Positive and Negative Impacts of Genomic Selection

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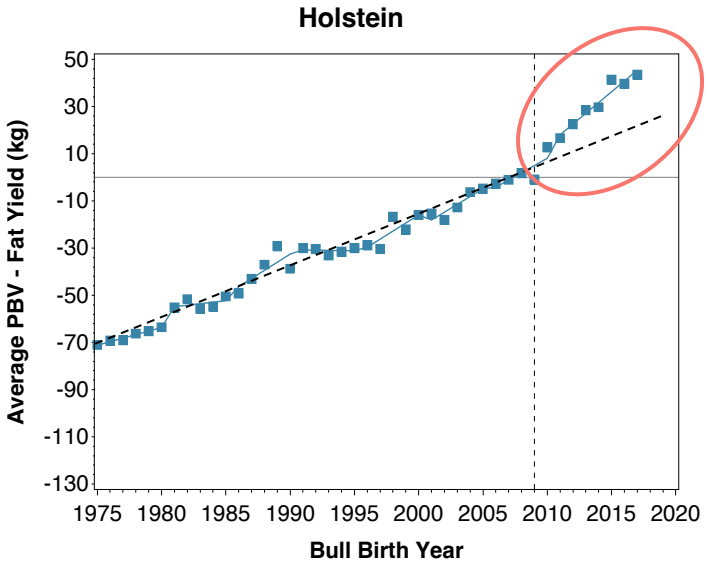
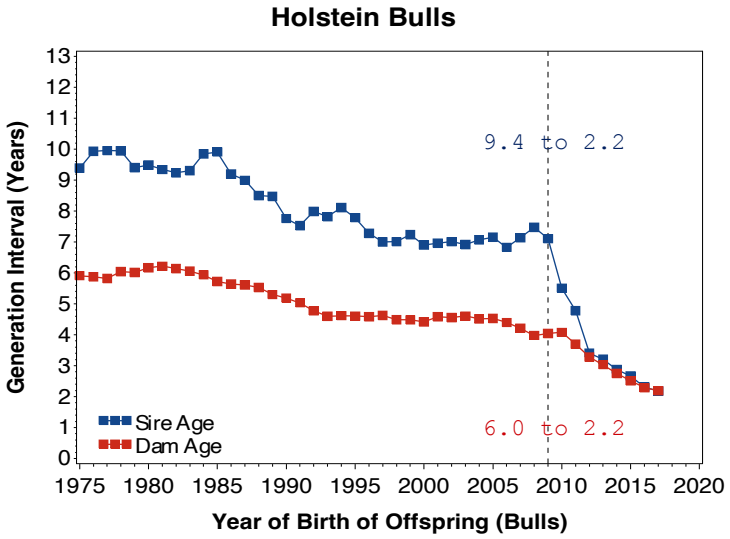
Changes after genomics - dairy

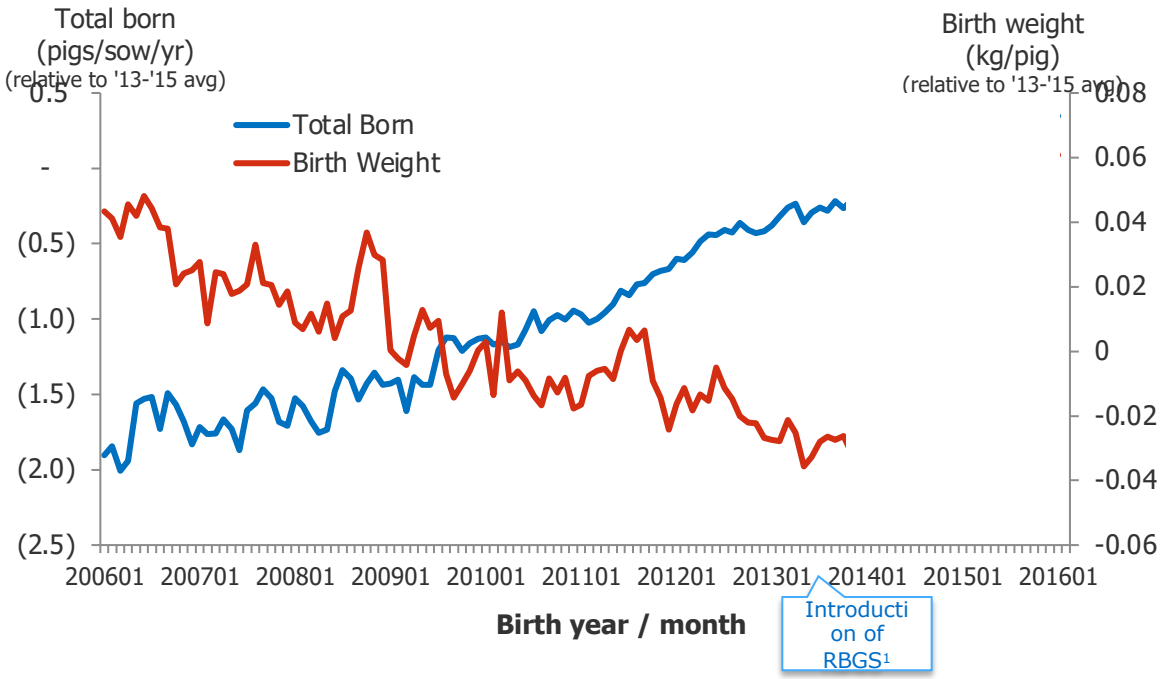
- > 2x after genomics for Holsteins

Guinan et al. (accepted)





Trend: genetic improvement in birth weight and total born
(PIC Genetic Nucleus)



1. Relationship based genomic selection
Source: PIC L02, L03 pure lines (Camborough)

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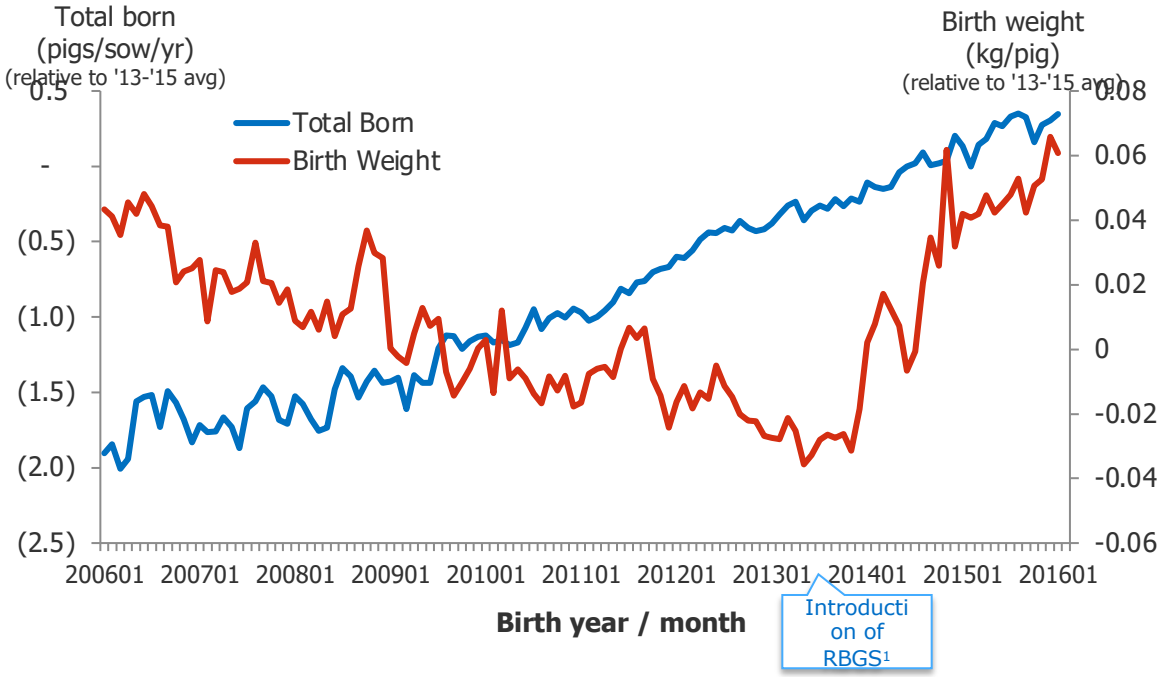

