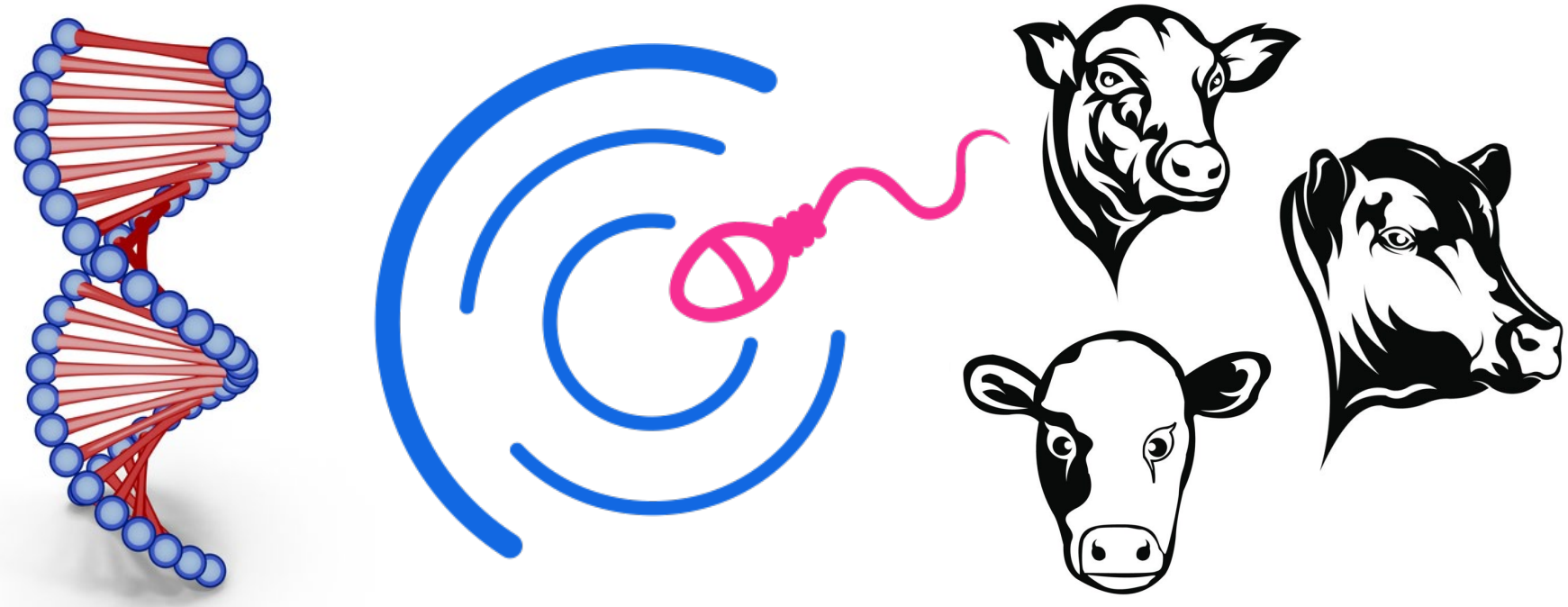
Mérito genômico e fertilidade em rebanhos de leite e de corte

Genomics of cattle reproduction

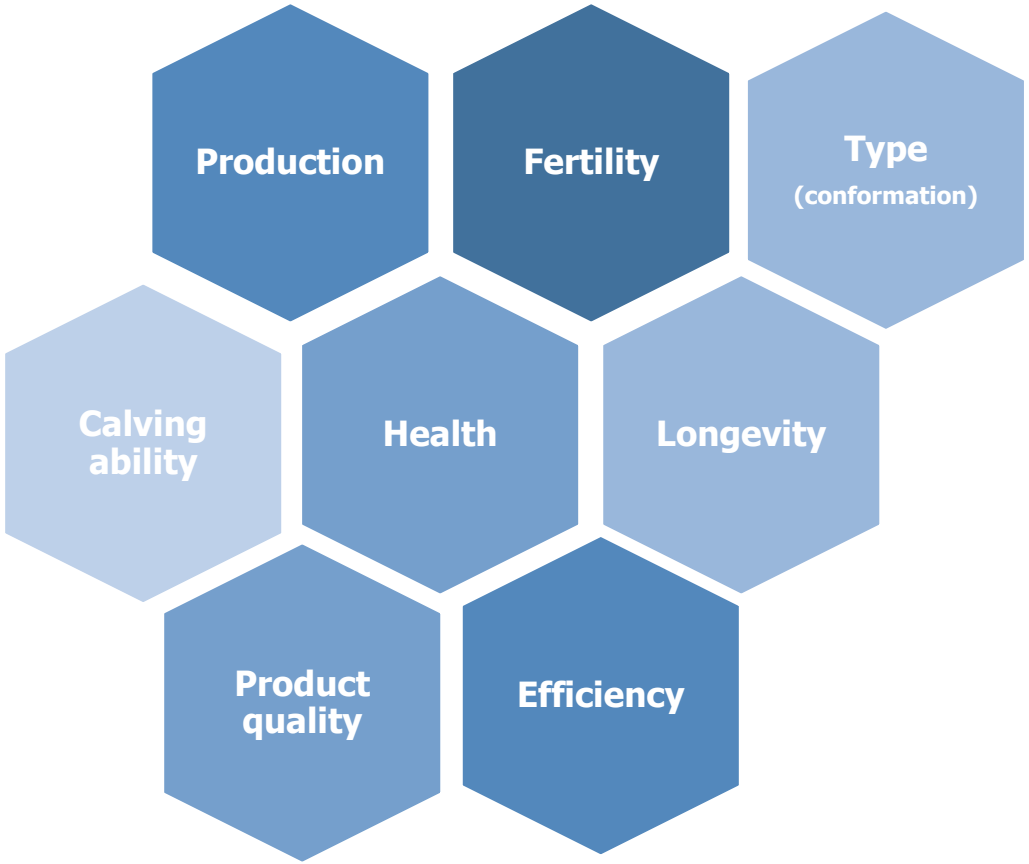


Francisco Peñagaricano

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

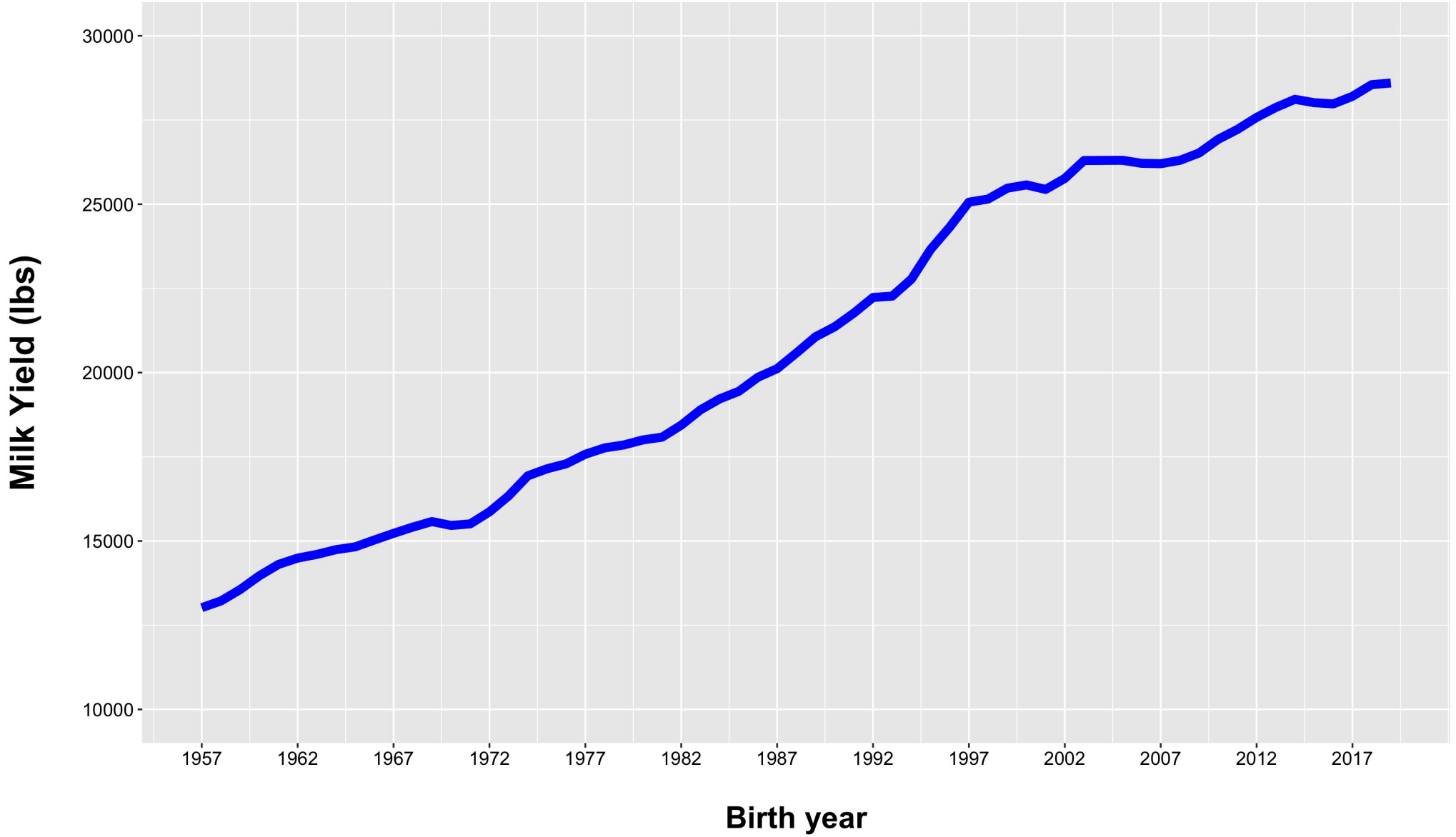
What's the goal of a selection program?

