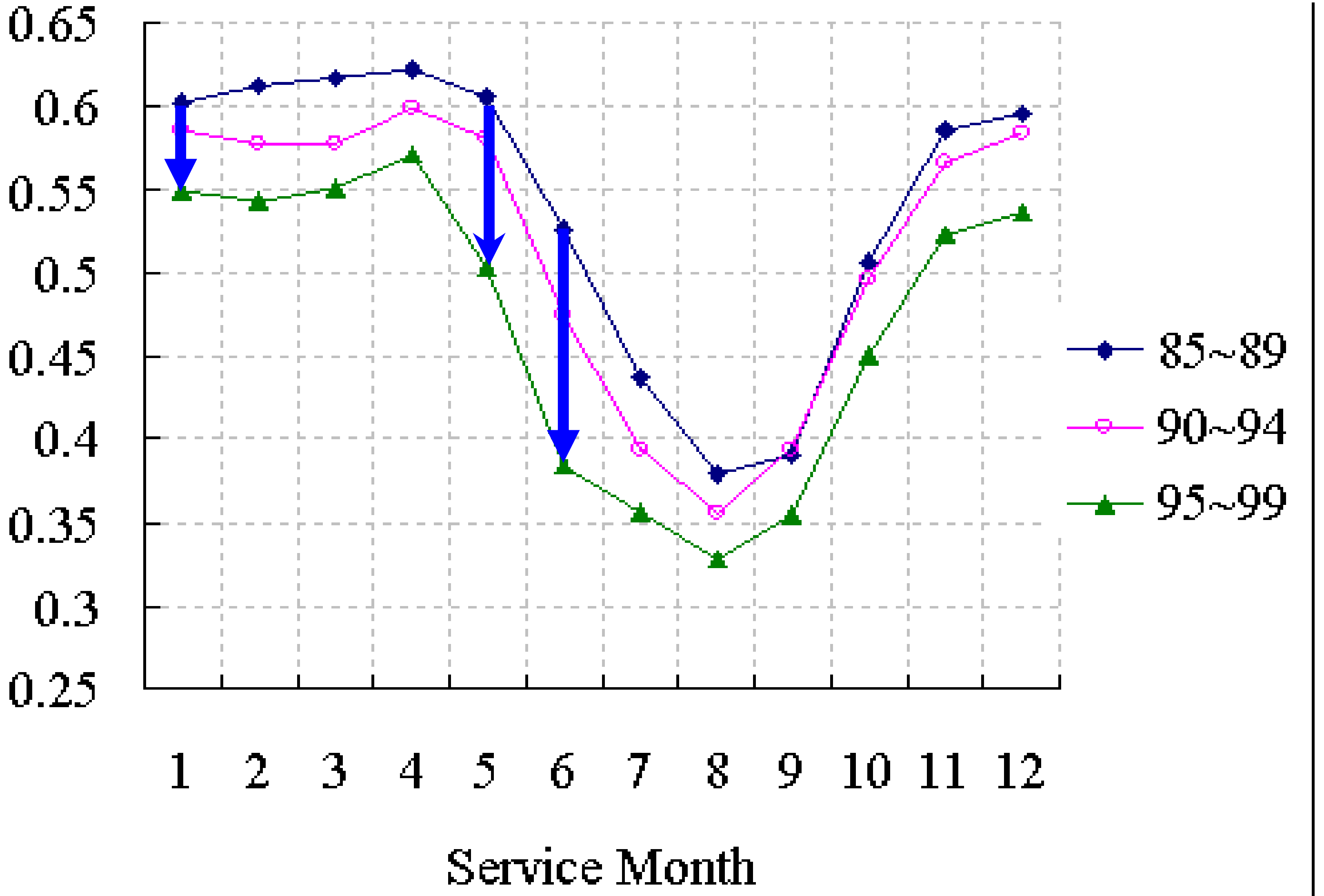
Studies in genetics of heat stress in dairy, beef and pigs

Ignacy Misztal
University of Georgia

Challenge of heat stress

- Strong effects of heat stress in dairy cattle
  - Lower fertility
  - Mortality/Morbidity
  - Production
- Perceived negative trends for heat tolerance
- Mainstream selection in Holsteins in milder/colder climates
- Selection against heat tolerance?
  - If so, can one select for heat tolerance?

Conception rate of U.S. Holsteins in Southeastern USA

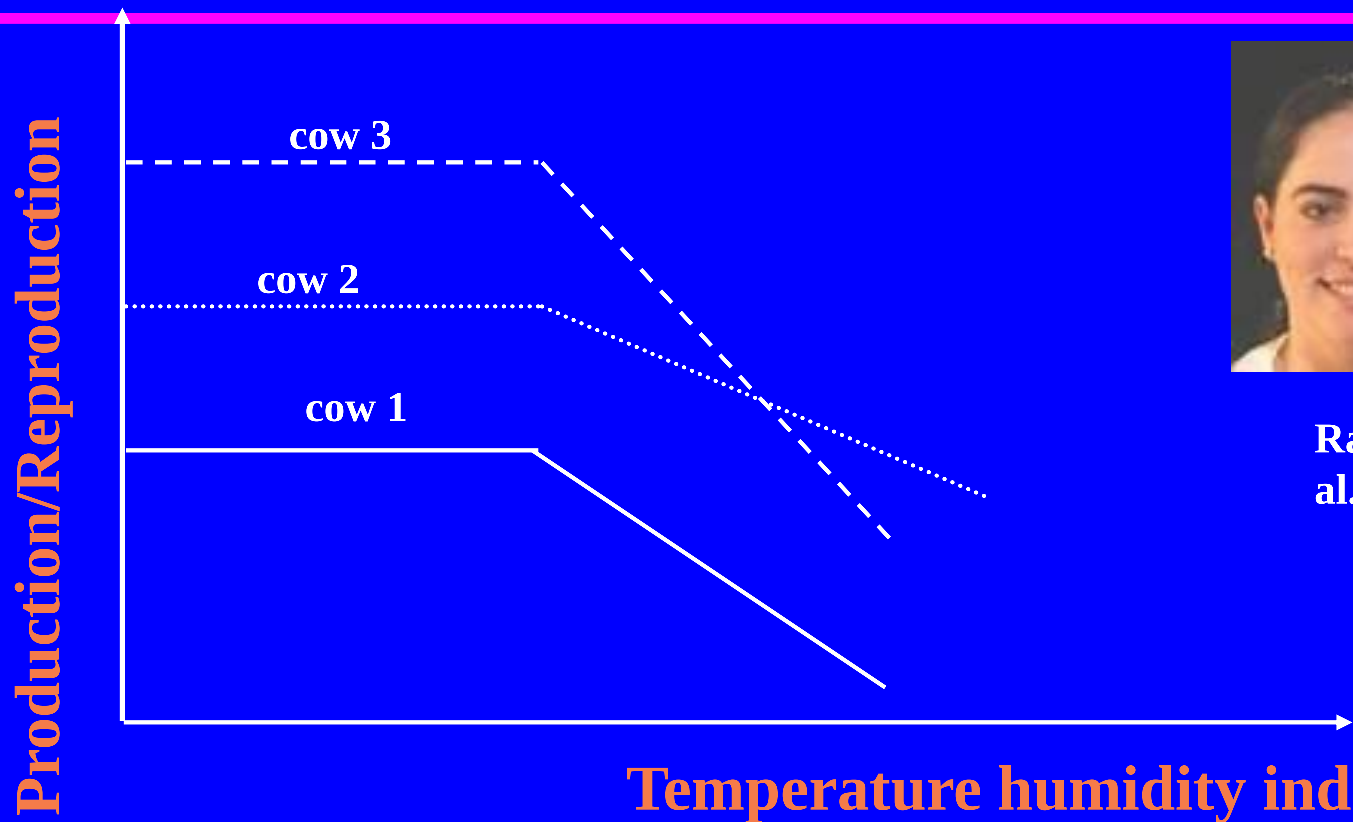


Huang et al., 2006

How to improve heat tolerance?

