Novel reproduction traits for genetic evaluation.

Matt Wolcott
Animal Genetics and Breeding Unit, University of New England, Armidale. Australia.
Outline

1. Developing new reproduction phenotypes.
   – Beef CRC research.

2. Implementation of new reproduction traits in industry.
   – Repronomics project.
   – ‘Kaiuroo’ intensive phenotyping in industry.

3. Recent research in temperate beef breeds.
   – Evaluating new reproduction traits in Angus and Hereford.
Beef CRC research:
Opportunities for selection to improve reproduction rates in tropical beef breeds.
(2000 – 2014)
The Beef CRC (Co-operative Research Centre for Beef Genetic Technologies)

Beef CRC research into the genetics of female reproduction

- Cross-discipline collaborative research project.
- Industry supported to focused on tropical beef genotypes.
- 14 year long progeny test experiment.
  - CRCII: Steer carcass and heifer puberty.
  - CRCIII: Cow rebreeding, lifetime reproduction and body composition.
Experimental design:

- 1030 Brahman females (6 herds).
- 1130 T. Composites (4 herds).
- Progeny of ~ 50 BRAH and 50 TCOMP Sires.
- Female reproduction intensively recorded.
- Half sib brothers feedlot finished (540kg liveweight).
Female management:

- Heifers first mated as 2 year olds.
- 3 month mating period.
- Managed under commercial conditions through up to 6 matings.
- Culled only on repeated failure to wean a calf.
Measuring female reproduction

- By ultrasound scanning for ovarian function.
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Pre-pubertal ovary (many small follicles)

Cycling ovary (One large CL)
Beef CRC

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Age at puberty (AP)
- From weaning till *corpus luteum* (CL) detected.
- 2 – 15 measurements / heifer.
Beef CRC

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Lactation anestrous interval (LAI)
• Lactating cows at 2\textsuperscript{nd} natural mating.
• Calculated as days from bull-in date to first detected CL.
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At end of CRC III: 60 records / female 356,000 scans
Beef CRC Key results

Lifetime weaning rate

- Closest trait to that in the breeding objective.
  
  \[ \text{Calves weaned} / \text{mating seasons in experiment.} \]

<table>
<thead>
<tr>
<th>MEASURE</th>
<th>Brahman</th>
<th>Tropical Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>1020</td>
<td>1117</td>
</tr>
<tr>
<td>Average</td>
<td>0.62</td>
<td>0.78</td>
</tr>
<tr>
<td>Sire EBV range</td>
<td>-0.11 to 0.16</td>
<td>-0.06 to 0.08</td>
</tr>
<tr>
<td>Heritability</td>
<td>0.11</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Beef CRC Key results

Age at puberty

- Very heritable for a reproduction trait ($h^2 = 0.5$ to $0.6$).
- Large genetic variation within genotypes.
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- Only 51% cycling into mating
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- Only 51% cycling into mating
- 13% failed to reach puberty by the end of their 1st mating season.
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Of those which did cycle:
- 90% conceived and 72% weaned a calf.
- Overall weaning rate of 62%.
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Massive opportunity to apply selection to improve AP in Brahman females
Lactation anestrus interval

- Also highly heritable ($h^2 = 0.3$ to 0.5).
- Also large variation within genotypes (breeds).
- Lots of opportunity to identify genetically superior animals.
- AP only directly influences first mating outcome.
- LAI impacts rebreeding in lactating females every year.
LAI EBVs for Brahman sires

*Australian EBVs = 2 x EPD.*
Beef CRC Key results

LAI EBVs for Brahman sires

*Australian EBVs = 2 x EPD.*

- Range of > 200 days in LAI EBVs.