improve traits that **increase revenues** or traits that **reduce expenses**



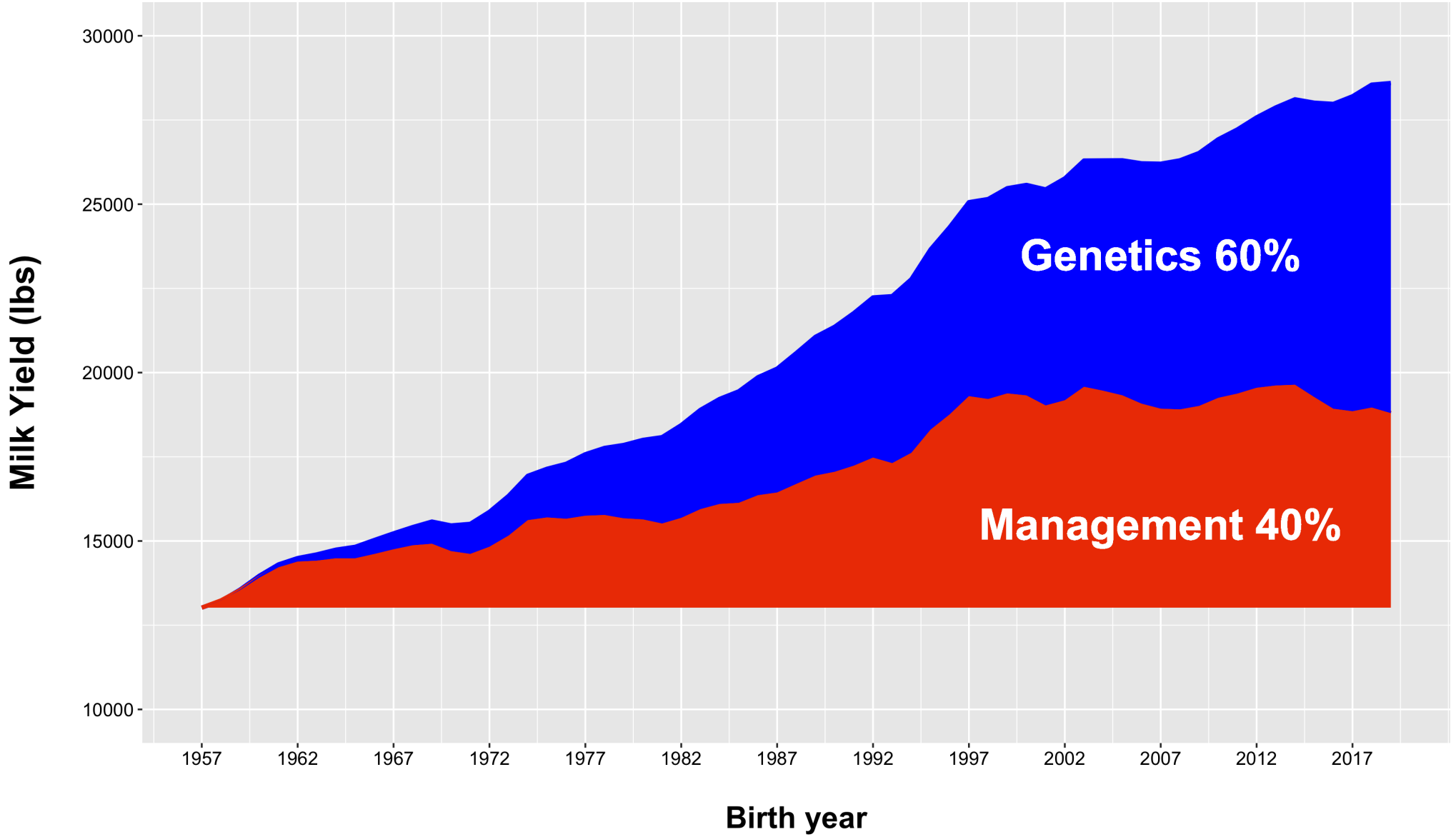
A successful story

Change in milk yield in the last 60 years



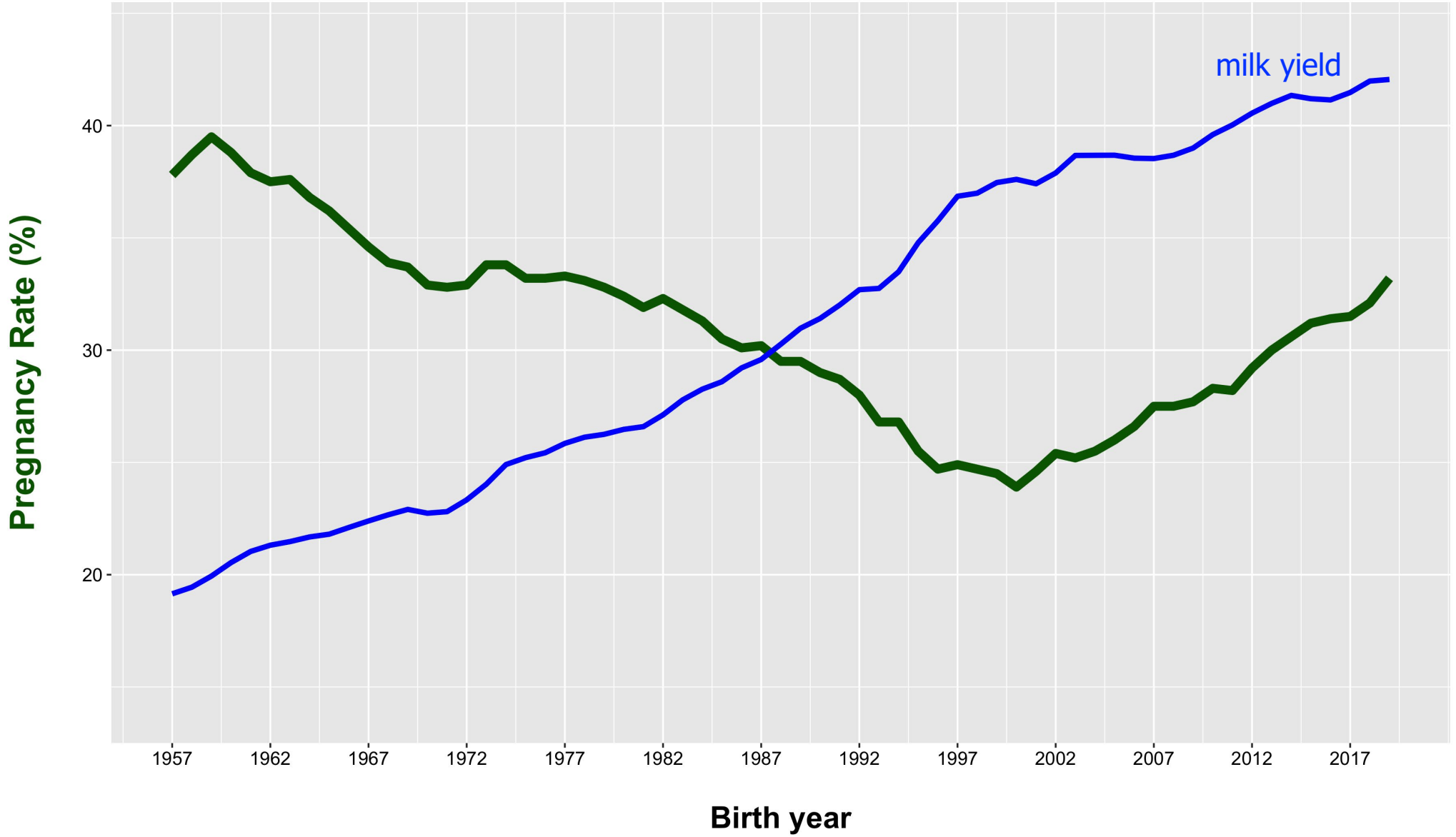
A successful story

Change in milk yield in the last 60 years



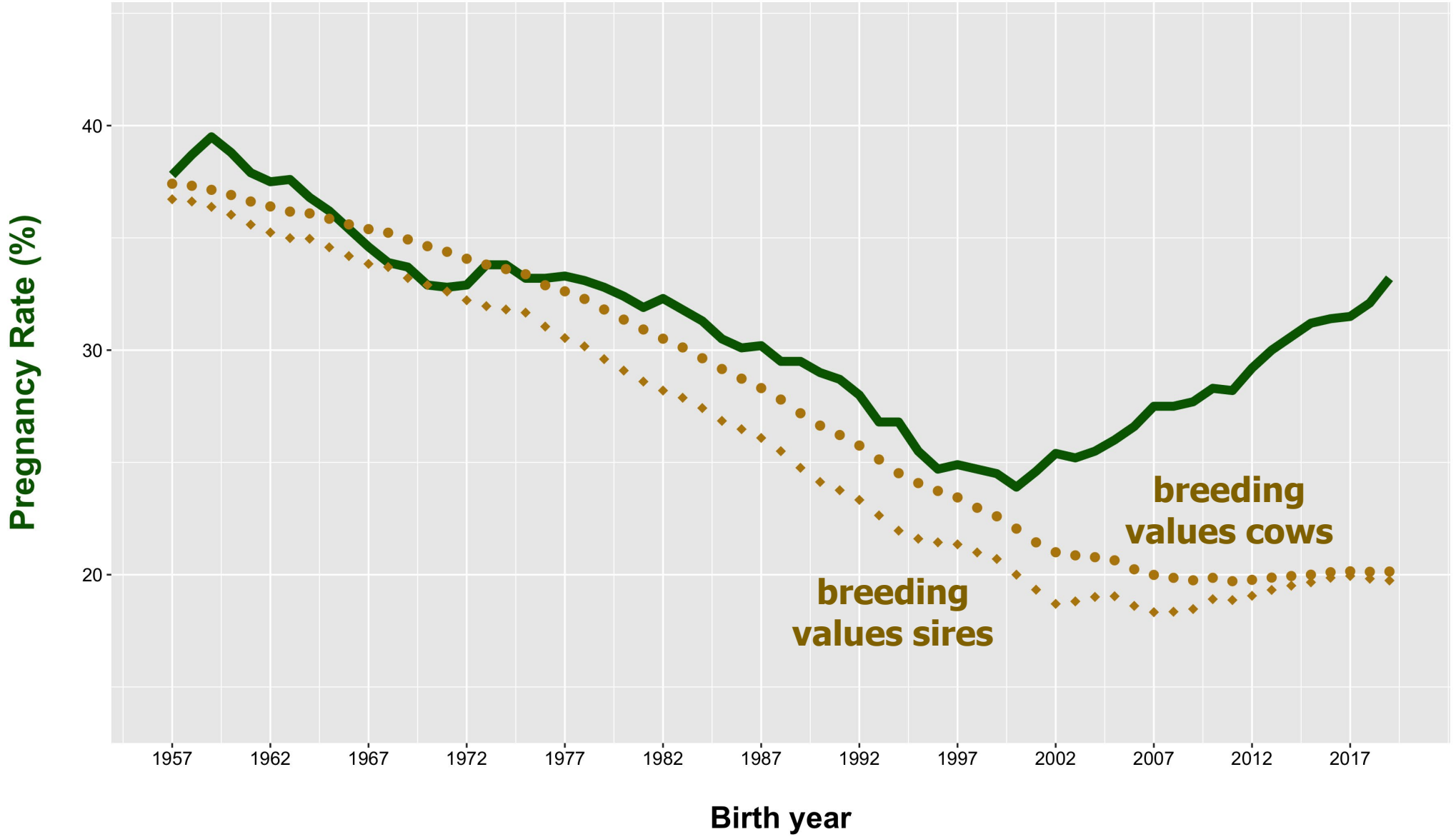
Another successful story

Change in fertility in the last 60 years



Another successful story

Change in fertility in the last 60 years



How do we evaluate female fertility?

- **daughter pregnancy rate (DPR)** (since 2003)

percentage of nonpregnant cows that become pregnant during a given 21-day period

DPR reflects cow's genetic ability to conceive sooner after calving

