Back to Basics: Don’t Overlook the Basics Among the New Technologies

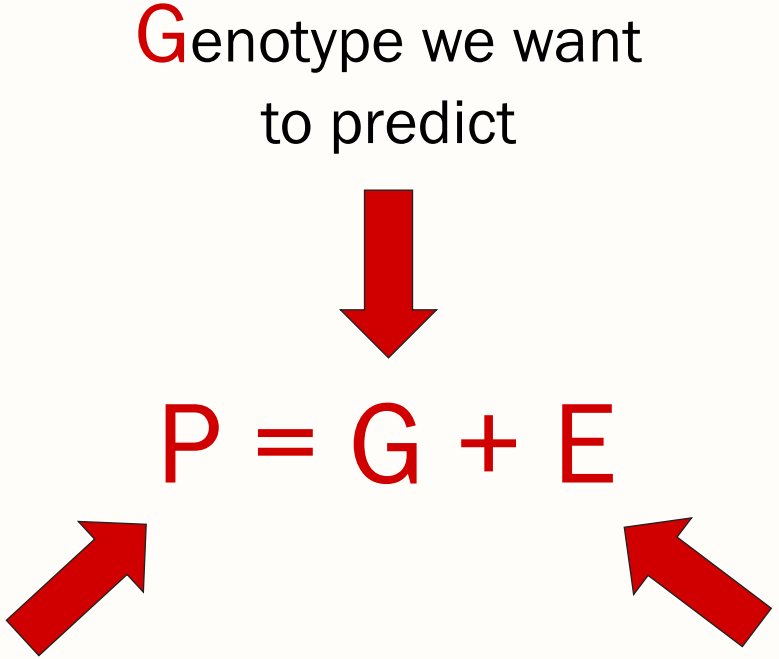
Ron Lewis

Genetics Forum, ASI Annual Convention
Sheraton Denver Downtown Hotel, Denver, CO
Jan. 11, 2024

What are the key basics?

- Asked five experts
- Considerable consistency in their answers
  - Understanding the breeder's equation
  - Establishing a breeding objective or goal
  - Interpreting Estimated Breeding Values (EBV)
  - Defining contemporary groups
  - Using crossbreeding

Back to Basics



- The genotype (G) is an animal's genetic or breeding value (BV) as a parent
- An estimated breeding value (EBV) is our prediction of BV

Understanding the breeder's equation

Understanding the breeder's equation

- An equation combining the factors affecting selection response

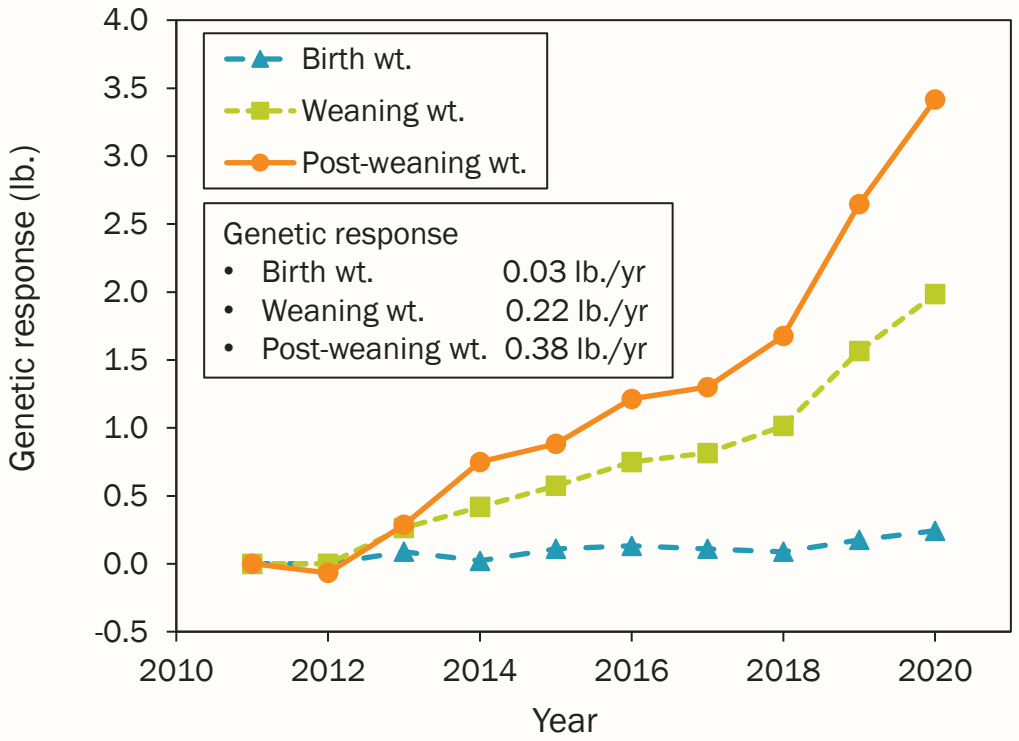
$$\Delta BV/_t = \frac{r_{BV,EBV}(i)\sigma_{BV}}{L}$$

Understanding the breeder's equation

- An equation combining the factors affecting selection response

$$\Delta BV/_t$$

Genetic response or change due to selection, typically expressed per year



Understanding the breeder's equation

- An equation combining the factors affecting selection response

$$\Delta BV/_t = \frac{r_{BV,EBV}(i)\sigma_{BV}}{L}$$

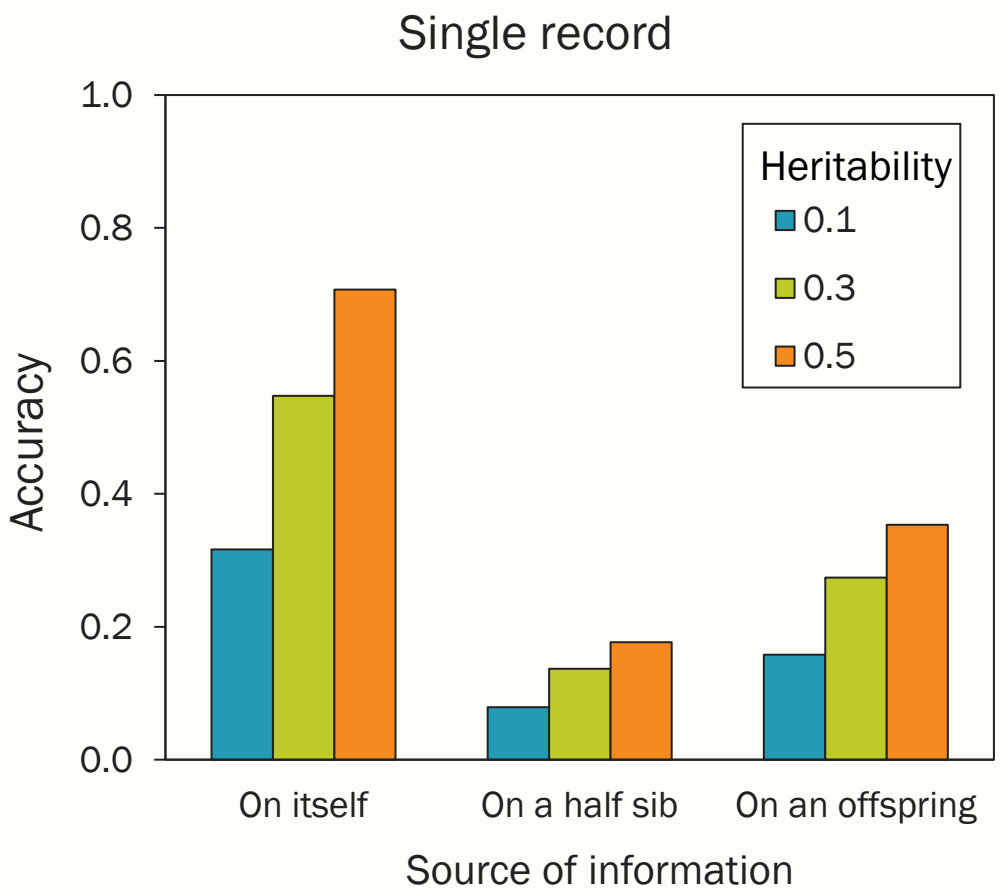
- Based on four factors
  - Accuracy ($r_{BV,EBV}$)
  - Selection intensity (i)
  - Variation in breeding value (σ_{BV})
  - Generation interval (L)

