Crossbreeding (1)

Lecture 19

Introduction to Breeding and Genetics

GENE 251/351

School of Environment and Rural Science (Genetics)
Crossbreeding: Overview

- reasons for crossbreeding
- understanding crossbreeding effects
- predicting crossbreeding effects
crossbreeding versus selection

• So far we have focused on selection
  – Improvement of a breed or population
  – Utilizing with breed variation

• Note that there is a lot of variation between breeds

• It might be quicker to improve via using other breeds
Crossbreeding Examples

2-Breed Cross

3-Breed Cross

Rotational Cross
Reasons for crossbreeding

1. Sire-Dam complementation
2. The averaging of breed effects
3. Grading up to a new breed
4. Step towards creation of synthetic/composite
5. To introduce a single gene
6. To exploit heterosis
Sire-Dam complementation

Combine the goodies of paternal and maternal breeds (or lines)

- Paternal: large, fast growth, good carcass
- Maternal: small mature size, good fertility

.........to increase the efficiency of the whole production system

Most common reason for crossbreeding

use of terminal sire breeds (Poll Dorset, White Suffolk)
paternal lines in pigs and poultry
Breed averaging

- has good characteristics from different (extreme) breeds
  - Dairy breed x Beef breed to make a dual purpose
  - Being intermediate for each trait might be more profitable overall

.........to increase the efficiency of each animal in the production system
Upgrading

• Gradually cross with a better breed
  
  A * B
  A x AB
  A x A(AB)
  A x A(A(AB))

  – “Holstein Friesianization” of many dairy breeds
Start of synthetic / composite

- Initial cross toward a synthetic

\[
\begin{align*}
A & \times B \\
C & \times AB \\
C & \times C(AB) \\
A & \times C(C(AB))
\end{align*}
\]
To introduce a single gene

**Introgression**

- Such is much easier when there is a marker for the single gene

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**Examples**

- Booroola gene in local breed
- Brahman breed over European breeds to introduce tick resistance
- Litter size major gene from the Meishan breed in pigs

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**Diagram:**

- **Commercial Recipient Breed**
- **Donor Breed**
- **F1**
- **Backcross**
- **Intercross**
- **Ongoing breed improvement**

**Legend:**

- \( T = 1 \) \( 2 \) \( 3 \) \( 4 \)
- Red dot = major gene
- Backcrossing to remove background genes of donor breed
To exploit heterosis

• Hybrid vigour for crossbred animals

• Usually more for traits related to ‘fitness’
  – Reproduction, adaptability, disease resistance etc.
  – Or...for traits that show more dominance

• Expect more heterosis if breeds are more apart
Annual Milk production per cow in Pakistan

- Sahiwal: 1200
- Friesian: 1600
- First Cross: 1800
- Further cross (50%): 1500
Annual Milk production per cow in Pakistan

Breed mean

- Sahiwal: 1200
- Friesian: 1600
- First Cross: 1800
- Further cross (50%): 1500

heterosis
A need to know the genetic basis of heterosis ...

<table>
<thead>
<tr>
<th>GENOTYPE</th>
<th>MERIT</th>
<th>=</th>
<th>Average of parental breeds</th>
<th>+</th>
<th>Heterosis</th>
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<tr>
<td>Breed A</td>
<td>10</td>
<td>=</td>
<td>10</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Breed B</td>
<td>12</td>
<td>=</td>
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<td>+</td>
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</tr>
<tr>
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<tr>
<td>A x (A x B)</td>
<td>?</td>
<td>=</td>
<td>10.5</td>
<td>+</td>
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We are able to predict this
Dominance and epistasis cause heterosis

**DOMINANCE** - wider genetic base leads to better performance. Eg. Two isozymes that operate efficiently at two different body temperatures might confer higher fitness to heterozygotes in a variable environment.

**EPISTASIS** - breakdown of favourable interactions leads to loss of performance. Potential to create animal that are “out of harmony” with themselves.
Dominance model of heterosis

Purebreed "A"

Genes from sire: A A A A A A A A
Genes from dam : A A A A A A A A

Heterosis expression = 0%

F₁ cross "A x B"

Genes from sire: A A A A A A A A
Genes from dam : B B B B B B B B

Heterosis expression = 100%
Dominance model of heterosis

F₂ cross
"(AxB) x (AxB)"
Genes from sire: A A B B A A B B
Genes from dam: A B A B A B A B

Heterosis expression = 50%

Backcross
"A x (AxB)"
Genes from sire: A A A A A A A A
Genes from dam: A B A B A B A B

Heterosis expression = 50%

3 breed cross
"C x (AxB)"
Genes from sire: C C C C C C C C
Genes from dam: A B A B A B A B

Heterosis expression = 100%
<table>
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<th>How much heterosis?</th>
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<tr>
<td>Purebreds</td>
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<tr>
<td>F1</td>
<td>100%</td>
</tr>
<tr>
<td>F2</td>
<td>50%</td>
</tr>
<tr>
<td>Backcross</td>
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We are able to predict this
Summary