Novel phenotypes to improve the rate of genetic gain in fertility for dairy cattle in New Zealand

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Research Objective

Genetic gain in fertility is accelerated through increased accuracy and reliability of sires using novel, earlier-in-life predictors of cow fertility.

Talk Overview

- Fertility Research Herd (pilot)
- Traits of Interest
- Large Scale Validation Study
  - Animal Selection
  - Phenotyping Protocols
  - Future Work

Fertility Research Herd

- ~500 Holstein-Friesian cows: half low and half high Fertility BV
- Translated to extreme divergence in reproductive phenotypes
- Provides a model to observe novel phenotypes that could be predictive of fertility

Traits of Interest

- Onset of Puberty
- Anogenital Distance (AGD)

Onset of Puberty

Meier et al., unpublished

Onset of Puberty

Heritability of 30% (Dennis et al, 2018)

Trait	High FBV (n=275)	Low FBV (n=249)	SD	P val.
Age at puberty (d)	358	379	6	<0.01
LWT at puberty (kg)	271	296	4	<0.01
Percentage mature LWT	51	55	1	<0.01

21 DAYS SOONER

25 KGs LIGHTER

Anogenital distance (AGD)

AGD is normally distributed, highly variable & moderately heritable

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Characterization of anogenital distance and its relationship to fertility in lactating Holstein cows

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Canadian HF – association with cow fertility

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The relationship between anogenital distance and fertility, and genome-wide associations for anogenital distance in Irish Holstein-Friesian cows

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Irish HF – no association with cow fertility

Validation Study

Animal Evaluation

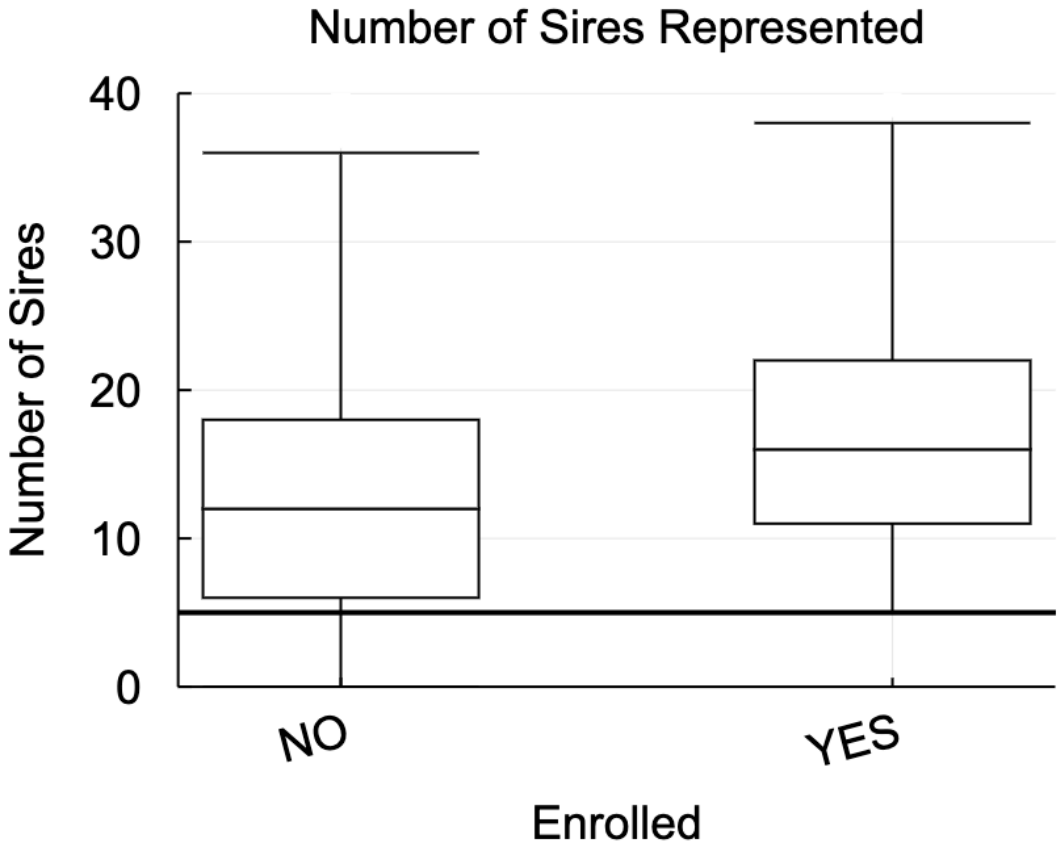
Improve statistical power to validate and extend key findings of the pilot study