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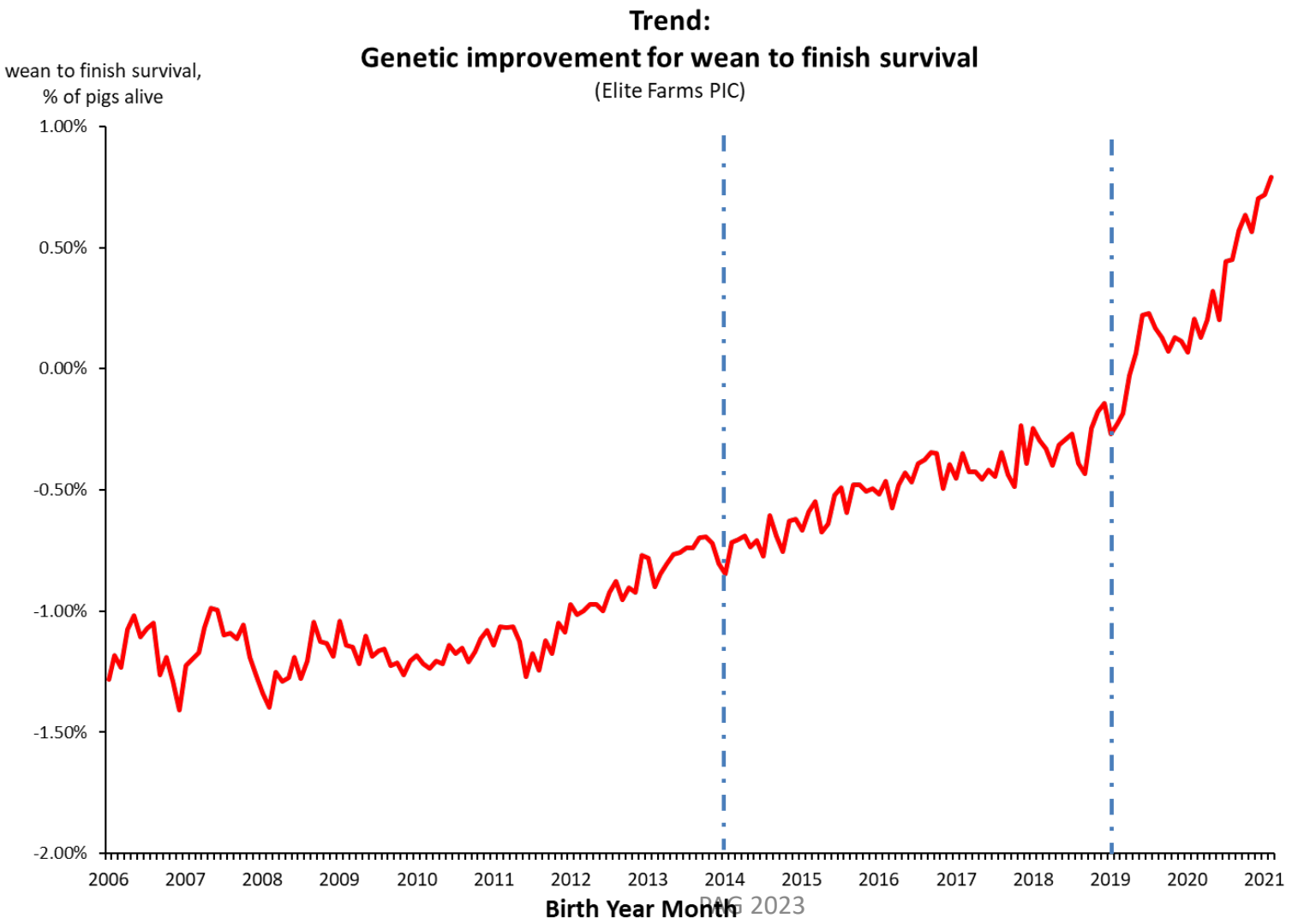
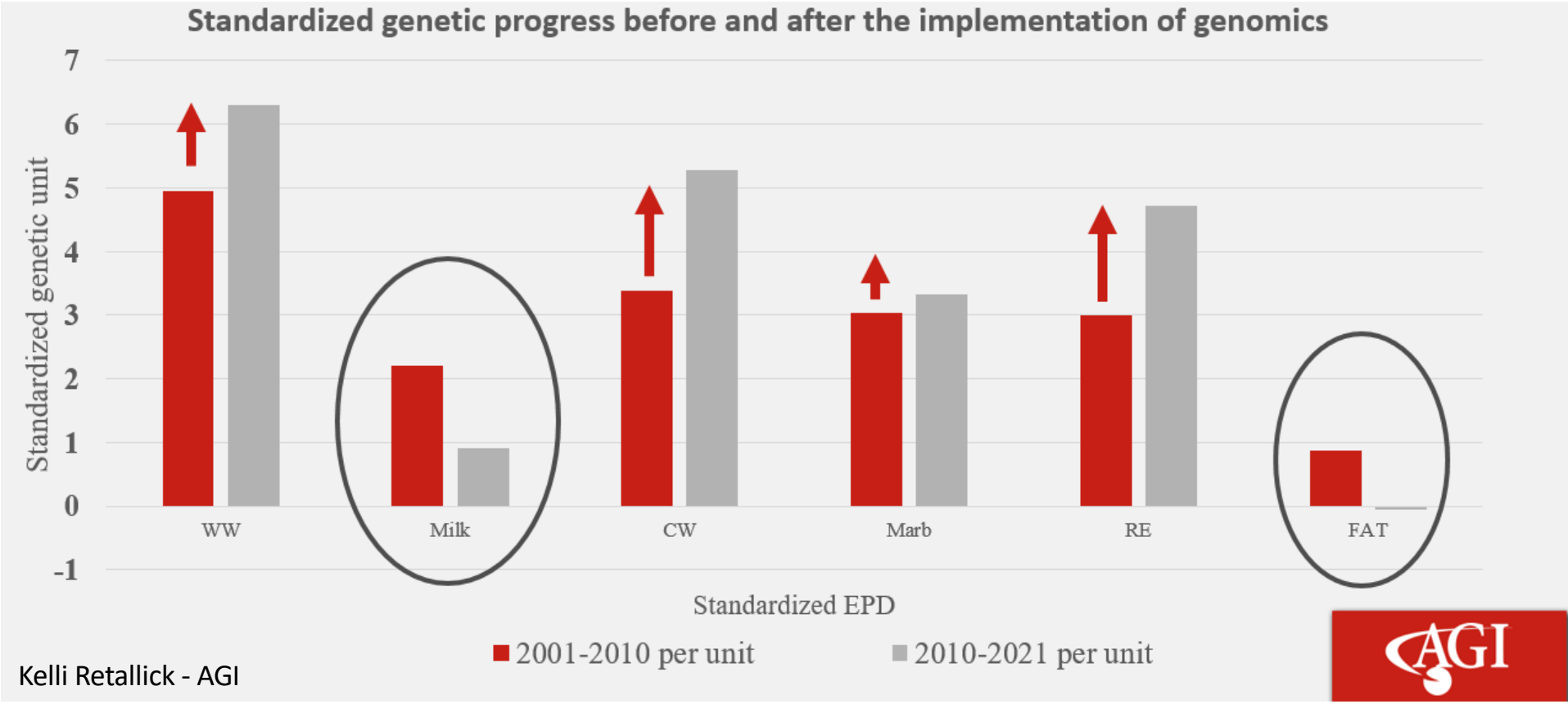
Pigs - wean to survival



