“NO BULL” DISCUSSION ON GENETIC MARKERS

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Genetic Markers

- What are they?
- What might they be used for?
- What is available, and from whom?
- Are they “fit for purpose”?
- What will the future hold?
What is a genetic marker?

- DNA is the blueprint of life, and contains a wealth of information (and misinformation) that influences the performance of the individual and its offspring.

- A typical genetic marker is a “signature” or a “signpost” that is unique to a precise small part of this large blueprint.

- There are millions of genetic markers.
What use is a genetic marker?

- A genetic marker simply indicates whether a particular piece of DNA is present in a sample.

- A commonly used kind of marker is a single nucleotide polymorphism (or SNP).

-AACTCGTACGTCA-  (A, T, G & C are nucleotides)

-AACTCGTACCTCA-  A polymorphism indicates various types vs monomorphic
Wealth of implications

- **Identity and Parentage**
  - A unique viral “signature” can prove an individual is infected by a virus (e.g. BVD)
  - Two (non mixed) samples that differ in signature must have come from different individuals
  - An individual that does not have the signature of its supposed parent is not an offspring
    - Collective signatures can be suggestive of ancestral origins (e.g. breed) or relatedness (genetic distance)
Wealth of Implications

- **Genetic Makeup**
  - A signature representing a known DNA “error” guarantees a defective gene
    - Many recessive diseases (e.g. BLAD, citrullinemia)
    - Coat color (e.g. black vs red)
    - Muscling (e.g. normal vs double muscled)
  - A signature sometimes associated with superior (or inferior) performance may help predict its own or its likely average offspring performance
    - Many such signatures have been observed in small studies
Applications in Cattle

- Quality Assurance and Source Verification
  - Not tamper proof
  - Not immediate
  - Useful as part of a “portfolio” approach

- Detecting Sub-clinical Disease
  - Direct evidence of pathogenic organism
Applications in Cattle

- Four Options
  - Reducing the Genetic Lag
    - Screening sale bulls
  - Increasing the Rate of Genetic Gain
    - Bull breeding herds
  - Parentage Testing in Multi-sire Pastures
  - Sorting Cattle for Alternate (optimized) Management
Applications in Cattle

- **Ideal Outcome**
  - Positive Value Proposition for all Stakeholders

- **Prerequisite**
  - Reliable, robust detection of signatures (Research)
  - Protection of Intellectual Property (Legal)
  - Genetic Testing Servicing (Business)
Reducing Genetic Lag
Expected Progeny Difference

- An Angus bull with WW EPD of +60 lb is expected to sire calves that weigh 60 lb more at weaning than the average base bull (Angus WW base is 1979 born)
  - Average ‘06 born regd bull had EPD +41 lb
  - Our bull would wean offspring 19 lb heavier
Offspring EPD

- The EPD of offspring is the average of the EPD of its sire and its dam
  - Genes are located on chromosomes
  - Animals have paired chromosomes
    - Cattle typically have 60 (i.e., 30 pairs)
  - An individual inherits one member from each chromosome pair from its sire, the other from its dam
Our bull with an EPD of 60 lb mated to cows with EPDs of 30 lb would produce calves with EPDs averaging 45 lbs \((60+30)/2\)
Registered Angus demonstrated 1.5 lb/yr (8 lb/5 years) for 25 years.
8 lb/5 yr Genetic Change

Average WW EPD (lbs)
8 lb/5 yr Genetic Change

Average WW EPD (lbs)

Generations

My herd average - 40 lb
8 lb/5 yr Genetic Change

Average WW EPD (lbs)

- Bulls now average +8 lb
- My new herd average - 20 lb
8 lb/5 yr Genetic Change

Average WW EPD (lbs)

Generations

My new herd average - 6 lb
8 lb/5 yr Genetic Change

Bulls now average +16 lb

My new herd average - 6 lb

Average WW EPD (lbs)
8 lb/5 yr Genetic Change

Average WW EPD (lbs)

Generations

My new herd average +5 lb
8 lb/5 yr Genetic Change

Average WW EPD (lbs)

Generations

Bulls 24 lb

My new herd average +5 lb
8 lb/5 yr Genetic Change

Average WW EPD (lbs)

Bulls 32 lb

Generations

My new herd average +15 lb
8 lb/5 yr Genetic Change

Average WW EPD (lbs)

Bulls 40 lb

My herd +24 lb
8 lb/5 yr Genetic Change

Lag = bull merit - cow merit
= 40 - 24 = 16
= two generations gain

Bulls 40 lb

My herd +24 lb
8 lb/5 yr Genetic Change

Average WW EPD (lbs)

Best Sale Bulls (identified using marker)

Average Sale Bull
8 lb/5 yr Genetic Change

Average WW EPD (lbs)

Best Sale Bulls (identified using marker)

