Crossbreeding to Improve Productivity
ASI Young Entrepreneur Meeting

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The Evolution of Modern Animal Breeding

• Purebred sires (1950s)
• Performance recording and ram tests (1950s and 1960s)
• Structured crossbreeding (1960s)
• New breed introductions (1970s)
• EPDs (1980s)
• Genomics (21st Century)
The Evolution of Modern Animal Breeding

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INTEGRATION OF THE TOOLS
The Evolution of Modern Animal Breeding

• Purebred sires (1950s)
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• EPDs / EBVs (1980s)
• Genomics (21st Century)

INTEGRATION OF THE TOOLS (Still Waiting!)
The History of Western Range Sheep is a History of Crossbreeding
Columbia (1912-1920)

The need: Larger, heavier lambs

The approach: Cross fine-wool ewes with long-wool rams

Today: Lots of emphasis on size
Continued emphasis on wool
White-faced Terminal Sire breed
Used to increase ewe size for heavy-lamb production
Large-Framed Lincoln Ram
Columbia (1912-1920)

The need: Larger, heavier lambs
The approach: Cross fine-wool ewes with long-wool rams
Today: Lots of emphasis on size
Continued emphasis on wool
White-faced Terminal Sire breed
Used to increase ewe size for heavy-lamb production
Targhee (1926-1938)

The need: Stabilize the long-wool contribution at ~25%
Create a true dual-purpose meat-wool ewe breed

The approach: Crosses of Rambouillet, Corriedale, Lincoln, & Columbia

Today: Dual-purpose meat-wool breed
Moderate size
**Polypay (1968-1980)**

The need: Greater lamb production potential
Higher prolificacy & enhanced out-of-season breeding
Acceptable fleeces and good carcasses

The approach: Cross Rambouillet, Targhee, Finnsheep and Dorset

Today: Mostly used in Midwest intensive and semi-intensive production
Popular in accelerated lambing programs
Katahdin (1960-1986)

The need: Easy-care ewe type
Climate adaptation for warm, humid parts of the country
Parasite resistance & no shearing

The approach: Cross temperate wool and Caribbean hair breeds
(Suffolk, Virgin Island White, Wiltshire Horn)
Fecal egg count EBVs

Today: One of the fastest growing US breeds
Siremax (1993-2001)

The need: High-fitness, high-performance terminal-sire breed
Lean growth, commercial fitness, and longevity
Selection based on objective performance records

The approach: Cross Suffolk, Columbia, Texel, and Hampshire
Select for growth and loin eye area using EBVs

Today: Increasingly popular as a crossbreed terminal-sire breed
*Leaders* in Performance-Based Genetic Improvement

**Targhee**

Western Range Index

**Katahdin**

Katahdin Ewe Productivity Index

**Siremax**

Carcass Plus Lean Growth Index

Polypay Ewe Productivity Index
Other Sheep Composites

- Various other Suffolk-Columbia-Texel-Hampshire composites
- Tamarack Prolific (uses the Booroola gene)
- Rafter 7 Composite (Australian Merino-Rambouillet)
- US MARC Composites:
  - Composites I, II, and III (all gone now)
  - Easy-Care Composite (50% Romanov, 25% White Dorper and 25% Katahdin)
WHY Crossbreed???

• To Optimize Gene Frequencies
  – Mix strengths of different breeds to create something that is needed but may not currently exit
  – Allows focus on Maternal Traits in the ewe flock and Growth and Carcass Value in the sires.

• To Utilize Heterosis
  – Important, positive effects on performance in both the crossbred lamb and the crossbred ewe.
# Average Heterosis in Crossbred Lambs

<table>
<thead>
<tr>
<th>Trait</th>
<th>Level of heterosis (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight</td>
<td>3.2</td>
</tr>
<tr>
<td>Weaning weight</td>
<td>5.0</td>
</tr>
<tr>
<td>Postweaning daily gain</td>
<td>6.6</td>
</tr>
<tr>
<td>Yearling weight</td>
<td>5.2</td>
</tr>
<tr>
<td>Conception rate</td>
<td>2.6</td>
</tr>
<tr>
<td>Prolificacy (litter size) of the dam</td>
<td>2.8</td>
</tr>
<tr>
<td>Survival, birth to weaning</td>
<td>9.8</td>
</tr>
<tr>
<td>Carcass traits</td>
<td>~ 0</td>
</tr>
<tr>
<td>Lambs born per ewe exposed</td>
<td>5.3</td>
</tr>
<tr>
<td>Lambs weaned per ewe exposed</td>
<td>15.2</td>
</tr>
<tr>
<td>Weight of lamb weaned per ewe exposed</td>
<td>17.8</td>
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</tbody>
</table>
### Average Heterosis the Crossbred Ewes