- Improve management or improve genetics?
- If genetics:
  - Define heat tolerance
  - Try to identify major genes if exist
  - Or polygenic model, now with genomic selection
  - Experimental data – good records but small size
  - National data – large data but how?

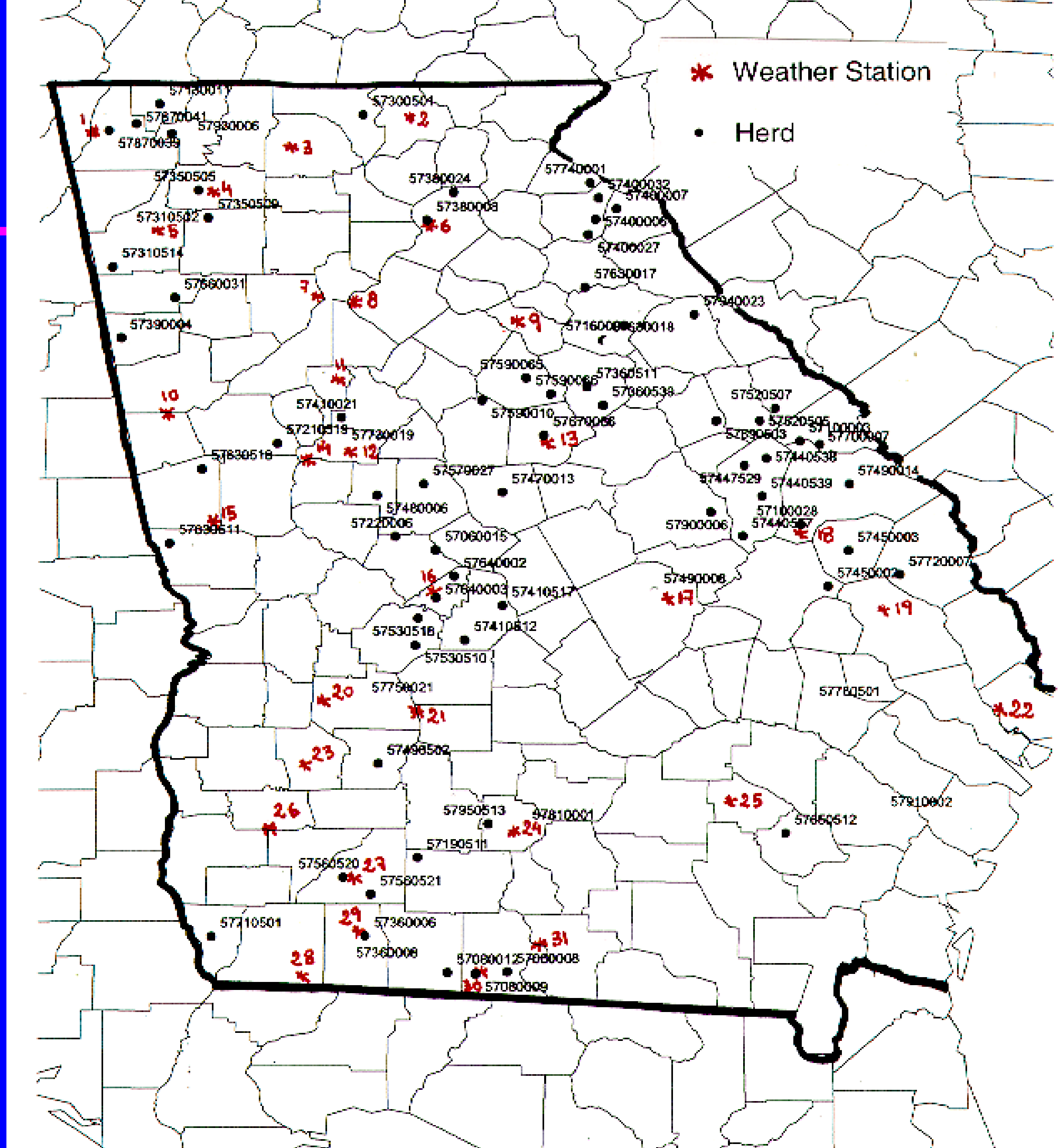
Assumptions for heat stress model with national data



