Genetic variation in the threshold of sensitivity to heat stress on milk production in Holstein cattle

J. P. Sánchez, I. Misztal, I. Aguilar, R. Rekaya

Universidad de León (Spain)
University of Georgia (USA)
INIA (Uruguay)

Introduction

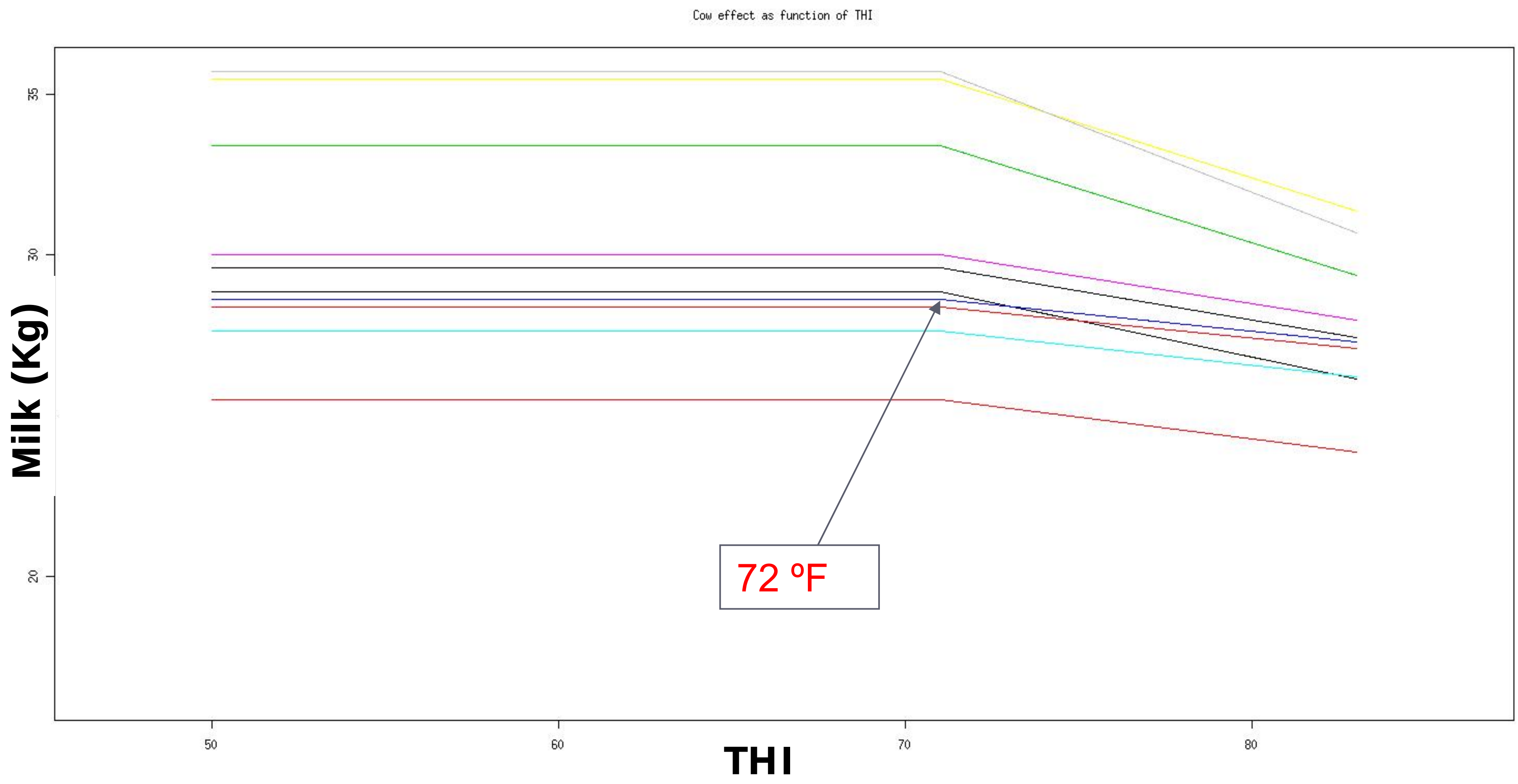
- Animals under heat stress produce less and have poorer reproductive performance than in the thermo-neutral zone.

