“Beef Cattle Industry Structure: Implications for whole genome selection”

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Should you use this bull?
Selection criteria – informal survey!

- Only if he looks right
- Only if he has marbling
- Only if he has the right DNA
- Only if he has the right pedigree
The basis of selection is the resemblance between relatives.
What you would really like to know is the future performance of his unborn calves!!
Should you use this bull?
What if I told you these calves belonged to the bull?
What if I told you these were his daughters’ calves?
Animal breeders use records of an animal's own performance and that of its relatives to predict an animal’s genetic merit or **ESTIMATED BREEDING VALUE (EBV)**.
Challenge for breeders is to identify those individuals that have the best breeding values at a young age.

\[ \Delta G = \text{intensity of selection} \times \frac{\text{accuracy of identifying the good ones}}{\text{genetic variation in the population}} \times \frac{1}{\text{generation interval}} \]
How can I increase my accuracy of identifying the good ones?

- Records, records, records (BREEDPLAN)
- Treating all animals in a group the same
- DNA testing???
What is a Genetic Marker?

A DNA sequence variation that has been associated with a given trait in one or more populations.
There are DNA-markers for simple traits

- DNA test result is highly predictive
  - Coat color
  - Polled/horned status
  - Certain genetic diseases (e.g. “curly calf”)
  - SCD (Prescribe Genomics, $90 per test)
  - “Exon 5” (Prescribe Genomics, $100/test)
Wagyu-specific DNA-makers

**SCD - Stearoyl-CoA desaturase (AA, VA, VV)**
- “the percentage of beef that is “not delicious” has increased as a result of increased fat of a high melting temperature
- ~ 18% AA, 74% VA, 8% VV

**Exon 5 – growth hormone (AA, AB, BB, BC, CC)**
- Only found in Wagyu,
- Purportedly associated with marbling
- No more information on frequency
There are several different DNA sequences of the SCD gene in Japanese Black cattle. These are categorized into 2 groups, A & V. Some Japanese Black cattle carry a special mutation that changes the corresponding amino acid from Valine (V) to Alanine (A) which has a significant relationship to the melting point of fat. Alanine type has a lower melting point than valine type. Therefore the preferred type is AA. By using the SCD gene we can select the cattle which can deposit a soft and oleic acid rich fat that is delicious and healthy.

At this time no gene tests should be used as the single selection criteria that a cattle farmer would use. Rather they should be seen as part of the selection process when choosing cattle for breeding. Cattle that show preferred genotypes for both GH Exon 5 and SCD provide the most likely animals to improve a cattle herd's performance BUT ONLY if all other factors are satisfactory.

Dr. Tadayoshi Mitsuhashi
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Dept. of Physiology & Genetic Regulation
National Institute of Agrobiological Sciences, Japan
An increasing number of companies are starting to offer DNA tests for production traits.
DNA-markers for production traits

- DNA test result may or may not be highly predictive of genetic merit
### Summary of NBCEC validations for commercially-available DNA-tests for complex (quantitative or multigenic) traits in beef cattle

(note: validations do not include tests for “simple” traits such as coat color, horned/poled, AM status etc.)

<table>
<thead>
<tr>
<th>Company</th>
<th>Test Name</th>
<th>Trait</th>
<th>Date of validation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Igenity</strong></td>
<td>Profile§</td>
<td>Fat Thickness</td>
<td>12/2008</td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Marbling Score</td>
<td>12/2008</td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Quality Grade (% ≥ Choice)</td>
<td>12/2008</td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Rib Eye Area</td>
<td>12/2008</td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Yield Grade</td>
<td>12/2008</td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Average Daily Gain</td>
<td>12/2008</td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Tenderness</td>
<td>12/2007</td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Residual Feed Intake (RFI) (for Bos indicus influenced cattle)</td>
<td>12/2007</td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Residual Feed Intake (RFI) (for Bos taurus cattle)</td>
<td>6/2008</td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Dry matter intake (DMI) (for Bos indicus influenced cattle)</td>
<td>12/2007</td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Heifer Pregnancy Rate</td>
<td></td>
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<tr>
<td></td>
<td>Profile§</td>
<td>Stayability (longevity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Maternal Calving Ease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Profile§</td>
<td>Docility</td>
<td></td>
</tr>
<tr>
<td><strong>Pfizer Animal Genetics (Bovigen)</strong></td>
<td>GeneSTAR® Tenderness MVP</td>
<td>Tenderness</td>
<td>2/2009</td>
</tr>
<tr>
<td></td>
<td>GeneSTAR® Marbling MVP</td>
<td>% IMF (Feedlot cattle)</td>
<td>2/2009</td>
</tr>
<tr>
<td></td>
<td>GeneSTAR® Feed Efficiency MVP</td>
<td>Net Feed Intake (NFI)</td>
<td>2/2009</td>
</tr>
<tr>
<td><strong>MMI genomics</strong></td>
<td>Tru-Marbling™</td>
<td>Marbling Score and Quality Grade</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tru-Tenderness™</td>
<td>Tenderness</td>
<td></td>
</tr>
</tbody>
</table>
Australian beef DNA results

