Uses of DNA information on Commercial Cattle Ranches

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Overview

- **What is working well**
  - Identification of recessive/single trait defects
    - Coat color
    - Horned
    - Genetic defects
  - Parentage

- **What is not working so well**
  - DNA tests for selection

- **What does the future hold?**
  - Tests that work across breeds?
Using DNA information to identify carriers of recessive traits

Images from an article by David S. Buchanan, Department of Animal Sciences, North Dakota State University

Compare dwarfism response in the 50s to the response to curly calf (AM)

An early '50's advertisement that superimposed a measuring stick in the picture of this bull who was nick-named "Short Snorter."

Based upon his height and age, he was less than a frame score 1.

Image from https://www.msu.edu/~ritchieh/historical/shortsnorter.jpg
A 1956 survey of Hereford breeders in the USA identified 50,000 dwarf-producing animals in 47 states. Through detailed pedigree analysis and test crosses, the American Hereford Association, in concert with breeders and scientists, virtually eliminated the problem from the breed. Because carrier status was difficult to prove and required expensive progeny testing, some entire breeding lines were eliminated.
Curly calf – Arthrogryposis multiplex

- From a scientific standpoint, AM is the complete deletion of a segment of DNA that encompasses two different genes.
- One of these genes is expressed at a crucial time in the development of nerve and muscle tissue. The mutation results in no protein being produced from this gene and therefore it is unable to carry out its normal function so homozygotes show phenotype.
- Dr. David Stefan of the University of Nebraska and Dr. Jon Beever of the University of Illinois worked to develop a genetic test from September – October, 2008.
From September 8 – November 3, 2008 identified genetic problem, developed test, and released carrier status of 736 bulls!

- In the 10 months following the release of the test, the AAA posted the results of tests for AM on about 90,000 cattle.

- These AM test costs less than $30.

- Of these, almost 5,000 bulls and more than 13,000 heifers have tested as carriers of AM. That leaves more than 22,000 bulls and more than 50,000 heifers which tested as free of AM.

From: Buchanan, D.S. Genetic Defects in Cattle.
Early extension education about dwarfism explaining carriers and inheritance

Image from Special Collections University Libraries, Virginia Tech: http://spec.lib.vt.edu/imagebase/agextension/boxseven/screen/AGR3618.jpg
If you breed a curly calf carrier cow (AMC) to an curly calf free bull (AMF), what is the chance that the offspring will be stillborn as a result of being curly calf?

1. 0
2. $\frac{1}{4}$ (25%)
3. $\frac{1}{2}$ (50%)
4. $\frac{2}{3}$ (66%)
5. $\frac{3}{4}$ (75%)
6. 1 (100%)

Results from a typical producer meeting
<table>
<thead>
<tr>
<th>DATE</th>
<th>AM</th>
<th>NH</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognized as genetic defect</td>
<td>November 15, 2008</td>
<td>June 12, 2009</td>
<td>July 14, 2010</td>
</tr>
<tr>
<td>Commercial test becomes available</td>
<td>January 1, 2009</td>
<td>June 15, 2009</td>
<td>October 4, 2010</td>
</tr>
<tr>
<td>Number of carriers recorded (current as of March 2011)</td>
<td>34,653</td>
<td>32,193</td>
<td>5,088</td>
</tr>
<tr>
<td>HEIFERS: Must test &amp; all can register if born before or on December</td>
<td>December 31, 2011</td>
<td>June 14, 2012</td>
<td>October 4, 2013</td>
</tr>
<tr>
<td>31, 2011</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HEIFERS: Only non-carriers can be registered if born on or after</td>
<td>January 1, 2012</td>
<td>June 15, 2012</td>
<td>October 5, 2013</td>
</tr>
<tr>
<td>BULLS: Must test &amp; all can register if born before or on December 31</td>
<td>December 31, 2009</td>
<td>June 14, 2010</td>
<td>October 4, 2011</td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BULLS: Only non-carriers can be registered if born on or after</td>
<td>January 1, 2010</td>
<td>June 15, 2010</td>
<td>October 5, 2011</td>
</tr>
</tbody>
</table>
“How do you make cost-effective use of DNA information in commercial animal production?”

