The value of performance recording

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Performance Recording

- Performance recording is the foundation for selection and is done through breed associations
- To achieve genetic improvement, you must carefully record appropriate phenotypes, on cohorts of animals and use them for selection
- Genomics can add real value, but more so in populations with a wide range of phenotypes, and more so when a sufficient number of animals (1,000s or tens of 1,000s) have been genotyped

Performance Recording in NZ

- Roughly 35,000 beef cattle across all breed associations in NZ are performance recorded
  - Three primary breed associations represent the Angus, Hereford and Simmental breeds
  - At most 10,000 bulls that are average or better would be produced from performance recorded herds each year
- Annual requirements are for approx 10,000 bulls replacements for the national beef herd and another 28,000 for the national dairy herd
- Most sale bulls are not performance recorded!

Performance Recording in NZ

- Performance recorded cattle are measured for
  - Some 95% with birth wt, calving ease & weaning wt
  - About 75% have a yearling weight record
  - About 40% have a “final weight” record
  - Around 50% have some kind of ultrasound measure
    - Varies by breed association but includes IMF, P8, rib
  - About 25% have scrotal circumference measured
    - Corresponds to about 9,000 bulls

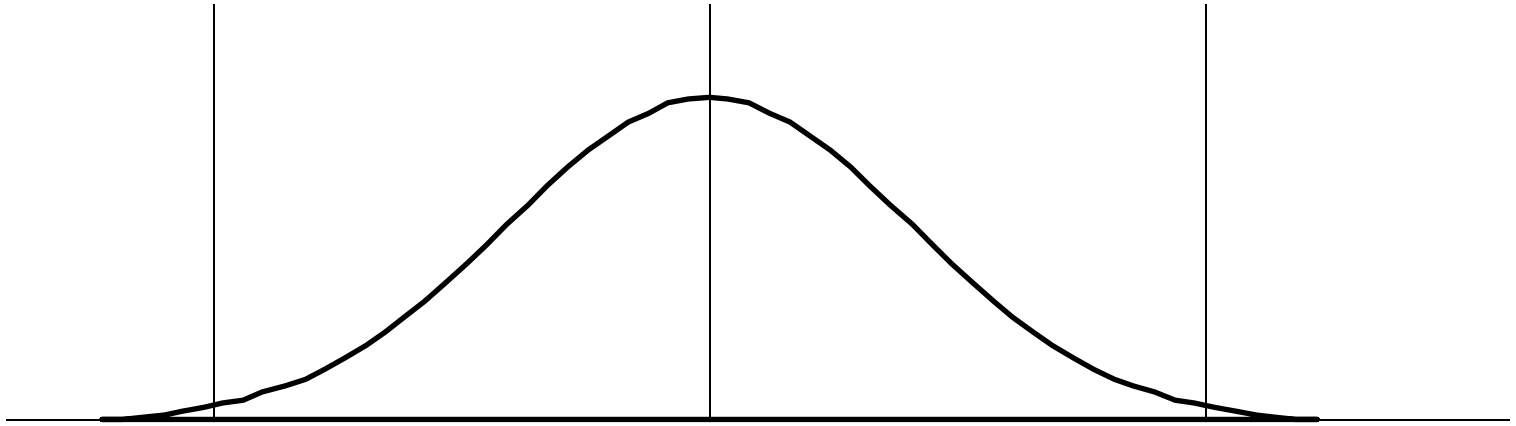
Performance Recording in NZ

- Virtually nothing else is recorded in worthwhile numbers except a few eye pigmentation records
- Pedigree records like birth date allow some reproductive traits to be characterized
- A broader scope of records would be beneficial
  - Reproductive performance – puberty, heifer pregnancy
  - Maternal performance – mature weights and condition
  - Terminal performance – carcass and meat quality
  - Disease traits

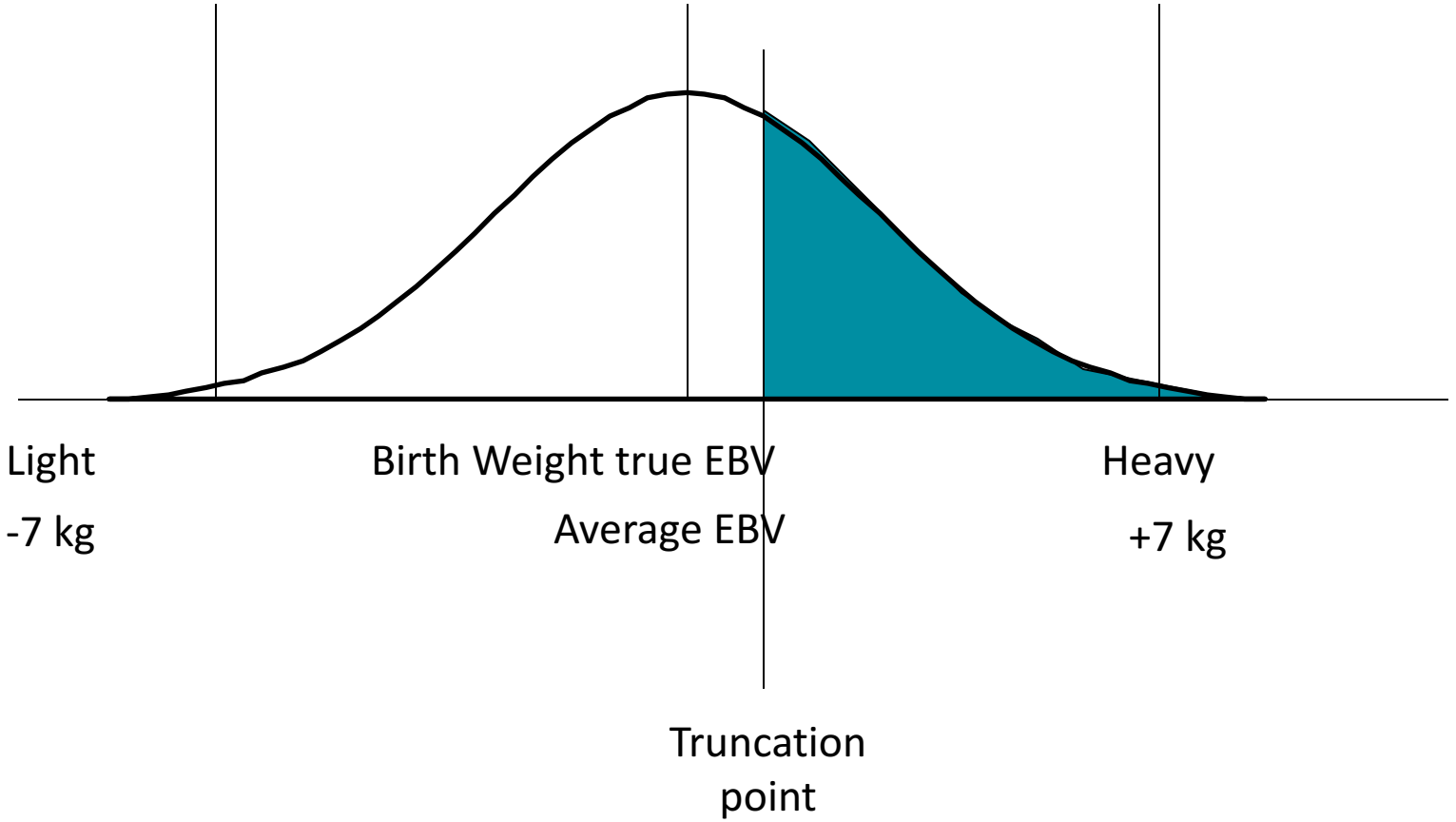
Birth Weight & Calving Ease

- Some Genetic Parameters
  - Birth Weight
    - Heritability = .45
    - phenotypic s.d. = 3.2 kg
    - Therefore genetic s.d. = 2.1 kg
      - (square root of 0.45 x 3.2 x 3.2)
- Birth weight is an “indicator” trait
  - It can indicate something about merit for calving ease
  - It can indicate something about merit for later weights
  - It is not itself an economically relevant trait (ERT)

True Merit for Birth Weight



Select the heaviest 40% (about *i*=1)



