Comparing an optimized milk MIR spectra-based indicator to the use of milk yield, fat and protein content and somatic cells as indicators for heat tolerance in dairy cows

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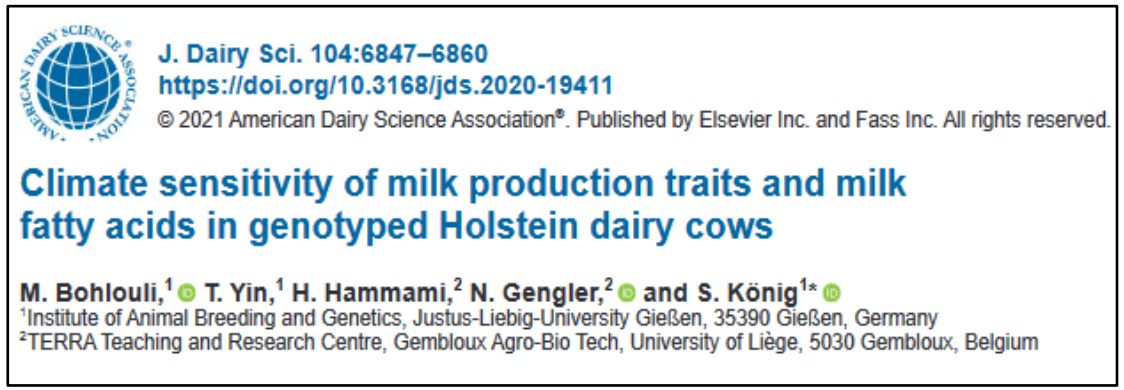
Introduction

Milk composition influenced by heat stress



J. Dairy Sci. 104:6847–6860
https://doi.org/10.3168/jds.2020-19411

Climate sensitivity of milk production traits and milk fatty acids in genotyped Holstein dairy cows

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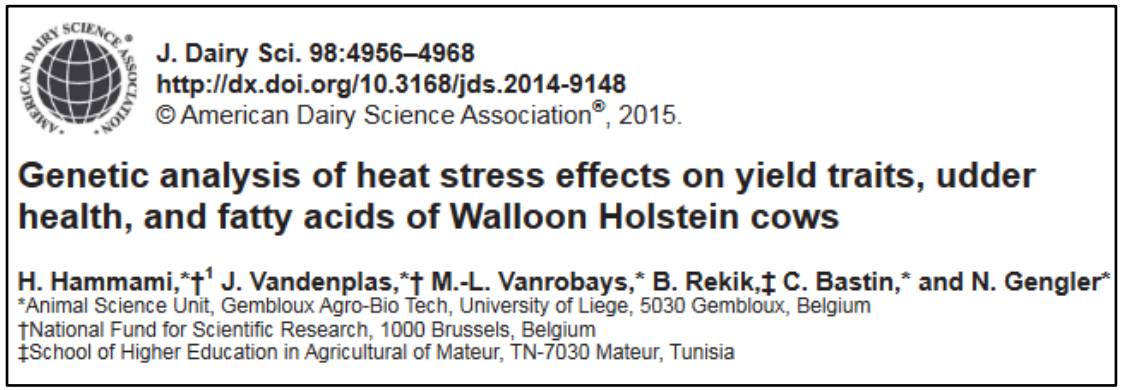

J. Dairy Sci. 98:4956–4968
http://dx.doi.org/10.3168/jds.2014-9148

Genetic analysis of heat stress effects on yield traits, udder health, and fatty acids of Walloon Holstein cows

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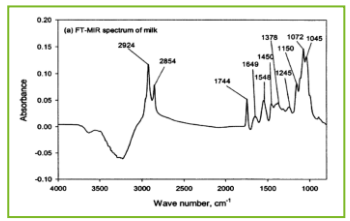
‡School of Higher Education in Agricultural of Mateur, TN-7030 Mateur, Tunisia

→ Detected by MIR
→ MIR spectra as an indicator of heat stress
→ Dale et al. : THI prediction based on milk composition

Introduction

Milk samples

MIR spectrometry analysis



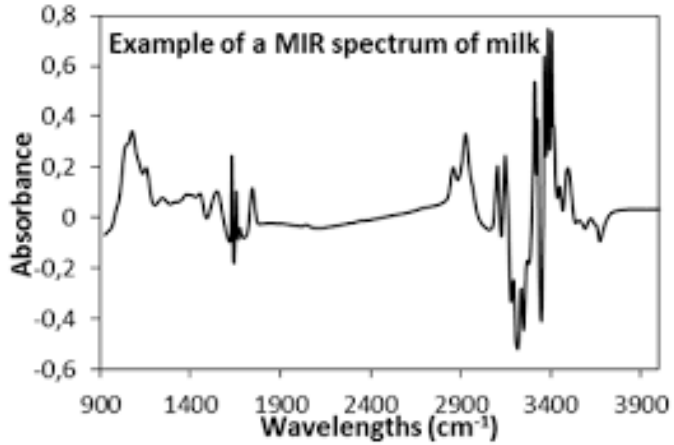
Raw data = MIR spectra

Prediction

equations

Quantification:

Fat, protein, urea, lactose…



→ Not optimized for Heat stress

→ Dale et al., : optimal combination of wavenumbers

Introduction

Work of Dale et al. :

Heat stress assessments in dairy cattle based on milk MIR spectral data

H. Amamou[1,2], M. Mahouachi[1], A. Werner[2], N. Gengler[3], J. Bieger[2], K. Drössler[2], H. Hammami[3], HappyMoo Consortium[4] and L.M. Dale[2]

[1]High School of Agriculture of Kef, University of Jendouba, 7119, Le Kef, Tunisia, [2]Regional Association for performance testing in livestock breeding of Baden-Wuerttemberg (LKVBW), Heinrich Baumann Str. 1-3, 70190 Stuttgart, Germany, [3]Gembloux Agro-Bio Tech, University of Liège, Passage des Déportés 2, 5030 Gembloux, Belgium, [4]http://www.happymoo.eu, 4 Rue des Champs Elysées, 5590 Ciney, Belgium; awerner@lkvbw.de

