Measuring puberty in heifers with ultrasound imaging – a tool to improve herd fertility
Beef breeding enterprises

- Fertility a major driver of profitability
- Earliest mating of heifers constrained by puberty
- Current EBVs for fertility traits – low/medium heritabilities
- High heritability of age/weight at puberty in *Bos indicus*
- Puberty difficult to measure – estimated % mature weight
- Monitoring the ovary – use of ultrasound imaging
- Data to calculate genetic parameters – heritabilities and correlations with other traits
- Ultimate aim to generate EBVs for *Bos taurus* for use in multi-trait selection strategies
- Pilot project 2015 – some results
Latest estimates of heritabilities of traits with EVBs from Angus Group BREEDPLAN

- Calving Ease Dir: 14%
- Gestation Length: 65%
- Birth Wt: 32%
- 200-Day Wt: 12%
- 400-Day Wt: 23%
- 600-Day Wt: 35%
- Mature Cow Wt: 40%
- Milk: 10%
- Scrotal Size: 39%
- Days to Calving: 7%
- Carcase Wt: 41%
- Eye Muscle Area: 34%
- Rib Fat: 45%
- Rump Fat: 32%
- Retail Beef Yield %: 60%
- Intra-muscular Fat %: 32%
Pilot project (2015)

- Collecting data on presence or absence of CL and/or development of follicles in relation to the heifers’ age/weight/fatness/frame score
- Need large data sets to crunch the numbers for genetic parameters that will generate EBVs
Scanning ewes for pregnancy, litter size and stage of gestation is now very widespread in the sheep industry.

Ultrasound imaging now used in many species for research and commercial applications.
Ultrasound is used in cattle for pregnancy diagnosis, early detection, stage of gestation, fetal sexing and imaging of the reproductive tract.
Bound to find ovaries if he goes deep enough.

Anything yet?
Follicle development

1. Estrus (Day 21 or 0)
   - Mature Follicle
   - Old Corpus Luteum
   - Immature Follicles

2. Ovulation (Day 1)
   - Ovum
   - Ruptured Follicle
   - Old Corpus Luteum

3. Regressing Corpus Luteum (Days 16-20)
   - Developing Follicle
   - Regressing Corpus Luteum
   - Corpus Albicans

4. Developing Corpus Luteum (Days 2-4)
   - New Corpus
   - Corpus Luteum

5. Mature Corpus Luteum (Days 5-15)
   - Mature Corpus
   - Luteum

Follicle development
Images of reproductive tract and ovarian structures (developing follicles) seen on the scanner screen.
Images of ovarian structures seen on the scanner screen. The presence of a *corpus luteum* (CL) is evidence of ovulation.
Some preliminary results

- Large variation in age and weight at first ovulation between herds
- Likely related to differences in maturity type
- Possible correlation with *Days to Calving* EBV
Thank you
Use of an intra-rectal ultrasound probe to image the reproductive tract of the cow
What’s it worth to increase fertility?

Increase of 1% in output by improvement in fertility = ~ $m 23 to NSW per year

(Based on ABS data for 2014/15 which would be conservative compared to current and future projected cattle market prices)
Can heifers improve herd fertility by an early start to their breeding life?

- Herd fertility is a major driver of productivity and profitability of beef breeding enterprises.
- Breeding females use 60-70% of energy intake for their own maintenance so must be efficient in calf production – a dry cow is a very expensive passenger.
- Replacement heifers contribute to the overall herd productivity only after their first mating/calving, which is constrained by attainment of puberty – variation in first calving at 2 or 3 yo.
- Long recognised that puberty is related to age and weight and considered as a proportion of mature size.

FIX
Can heifers improve herd fertility by an early start to their breeding life?

• Age and weight at puberty (which are highly correlated) have been shown to be heritable traits, and related to early and lifetime reproductive performance.
• There are few of the currently available EBVs that relate to fertility, with *Days to Calving* essentially the only one with a direct effect.
• Thus the generation of EBVs related to puberty has the potential to provide an extra selection tool to increase herd fertility.