- **heifer conception rate (HCR)** (since 2009)

percentage of inseminated heifers that become pregnant at each service

HCR reflects heifer's ability to conceive

- **cow conception rate (CCR)** (since 2009)

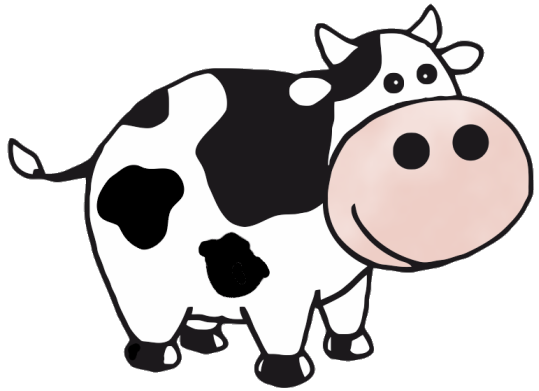
percentage of inseminated cows that become pregnant at each service

CCR reflects cow's ability to conceive

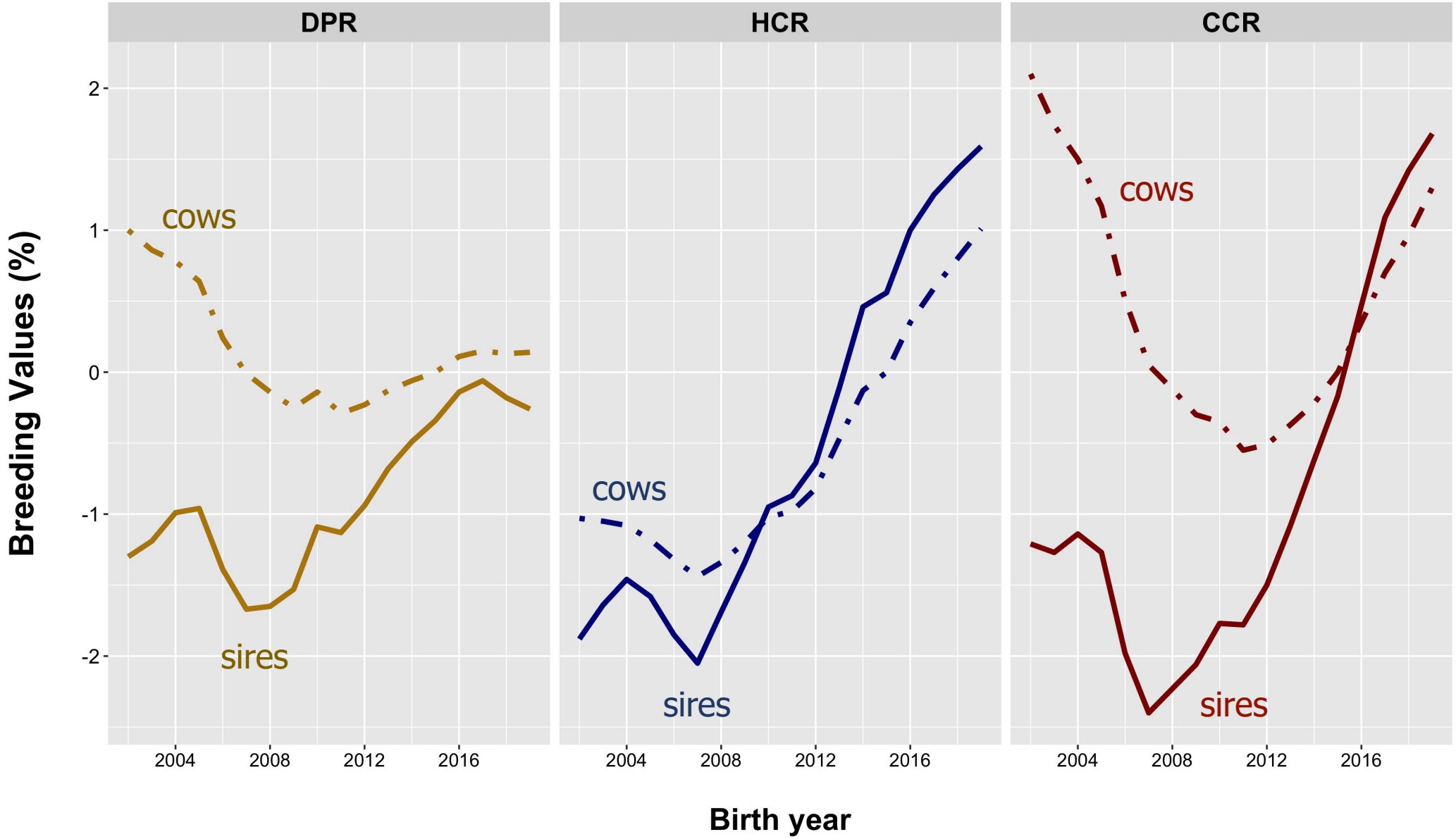
- **early first calving (EFC)** (since 2019)

age at first calving

EFC reflects heifer's ability to calve earlier

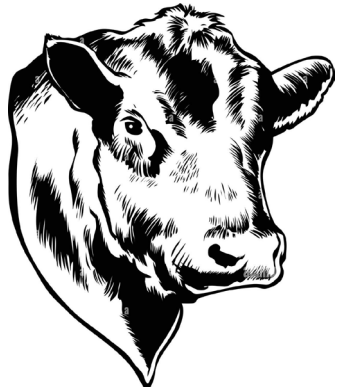


Genetic trends for fertility traits



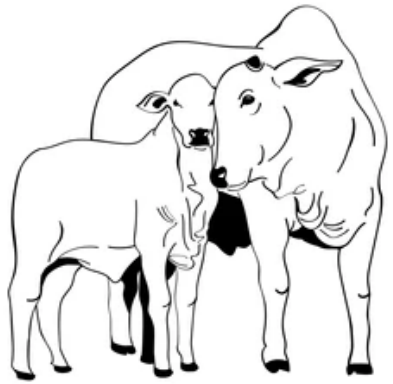
How do we evaluate female fertility?