EAAP, 2021

→ Standardized spectra data from 120 farms (Baden-Wuerttemberg) from 2012 – 2019

→ Mean of the test-day THI and the 3 previous days

→ GLMNET model → $R^2 = 0,89$

Objectives of this work

→ Compare this MIR indicator with classical traits

→ Evaluate this MIR indicator, also in a genetic evaluation context

Data

- 99 450 Walloon cows
- 175 253 animals in pedigree

- From 2015 to 2022

→1 540 492 records

THI from 16.8 to 79.1

Variance estimation : AI-REML

Effect of THI

Adapted from: McWhorter et al., 2022

y = THI + HY + (DIM-s) + lact + age + a + pe + e

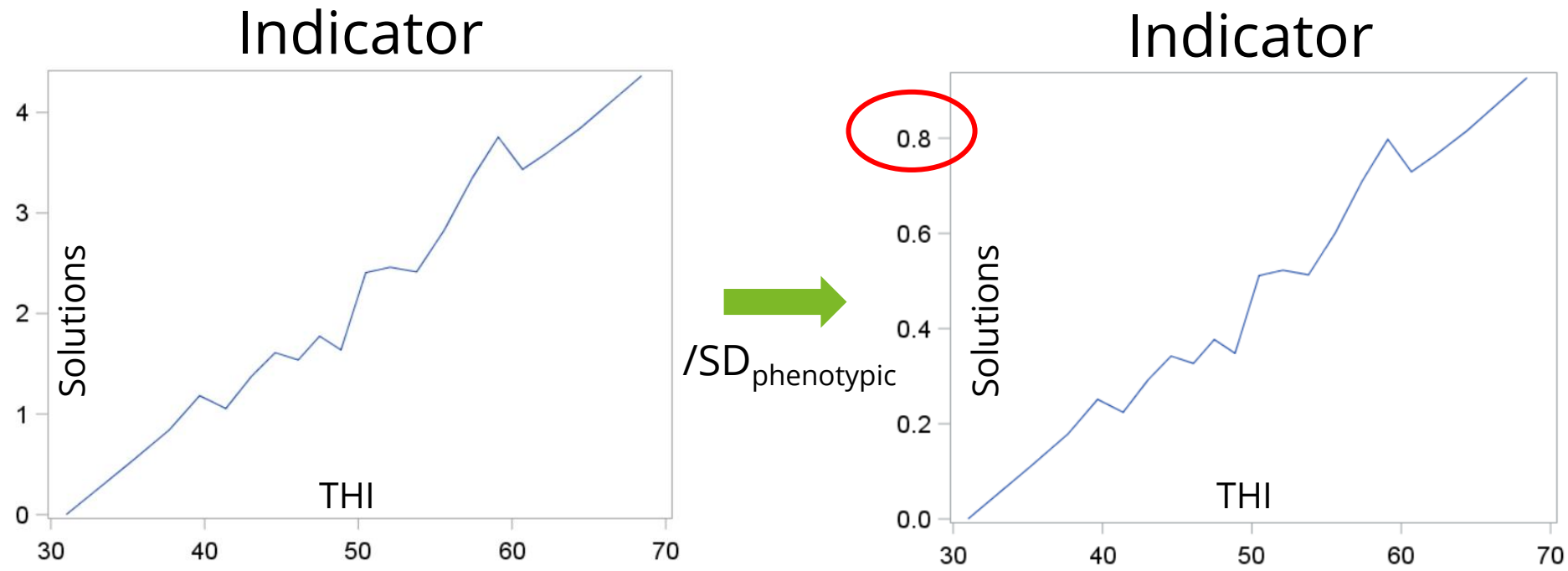
THI : Mean of test-day average THI and the 3 previous days
→ 20 equal classes
HY : Herd and year of the test-day
DIM-s : Day in milk - season of calving
lact : Lactation number
age : Age at calving

Fixed effects

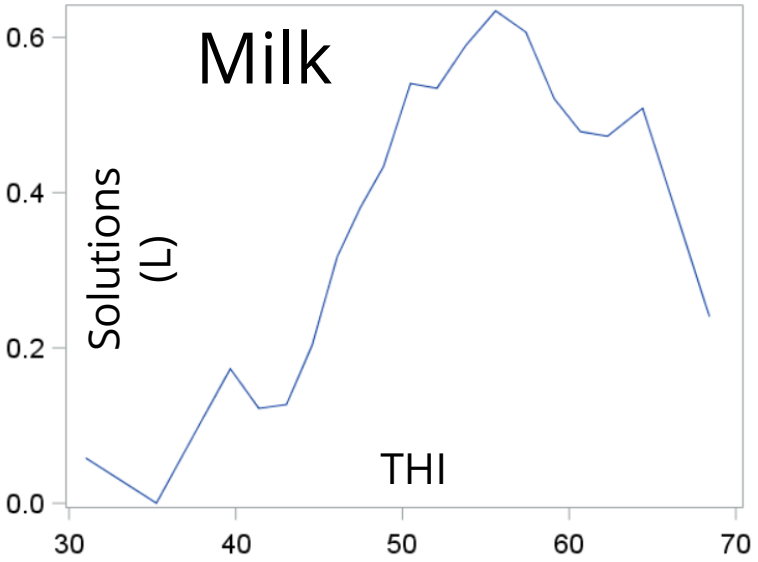
a : additive genetic
pe : permanent environment

