Novel reproduction traits for genetic evaluation.

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

agbu

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.

agbu

Beef CRC research:

Opportunities for selection to improve reproduction rates in tropical beef breeds.

(2000 – 2014)

agbu

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.

agbu

The Beef CRC

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).

agbu

Beef CRC

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.

agbu

Beef CRC

Measuring female reproduction

- By ultrasound scanning for ovarian function.

agbu

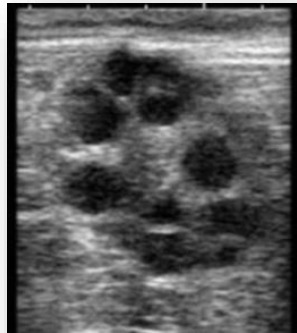## Measuring female reproduction

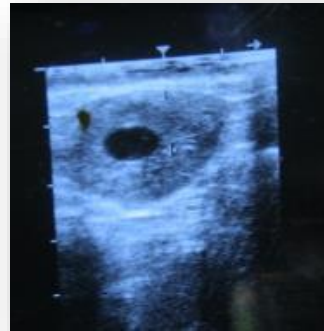- By ultrasound scanning for ovarian function.

Beef CRC

Measuring female reproduction

- By ultrasound scanning for ovarian function.

Pre-pubertal ovary
(many small follicles)

Cycling ovary
(One large CL)
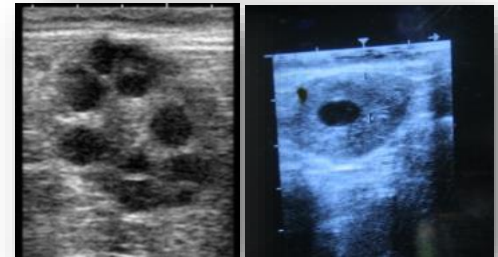
agbu

Beef CRC

Measuring female reproduction

- By ultrasound scanning for ovarian function.

Age at puberty (AP)

- From weaning till *corpus luteum* (CL) detected.
- 2 – 15 measurements / heifer.

agbu

Beef CRC

Measuring female reproduction

- By ultrasound scanning for ovarian function.

Age at puberty (AP)

- From weaning till *corpus luteum* (CL) detected.
- 2 – 15 measurements / heifer.

Lactation anestrous interval (LAI)

- Lactating cows at 2nd natural mating.
- Calculated as days from bull-in date to first detected CL.
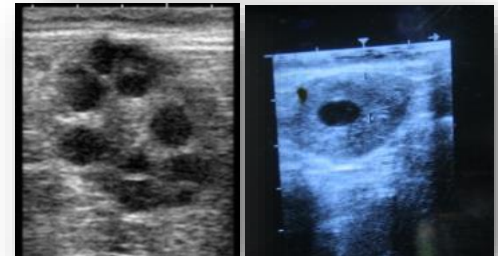
Beef CRC

Measuring female reproduction

- By ultrasound scanning for ovarian function.

Age at puberty (AP)

- From weaning till *corpus luteum* (CL) detected.
- 2 – 15 measurements / heifer.

Lactation anestrous interval (LAI)

- Lactating cows at 2nd natural mating.
- Calculated as days from bull-in date to first detected CL.

**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.

  = *Calves weaned / mating seasons in experiment.*

MEASURE	Brahman	Tropical Composite
Number	1020	1117
Average	0.62	0.78
Sire EBV range	-0.11 to 0.16	-0.06 to 0.08
Heritability	0.11	0.07

agbu

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.

agbu

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.