Changes after genomics - beef



Kelli Retallick - AGI

Negative effects of genomic selection

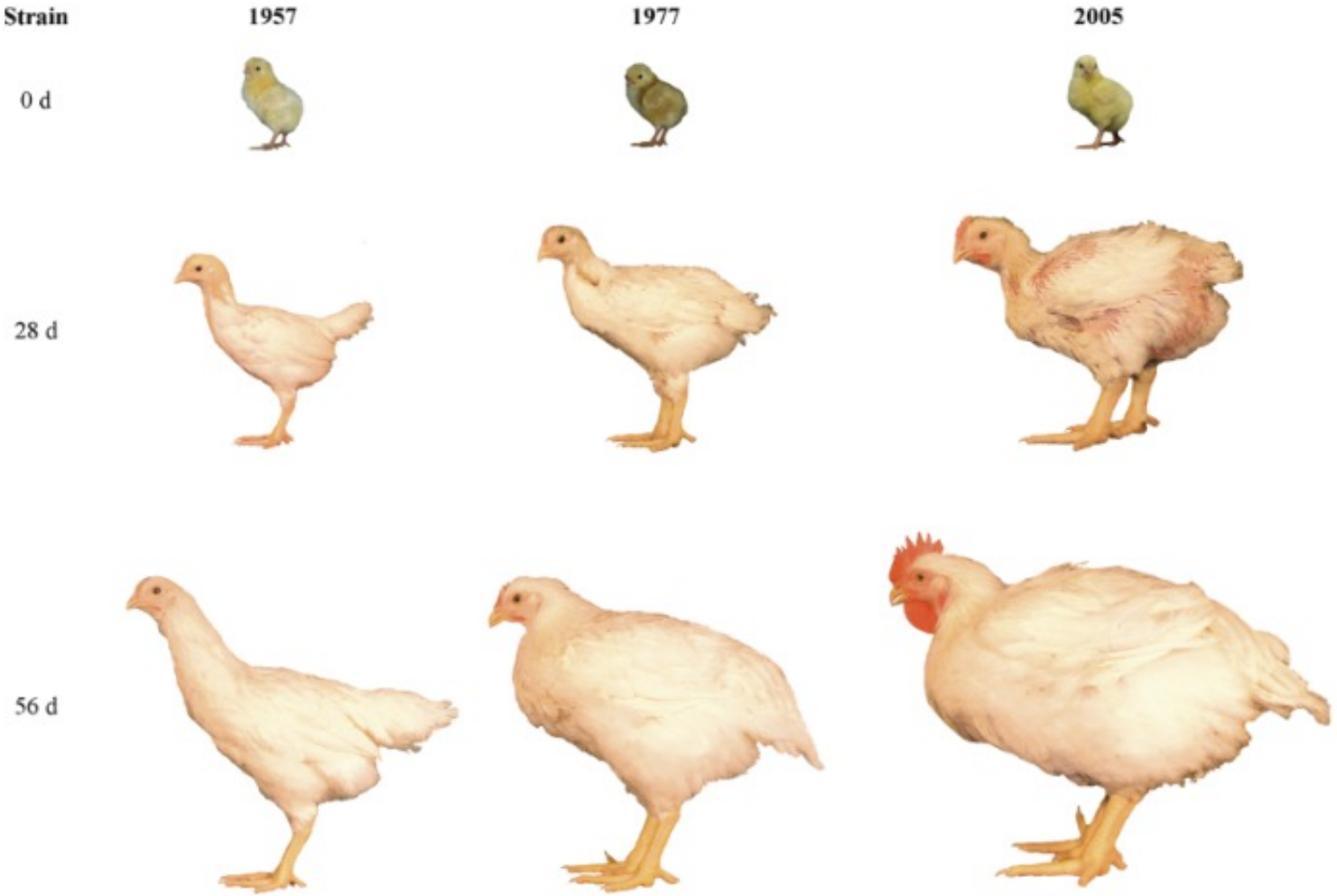
- Informal industry reports:
  - Deteriorating sow survival in pigs
  - Deteriorating feet & legs in beef
  - Increased sensitivity to heat stress in dairy
  - Deteriorating disease resistance across species

- Recessive genes or pleiotropy?

Genetic selection as optimization

- Selection for one trait or an index
- Gains on selected traits
- Losses on correlated antagonistic traits

- Losses in artificial selection
  - Fighting ability, speed, mating behaviors,…
  - Losses compensated by improved environment/management



Zuidhof et al. (2014) http://dx.doi.org/10.3382/ps.2014-04291

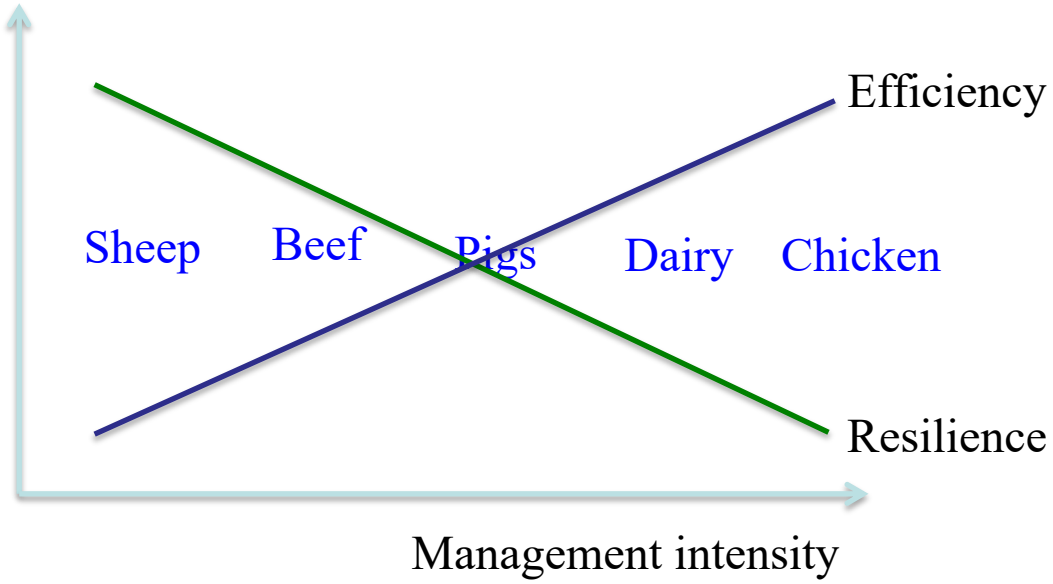
Side effects of intensive selection for growth in broiler chicken