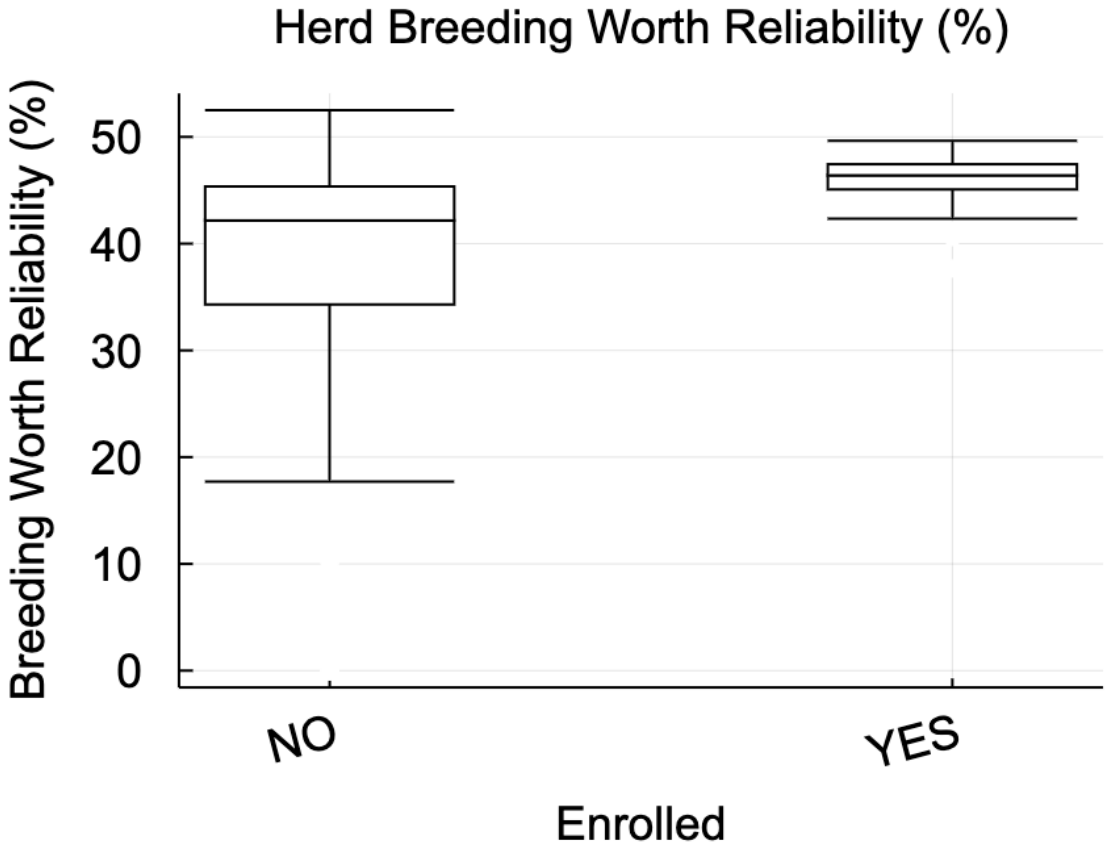
Validation Study

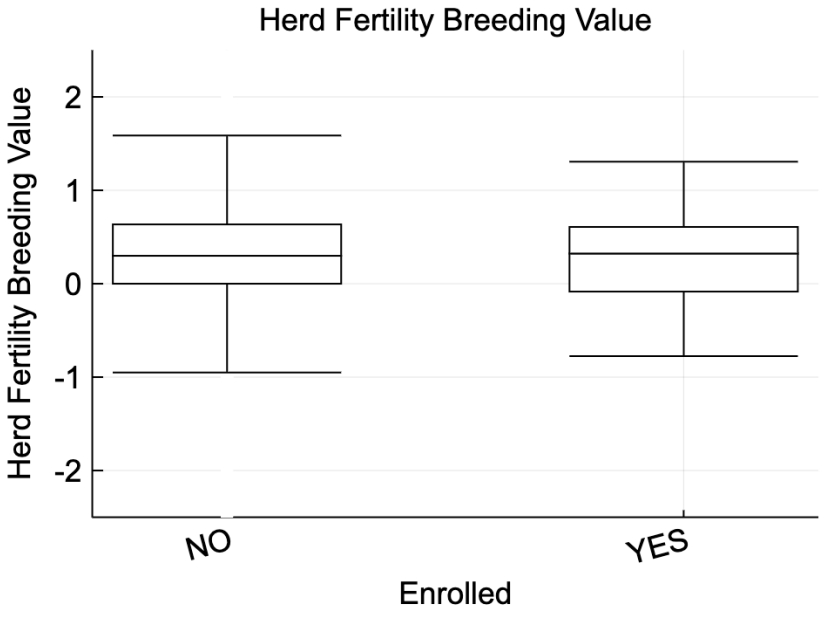
- Variances/Heritability's
  - Age of puberty (P4 measures, Pedometers)
  - AGD
- Covariances
  - Lactation (August 2020 to June 2021)
  - Fertility (October 2020)
- GWAS
  - Age of puberty
  - AGD