Range in age at puberty for BRAH heifers.
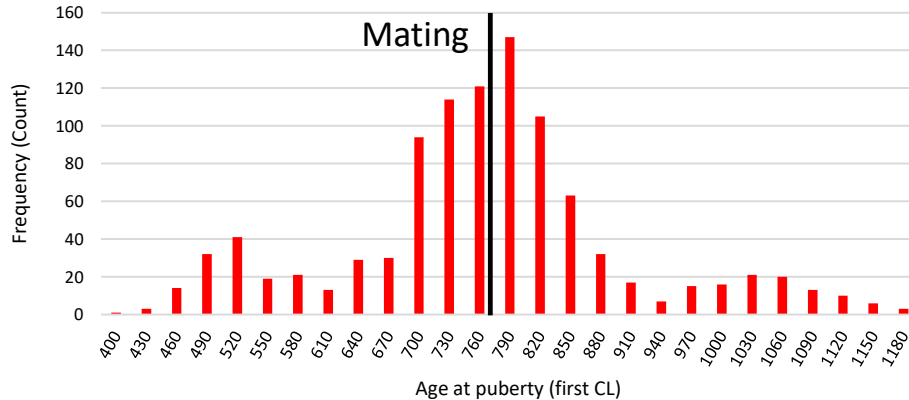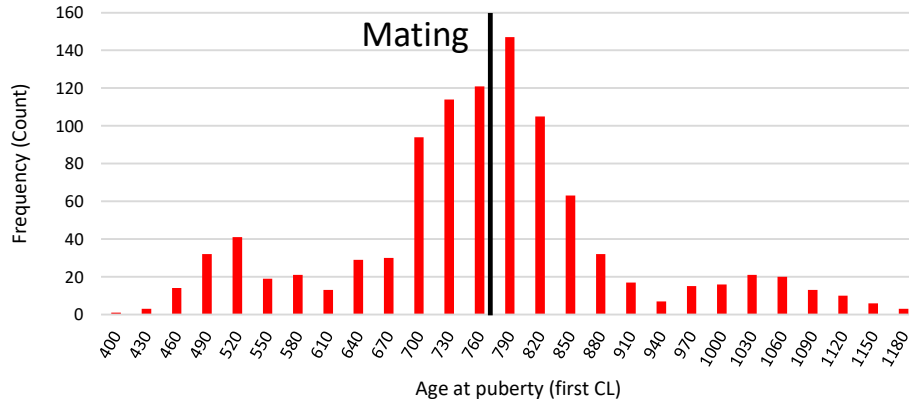- Mated as 2 year olds.

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.

Range in age at puberty for BRAH heifers.
- Mated as 2 year olds.
- Only 51% cycling into mating

agbu

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 (breeds).

Range in age at puberty for BRAH heifers.
- Mated as 2 year olds.
- Only 51% cycling into mating
- 13% failed to reach puberty by the end of their 1st mating season.

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 (breeds).

Range in age at puberty for BRAH heifers.
- Mated as 2 year olds.
- Only 51% cycling into mating
- 13% failed to reach puberty by the end of their 1st mating season.

Of those which did cycle:
- 90% conceived and 72% weaned a calf.
- Overall weaning rate of 62%.