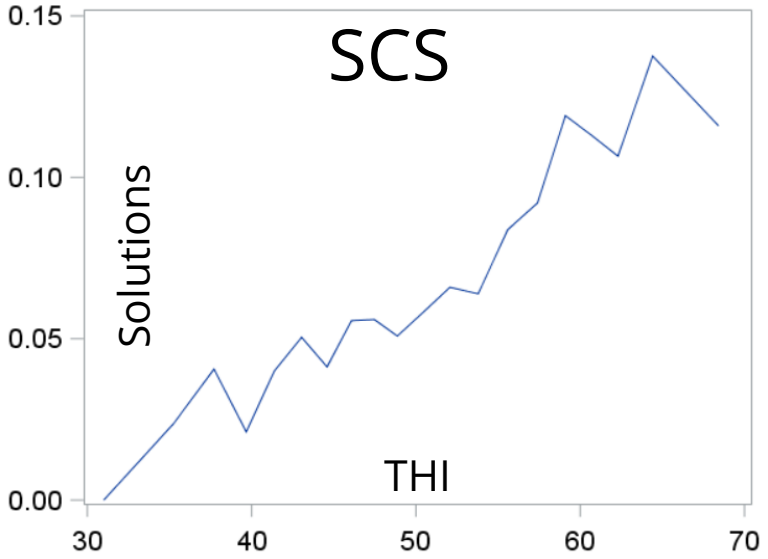
Random effects

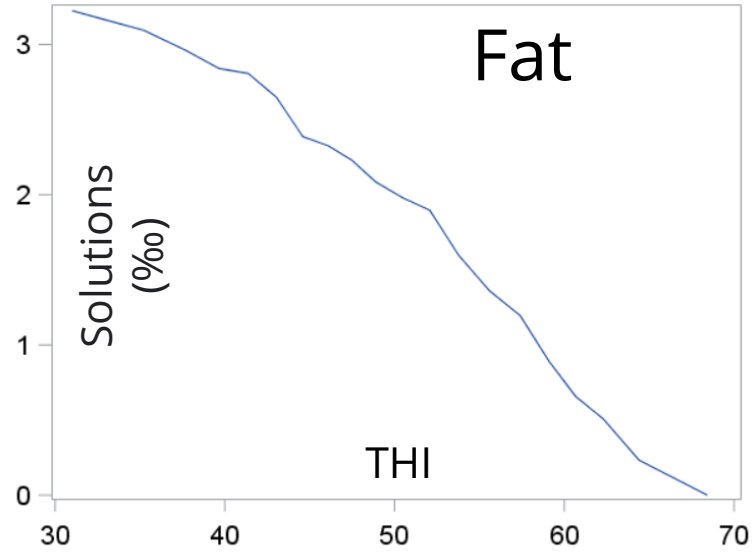
Effect of THI

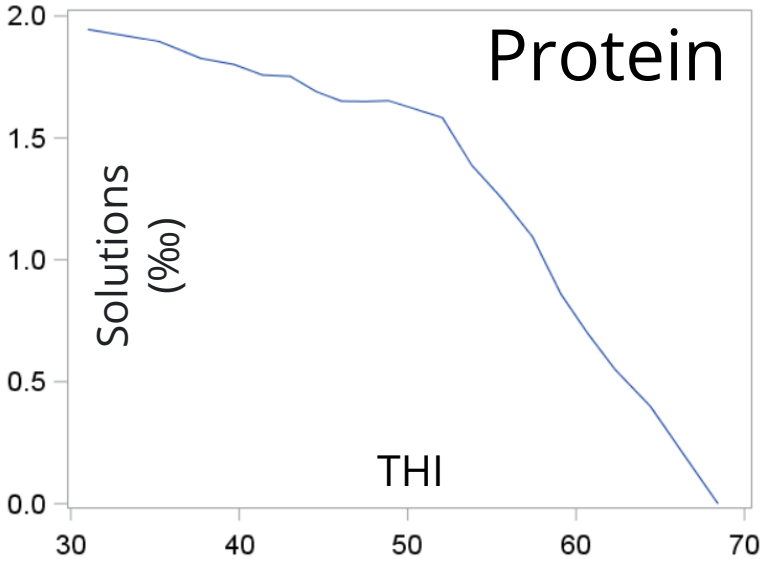


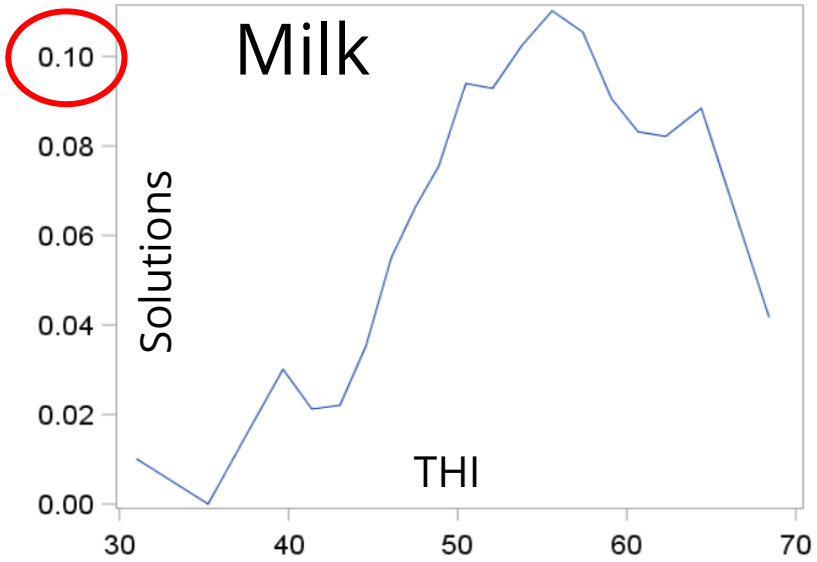
THI_{pred} ↗ → $THI_{station}$ ↗

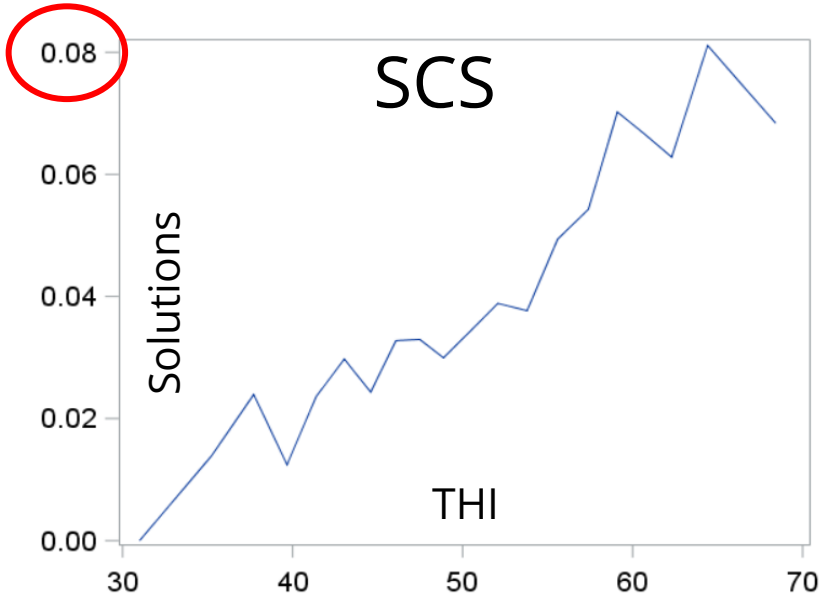

Milk
Solutions (L)
THI
0.0
0.2
0.4
0.6
30
40
50
60
70

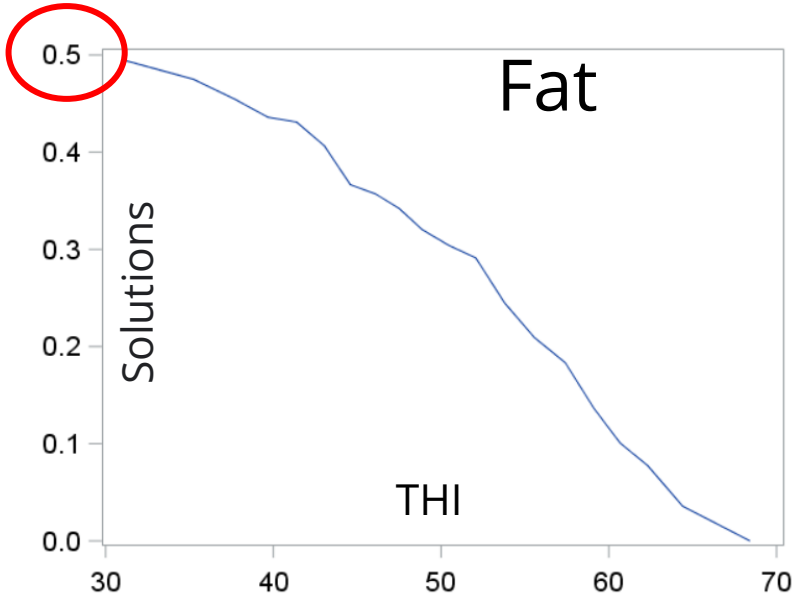

SCS
Solutions