- Regions where this problem is endemic
  - Tropical and Sub-Tropical Regions
  - Desert and Semi-Desert Regions
  - Global Warming!!!

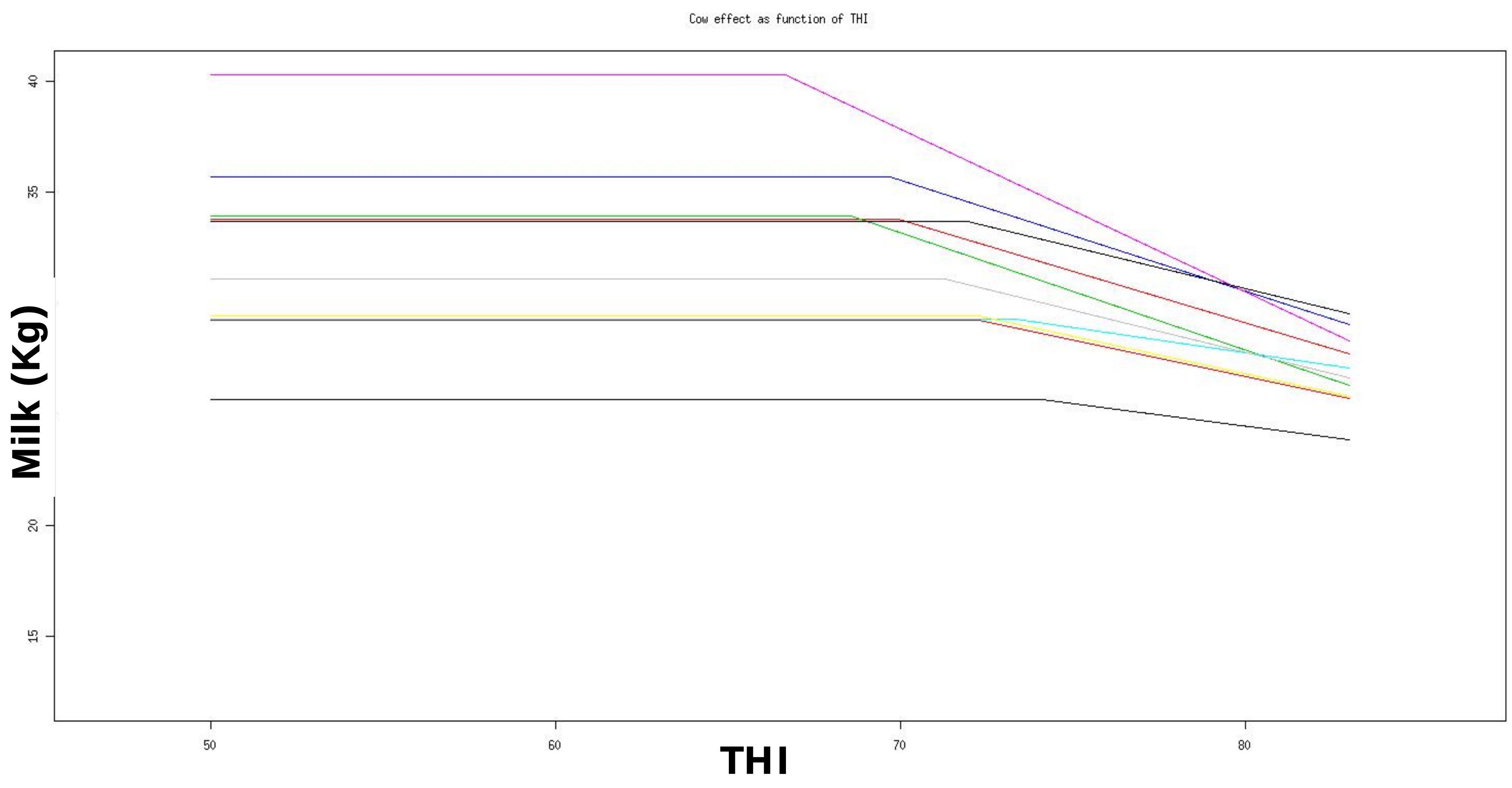
Introduction

- Solutions for alleviating this problem
  - Facilities and Management (Fans, Cooling, AC)
  - Intrinsically resistant animals (Genetic Improvement)
    - Beef cattle (Crossbreeding Specialized X Local breeds)
    - Dairy cattle (Selection within specialized breeds)
