Heat stress and Dutch dairy cattle

Jeremie Vandenplas, Mario Calus, Mathijs van Pelt, Han Mulder

March 1, 2023

WAGENINGEN
UNIVERSITY & RESEARCH

Table of contents

- Introduction
- Data
- Models
- TD and weather data
- Effect of THI on milk production traits and SCS
- Genetic-by-THI on milk production traits and SCS
- Conclusions and next steps

RUMIGEN

EU project (`www.rumigen.eu`)

Title

- "Towards improvement of ruminant breeding through genomic and epigenomic approaches"

Main aim

- To produce robust and efficient cattle able to manage the trade-offs between production and adaptation to extreme climate conditions

Partners from Belgium, Denmark, France, Italy, the Netherlands, Norway, Spain , Sweden, and United Kingdom

Introduction

Part of WP3

Collaboration between

- France (Idele, INRAE)
  - Holstein, Montbeliarde
- Spain (INIA—CSIC, IRIAF)
  - Holstein
- the Netherlands (Wageningen University and Research)
  - Holstein, MRY

General aim

- Evaluation of impact of heat-stress on performances of dairy cattle
- Definition of new traits related to heat tolerance

Aim

To investigate

1. the impact of heat-stress
2. genetic-by-THI interactions

on milk production traits and SCS of Dutch Holstein and MRY cows

Weather data

Extracted from the KNMI website

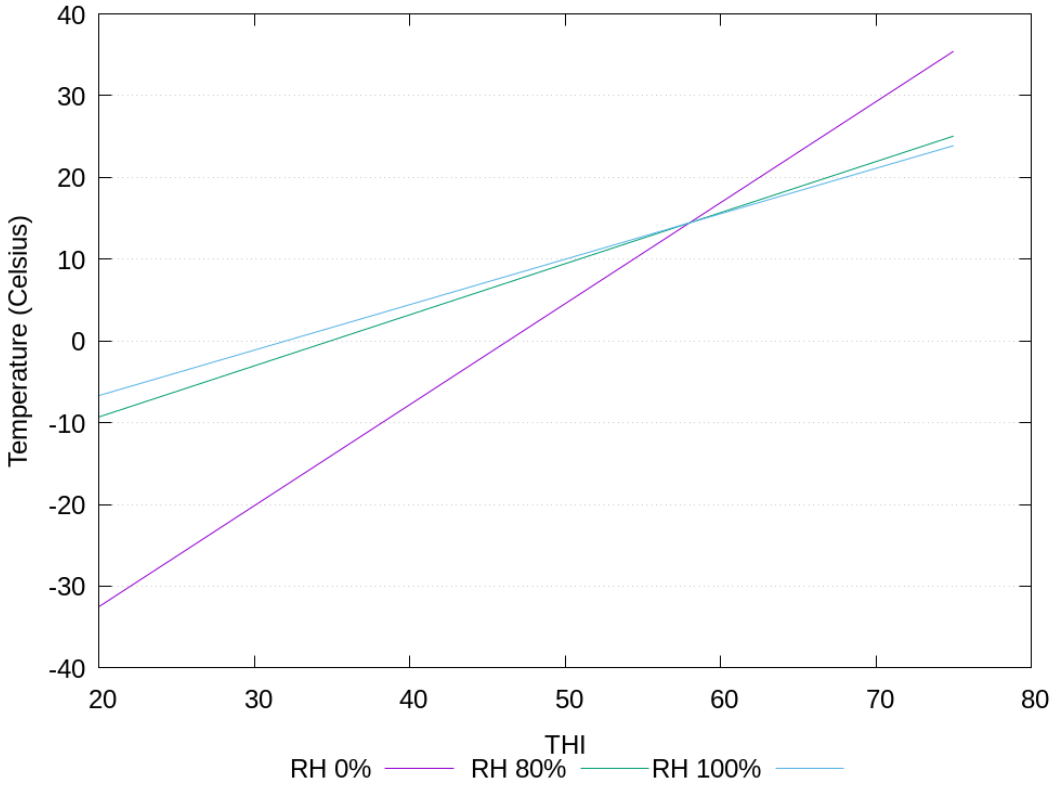
- 34 Dutch weather stations

Many measurements (min., max., average temperature and relative humidity)
$\Rightarrow$ Summarized in daily THI:

$$THI = (1.8 * T + 32) - (0.55 - 0.0055RH) * (1.8 * T - 26)$$

T: daily average temperature (degrees Celsius)
RH: daily average relative humidity

THI: insight



Temp.	Min. THI	Max. THI
-10	14	38
0	32	46
5	41	50
10	50	54
30	70	86

Test-day records

Milk production traits and SCS

First & second parities

Each herd associated with the closest weather station (partial ZIP code)

- Average distance: 14.6 km

Based on preliminary investigations, each TD record associated with the average of the THI at one to three days before (3-day average THI)

Effect of THI on performances

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Za} + \mathbf{Wp} + \mathbf{e}$$

Fixed effects $\mathbf{b}$:

- Herd - year of test (contemporary group)
- DIM
- Age at calving (months) - year of calving - season of calving
- Age at calving (months) - year of calving - season of calving - lactation stage
- Stadium of gestation
- THI (class)

Random effects:

- Animal ($\mathbf{a}$)
- Permanent environment ($\mathbf{p}$)
- residual ($\mathbf{e}$)