Enrollment Criteria

- Excellent data recording
- Variety of sires represented
- Majority Friesian

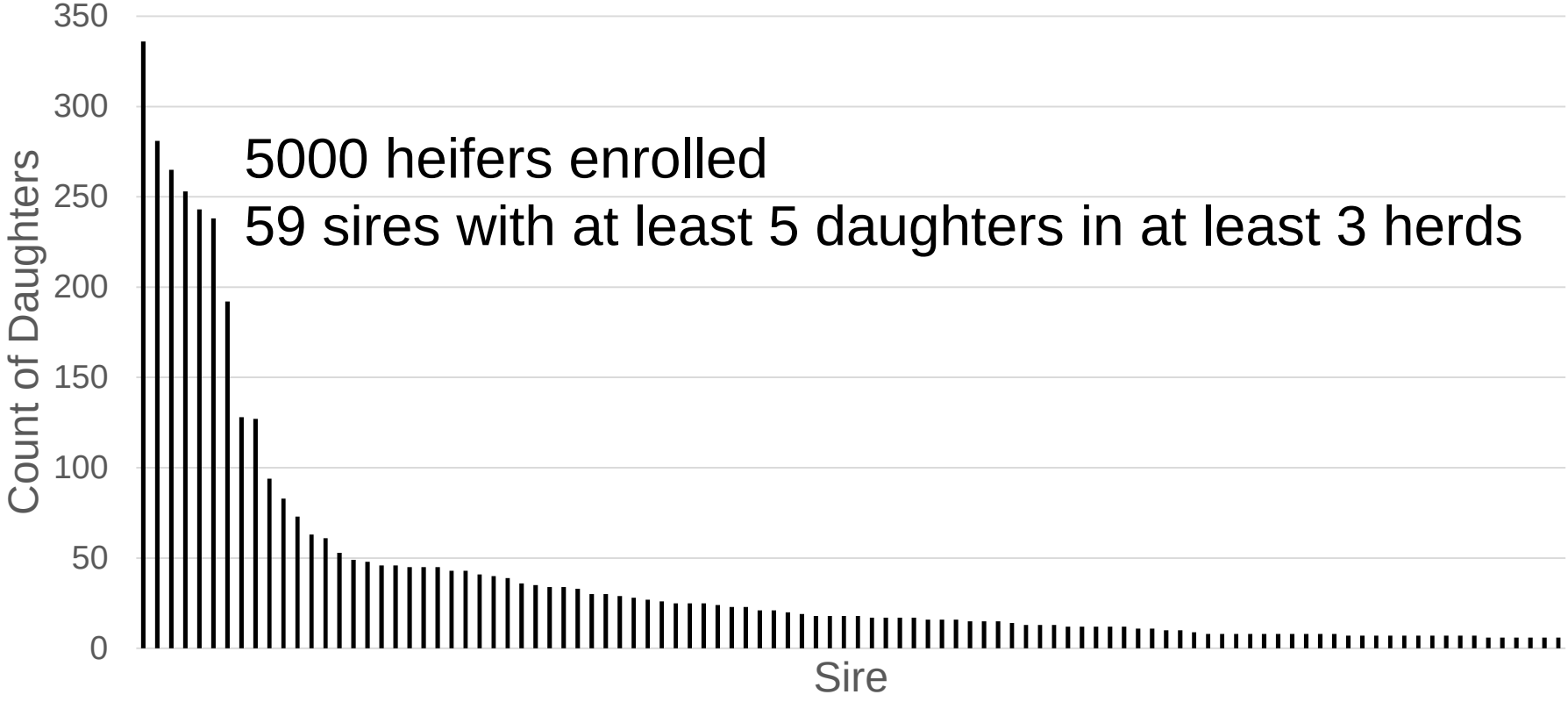






Animal Evaluation

Sire Representation



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Phenotyping - Puberty

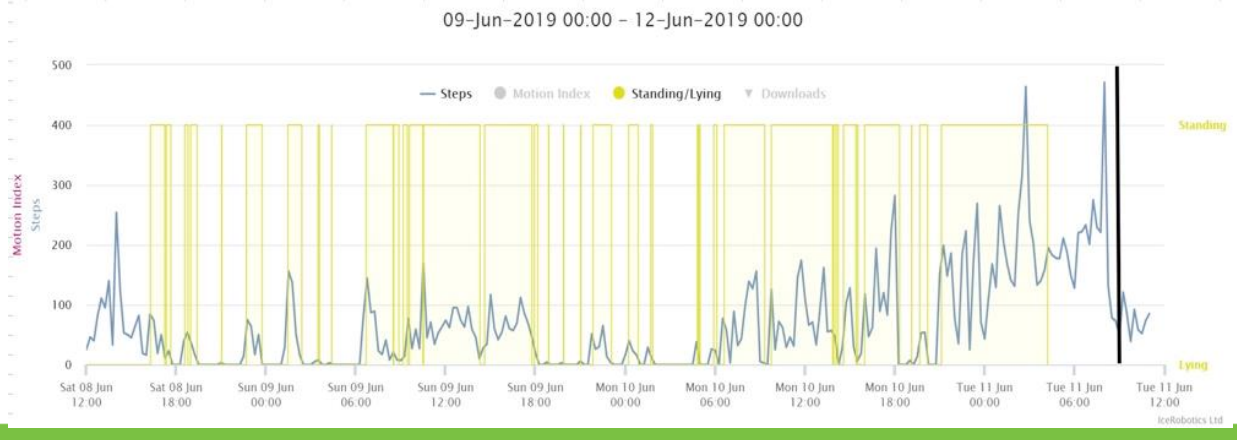
- Three blood samples for plasma progesterone (P4) – monthly intervals
  - Weekly is optimal but not practical
  - Expect lower heritability of ~18%*
  - Sufficient to meet our research objective*
- First samples timed for when 50% of the animals have reached puberty