      - UGA evaluation model (Ravagnolo & Misztal, 2000)
        - Weather station data + Production data
        - Combination of Temperature and Humidity of the third day previous milking in an Index (THI).

Traditional Model



Alternative Model



Objective

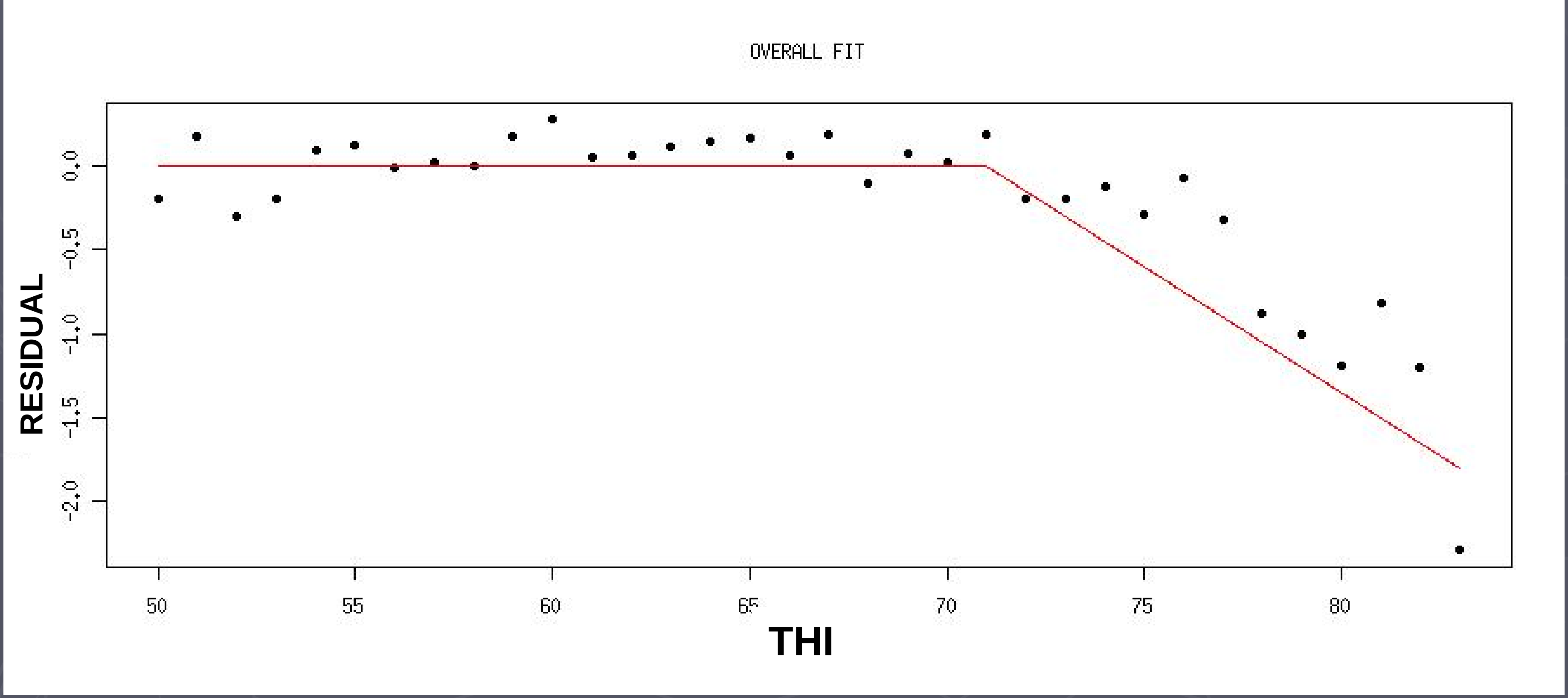
- Determine if the alternative model is preferable over traditional one for studying effects of heat stress on milk production.