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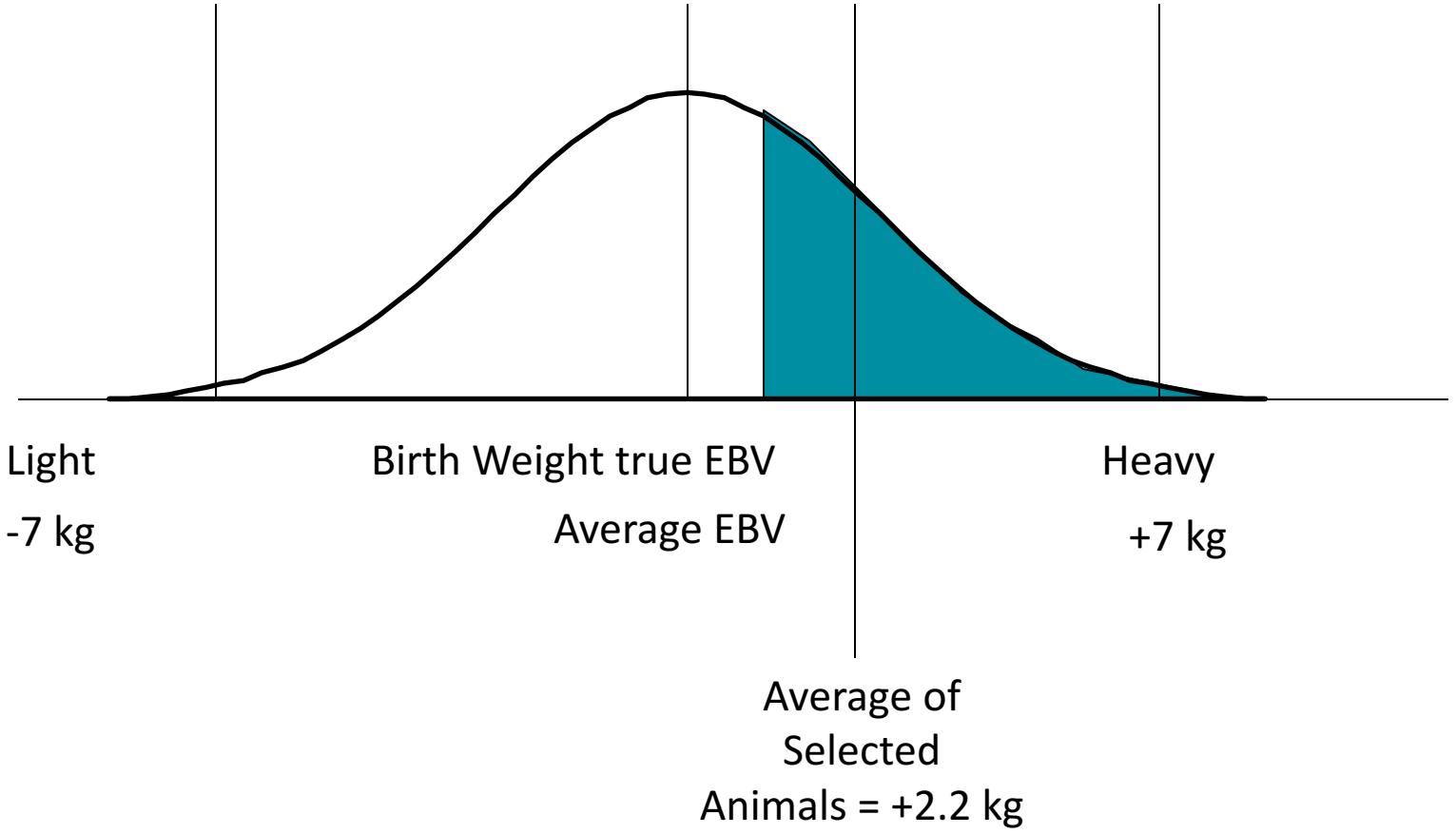

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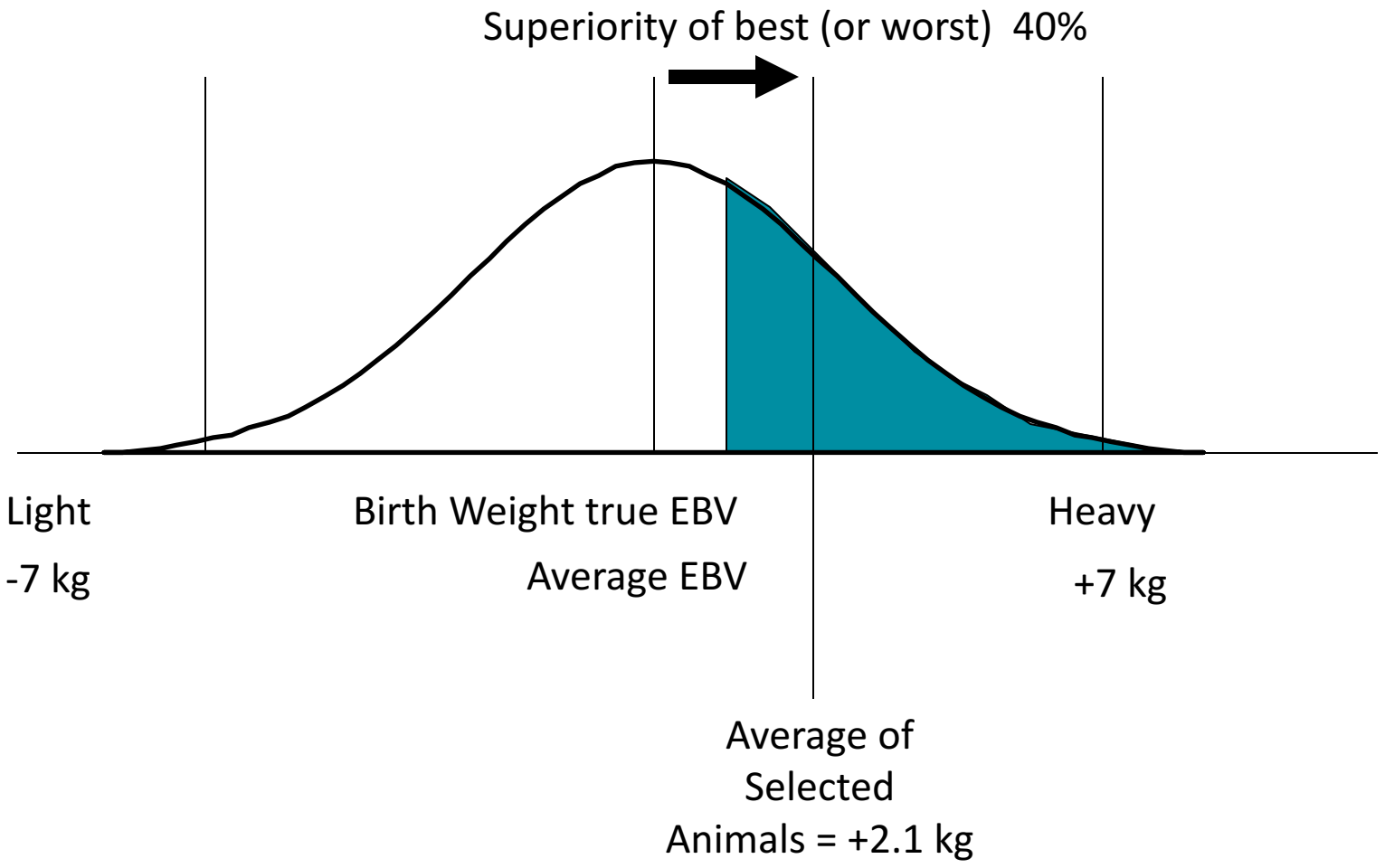
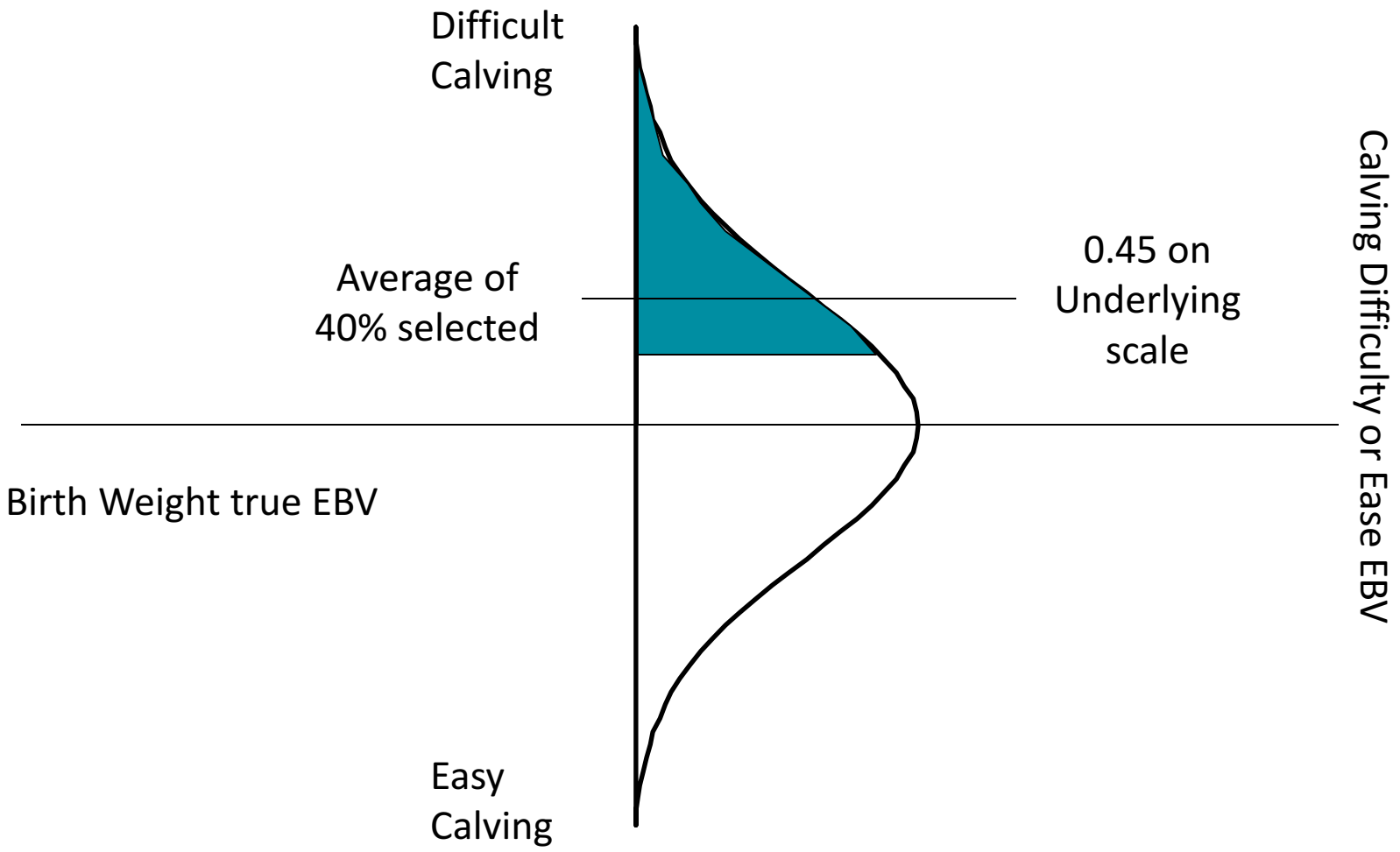