- Unlimited appetite / obesity ➔ artificial lighting
- Poor survival of males ➔ male supplementation
- Increased susceptibility to diseases ➔ antibiotics
- Low hatchability ➔ alternate heating/cooling of incubators
- …

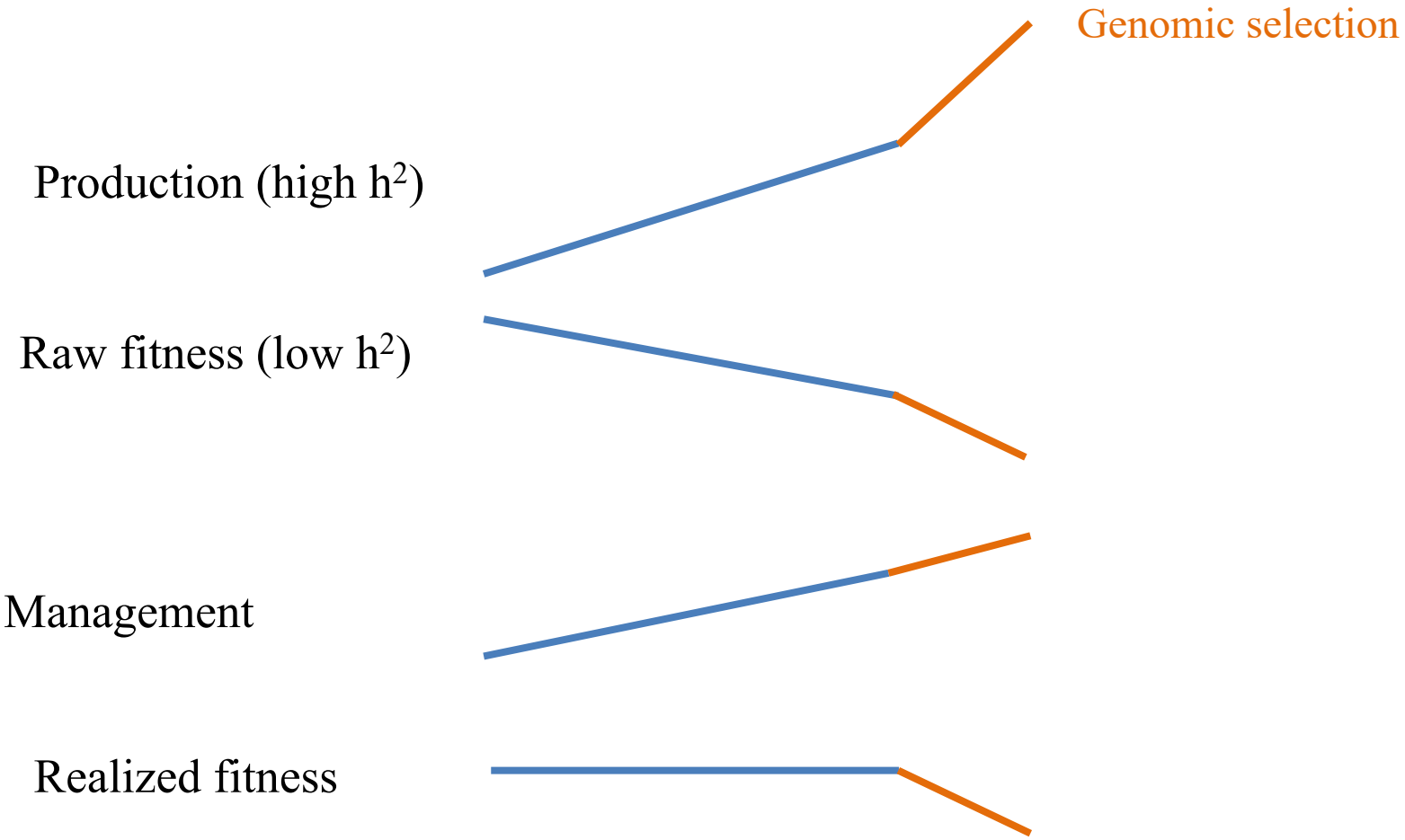
All companies – similar problems at same time