Beef CRC Key results

Age at puberty

- Very heritable for a reproduction trait (h^2 = 0.5 to 0.6).
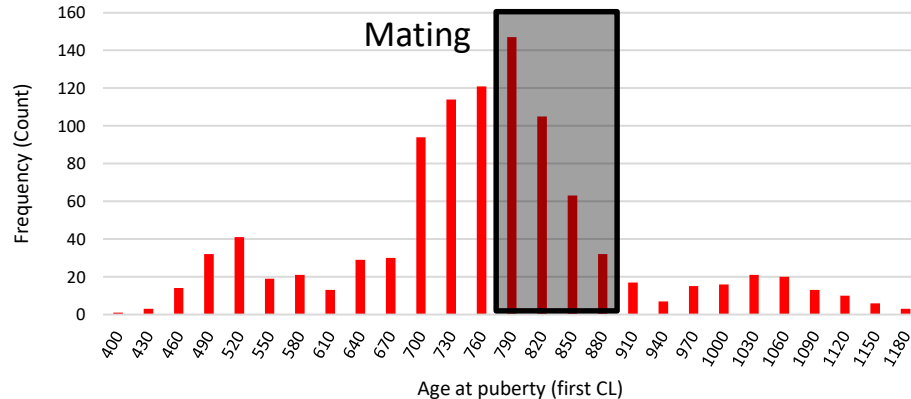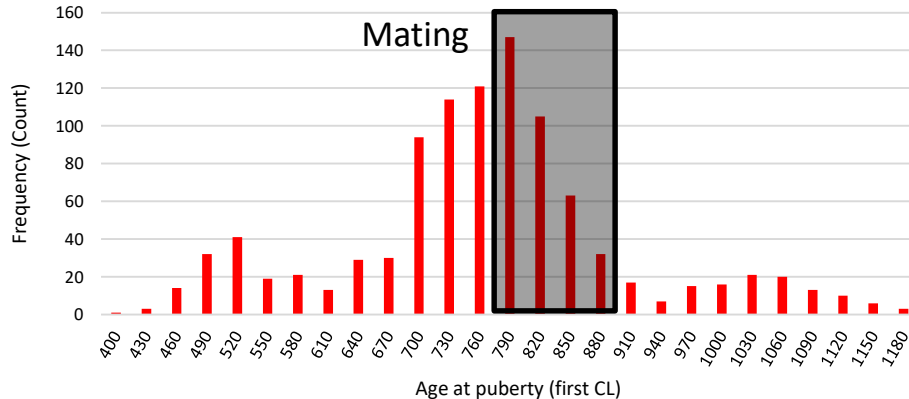- Large genetic variation within genotypes (breeds).
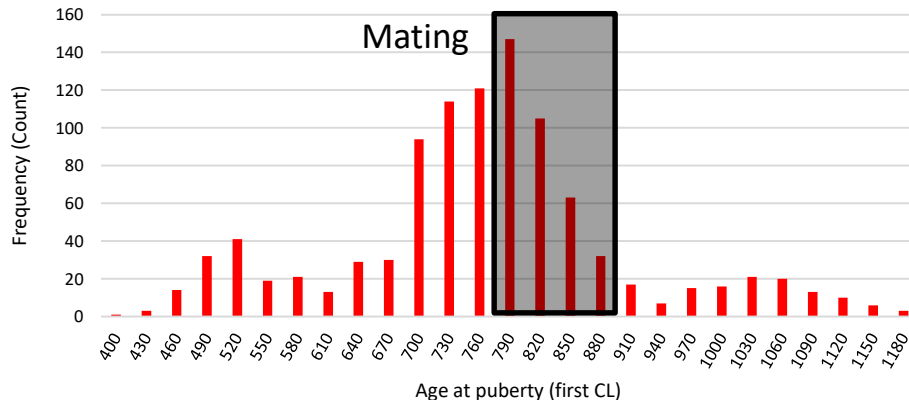
Range in age at puberty for BRAH heifers.
- Mated as 2 year olds.
- Only 51% cycling into mating
- 13% failed to reach puberty by the end of their 1st mating season.

Of those which did cycle:
- 90% conceived and 72% weaned a calf.
- Overall weaning rate of 62%.

Massive opportunity to apply selection to improve AP in Brahman females

Beef CRC Key results

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.

agbu

Beef CRC Key results

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.

Beef CRC Brahman Sire	LAI EBV (days)
LANCEFIELD 4999M	-100
MR V8 797/3 (IMP US)	-95
TARTRUS 3886 (AI) (ET)	-89
CONA CREEK 2722	-71
NEWCASTLE WATERS TOBY G774 (ET)	-63
LANCEFIELD 4461	-60
McKELLAR RICARDO 3/840 (IMP US)	-58
TARTRUS ABEL MANSO 4182 (AI) (ET)	-55
BELMONT 96-478	-52
CARINYA 1926	-40
.	.
CBV PROVIDOR 96-6822	51
CARINYA MAX 1739	54
TARTRUS 2415 (ET)	57
TARTRUS 3292	62
JDH DENVER DE MANSO 818/7 (IMP US)	63
LANCEFIELD AMBITION 7736	65
LYNDHURST 1660/7	73
WAVERLEY SUPREME DE MANSO 6263	79
TARTRUS MR MANSO 025 (ET)	114
BELMONT 79/96 (AI)	169

agbu

Beef CRC Key results

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.

Beef CRC Brahman Sire	LAI EBV (days)
LANCEFIELD 4999M	-100
MR V8 797/3 (IMP US)	-95
TARTRUS 3886 (AI) (ET)	-89
CONA CREEK 2722	-71
NEWCASTLE WATERS TOBY G774 (ET)	-63
LANCEFIELD 4461	-60
McKELLAR RICARDO 3/840 (IMP US)	-58
TARTRUS ABEL MANSO 4182 (AI) (ET)	-55
BELMONT 96-478	-52
CARINYA 1926	-40
.	.
CBV PROVIDOR 96-6822	51
CARINYA MAX 1739	54
TARTRUS 2415 (ET)	57
TARTRUS 3292	62
JDH DENVER DE MANSO 818/7 (IMP US)	63
LANCEFIELD AMBITION 7736	65
LYNDHURST 1660/7	73
WAVERLEY SUPREME DE MANSO 6263	79
TARTRUS MR MANSO 025 (ET)	114
BELMONT 79/96 (AI)	169

agbu

Beef CRC Key results

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.

