TOWARDS IMPROVEMENT OF **RUMI**NANT BREEDING
THROUGH **GEN**OMIC AND EPIGENOMIC APPROACHES

'Should we consider fertility when improving thermotolerance in dairy cattle?

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Justification & Objective

Current methods to predict breeding values/select for heat tolerance are based on estimation of individual decay through random regression (broken line or polynomial models):

- Reducing milk production is a physiological mechanism to reduce heat sensitivity
- Antagonism between productive level and slope of decay under heat stress has been observed in a number of populations

➔ Selection of animals with smaller decays in production may result in:

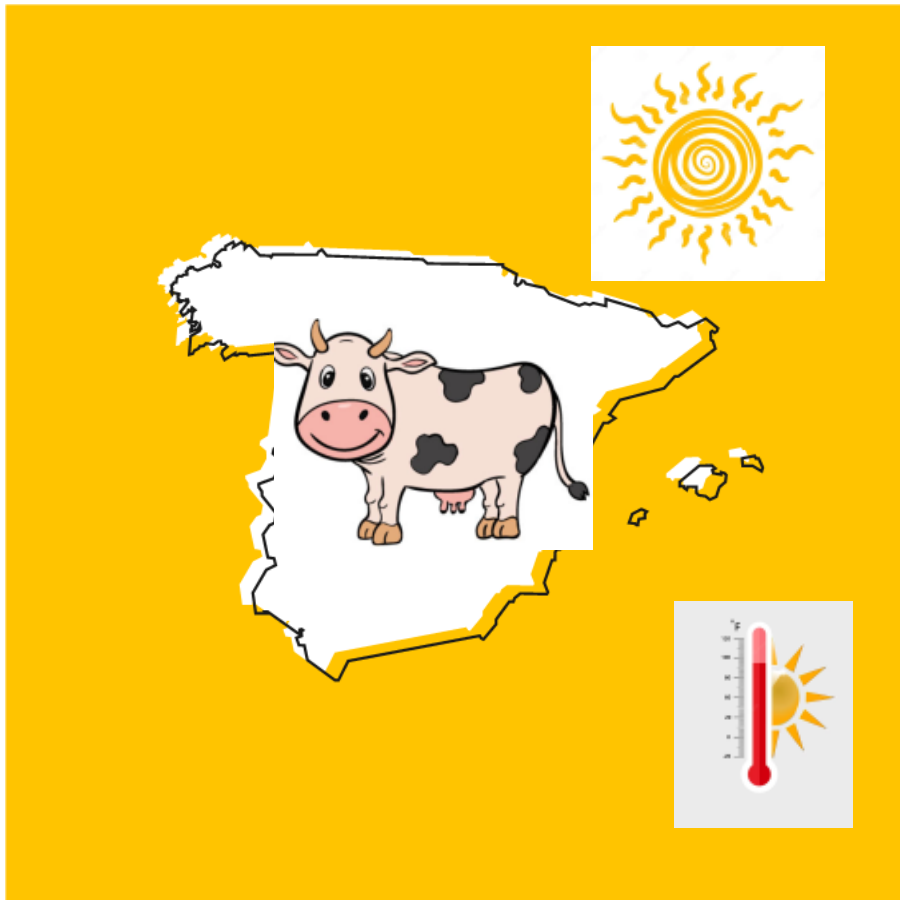
a) selection of less productive cows → decrease of overall productive level, or
b) selection of animals that are able to maintain high productive levels under heat stress → not being able to maintain homeostasis? Less functional?

Justification & Objective

Should we consider decays in other traits such as fertility, in the idea that animals that are able to keep reproductive functions under heat stress will be less sensitive to heat?

Objective:

In this study, indicators of heat tolerance obtained from the outcome of artificial insemination (AI) and meteorological data have been analysed and the relationship with traditional productivity indicators quantified.