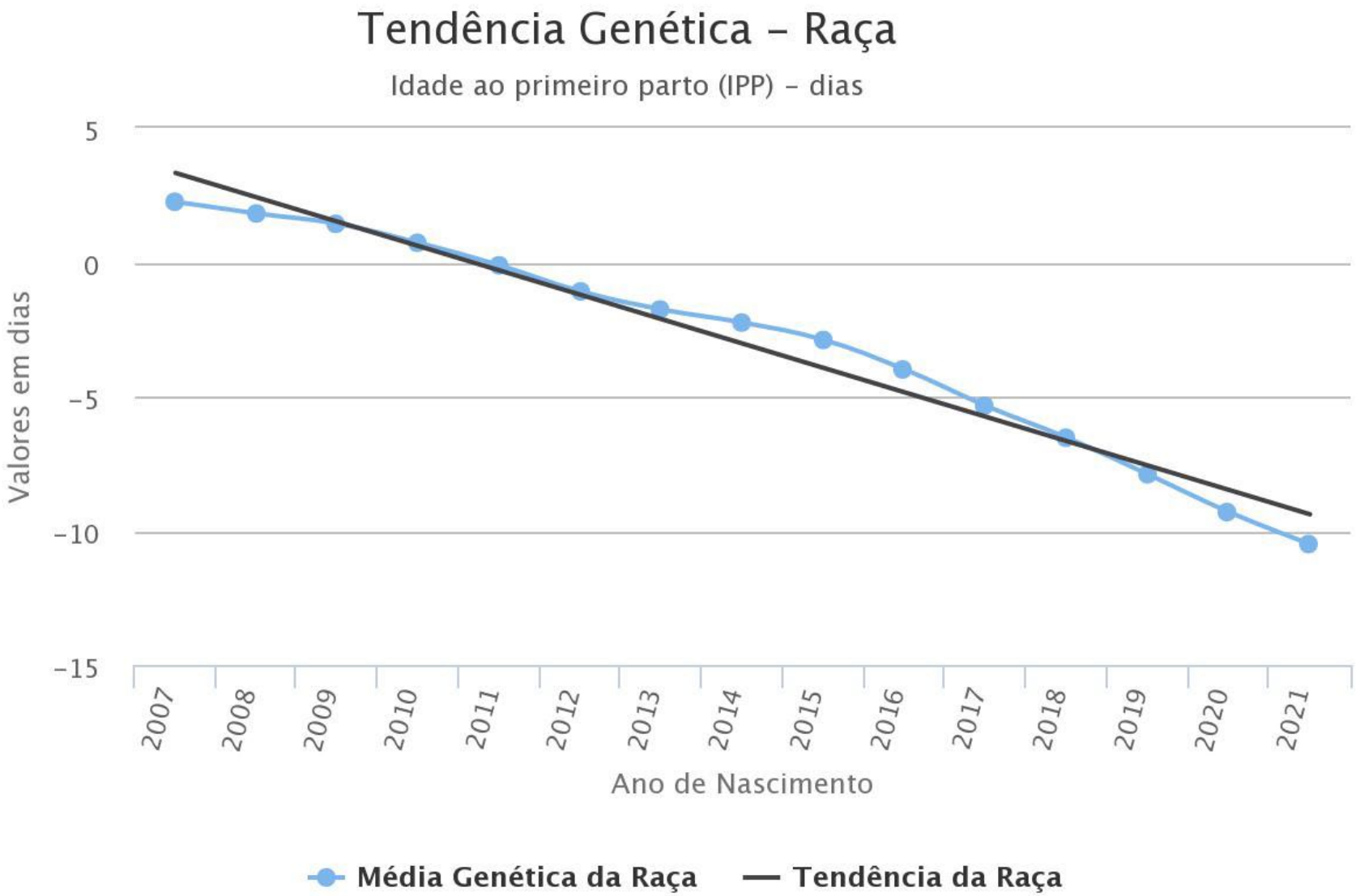
- **heifer pregnancy**
  it reflects heifer's ability to become pregnant



- **age at first calving**
  it reflects heifer's ability to calve earlier

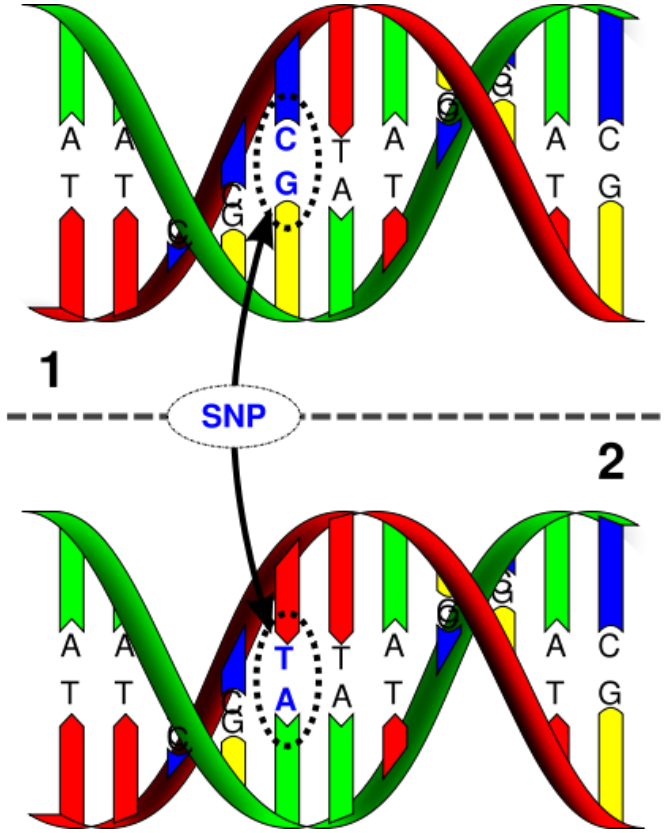
Genetic trends for fertility traits

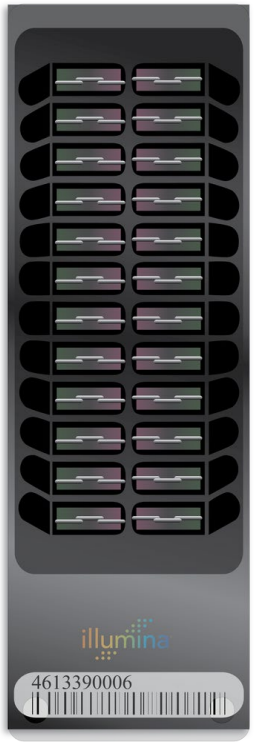




https://www.abczstat.com.br/

Genomic selection: the latest revolution





the use of genetic markers across the genome to predict breeding values

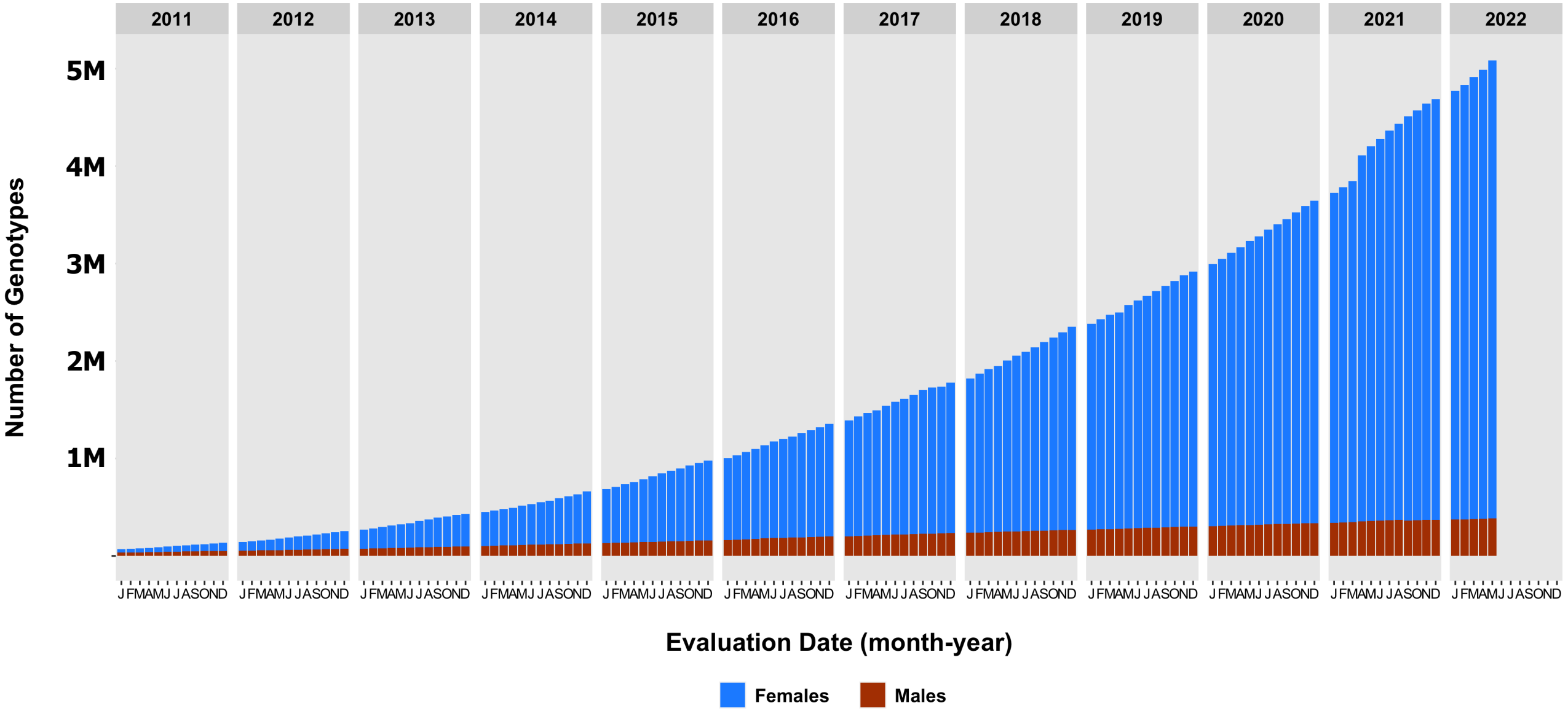
allows to select animals at an early age

all relevant traits are sex limited

and cannot be measured until females begin lactating

US Holstein genotypes

5.1 million genotyped animals!