THI
0.00
0.05
0.10
0.15
30
40
50
60
70

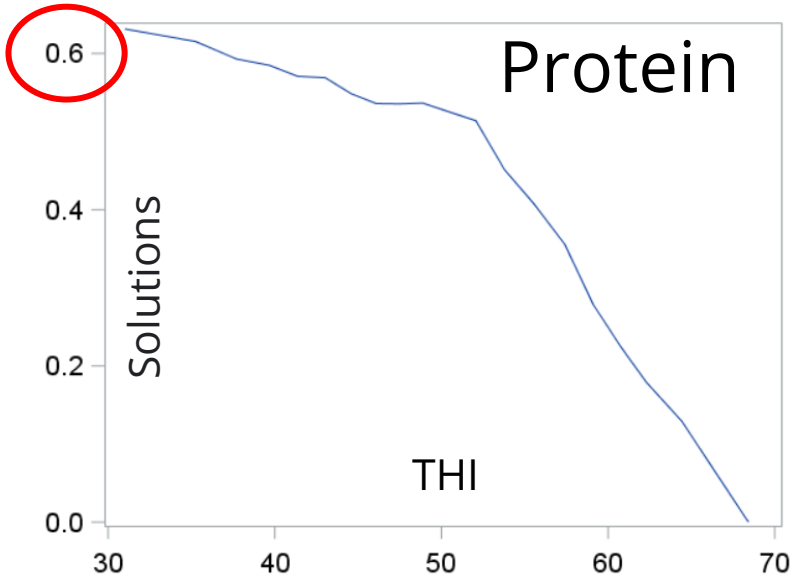

Fat
Solutions (‰)
THI
0
1
2
3
30
40
50
60
70


Protein
Solutions (‰)
THI
0.0
0.5
1.0
1.5
2.0
30
40
50
60
70

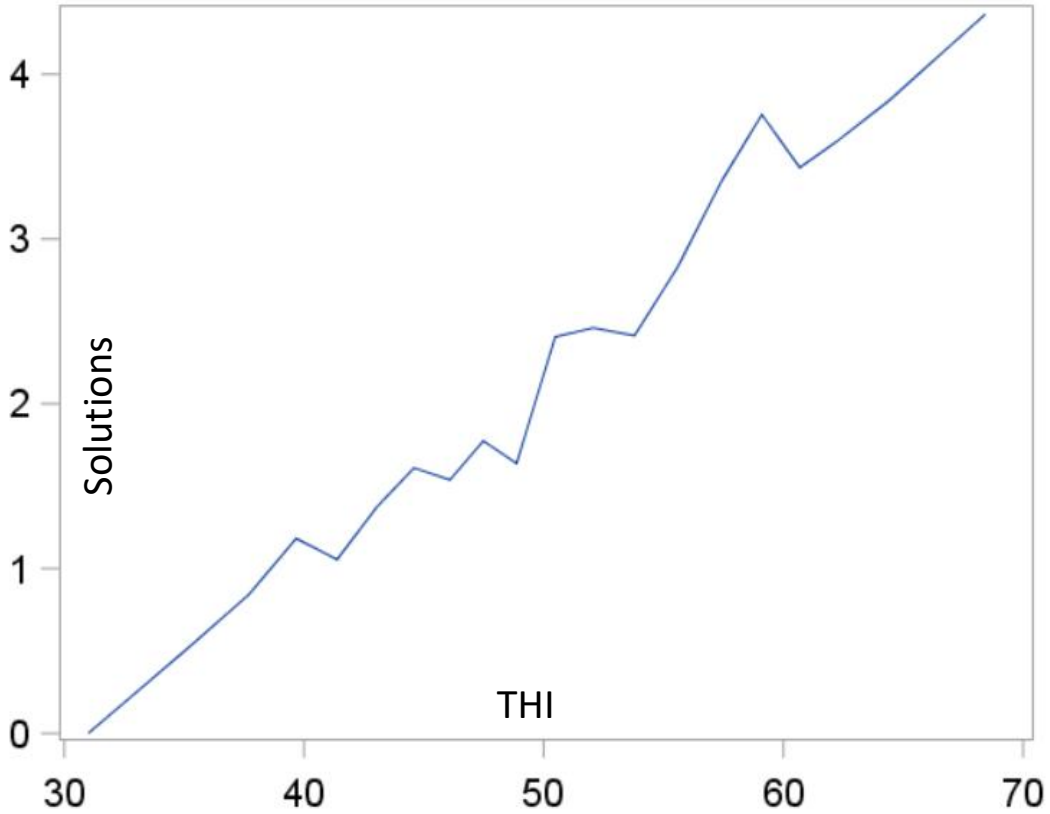

Milk
Solutions
THI
0.10
0.08
0.06
0.04
0.02
0.00
30
40
50
60
70


SCS
Solutions
THI
0.08
0.06
0.04
0.02
0.00
30
40
50
60
70


Fat
Solutions
THI
0.5
0.4