<table>
<thead>
<tr>
<th>Trait</th>
<th>Level of heterosis (%)</th>
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<tbody>
<tr>
<td>Fertility</td>
<td>8.7</td>
</tr>
<tr>
<td>Prolificacy (litter size)</td>
<td>3.2</td>
</tr>
<tr>
<td>Postweaning daily gain</td>
<td>6.6</td>
</tr>
<tr>
<td>Ewe body weight</td>
<td>5.0</td>
</tr>
<tr>
<td>Fleece weight</td>
<td>5.0</td>
</tr>
<tr>
<td>Lamb birth weight</td>
<td>5.1</td>
</tr>
<tr>
<td>Lamb weaning weight</td>
<td>6.3</td>
</tr>
<tr>
<td>Lamb survival, birth to weaning</td>
<td>2.7</td>
</tr>
<tr>
<td>Lambs born per ewe exposed</td>
<td>11.5</td>
</tr>
<tr>
<td>Lambs weaned per ewe exposed</td>
<td>14.7</td>
</tr>
<tr>
<td>Weight of lamb weaned per ewe exposed</td>
<td>18.0</td>
</tr>
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**Cumulative Heterosis from Crossbred Lamb and Crossbred Ewe**

- Weight of lamb weaned per ewe exposed: 39.0%
# Average Heterosis in Crossbred Lambs

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<td>2.8</td>
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<td><strong>Survival, birth to weaning</strong></td>
<td><strong>Up to 9.8</strong></td>
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<td>15.2</td>
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</tr>
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</tr>
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<td>------------------------</td>
</tr>
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Cumulative Heterosis from Crossbred Lamb and Crossbred Ewe

Weight of lamb weaned per ewe exposed ≥ 28.0%
Three-Breed Cross

Targhee x Merino (for example) crossbred ewes

Terminal Sire rams

3-way cross market lambs (all go to market)

1) Maximum heterosis in ewe and lamb
2) Optimal adaptation to a range environment in the ewe
3) Enhance growth, carcass merit, and value of the crossbred lamb
Three-Breed Cross

- Purchased Merino rams (for example)
- Targhee ewes (for example) x Targhee rams (to produce replacements)
- Targhee x Merino crossbred ewes x Purchased Terminal Sire rams
- 3-way cross market lambs (all go to market)
Three-Breed Cross

- Purchased Merino rams (for example)
- Targhee ewes (for example)
- Targhee x Merino crossbred ewes
- Targhee rams (to produce replacements)
- Purchased Terminal Sire rams

Breeding groups:
- Breeding group 1 (~10% of ewes)
- Breeding group 2 (~30% of ewes)
- Breeding group 3 (~60% of ewes)

3-way cross market lambs (all go to market)
Terminal Cross

Well-adapted white-faced Western range ewes

X

Purchased Terminal Sire rams

3-way cross market lambs (all go to market)
USSES Terminal Sire Breed Evaluation Cycle 1

Columbia × Composite × Suffolk × Texel → F₁ Progeny

Rambouillet
Terminal Sire Breed Evaluation
Cycle 2

Suffolk  Siremax  USSES Composite

×

F₁ Progeny

Rambouillet  Targhee  Polypay
Terminal Cross

Well-adapted whitefaced Western range ewes

- Rambouillet
- Targhee
- Merino
- Polypay
- Mutton Merino
- Columbia
Using Breed Resources to Design Crossbred Ewes

Well-adapted whitefaced Western range ewes

Rambouillet
Targhee
Merino (↓fiber diameter)
Polypay (↑lamb drop)
Mutton Merino
Columbia (↑wts of finished lambs)
Returns over feed costs as a % of the base flock for 1 additive SD change in each trait in Targhee sheep

- WW = weaning wt
- FW = fleece wt
- MM = maternal WW
- FD = ↓ fiber diameter
- YW = yearling wt
- SL = staple length
- PLC = % lamb crop born

Relative returns, %

Selection criterion

High feed costs Low feed costs
Effects of flock prolificacy on weight of lamb weaned

- High triplet survival
- Low triplet survival

Flock prolificacy, lambs born per ewe lambing

Weight of lamb weaned, kg/ewe
Average litter size of adult (4- through 6-yr-old) ewes lambing between 1992 and 2016

Western Range Index
WHY Develop New Breed???