<table>
<thead>
<tr>
<th>Beef CRC Brahman Sire</th>
<th>LAI EBV (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANCEFIELD 4999M</td>
<td>-100</td>
</tr>
<tr>
<td>MR V8 797/3 (IMP US)</td>
<td>-95</td>
</tr>
<tr>
<td>TARTRUS 3886 (AI) (ET)</td>
<td>-89</td>
</tr>
<tr>
<td>CONA CREEK 2722</td>
<td>-71</td>
</tr>
<tr>
<td>NEWCASTLE WATERS TOBY G774 (ET)</td>
<td>-63</td>
</tr>
<tr>
<td>LANCEFIELD 4461</td>
<td>-60</td>
</tr>
<tr>
<td>McKELLAR RICARDO 3/840 (IMP US)</td>
<td>-58</td>
</tr>
<tr>
<td>TARTRUS ABEL MANSO 4182 (AI) (ET)</td>
<td>-55</td>
</tr>
<tr>
<td>BELMONT 96-478</td>
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</tr>
<tr>
<td>CARINYA 1926</td>
<td>-40</td>
</tr>
<tr>
<td>CBV PROVIDOR 96-6822</td>
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</tr>
<tr>
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</tr>
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Beef CRC Key results

LAI EBVs for Brahman sires

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- Range of > 200 days in LAI EBVs.
- Best sire’s progeny will have a lactation anestrus period 3 months shorter than the worst.

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LAI EBVs for Brahman sires

*Australian EBVs = 2 x EPD.*

- Range of > 200 days in LAI EBVs.
- Best sire’s progeny will have a lactation anestrus period 3 months shorter than the worst.
- If mating for 3 months, the progeny of the worst sires won’t (*on average*) cycle before the end of mating.

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Beef CRC Key results

Male reproduction

• Male progeny of cows evaluated for AP and LAI
  – Retained as bulls.
  – Semen sampled at 12, 18 and 24 months old.
  – Sperm morphology assessment of 100 cells/sample.
  – Identified and classified non-viable cells.
  – Percent normal sperm = proportion of viable sperm cells.
Beef CRC Key results

Percent normal sperm

- Genetic variation (and $h^2$) very age dependent.
Beef CRC Key results

Percent normal sperm

- Genetic variation (and $h^2$) very age dependent.

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<th>Age (months)</th>
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<td>0</td>
<td>0.0</td>
<td>297</td>
<td>0.4</td>
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<tr>
<td>18</td>
<td>199</td>
<td>0.3</td>
<td>97</td>
<td>0.2</td>
</tr>
<tr>
<td>24</td>
<td>75</td>
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Beef CRC Key results

Percent normal sperm

- Genetic variation (and $h^2$) very age dependent.
- Very few Brahman bulls produced a viable sample at 12 months old.
  - 18 mths showed greatest $V_a$ and $h^2$.
- For Tropical Composites PNS showed greatest potential for selection at 12 months of age.

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Additive variance and heritability for PNS in 1300 Brahman and 2000 Tropical Composite bulls.
Beef CRC Key results

PNS vs female reproduction

• For Brahmans, PNS at 18 and 24 months had moderate favourable genetic relationships with female reproduction traits.
Beef CRC Key results

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Beef CRC Key results

PNS vs female reproduction

- For Brahmans, PNS at 18 and 24 months had moderate favourable genetic relationships with female reproduction traits.

- Measures in selection candidates can be exploited to select to improve female reproduction.

- Opportunity to increase genetic gains for female reproduction.

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Beef CRC showed that:

- Accurate descriptors of female reproduction highly heritable.
- Opportunity to make rapid genetic progress in tropical beef breeds.
- Male traits can be exploited as genetic indicators of AP & LAI.
- Difficult, expensive and ‘expertise intensive’ to record.
- Prime candidates for recording in reference populations.
Beef CRC outcomes

In BREEDPLAN evaluation for tropical breeds:

• AP and LAI analysed as correlated traits with days to calving.
  – Recorded intensively in reference population.
  – Genomics helps spread accuracy to related animals.
  – Increase accuracy and spread of DTC EBVs.