Preliminaries

Population Response

Conception Rate – Heat load

Data & Models – Population Response

TOWARDS IMPROVEMENT OF RUMINANT BREEDING THROUGH GENOMIC AND EPIGENOMIC APPROACHES

Data :

- Initially

4,508,314 AI records from 1,091,612 cows in 7,970 herds

- Data from first lactation-first AI:

913,493 AI records/cows in 7,858 herds

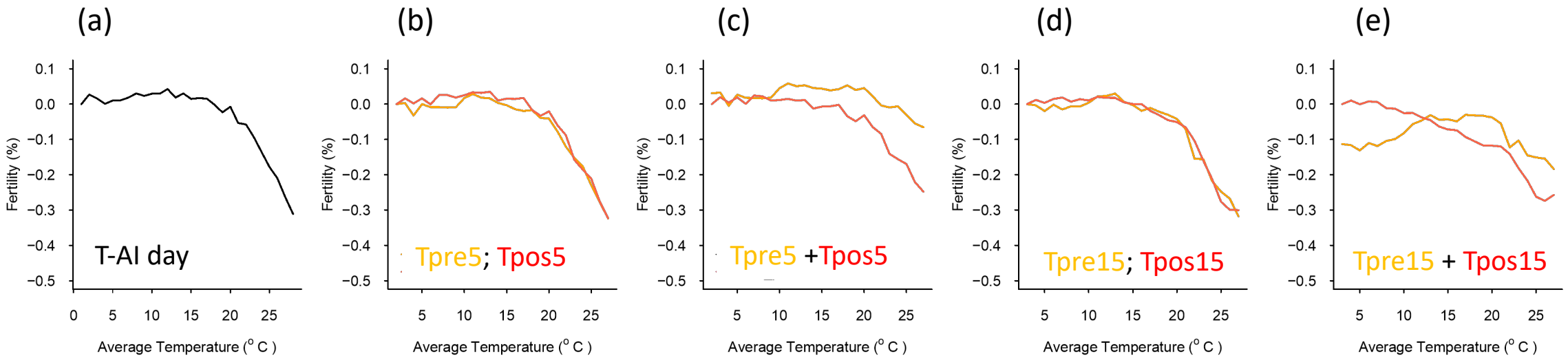
Model:

$$y = VWP\_c(f)+Stype\_c(f)+Age\_c(f)+Tavg\_c(f)+ HY(r)+ animal(r)+e$$

y: ***CR first lactation****, first AI; VWP_c: class of voluntary weaning period (21 d period classes, up to 105 days and later); Stype_c: Sexed vs. No Sexed; Age_c: class of age of cow at calving (classes from genetic evaluations for milk traits),* ***Tavg_c: class of average temperature (1 ºC class) on day of insemination (0), 5, 10, 15 or 30 days before and after AI,*** *HY: random herd-year of insemination; animal: random additive genetic effect of cow*