Genetic-by-THI interactions

$$\mathbf{y} = \mathbf{Xb} + \mathbf{ZQu} + \mathbf{WQp}_r + \mathbf{e}$$

Fixed effects $\mathbf{b}$:

- Herd - test-day (contemporary group)
- DIM
- Age at calving (months) - year of calving - season of calving
- Age at calving (months) - year of calving - season of calving - lactation stage
- Stadium of gestation

Random effects:

- Animal additive genetic regression coefficients ($\mathbf{u}$)
- Permanent environment regression coefficients ($\mathbf{p}_r$)
- residual ($\mathbf{e}$)
    - Heterogeneous residual variances (33 classes)

Genetic-by-THI interactions

$$\mathbf{y} = \mathbf{Xb} + \mathbf{ZQu} + \mathbf{WQp}_r + \mathbf{e}$$

Standardized Legendre coefficients $\mathbf{Q}$:

- Intercept
- DIM: first and second order (range(DIM): 5 - 305)
- THI: first and second order (range(THI): 10 - 83)

TD records - after editing

MRY: 2010-2022
Holstein:

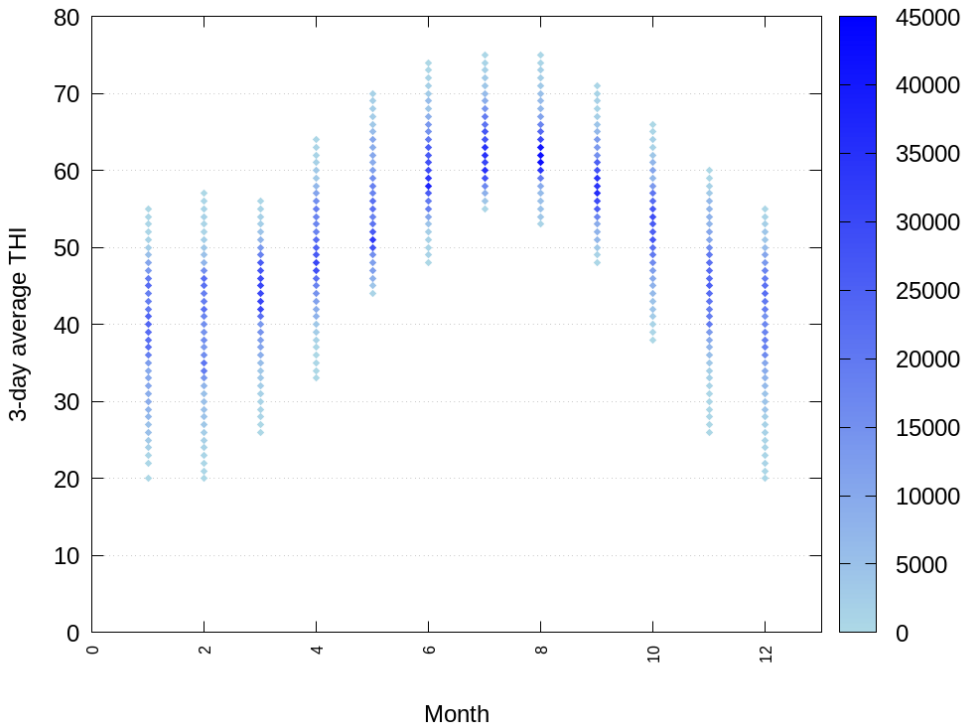
- Population level: 2010-2022
- GxTHI: 2016-2022

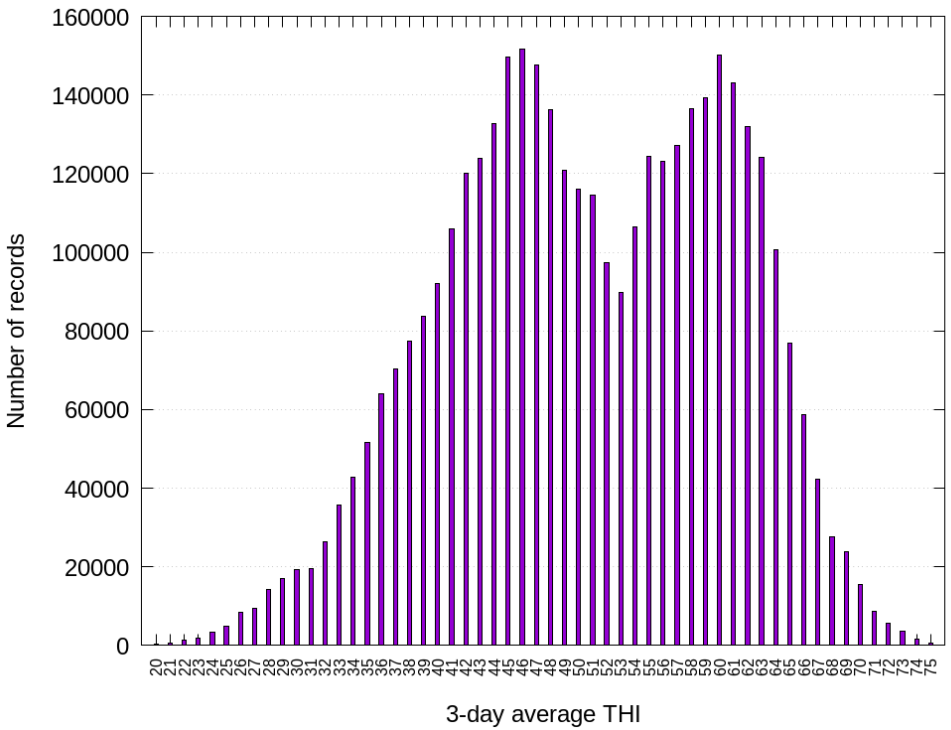
Table: Descriptive statistics for milk yield and first parity cows