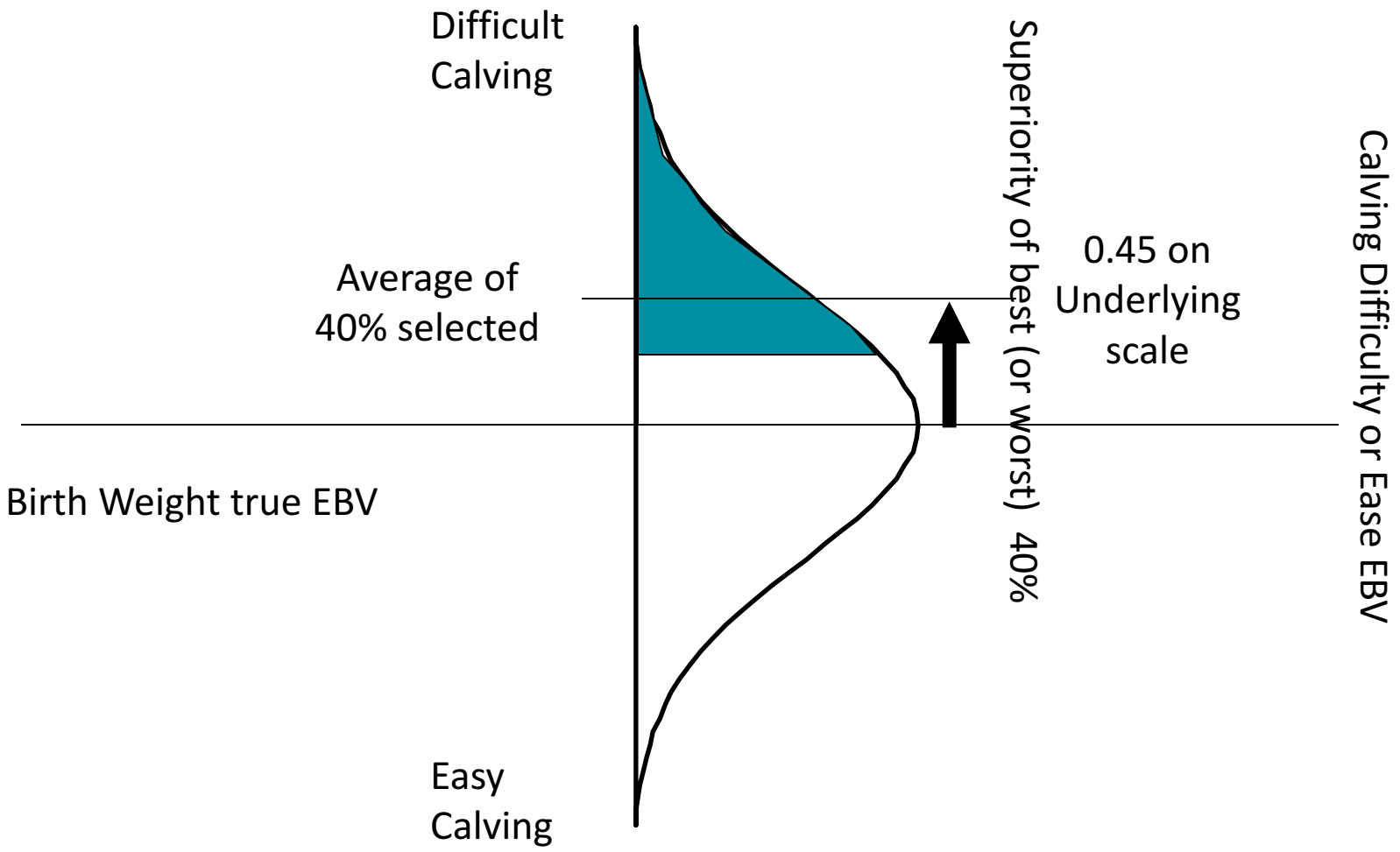
Birth Weight & Calving Ease

- Some Genetic Parameters
  - Calving Ease
    - Heritability = .15
    - (underlying) phenotypic s.d. = 1.168
    - Therefore genetic s.d. = 0.45
- Calving ease is an economically relevant trait