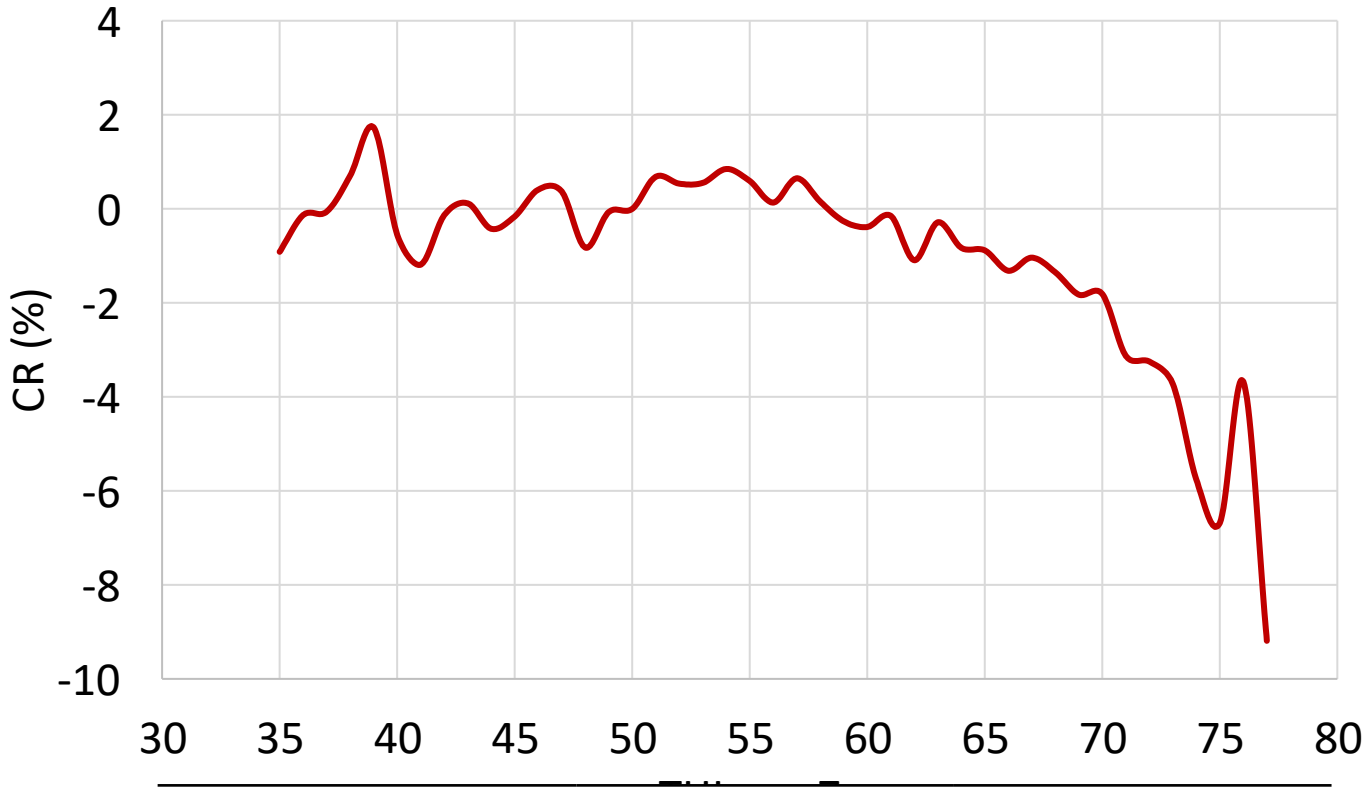
Results – Population Response

Population responses curves *for (a) average temperature the day of insemination; (b) average temperature for periods ±5 days of insemination modeled separately; (c) as b, but modeled jointly; (d) average temperature for periods ±15 days of insemination modeled separately; (e) as d, but modeled jointly*



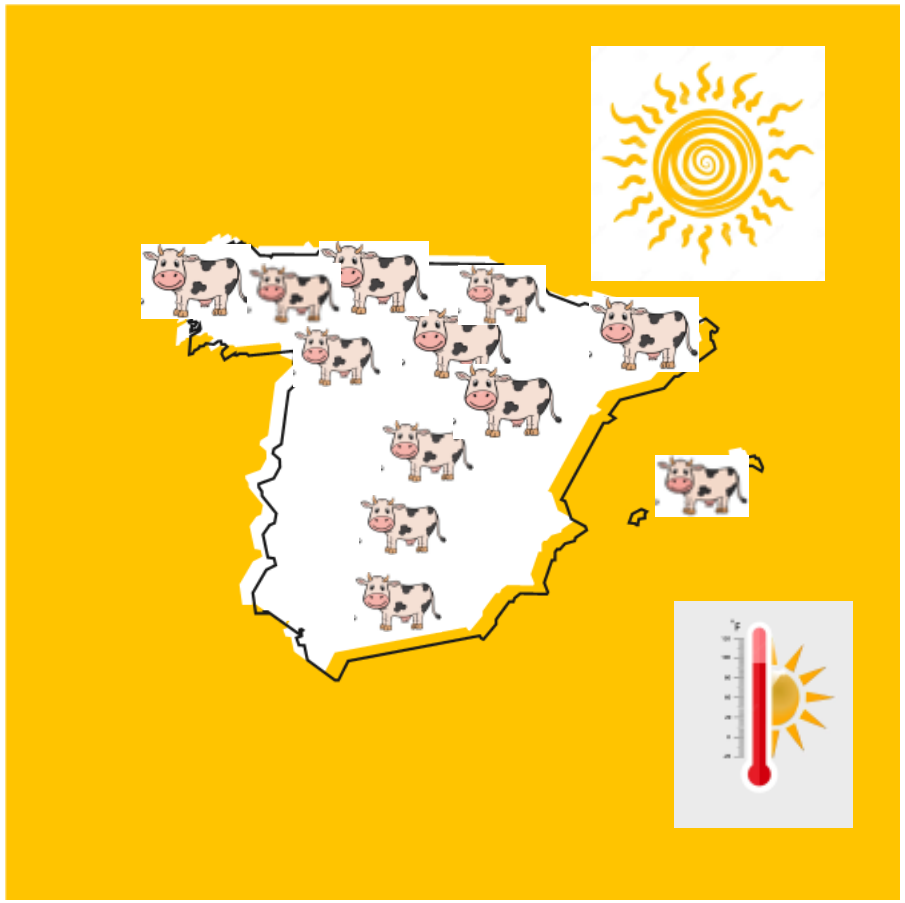
Rumigen consensus: heat load indicator = THI_0+7days after AI