*Amer & Dennis, AbacusBio

Phenotyping - Puberty

Subset of 2000 heifers to wear pedometers for three months

- Potential for wider phenotyping in the future
- Higher resolution than P4



Phenotyping – Other

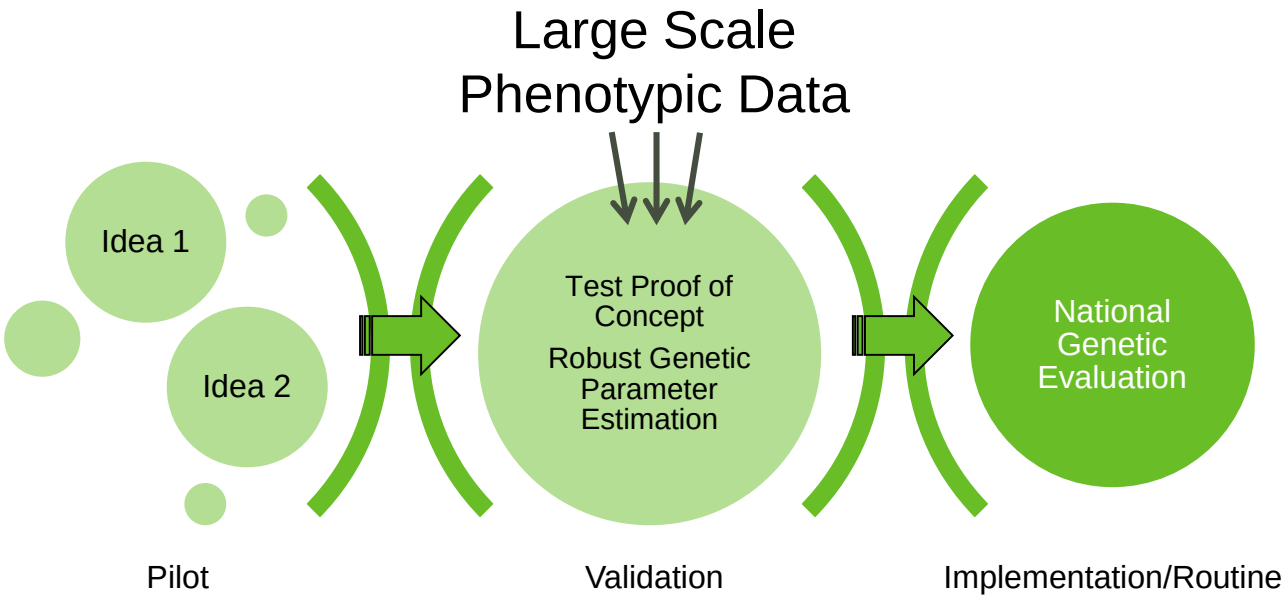
- Weight / Height (once)
- Anogenital Distance (once)
- Lactation (August 2020 to June 2021)
- Fertility (October 2020)

Genotyping

Genotyped Weatherby's Versa chip (50k, Illumina)

- Sire verification
- Increased accuracy of breed proportions
- GWAS

Future


Large Scale
Phenotypic Data
Idea 1
Idea 2
Test Proof of Concept
Robust Genetic Parameter Estimation
National Genetic Evaluation
Pilot
Validation