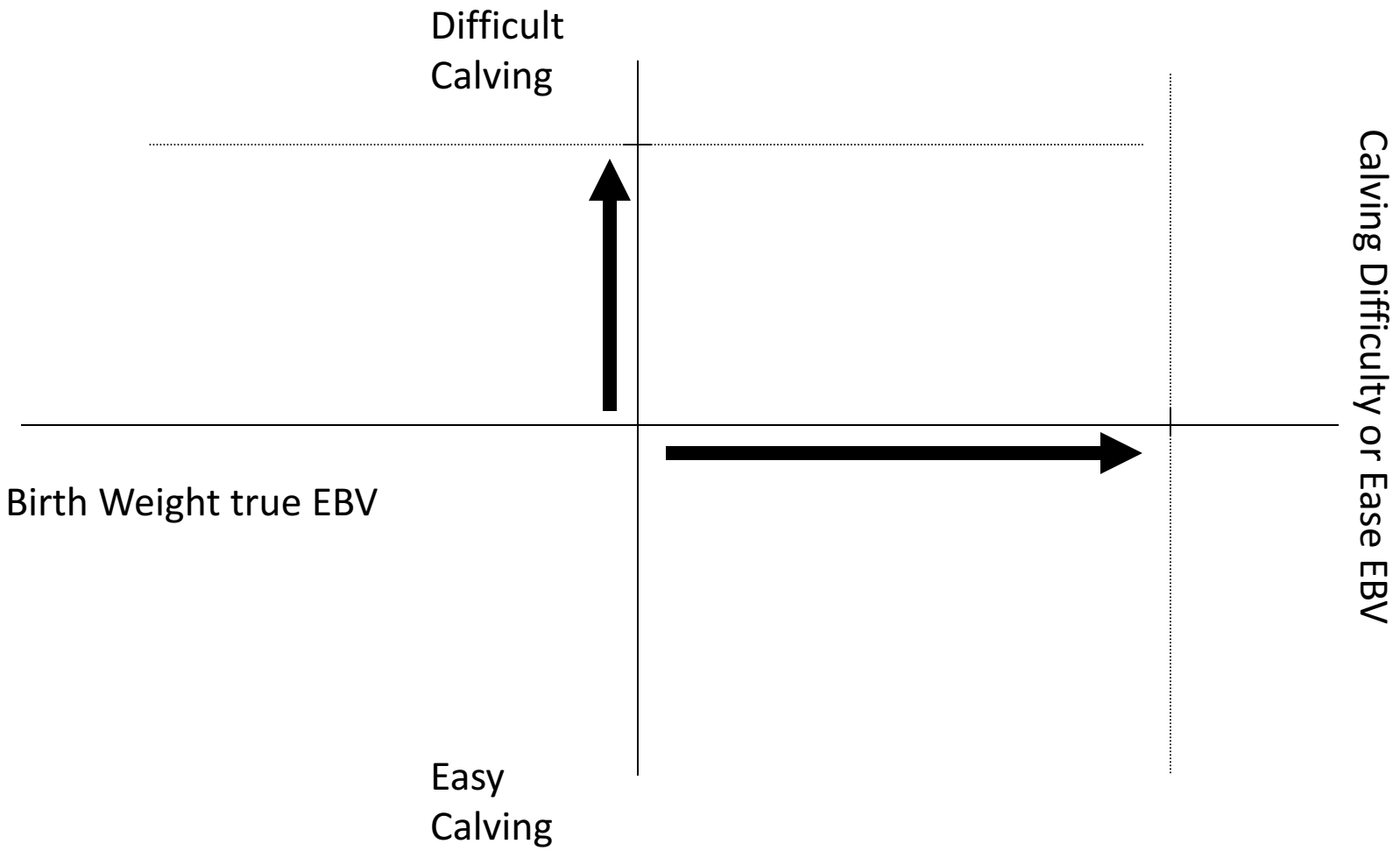
True Merit for Calving Ease



True Merit for Calving Ease



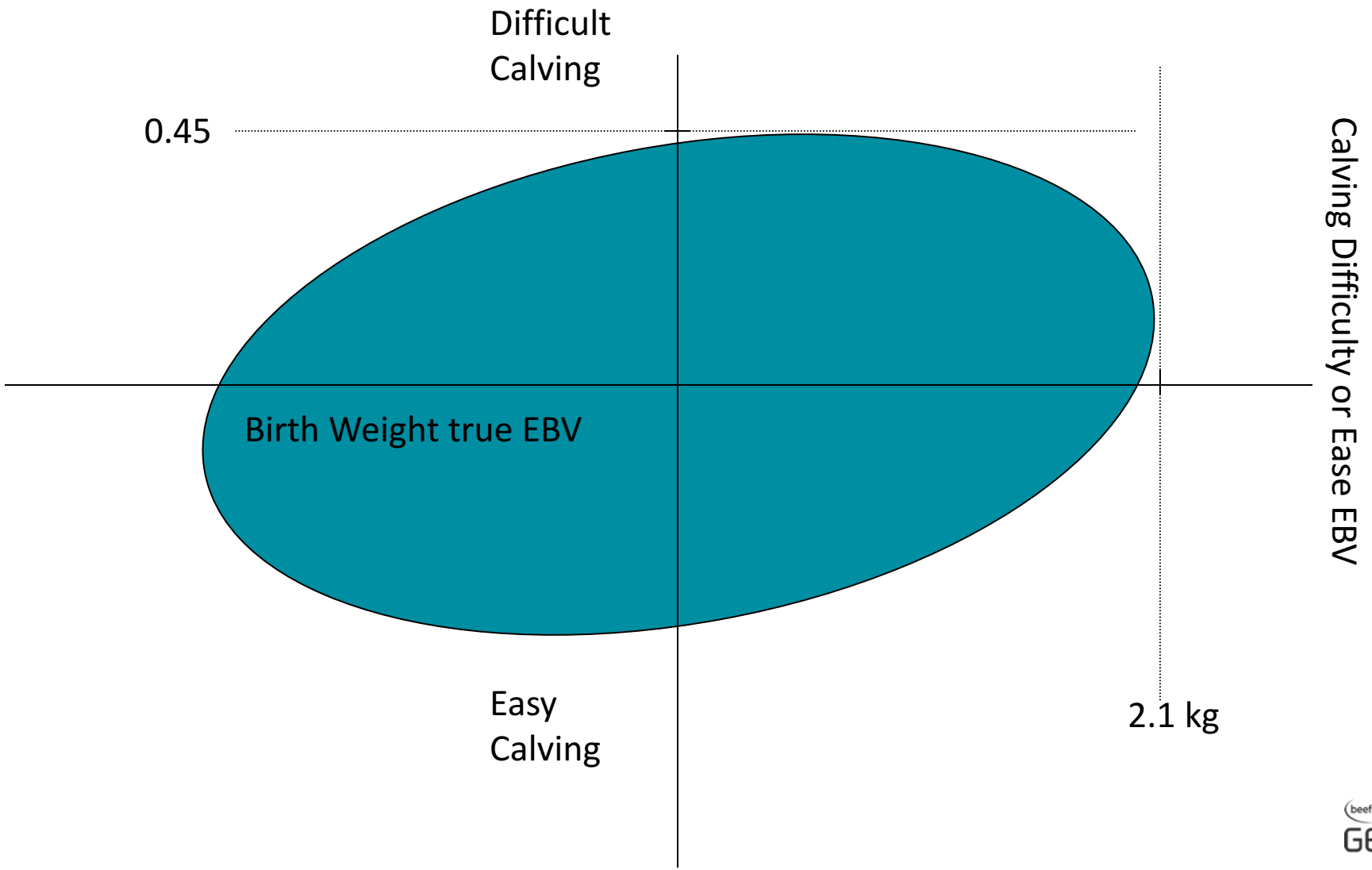
Bivariate Analysis



Birth Weight & Calving Ease

- Some Genetic Parameters
  - Birth Weight
    - genetic s.d. = 4.7 lb
  - Calving Ease
    - genetic s.d. = 0.45
  - Birth Weight & Calving Ease
    - Genetic correlation = -.4
      - Bulls with heavier birth weight calves are not as easy calving