	MRY	Holstein (2010-)	Holstein (2016-)
Pedigree (3 gen.)	21,490	835,874	562,815
Phenotyped animals	12,257	493,997	259,128
Herds	87	1582	1579
TD records	93,099	3,923,062	1,948,762

Number of TD records per THI/month - Holstein

Period: 2010 - 2022





WAGENINGEN
UNIVERSITY & RESEARCH

Some numbers

Milk yield
Period: 2010 - 2022

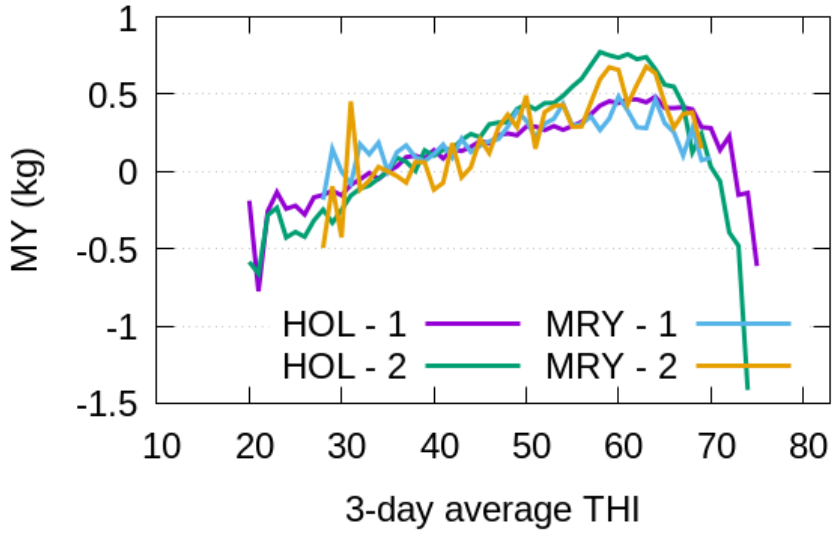
	MRY	Holstein
Min. THI	28	20
Max. THI	70	75
# TD records $\geq$ 70	533	35,775

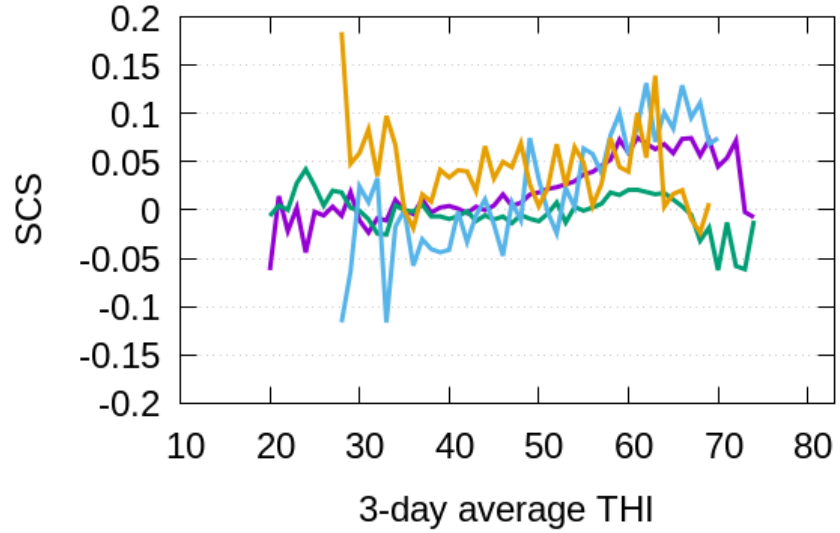
Effect of THI on milk production traits and SCS