GOAL: Determine how DNA-based information is best incorporated into commercial cattle production systems

1. Which of several incorporation methods is best?
2. Which is feasible for commercial ranches to use?
3. Which provides the most/any economic benefit?

Research objectives: Determine association between breed-association genetic predictions (EPDs), and DNA-based genetic predictions (stars, scores, MBVs, MVPs, GEPDs) and evaluate their ability to predict the genetic potential of 125 commercial sires based on the performance and carcass records of their offspring
USDA-funded project entitled: “Integrating DNA information into beef cattle production systems”

Four ranches on this project (UC Davis and 3 commercial cooperators in Siskiyou Co.)

- Cowley 900 (550 Spring; 350 Fall) 45
- Kuck 500 (200 Spring; 300 Fall) 16
- Mole-Richardson 700 (Fall) 40
- UC Davis 300 (Fall) 26

Approximately 125 Angus bulls, and 2,400 cows per year on project
Happy Cows come from Siskiyou County
Work flow and collaborators

- DNA on all bulls goes for 50K whole genome scan – collaboration with Jerry Taylor (MO) and John Pollak (Meat Animal Research Center (NE))
- Molecular breeding value (MBV) prediction of genetic merit based on MARC training data set – collaboration with Dorian Garrick (IA) and Mark Thallman, U.S. Meat Animal Research Center (NE)
- Ranch data including sire groupings, birth dates and weaning weights on all calves, all EIDed, and “DNAed” for parentage determination – collaboration with Dan Drake and producers (CA)
- Steer feedlot in weights, treatments, and carcass traits (Hot weight, grading information and meat sample collected in the processing plant – collaboration with Harris Ranch (CA)
- Compile data and compare three sources of genetic estimates: breed EPDs (bEPDs), commercial ranch EPDs (rEPDs), and MBVs, Kristina Weber, UC Davis, PhD student
Commercial ranch applications
A key issue in commercial situations is ease of DNA sampling, tracking and quality of resultant DNA.
Sampling Summary: Total

- **BirthWeight**: 53% done, 1001 records completed, 870 records sampled in 2011-2013.
- **WeanWeight**: 45% done, 2767 records completed, 3320 records sampled in 2011-2013.
- **In weight**: 42% done, 2091 records completed, 2901 records sampled in 2011-2013.
- **Carcass traits**: 48% done, 2117 records completed, 2540 records sampled in 2011-2013.
Benefits of DNA-based parentage identification

- Correct pedigree errors thereby improving the rate of genetic gain
- Enables the use of multi-sire breeding pasture
  - Higher fertility
  - Elimination of sire failure
  - Tighter calving season
- Reduces the need for different breeding pastures
  - Allows for better pasture management
  - Less sorting and working of animals into different groups
- Reduces the need to disturb newborn animals
  - Labor savings so can focus on concentrate on offspring survival
  - Worker safety improvement
  - Better bonding of offspring with dam
- Enables the development of commercial-ranch genetic evaluations

Calf output per bull

Late (61+ days)

Later (31-60 days)

Early (1-30 days)
Total gross income from steers derived from 5 calf crops from 16 commercial bulls.
DNA-based tests for cattle

What is working well
  – Identification of genetic defects
  – Parentage

What is not working so well (at present)
  – DNA tests for selection
The Power of the IGENITY® profile for Angus

The American Angus Association® through its subsidiary, Angus Genetics Inc.® (AGI), has a vision to provide Angus breeders with the most advanced solutions to their genetic selection and management needs.

Genomic-enhanced Expected Progeny Differences (EPDs) can now be calculated for your animals using the highly predictable American Angus Association database along with IGENITY® profile results to provide a more thorough characterization of economically important traits and improved accuracy on young animals.