Beef CRC Brahman Sire	LAI EBV (days)
LANCEFIELD 4999M	-100
MR V8 797/3 (IMP US)	-95
TARTRUS 3886 (AI) (ET)	-89
CONA CREEK 2722	-71
NEWCASTLE WATERS TOBY G774 (ET)	-63
LANCEFIELD 4461	-60
McKELLAR RICARDO 3/840 (IMP US)	-58
TARTRUS ABEL MANSO 4182 (AI) (ET)	-55
BELMONT 96-478	-52
CARINYA 1926	-40
.	.
CBV PROVIDOR 96-6822	51
CARINYA MAX 1739	54
TARTRUS 2415 (ET)	57
TARTRUS 3292	62
JDH DENVER DE MANSO 818/7 (IMP US)	63
LANCEFIELD AMBITION 7736	65
LYNDHURST 1660/7	73
WAVERLEY SUPREME DE MANSO 6263	79
TARTRUS MR MANSO 025 (ET)	114
BELMONT 79/96 (AI)	169

agbu

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.

agbu

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.

Additive variance and heritability for PNS in 1300 Brahman and 2000 Tropical Composite bulls.

Age (months)	Brahman		Tropical Composite	
	V_a	h^2	V_a	h^2
12	0	0.0	297	0.4
18	199	0.3	97	0.2
24	75	0.2	97	0.3

agbu

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.

Additive variance and heritability for PNS in 1300 Brahman and 2000 Tropical Composite bulls.

Age (months)	Brahman		Tropical Composite	
	V_a	h^2	V_a	h^2
12	0	0.0	297	0.4
18	199	0.3	97	0.2
24	75	0.2	97	0.3

agbu

PNS vs female reproduction

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

agbu

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.

Genetic correlations of Brahman PNS with female age at puberty (AP) and lactation anoestrus interval (LAI)

Bull age	AP	LAI
12 months	.	.
18 months	-0.5	-0.6
24 months	-0.3	-0.7

agbu

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.

Genetic correlations of Brahman PNS with female age at puberty (AP) and lactation anoestrus interval (LAI)

Bull age	AP	LAI
12 months	.	.
18 months	-0.5	-0.6
24 months	-0.3	-0.7

agbu

Beef CRC summary

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.

agbu

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.

Novel reproduction traits:

Recording hard to measure phenotypes in industry.

1. The Repronomics project.

agbu

Accelerating ΔG 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.

agbu

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.

agbu

Novel reproduction traits:

Recording hard to measure phenotypes in industry.

2. 'Kaiuroo' MDC project.

agbu

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)
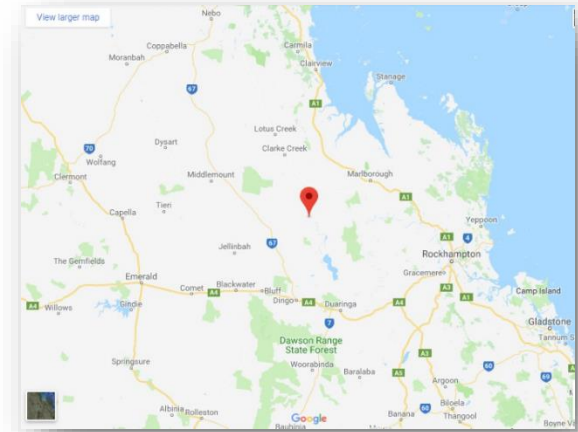
Kaiuroo snapshot

- 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.

agbu

- Implemented ovarian scanning program
  - Age at puberty.
  - Lactation anoestrous interval.

- All bulls morphology tested
  - Percent normal sperm.

agbu

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.

agbu

- 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.

agbu

Novel reproduction traits:

Recording hard to measure phenotypes in industry.