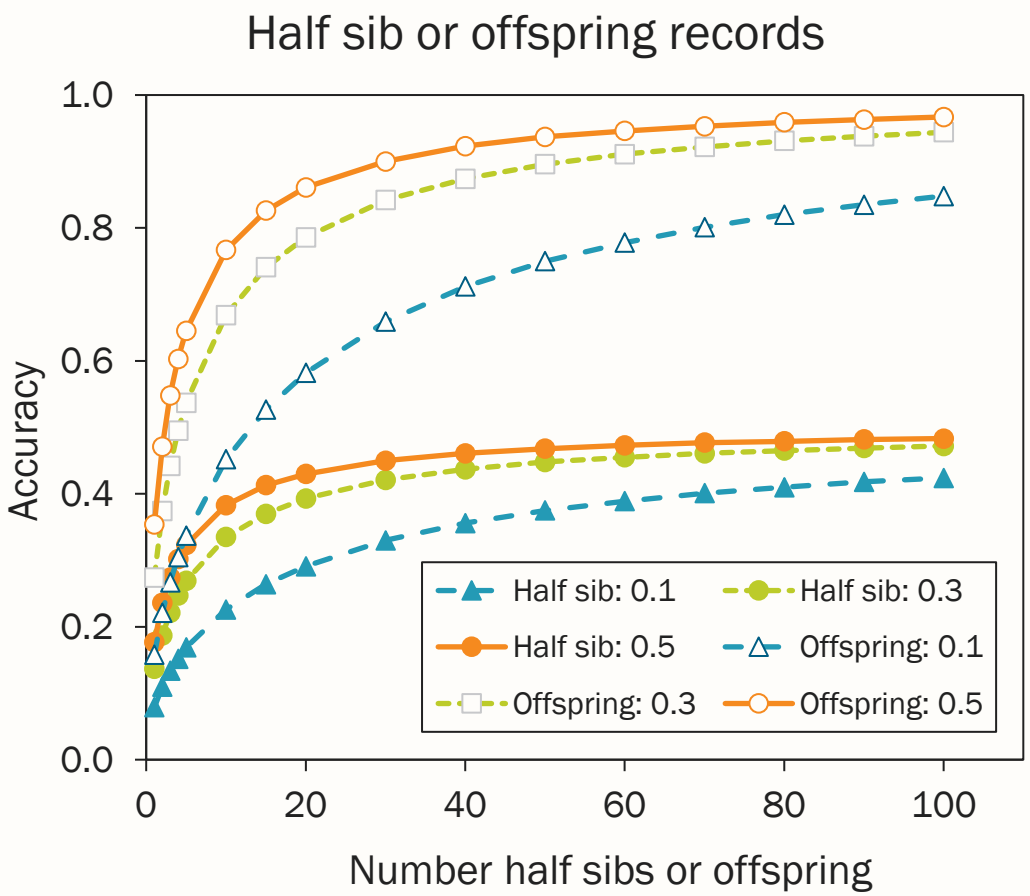
Accuracy $(r_{BV,EBV})$

- Measure of strength of the relationship between breeding values (BV) and their predictions (EBV)
  - The more accurate our predictions, the better we discern animals with the best breeding values for a trait
- Affected by
  - Heritability
    - ❖ Measures how closely offspring resemble their parents
  - Amount and kinds of information available

Ranges in value from 0 to 1

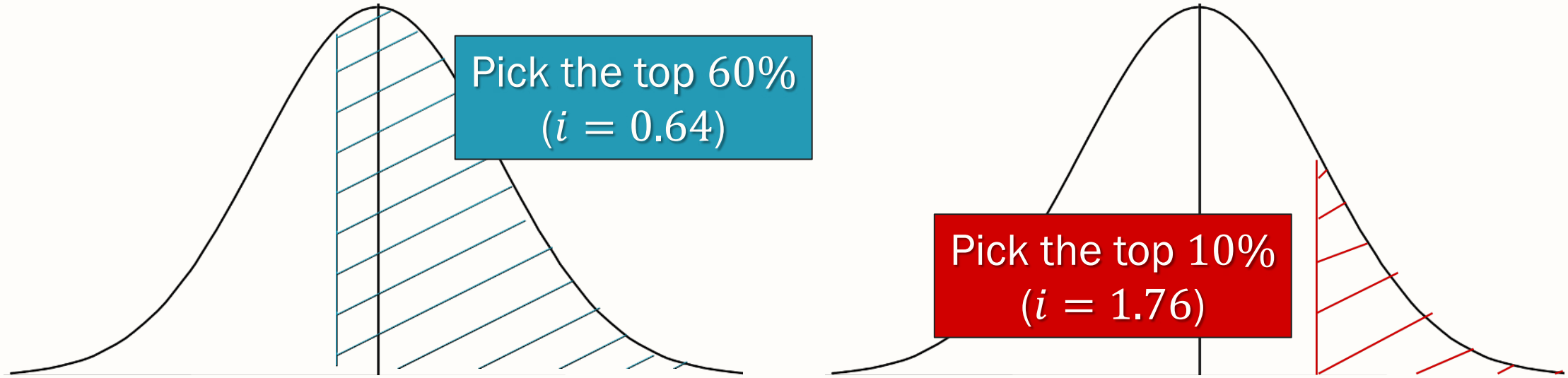
Accuracy ($r_{BV,EBV}$)





Selection intensity (i)

- Measures how choosy breeders are in deciding which animals are selected
  - Intense selection means picking only the very best animals
  - With more intense selection, genetic change is quicker

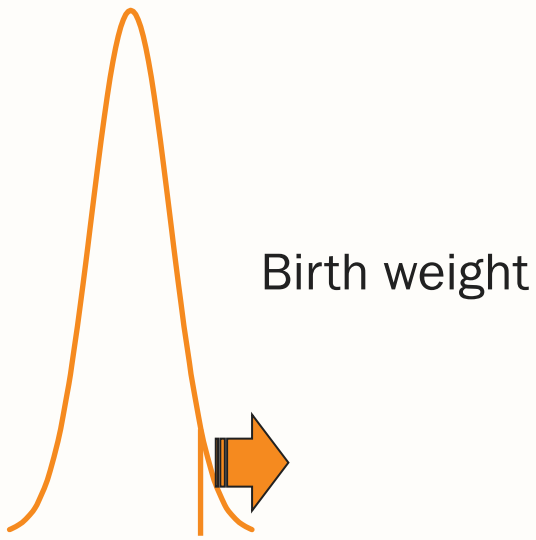


Variation in breeding value (σ_{BV})