**FIX**
First Some Beef Industry Stats
### Australian Beef Cattle Industry (ABS stats 2014/15)

<table>
<thead>
<tr>
<th></th>
<th>Australia</th>
<th>NSW</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total beef cattle</td>
<td>~ 25 m</td>
<td>~ 5.3 m</td>
<td>21%</td>
</tr>
<tr>
<td>Breeders (females &gt; 1 yo)</td>
<td>~ 12.5 m</td>
<td>~ 2.7 m</td>
<td>21%</td>
</tr>
<tr>
<td>Farm (beef) businesses</td>
<td>~ 66,000</td>
<td>~ 27,000</td>
<td>37%</td>
</tr>
<tr>
<td>Gross value total agric. production</td>
<td>$b 54</td>
<td>$b 12</td>
<td>23%</td>
</tr>
<tr>
<td>Gross value of beef production</td>
<td>$b 11.5</td>
<td>$b 2.3</td>
<td>20%</td>
</tr>
<tr>
<td>Beef % of total agriculture</td>
<td>22%</td>
<td>19%</td>
<td></td>
</tr>
</tbody>
</table>

Output from the Beef Industry is a major component of the total value of agricultural production – both Nationally and for NSW.
Australian Beef Industry

Average calf branding rates (%) and numbers of breeding females

TOTAL ~ 12.5 m

ABS data 2014/15

Total beef cattle ~ 25 m
Beef calf branding rates in Australia’s northern and southern production systems, 1978–79 to 2014–15

Note: Data not available for 2001–02 and 2002–03.

Source: ABARES
What’s it worth to increase fertility?

Increase of 1% in output by improvement in fertility = $m 22,930 to NSW per year

(Based on ABS data for 2014/15 which would be conservative compared to current and future projected cattle market prices)
NSW DPI Beef Research

National Livestock Genetics Consortium (NLGC)

BREEDPLAN Evaluation (AGBU)

Gene Expression/Genomics

BIN PROGRAMS
GI Muscling & Trangie Herds

Fertility
Growth
Scans
Efficiency

Not RBY

RRD4P Program
Lean Meat Yield
Meat Quality

Carcass

Heifer and cow production

Maternal Models

3D Cameras
Objective measurement
BT & BI & Euro
(ACC)

BeefSpecs
On-farm decision making
Drafting tool
Optimisation

RBY Project
(John Dee)

NSW DPI Beef Research

Supply

End Product

Production System Flow
Genetic control of reproduction traits

- Heritabilities of most traits affecting fertility are typically low (< 0.3)

- Use of EBVs for Days to calving and Calving ease are recommended in multi-trait selection indices

- Days to calving is the trait with most direct effect on fertility – others (calving ease, birth weight, gestation length) do have effects on output, mainly through survival

- Genetic selection for twinning – slow improvement and permanent effects not always beneficial
Genetic control of reproduction traits

• Increased recent interest in heritabilities for pubertal traits due to encouraging results

• Studies in Beef CRC for *Bos indicus* and composites in Northern Aust herds showed heritabilities for puberty traits > 0.5 and that

• Similar data for *Bos taurus* in Southern Aust herds was scant

• Genetic potential for fertility may be masked by the use of AI in the seedstock herds
Genetic control of reproduction traits

• The factors above prompted our interest to run a pilot project to monitor puberty in *Bos taurus* heifers – the project is conducted jointly with Dr Rob Banks, AGBU, Armidale, and DPI genetists following his enthusiastic promotion of the concept

• The progression for the future is aimed to
  
  – Collect sufficient data to calculate genetic parameters – heritabilities and correlations between traits – from a large sample of industry herds
  
  – Eventually generate EBVs for use in selection programs to increase herd fertility
BREEDPLAN EBVs now commonly used within the industry – these are available for bulls at live sales or for semen used for AI programs