Ravagnolo et al., 2001

Breeding value = a + f(THI)*v

a – regular breeding value   v – heat-tolerance breeding value
f(THI) – function of temperature humidity index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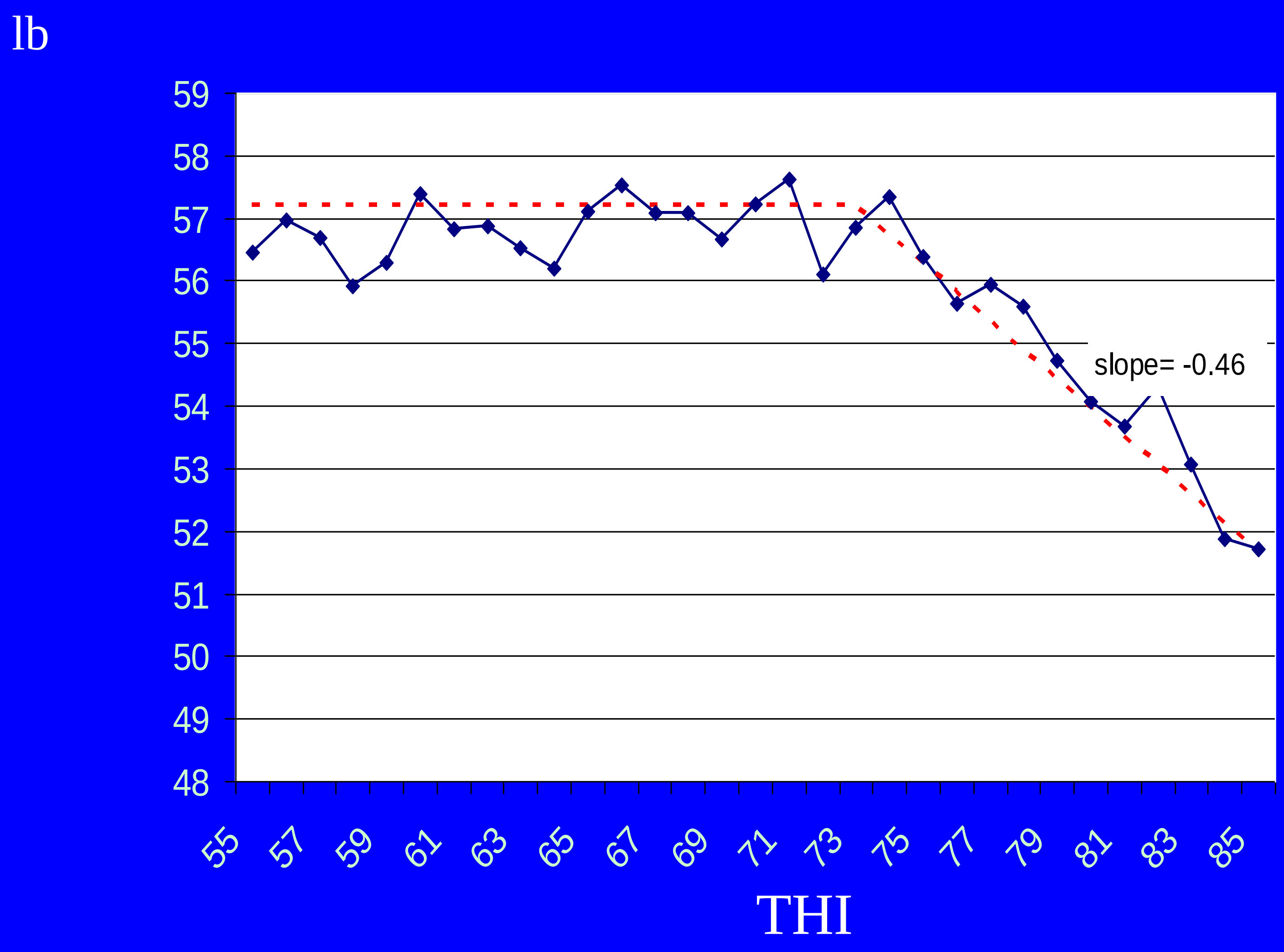
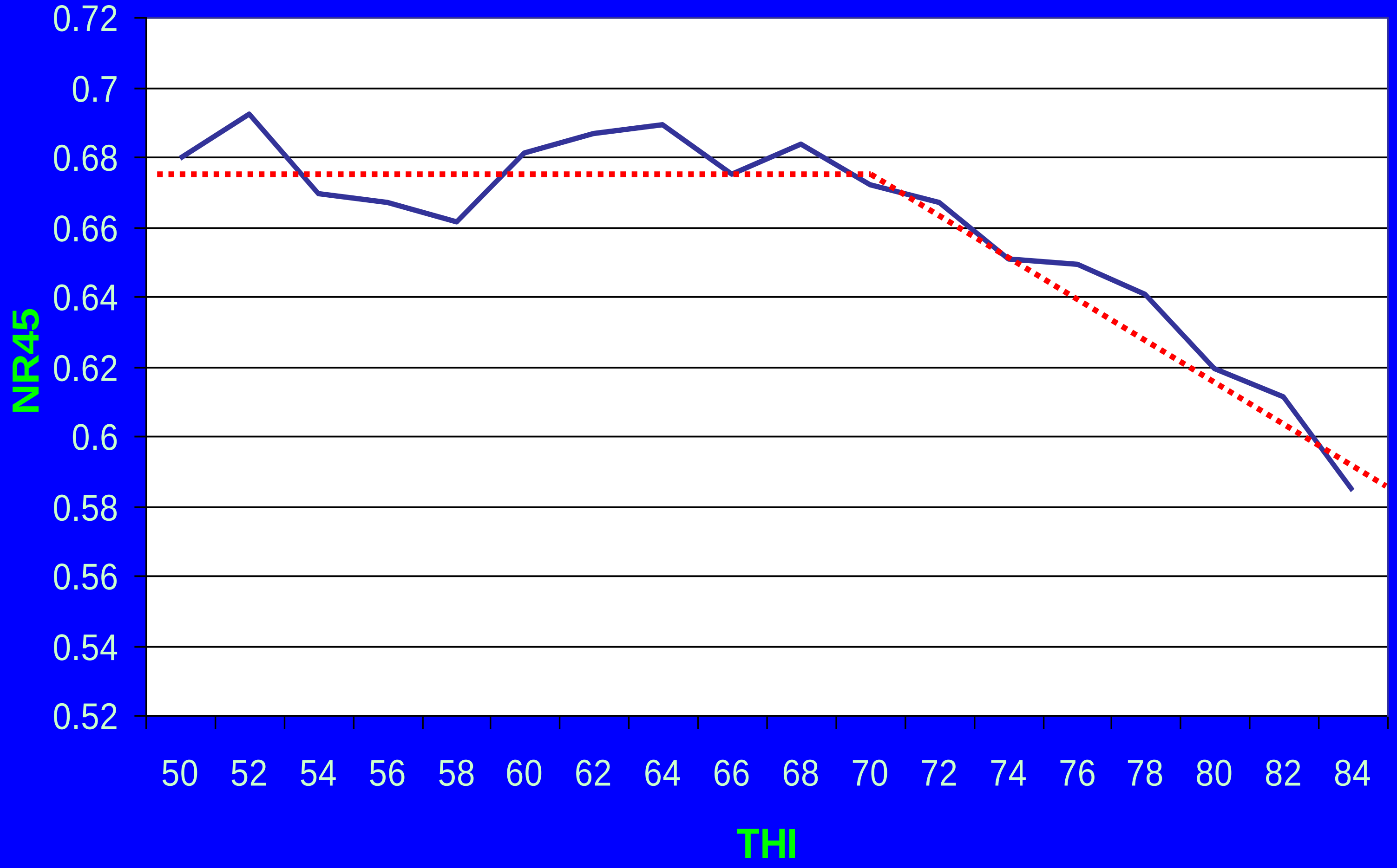
Effect of THI on daily milk production



Effect of THI on fertility (non-return rate at 45 days)