Eitan and Soller, 2014

Resilience/efficiency and management intensity



Hypothetical trend changes with genomics

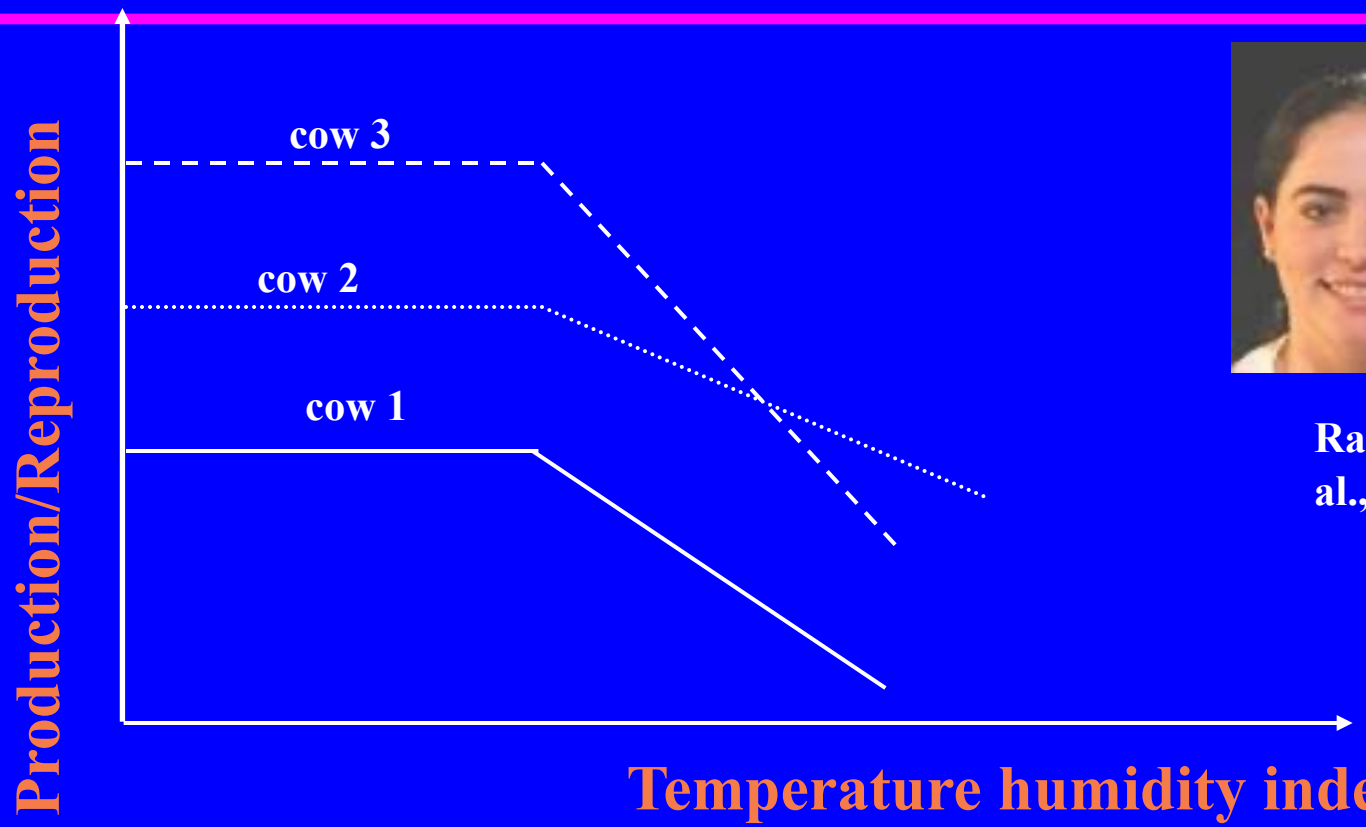


Can we improve heat tolerance in dairy – genetics or management?

- Cows more susceptible to heat stress
  - Poor fertility
  - Mortality
  - Poor survival

- Questions
  - Are animals indirectly selected against heat tolerance?
  - Is genetic selection for heat tolerance possible?
  - Is genetic selection preferable to managemental improvements?

Assumption for heat stress model

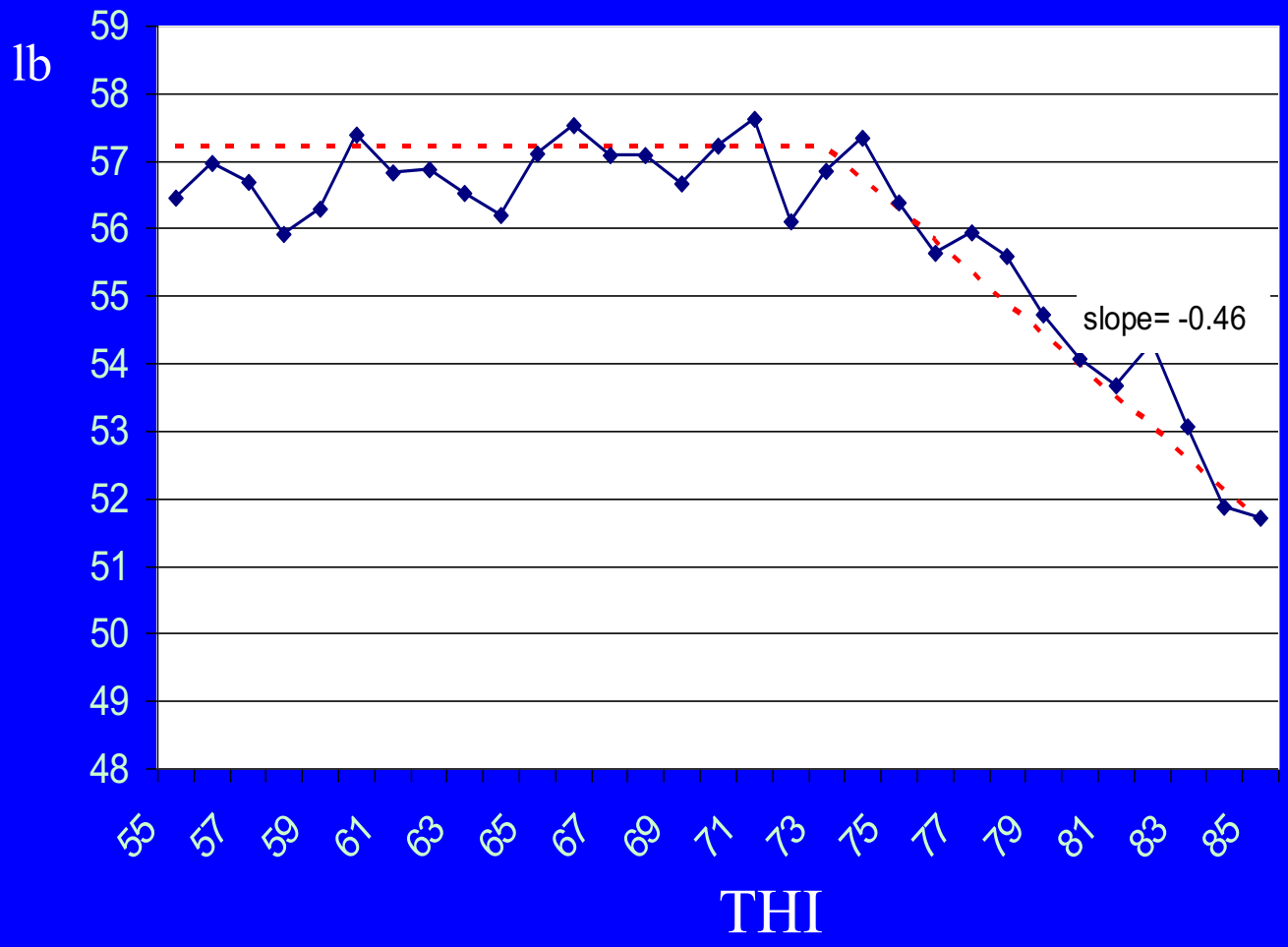


Ravagnolo et al., 2001

Breeding value: $BV = a + f(THI)*v$

a – regular breeding value v – heat-tolerance breeding value
f(THI) – function of temperature humidity index