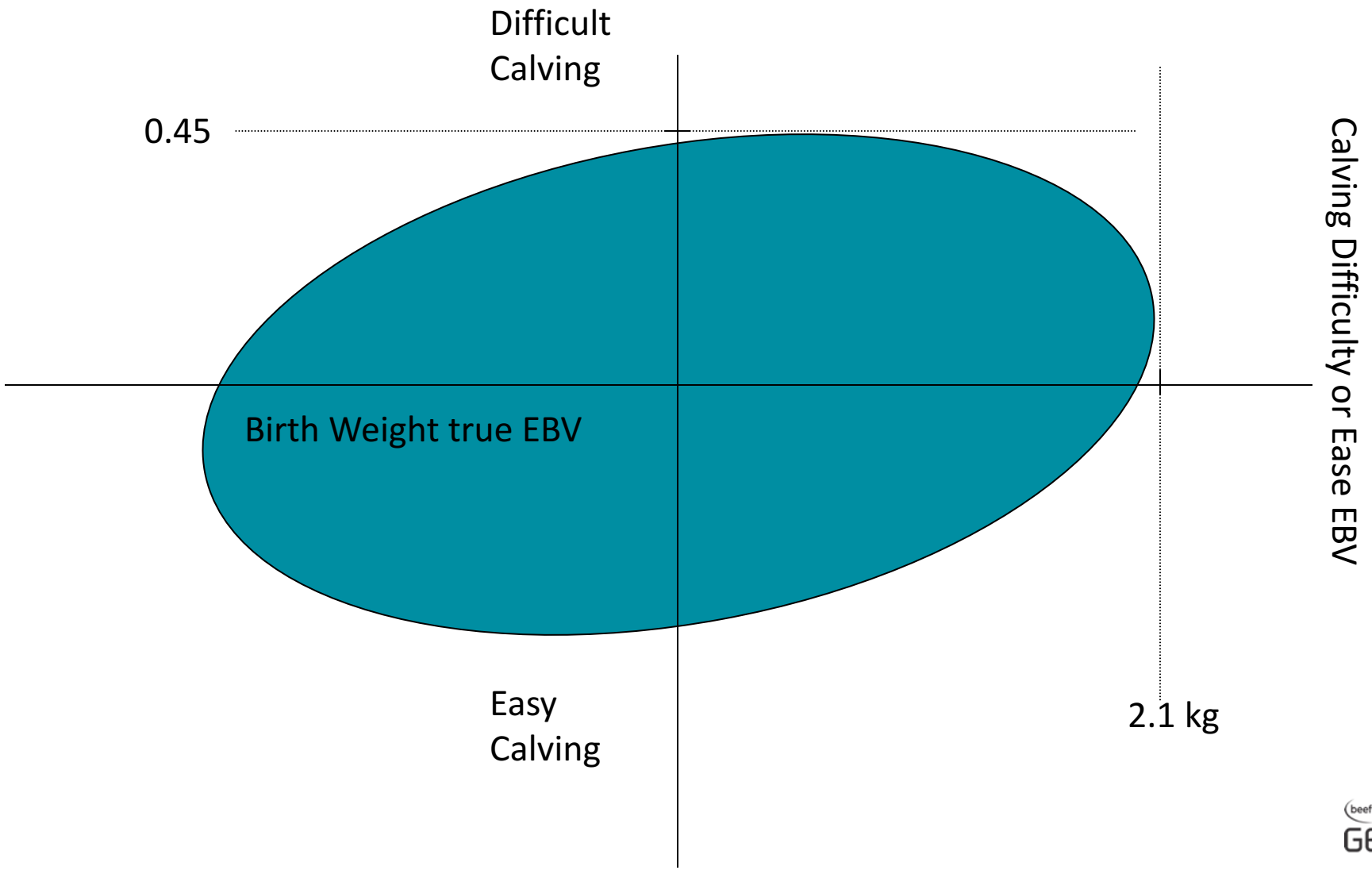
Frontier for 40% selected



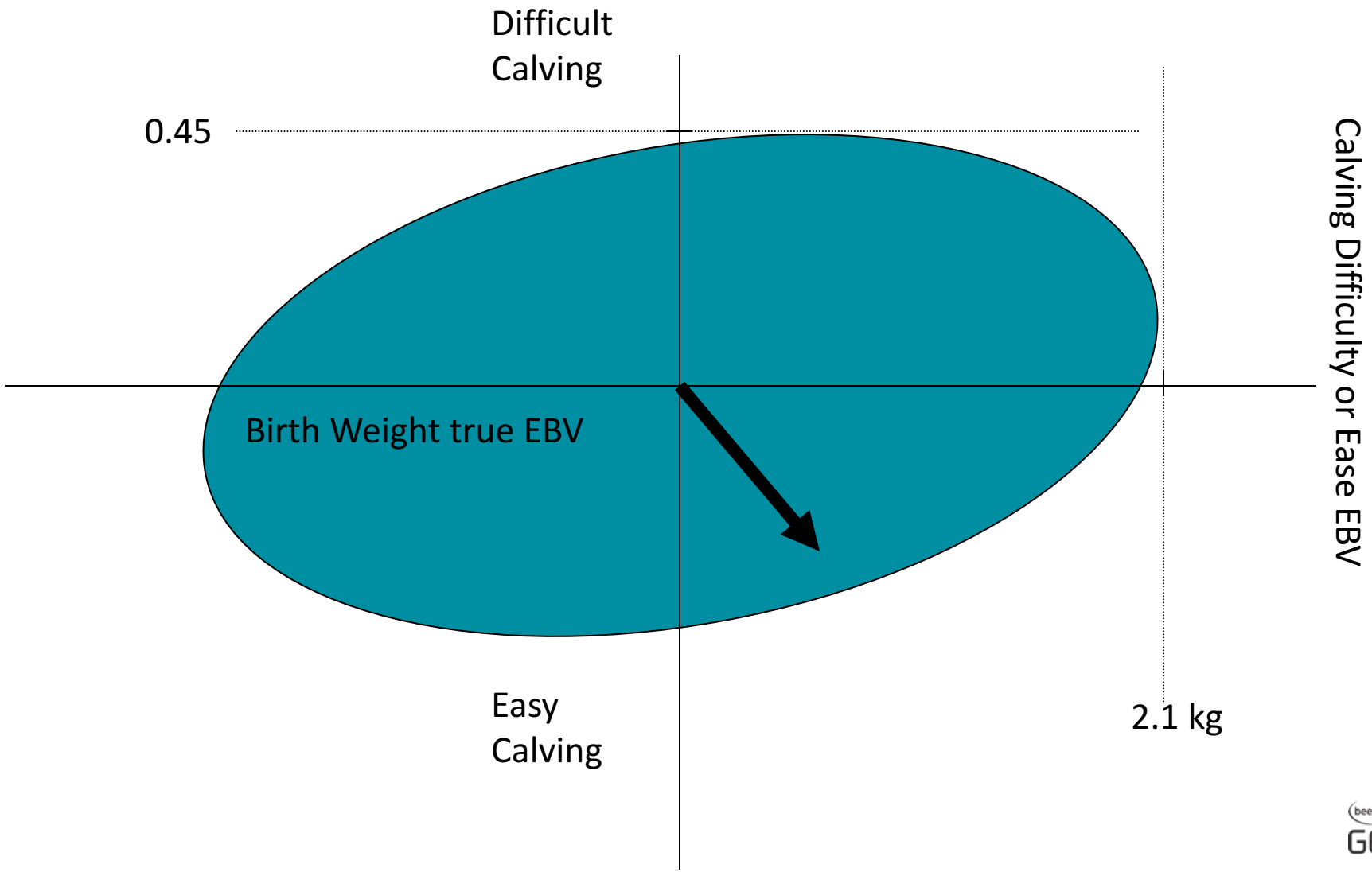
Determinants of the Frontier

- Genetic variation and covariation determine the frontier or potential for simultaneously changing two traits

Where would You like to go?