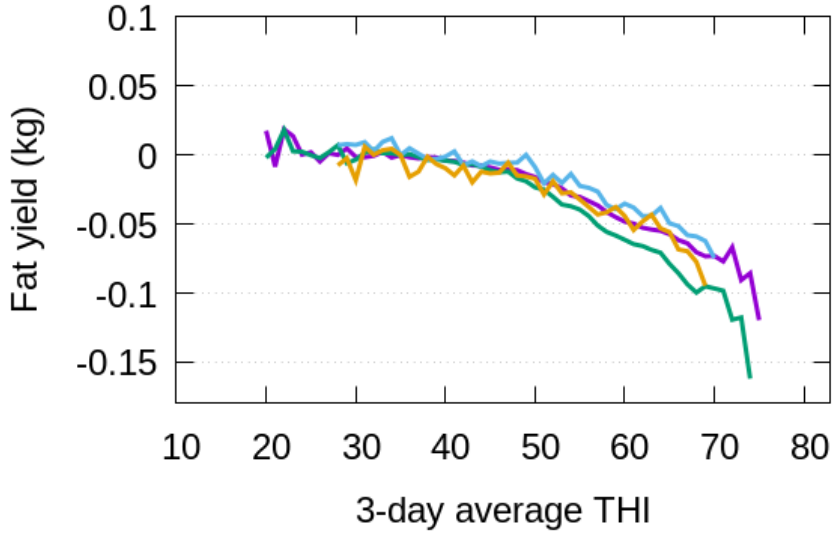
Traits

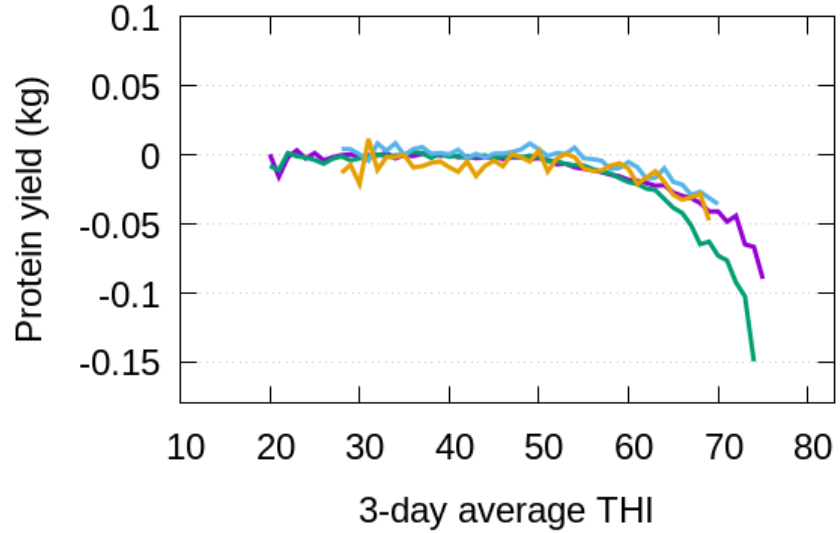
- MY, PY, FY
- SCS
- Protein content, Fat content
- Urea
- Lactose content