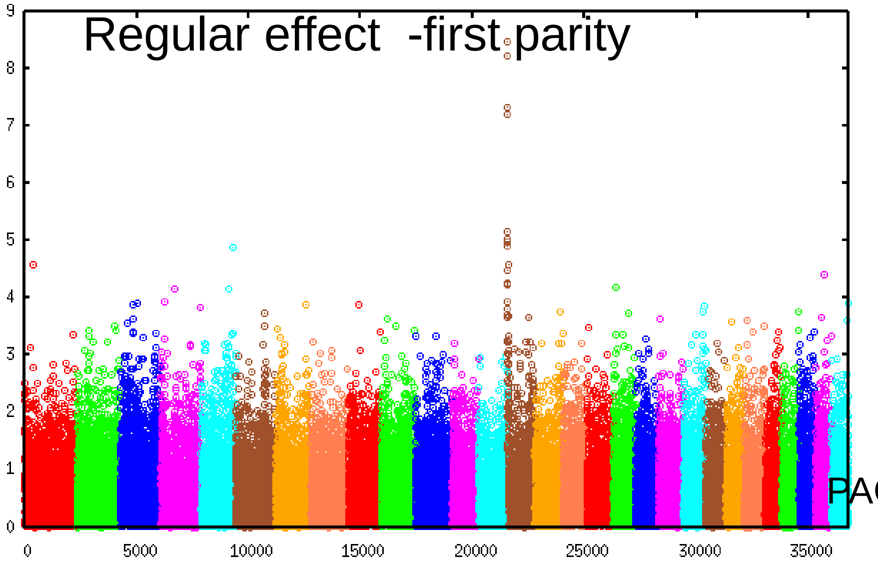


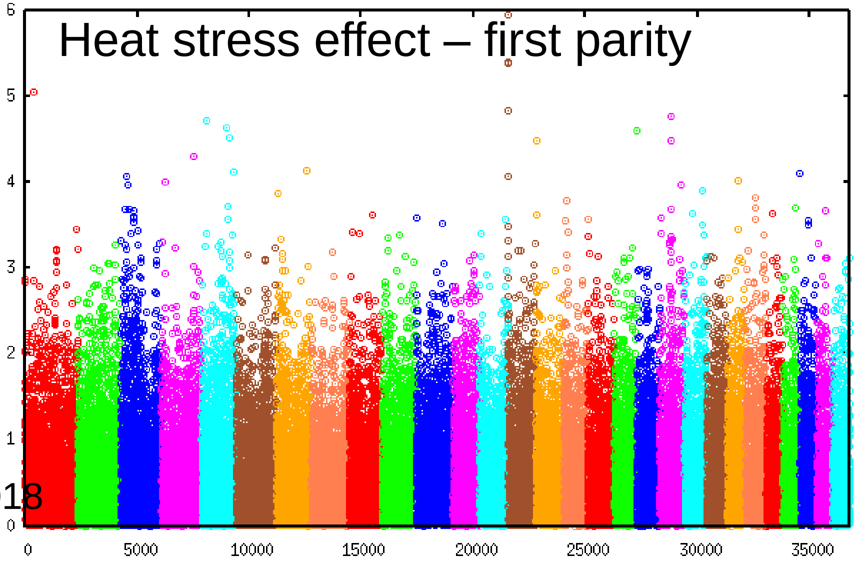
Genetics results

- Heat stress begins at about 72F THI (22C at 100% humidity)
- Genetic variability for heat tolerance present but not big
- Relationship between regular and heat tolerance genetics antagonistic at ~ -0.4

ssGBLUP for Heat Stress in Holsteins (Aguilar, 2011)

- Multiple-Trait Test-Day model, heat stress as random regression
  - ~ 90 millions records, ~ 9 millions pedigrees
  - ~ 3,800 genotyped bulls