- Unlike the other factors that influence the rate of genetic response, variation in breeding value is difficult to manipulate
  - Tends to be fixed within a population
  - With intensive enough selection, variation in breeding value can be reduced
    - ❖ In practice, is unlikely of much concern in short to medium term

Variation in breeding value (σ_{BV})

- Still, it impacts genetic response

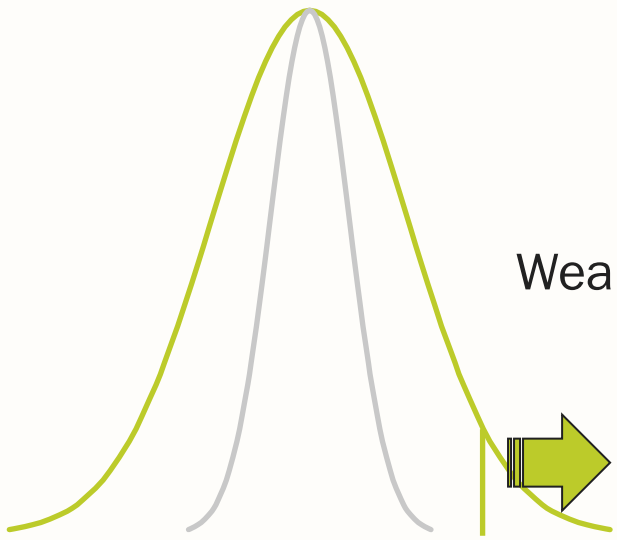


Breed-type	Birth weight (lb.)	Weaning weight (lb.)	Post-weaning weight (lb.)
Hair	0.39	1.83	3.01
Semi-prolific	0.43	1.59	3.93
Fine wool	0.45	1.43	2.66
Terminal sire	0.59	3.16	6.20

Variation in breeding value (σ_{BV})

- Still, it impacts genetic response

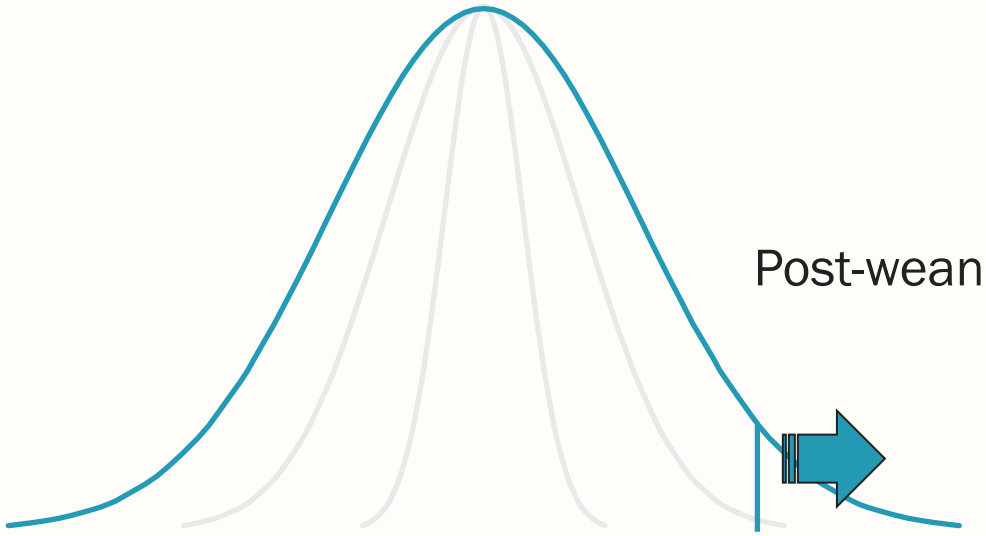
Breed-type	Birth weight (lb.)	Weaning weight (lb.)	Post-weaning weight (lb.)
Hair	0.39	1.83	3.01
Semi-prolific	0.43	1.59	3.93
Fine wool	0.45	1.43	2.66
Terminal sire	0.59	3.16	6.20



Variation in breeding value (σ_{BV})

- Still, it impacts genetic response

Breed-type	Birth weight (lb.)	Weaning weight (lb.)	Post-weaning weight (lb.)
Hair	0.39	1.83	3.01
Semi-prolific	0.43	1.59	3.93
Fine wool	0.45	1.43	2.66
Terminal sire	0.59	3.16	6.20



Generation interval (L)

- The amount of time required to replace one generation with the next
- Alternatively, the average age of parents when their selected offspring are born

Breed	Males (year)	Females (year)	Overall (year)
Katahdin†	2.65	3.24	2.94
Suffolk‡	2.40	3.40	2.92
Targhee§	2.60	3.75	3.10

†Nilson et al. (2024)
‡Wilson et al. (2022)
§Wilson et al. (2024)

Accuracy versus generation interval

- Accuracy and generation interval typically move in the same direction

$$\Delta BV/_t = \frac{r_{BV,EBV}(i)\sigma_{BV}}{L}$$

  - Improving accuracy entails collecting more records, which takes more time
- New technologies
  - Genomics allows us to improve accuracy without increasing generation interval

Understanding the breeder's equation

- An equation combining the factors affecting selection response

$$\Delta BV/_t = \frac{r_{BV,EBV}(i)\sigma_{BV}}{L}$$

What is the genetic response in males?

Trait	Accuracy	Selection intensity	Variation in breeding value (lb.)	Generation interval (year)	Genetic response (lb./year)
Weaning weight	0.361	1.76	1.83	2.65	0.439
Post-weaning weight	0.436	1.76	3.01	2.65	0.872