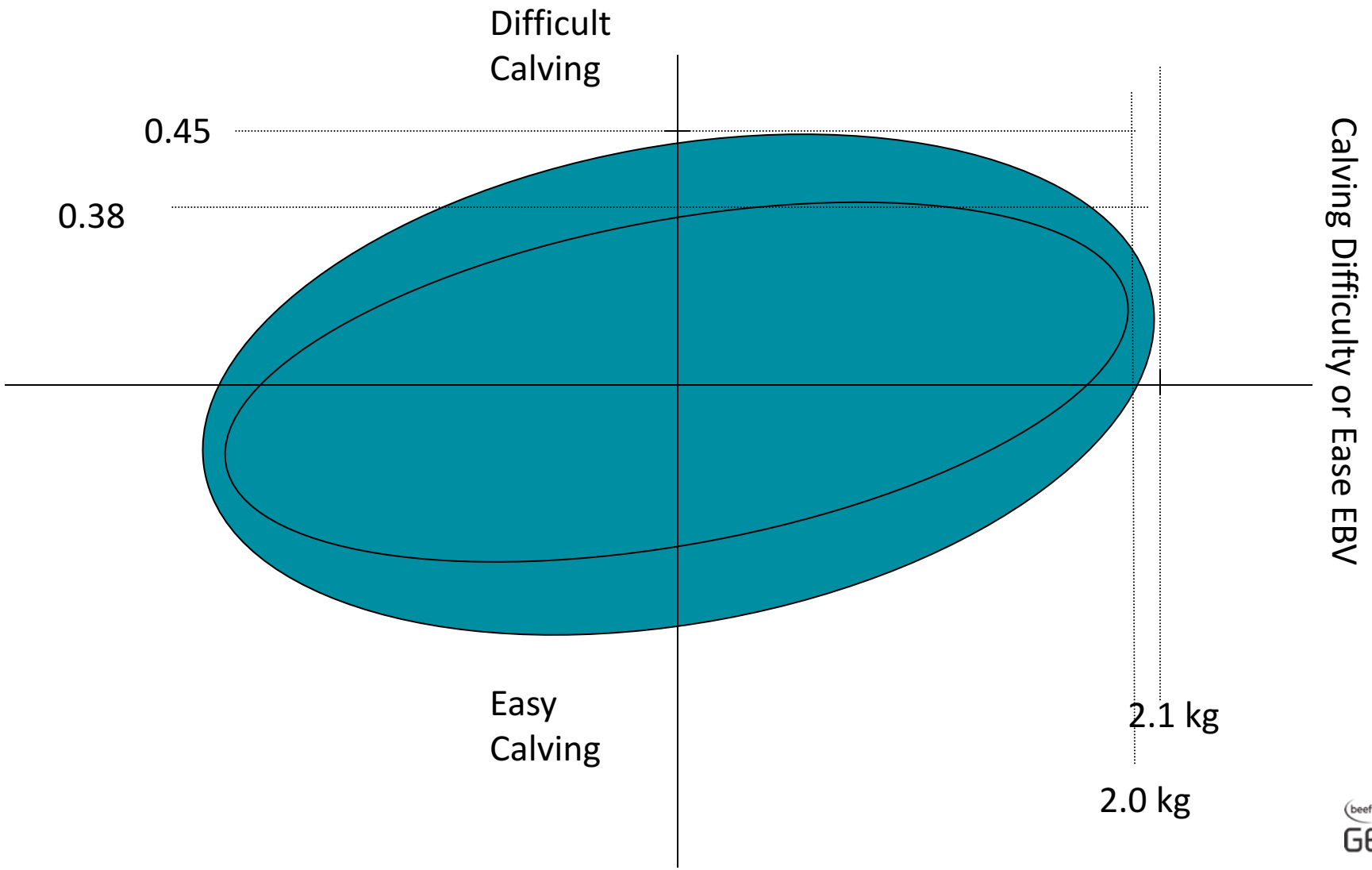
Increase Birth wt with Easy Calving



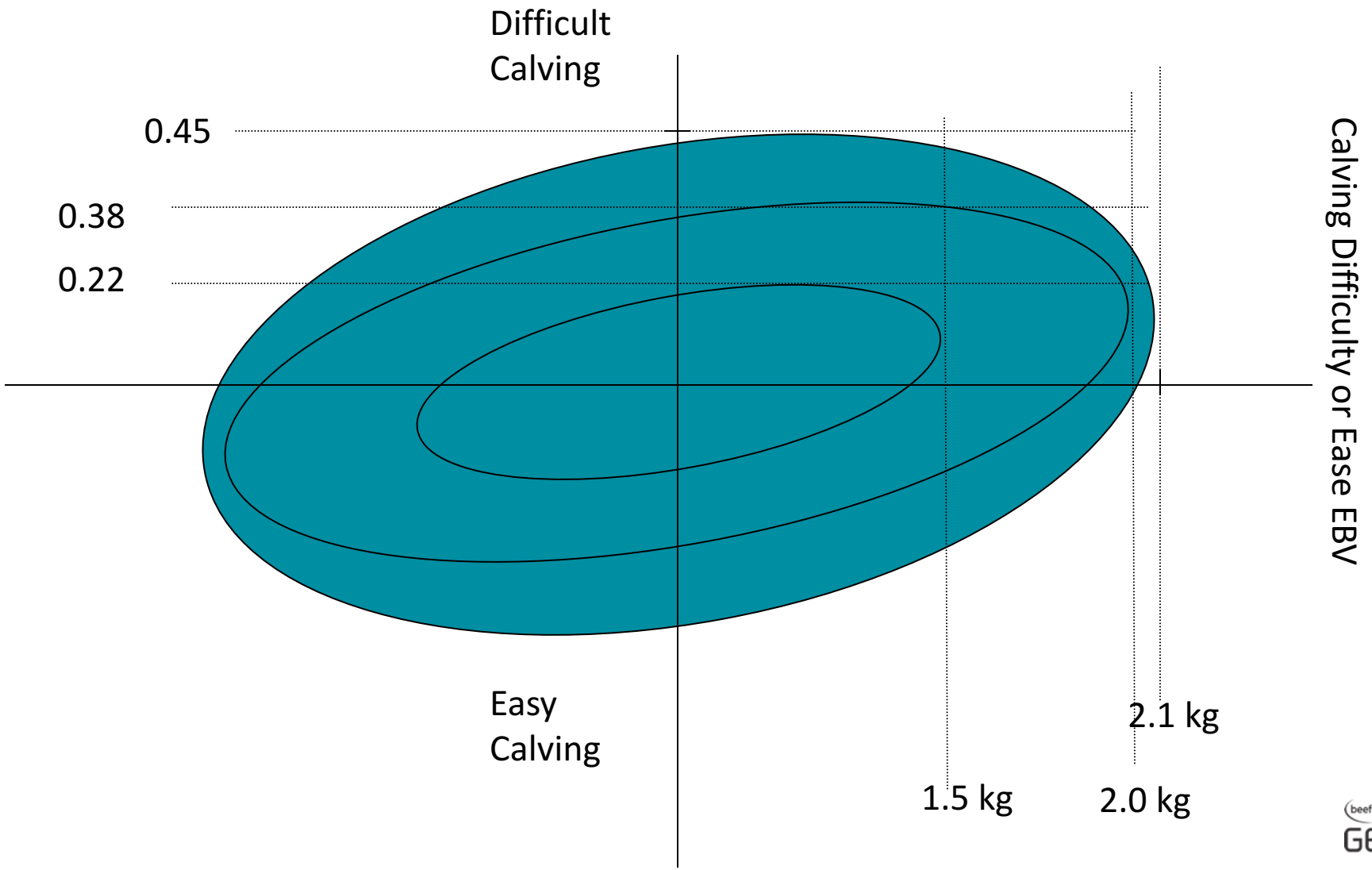
True and Estimated Merit

- In practice, we never know the true EBV, but we can predict the EBV from phenotypic observations on birth weight and calving ease
  - These predictions will have errors, the size of the errors depending upon the amount of information used in our predictions
  - Suppose we predict sire merit using the bull's own birth wt and calving score and like information on say 50 offspring

Sire with own record+50 Offspring



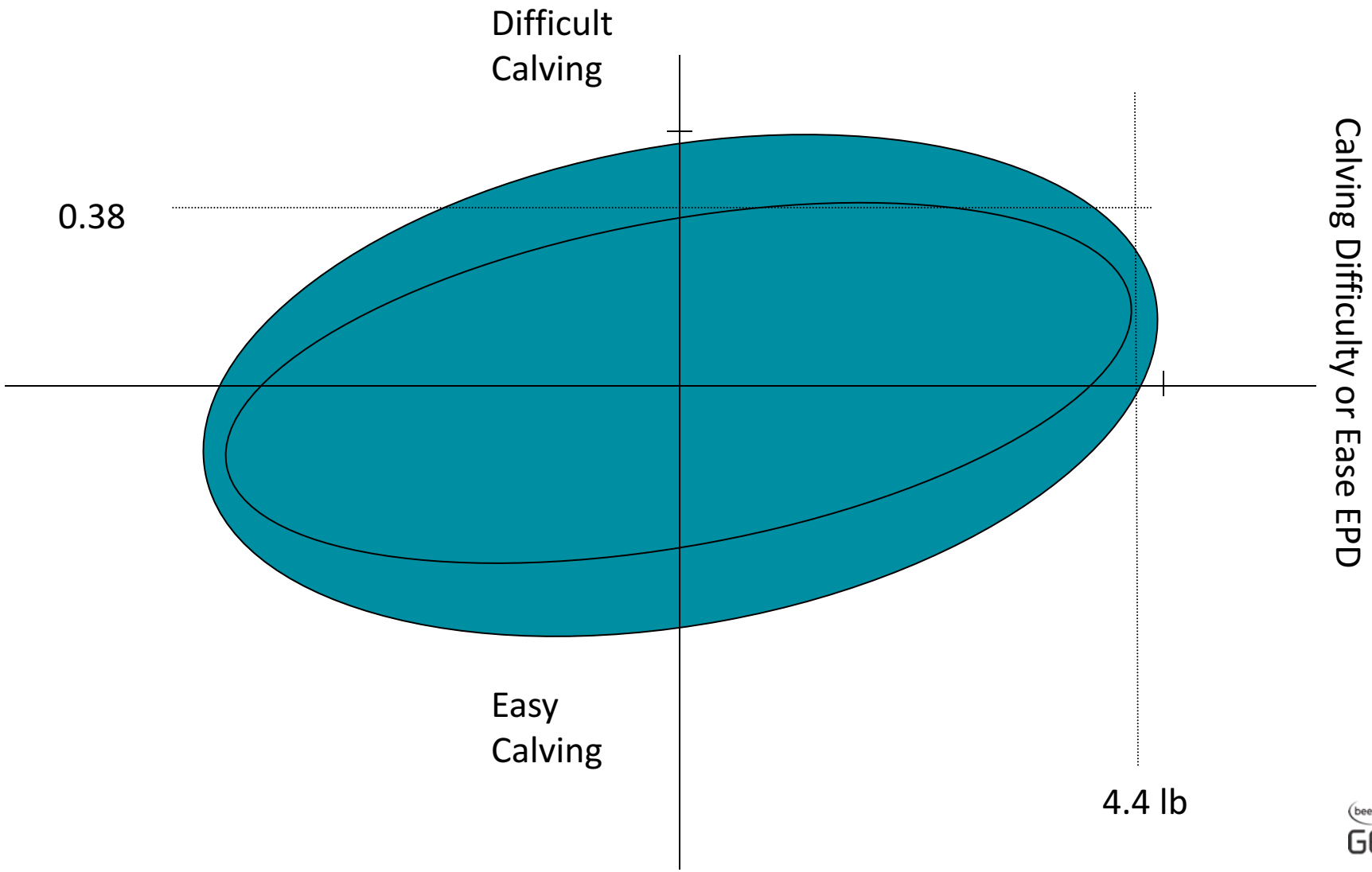
Sire with own record+1 Offspring



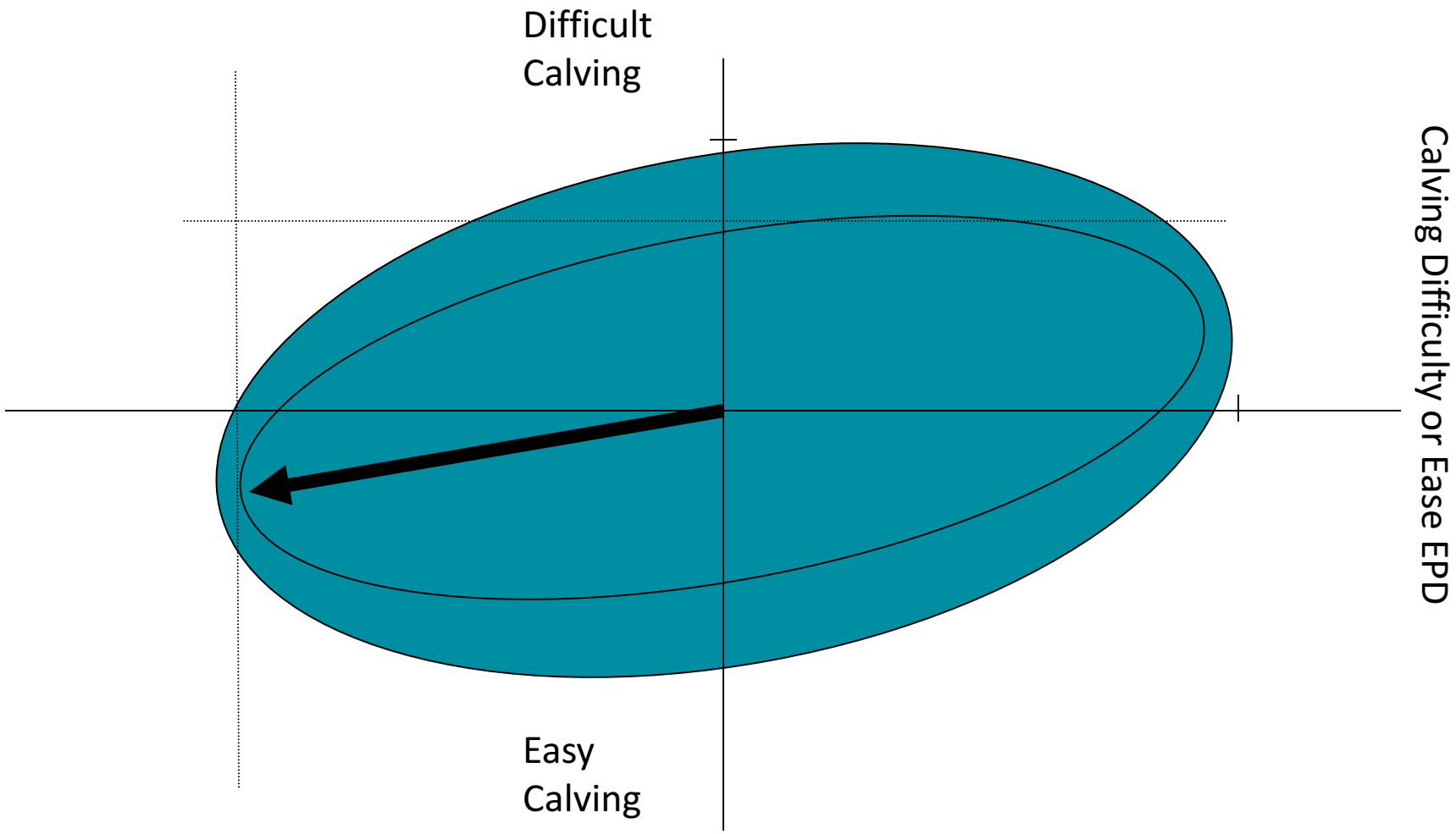
True and Achievable Potential

- Genetic variation and covariation determine the frontier or potential for simultaneously changing two (or more) traits
- The amount and nature of information available (on the ERT and indicator traits) determines the extent to which you can realize this potential

