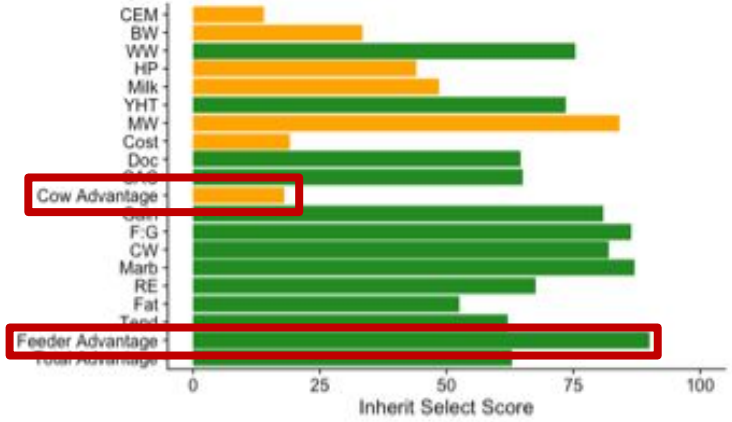
CED	BW	WW	YW	DMI	SC	DOC	MW	MILK
+13	-.4	+73	+119	+1.26	+.73	+24	+25	+34
10%	20%	25%	40%	70%	60%	25%	85%	10%

CLAW	ANGLE	HP	CEM	PAP	CW	MARB	RE	FAT
+.38	+.30	+17.6	+14	+1.78	+51	+.80	+.68	+.009
10%	1%	4%	5%	65%	40%	25%	40%	45%

$M	$W	$F	$G	$B	$C
+113	+83	+95	+61	+156	+315
1%	3%	35%	25%	25%	4%

Which bull would you choose?

INHERIT™ select



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BULL #2

CED	BW	WW	YW	DMI	SC	DOC	MW	MILK
+13	+0	+63	+117	+.76	+1.33	+18	+89	+23
10%	25%	50%	40%	35%	20%	50%	20%	70%

CLAW	ANGLE	HP	CEM	PAP	CW	MARB	RE	FAT
+.50	+.48	+8.3	+16	-1.53	+64	+2.21	+1.14	+.038
55%	50%	85%	2%	4%	15%	1%	2%	85%

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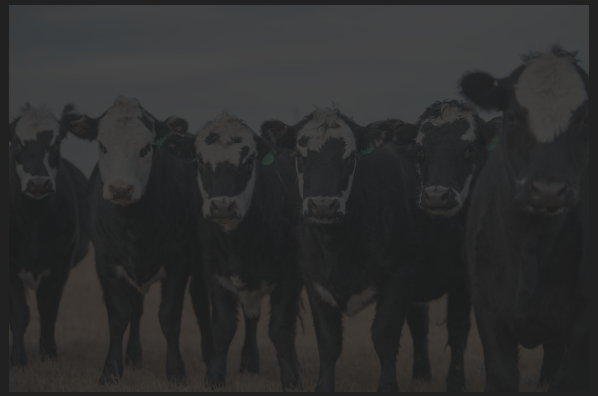