Effect of THI on MY, FY, PY, and SCS









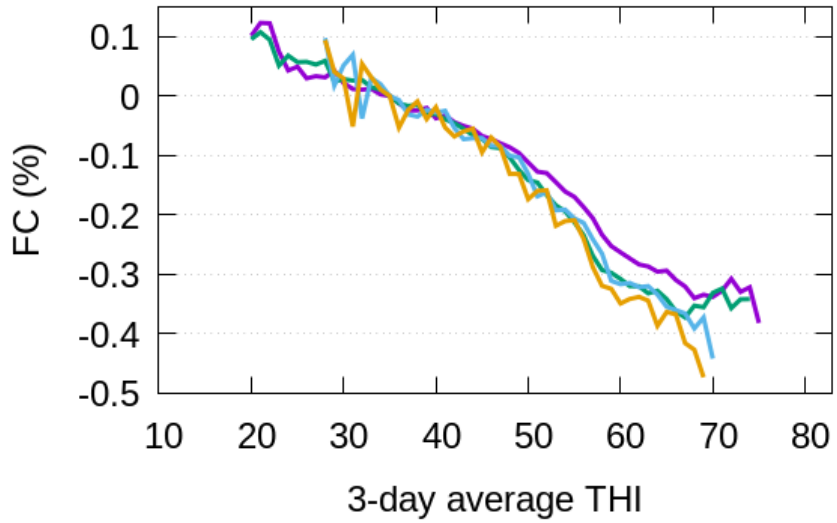
WAGENINGEN
UNIVERSITY & RESEARCH

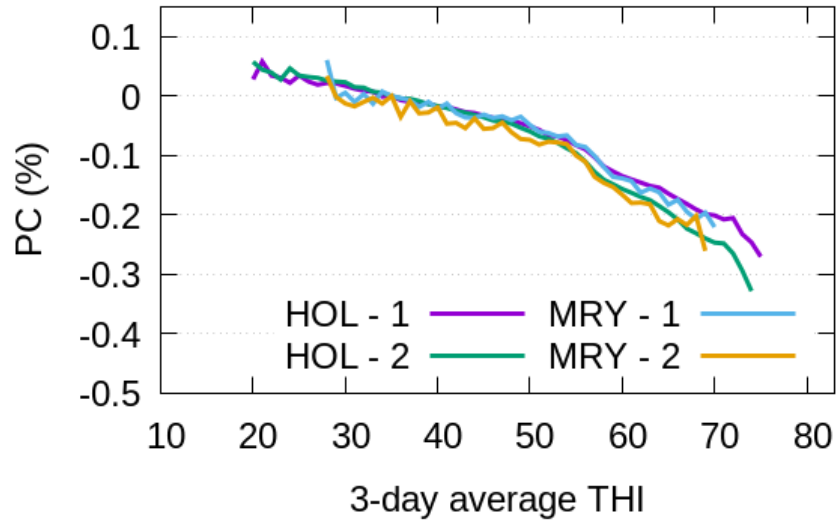
Effect of THI on MY, FY, PY, and SCS

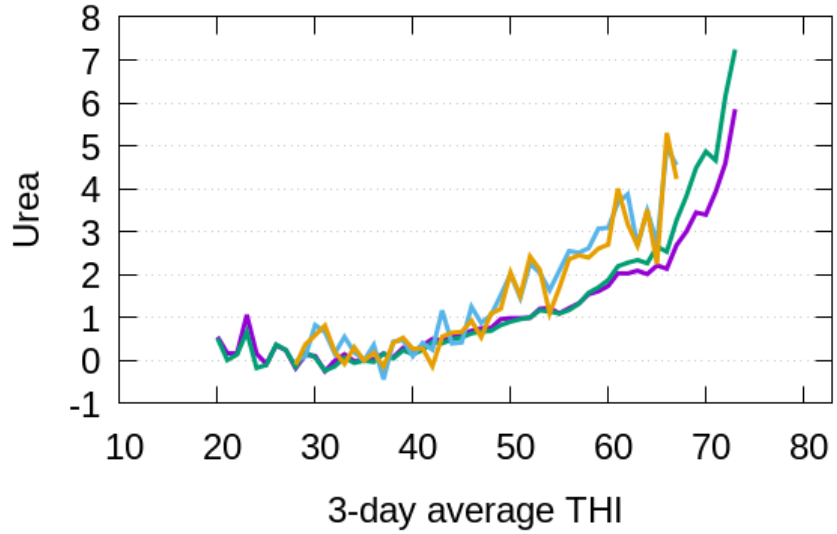
Optimal THI

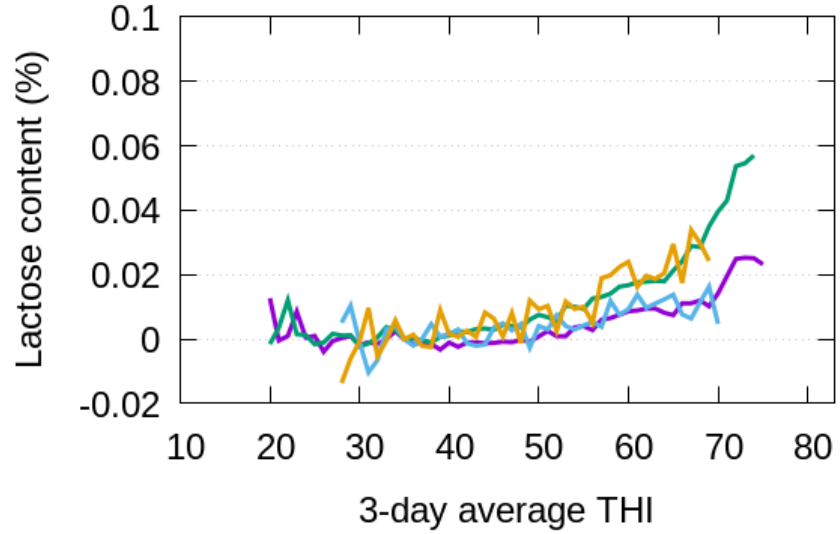
- Similar for Holstein and MRY
- Different across traits
- MY: around 60-65
- FY and PY: around 50-55
- SCS: unclear

Effect of THI on FC, PC, urea and lactose









WAGENINGEN
UNIVERSITY & RESEARCH

Effect of THI on FC, PC, urea and lactose

Optimal THI

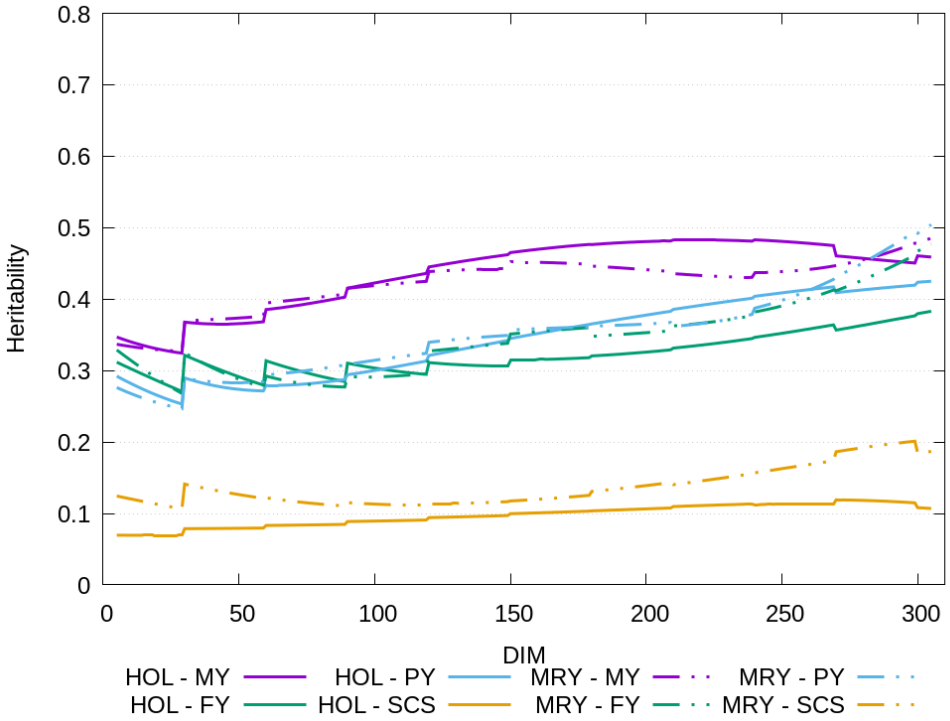
- Similar for Holstein and MRY
- Different across traits
- FC and PC: around 30
  - Impact of yields?
- Urea: around 40
- Lactose: around 55