Understanding the breeder's equation

- An equation combining the factors affecting selection response

Weaning weight

$$\Delta BV/_t = \frac{0.361(1.76)1.83}{2.65} = 0.439 \text{ lb./year}$$

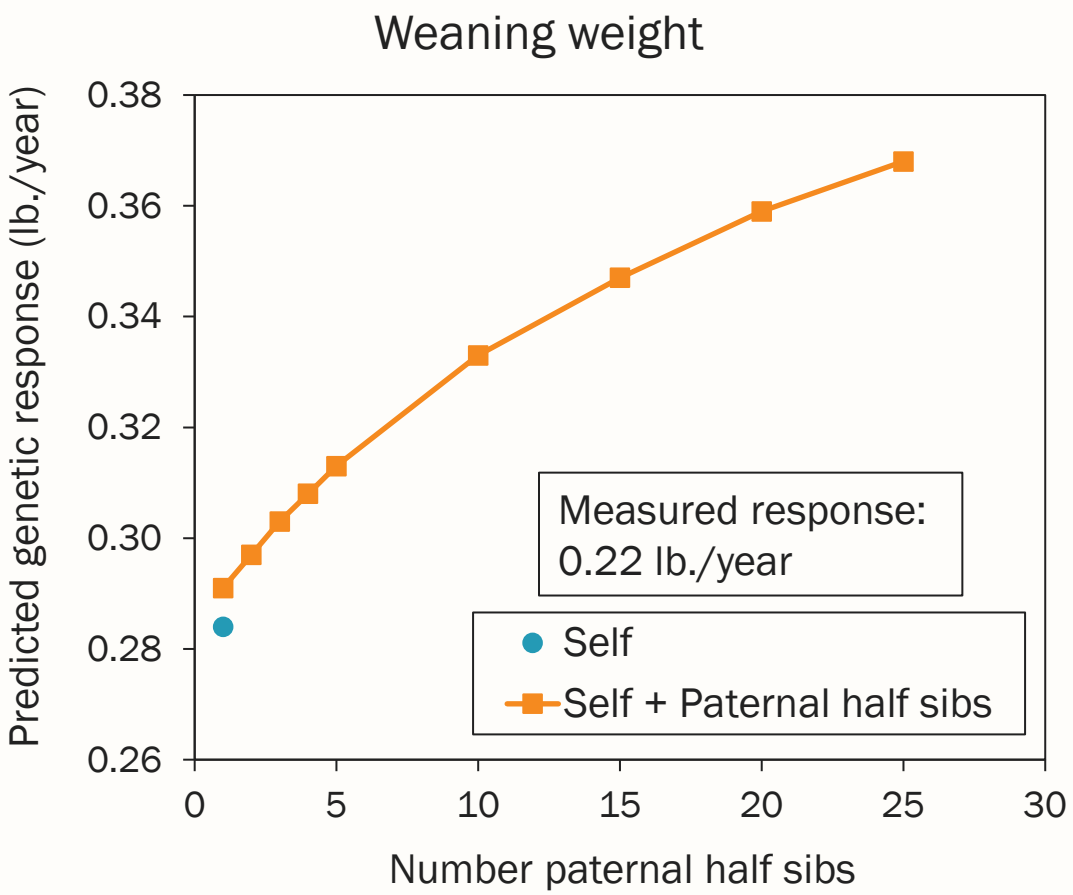
Post-weaning weight

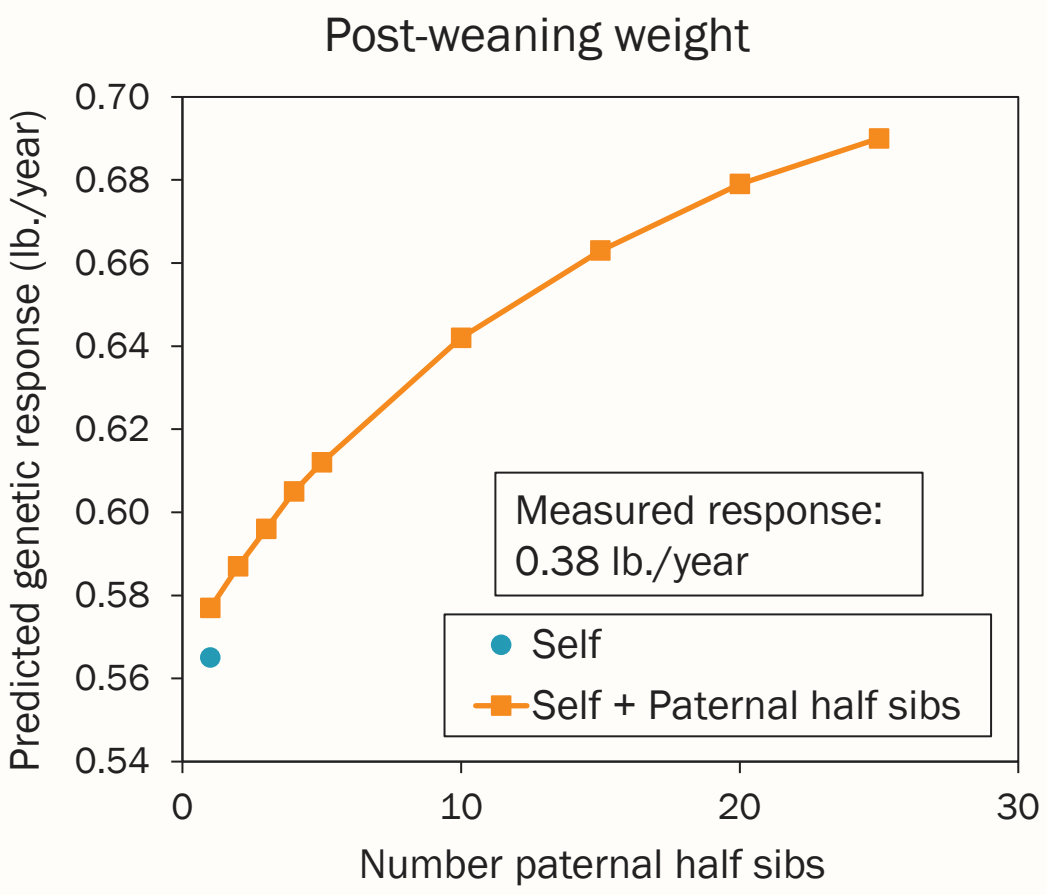
$$\Delta BV/_t = \frac{0.436(1.76)3.01}{2.65} = 0.872 \text{ lb./year}$$

What is the genetic response in males?

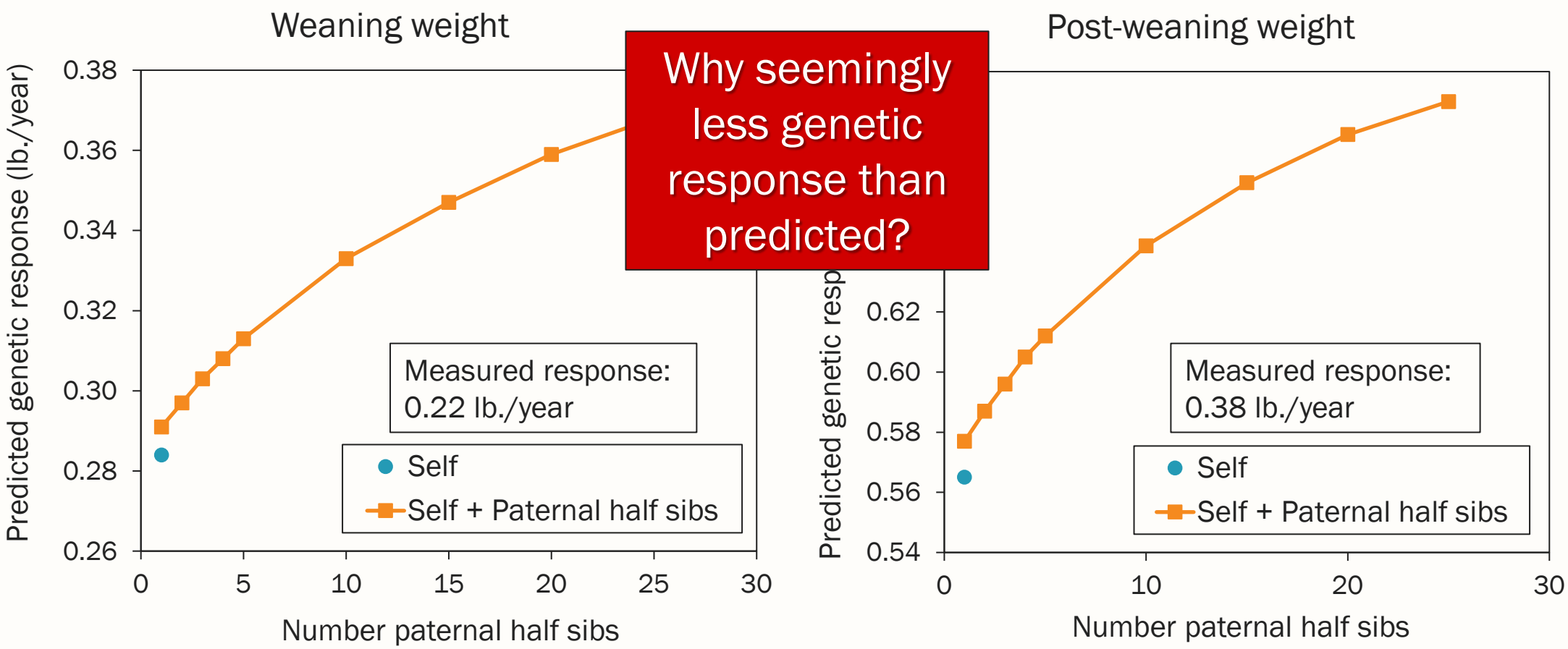
Trait	Accuracy	Selection intensity	Variation in breeding value (lb.)	Generation interval (year)	Genetic response (lb./year)
Weaning weight	0.361	1.76	1.83	2.65	0.439
Post-weaning weight	0.436	1.76	3.01	2.65	0.872