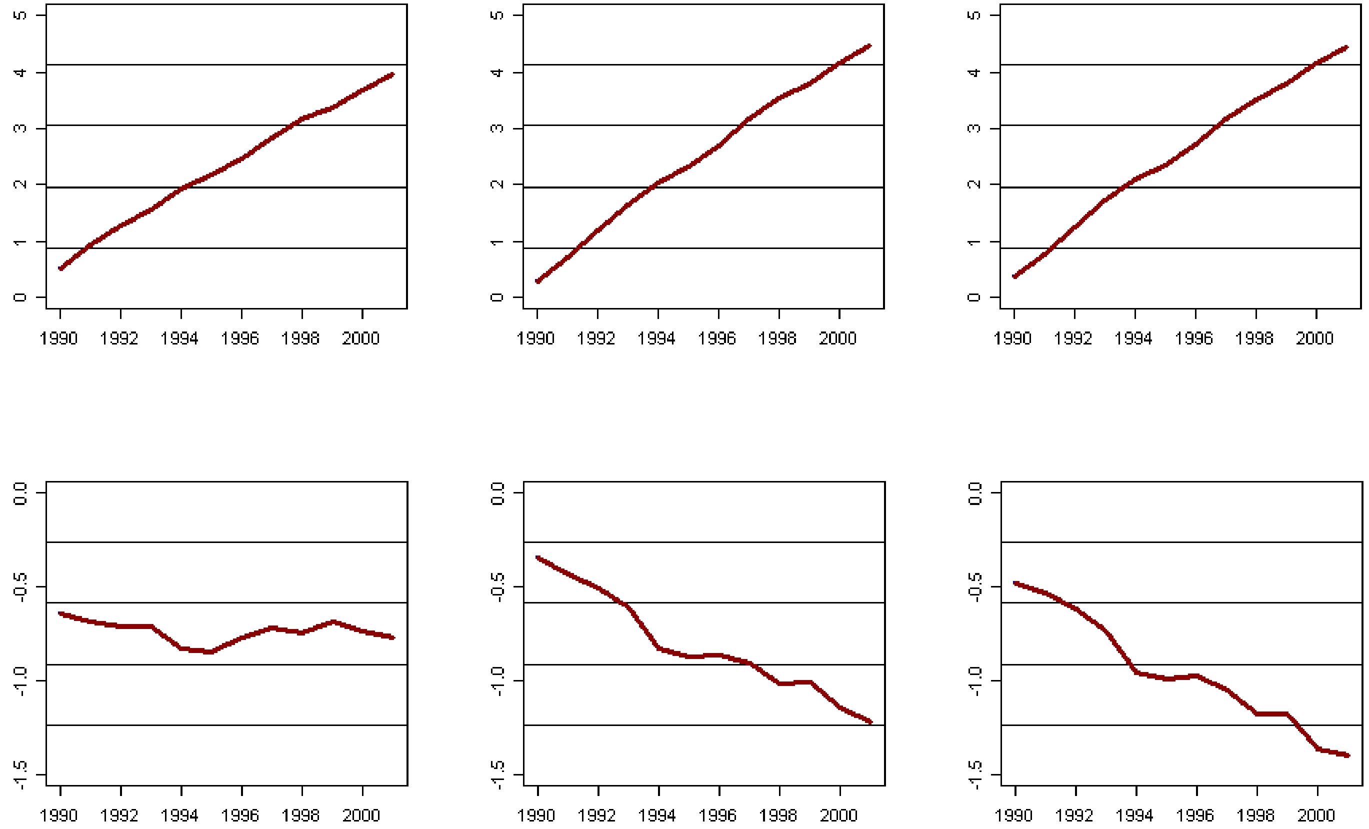
Genetic trends for milk

Parity

1 2 3

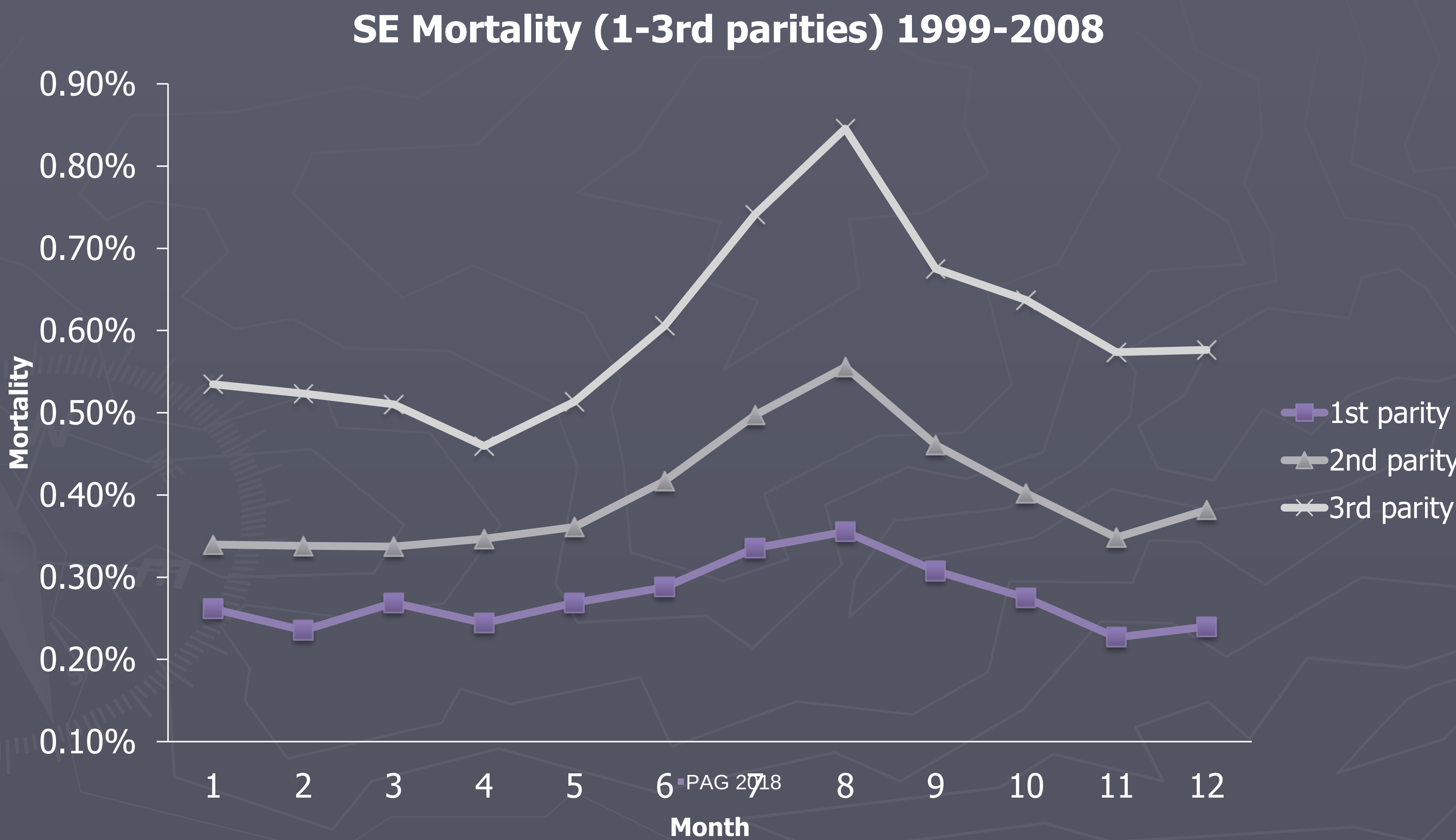
Regular effect

Heat stress effect



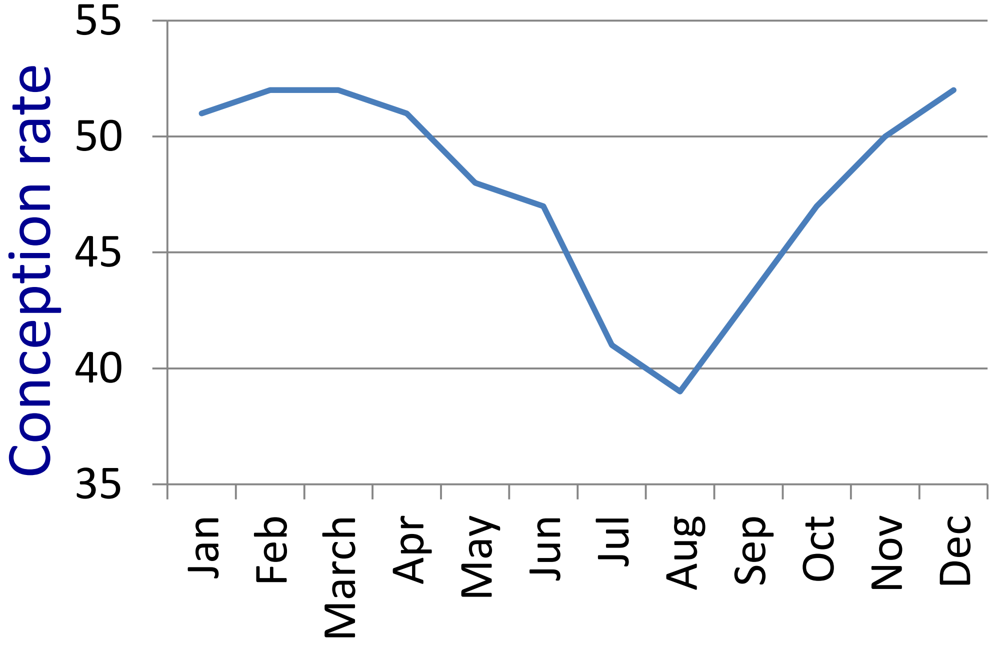
Mortality in SouthEast

Tokuhisa et al. (2011)



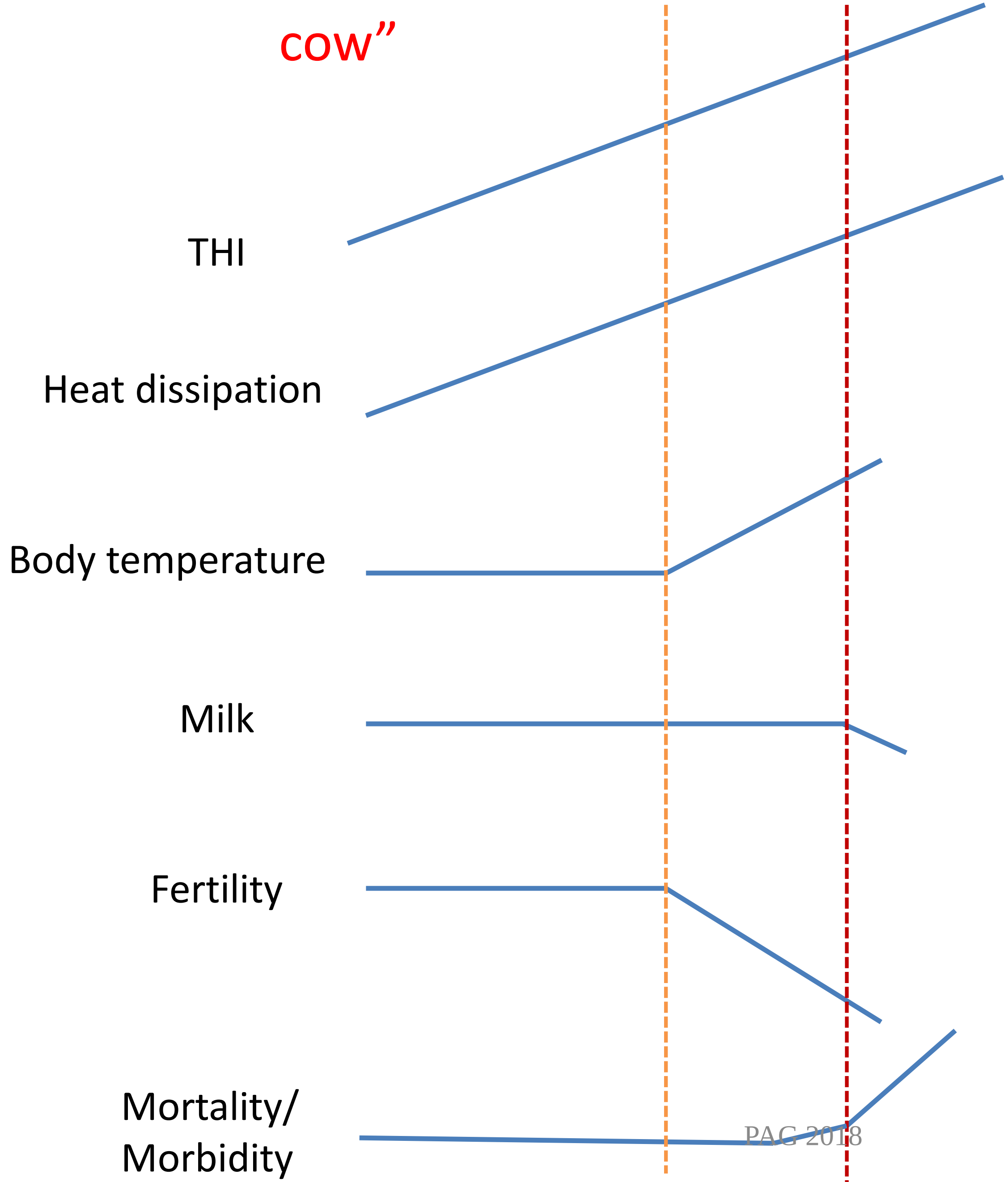
Is heat stress important in less intensive environments? - Iranian Holsteins