Material & Methods

- Animals
  - Herd sampling from the US Holstein data set.
    - Records → 353,376
    - 1st Parity Cows → 38,383
    - CG (Herd-Test-Day) → 15,508
    - Animals → 95,962

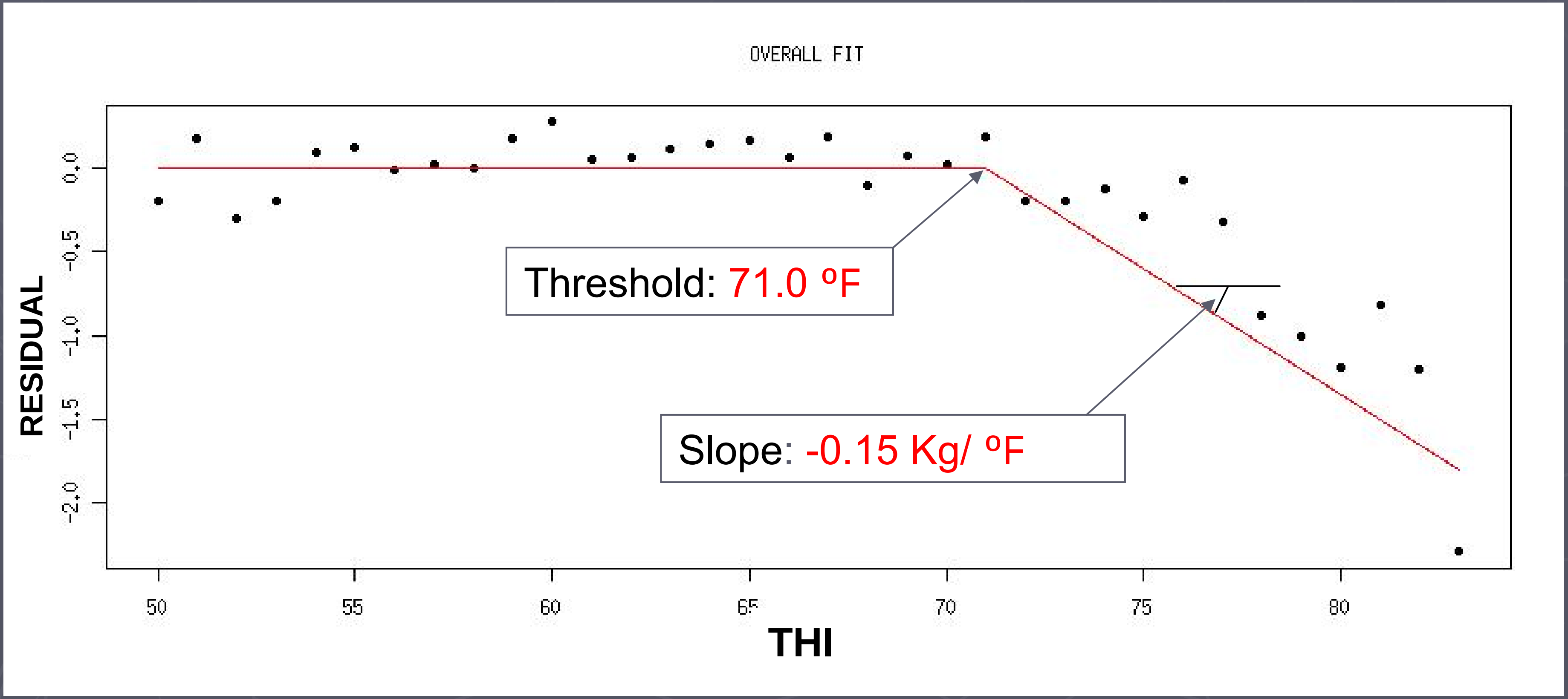
- Residuals after fitting for effects not completely associated to THI

Milk= HY + AGE + DIM*FREQ + ID + e



- Bayesian Non Linear Model for estimating threshold and slope.