Average Sale Bull
8 lb/5 yr Genetic Change

Average WW EPD (lbs)
8 lb/5 yr Genetic Change

Average WW EPD (lbs)

Best Sale Bulls (identified using marker)

Average Sale Bull

Stop using markers
Increasing Genetic Gain

- Genetic gain comes about when above-average bulls are used as sires in bull-breeding herds
Illustration

Sires

Dams

Offspring w/o records
Genetic Basis

Sire Choice accounts for 1/4 variance

1/2

Mendelian Sampling accounts for 1/2 variance

1/2

Dam Choice accounts for 1/4 variance
Gene Assisted Selection (GAS)
Illustration

Sires

Dams

Offspring w/o records

One Genetic Marker

One Genetic Marker
Illustration

Sires

Dams

Offspring w/o records

Many Genetic Markers
Increasing Genetic Gain

- Average IMF EPD
- Birth year
- Outcome for Effective Markers
- Actual Angus IMF genetic trend
Increasing Genetic Gain

- No evidence that genetic markers have increased the rate of genetic gain in bull breeding herds of beef cattle
- In theory, genetic markers could increase gain if we had enough of them and they were reliable
Multi-Sire Mating Groups

- Bulls can be an investment or a liability
  - Distinguishing the bulls that add value from those that simply drain resources requires
    - Quantifying the number (& timing) of breeding success among bulls competing for the same cows
    - Accumulating the value of each bulls offspring
    - Perhaps using these records to progeny test the bulls and obtain EPDs
Steer Calves per Bull

Van Eenennaam, Drake & Garrick, WSASAS, 2008

Number of steer calves

Age of Sire when Offspring Born (years)
Average Carcass Value per Bull

Individual Sires (sorted by value)
Total Steer Offspring Value

Steers from birthyear 2006

Value of steer carcasses ($X1000)

Age of Sire (years)
Management Sorting of Cattle

- Feedlots are more efficient if cattle in each pen can be harvested together
  - Partly harvesting pens reduces performance
  - Partly filled pens lose yardage revenue
  - Mixing pens reduces performance

- Markers could be used to sort cattle into likely harvesting date, based on knowledge of weight gain, marbling or fat accumulation

- Not a new idea
BULLsBALLs.com 800.491.1140
The Original Truck Balls!
What markers are available?

- Principally three companies
  - Merial-owned Igenity
  - Pfizer-owned Bovigen
  - MetaMorphix
- Parentage (Any markers) & Genetic Evaluation
- BVD-PI (Actual viral sequence)
- Horned-Polled (Association)
- Coat Color (Actual gene)
- Docility
- Maternal Traits (Heifer Pregnancy, Stayability, Calving Ease)
- Carcass Composition (Tenderness, Marbling, QG, YG, c/c wt, BF)
- Tenderness Validated (Several Calpain and Calpastatin markers)
Bovigen

- SureTRAK (Any markers)
- SireTRACE (Any markers)
- BLACK (actual gene)
- FEED EFFICIENCY (4 markers)
- GeneStar TENDERNESS (3 markers) Validated
- GeneStar QUALITY GRADE (4 markers) Validated
- Elite Tender (beef product guarantee)
MetaMorphix

- Parentage and Identification (Any markers)
- Tru-Coat Color (*Actual gene*)
- Tru-Polled (Association)
- Tru-Marbling (128 markers)
- Tru-Tenderness (11 markers)
Will they work in my breed/herd?

- It depends!
- Tenderness (based on calpain and calpastatin) has been validated but the association is different in *Bos indicus* vs *Bos taurus* breeds
- Quality Grade test from Bovigen has been validated
- New tests such as feed efficiency are difficult to validate – require an independent data set
- New tests are tending to use larger panels of markers
Should I use them in my herd?

- Value proposition is different depending upon whether you are using them for marketing, to reduce lag, increase gain or for management
- Be wary if you will not be able to produce data in your circumstances to confirm their value and the tests have not been independently validated
- Read the information on the company websites and at University of California, Davis, and National Beef Cattle Evaluation Consortium websites (see written paper for url addresses)
- Ask the company for validation results
Markers of the future

- In January 2008 Illumina released a panel that can undertake 50,000 tests spread throughout the genome for around $200.
- This panel will herald a new era in genetic markers, known as genomic selection.
- Studies using various datasets are currently underway, including 3,500 Cycle VII animals from US MARC and 2,000 AI bulls from 8 breeds.
  - Much more information will be available in the next 12 months.
Summary

- Genetic markers offer a number of opportunities in beef cattle production and improvement
  - Real opportunities for characterizing and improving bull management in multi-sire pastures
- Several companies are competing in the marketplace with new services
  - Simple tests are being replaced with panels
- New genotyping approaches will likely revolutionize the nature and scope for the use of genetic markers over the next year or two