Small effect for milk



Mokhtar et al, 2012

Profile of a “heat-tolerant cow”



- What is a heat tolerant cow?
  - Milk as long as possible?
  - Reduces production when dangerous?
  - Reduces production early to maintain reproduction
- Thresholds management specific
  - Match genotype to environment

Partially based on Dikmen et al. (2012)

QTLs for heat stress

- Slick hair gene (Olsen et al., 2010)
- Gene for spring shedding in beef?

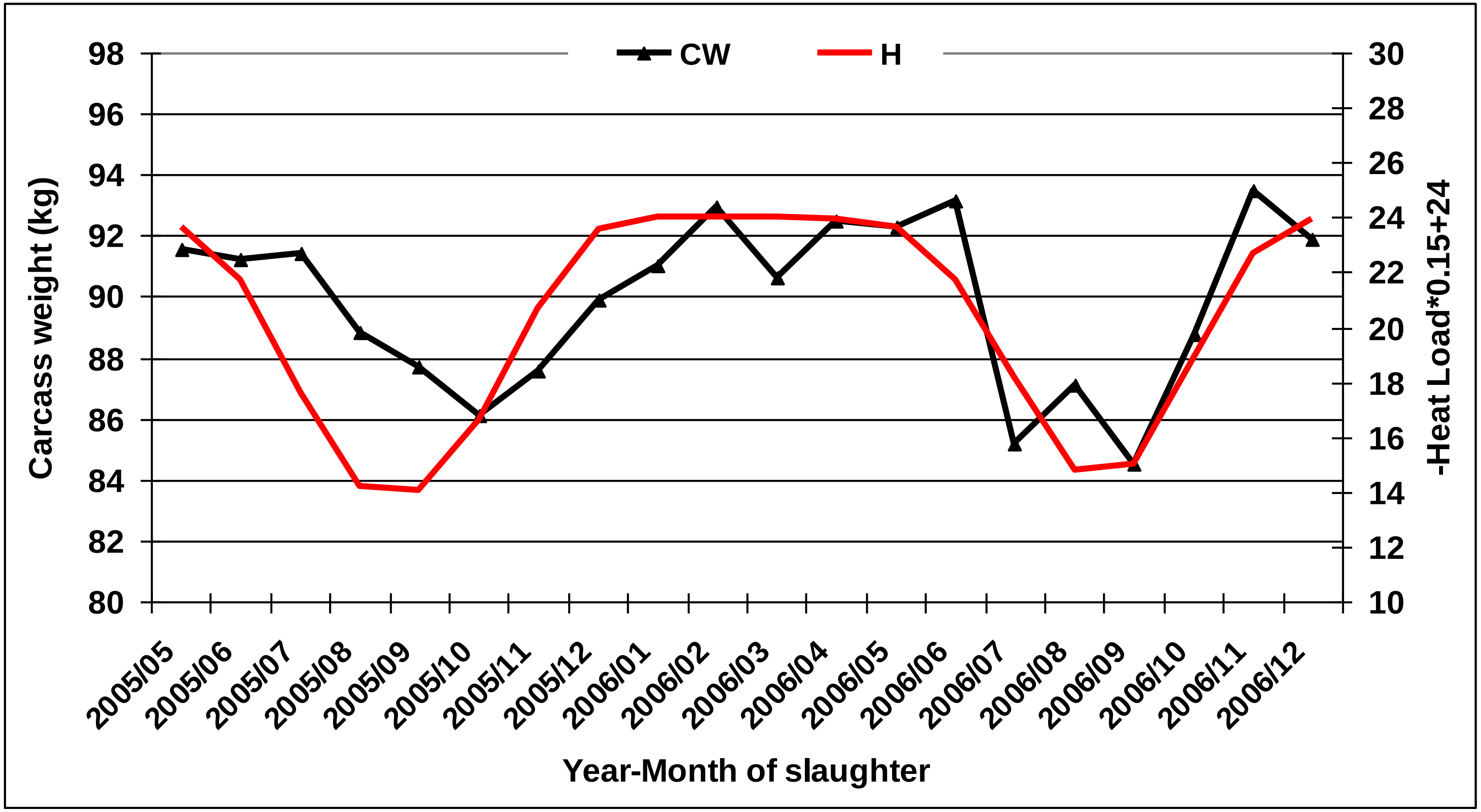
- Markers for rectal temperature (Dikmen et al., 2013)
  - Max 0.44% for 1 Mbase region

- Studies in AZ (Collier et al., 2012)
  - 500 SNP from microarray studies
  - 500 SNP from GWAS
  - 5 in common

Genetics of growth in pigs under different heat loads (Zumbach et al., 2007)

- Pigs in NC or TX exposed to heat stress
- Heat stress affect growth
- How to model heat stress for growth?