• Percent normal sperm published as an EBV.
  • For Brahman and Santa Gertrudis (DM coming).
  • Allows breeders to select to improve PNS directly.
  • Analysed as a correlated trait with female reproduction.
Novel reproduction traits:
Recording hard to measure phenotypes in industry.
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Recording hard to measure phenotypes in industry.

1. The Repronomics project.
The Repronomics project

Accelerating $\Delta G$ for female reproduction

• Large industry (MLA) funded project
  – Led by Dr. David Johnston.
  – Applying Beef CRC results in industry.

• Intensively recording female reproduction.
  – Heifers scanned to determine age at puberty.
  – Lactating first calvers scanned to measure lactation anoestrus interval.
  – Males finished and slaughtered for carcass traits.
The Repronomics project

Expands the Beef CRC focused on tropical breeds.

- Purebred Brahman, Santa Gertrudis and Droughtmaster.
- And X-breeds in *next* phase of the project.
- Results are incorporated in genetic evaluations.
  - AP and LAI already analysed for Brahmans.
  - Coming soon for Santa Gertrudis and Droughtmaster.
Novel reproduction traits:
Recording hard to measure phenotypes in industry.

2. ‘Kaiuroo’ MDC project.
Kaiuroo snapshot

- The ‘Kaiuroo Aggregation’
  - 5 neighbouring properties.
  - In the Fitzroy River basin.
  - 34,500ha with 600ha irrigated leucaena.
  - 1,000 Brahman stud female.
  - 5,000 commercial cows (Brahman and X-bred)
• Commercial steers to organic market
  – Australian certified organic.
  – Tight specifications around weight and growth (> 480kg live with minimum ADG).
  – Significant premium for compliant animals.

• High cost of production to meet market specifications
  – AGBU approached in 2014 to help with breeding program to increase compliance rate and profitability.
Kaiuroo breeding program

• Reviewed Kaiuroo breeding program 2014.
  – Low reproduction rates (stud and commercial).
  – Below breed average DTC & SC.
  – Breed average growth, fat, EMA, SF, FT.

• Review concluded that:
  – Targeted breeding program could improve $.
  – Intensive recording in stud would increase ΔG.
  – Production system and market unique enough for a custom selection index.
Kaiuroo breeding program

• Implemented ovarian scanning program
  – Age at puberty.
  – Lactation anoestrous interval.

• All bulls morphology tested
  – Percent normal sperm.
Kaiuroo research

MLA Donor Company (MDC)

• Clear benefit at the industry (breed) level.
  – Brahman BREEDPLAN genetic evaluation.
  – Only source of PNS data when established.

• Received industry support for
  – Intensive recording of reproduction traits.
  – Genotyping of all recorded males and females.

• Satellite project to Repronomics®.
Kaiuroo MDC outcomes

• Records collected
  – 700 heifers scanned for age at puberty
  – 365 lactating first calvers scanned for LAI.
  – 725 bulls evaluated for percent normal sperm.
  – All animals genotyped with custom *indicus* 35K chip.

• Sires evaluated
  – 70 bulls with progeny evaluated in 3 year project.
  – With a total of 7,120 progeny in Brahman analysis.
  – 26 of which have 2,380 progeny outside of Kaiuroo.
Kaiuroo MDC outcomes

• On average, sire PNS EBVs increased accuracy by ~ 30%.

• Female reproduction EBV accuracy improved by 7 – 15%.
  – In addition to large boost from Repronomics project.

• Improving opportunity for Brahman breeders to select for greater profitability.
Novel reproduction traits:
Recording hard to measure phenotypes in industry.

3. Extending what we’ve learned in tropical breeds to *Bos taurus* cattle.
Trans-Tasman beef cow productivity project

Objectives:

• Apply serial scanning methods developed in the Beef CRC.

• To estimate age at puberty (AP) in temperate beef heifers (Hereford & Angus).

• Quantify variation in AP in the current seedstock population.