Understanding the breeder's equation





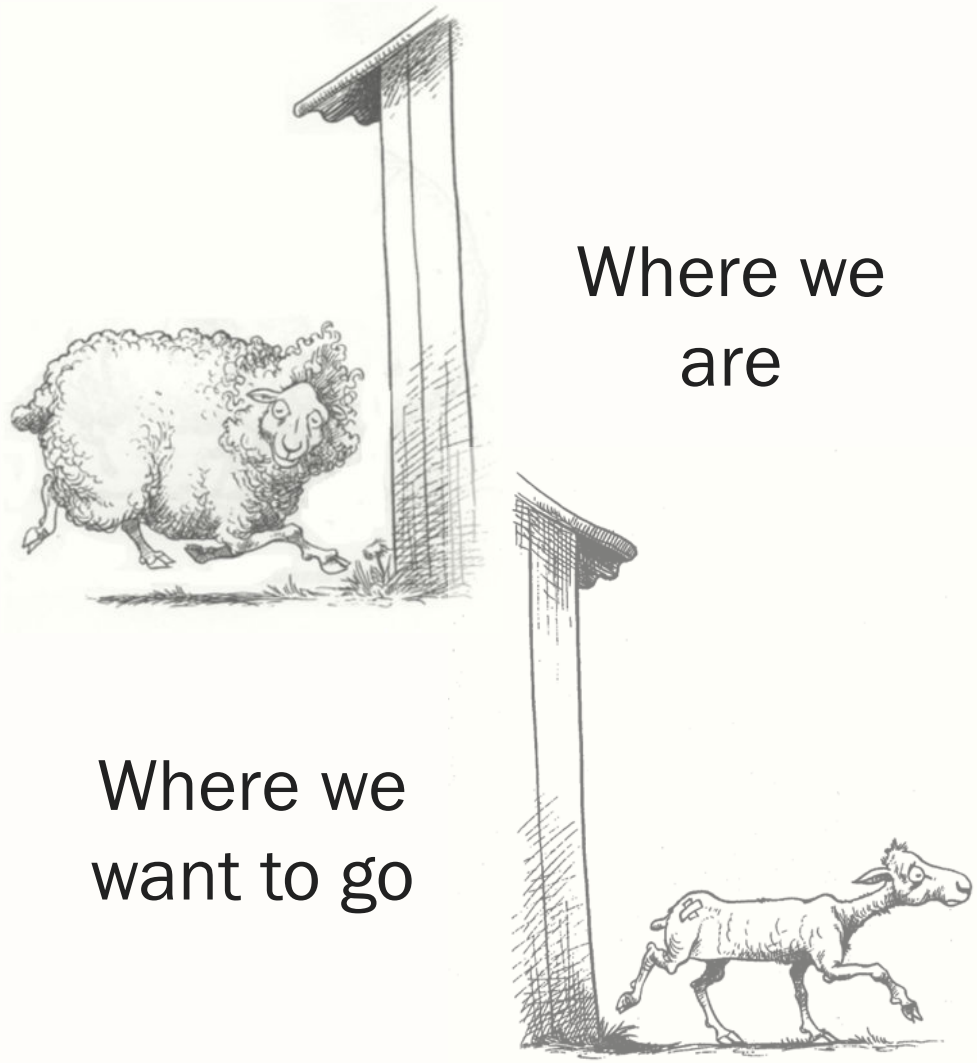
Understanding the breeder's equation



Establishing a breeding objective or goal

Breeding goal

- We seldom select for one trait in isolation
  - Profit usually depends on several traits
  - Optimizing profit depends on placing the right emphasis on each trait to be improved
- A breeding goal defines that balance



Breeding goal

- When selecting for more traits simultaneously, make less genetic progress in each individual trait
- Need to be cautious in deciding which traits to include in the breeding goal
  - Only include economically relevant traits
- Formalized as a selection index

Selection Indexes: Application and Comparison of Various Production Indices Available to the U.S. Sheep Industry

Dr Tom Murphy, U.S. Meat Animal Research Center

Interpreting Estimated Breeding Values (EBV)

Interpreting EBV

Genotype we want to predict (EBV)

$$P = G + E$$

Phenotype we measure

Environmental influences, both known and unknown, we want to account for

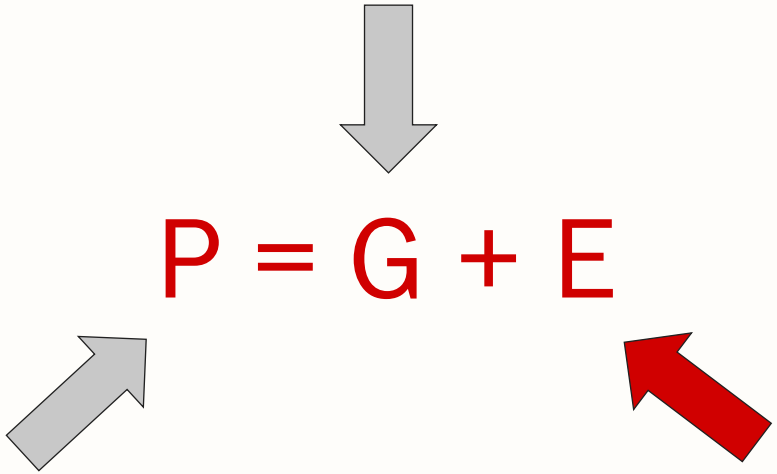
Interpreting EBV

Trait	Sire A	Sire B	Sire difference	Offspring difference
Maternal weaning weight (lb.)	1.2	0.6	0.6	0.3
Post-weaning weight (lb.)	4.7	2.9	1.8	0.9
Post-weaning fecal egg count (%)	-80	-65	-15	-7.5
Number lambs born (count)	6	6.2	-0.2	-0.1
Number lambs weaned (count)	10	10.3	-0.3	-0.15