Sire with 50 Offspring

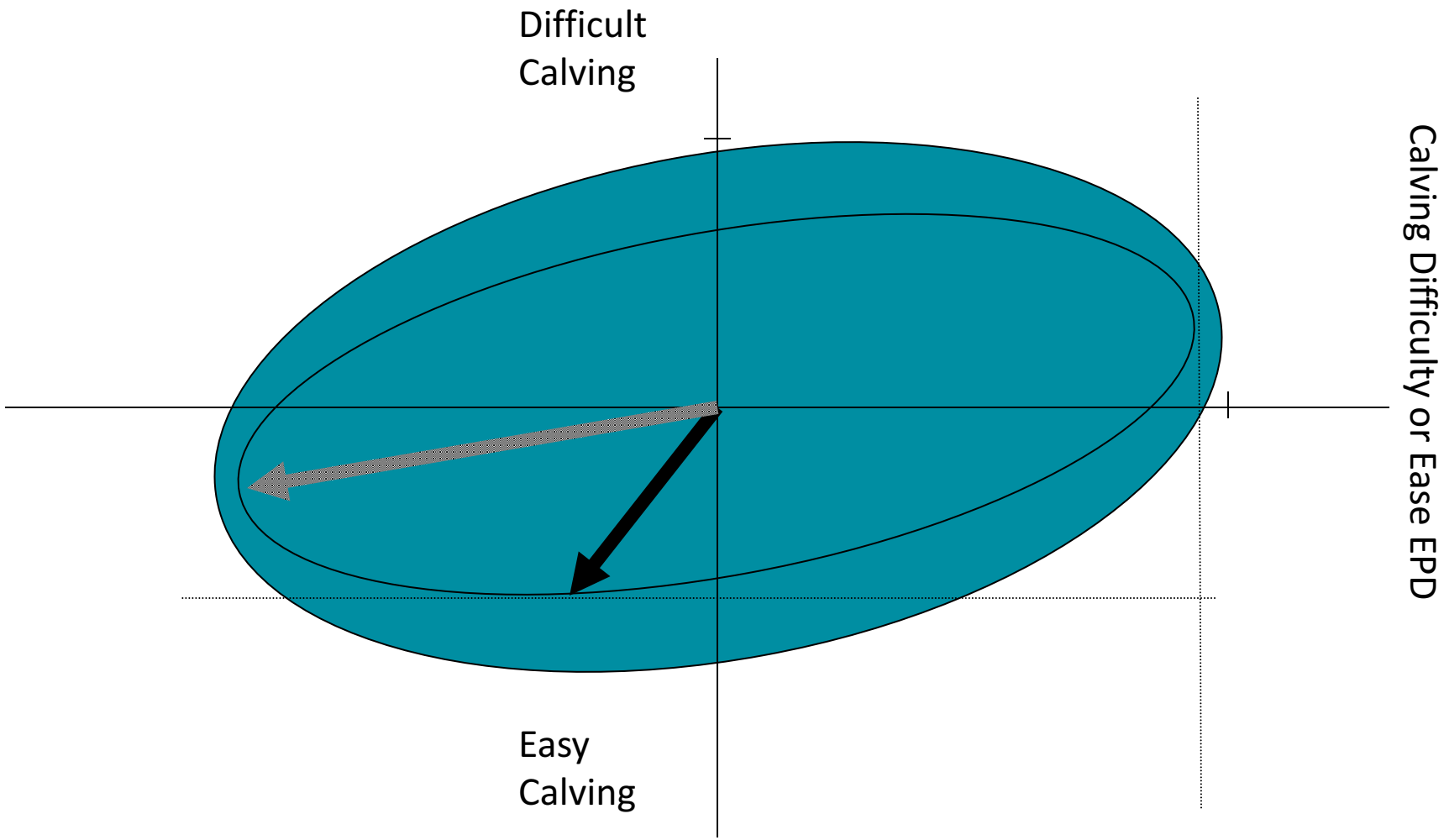


Selection for Low Birth Weight



Birth wt would reduce by 2.0 kg and calving ease by 0.18

Selection on Calving Ease

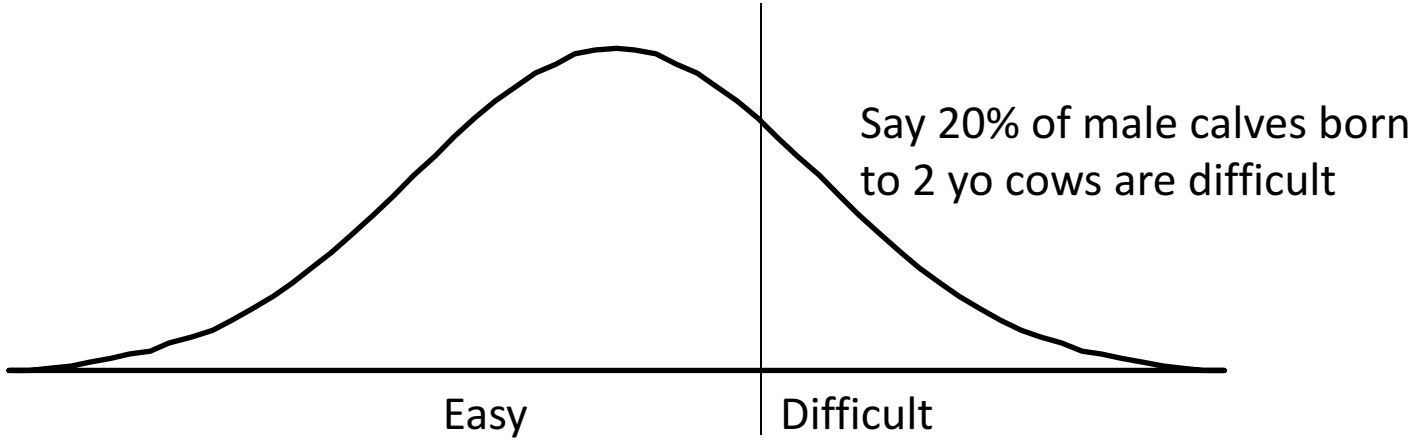


Birth wt would reduce by 1.0 kg and calving ease by 0.38

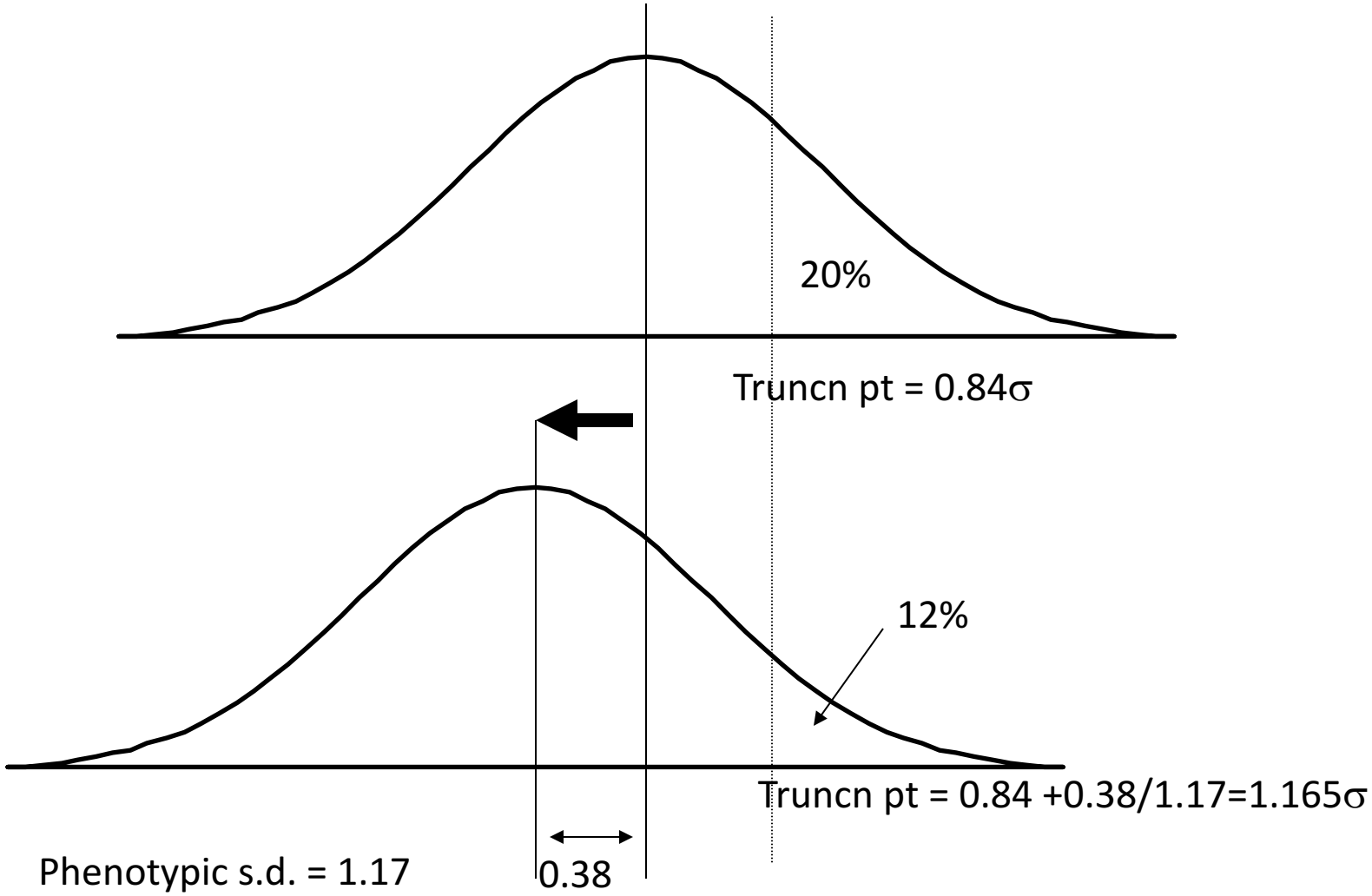
Underlying Scale

The improvement in calving ease is based on an underlying scale which must be transformed to express the results in terms of numbers of difficult calvings

The transformation depends upon the average level of difficult calvings



Underlying Scores to Calvings



Selection on Calving Ease

- After perhaps a generation of selection on progeny-tested calving ease EBV
  - Difficult calvings among bull calves born to 2yo would reduce from 20% to 12%
  - Birth weight would have reduced 1.0 kg as a correlated response

Selection on Birth Weight

- To achieve the same reduction (from 20% to 12%) by selection for low birth weight EPD would
  - Take more than twice as many years of selection
  - Would be associated with about a 4.0 kg reduction in birth weight

- You need to record the relevant phenotypes AND select on the appropriate EBV or index to maximize the value of the performance recording

Carcass & Ultrasound Traits

- This is a similar issue to calving ease and birthweight
  - Ultrasound IMF is an indicator of marbling
  - Restaurants and consumers want marbling for a good eating experience and are not interested in IMF itself
- Relevant genetic parameters
  - Heritability marbling 0.54
  - Genetic sd marbling 0.65
  - Heritability intramuscular fat % 0.50
  - Genetic correlation between marbling and IMF% 0.72

Closed Herd Rate of Genetic Gain

intensity of selection dictated by proportion of candidates selected

accuracy of selection

amount of genetic variation in population

$$\Delta G = \frac{\left[\left(ir_{TI} \right)_S + \left(ir_{TI} \right)_D \right] \sigma_g}{L_S + L_D}$$

Annual Change in Merit/Performance

average ages of selected sires (& dams) when offspring are born

Simplistic – two selection paths

S=Sires, D=Dams

Improving Marbling

- ~~Direct Selection~~

$$r_{TI} = \sqrt{h^2}$$

- Indirect selection (u/s IMF%)

$$r_{TI} = \sqrt{r_g^2 h^2_{indicator}}$$

- Progeny testing (c/c marbling)

$$r_{TI} = \sqrt{\frac{0.25nh^2}{1+(n-1)0.25h^2}}$$

- Genotyping/Genomic Selection

$$r_{TI} = \sqrt{p}$$

- Genomic and Phenotypic

$$r_{TI} = \sqrt{p+(1-p)r_g^2 h^2_{indicator}}$$

Generation Intervals - Cows

- Suppose the cows in the bull breeding herd calve at 2, 3, 4, 5, 6, 7, 8 yr
  - The cow generation interval (average age of cows when offspring are born) will be 5 yrs

Generation Interval - Bulls

- Ultrasound & Genomic Assessment
  - Bulls would be measured at 1yr then used as yearlings and again as 2 yr old
  - Bulls would be 2 and 3 when offspring born
  - Average bull gen interval would be 2½ yr

Genetic Gain – driven by accuracy

Scenario		Gen Interval	Accuracy	Annual Gain
Ultrasound individual	Males only Both sexes	2½ + 5	0.5	0.09 0.13

Investing more in phenotypes gives more gains

Genetic Gain – driven by accuracy

Scenario		Gen Interval	Accuracy	Annual Gain
Ultrasound individual	Males only Both sexes	2½ + 5	0.5	0.09 0.13
Genomic test	10% accounted	2½ + 5	0.32	0.06
	20% accounted	2½ + 5	0.45	0.08