Theoretical and realized heat loads

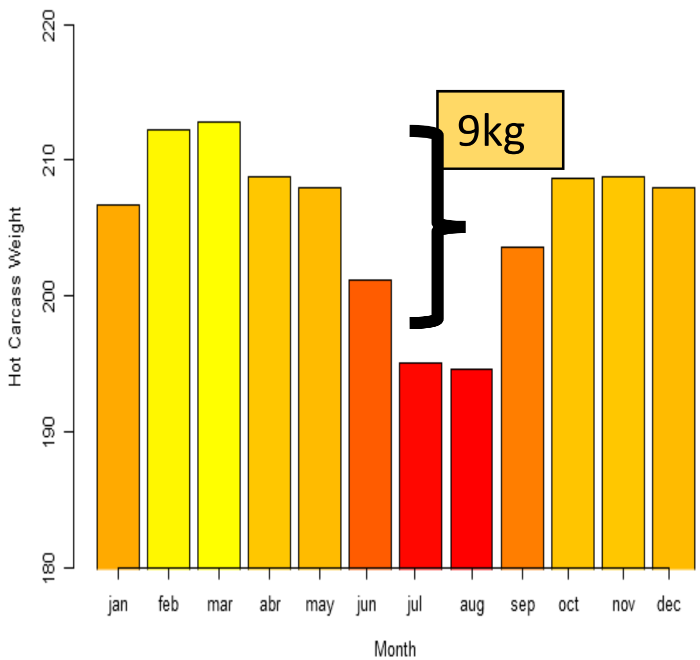


Zumbach et al., 2007

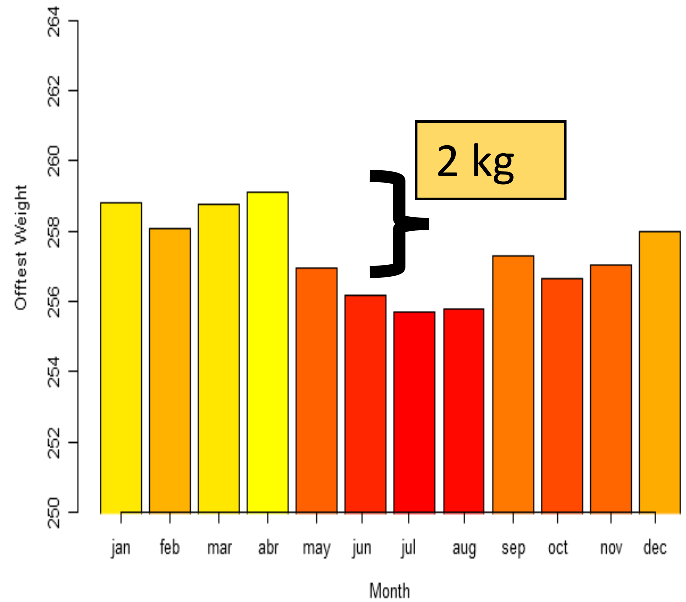
Heat stress in purebred and crossbred pigs

Fragomeni et al., 2016

Crossbred



Purebred



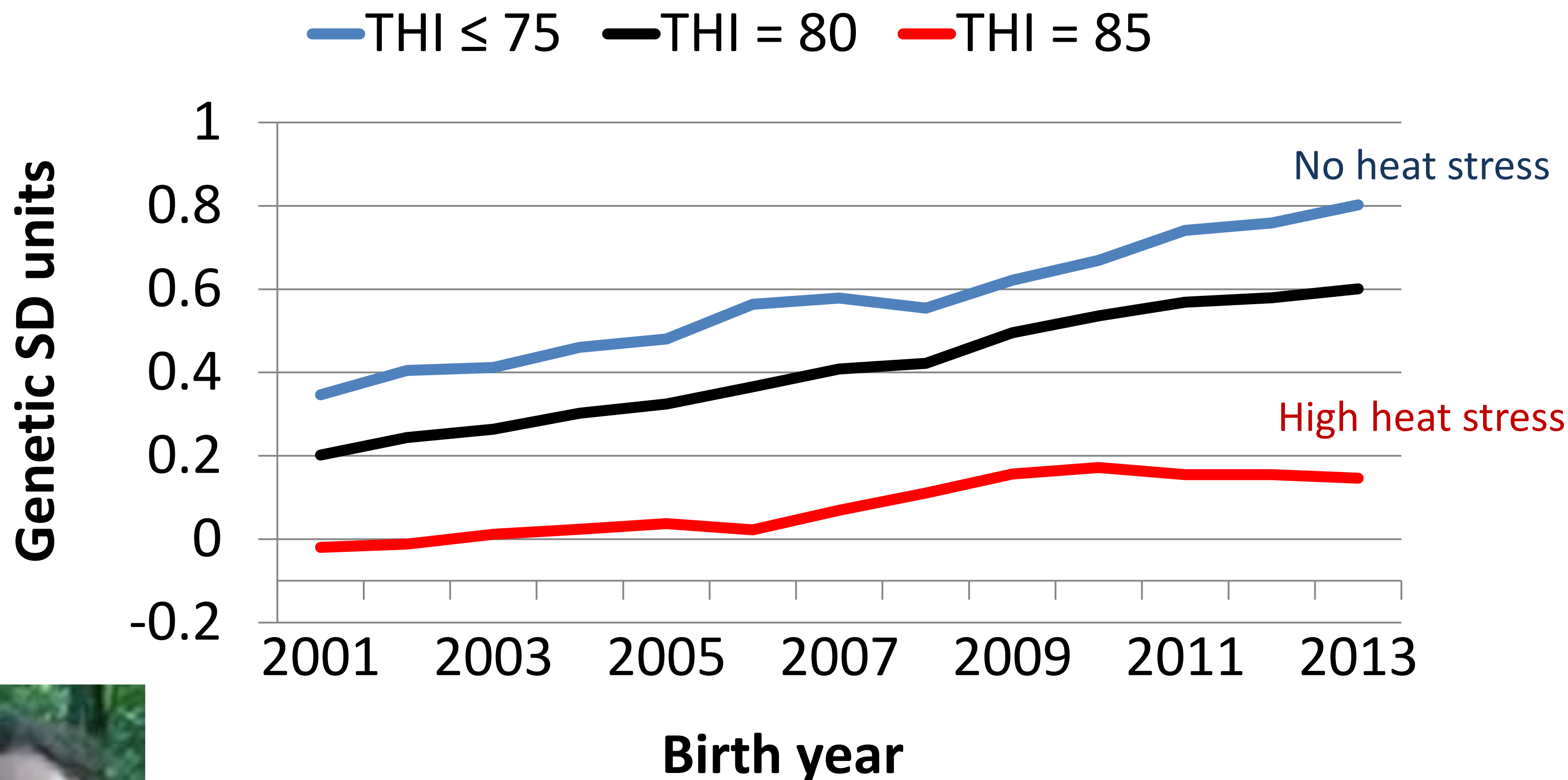
Better environment almost eliminates heat stress

Beef

- Annual economic losses from heat stress (St-Pierre et al., 2003)
  - $87 million for beef cows
  - $282 million for finishing cattle

- Limited quantifiable heat stress for Angus in US (Bradford et al., 2016)
  - Adaptation of beef industry for local condition
    - Timing of breeding
    - Crossbreeding