3. Extending what we've learned in tropical breeds to *Bos taurus* cattle.

agbu

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.

agbu

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.

agbu
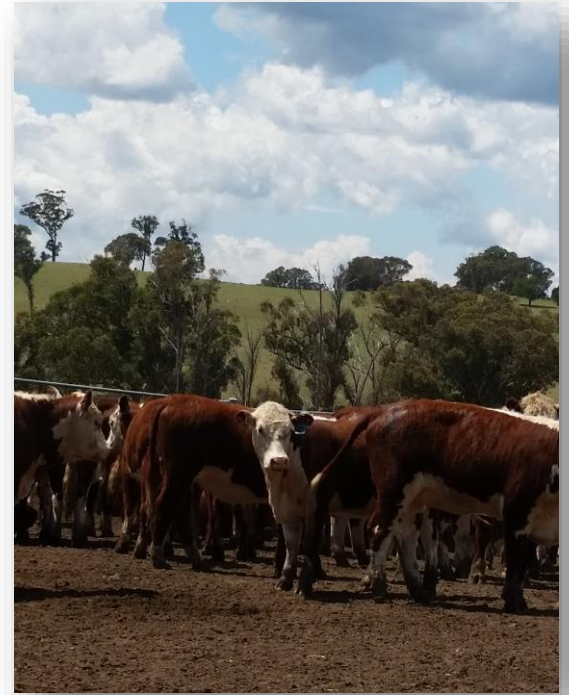
Experimental design

- Scanning commenced from first observed oestrus behaviour.

- Repeated every 4 – 6 weeks to mating.

- Averaged 3 scans in Herefords and 4 in Angus herds.

agbu
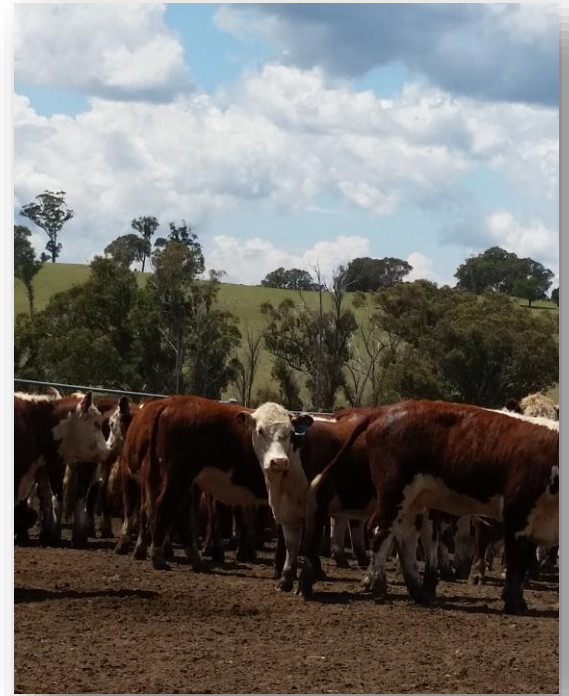
Traits analysed

- 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)

agbu

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)

Not accredited scanners (or experienced BCS scorers)

agbu

Key results

- 52% of heifers were pubertal as they entered their first mating.

agbu

Trans-Tasman beef cow productivity project

Descriptive statistics for heifer ovarian scanned traits

Breed / Trait	Units	Number of records	Mean	sd
Angus				
Age at puberty	Days	1546	344.5	64.0
AP (penalty)	Days	2939	393.2	72.2
Percent Pubertal	%	2939	52.6	50.0
Hereford				
Age at puberty	Days	481	365.8	38.3
AP (penalty)	Days	902	396.2	44.3
Percent Pubertal	%	917	52.4	50.0

agbu

Key results

- 52% of heifers were pubertal as they entered their first mating.

- On average, heifers were in good condition going into mating.

agbu

Trans-Tasman beef cow productivity project

## Descriptive statistics for heifer growth and body composition traits

Breed / Trait	Units	Number	Post-weaning	Into mating
Angus				
Age	Days	3205	297.1	412.8
Liveweight	kg	3196	299.6	367.2
Hip Height	cm	3198	116.9	123.8
Condition score	1 – 5 score	3201	2.9	3.3
P8 fat depth	mm	3203	4.9	6.9
Hereford				
Age	Days	995	270.4	401.1
Liveweight	kg	963	262.8	343.8
Hip Height	cm	962	116.5	122.8
Condition score	1 – 5 score	964	2.6	3.4
P8 fat depth	mm	961	3.6	7.2

agbu

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.

agbu

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.

