GENETIC IMPROVEMENT FOR FORAGE USE

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University of Nebraska

GENETIC IMPROVEMENT PRINCIPLES FOR THE COWHERD

Spangler’s interpretation

Qualifications

- Fertile at a young age
- Short post-partum interval
- Maternal calving ease
- Adapted to stress
- Optimal milk
- Optimal docility
- Efficient grazer (i.e. maintains body condition)
Kinds of Efficiency

- **Feed Efficiency**
  - To some defined endpoint
- **Metabolic Efficiency**
  - Maintenance requirement
- **Production Efficiency**
  - Output at some endpoint given inputs to the point
- **Economic Efficiency**
  - Value of output given input costs

Importance of Feed Efficiency

- Feed costs = 66% in calf feeding systems
- Feed costs = 77% in yearling finishing systems
  - Anderson et al. 2005
- 10% improvement in gain = +18% profit
- 10% improvement in efficiency = +43% profit
  - Fox et al. 2001
- Efficiency increases have 7-8 times the economic impact of comparable increases in gain
  - Okine et al. 2004
Understanding the components of feed efficiency

- More efficient cattle may have improved digestion or metabolism of nutrients, or
- More efficient cattle may utilize absorbed nutrients more efficiently

What Role Does Genetics Play?

<table>
<thead>
<tr>
<th></th>
<th>ADG</th>
<th>DMI</th>
<th>RFI</th>
<th>G:F</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG</td>
<td>0.26</td>
<td>0.56</td>
<td>-0.15</td>
<td>0.31</td>
</tr>
<tr>
<td>DMI</td>
<td>0.40</td>
<td>0.66</td>
<td>-0.60</td>
<td></td>
</tr>
<tr>
<td>RFI</td>
<td>0.52</td>
<td>-0.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G:F</td>
<td>0.27</td>
<td></td>
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<td></td>
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</tbody>
</table>

Defining Efficiency for Cow Herd

- Lbs of calf weaned per cow exposed
  - Conception rate, calving rate, calf survival, lactation, growth to weaning
- Lbs. of calf weaned per cow exposed per unit energy consumed
  - Conception rate, calving rate, calf survival, lactation, growth to weaning, energy consumed
- Calf value ($) per $100 input cost
- Much work to be done…
“Anytime the matter of cow efficiency becomes overwhelmingly complex, we should revert to basics..."  

Profit = Wean. Wt. x % calf crop x $/lb X # of cows – annual cost of cow-calf operation"  

---Dr. Robert Totusek, Oklahoma State University---

Improving Efficiency

- [Dam Weight*Lean Value of Dam + No. Progeny*Progeny Weight*Lean Value of Progeny] - [Dam Feed*Value of Feed for Dam + No. Progeny*Progeny Feed*Value of Feed for Progeny].

- By simply increasing number of progeny per dam through either selection, heterosis from crossing, or better management, we will increase efficiency of production.

Problem...

We do a very poor job of measuring (and valuing) input
Life cycle energy intake/kg edible product

- Efficiency of growth in cows is NOT the target
- Maintenance requirement and efficiency are the target

Dickerson, 1978

Maintenance Energy Requirement

<table>
<thead>
<tr>
<th>High Maintenance</th>
<th>Low Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>High milk production</td>
<td>Low milk production</td>
</tr>
<tr>
<td>High visceral organ weight</td>
<td>Low visceral organ weight</td>
</tr>
<tr>
<td>High body lean mass</td>
<td>Low body lean mass</td>
</tr>
<tr>
<td>Low body fat mass</td>
<td>High body fat mass</td>
</tr>
<tr>
<td>High output</td>
<td>Low output</td>
</tr>
<tr>
<td>High input</td>
<td>Low input</td>
</tr>
</tbody>
</table>

Animal Nutrient Requirements

Effect of Cow Body Size

K.C. Olson, 2005
Animal Nutrient Requirements

Effect of Milk Production Level and Pregnancy

![Graph showing metabolizable energy requirements for different milk production levels and pregnancy stages.](image)