Effect of THI on daily milk production

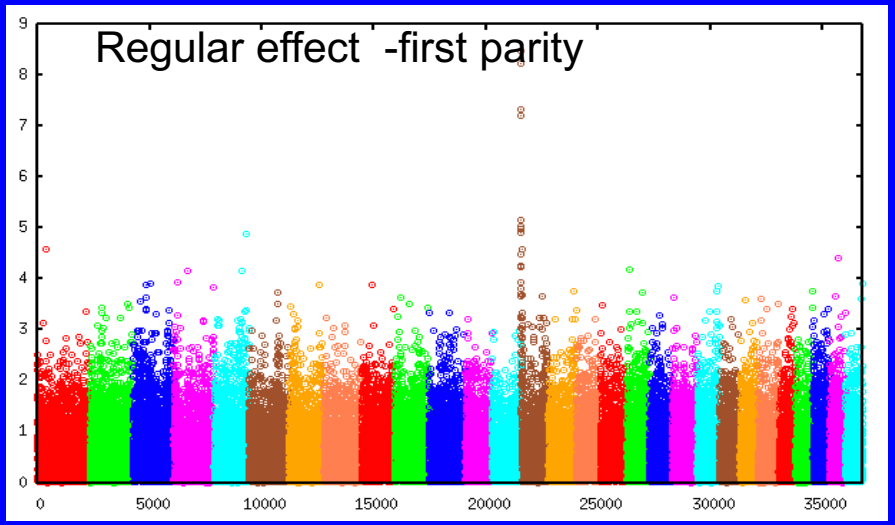


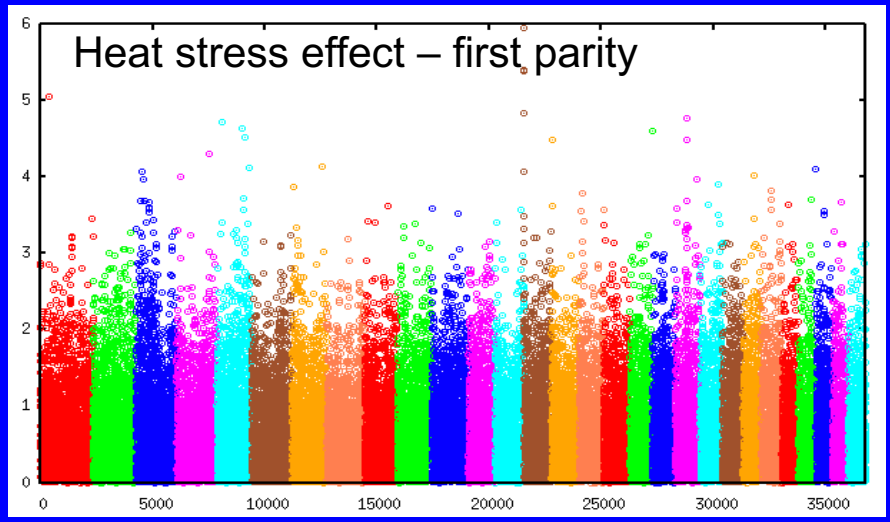
National evaluation of Holstein for heat stress (Aguilar et al., 2009)

- Holstein U.S. test days
- 3 parities
- 3-trait random-regression model
- Heat stress effect

ssGBLUP for Heat Stress in Holsteins (Aguilar, 2011)

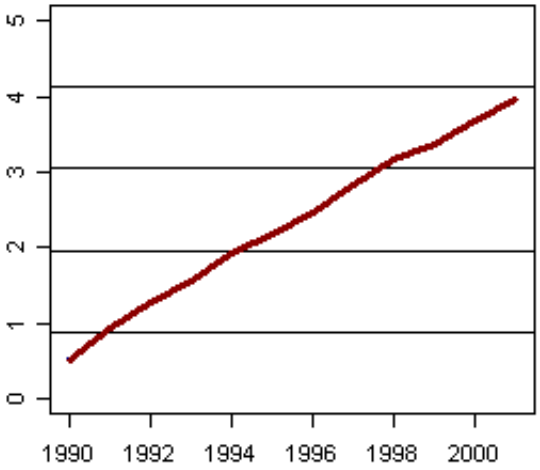
- ~ 90 millions records, ~ 9 millions pedigrees
- ~ 3,800 genotyped bulls





Genetic trends of daily milk yield for 3 parities – regular effect

First



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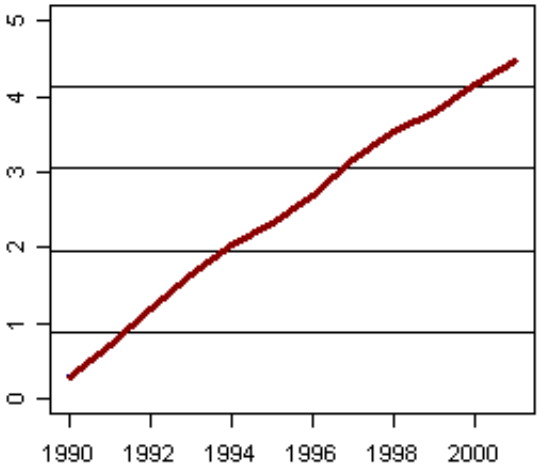

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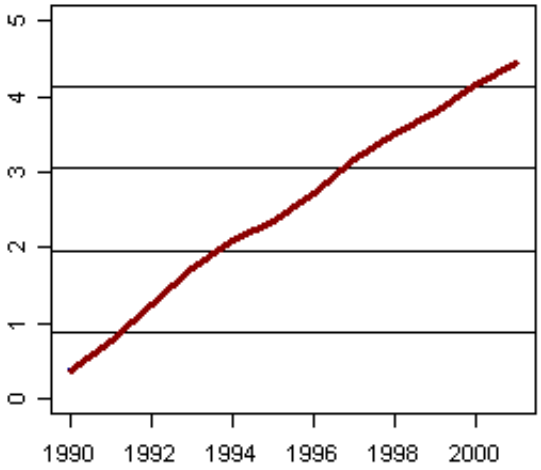
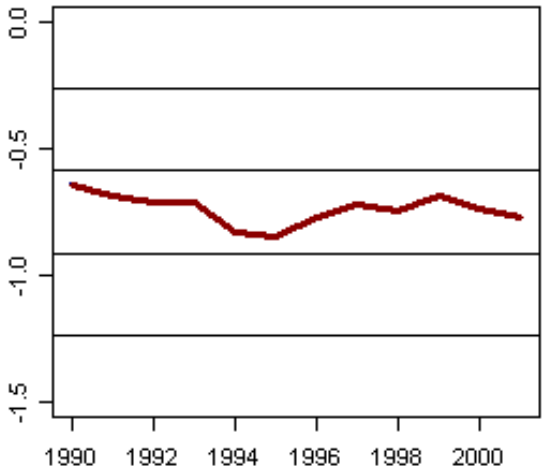


Genetic trends for heat stress effect at 5.5º C over the threshold

First



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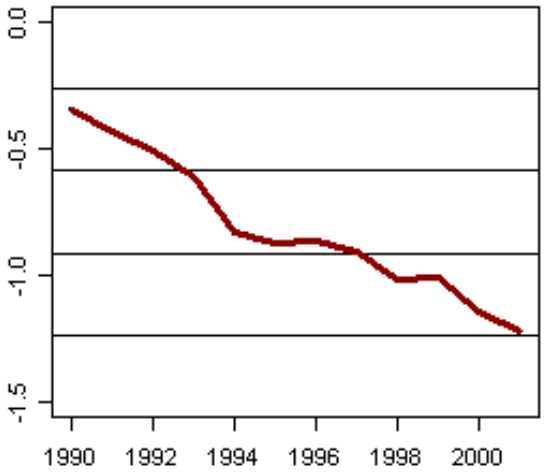

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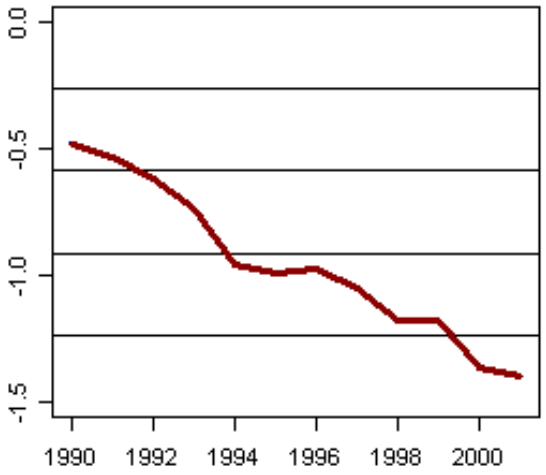


All methodology and programs ready - why no implementation?