WW Direct Genetic Trend for Angus in Southeast

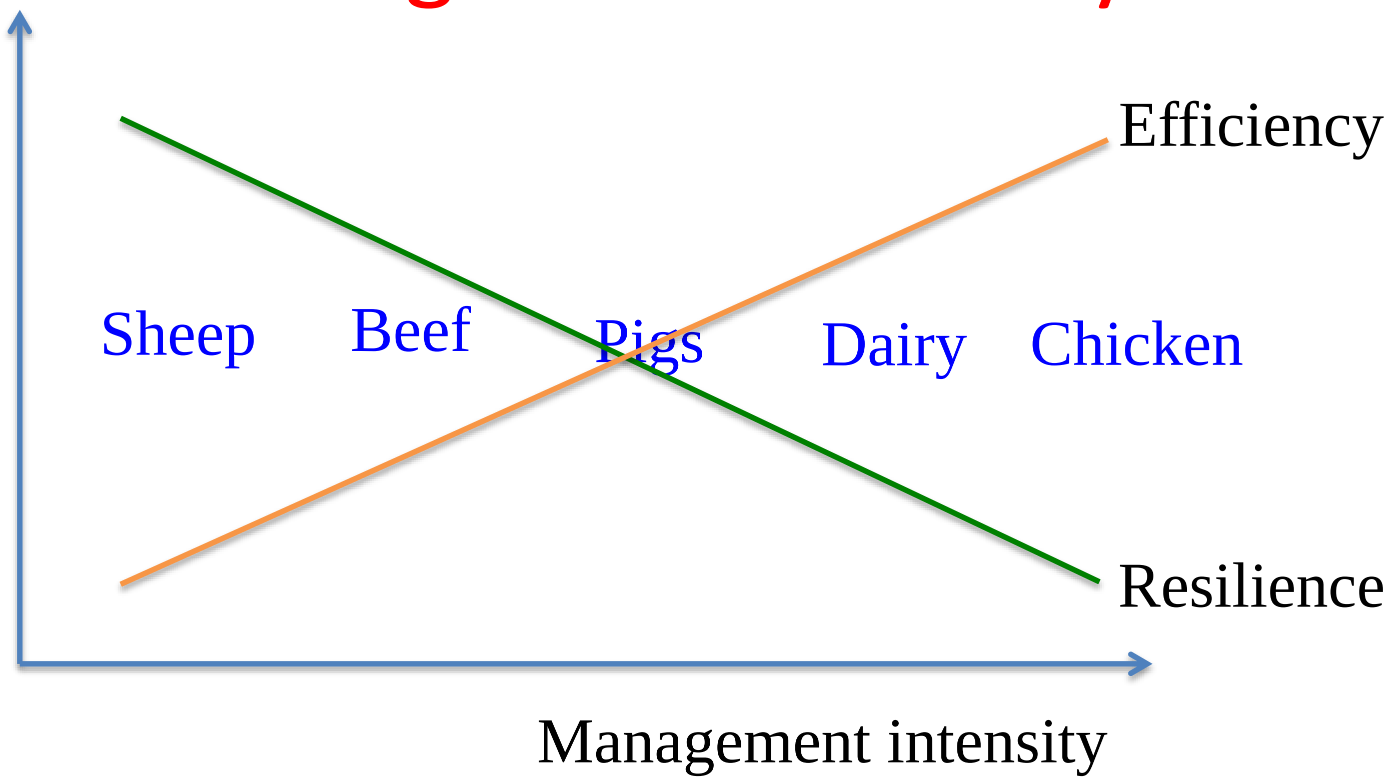


PAG 2018 Bradford et al., 2016

Selection as optimization

- Gains for selected and higher h^2 traits
- Correlated losses for unselected or low h^2 traits
- Effect of losses reduced/eliminated by management
- New management changes traits over time

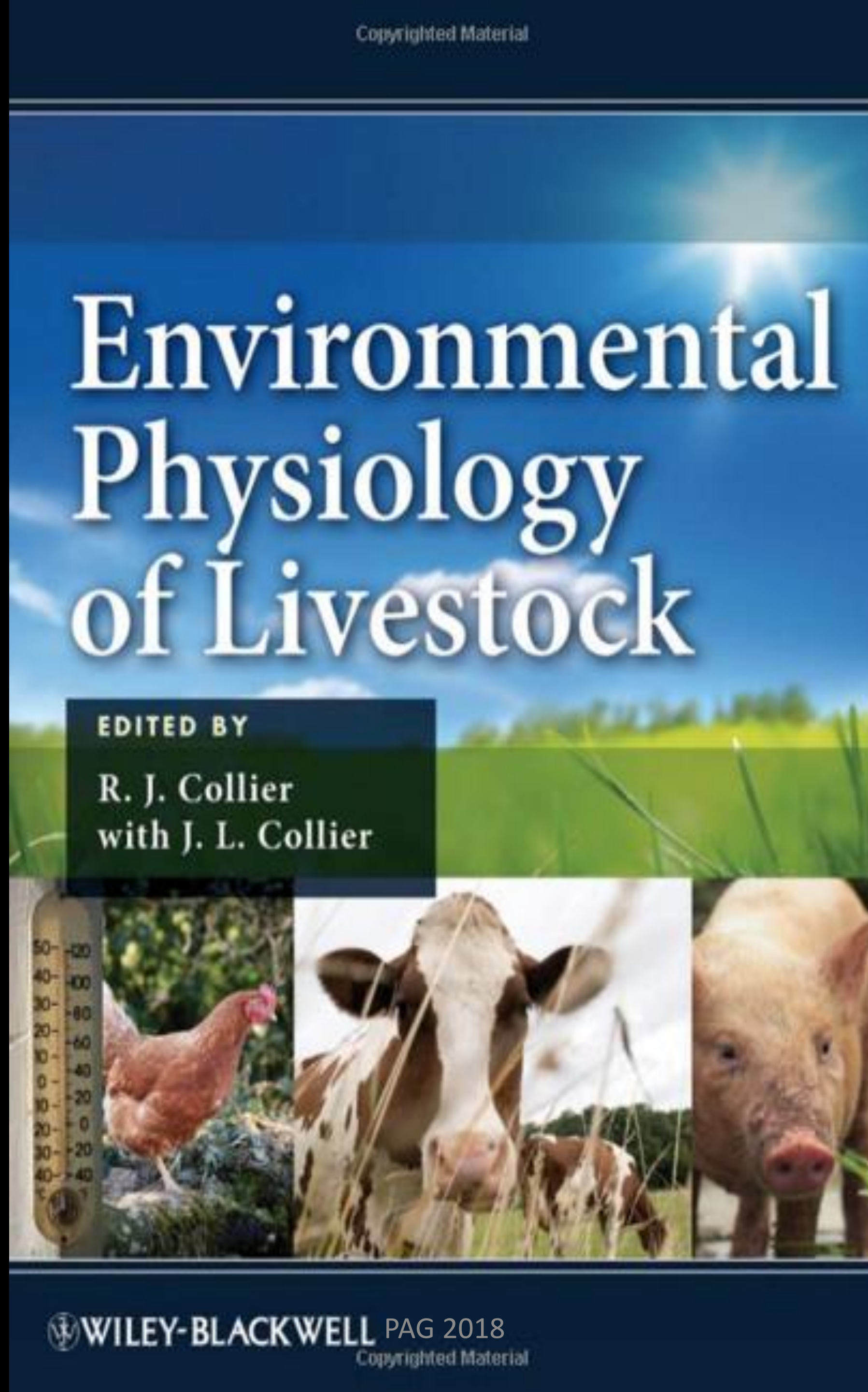
Resilience (heat tolerance)/efficiency and management intensity



Does industry need heat tolerant animals?

- Genetic evaluation for Holsteins in Australia (Nguyen et al., 2016)
- Genetic evaluation for pigs by Smithfield

- USA Holsteins in Southeast – not enough replacements before cow removed
    - ➔Improved cooling
    - ➔Sexed semen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Conclusions

- Heat tolerance and production antagonistic
- Definition of heat tolerance tricky
- Interaction of genetics and management – different by species
- Genetic evaluation for heat tolerance possible

Acknowledgements

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

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