Milk= HY + AGE + DIM*FREQ + ID + b*max(0,THI-T_0) + e



Hierarchical Models

1st Hierarchical Stage

- Traditional Model

$$y_{fgjik} = \mathbf{x}'_{1,ik}\boldsymbol{\beta}_1 + ID_{INT,i} + ID_{SLO,i} \times \max\left\{0, \left(THI_{ik} - \tau_0\right)\right\} + e_{fgjik}$$

- Alternative Model

$$y_{fgjik} = \mathbf{x}'_{1,ik}\boldsymbol{\beta}_1 + ID_{INT,i} + ID_{SLO,i} \times \max\left\{0, \left(THI_{ik} - ID_{THR,i}\right)\right\} + e_{fgjik}$$

2nd Hierarchical Stage

$$\mathbf{ID} = \mathbf{X}_2\boldsymbol{\beta}_2 + \mathbf{Za} + \mathbf{e}$$

MCMC Implementation

- All conditional posterior distributions, except those for thresholds, had known forms
  - Random-Walk Metropolis
- 250,000 iterations
  - 25,000 Burn-in & 1/25 Retained
- CONSTRAINTS
  - Threshold in the traditional model = 71.0
  - Threshold Average in the alternative model = 71.0

Model Comparison (DIC)

	DIC	pD
Traditional M.	1,338,527	51,096
Alternative M.	1,325,871	52,670

Correlations between EBV

		Alternative			Traditional	
		Int. EBV	Slo. EBV	Thr. EBV	Int. EBV	Slo. EBV
Alter.	Int. EBV	1.00				
	Slo. EBV	-0.85	1.00			
	Thr. EBV	-0.80	0.99	1.00		
Tradi.	Int. EBV	0.95	-0.66	-0.60	1.00	
	Slo. EBV	-0.56	0.49	0.42	-0.57	1.00