Results – Population Response



Mattalia et al., EAAP 2023

Breed-Country	Threshold (THI units)	Slope (%CR/unit THI)
HOL-SPA	64	-0,51



Random regression

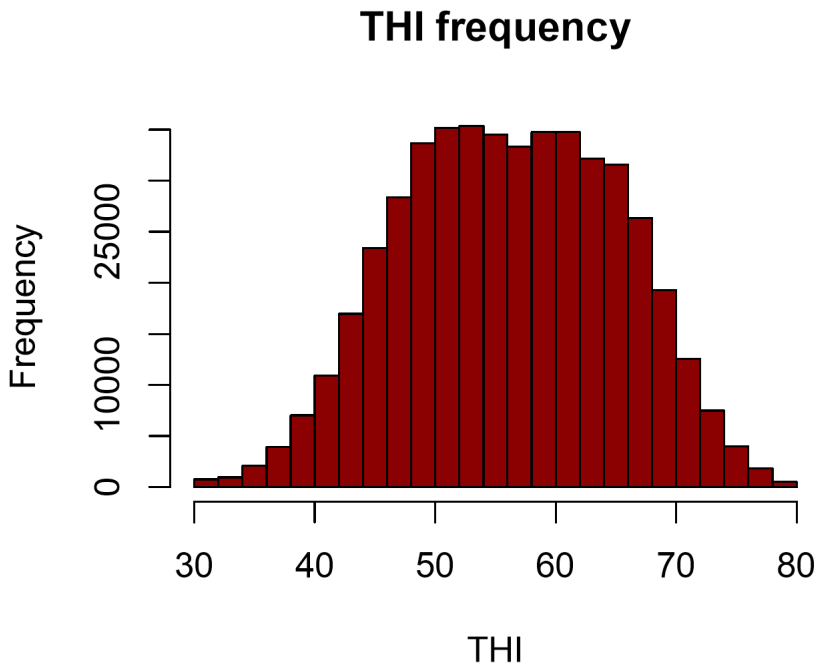
Individual response - CR

Data & Models – Individual Response

1. DATA Fertility: First lactation-first AI filtered.

Cows	471,793
Herds	3,959
CR mean	45.4%

2. DATA THI



Min	1%	10%	25%	50%	75%	90%	99%	Max
31	37	44	49	56	63	68	75	78

Data & Models – Individual Response

$$y = VWPc(f)+Agec(f)+THI0\text{-}7c(f)+ HY(r)+ animal(r)+ b(r) *(THI07avg\text{-}To)+ e$$

- *y: (CR=0/1) first lactation, first AI*
- *VWPc, Agec, HY: as in Population response*
- *THI0-7c: class of average THI on day of AI and subsequent 7 days*
- *Animal: random additive genetic effect of cow (b_{level})* → ***EBV_{level}***
- *b: random additive genetic value for individual slope of response (b_{slope})* →***EBV_{slope}***
- *THIo=heat stress threshold = 66, If((THI07avg-THI)<0, 0)*

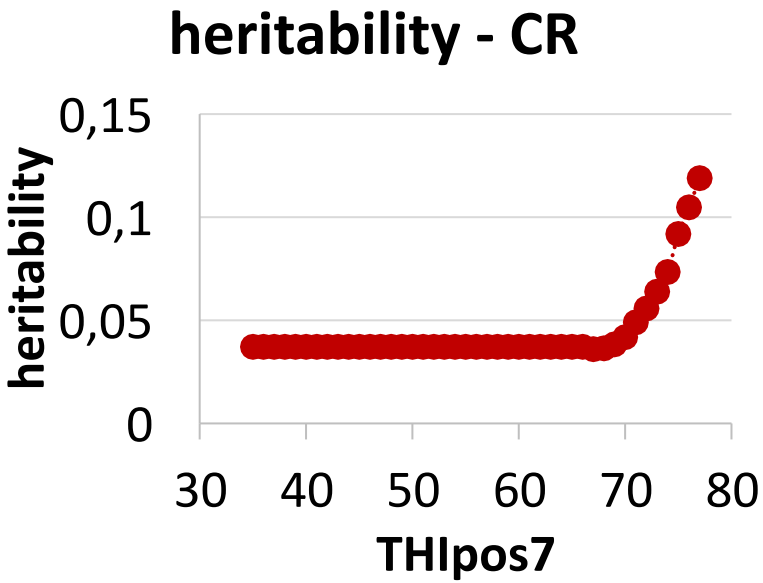
$$(co)Var(b_{level}, b_{slope}) = \begin{bmatrix} \sigma^2_{level} & \sigma_{level,slope} \\ \sigma_{level,slope} & \sigma^2_{slope} \end{bmatrix}$$

