Genetics

Introduction
- Genetic gain in milk production through selection is approximately 150 lbs/yr
- Majority of the gain (70%) is through sire selection
- Artificial insemination and genetic improvement are closely related
  - 70% AI use in US
  - $150-200 from milk

How A.I. Bulls are Proven
- Elite Cows
- Contract Mating
- Elite Bulls
- Breeder Mating
- Decisions
- Calves Born
- Data Collected
- Enter A.I. Stud
- Heifer Calves
- Semen Collected
- Culled

Young Sires
- New bulls being collected and sampled
- Genetic merit is calculated by using average PTA values of the parents
- Takes almost 5 years before the initial proof of the young sire is released
- 1 in 10 young sires make the active list
- Total cost = $40,000-50,000

897 Bulls in Stud

A.I. Studs

<table>
<thead>
<tr>
<th>A.I. Studs</th>
<th># Bulls</th>
<th>% of Bulls</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS Global, Inc.</td>
<td>160</td>
<td>18</td>
</tr>
<tr>
<td>Select Sires</td>
<td>134</td>
<td>15</td>
</tr>
<tr>
<td>Genex/CRI</td>
<td>93</td>
<td>10</td>
</tr>
<tr>
<td>Alta Genetics</td>
<td>93</td>
<td>10</td>
</tr>
<tr>
<td>Central Valley</td>
<td>82</td>
<td>9</td>
</tr>
<tr>
<td>Taurus</td>
<td>78</td>
<td>9</td>
</tr>
<tr>
<td>Accelerated Genetics</td>
<td>70</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>710</td>
<td>79</td>
</tr>
</tbody>
</table>
Reliability (Repeatability)

- A measure of degree to which multiple measurements repeat themselves
- Measurement which is highly repeatable (0.99), need not be performed again

Select or Not Select?

- Accuracy is the correlation between predicted genetic value and the true genetic value
- \( \text{Accuracy}^2 = \text{Reliability} \)

<table>
<thead>
<tr>
<th>Daughters in Different Herds</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.25</td>
</tr>
<tr>
<td>50</td>
<td>0.88</td>
</tr>
<tr>
<td>100</td>
<td>0.93</td>
</tr>
<tr>
<td>1000</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Heritability

- Limiting factor in rate of genetic change
- Definition
  - Proportion of observed variation in a particular trait (e.g., milk yield) that can be attributed to inherited genetic factors in contrast to environmental ones
  - The higher the number on a trait, the more heritable it will be

Heritabilities

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heritability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield</td>
<td>0.25</td>
</tr>
<tr>
<td>Mature weight</td>
<td>0.50</td>
</tr>
<tr>
<td>Reproductive efficiency</td>
<td>0.10</td>
</tr>
<tr>
<td>Feed efficiency</td>
<td>0.35</td>
</tr>
<tr>
<td>Mastitis Incidence</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Breeding Value (BV)

- Part of animal’s genetic makeup transmitted to offspring
- BV = Predicted Transmitting Ability (PTA)
- Genotype
- Calculated by USDA using a procedure called the animal model
- Sire PTA determined 4x/yr by USDA
- collect production info through testing programs

Sire Breeding Value

[Graph showing sire breeding value over years from 1957 to 1997]
Genetic Base

- Reference point for genetic evaluations
- Base is defined by making the average PTA for all cows born in a certain year equal to zero
- Average PTA’s of cows born in 2000 = 0
- Evaluations are expressed relative to the base year
- Base changes every 5 years

Predicted Transmitting Ability

<table>
<thead>
<tr>
<th>Name</th>
<th>Herds</th>
<th>Daugh</th>
<th>Rel</th>
<th>Milk</th>
<th>Fat</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rudolph</td>
<td>25,809</td>
<td>98,881</td>
<td>99</td>
<td>1589</td>
<td>38</td>
<td>49</td>
</tr>
<tr>
<td>Ozzie</td>
<td>54</td>
<td>83</td>
<td>85</td>
<td>2810</td>
<td>101</td>
<td>72</td>
</tr>
<tr>
<td>Charles</td>
<td>14,936</td>
<td>46,672</td>
<td>99</td>
<td>-522</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>Jackson</td>
<td>24</td>
<td>38</td>
<td>74</td>
<td>2791</td>
<td>84</td>
<td>71</td>
</tr>
</tbody>
</table>