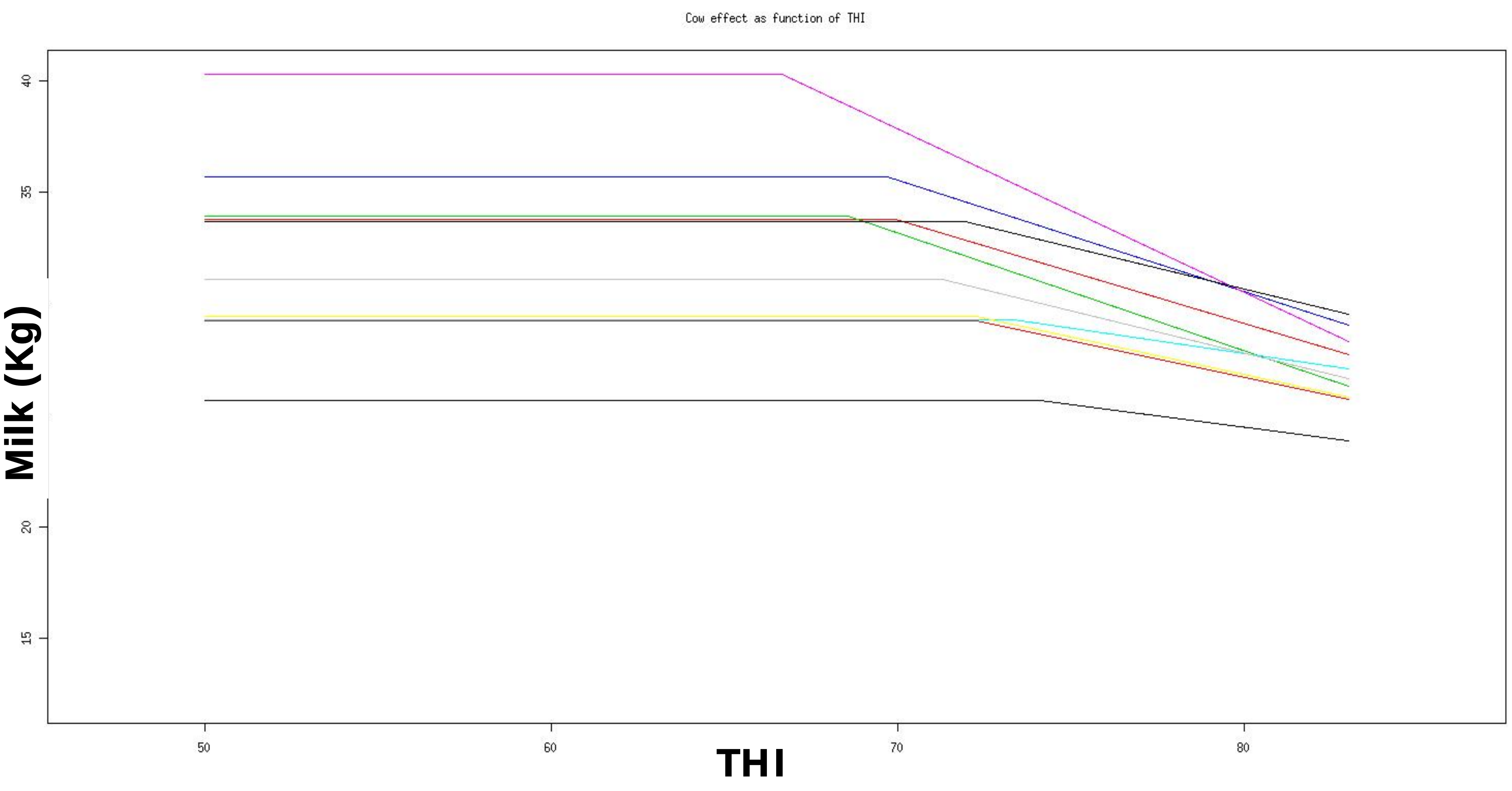
Variance Components (Posterior Stat.) Traditional Model

Parameter	P. Mean	P. SD	95%HPD		ESS
h^2_{INT}	0.27	0.02	0. 23	0.31	296
h^2_{SLO}	0.28	0.07	0.14	0.40	32
$\rho_{g,INT-SLO}$	-0.40	0.11	-0.62	-0.19	48
$\rho_{p,INT-SLO}$	-0.47	0.04	-0.55	-0.39	79
σ^2_e	14.06	0.04	13.99	14.13	5279

Variance Components (Posterior Stat.)
Alternative Model

Parameter	P. Mean	P. SD	95%HPD		ESS
h^2_{INT}	0.29	0.02	0.25	0.33	199
h^2_{SLO}	0.32	0.04	0.25	0.41	39
h^2_{THR}	0.56	0.05	0.47	0.65	31
$\rho_{g,INT\text{-}SLO}$	-0.62	0.08	-0.77	-0.46	24
$\rho_{g,INT\text{-}THR}$	-0.53	0.05	-0.63	-0.42	60
$\rho_{g,SLO\text{-}THR}$	0.95	0.03	0.90	0.99	7
$\rho_{p,INT\text{-}SLO}$	-0.45	0.03	-0.52	-0.40	37
$\rho_{p,INT\text{-}THR}$	-0.26	0.04	-0.35	-0.18	33
$\rho_{p,SLO\text{-}THR}$	0.97	0.01	0.95	0.99	28
σ^2_e	13.51	0.04	13.43	13.58	579