Genomics increases reliability

reliability: how accurate genetic merits are estimated

estimate **as precisely as possible** the **genetic merit** of a bull/heifer calf

selection decisions are based on **parent average**

reliability ranges from **0** to **0.35**

genomic testing

selection decisions are based on **genomic breeding values**

reliability ranges from **0.65** to **0.80**

↑ reliability → ↑ annual genetic gain

Genomic vs traditional reliabilities

CDCB
COUNCIL ON DAIRY CATTLE BREEDING

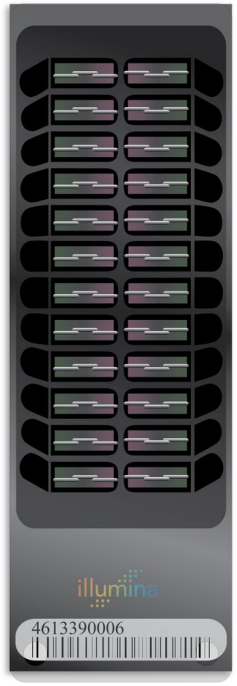
2896 Holstein young available bulls (Apr 2022)

Traits	PTA			Reliability (%)		
	Genomic average	Traditional average	Difference	Genomic average	Traditional average	Difference
Net merit ($)	710	554	156	74	30	44
Milk (pounds)	909	813	94	81	35	46
Fat (pounds)	70.0	57.7	12.3	81	35	46
Protein (pounds)	42.4	36.8	5.6	81	35	46
Somatic cell score	2.83	2.90	-0.07	77	31	46
Productive life (months)	3.9	2.5	1.4	76	26	50
Livability	0.8	-0.1	0.9	72	19	53
Daughter pregnancy rate	-0.3	-0.6	0.3	75	26	49
Cow conception rate	0.7	0.2	0.5	75	26	49
Heifer conception rate	0.9	0.5	0.4	73	27	46
Sire calving ease	2.0	2.1	-0.1	70	46	24
Daughter calving ease	2.1	2.3	-0.2	63	34	29
Final score	0.91	0.95	-0.04	79	29	50

Gains in reliability are greater for fertility and longevity traits

Does genomics work?

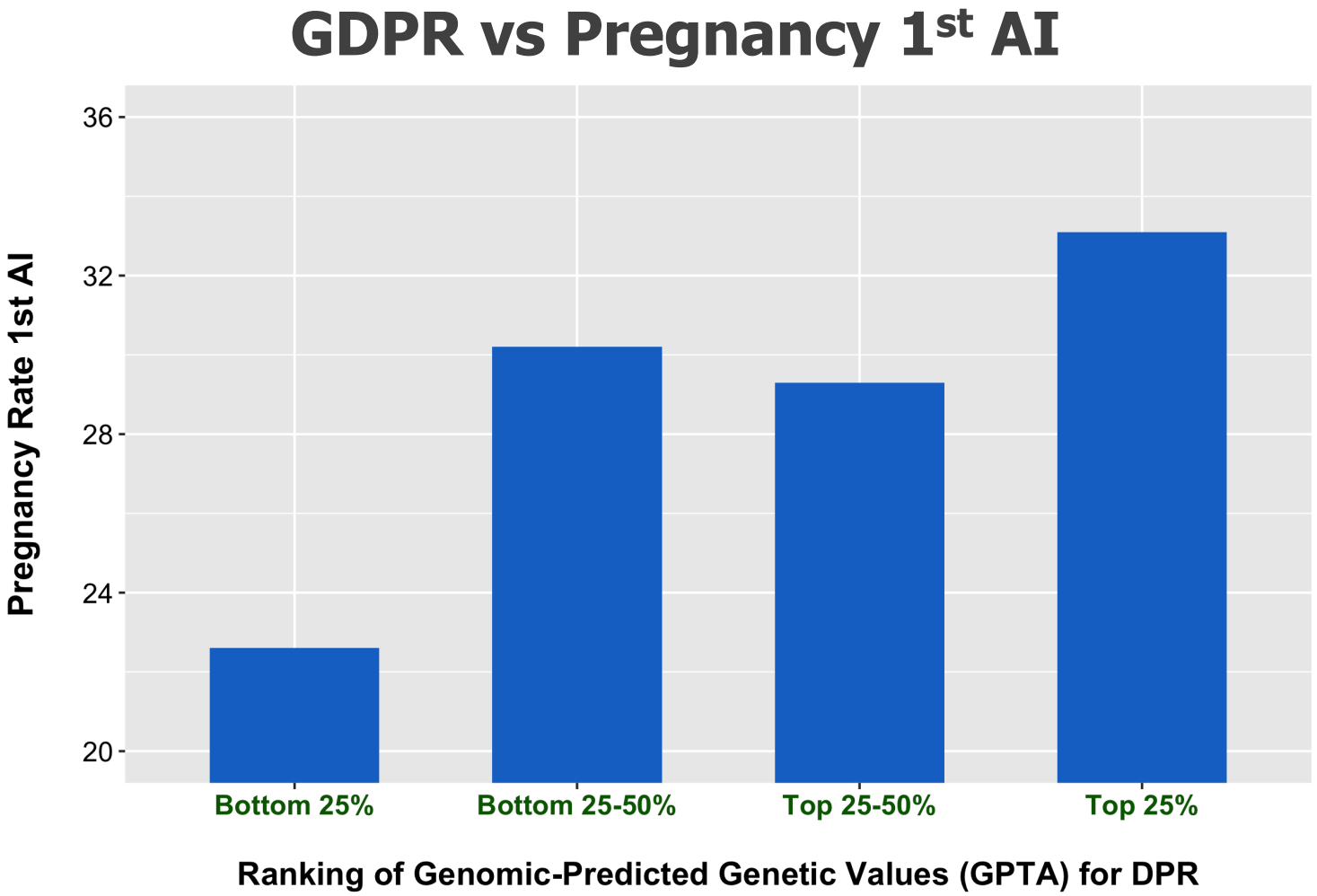
Can genomic testing predict future performance?