K.C. Olson, 2005

<table>
<thead>
<tr>
<th>Cow Size</th>
<th>Milking Level</th>
<th>lb of milk/lb cow/day</th>
<th>lb TDN Needed</th>
<th>lb CP Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>Average</td>
<td>10</td>
<td>12.4</td>
<td>1.9</td>
</tr>
<tr>
<td>1000</td>
<td>Above Avg</td>
<td>20</td>
<td>14.8</td>
<td>2.6</td>
</tr>
<tr>
<td>1000</td>
<td>Superior</td>
<td>30</td>
<td>17.2</td>
<td>3.5</td>
</tr>
<tr>
<td>1200</td>
<td>Average</td>
<td>10</td>
<td>13.8</td>
<td>2.1</td>
</tr>
<tr>
<td>1200</td>
<td>Above Avg</td>
<td>20</td>
<td>16.2</td>
<td>2.8</td>
</tr>
<tr>
<td>1200</td>
<td>Superior</td>
<td>30</td>
<td>18.7</td>
<td>3.5</td>
</tr>
<tr>
<td>1400</td>
<td>Average</td>
<td>10</td>
<td>15.2</td>
<td>2.3</td>
</tr>
<tr>
<td>1400</td>
<td>Above Avg</td>
<td>20</td>
<td>17.6</td>
<td>3.0</td>
</tr>
<tr>
<td>1400</td>
<td>Superior</td>
<td>30</td>
<td>20.1</td>
<td>3.7</td>
</tr>
</tbody>
</table>


Effect of Mature Weight and Milk Potential on ME Required

![Bar graph showing the effect of mature weight and milk potential on metabolizable energy required.](image)

↑ 27% Wt.
↑ 16% Milk
Economic Efficiency
van Oijen et al. (1993)

<table>
<thead>
<tr>
<th>Low</th>
<th>Med.</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weaning</td>
<td>496.40</td>
<td>493.60</td>
</tr>
<tr>
<td>Slaughter</td>
<td>810.1</td>
<td>808.40</td>
</tr>
<tr>
<td><strong>Expense</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weaning</td>
<td>549.80</td>
<td>553.40</td>
</tr>
<tr>
<td>Slaughter</td>
<td>814.20</td>
<td>837.50</td>
</tr>
<tr>
<td><strong>Econ. Eff.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weaning</td>
<td>90.3</td>
<td>89.2</td>
</tr>
<tr>
<td>Slaughter</td>
<td>99.5</td>
<td>96.5</td>
</tr>
</tbody>
</table>

Genetic Trends for Milk, lbs.

Adapted from Spring 2009 Genetic Trends from Breed Associations and 2011 AB-EPD factors

Input EPD (or Indexes)

- Angus $EN$
- Maintenance energy (ME)
- Red Angus
- Uses mature weight (corrected for BCS) and milk*

**EXAMPLE**
Bull A +10
Bull B +0

Daughters from bull A should require 10 Mcal/mo. more than those of Bull B (about 11-20 lbs. of forage per month)
Biological type

<table>
<thead>
<tr>
<th>Production Environment</th>
<th>Traits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feed Availability</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Adapted from Gosey 1994.

Cow Efficiency of Breeds Fed at Differing Levels of Dry Matter

Low Feed Environment

Jenkins and Ferrell 1994. JAS 72:2787

1,000 kg/yr ~ 22 lb/d
2,000 kg/yr ~ 44 lb/d
3,000 kg/yr ~ 66 lb/d
8,000 kg/yr ~ 176 lb/d
10,000 kg/yr ~ 220 lb/d

A cow with high production potential has no energy leftover for reproduction

A cow with low production potential has extra energy for lactation and reproduction

Dunn et al., 2010
A cow with low production potential can’t put the extra energy into milk or calf growth. She just gets fatter.

A cow with high production potential puts the extra energy into lactation.

Webster Definition: OPTIMUM

1: the amount or degree of something that is most favorable to some end; especially: the most favorable condition for the growth and reproduction of an organism

2: greatest degree attained or attainable under implied or specified conditions

Genetic Trends for Weaning Weight, lb

Adapted from Spring 2012 Genetic Trends from Breed Associations and 2012 AB-EPD factors (Kuehn and Thallman, 2012)
Genetic Trends for Yearling Weight, lb

Growth—Related to Mature Size

<table>
<thead>
<tr>
<th>MW</th>
<th>MWV</th>
<th>YW</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.57</td>
<td>0.62</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Northcutt and Wilson, 1993

Mature Size and Carcass

<table>
<thead>
<tr>
<th>MW</th>
<th>HT</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCWT</td>
<td>0.81</td>
<td>0.89</td>
</tr>
<tr>
<td>BW</td>
<td>-0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>FAT</td>
<td>-0.02</td>
<td>-0.16</td>
</tr>
<tr>
<td>LMA</td>
<td>0.34</td>
<td>0.25</td>
</tr>
<tr>
<td>MARB</td>
<td>-0.15</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

Nephawe et al., 2004
Relationship Between Cow Wt. and Adj. 205d Calf Wt.- ARK

- Increase Cow Wt. 100 lb. increases calf wt 15 lb.