Graphical Illustration of Correlation between Parameters



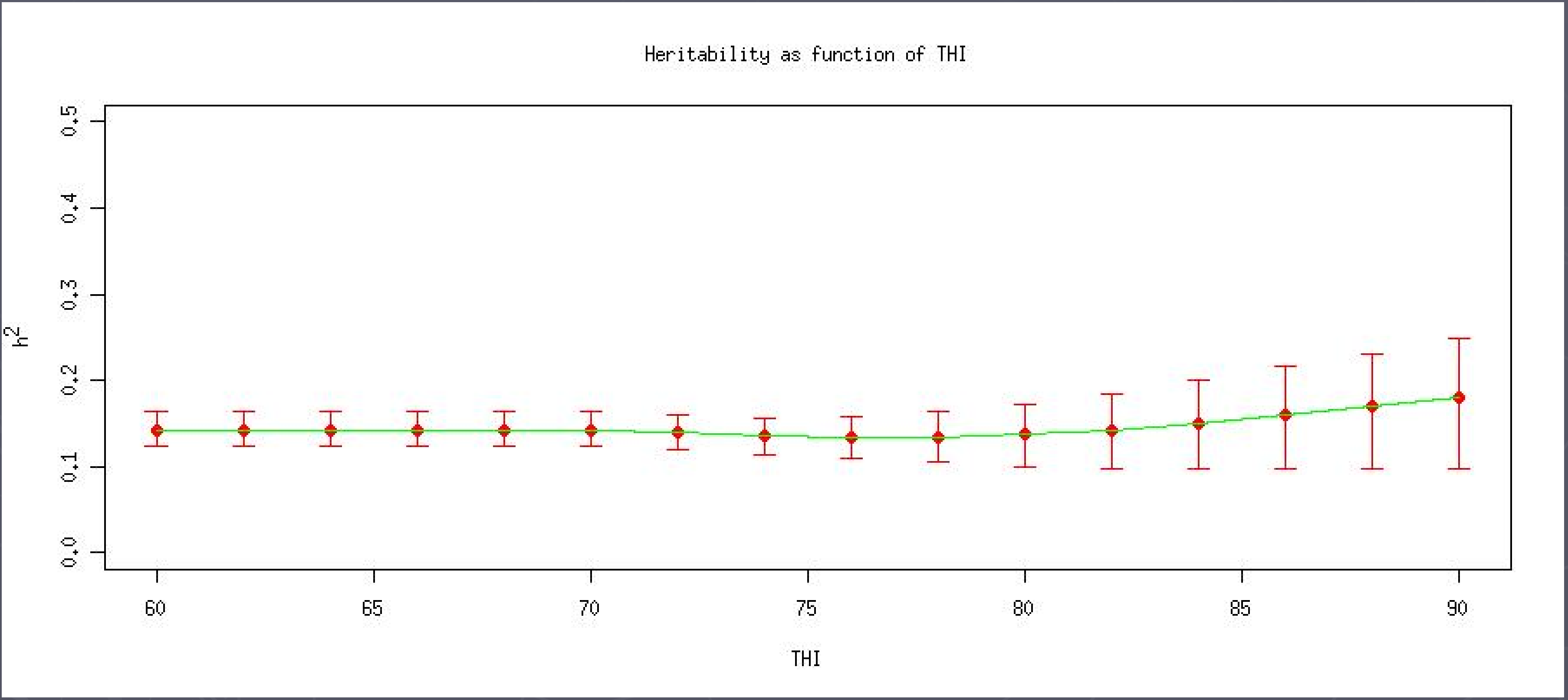
Conclusions

- The heritability of the onset of heat stress is high and selection for this unobserved trait could be successful.

- Both heat tolerance definitions are consistent to each other:
  - The greater the onset of heat stress, the less negative is the decay in production with increase in THI (genetically and environmentally).

- High genetic correlation between heat tolerance definitions.

Milk Production Heritability Traditional Model



Milk Production Heritability (Approximation) Alternative Model