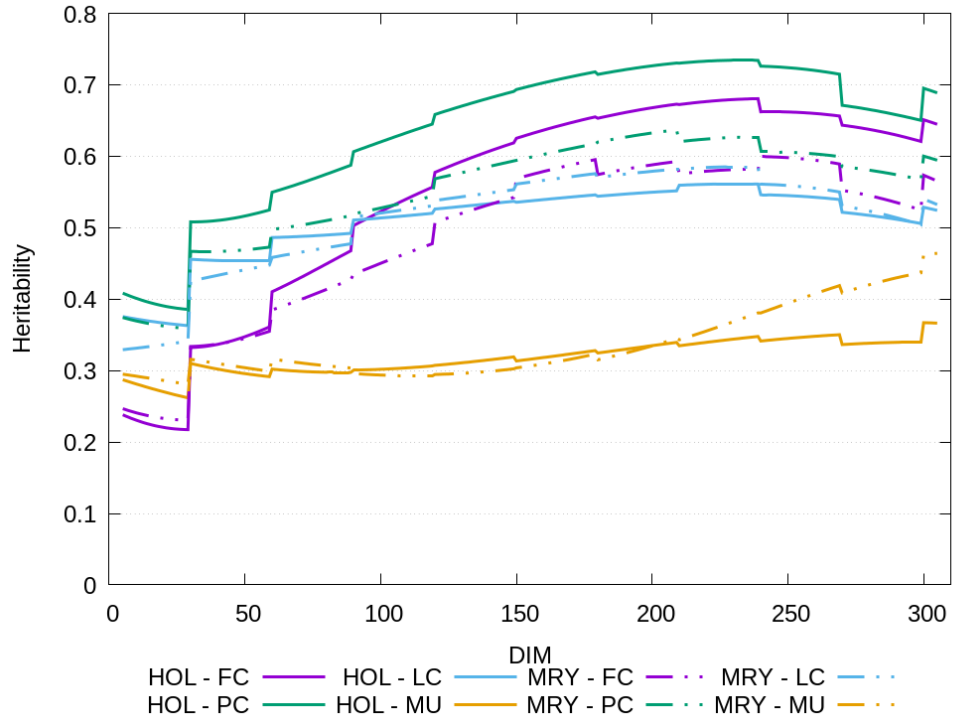
Genetic-by-THI on milk production traits and SCS

Traits

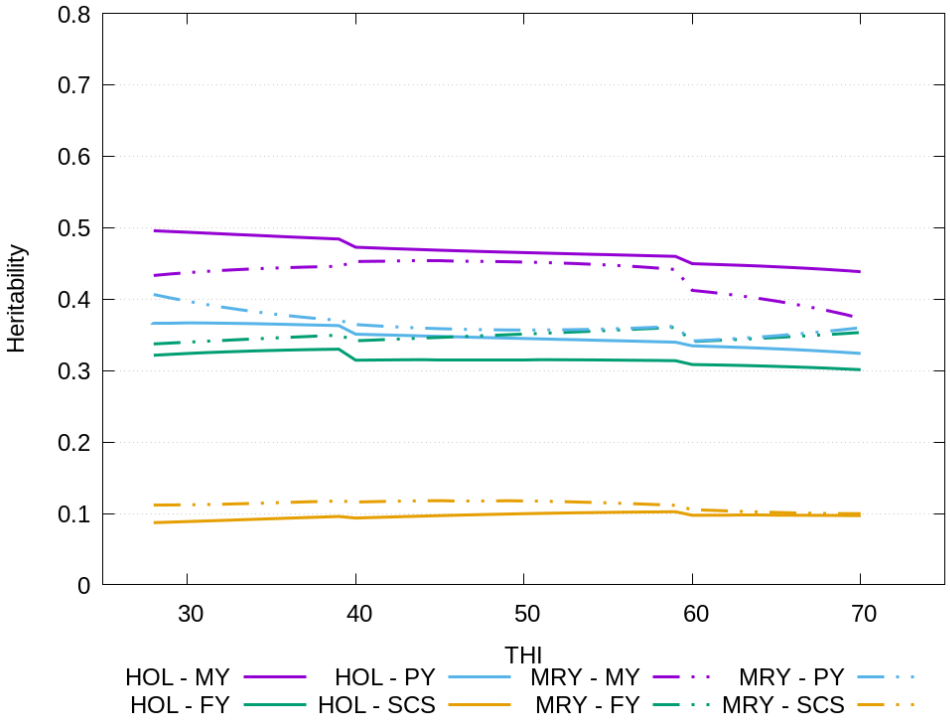
- MY, PY, FY
- SCS
- Protein content, Fat content
- Urea
- Lactose content