PTA Production

<table>
<thead>
<tr>
<th>Name</th>
<th>Milk</th>
<th>Fat</th>
<th>Protein</th>
<th>PL</th>
<th>SCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rudolph</td>
<td>1589</td>
<td>38</td>
<td>49</td>
<td>2.8</td>
<td>2.96</td>
</tr>
<tr>
<td>Ozzie</td>
<td>2810</td>
<td>101</td>
<td>72</td>
<td>0.9</td>
<td>2.85</td>
</tr>
<tr>
<td>Charles</td>
<td>-522</td>
<td>19</td>
<td>7</td>
<td>2.6</td>
<td>3.4</td>
</tr>
<tr>
<td>Jackson</td>
<td>2791</td>
<td>84</td>
<td>71</td>
<td>0</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Type Production Indexes

- Holstein TPI
  - PTA Protein: PTA Fat: Type: UC: FL
  - 3:1:1:0.65:0.35
- Jersey - JPI
  - PTA Protein: PTA Fat: Functional Trait Index: PL: Functional Udder Index: SCS
  - 10:4:3:1:1:1
- Other color breeds use PTI

Merit Indexes (Lifetime Profit)

- Merit ($) = Yield$ + Udder$ + Other$
- Net Merit
- Fluid Merit
- Cheese Merit
- Yield $ - Milk, fat, and protein lbs
- Udder $ - somatic cell score (SCS) and udder composite (UC)
- Other $ - Productive life (PL), body size composite (BSC), and feet and legs (F&L)

Merit Indexes

<table>
<thead>
<tr>
<th>Name</th>
<th>NM</th>
<th>FM</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rudolph</td>
<td>454</td>
<td>448</td>
<td>461</td>
</tr>
<tr>
<td>Ozzie</td>
<td>680</td>
<td>768</td>
<td>668</td>
</tr>
<tr>
<td>Charles</td>
<td>105</td>
<td>-50</td>
<td>141</td>
</tr>
<tr>
<td>Jackson</td>
<td>573</td>
<td>664</td>
<td>559</td>
</tr>
</tbody>
</table>
Which Index?

<table>
<thead>
<tr>
<th>Protein Differential (cents/0.1%)</th>
<th>Merit Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 9</td>
<td>FM</td>
</tr>
<tr>
<td>10 to 25</td>
<td>NM</td>
</tr>
<tr>
<td>&gt;26</td>
<td>CM</td>
</tr>
</tbody>
</table>

- Pacific NW average = 0.17/0.1%

Relative Net Income

- Yield traits are strongly related (+) to relative net income (RNI) and productive life (PL).
- Dairy Form is the only linear trait with a positive relationship to RNI.
- Stature, Strength, FU Attachment and Udder Depth are negatively related to RNI. (these traits associated with less $ income over lifetime of the cow)

Function Type

- Conformation required for high producing cows
- Traits include
  - Udder: Cleft, attachments, teat placement, depth
  - Feet and legs: Pastern, depth of heel, set of leg

Type Scores

- PTA Type (PTAT) = daughters expected to score x points higher than bull with PTA Type = 0
- UDC = udder composite score - ability for udder improvement
- FL = Feet & Legs - ability for feet and leg improvement

How to Select Sires?

- Define your market
- Stay within 90th percentile if possible
- Use tools to evaluate sire (TPI, NM$...)
- Dams of sires have high milk yield and linear score
- Sires of sires generally have high NM$ and PTA type
- So when you select for one your selecting for the other
How Many Bulls?

- 1 bull can maximize potential results......
  BUT can increase your risks
- Recommendation:
  - Use 5-15 bulls/200 cow herd
  - Use 6-20 young bulls/200 cow herd

Who Scores Cows?