	50% accounted	2½ + 5	0.71	0.13

Accurate genomic tests can be as good as indicator traits
But getting accurate genomic tests requires lots of phenotypes

Genetic Gain – driven by accuracy

Scenario		Gen Interval	Accuracy	Annual Gain
Ultrasound individual	Males only Both sexes	2½ + 5	0.5	0.09 0.13
Genomic test	10% accounted	2½ + 5	0.32	0.06
	20% accounted	2½ + 5	0.45	0.08
	50% accounted	2½ + 5	0.71	0.13
Genomic & ultrasound	10% accounted	2½ + 5	0.58	0.11
	20% accounted	2½ + 5	0.64	0.12
	50% accounted	2½ + 5	0.79	0.14

Phenotypes add value to genomic tests especially if genomic tests are not near perfect

Generation Interval - Bulls

- Progeny test
  - Young bulls used as yearlings, progeny test offspring would be born when bulls are 2
  - Progeny harvested at 2 (when their PT sires are 4) and measured for carcass marbling
  - PT bulls used for breeding at 4 and 5 yr their offspring would be born when bulls are 5 and 6
  - Average Bull generation interval would be 5½ yr

Genetic Gain – progeny testing

Scenario		Gen Interval	Accuracy	Annual Gain
Ultrasound individual	Males only Both sexes	2½ + 5	0.5	0.09 0.13
Progeny test	n= 5 offspring	5½ + 5	0.66	0.09
	n= 20	5½ + 5	0.87	0.11
	n= 100	5½ + 5	0.97	0.13
Genomic test	10% accounted	2½ + 5	0.32	0.06
	20% accounted	2½ + 5	0.45	0.08
	50% accounted	2½ + 5	0.71	0.13
Genomic & ultrasound	10% accounted	2½ + 5	0.58	0.11
	20% accounted	2½ + 5	0.64	0.12
	50% accounted	2½ + 5	0.79	0.14

Progeny Tests are the gold standard for accuracy
but struggle to be competitive for gain if animals can be measured directly

Conclusions

- Gain is driven by accuracy of EBV at selection age
  - At the same selection age, investing in phenotypes can directly influence gain by increasing accuracy

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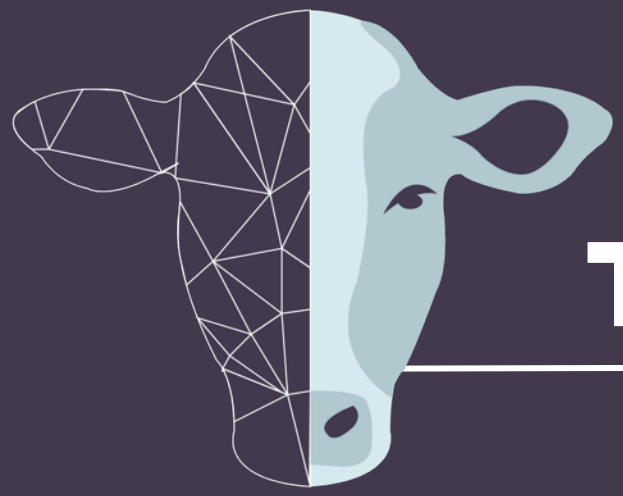
- Progeny testing can give you any accuracy you are prepared to pay for, but increased generation intervals erode the value of extra accuracy
  - Impact on generation intervals and gain is trait specific

Conclusions

- Gain is driven by accuracy of EBV at selection age
  - At the same selection age, investing in phenotypes can directly influence gain by increasing accuracy
- Progeny testing can give you any accuracy you are prepared to pay for, but increased generation intervals erode the value of extra accuracy
  - Impact on generation intervals and gain is trait specific
- Genomic testing can be competitive to progeny testing, but only if genomic tests are accurate
  - Accurate genomic tests rely on lots of phenotypes
  - Accurate genomic tests rely on lots of genotypes

Final Word

- NZ has an opportunity to improve the returns from its beef industry by achieving higher rates of gain
  - This relies on performance recording more cattle
    - Many bulls are being sold without having been recorded
    - Or are being home recorded but the data not being shared
  - This could be achieved by extending the level of performance recording in nature and scope
  - The benefits from genomics are dictated by its accuracy
    - The accuracy is limited by the extent of genotyping
    - The value of genotyping is increased when prediction can be applied over the full range of economically relevant traits



Thank you.

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