Using the IGENITY profile for Angus, breeders receive comprehensive genomic results for multiple, economically important traits.

1. Dry Matter Intake
2. Birth Weight
3. Mature Height
4. Mature Weight
5. Milk
6. Scrotal Circumference
7. Weaning Weight
8. Yearling Weight
9. Marbling
10. Ribeye Area
11. Fat Thickness
12. Carcass Weight
13. Tenderness
14. Percent Choice (quality grade)
15. Heifer Pregnancy
16. Maternal Calving Ease
17. Direct Calving Ease
18. Docility
19. Average Daily Gain
20. Feed Efficiency
21. Yearling Height
Lead Today with 50K

1. Birth weight
2. Weaning weight
3. Weaning maternal (milk)
4. Calving ease direct
5. Calving ease maternal
6. Marbling
7. Backfat thickness
8. Ribeye area
9. Carcass weight
10. Tenderness
11. Postweaning average daily gain
12. Daily feed intake
13. Feed efficiency (net feed intake)

50K SNP chip assays
50,000 SNPs spread throughout genome
**GAR Predestined**

From start to finish—conception to carcass—no other bull in the beef business today adds as much real value to cattle as Predestined. Ranking as the #1 bull for $B in the breed—our customers tell us that their Predestined-sired cattle return the most dollars to their pockets—they know that $B works. Unlike any other 036 son, Predestined tones down size, adds depth of flank, superior feet and legs and a pleasant disposition to his offspring. His conception rate is high and he's been a standout in timed-AI programs. His progeny look good—his bulls are thick and his heifers are fancy—and they always display additional shape and capacity. He ended 2006 as our top-seller and rightfully so—Predestined's many talents for creating value are for real.
Beef Improvement Federation (BIF)

“BIF believes that information from DNA tests only has value in selection when incorporated with all other available forms of performance information for economically important traits in NCE, and when communicated in the form of an EPD with a corresponding BIF accuracy.”
Combining EPD Info with DNA test results improves genetic prediction accuracy Beef Magazine (02/2011)

Commercially available DNA Tests for Beef Cattle (06/2010)

Value of DNA Information for beef bull selection (06/2010)

Are DNA tests for you? Beef Magazine (03/2010)

DNA markers... Revolution or Evolution? ABS Breeders Journal (Fall/Winter 2009)

Do DNA tests work? Beef Magazine (10/2009)

Basics of DNA Markers and Genotyping (06/2009)

DNA-Based Progeny Testing (06/2009)

Fundamentals of Expected Progeny Differences (06/2009)

Marker-Assisted Selection in Beef Cattle Handout (06/2009)

The Value of Improving Accuracy of Yearling Bulls (06/2009)


What does the future hold?
“1954 version of what 'home computers' might look like in 50 years time (i.e. 2004)”
Wrong Expert Predictions

I think there's a world market for about five computers.
Thomas J. Watson, chairman of the board of IBM. 1943

There is no reason anyone would want a computer in their home.
Ken Olson, president of Digital Equipment Corp. 1977
“what escaped their vision was that science might come up with new and different ways of commercializing and using new technologies.”
“Good morning.

Is there a reason why we wouldn’t do the Ingenity DNA test on each of our 62 yearling bulls at $40 per head to get information on birth weight, carcass weight, yield grade, back fat, ribeye area, etc.? I realize our bulls aren’t purebreds, but isn’t a cow a cow when it comes to DNA testing?”
Marker location relative to the gene of interest in two breeds when using the (A) 50K SNP chip assay (markers spaced at ~ 70 kb intervals), or (B) the high density 700 K SNP chip assay (markers spaced at ~ 5 kb intervals)
High density panels offer the opportunity to accelerate discovery of the causal mutations underlying genetic variation – especially if combined with full sequence data on key ancestors.
The beef industry needs to share data and profit between sectors to most benefit from DNA technologies.