Defining contemporary groups

Defining contemporary groups

Genotype we want to predict (EBV)



$$P = G + E$$

Phenotype we measure

Environmental influences, both known and unknown, we want to account for

Defining contemporary groups

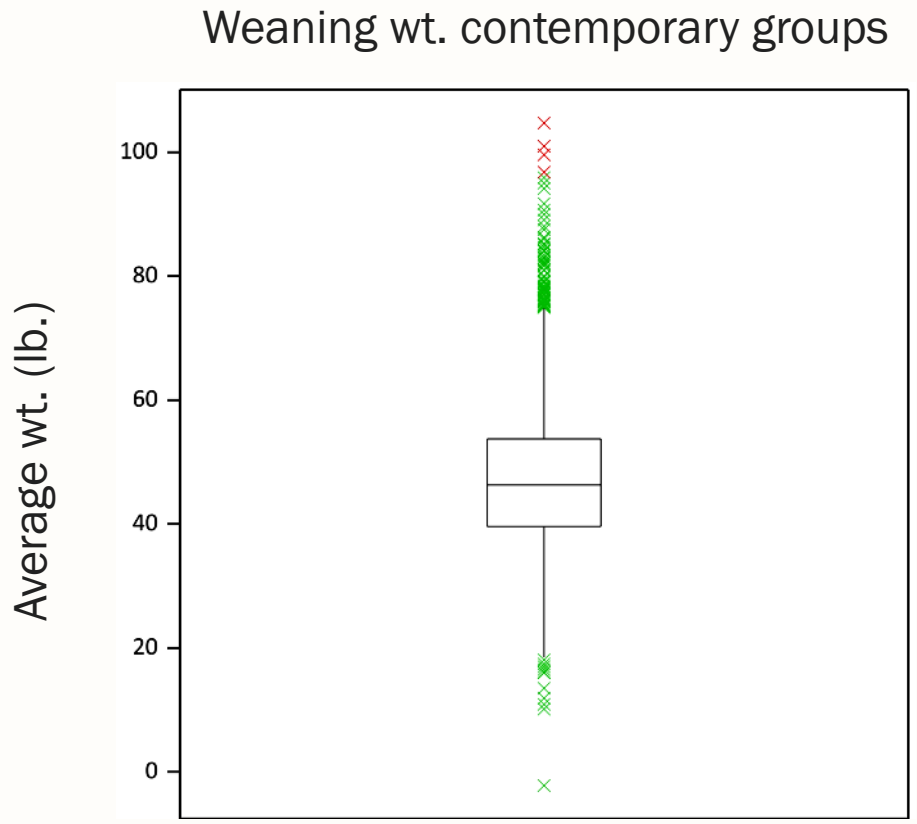
- A contemporary group is a set of animals that have had an equal opportunity to perform
  - Same sex
  - Managed alike
  - Exposed to the same environmental conditions and feed resources
- Best way for us to account for known environmental effects so that the remaining differences among animals may be attributed to breeding value

Defining contemporary groups

- An illustration
  - Born in the same flock and year
  - Raised under similar management conditions
  - Same sex
  - Born within a fixed period (e.g., within 35 days)
  - Measured on a given date

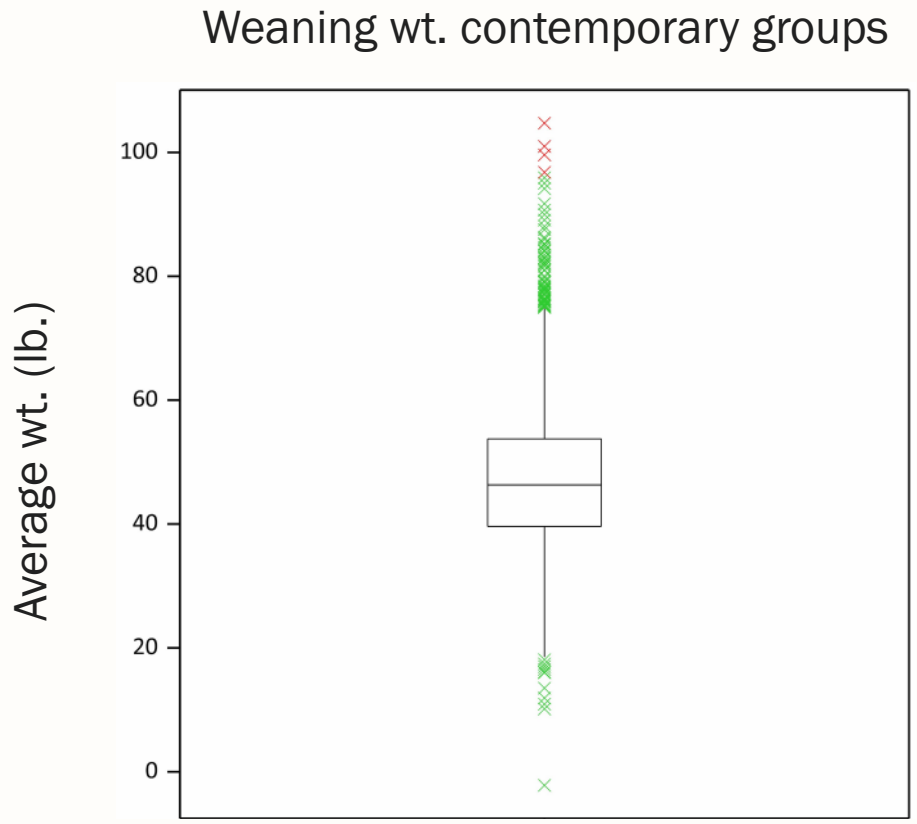
Should include multiple sire families

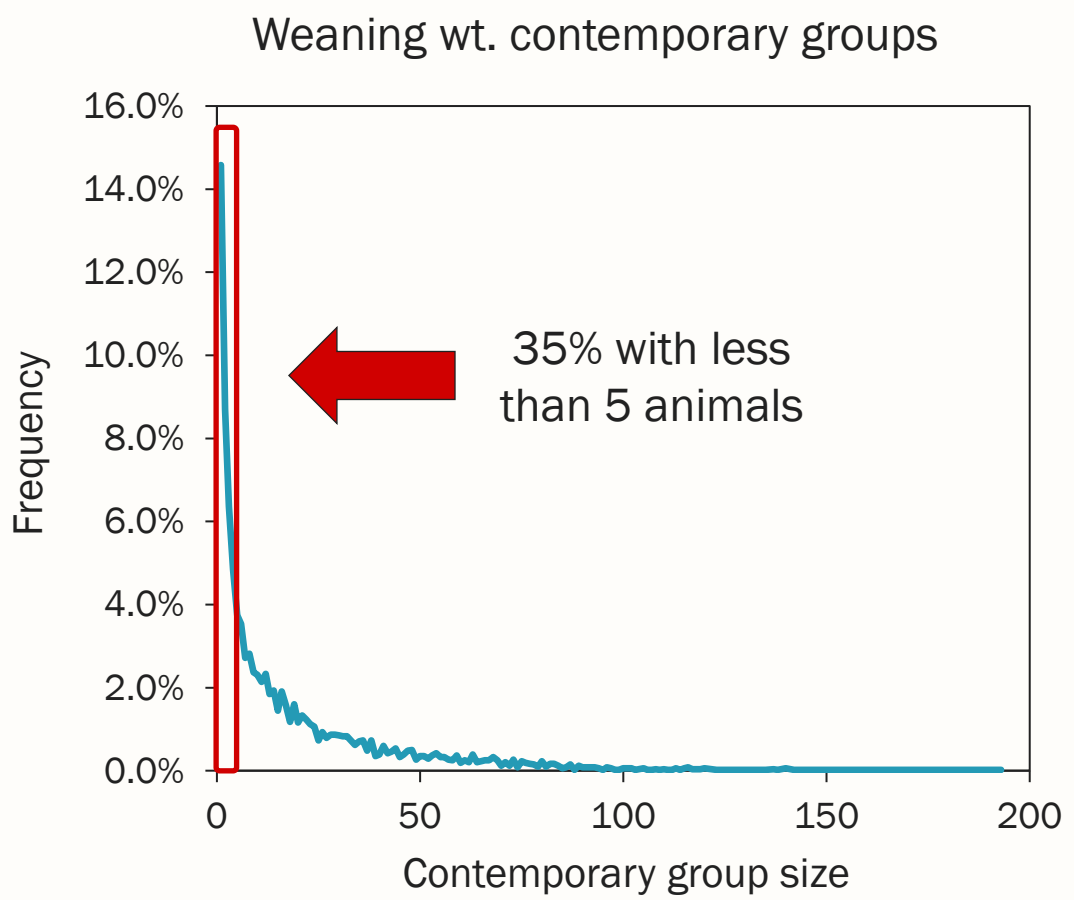
Defining contemporary group



- Data are
  - 91,627 weaning weights
  - 4,815 contemporary groups
- Reflects considerable variation among contemporary group means