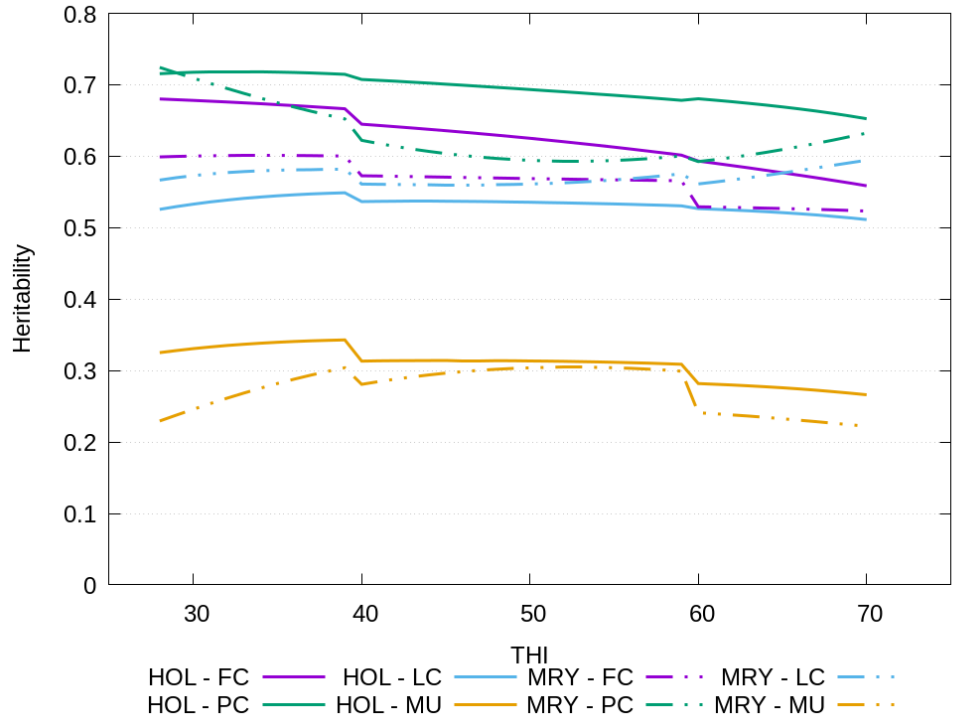
Heritability at THI = 50 (first parity)