0.3
0.2
0.1
0.0
30
40
50
60
70


Protein
Solutions
THI
0.6
0.4
0.2
0.0
30
40
50
60
70

Effect of THI on indicator



How to differentiate between thermotolerant and thermosensitive?

Effect of THI

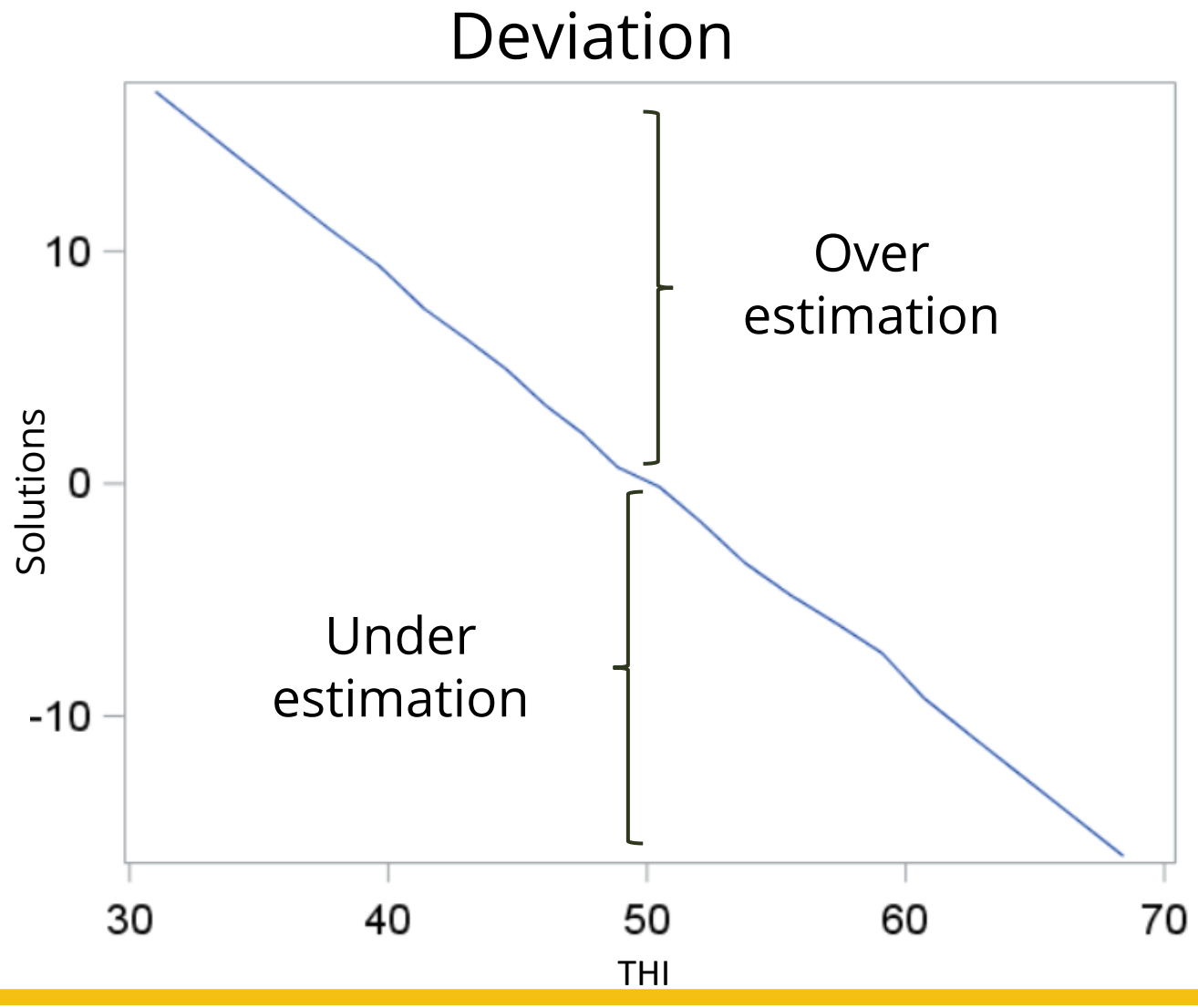
For an easier visualization:

Use the deviation between the indicator (predicted THI) and the THI obtained from weather station as a phenotype

