Crossbreeding and Heterosis

ANSC327
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Fourth Lecture (Siewerdt)

Definitions

- Hybridization: mating between animals of different species; the progeny usually infertile (why?)
  - Mating a male ass (jack) with a female horse (mare) produces a **mule**
  - Mating of a male horse (stallion) with a female ass (jenny) produces a **hinny**
- Crossbreeding: mating between animals of different breeds (lines, varieties, strains)

Definitions

- Heterosis: observed increase in production of crossbred animals compared to the parental breeds

$$H = \bar{y}_{CROSSBRED} - \tfrac{1}{2}(\bar{y}_{Breed1} + \bar{y}_{Breed2})$$

$$H\% = \frac{100 \times H}{\tfrac{1}{2}(\bar{y}_{Breed1} + \bar{y}_{Breed2})}$$

Heterosis: Example

- Trait: litter size in pigs
- Landrace gilts: average of 8.6 piglets
- Large White gilts: average of 10 piglets
- Crossbred gilts: average of 11 piglets

$$H = 11 - \tfrac{1}{2}(8.6 + 10) = 11 - 9.3 = 1.7\ piglets$$

$$H\% = \frac{100 \times 1.7}{\tfrac{1}{2}(8.6 + 10)} = 18.3\%$$

Heterosis: Basis and Types

- Genetic basis for heterosis
  - (Think gene action!)
- Individual heterosis: attributed exclusively to the genes that the animal carries
- Maternal heterosis: attributed to the genes that the mothers carry that are reflected in the progeny
- Paternal heterosis: attributed to the genes of the father, reflected in the progeny

Working Example, Slide 1

- Male: Merino (M)
- Female: Suffolk (S)
- Progeny: 50% M, 50% S
  - Progeny expresses 100% individual heterosis
  - No maternal heterosis
  - No paternal heterosis
  - Maternal effects from the Suffolk breed

Working Example, Slide 2

- Male: Merino (M)
- Female: Merino x Suffolk cross
- Progeny: 75% M, 25% S
  - Progeny expresses 50% individual heterosis
  - Progeny expresses 100% maternal heterosis
  - No paternal heterosis
  - 50% of maternal effects from the Suffolk breed; other 50% from Merino

Reciprocal Cross

- Reverse male and female breeds
- No impact on direct genetic effect of progeny
- No impact on individual heterosis of progeny
- Maternal effect is different
- Reciprocal effect: basis is the difference between maternal effects of the 2 breeds

Working Example, Slide 3

- Male: Suffolk (S)
- Female: Merino (M)
- Progeny: 50% S, 50% M
  - Progeny expresses 100% individual heterosis
  - No maternal heterosis
  - No paternal heterosis
  - Maternal effects from the Merino breed

Working Example, Slide 4

- Male: Suffolk (S)
- Female: Merino x Suffolk cross
- Progeny: 75% S, 25% M
  - Progeny expresses 50% individual heterosis
  - Progeny expresses 100% maternal heterosis
  - No paternal heterosis
  - 50% of maternal effects from the Suffolk breed; other 50% from Merino

Heterosis: Key Ideas

- Always refers to <u>two</u> breeds (h_{AB})
- Not affected by reciprocal cross ($h_{AB} = h_{BA}$)
- Specific for each pair of breeds
  - e.g., with three breeds, define h_{AB}, h_{AC}, h_{BC}
- Independent of maternal effects
- Indicates feasibility of using crossbreeding as a strategy in a breeding plan
- Usually high in reproductive traits, low in production or carcass traits

Mating Systems

- Population substitution: absorption of a local breed by an exotic breed
- Exploiting complementarity: combine desirable traits of two or more breeds (additive genetics effects)
- Exploiting heterosis: allows dominance to be expressed by creating heterozygocity in the progeny

Industrial Crosses

F_1 terminal cross

- Two breeds, progeny carries 50% alleles from each breed
- A x B ➔ AB
  - 50% alleles A
  - 50% alleles B
  - 100% individual heterosis
- Use reciprocal cross?

Fixed 3-way cross

- Three breeds, progeny carries 50% alleles from one breed, 25% of other two
- C x (A x B) ➔ C(AB)
  - 50% alleles C
  - 25% alleles A
  - 25% alleles B
  - 100% individual heterosis
  - 100% maternal heterosis

Absorbing Cross

- Local breed: L
- Exotic breed: E (usually males)
- Start with E x L ➔ 50%E 50%L
- Next, E x (EL) ➔ 75%E 25%L
- Third: E x (E(EL)) ➔ 87½% E 12½% L
- Limit: 100% alleles from exotic breed
- Heterosis pattern (individual, maternal)

Rotation Cross

- Alternate use of two breeds (A, B)
- Start with A x B ➔ 50%A 50%B
- Next, B x (AB) ➔ 75%B 25%A
- Third: A x (B(AB)) ➔ 62½%A 37½%B
- Fourth: B x (A(B(AB))) ➔ 69%B 31%A
- Equilibrium ratio: 2/3 – 1/3 (higher proportion from last breed used
- Heterosis pattern (individual, maternal)