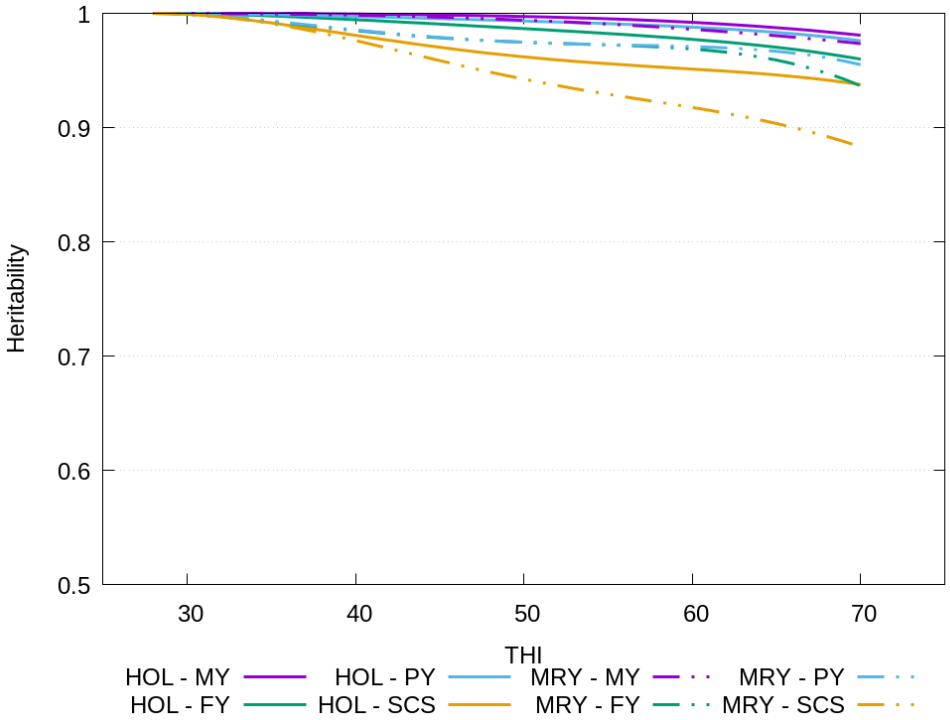


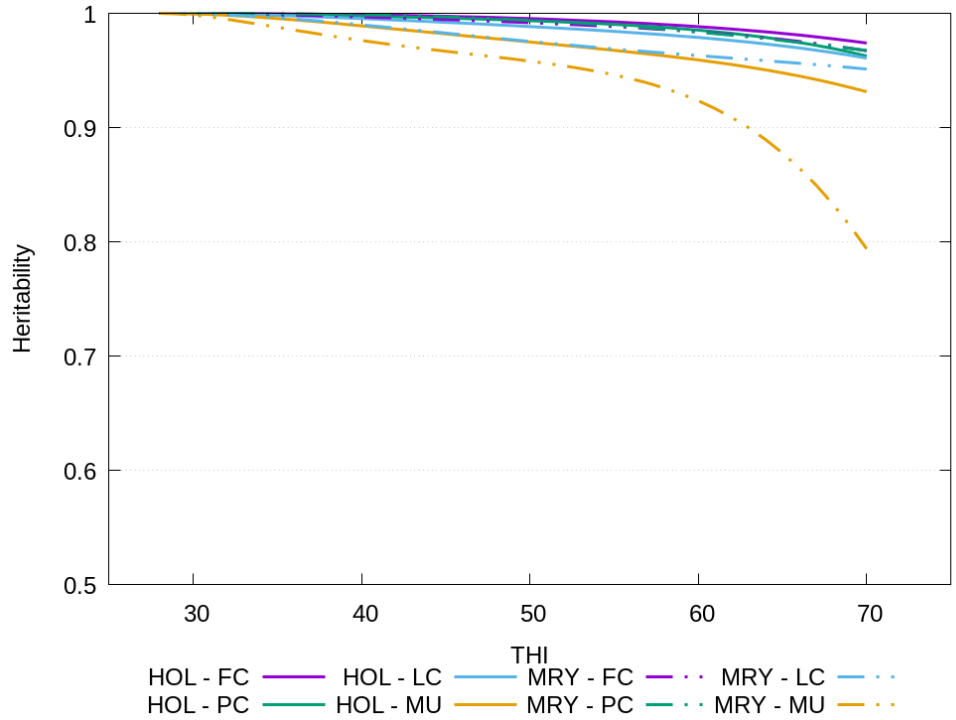
Heritability at DIM = 150 (first parity)





Genetic correlations between different THI (DIM = 150)





Similar results for other other DIM, parity, trait

Most genetic correlations > 0.90

$\Rightarrow$ (No)Weak genetic-by-THI interactions

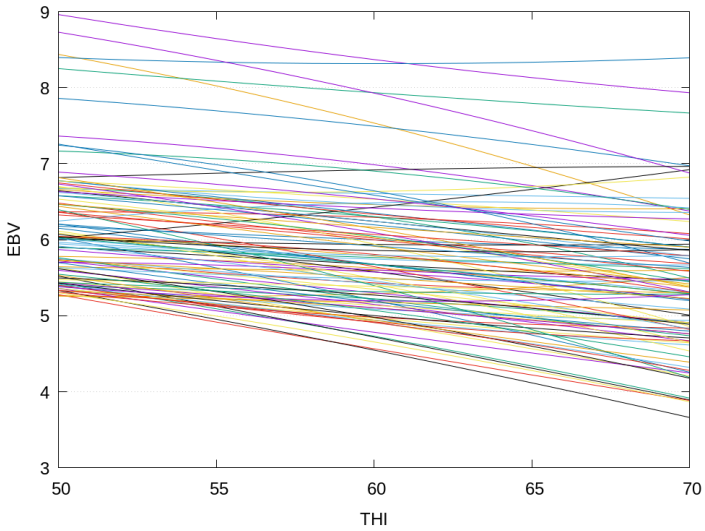
WAGENINGEN
UNIVERSITY & RESEARCH

EBV changes between THI = 50 and THI = 70

Top 100 HOL sires with $\geq$ 20 daughters with records

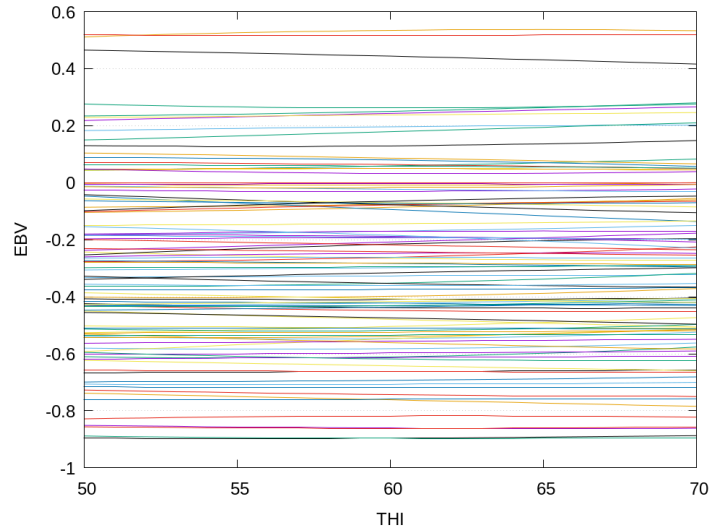
- Based on EBV for MY at THI = 50 and DIM = 150

MY



Corr(THI=50, THI=70) = 0.79

SCS



Corr(THI=50, THI=70) > 0.99

Level and slope

Level = Breeding value at THI = 50 and at DIM = 150
Slope = First derivative at THI = 70

Genetic correlations between level and slope

- Mainly negative moderate
  $\Rightarrow$ Detrimental of production traits

Breed	Parity	MY	FY	PY	SCS
Holstein	1	-0.40	-0.10	-0.16	-0.05
	2	-0.35	-0.03	-0.08	-0.14
MRY	1	-0.44	-0.19	-0.28	0.33
	2	-0.24	-0.02	-0.06	-0.25

Conclusions

Similar impact of heat-stress for Holstein and MRY
Optimal THI different across traits

- MY: around 60-65
- FY, PY: around 50-55
- SCS: unclear

No/weak G-by-THI interactions

- Small re-ranking of Top 100 sires for MY

Next steps

Production traits

- EAAP
- Paper (to be written)

Fertility traits

- CR for first-parity MRY cows (Han)
- CR for first-parity Holstein cows (Mario)
- Other traits (MSc student - Mario)

GWAS & meta-analysis across countries

- Milk production traits
- CR1