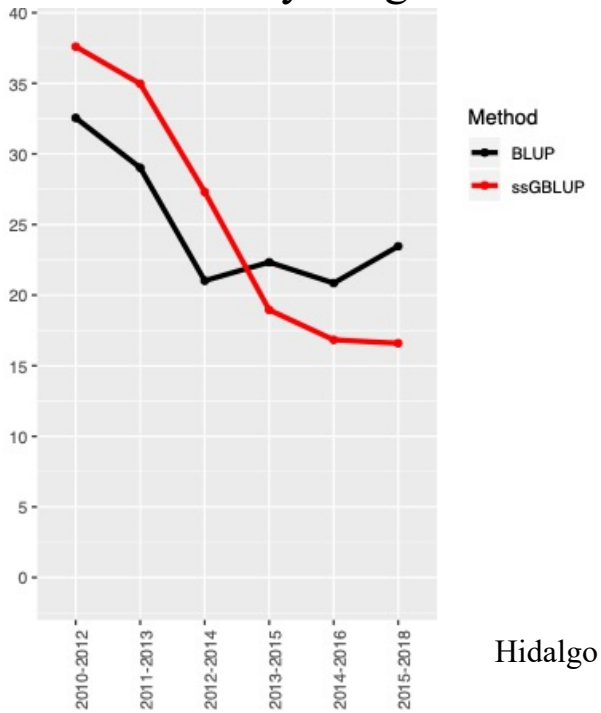
- No heat stress in USDA study by Wright et al. (2015)
- Poor milk and fertility ➔ better sprinklers and fans
- Still poor fertility and poor heat detection ➔ timed AI
- Low survival and not enough replacements ➔ sexed semen

Genomics in the end?

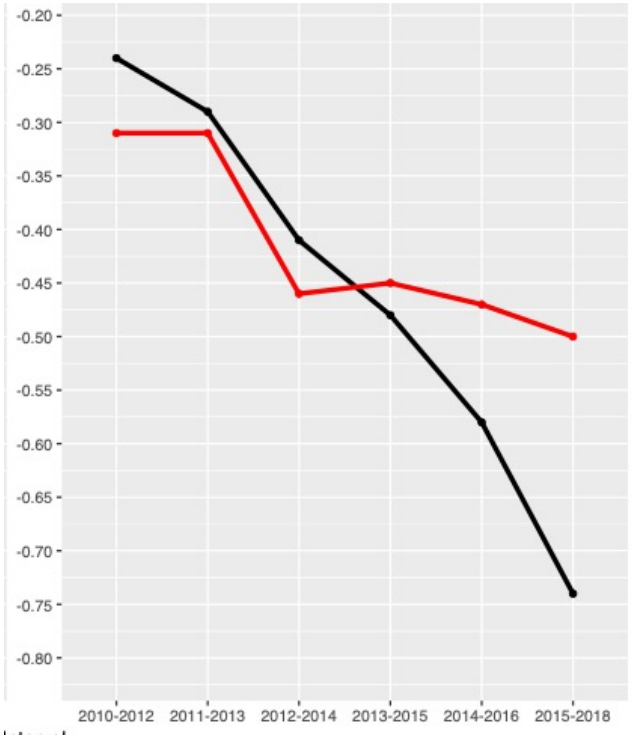
- Heat stress moving north
  - In Canada, threshold of heat stress 57 for protein (Campos et al., 2022)
- With genomics, high reliability even for cows
- Genetic evaluation for heat stress in Australia
- New interest by AI companies, e.g., Select Sires (Taylor et al., 2022)

Changes in (co)variances in pigs due to genomic selection

Heritability for growth



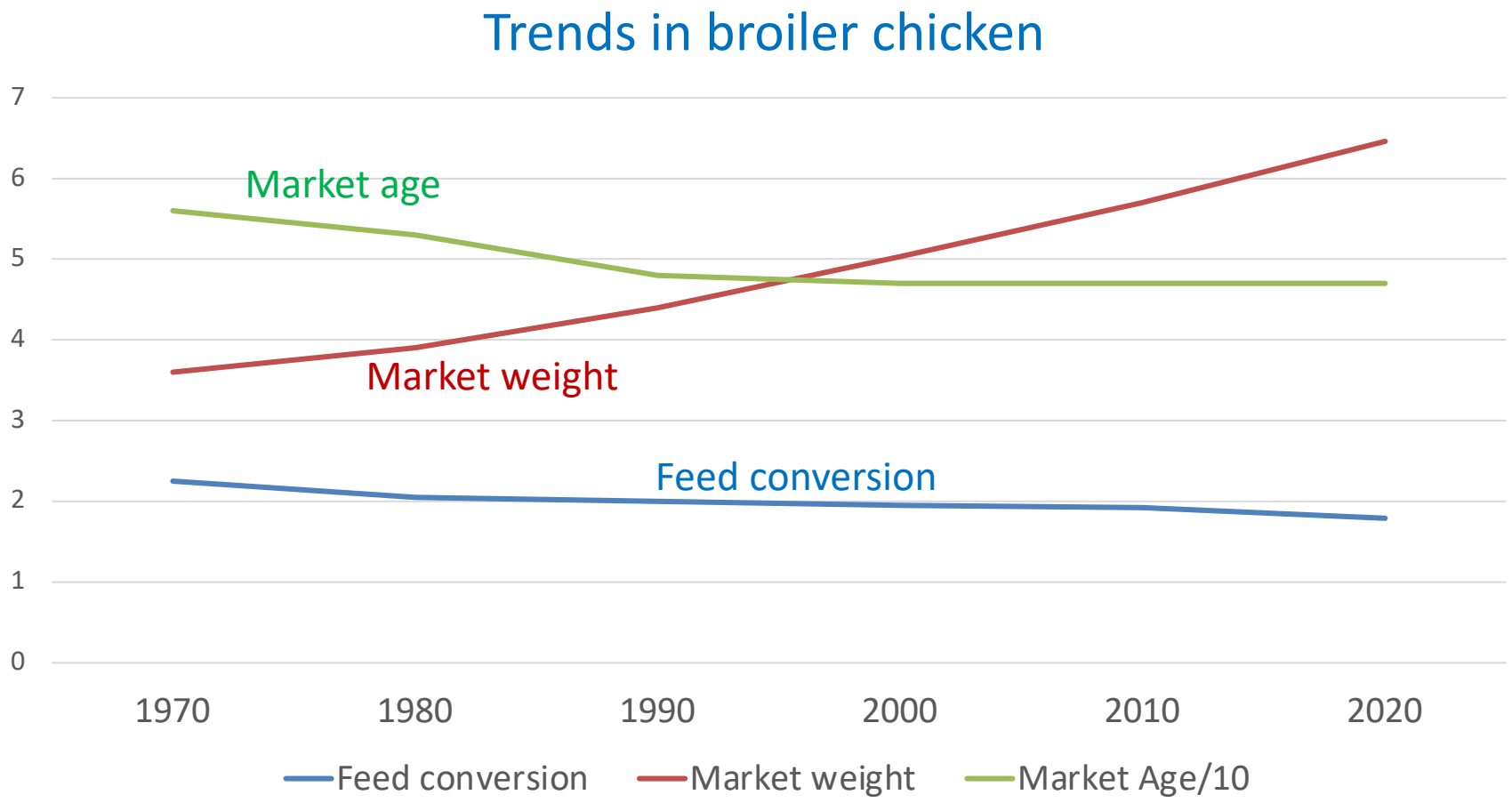
Genetic correlation with reproduction



Hidalgo et al. (2019)

Heritability decreases, antagonistic correlations intensify

Fundamental limits of selection



https://www.nationalchickencouncil.org/about-the-industry/statistics/u-s-broiler-performance/

How to mitigate negative effects of genomic selection?