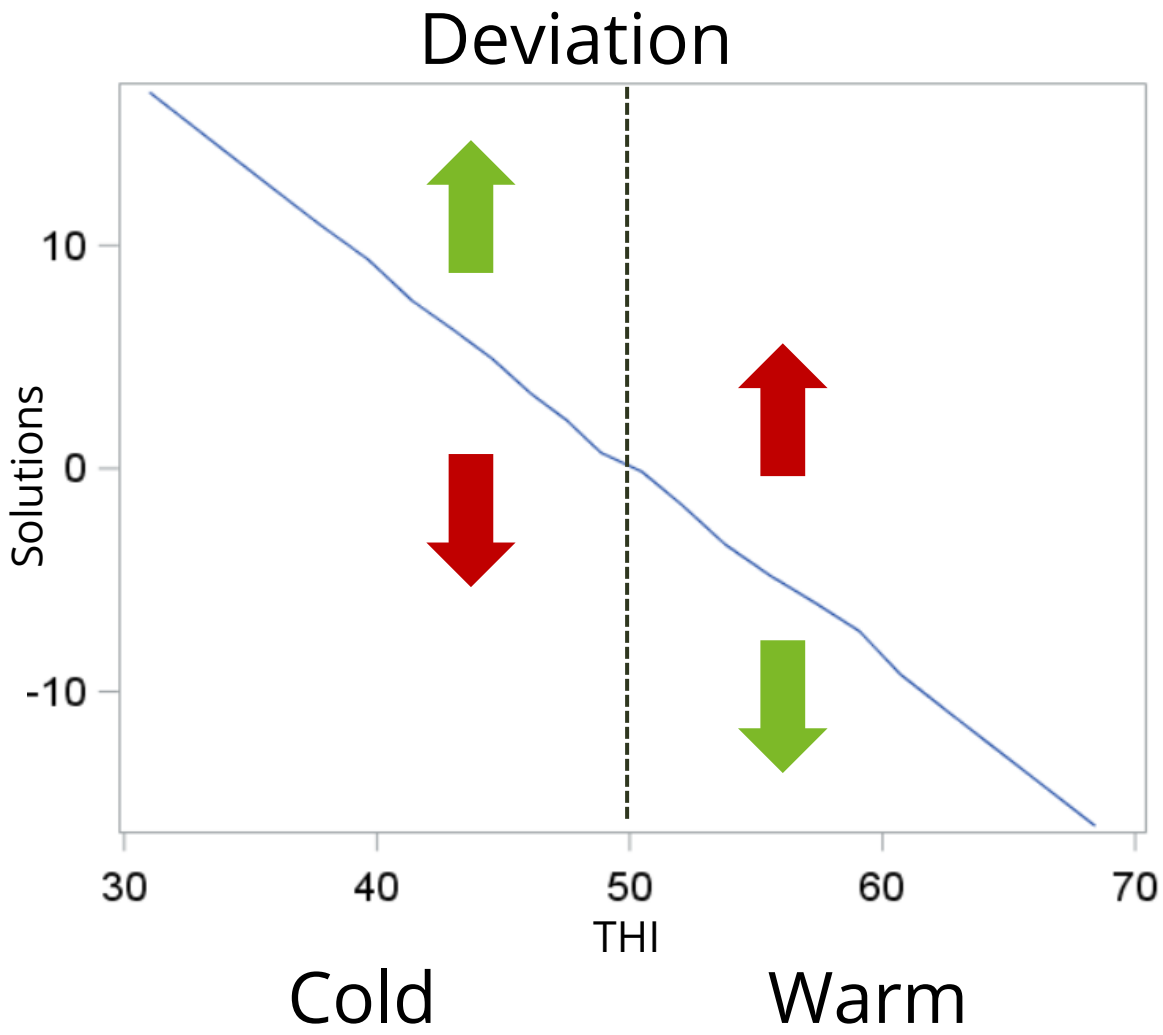
y_d = indicator (THI_{pred}) – $THI_{station}$