Implementation/Routine

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- Farmer Levy (DairyNZ Inc.)

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Thank you

DairyNZ

Observations: Fertility Research herd

1st lactation - 2017/18 (raw means)

Parameter (%)	High Fertility BV	Low Fertility BV
Numbers	257	224
3-week submission rate	87	48
6-week in-calf rate	**67**	**33**
Not-in-calf rate (12 weeks mating)	18	42

2nd lactation - 2018/19 (raw means)

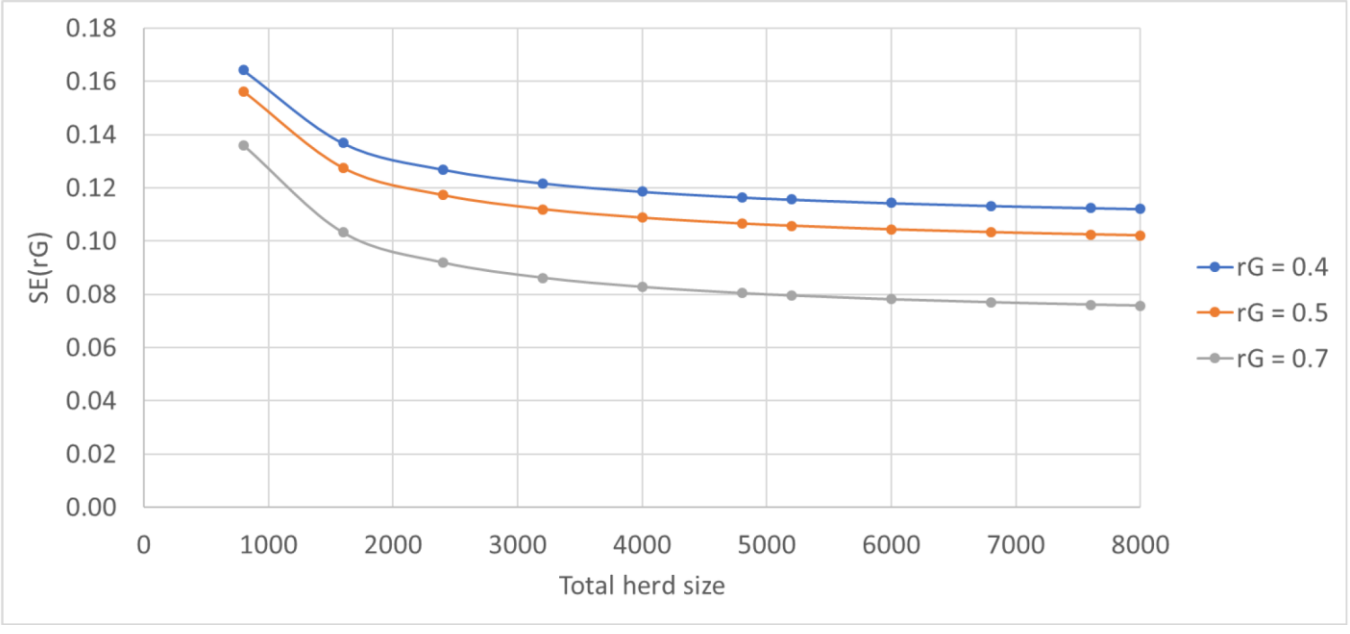
Parameter (%)	High Fertility BV	Low Fertility BV
Numbers	204	121
3-week submission rate	87	55
6-week in-calf rate	**74**	**39**
Not-in-calf rate (11 weeks mating)	13	44