• Determine genetic parameters for age at puberty and associated traits.
  – genetic correlations with growth and body composition.
Experimental design

• Data collected in 7 Angus and 3 Hereford seedstock herds

• All heifers scanned were registered with Angus Australia or Herefords Australia.

• Dates of birth, genotypes and pedigree recorded.
Trans-Tasman beef cow productivity project

Experimental design

• Scanning commenced from first observed oestrus behaviour.

• Repeated every 4 – 6 weeks to mating.

• Averaged 3 scans in Herefords and 4 in Angus herds.
Trans-Tasman beef cow productivity project

Traits analysed

• Pubertal into mating (PUB).
  – Binary trait: displayed a CL up to mating (1) or not (0)

• Age at puberty (AP: in cycling females only)
  – Date of first CL – DOB.

• Penalised AP (APP: available for all females)
  – Maximum AP of contemporary group + 21 days (1 cycle).
  – For females which failed to display a CL up to mating.
Trans-Tasman beef cow productivity project

Traits analysed

• Also recorded growth and body composition traits at each scan:
  – Liveweight (kg)
  – Hip Height (cm)
  – P8 fat depth (mm)
  – Body condition score
    • 1 (poor) to 5 (fat)
Traits analysed

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  - Hip Height (cm)
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    - 1 (poor) to 5 (fat)

Not accredited scanners (or experienced BCS scorers)
Trans-Tasman beef cow productivity project

Key results

• 52% of heifers were pubertal as they entered their first mating.
Descriptive statistics for heifer ovarian scanned traits

<table>
<thead>
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<th>Units</th>
<th>Number of records</th>
<th>Mean</th>
<th>sd</th>
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</thead>
<tbody>
<tr>
<td><strong>Angus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at puberty</td>
<td>Days</td>
<td>1546</td>
<td>344.5</td>
<td>64.0</td>
</tr>
<tr>
<td>AP (penalty)</td>
<td>Days</td>
<td>2939</td>
<td>393.2</td>
<td>72.2</td>
</tr>
<tr>
<td>Percent Pubertal</td>
<td>%</td>
<td>2939</td>
<td>52.6</td>
<td>50.0</td>
</tr>
<tr>
<td><strong>Hereford</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at puberty</td>
<td>Days</td>
<td>481</td>
<td>365.8</td>
<td>38.3</td>
</tr>
<tr>
<td>AP (penalty)</td>
<td>Days</td>
<td>902</td>
<td>396.2</td>
<td>44.3</td>
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<tr>
<td>Percent Pubertal</td>
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Trans-Tasman beef cow productivity project

Key results

• 52% of heifers were pubertal as they entered their first mating.
• On average, heifers were in good condition going into mating.
## Trans-Tasman beef cow productivity project

### Descriptive statistics for heifer growth and body composition traits

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<td></td>
</tr>
<tr>
<td>Age</td>
<td>Days</td>
<td>3205</td>
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<td>Liveweight</td>
<td>kg</td>
<td>3196</td>
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<td>367.2</td>
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<tr>
<td>Hip Height</td>
<td>cm</td>
<td>3198</td>
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<td>123.8</td>
</tr>
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<td>1 – 5 score</td>
<td>3201</td>
<td>2.9</td>
<td>3.3</td>
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<tr>
<td>P8 fat depth</td>
<td>mm</td>
<td>3203</td>
<td>4.9</td>
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<tr>
<td><strong>Hereford</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Days</td>
<td>995</td>
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<tr>
<td>Liveweight</td>
<td>kg</td>
<td>963</td>
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<td>343.8</td>
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<tr>
<td>Hip Height</td>
<td>cm</td>
<td>962</td>
<td>116.5</td>
<td>122.8</td>
</tr>
<tr>
<td>Condition score</td>
<td>1 – 5 score</td>
<td>964</td>
<td>2.6</td>
<td>3.4</td>
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<tr>
<td>P8 fat depth</td>
<td>mm</td>
<td>961</td>
<td>3.6</td>
<td>7.2</td>
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</tbody>
</table>
Trans-Tasman beef cow productivity project

Key results

- 52% of heifers were pubertal as they entered their first mating.
- On average, heifers were in good condition going into mating.
- No difference between Hereford and Angus heifers.
Trans-Tasman beef cow productivity project

![Bar chart showing cumulative percent puberty at different scanning times for Hereford and Angus cattle.]