→ **y_d = THI + HY + (DIM-s) + lact + age + a + pe + e**

Effect of THI



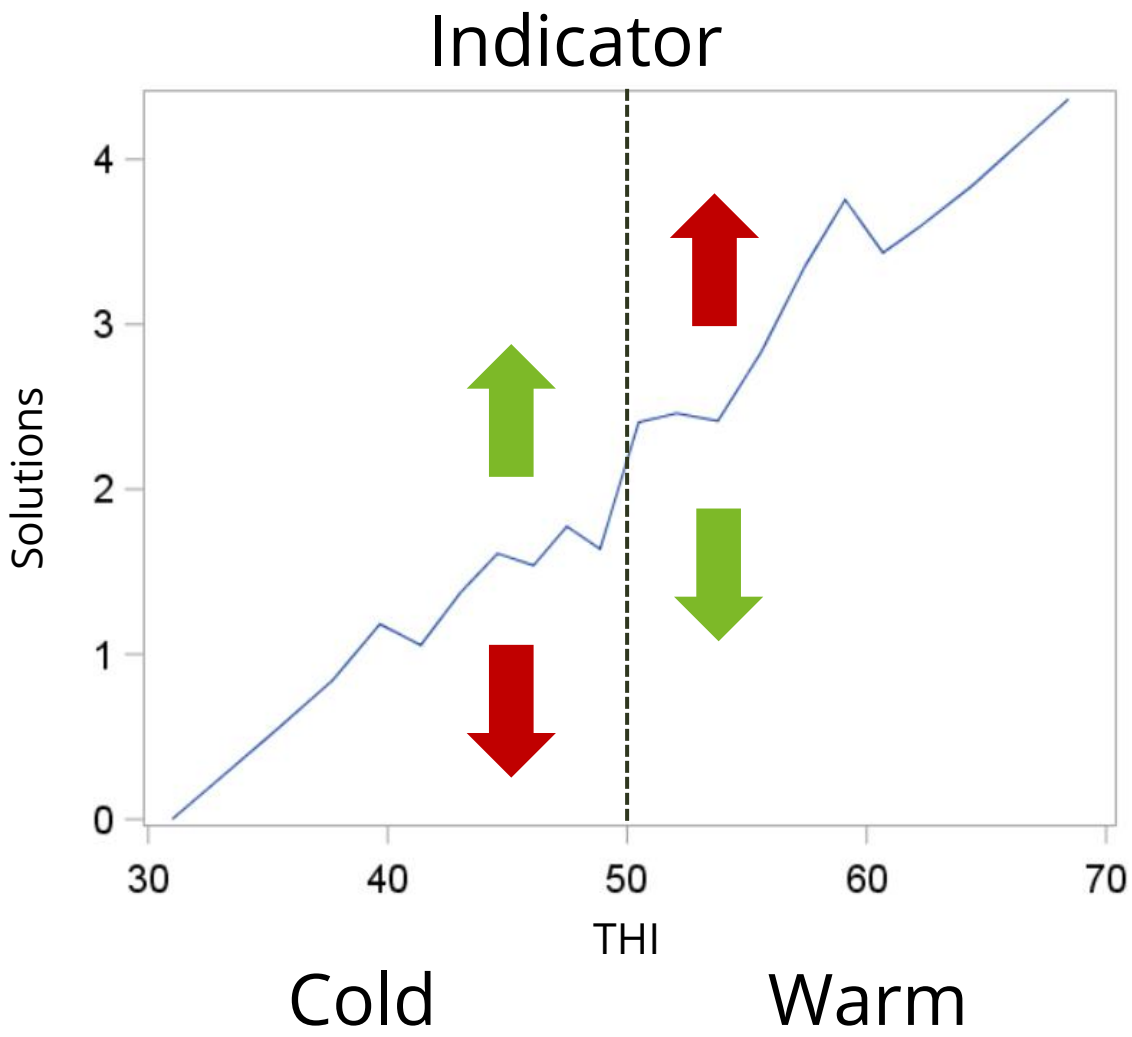
Effect of THI



Thermotolerant

Thermosensitive

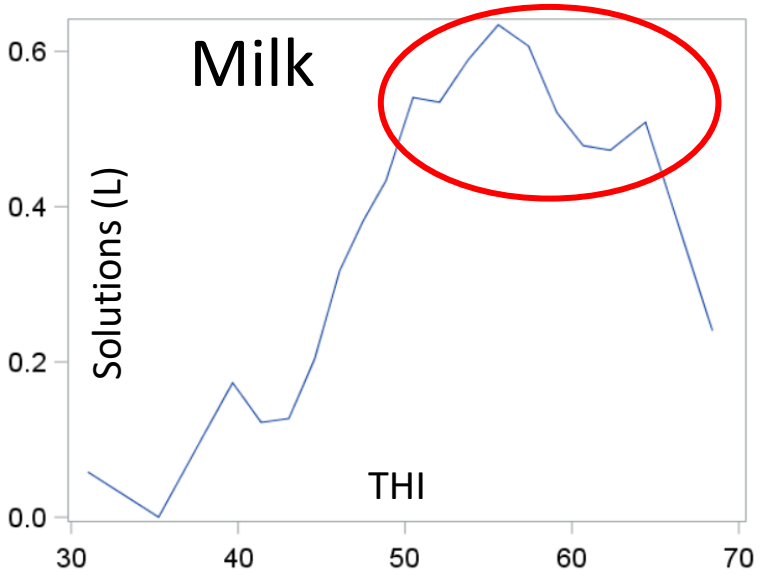
Effect of THI

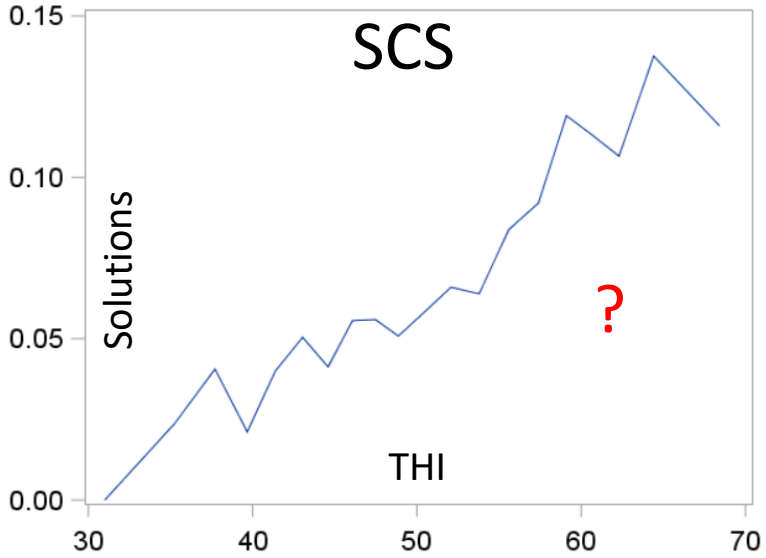


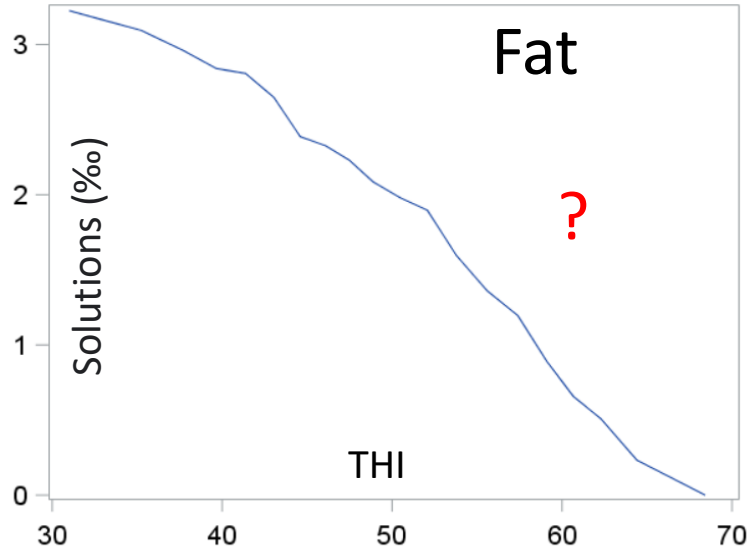
Thermotolerant

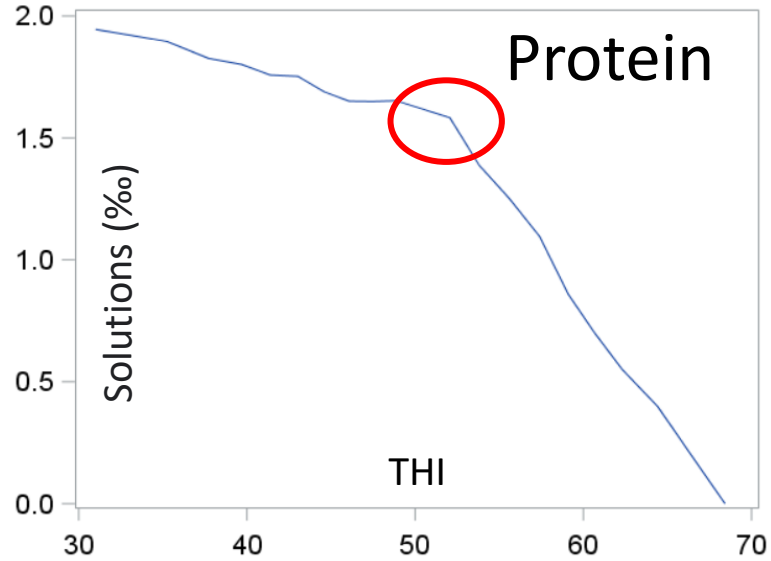
Thermosensitive