• To Optimize Gene Frequencies
  – Mix strengths of different breeds to create something that is needed but does not currently exit

• To Utilize Heterosis
  – Without maintaining several breeds and using structured crossing
  – Composites can be managed just like pure breeds
Using Breed Resources to Design Crossbred Ewes

<table>
<thead>
<tr>
<th>Year</th>
<th>Need</th>
<th>Breed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>Targhee</td>
</tr>
<tr>
<td>1</td>
<td>Finer fleeces</td>
<td>Rambouillet</td>
</tr>
<tr>
<td>2</td>
<td>Finer fleeces</td>
<td>Rambouillet</td>
</tr>
<tr>
<td>3</td>
<td>More lambs</td>
<td>Polypay</td>
</tr>
<tr>
<td>4</td>
<td>Size</td>
<td>Columbia</td>
</tr>
<tr>
<td>5</td>
<td>Finer fleeces</td>
<td>Merino/Merino cross</td>
</tr>
<tr>
<td>6</td>
<td>Moderate size</td>
<td>Targhee</td>
</tr>
<tr>
<td>7</td>
<td>Moderate size</td>
<td>Targhee</td>
</tr>
</tbody>
</table>
**Lambs Born per Ewe Exposed**

**Ewe Lambs**
- RA: 0.3 (Weaned), 0.7 (Alive at 3 days), 2 (Born)
- PP: 1.0 (Weaned), 0.7 (Alive at 3 days), 1 (Born)

**Adult Ewes**
- RA: 1.5 (Weaned), 1.3 (Alive at 3 days), 1.5 (Born)
- PP: 1.9 (Weaned), 1.5 (Alive at 3 days), 1.9 (Born)

**Pounds of Lambs Weaned per Ewe Exposed**

**Ewe Lambs**
- RA: 13 (Weaned), 46 (Alive at 3 days), 95 (Born)
- PP: 0 (Weaned), 0 (Alive at 3 days), 109 (Born)

**Adult Ewes**
- RA: 0 (Weaned), 0 (Alive at 3 days), 0 (Born)
- PP: 0 (Weaned), 0 (Alive at 3 days), 0 (Born)
Cumulative (4-year) Number of Lambs Produced

- Born
- Alive at 3 days
- Weaned

<table>
<thead>
<tr>
<th>Dam breed</th>
<th>RA</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2 years</td>
<td>3.6</td>
<td>4.9</td>
</tr>
<tr>
<td>+31%</td>
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Cumulative (4-year) Weight of Lamb Weaned

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<tr>
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<td>218</td>
<td>270</td>
</tr>
<tr>
<td>+24%</td>
<td></td>
<td></td>
</tr>
</tbody>
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Lambs Born per Ewe Exposed

Pounds of Lambs Weaned per Ewe Exposed

Lambs Born per Ewe Lambing
Cumulative (4-year) Number of Lambs Born

Cumulative (4-year) Weight of Lamb Weaned

B)

- **RA**
  - Number of lambs: 2.9
  - Weaned: 3.6
  - Alive at 3 days: 4.9
  - Born: 5.9

- **PP**
  - Weaned: 3.8
  - Alive at 3 days: 4.9
  - Born: 5.9

- **RW-RA**
  - Weaned: 4.8
  - Alive at 3 days: 4.9
  - Born: 5.9

A)

- **RA**
  - Weight weaned: 218 lb
  - (24%)

- **PP**
  - Weight weaned: 270 lb
  - (55%)

- **RW-RA**
  - Weight weaned: 337 lb
  - (55%)
Using Breed Resources to Design Crossbred Ewes

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Making it work:
1) Reliable, performance based source flocks for all breeds
2) A reasonable knowledge of the breed effects on economically important traits
3) Some capacity to evaluate performance in commercial ewes (at least by sire breed)
4) Rigorous ewe culling on performance (at least wet vs. dry and no. born)
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INTEGRATION OF THE TOOLS (Still Waiting!)
The Genetic Improvement Pyramid

Maternal breeds

- 6,250 rams with EBVs
- 187,500 replacement ewe lambs per year

Multiplier flocks

- 312,500 ewes
- 7,250 lambings
- Supports 750,000 to 1 million breeding ewes in Commercial flocks

Elite Nucleus Flocks with EBVs

- Supports 750,000 to 1 million breeding ewes in Commercial flocks
The Genetic Improvement Pyramid

Terminal Sires

- 610 rams with EBVs
- 37,000 rams from Multiplier flocks

Multiplier flocks

- 30,500 ewes with EBVs
- 2,500 lambings

Commercial flocks

- 2 million breeding ewes with no EBVs
- 2,440 rams with EBVs

Elite Nucleus Flocks with EBVs
Leaders in Performance-Based Genetic Improvement

Targhee

Limited involvement in NSIP

Columbia

Challenged to find a common vision for the breed

Polypay

Western Range Index

Polypay Ewe Productivity Index