Currently Situation: DNA tests for selection

**Bad News**
- Tests are breed specific – only Angus
- Data reporting is varied and hard to interpret
- No independent estimate of test accuracy

**Good News**
- Larger SNP panels (700+K) might help tests work across breeds and in crossbreds
- DNA information is stating to get integrated into EPDs (Angus)
“This project is supported by National Research Initiative Grant no. 2009-55205-05057 from the USDA National Institute of Food and Agriculture.”
Questions?
<table>
<thead>
<tr>
<th>Trait</th>
<th>h²</th>
<th>Igenity® Angus Profile</th>
<th>Pfizer HD 50K for Angus</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Included</td>
<td>% Genetic variation¹</td>
</tr>
<tr>
<td>Average Daily Gain</td>
<td>0.28</td>
<td>X</td>
<td>na</td>
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<tr>
<td>Net/residual Feed Intake</td>
<td>0.39</td>
<td>X</td>
<td>na</td>
</tr>
<tr>
<td>Dry matter intake</td>
<td>0.39</td>
<td>X</td>
<td>na</td>
</tr>
<tr>
<td>Tenderness</td>
<td>0.37</td>
<td>X</td>
<td>na</td>
</tr>
<tr>
<td>Calving Ease (Direct)</td>
<td>0.10</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Birth weight</td>
<td>0.31</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Weaning Weight</td>
<td>0.25</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Yearling Weight</td>
<td>0.60</td>
<td>X</td>
<td>na</td>
</tr>
<tr>
<td>Calving ease (maternal)</td>
<td>0.10</td>
<td>X</td>
<td>na</td>
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<tr>
<td>Milking Ability</td>
<td>0.25</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Heifer Pregnancy</td>
<td>0.20</td>
<td>X</td>
<td>na</td>
</tr>
<tr>
<td>Stayability</td>
<td>0.10</td>
<td>X</td>
<td>na</td>
</tr>
<tr>
<td>Docility</td>
<td>0.37</td>
<td>X</td>
<td>na</td>
</tr>
<tr>
<td>Yield grade</td>
<td>0.64</td>
<td>X</td>
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<tr>
<td>Carcass weight</td>
<td>0.39</td>
<td>X</td>
<td>29</td>
</tr>
<tr>
<td>Backfat thickness</td>
<td>0.36</td>
<td>X</td>
<td>25</td>
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<tr>
<td>Ribeye area</td>
<td>0.40</td>
<td>X</td>
<td>34</td>
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<tr>
<td>Marbling score</td>
<td>0.37</td>
<td>X</td>
<td>42</td>
</tr>
<tr>
<td>Percent choice</td>
<td>X</td>
<td>na</td>
<td></td>
</tr>
</tbody>
</table>

Industry breakdown of $\Delta G$ value derived from increased accuracy from genomic selection

## Value of improved selection response for beef seedstock sector due to DNA-test increase in index accuracy

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Accuracy of DNA test used</th>
<th>GRASS INDEX</th>
<th>FEEDLOT INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Terminal</td>
<td>Maternal</td>
</tr>
<tr>
<td>Improvement in selection response</td>
<td>%</td>
<td>Intermediate</td>
<td>29</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>54</td>
<td>81</td>
</tr>
<tr>
<td>Increased value derived from $\Delta G$ in commercial sires</td>
<td>$/DNA test</td>
<td>Intermediate</td>
<td>45</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>83</td>
<td>124</td>
</tr>
<tr>
<td>Increased value derived from $\Delta G$ in stud sires</td>
<td>$/DNA test</td>
<td>Intermediate</td>
<td>160</td>
<td>203</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>297</td>
<td>366</td>
</tr>
<tr>
<td>Total value per test to seedstock operator</td>
<td>$/DNA test</td>
<td>Intermediate</td>
<td>$204$</td>
<td>$272$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>$380$</td>
<td>$490$</td>
</tr>
</tbody>
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