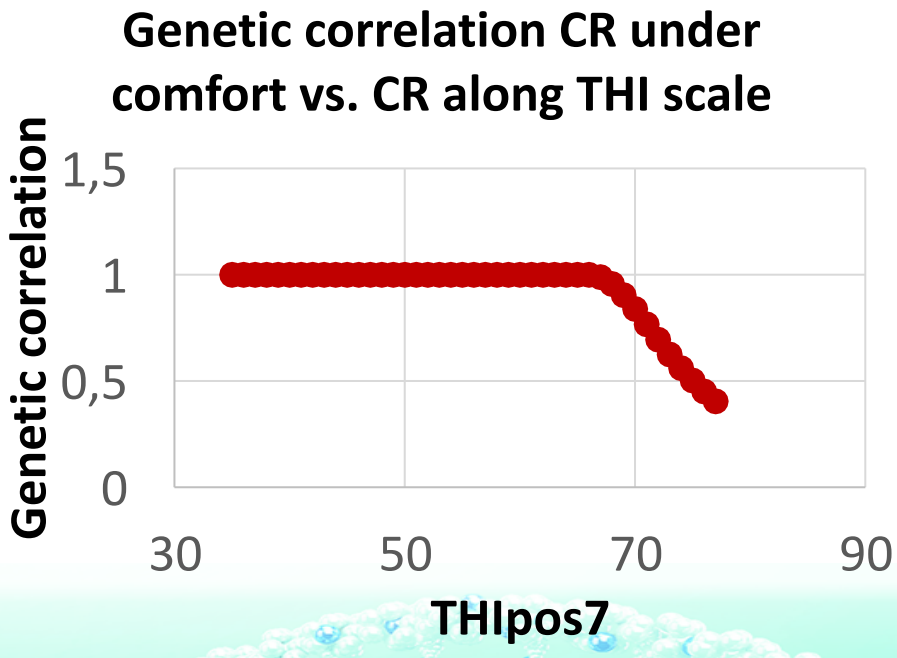
Solved as linear animal model using ***Gibbsf90+***