As part of its role in delivering DNA markers to the Australian beef industry, Beef CRC has agreed to independently test new panels of DNA markers as they are commercialised by companies such as Pfizer Animal Genetics, Ingenuity Aerial and Metamorphic Inc.

Results of all independent testing of commercially-available DNA markers undertaken by Beef CRC will be presented on this site, outlining the size and direction of effect and the amount of genetic variation that is accounted for by each panel of markers for the different traits (e.g. marbling, feed efficiency, tenderness etc).

Additional information is provided to help beef businesses interpret the results for themselves to determine the value to their own businesses from an investment in the particular panel of DNA markers.

Those decisions very much depend on the individual business’ attitude to risk and can only be made effectively by the individual business.

It is possible that the panel of markers has also been independently evaluated in North American herds by the US National Beef Cattle Evaluation Consortium, so for further information on the size and direction of effect of the markers in those populations, please visit http://www.ansci.cornell.edu/mbbe/

Pfizer GoneStar results
Pfizer interpretation
Genetic variation explained by DNA-tests that have been independently assessed by AGBU in Australia.

<table>
<thead>
<tr>
<th>Population</th>
<th>IMF%</th>
<th>MSA Marble Score</th>
<th>SF (kg)</th>
<th>NFI (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Bos taurus</em></td>
<td>0.3%</td>
<td>1.7%</td>
<td>2.9%</td>
<td>6.2%</td>
</tr>
<tr>
<td>2. <em>Bos indicus</em></td>
<td>0.4%</td>
<td>0.9%</td>
<td>8.0%</td>
<td>5.4%</td>
</tr>
<tr>
<td>3. <em>Bos taurus x Bos indicus</em></td>
<td>0%</td>
<td>0%</td>
<td>1.6%</td>
<td>0%</td>
</tr>
<tr>
<td>4. <em>Bos indicus X Brahman</em></td>
<td>1.5%</td>
<td>3.6%</td>
<td>29.9%</td>
<td>0%</td>
</tr>
</tbody>
</table>
It seems appropriate that the application of DNA testing to beef cattle production is undergoing an evolutionary process....
The bovine genome is similar in size to the genomes of humans, with an estimated size of 3 billion base pairs.

Human & cattle genomes are 83% identical.
Whole genome-assisted selection (WGS)

- The sequencing of the bovine genome allowed for the development of a 50,000 marker chip!
- Can simultaneously test 50,000 markers
Whole-genome selection
Application of WGS in Dairy Cattle Has Been Successful

Training Population: 5000 Progeny Tested Bulls

Validation: New Progeny Tested Bulls

Application: New Sire Candidates

Slide courtesy of Marc Thallman, US MARC
The beef cattle industry is different to dairy!

- Little use of AI
- Relatively few high accuracy sires for training
- Multiple competing selection goals – cow/calf, feedlot, processor – little data sharing between sectors
- Few/no records on many economically-relevant traits
- Crossbreeding is important
- Many different breeds
Whole genome selection in US beef cattle industry

Training populations:
- US Meat Animal Research Center population
- Angus AI sires
- DNA Testing Companies

Validation:
- 2,000 Bull Project

Application:
- Seedstock Breeders

Slide courtesy of Marc Thallman, US MARC
Validation: Purpose is to estimate how predictive DNA tests are in different breeds

- Angus 402
- Hereford 317
- Simmental 253
- Red Angus 173
- Gelbvieh 136
- Limousin 131
- Charolais 125
- Shorthorn 86

- Brangus 68
- Beefmaster 64
- Maine-Anjou 59
- Brahman 53
- Chiangus 47
- Santa Gertrudis 43
- Salers 42
- Braunvieh 27
What about Wagyu?
Questions?