genomic testing

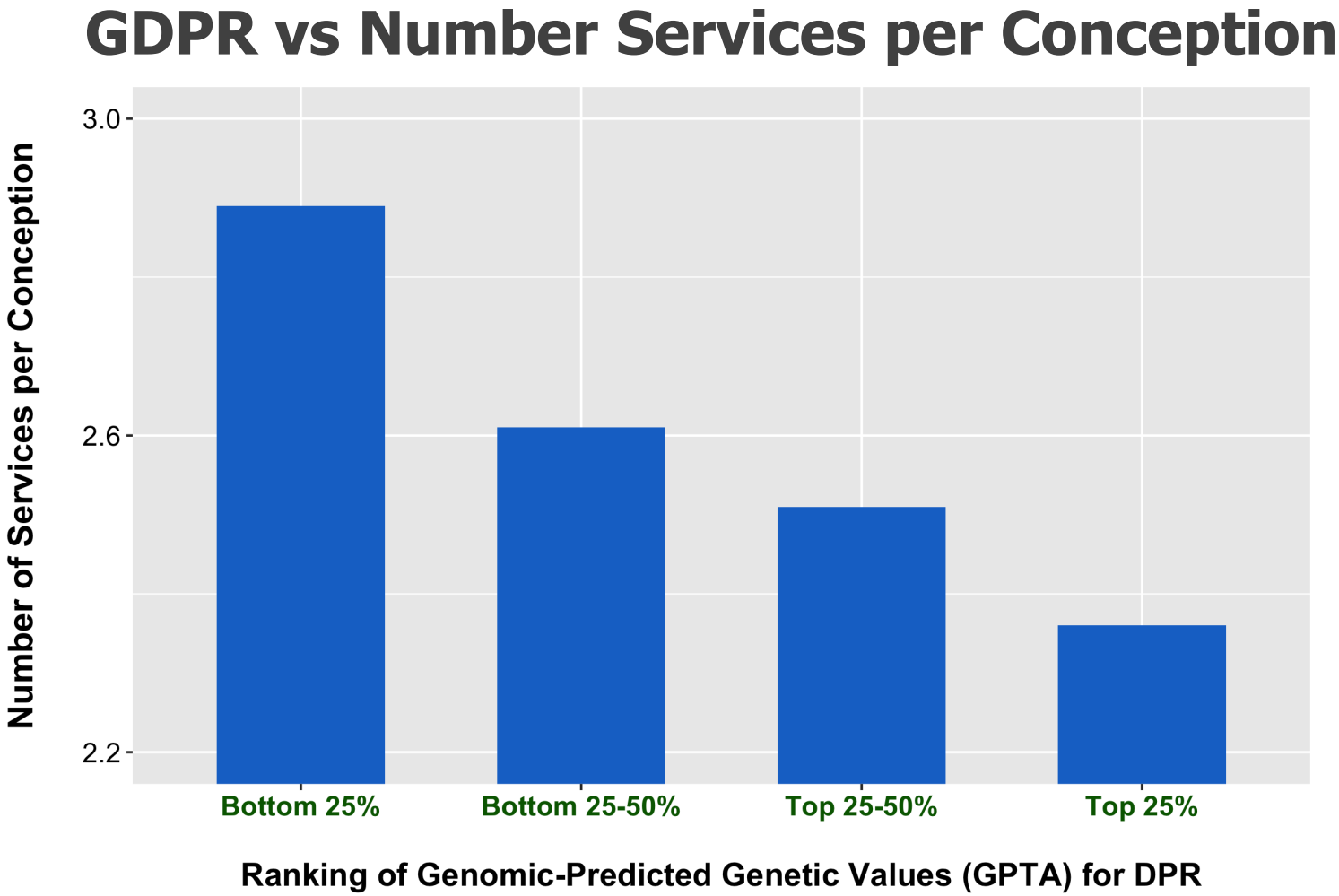
Production
Health
Reproduction

Predicting fertility using genomic testing



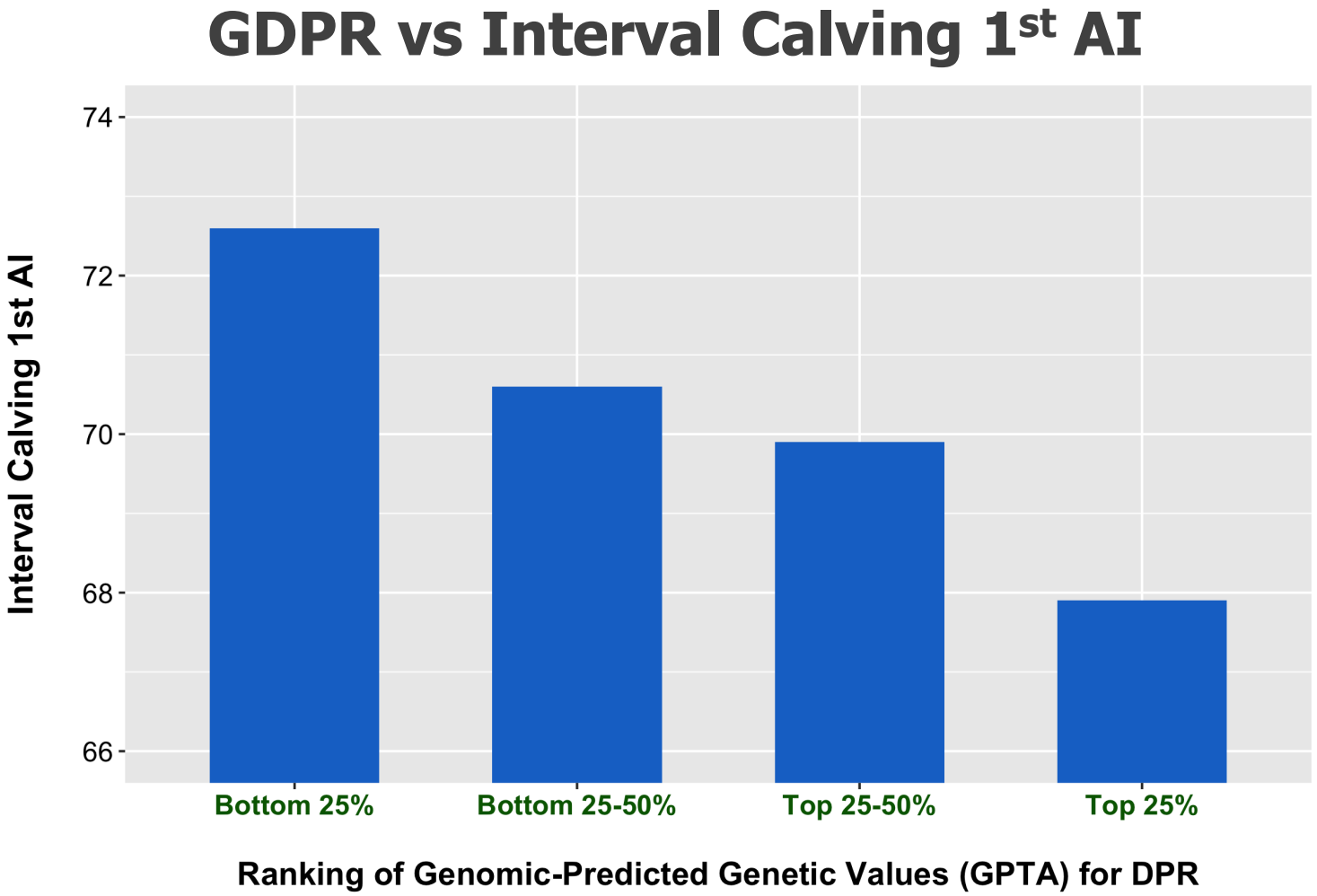
Lima, Silvestre, Peñagaricano and Thatcher (2020) Journal of Dairy Science

Predicting fertility using genomic testing



Lima, Silvestre, Peñagaricano and Thatcher (2020) Journal of Dairy Science

Predicting fertility using genomic testing



Lima, Silvestre, Peñagaricano and Thatcher (2020) Journal of Dairy Science

Does genomics work?

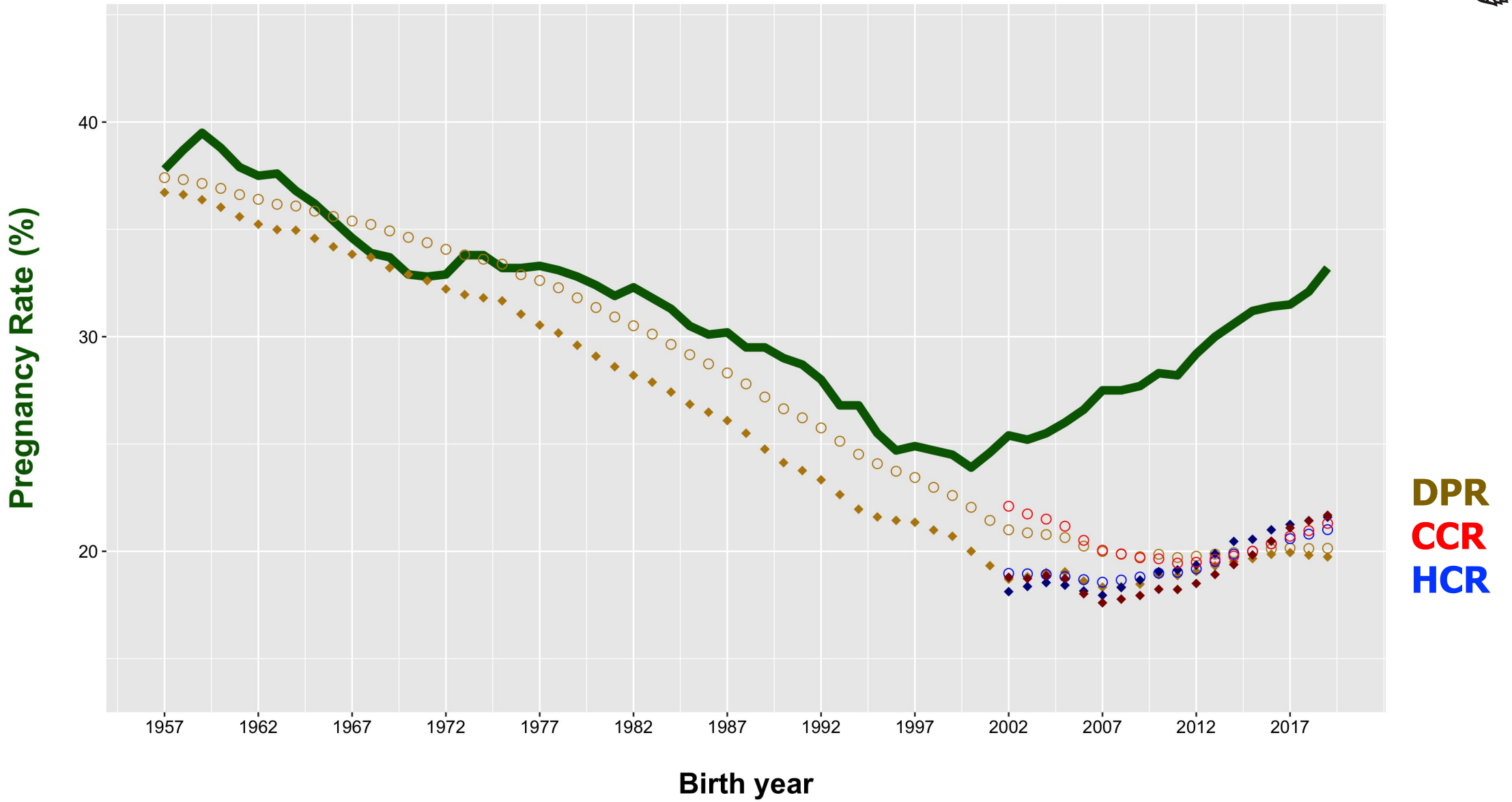
Can genomic testing predict future performance?

Genomic testing

- can be effectively used to predict performance
- more accurate than using sire's genomic values
- can be used to make proper selection decisions

How fast can we move?

Genetic merits are slowly but steadily improving



Selection index: best selection tool!

Trait	NM$	FM$	CM$
Milk	0.30	21.9	-2.2
Fat	28.6	28.3	27.2
Protein	19.6	0.0	20.9
PL	15.9	15.7	15.1
SCS	-2.8	-1.6	-3.5
BWC	-9.4	-9.3	-8.9
UDC	3.4	3.4	3.2
FLC	0.4	0.4	0.4
DPR	4.1	4.1	3.9
CA$	2.9	2.8	2.7
HCR	0.4	0.4	0.4
CCR	1.0	1.0	0.9
LIV	4.4	4.3	4.2
HTH$	1.2	1.2	1.2
RFI	-3.8	-3.8	-3.6
EFC	1.2	1.2	1.1
HLIV	0.5	0.5	0.5

fertility ≈ 6.5%

fitness ≈ 34%

fertility, longevity, health

Are current traits good fertility traits?

- **these traits that can be easily measured on many cows**

  e.g.: roughly 700k-800k Holstein cows per birth year

- **there traits are lowly heritable**

  h^2 estimates: HCR/CCR around 1-2% & DPR around 4%

- **these traits are distant from cow's reproductive physiology**

- **there traits are impacted by managerial practices**

  voluntary waiting periods, synchronization protocols

Synchronization protocols

- **synchronization protocols are great management tools!**

- **synchronization protocols mask cows' fertility ability**

  genetically superior and inferior cows may show similar phenotypes

- **genetic programs rely on the collection of accurate phenotypic data**

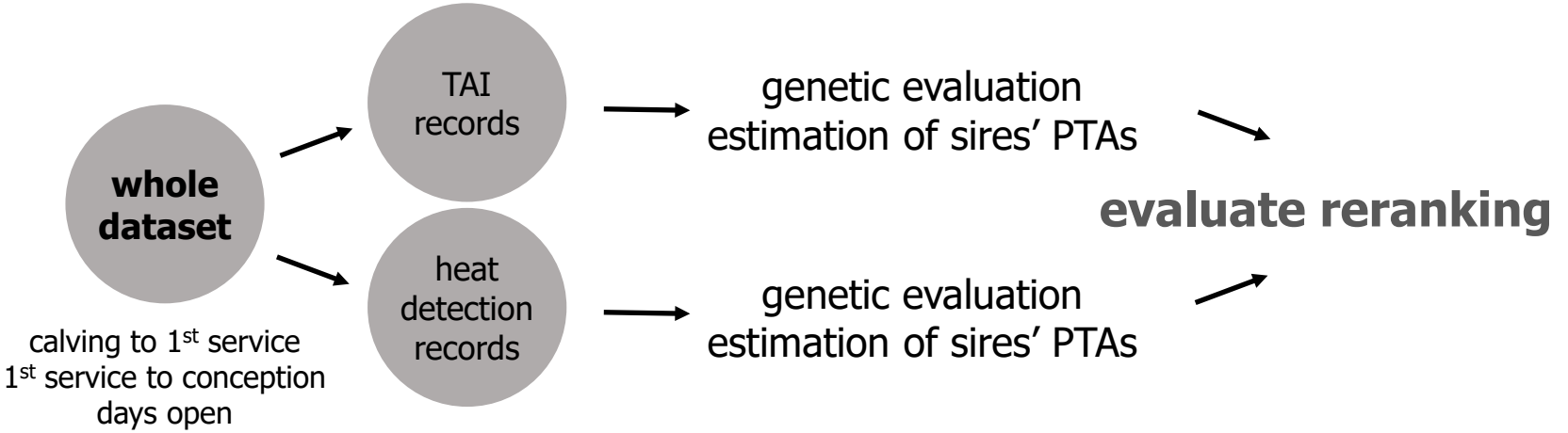
  records collected on treated cows may bias genetic evaluations