- Identify declining traits, record, evaluate and put in selection index
  - Need updated index with current genetic parameters
  - No good methods for parameter estimation with large-scale genomics
  - Lag from action to market

- If recording difficult, use “umbrella” traits: survival, productive life…

Expected and realized accuracies

Specie	Trait	#phen	#genot	h^2	expected ACC	realized ACC
Pig	growth	150k	53k	0.21	**0.84**	**0.83**
Pig	fertility	25k	53k	0.04	**0.44**	**0.42**
chicken	growth	820k	150k	0.30	**0.94**	**0.58**
				0.13	**0.89**	**0.89**

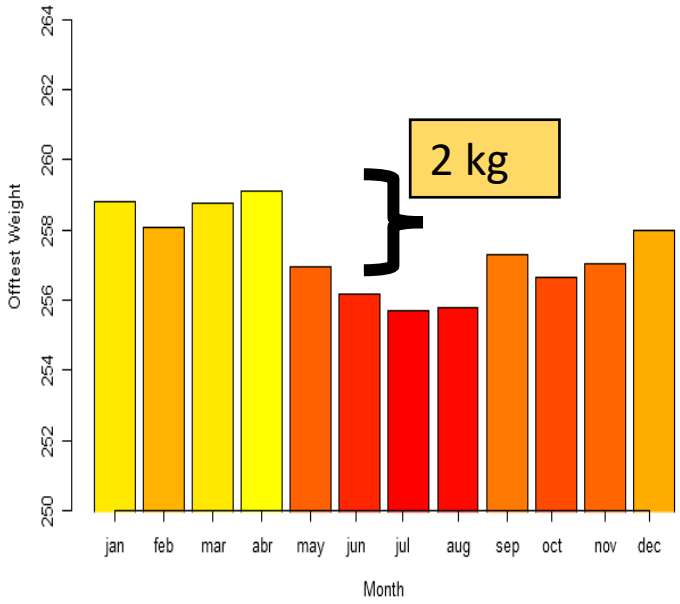
Hollifield et al., 2021

Hidalgo et al., 2021

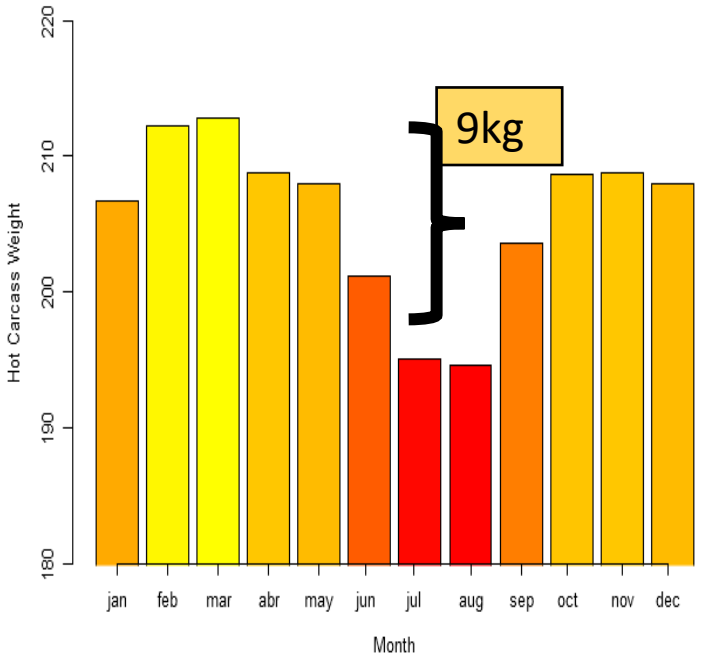
Losses and management level during heat stress

Fragomeni et al., 2016

Purebred



Crossbred



G x E important

Conclusions

- Selection as optimization – winner and loser traits
- Decline in low h^2 traits compensated by improved management
- With genomic selection
  - Variances decline
  - Trait antagonism intensifies
  - Faster progress for high h^2 traits
  - Faster decline for antagonistic unselected traits
  - Management cannot catch up

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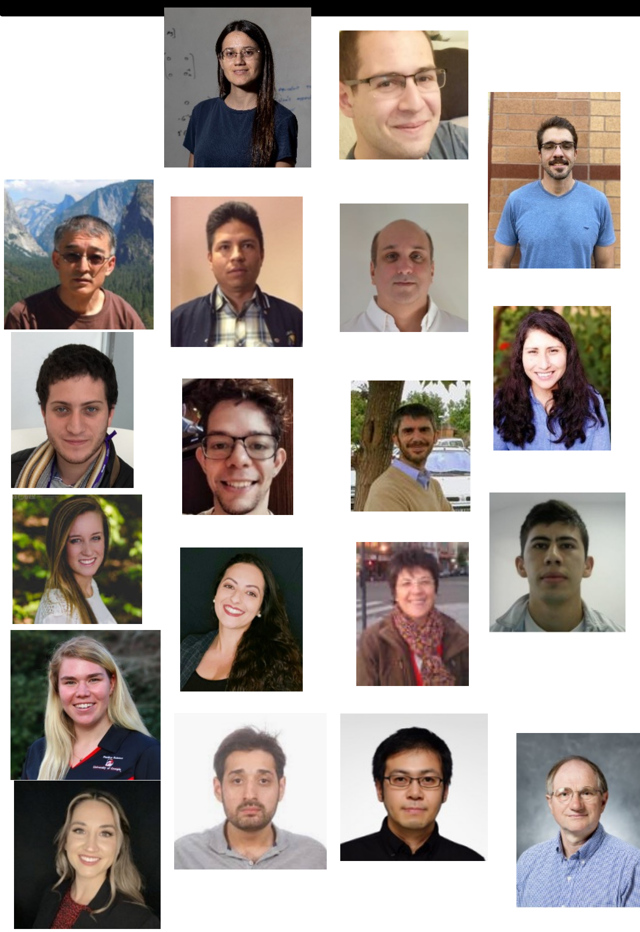
UGA AB&G team



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Cobb

CDCB
COUNCIL ON DAIRY CATTLE BREEDING

SEMEX
Genetics for Life

ABCZ

Rural Development Administration
National Institute of Animal Science

WAGYU
AMERICAN WAGYU ASSOCIATION

BAYER Crop Science

THE MASCHHOFFS
Progressive Farming. Family Style.

ABS

USDA United States Department of Agriculture
Agricultural Research Service
Warmwater Aquaculture Research Unit

DNA GENETICS
Greater gains. Improved performance.

PEAK

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ANCP

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