- **Post-Weaning**
  - Hereford: ~0.2
  - Angus: ~0.25
- **Scan 2**
  - Hereford: ~0.3
  - Angus: ~0.4
- **Scan 3**
  - Hereford: ~0.4
  - Angus: ~0.5
- **Into Mating**
  - Hereford: ~0.5
  - Angus: ~0.5
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• On average, heifers were in good condition going into mating.

• No difference between Hereford and Angus heifers.

• Puberty traits heritable for both breeds.
Trans-Tasman beef cow productivity project

Genetic parameters for heifer puberty traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Units</th>
<th>$\sigma_a$</th>
<th>$h^2$</th>
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</thead>
<tbody>
<tr>
<td><strong>HEREFORD</strong></td>
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</tr>
<tr>
<td>Age at puberty</td>
<td>Days</td>
<td>363.0</td>
<td>0.26</td>
</tr>
<tr>
<td>AP (penalty)</td>
<td>Days</td>
<td>588.7</td>
<td>0.38</td>
</tr>
<tr>
<td>Percent Pubertal</td>
<td>%</td>
<td>0.05</td>
<td>0.36</td>
</tr>
<tr>
<td><strong>ANGUS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at puberty</td>
<td>Days</td>
<td>325.1</td>
<td>0.27</td>
</tr>
<tr>
<td>AP (penalty)</td>
<td>Days</td>
<td>971.8</td>
<td>0.37</td>
</tr>
<tr>
<td>Percent Pubertal</td>
<td>%</td>
<td>0.08</td>
<td>0.32</td>
</tr>
</tbody>
</table>
Key results

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• No difference between Hereford and Angus heifers.

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• Genetic correlations with body composition traits were low.
Trans-Tasman beef cow productivity project

Genetic correlations: APP vs into-mating growth and body composition

<table>
<thead>
<tr>
<th>Into-mating</th>
<th>Genetic correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liveweight (kg)</td>
<td>-0.20</td>
</tr>
<tr>
<td>Hip Height (cm)</td>
<td>-0.05</td>
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<tr>
<td>P8 fat depth (mm)</td>
<td>-0.14</td>
</tr>
<tr>
<td>Condition score (1 -5)</td>
<td>-0.26</td>
</tr>
</tbody>
</table>
Trans-Tasman beef cow productivity project

Key results

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Next steps

• Need to record the trait in naturally mated females.

• New project will mate 2,000 females annually in research herds.

• Evaluate age at puberty and lactation anoestrus interval.

• In females sourced from well recorded Breedplan herds.

• For Angus, Hereford, Shorthorn, Wagyu, Charolais and Brahman.
Conclusions

- Proven and implemented opportunities to rapidly improve accuracy of reproduction EBVs in tropical breeds.
- Reference population projects in commercial seedstock herds have been undertaken successfully.
- Research in temperate breeds at much earlier stage.
- Early results suggest AP warrants monitoring & can be improved by selection.
- More research needed to understand LAI and interactions with other aspects of productivity.
Thank you

Many people to thank for all their work in making this data available:

• Beef CRC co-operating breeders
• Beef CRC researchers & technicians.
• Beef-CRC co-operating processors.

• Norther Pastoral Companies
  – Stanbroke.
  – Australian Agricultural Company. (AA Co.)
  – North Australian Pastoral Company (NAPCo).
Thank you

Many people to thank for all their work in making this data available:

• Beef and Lamb NZ.
• Meat and Livestock Australia.
• Angus Australia.
• Herefords Australia Ltd.
• AbacusBio.