Impact of synchronization protocols

J. Dairy Sci. 104:11820–11831
https://doi.org/10.3168/jds.2021-20495

Effect of synchronized breeding on genetic evaluations of fertility traits in dairy cattle

C. Lynch,[1] G. A. Oliveira Junior,[1] F. S. Schenkel,[1] and C. F. Baes[1,2]*
[1]Centre for Genetic Improvement of Livestock, Department of Animal Biosciences, University of Guelph, Guelph, ON, N1G 2W1, Canada
[2]Institute of Genetics, Department of Clinical Research and Veterinary Public Health, University of Bern, Bern, 3001, Switzerland



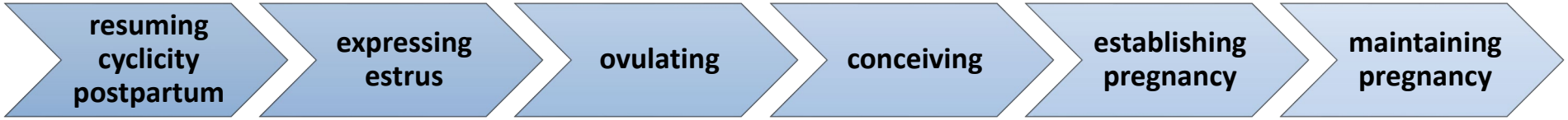
large reranking across traits and parities!

results suggest that synchronization protocols may bias genetic evaluations

solution: consider TAI vs heat-detection as different traits?

Do we need new fertility traits?

- ❑ **traits that more closely describe cows' reproductive physiology**



- ❑ **traits with sizeable heritability**
- ❑ **traits largely unaffected by managerial practices**
- ❑ **what to measure?**

physiological traits:
antral follicle count, anti-Müllerian hormone, progesterone, pregnancy-associated glycoproteins, etc.

anatomical traits:
reproductive tract size/position, anogenital distance, etc.

Novel traits in the genomics era

Genomics has created opportunities to improve traits that are critically important,

but too difficult or expensive to measure on the entire population

Relevant Phenotypes
+ Genotypes

small reference population

genomic PTAs for the entire population
(including young selection candidates)