AGD vs. cow fertility

Fertility traits	'Short' <105 mm	'Long' ≥105 mm	
Number (n)	360	112	
3-wk submission rate	74 ± 4	47 ± 6	<0.001
6-wk submission rate	83 ± 4	56 ± 6	<0.001
6-wk in-calf rate	57 ± 4	29 ± 5	<0.001
Final in-calf rate	77 ± 3	53 ± 5	<0.001

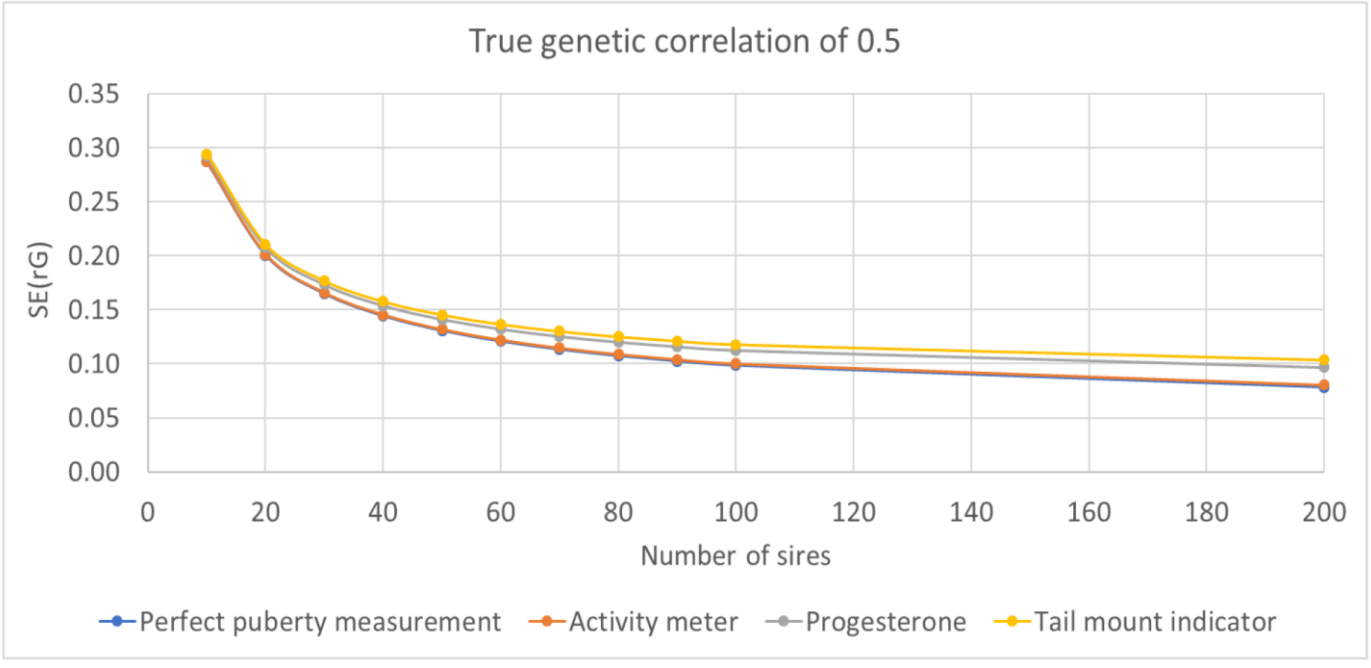
In this population, AGD is variable, normally distributed, moderately heritable and associated with cow fertility