Gadbrey et al., 2006

Individual Performance vs. Herd Level Performance

Efficiency has to be viewed from an operation standpoint and not from a per cow or per steer basis. – Steve Radakovich at Beef Cow Efficiency Forum, 1984

Mature Weight of Cows

Average Calf Weaning Weight
“Thus, as we strive to improve growth rate in the cattle industry and to make the commercial cow more efficient from the standpoint of utilizing nutrients, we must insure that we do not deviate from the goal of maintaining an optimum level of reproductive efficiency.”
—Dr. Larry R. Corah, K-State

Relative Economic Weights for Integrated Beef Firm

Reproduction: Growth: End Product

2:1:1

(Melton, 1995)

Measures of Reproduction

- Heifer pregnancy
  - Bull A +10
  - Bull B +6
  
  Daughters from Bull A are 4% more likely to become pregnant and have a calf as first calf heifers.
- Stayability (Longevity)
  - Bull A +14
  - Bull B +8
  
  Daughters from Bull A are 6% more likely to stay in the herd until age 6.
Calving Ease

- Maternal calving ease
- No assistance needed at calving

<table>
<thead>
<tr>
<th>Calving Ease Score</th>
<th>Decrease in Conception*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3%</td>
</tr>
<tr>
<td>3</td>
<td>11%</td>
</tr>
</tbody>
</table>

* 90 days post-partum

Spangler et al., 2006

Multiple-Trait Selection

- Bio-Economic Index Values
  \[ H = EPD_{a1} + EPD_{a2} + EPD_{a3} + \ldots \]
- Angus, Charolais, Gelbvieh, Hereford, Limousin, Simmental
- Both maternal and terminal index values
- The best widely available method

Terminal or Maternal?

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Maternal</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B$, $F$, $G$ (Angus)</td>
<td>$W$, $EN$</td>
</tr>
<tr>
<td>$T I$ (Simmental)</td>
<td>$API$</td>
</tr>
<tr>
<td>$CHB$ (Hereford)</td>
<td>$B M I$, $B I I$, $C E Z$</td>
</tr>
<tr>
<td>$M T I$ (Limousin)</td>
<td></td>
</tr>
<tr>
<td>$F M$ and $C V$ (Gelbvieh)</td>
<td></td>
</tr>
<tr>
<td>Charolais</td>
<td></td>
</tr>
</tbody>
</table>
Heterosis

- Hybrid Vigor
- Superiority of a crossbred animal as compared to the average of its straightbred parents
- More divergent parental lines = more heterosis
- NOT available from within breed matings

Why Crossbreed?

- Breed Complementarity
  - There's not a breed that's the best at everything
- Capture dominance and epistasis
  - Heterosis (hybrid vigor)
- Dramatically improve production efficiency at the cow-calf level

Inversely Related

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heritability</th>
<th>Heterosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reproduction (fertility)</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Production (growth)</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Product (carcass)</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>
Adapted from Cundiff and Gregory, 1999.

Advantages of the Crossbred Cow

<table>
<thead>
<tr>
<th>Trait</th>
<th>Observed Improvement</th>
<th>% Heterosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longevity</td>
<td>1.36</td>
<td>16.2</td>
</tr>
<tr>
<td>Cow Lifetime Production:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. Calves</td>
<td>0.97</td>
<td>17.0</td>
</tr>
<tr>
<td>Cumulative Wean. Wt., lb.</td>
<td>600</td>
<td>25.3</td>
</tr>
</tbody>
</table>

“Missing” Homozygotes

Harmful recessive effects on fertility detected by absence of homozygous haplotypes.

Predicting Crossbred Animals
Summary
- Concentrate on Economically Relevant Traits (ERTs)
- Understand the differences between sources of information
- Know that EPDs and Economic Index values are more valuable than actual records or ratios
  - EPD 7-9 times more effective in generating response to selection than actual measurements

Summary
- Know your costs
  - Select on PROFIT not just revenue
- Multiple trait selection is critical and could become more cumbersome
  - Economic indexes help alleviate this
  - Use index values that meet your breeding objective

Thank You!
- http://beef.unl.edu
- www.nbcec.org
- www.beefefficiency.org