one current example: dairy cow feed efficiency

Estrus expression

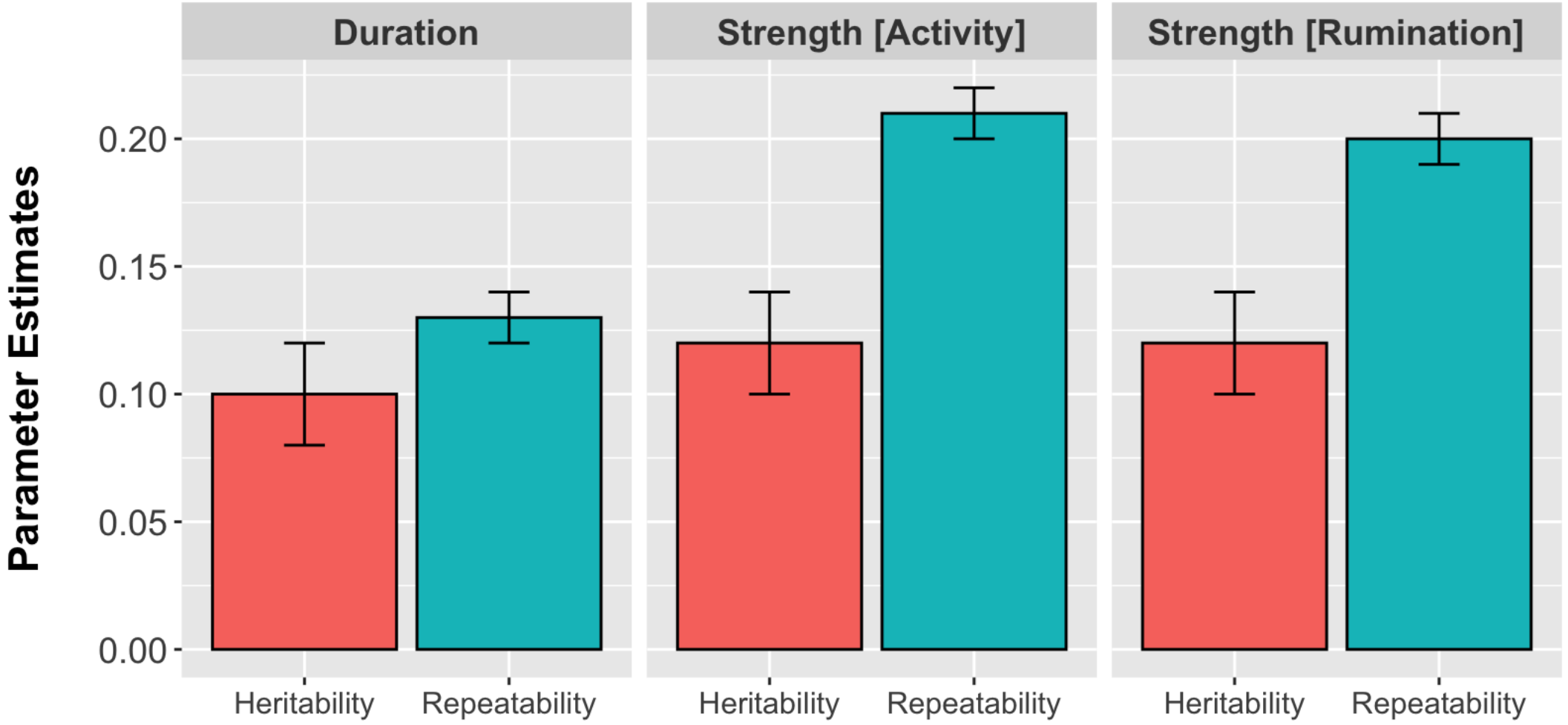
our approach

improve estrus expression through genetic selection

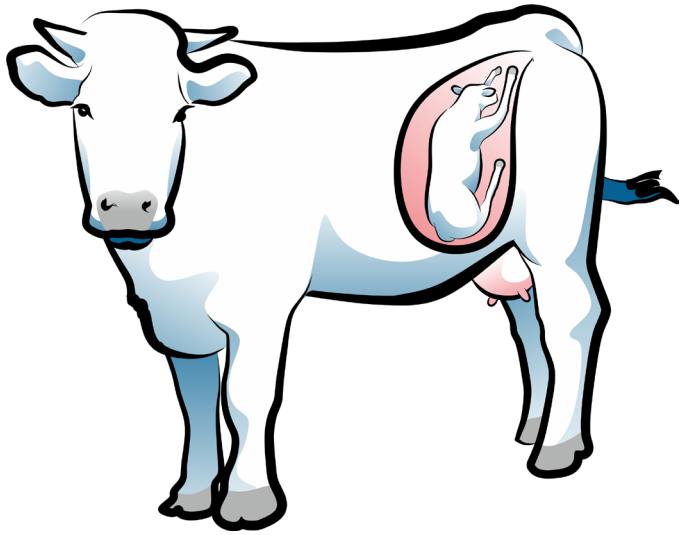
NO HORMONES

↑ estrus expression → ↑ estrus detection → ↑ pregnancy rate →

Estrus expression



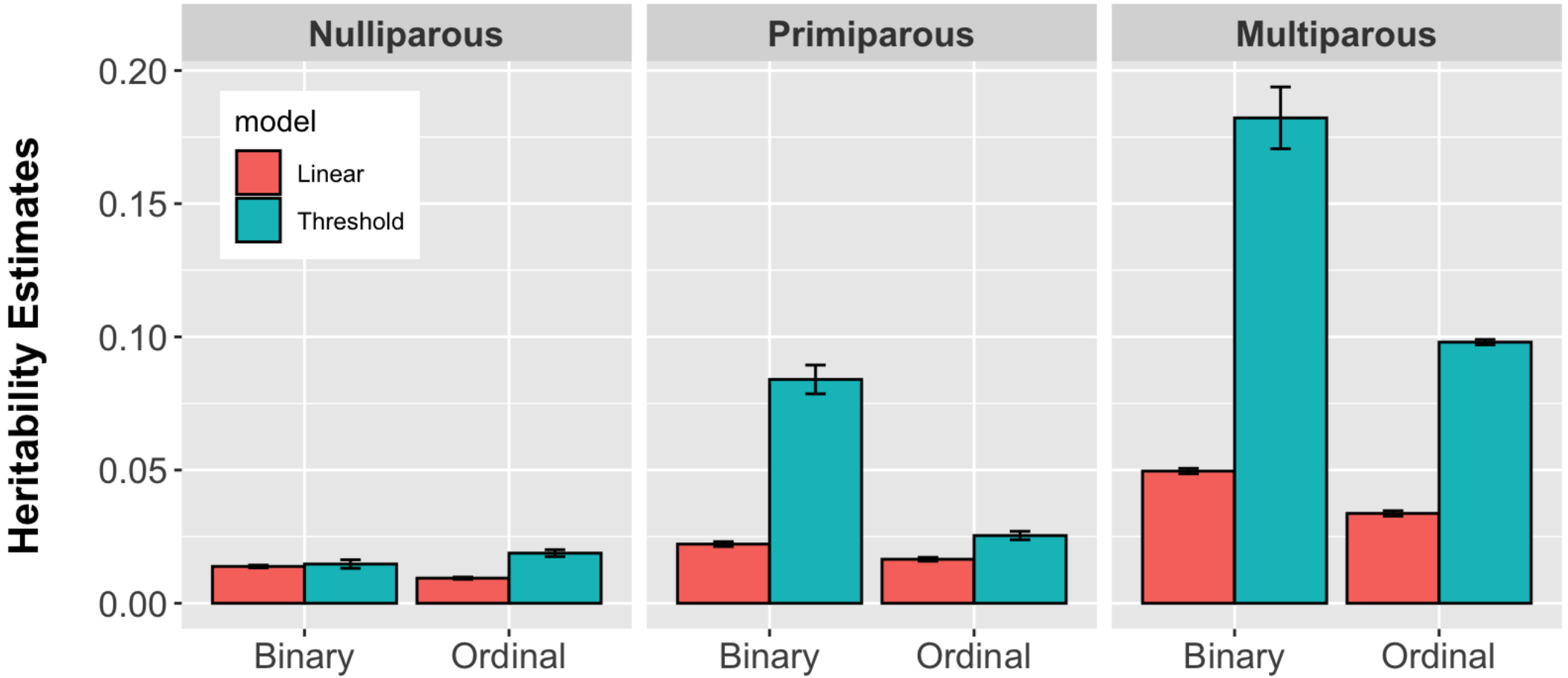
Fetal loss



fetal loss
(pregnancy maintenance)

- ❑ pregnancy loss is a major factor causing poor reproductive performance
- ❑ cost of pregnancy loss increases with gestation length
- ❑ **fetal losses are less frequent but have a greater economic impact**

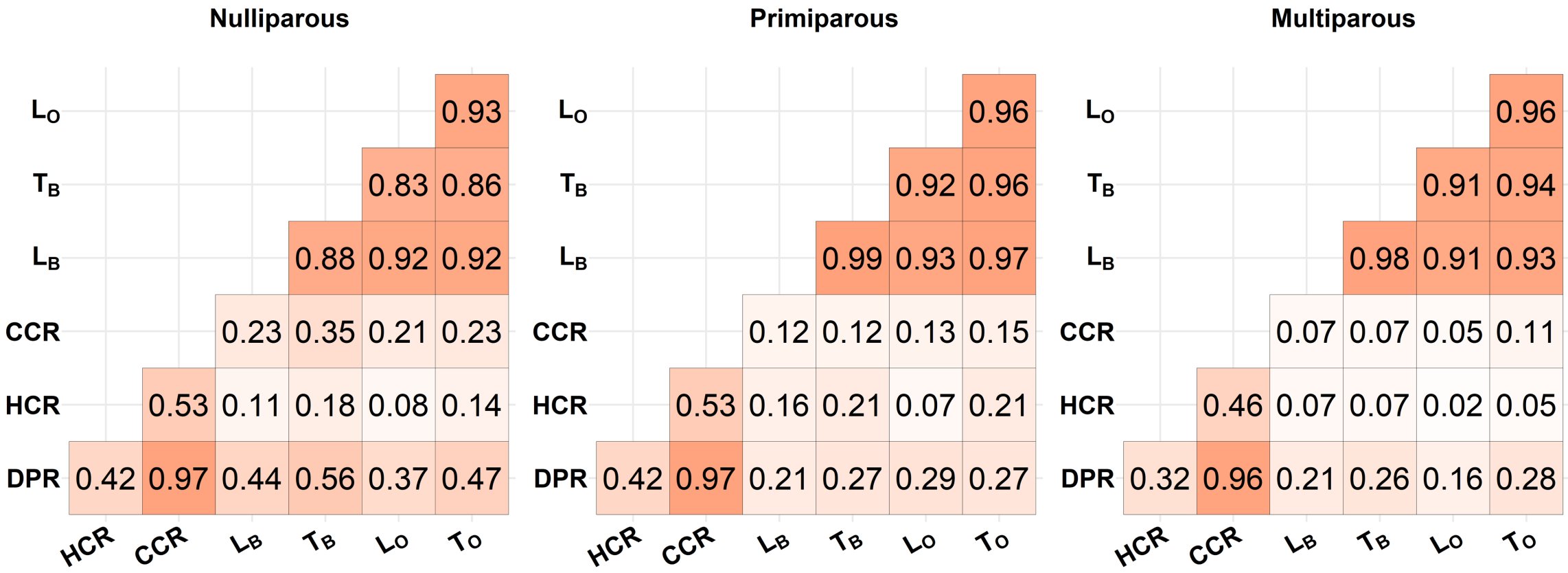
Heritability of fetal loss



Sigdel, Bisinotto, and Peñagaricano (2022) Journal of Dairy Science

Is fetal loss a novel fertility trait?

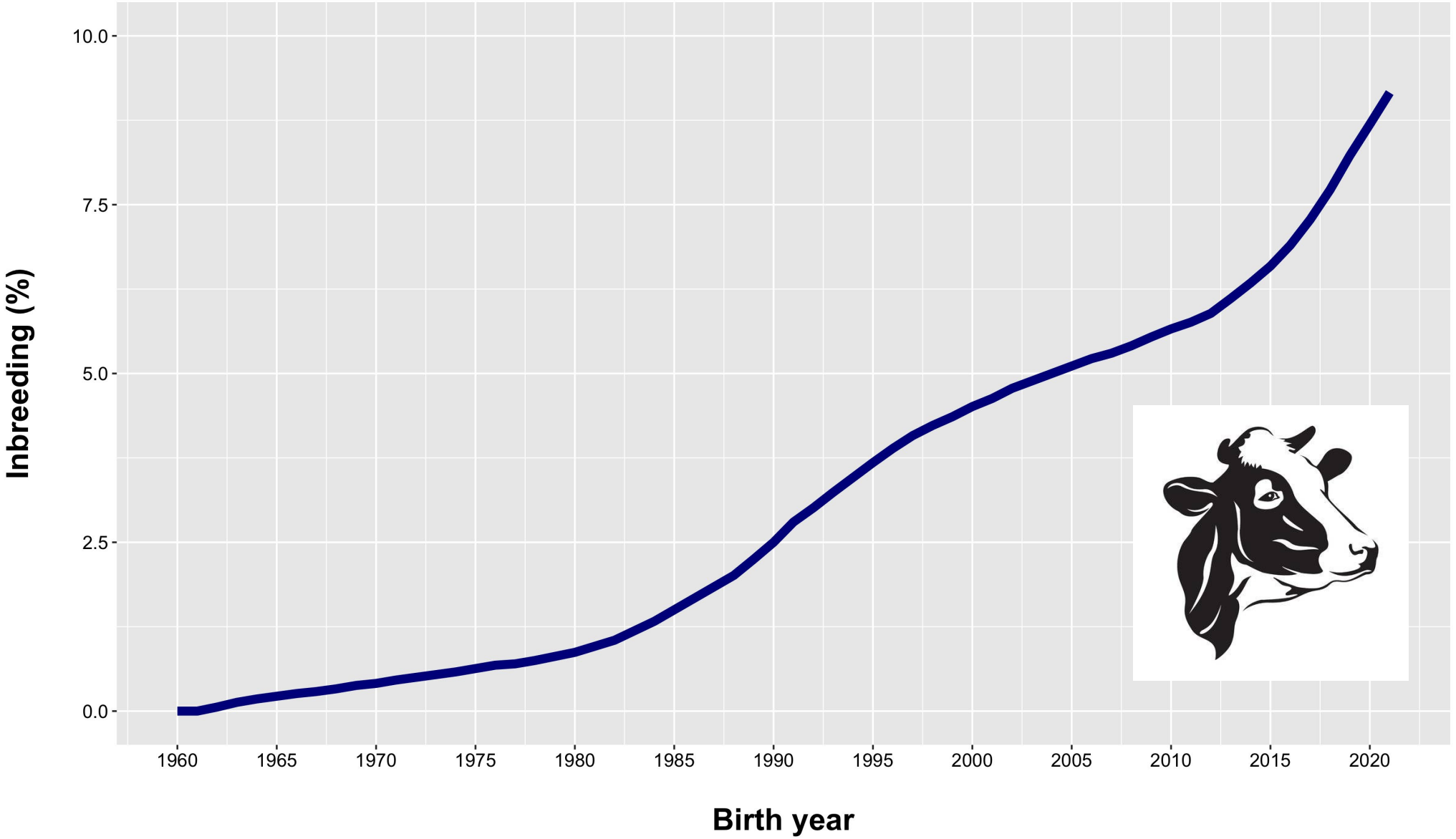
Genetic correlations of fetal loss versus other fertility traits



Binary trait **Ordinal trait**

Sigdel, Bisinotto, and Peñagaricano (2022) Journal of Dairy Science

Inbreeding: should we be concerned?



Take home messages

- selection indices consider multiple traits, not only fertility
- genomic selection contributed to stop the decline in dairy cow fertility
- genomic merits for fertility traits are slowly but steadily improving

- genomic predictions can effectively predict future performance
- genomic testing allows tracking of genetic recessive effects
- genomics facilitates the selection for novel traits

- potential interaction genetics-by-repro-management deserves attention
- how to balance rapid genetic progress and adequate genetic diversity?
- basic (functional) research benefits applied selection

Thanks for your attention!

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