Estimating the genetic correlation



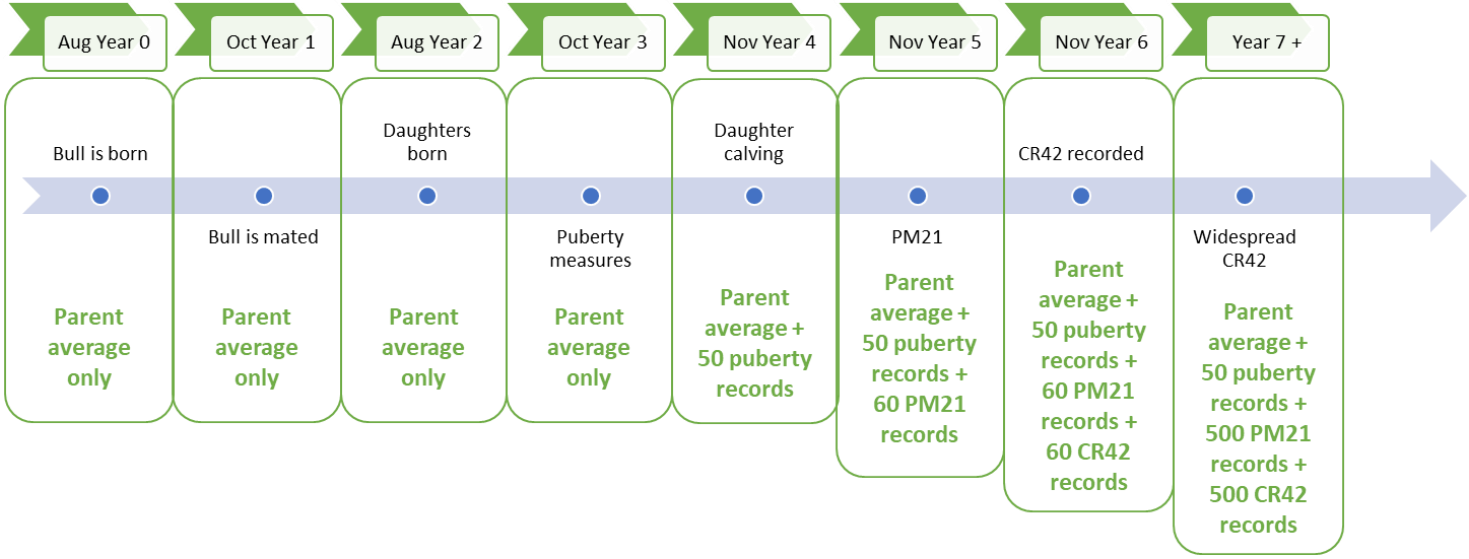
SFM estimates based on 80 sires
Amer & Dennis, AbacusBio

Number of sires is key to accurate rg



SFM estimates based on 4000 heifers
Amer & Dennis, AbacusBio

Fertility information from a bull's daughters



What we learnt from SFM

Phenotype	Heritability
Perfect age at puberty	0.36
Activity meter with minor errors	0.33
Single progesterone	0.07 to 0.1
Two progesterone (4 wks apart)	0.15
Three progesterone (4 wks apart)	0.18

*Modelling accounts for progesterone detected between days 6 and 17 of 21 d cycle
Amer & Dennis, AbacusBio

When do we start sampling?

Average heifer age (d)	Week 1 (% attained puberty)	Week 5 (% attained puberty)	Week 9 (% attained puberty)	Heritability*
Too early	244 (2%)	272 (9%)	300 (23%)	0.135
Early	272 (9%)	300 (24%)	328 (43%)	0.180
Little early	**300 (23%)**	**328 (43%)**	**356 (63%)**	**0.195**
Little late	328 (43%)	356 (63%)	386 (79%)	0.180
Late	356 (65%)	386 (80%)	414 (90%)	0.128
Very late	386 (79%)	414 (88%)	442 (93%)	0.080

*Modelling accounts for progesterone detected between days 6 and 17 of 21 d cycle
Amer & Dennis, AbacusBio