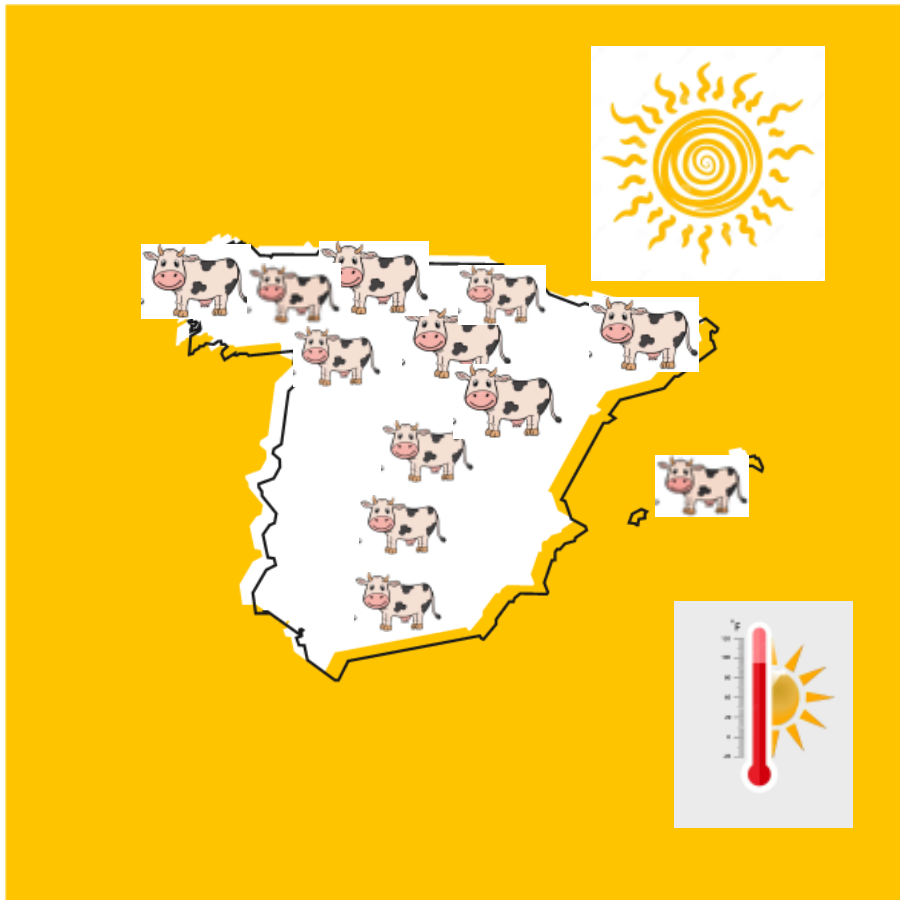
Results– Individual Response

EBV Bulls (> 20 daughters)	
EBV_{level}	EBV_{slp} (CR/ºTHI)
Min. :-0.22	Min. :-0.03
1st Qu.:-0.04	1st Qu.:-0.01
Median : 0.002	Median :-0.007
Mean : 0.007	Mean :-0.008
3rd Qu.: 0.06	3rd Qu.:-0.004
Max. : 0.26	Max. : 0.02

$$\text{Var-Cor}(b_{level}, b_{slope}) = \begin{bmatrix} 0.9x10 - 2 & -0.18 \\ -0.18 & 0.02x10 - 2 \end{bmatrix}$$







Trade-offs

HT-Production vs. HT-CR

Data & Models – Trade-offs

	Spanish Holstein
# cows with records	302,152
# CR records	278,588
# PY records	703,574
# sires	9,002 (1,824 >20 dau)
Average # daughters per sire	109
Average CR % (s.d.)	45.44 (49.8)
Average PY g/d (s.d.)	1090 (211)
Average THIf (s.d.)	56.21 (8.6)
Average THIp (s.d.)	58.84 (9.6)

Model: 2 trait (CR, one production trait) MT **sire model**

Production (P):

Fixed: Agec, DIMc, Leg_cubic(THIavg-2d,0)

Random: HY, **Leg_quad**(THIavg-2,0)-AG(**sire**), **Leg_quad**(THIavg-2,0)-PE(**cow**), error

CR (F):

Fixed: Agec, VWPc, THIpost7 (**BL**, THIo=66),

Random: HY, AG(**sire**), b(THIpost7**BL**)(**sire**)

Results– Trade-offs

Correlations Intercept (int)-Slopes (Slp) for production (P) and fertiity (F) traits

Milk yield	intP	SlpP_50	SlpP_60	SlpP_65	SlpP_70	SlpP_75	intF	SlpF
intP	1.00	0.10	-0.30	-0.40	-0.43	-0.44	-0.33	-0.21
SlpP_50		1.00	0.56	0.18	-0.06	-0.20	-0.29	0.38
SlpP_60			1.00	0.92	0.80	0.70	0.19	0.62
SlpP_65				1.00	0.97	0.93	0.37	0.56
SlpP_70					1.00	0.99	0.44	0.47
SlpP_75						1.00	0.48	0.41
intF							1.00	-0.12
SlpF								1.00

TN

HS

- Antagonism P level, P Tolerance increases with THI values (up to -0.44)
- Antagonism levels P-F (-0.33), P level and F Tolerance (-0.21)
- **Tolerance P and Tolerance F positively correlated!!!**
- Weak antagonism F level, F tolerance (-0.12)

Conclusions

- Fertility is affected under heat stress in this population (as expected)
- Individual variability for the genetic component of reaction to heat stress in fertility performance exists (although heritability of tolerance measured by slope of reaction is expected to be low)
- A GxE interaction between the genetic component for fertility under comfort compared with the genetic component under heat stress has been observed (more severe than for the same correlation for production traits).
- Indicators of tolerance based on fertility and production seem to work in the same direction.

'Should we consider fertility when improving thermotolerance in dairy cattle?

Yes, but small precision and correlation with thermotolerance measured by productive traits should be accounted for

Aknowledgements

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