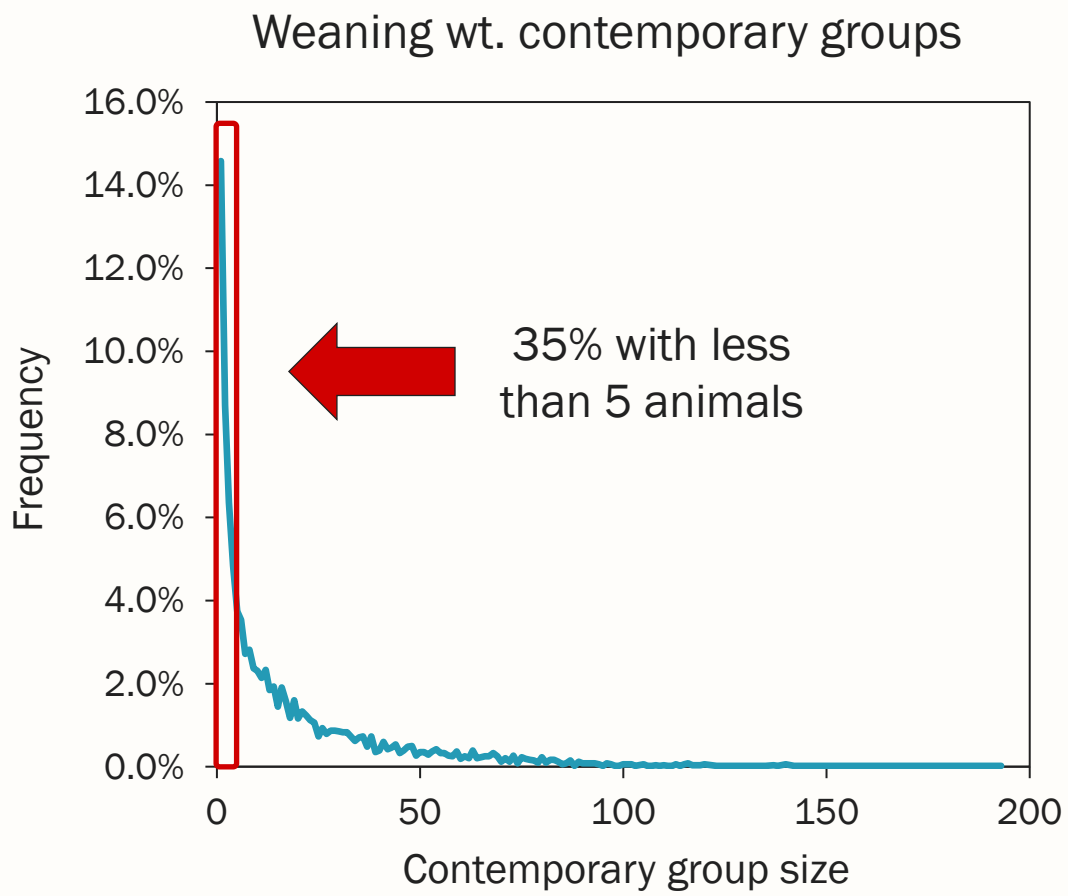
Defining contemporary groups





Defining contemporary groups

- Contemporary groups need to be large enough to reliably reflect mean performance of the group
- It is a balance
  - Enough distinct contemporary groups to account for environmental effects
  - Not so many that they are too small in size



Using crossbreeding

Using crossbreeding

- We enjoy a multitude of breed-types differing in their attributes

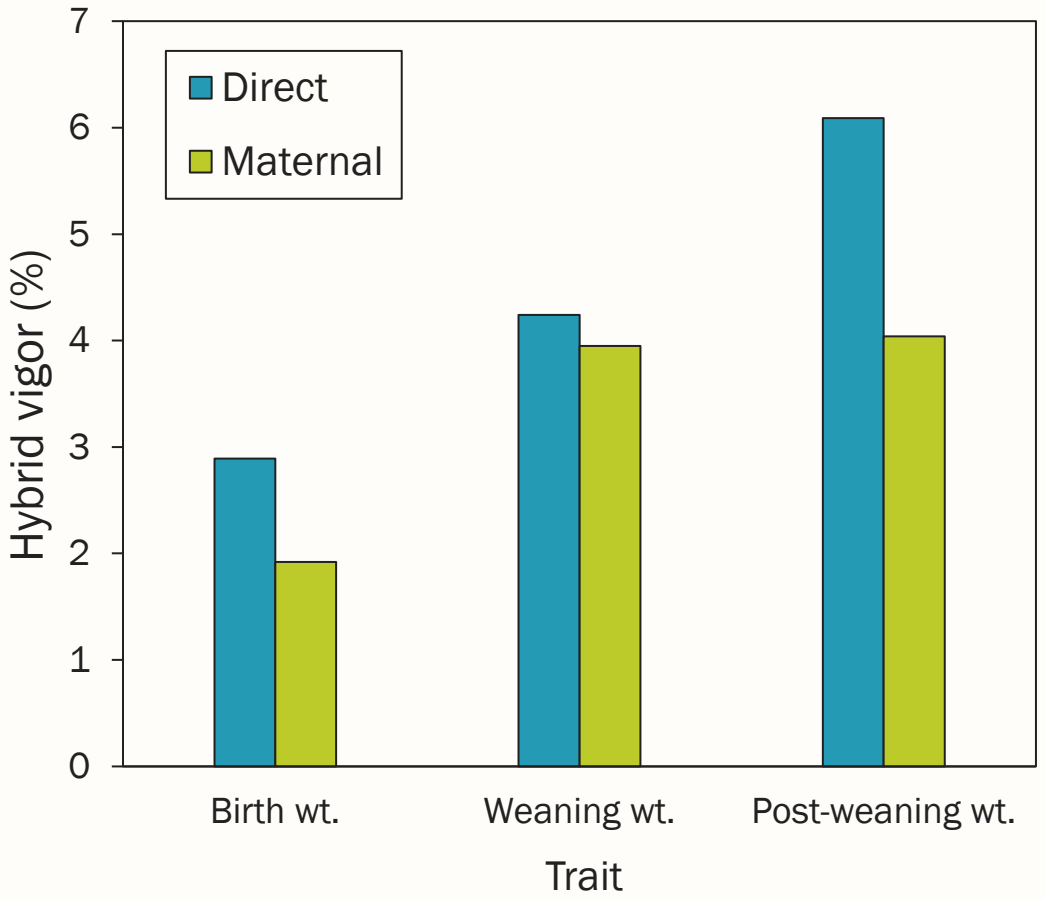
Using crossbreeding

- We enjoy a multitude of breed-types differing in their attributes
- Primary reasons for crossbreeding
  - To take advantage of breed differences
  - To use particular breeds or their crosses as either females or as males in the mating system
  - To utilize hybrid vigor