- Puberty traits heritable for both breeds.

agbu
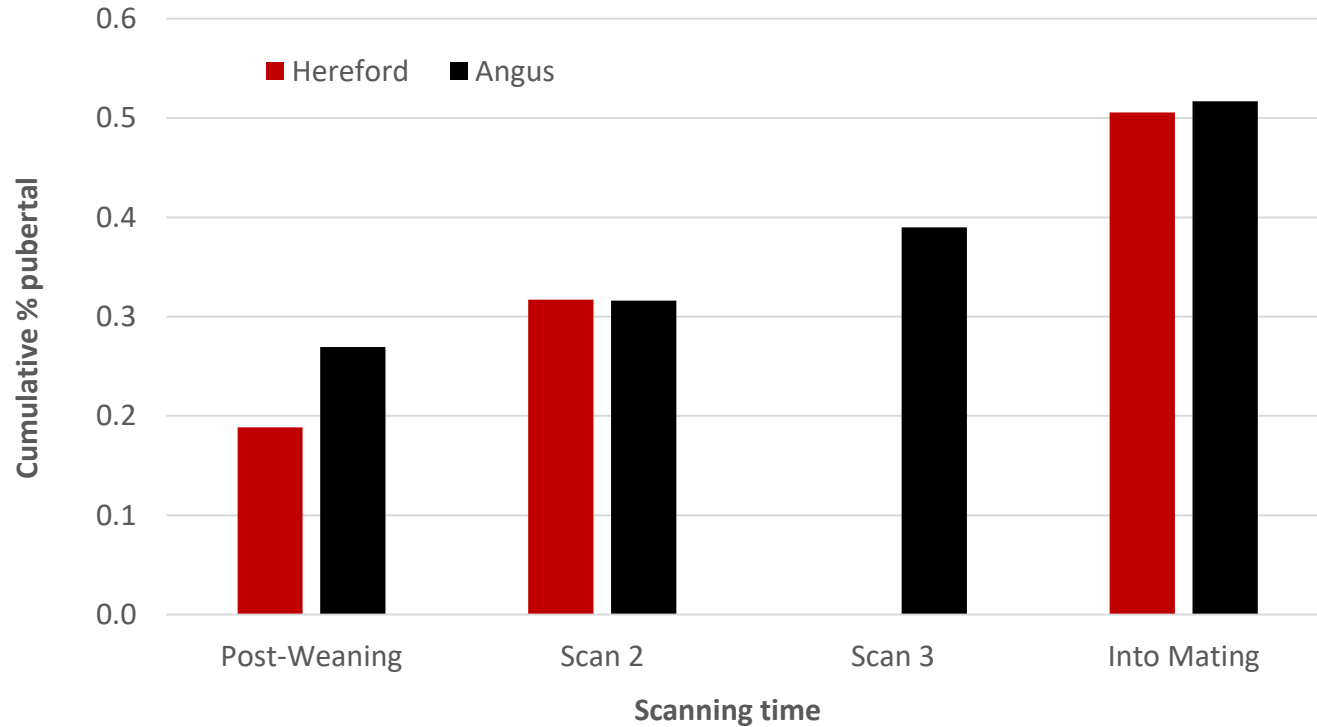
Trans-Tasman beef cow productivity project

Genetic parameters for heifer puberty traits

Trait	Units	σ_a	h^2
HEREFORD			
Age at puberty	Days	363.0	0.26
AP (penalty)	Days	588.7	0.38
Percent Pubertal	%	0.05	0.36
ANGUS			
Age at puberty	Days	325.1	0.27
AP (penalty)	Days	971.8	0.37
Percent Pubertal	%	0.08	0.32

agbu

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.

- Puberty traits heritable for both breeds.

- Genetic correlations with body composition traits were low.

agbu

Trans-Tasman beef cow productivity project

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

Into-mating	Genetic correlation
Liveweight (kg)	-0.20
Hip Height (cm)	-0.05
P8 fat depth (mm)	-0.14
Condition score (1 -5)	-0.26

agbu

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.

- Puberty traits were heritable for both breeds.

- Genetic correlations with body composition traits were low.

agbu

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.

agbu

Accelerating genetic gains for reproduction traits

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.

agbu

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.