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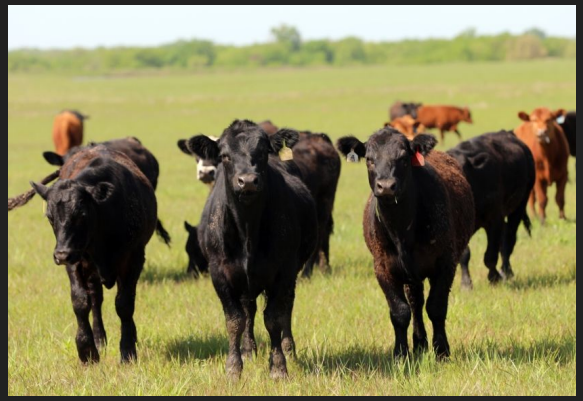
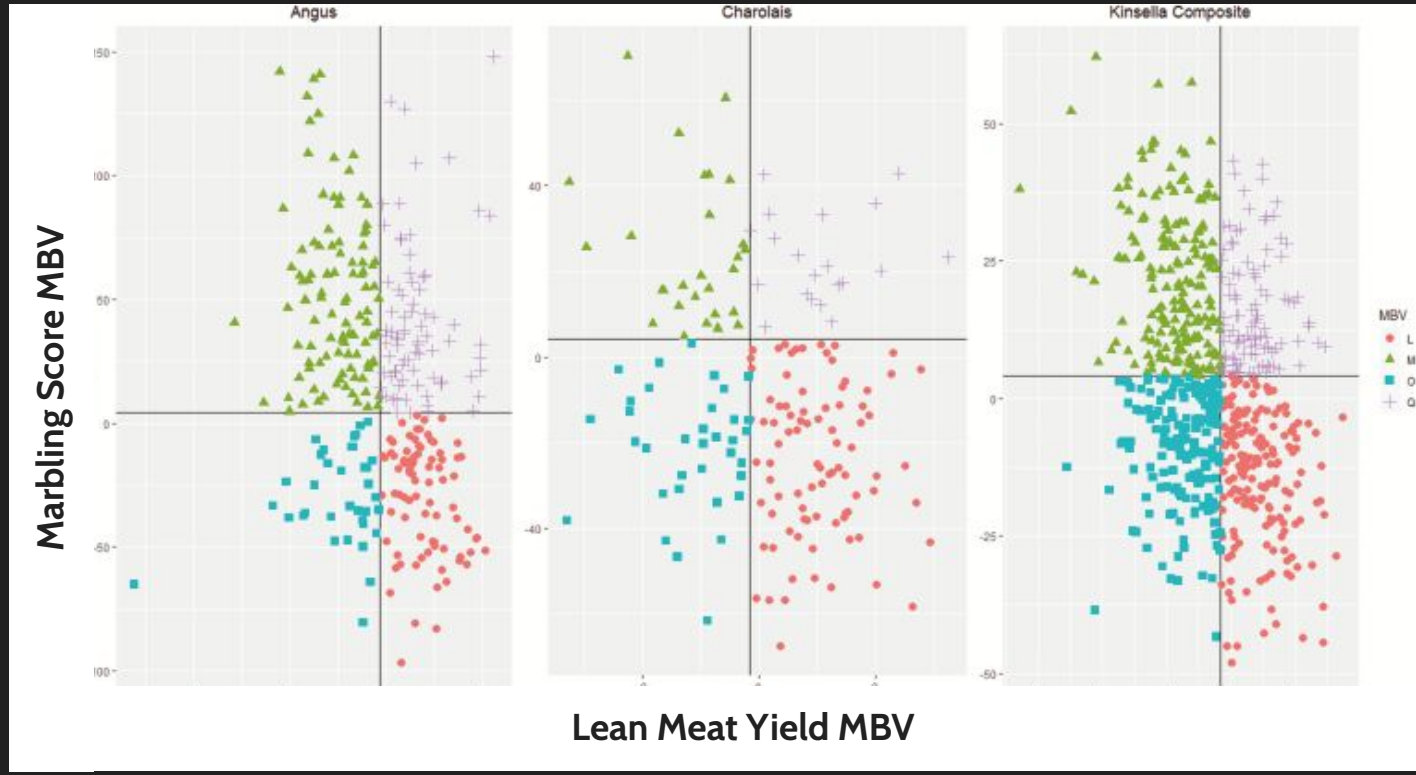


Add value to feeder calves

Buyers of feeder cattle want the maximum amount of information on the animals they are purchasing

Feeder calf genomic testing works

Trait	r	h^2
HCW	0.53	0.43
FAT	0.59	0.39
REA	0.58	0.45
LMY	0.58	0.43
MARB	0.58	0.43



Akanno et al. 2019 JAS

EBVs are our best statistical guesses of an animal's genetic merit

More information in EBV calculations help increase their accuracy

InterBull evaluations can help leverage additional records & improve EBVs

Genomic tests can be used to help predict genetic merit for a variety of important traits.

Reach out with questions!

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@TroyNRowan

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