<table>
<thead>
<tr>
<th>BREEDPLAN EBVs</th>
<th>Weight/growth</th>
<th>Fertility/calving</th>
<th>Carcase</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Birth wt</td>
<td>Days to calving</td>
<td>Carcase wt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Milk</td>
<td>Gestation length</td>
<td>Eye muscle area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200 day growth</td>
<td>Calving ease</td>
<td>Fat depth</td>
</tr>
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<td></td>
<td></td>
<td>400 day growth</td>
<td>Scrotal size</td>
<td>Intramuscular fat</td>
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<td></td>
<td></td>
<td>600 day growth</td>
<td></td>
<td>Retail beef yield</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature cow wt</td>
<td></td>
<td>Shear force</td>
</tr>
</tbody>
</table>

- Traits relating to fertility have only low/medium heritabilities
- Many traits difficult to measure or measured late in life
- Early measured traits can accelerate genetic gain
A bit of reproductive physiology
Ovaries from cows given superovulation treatment showing many developing follicles and corpora lutea (CL)
The activity of the ovary was difficult to observe and monitor (previously mainly by serial slaughter) prior to the use of ultrasound imaging – which then allowed us to see it in real time, sequentially and non-destructively.
Ultrasound imaging is particularly useful to observe the activity of the ovaries of heifers to determine when follicles are reaching advanced stages of development and proceed to ovulation as evidenced by the presence of a corpus luteum (CL)

Thus to determine first ovulation and onset of puberty
Ultrasound imaging has become a very handy tool for use in many species and for both research and commercial applications.
What do we see on the images?
Follicle and CL development in the ovary
So – now some details about the heifer puberty project
The pilot project was commenced in 2015
We scanned Angus heifers at DPI Ag Research Centre at Trangie and a commercial Angus stud

Data collected at ultrasound scanning events
• Animal ID with known birth date – provides age at scan
• Liveweight
• Hip height (estimates frame score - maturity type)
• P8 fat depth (ultrasound measured)
• Features of the ovaries
  • For each side (right and left ovaries)
    • Presence (or absence) of a corpus luteum (CL)
    • If no CL – size of largest follicle (e.g. small only, 5, 8, 10 or > mm)
Expected outcomes

• Estimate genetic variation for puberty traits in industry herds
• Generation of EBVs and correlations – providing extra traits for selection
• Increase fertility by
  • Earlier mating
  • Improved conception rates
  • Increased lifetime reproductive output
• Assist genetic gain by earlier selection and mating of heifer replacements
• Correlated improvement in male fertility and attainment of puberty
• Determine least number of scans required (practicality)
That’s about it (for now)
Thank you
Follicle development

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DEVELOPING CORPUS LUTEUM (Days 2-4)
- New Corpus Luteum
- Regressed Corpus Luteum (Corpus Albicans)

MATURE CORPUS LUTEUM (Days 5-15)
- Mature Corpus Luteum
- Corpus Albicans
Fertility driving efficiency (70% maintenance) production and profitability
Johnno - Genetic correlations
between early-in-life reproductive measures and lifetime reproduction traits
were moderate to high.
Heifer age at puberty was highly ($rg= -0.71$
0.11) and moderately ($rg = -0.40$ 0.20) genetically correlated with pregnancy
rate at first annual mating (mating 1) and
lifetime annual calving rate, respectively in Brahman (BRAH). In Tropical
Composite (TCOMP), heifer age at puberty was
highly correlated with reproductive outcomes from the first re-breed (mating 2),
mainly due to its association with lactation
anoestrous interval ($rg = 0.720.17$).
Corbet – single u/s at 600 days -
Estimates of heritability of incidence of CL at 600d (0.20 to 0.32)
Beef industry / NSW
Fertility
Production chain
DPI research
Genetic control
Anatomy
Ovary
Follicular development
Imaging procedure
Recording
Use of data
Correlation with fertility
Develop EBV
Early mating/better conception rates/increase lifetime output/improve male fertility