Hybrid vigor (or heterosis)

- Increased productivity due to increased heterozygosity associated with crossing pure breeds (or very distinct lines)
- Tends to be higher when crossing breeds that are more genetically distinct

Hybrid vigor (or heterosis)

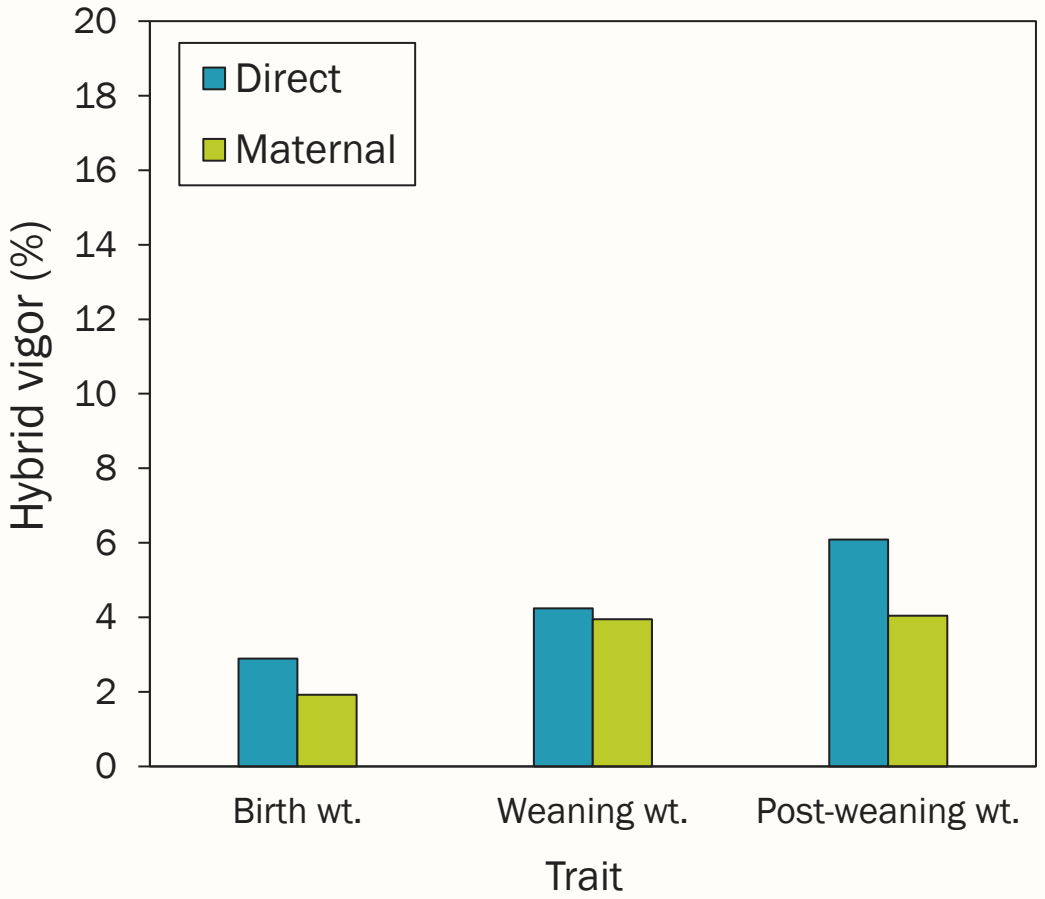


- Large multi-year study at U.S. Sheep Experiment Station
  - Sire breeds: Siremax, Suffolk, Texel, Columbia, PC
  - Dam breeds: Columbia, Polypay, Rambouillet, Suffolk, Targhee, PC
- Assessed direct (individual) and maternal (dam) heterosis on body weights

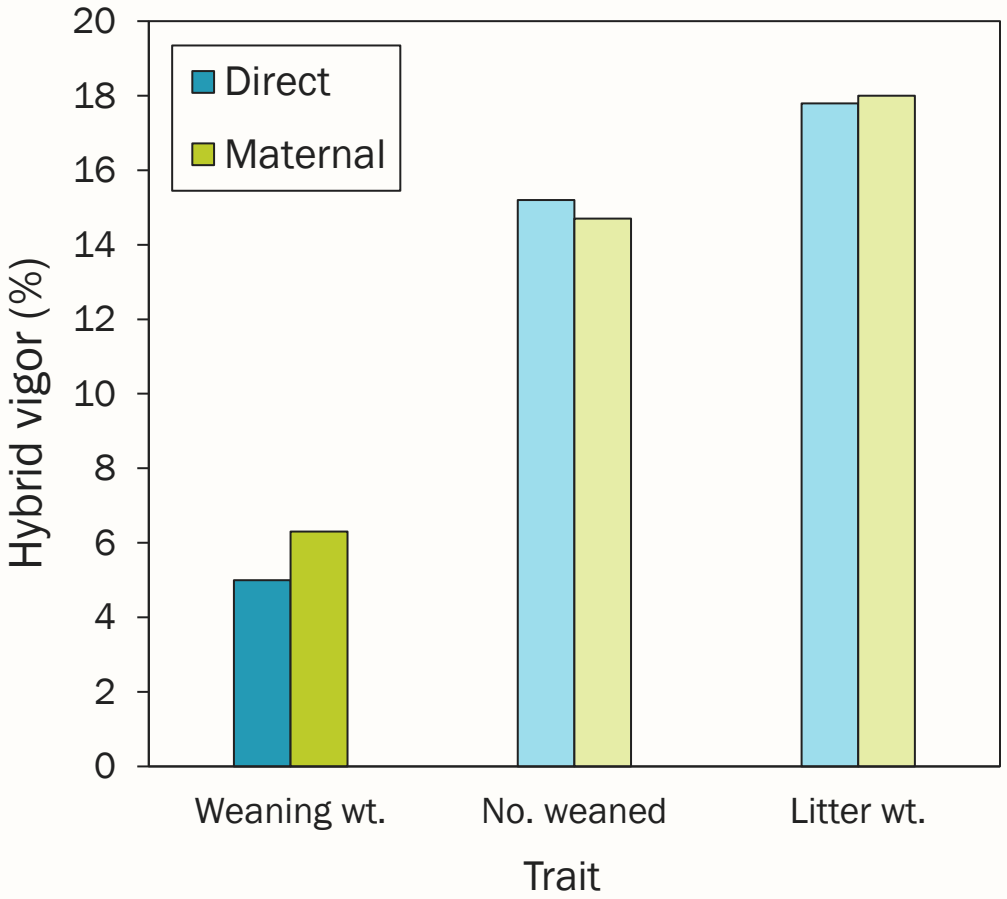
Vargas Jurado et al. (2023)

Hybrid vigor (or heterosis)

Vargas Jurado et al. (2023)



Leymaster (2002)



Using crossbreeding

- Systematic (designed) crossbreeding systems can generate substantial improvements in performance

What are the key basics?

$$P = G + E$$

- Understanding the breeder's equation
- Establishing a breeding objective or goal
- Interpreting Estimated Breeding Values (EBV)
- Defining contemporary groups
- Using crossbreeding

Thanks, and any questions?