- Breed organizations
  - Holstein, Jersey, Brown Swiss
- Holstein calculates PTA Type for Holstein bulls
- USDA calculates PTA Type for colored breeds

Classification

- Sorts cows into groups based upon conformation
  - Excellent >90
  - Very Good 85-89
  - Good Plus 80-84
  - Good 75-79
  - Fair 65-74
  - Poor <65

Breakdown of Traits

- Mammary System (40%)
- Dairy Character (20%)
- Feet & Legs (15%)
- Frame (15%)
- Body Capacity (10%)

Classification

- Udder (92 pts x 40%) 37.6
- Dairy Character (86 pts x 20%) 17.20
- Feet & Legs (82 pts x 15%) 12.30
- Frame (83 pts x 15%) 12.45
- Body Capacity (84 pts x 10%) 8.4
- Final Score 88

Inbreeding

- Mating of related individuals
- Inbred animals become homozygous
- Lifetime net income -$24/1% inbreeding
- US Holsteins about 5% inbred
- US Jerseys about 7% inbred
Inbreeding

- Pawnee Farm Arlinda Chief and Round Oak Rag Apple Elevation accounted for nearly one fourth of all genes in Holstein cattle in 1990.

Calculating Inbreeding

\[ \sum \frac{1}{2^{n+1}} \]

- \( \sum \) is Greek for summation
- \( n \) is the number of generations in each pathway connecting the parents of offspring through a common ancestor
- Ex: Mating sire to daughter
- \( \frac{1}{2^{1+1}} = \frac{1}{4} = 0.25 \)

- Inbreeding Calculator (Holstein USA)

Inbreeding

- Bad Things
  - Depression of milk, fat and protein
  - In Holsteins, each 1% increase in inbreeding, an average decrease 60 pounds of milk occurs
  - Increased expression of deleterious diseases
    - SMA, BLAD, Mule-Foot

Inbreeding

- Good Things
  - Genotypes of inbred individuals are more predictable because of a more uniform gene pool

It’s only considered inbreeding when the mating doesn’t work!!
### Sires of Sires (Holstein)

<table>
<thead>
<tr>
<th>Sire</th>
<th># of Bulls in Stud</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duster</td>
<td>44</td>
</tr>
<tr>
<td>Bellwood</td>
<td>36</td>
</tr>
<tr>
<td>Rudolph</td>
<td>36</td>
</tr>
<tr>
<td>Aerostar</td>
<td>31</td>
</tr>
<tr>
<td>Patron</td>
<td>27</td>
</tr>
<tr>
<td>Elton</td>
<td>26</td>
</tr>
<tr>
<td>Mandel</td>
<td>26</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>684</strong></td>
</tr>
</tbody>
</table>

### MG Sires of Sires

<table>
<thead>
<tr>
<th>Sire</th>
<th># MG Bulls in Stud</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackstar</td>
<td>76</td>
</tr>
<tr>
<td>Mascot</td>
<td>59</td>
</tr>
<tr>
<td>Aerostar</td>
<td>43</td>
</tr>
<tr>
<td>Mark</td>
<td>43</td>
</tr>
<tr>
<td>Leadman</td>
<td>40</td>
</tr>
<tr>
<td>Elton</td>
<td>38</td>
</tr>
<tr>
<td>Rockie</td>
<td>23</td>
</tr>
</tbody>
</table>

### TO-MAR BLACKSTAR-ET

- Born 5/17/83
- Semen released 4/10/84
- 18 sons in stud
- 196 grandsons in stud
- Genetic equivalent of 50 sires
- 7.4% of active Holstein sires

### Options for Reducing Inbreeding

- Knowledge of pedigree
- Inbreeding usually occurs within the 3-4 generation
- Programs offered through breed organizations
  - Red Book, Kinship values
  - “Outcross” sires
    - Bulls not directly from the elite cow families
    - Rare and usually unable to compete for rankings in production and type
- Crossbreeding
  - Mating two individuals from two different breeds

### What is the most common cross?

- Crockett Farms ADAM -ET

**Holstein Sire x Jersey Dam**