Determine the threshold

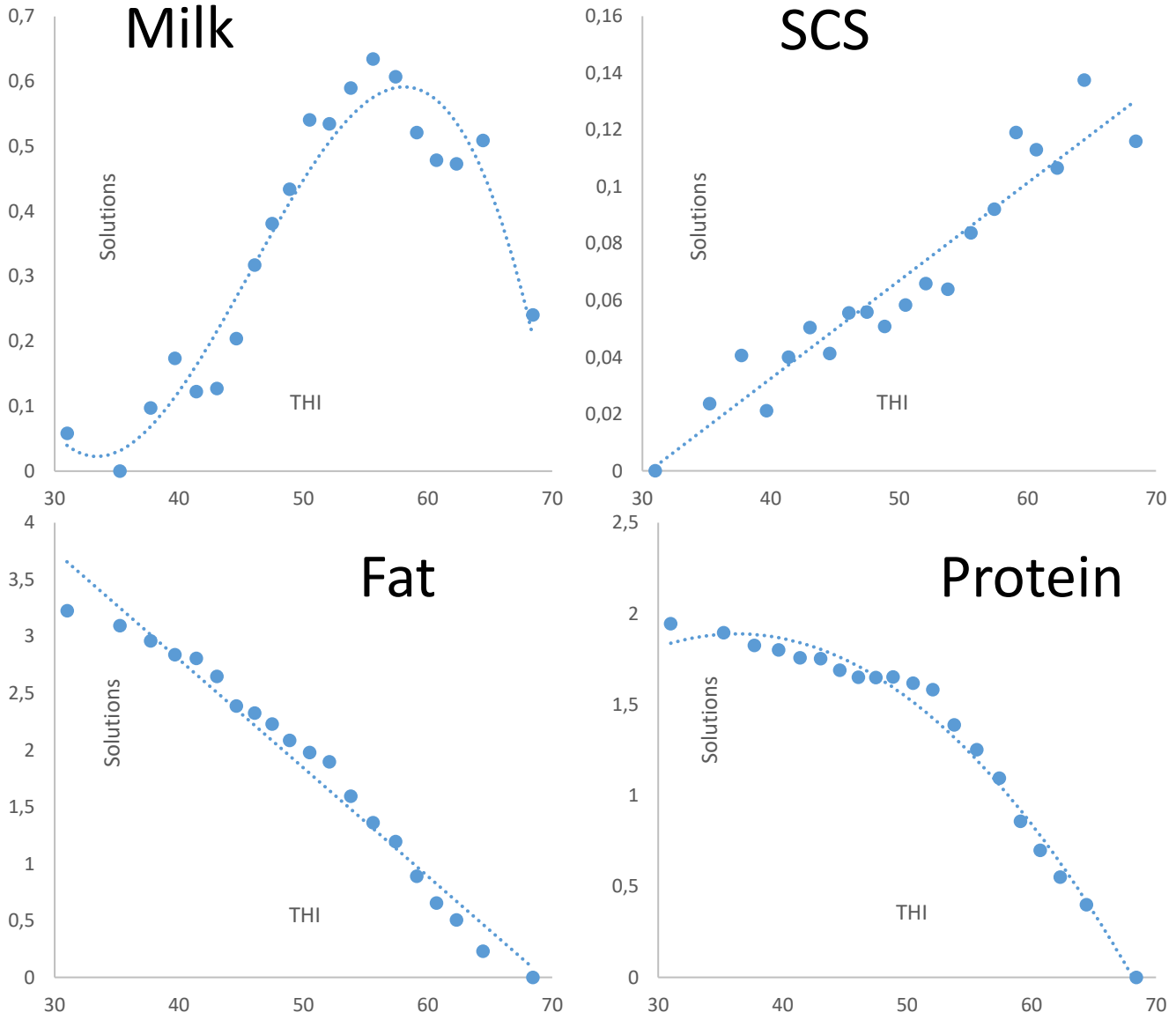








Determine the threshold



Adding polynomials

Determine the threshold

$$y = \sum^{q} bx(THI=T) + HY + (DIM\text{-}s) + lact + age + a + pe + e$$

$\sum^{q} bx(THI=T)$: Legendre polynomial
HY : Herd and year of the test-day
DIM-s : Day in milk-season of calving
lact : Lactation number
age : Age at calving

} Fixed effects

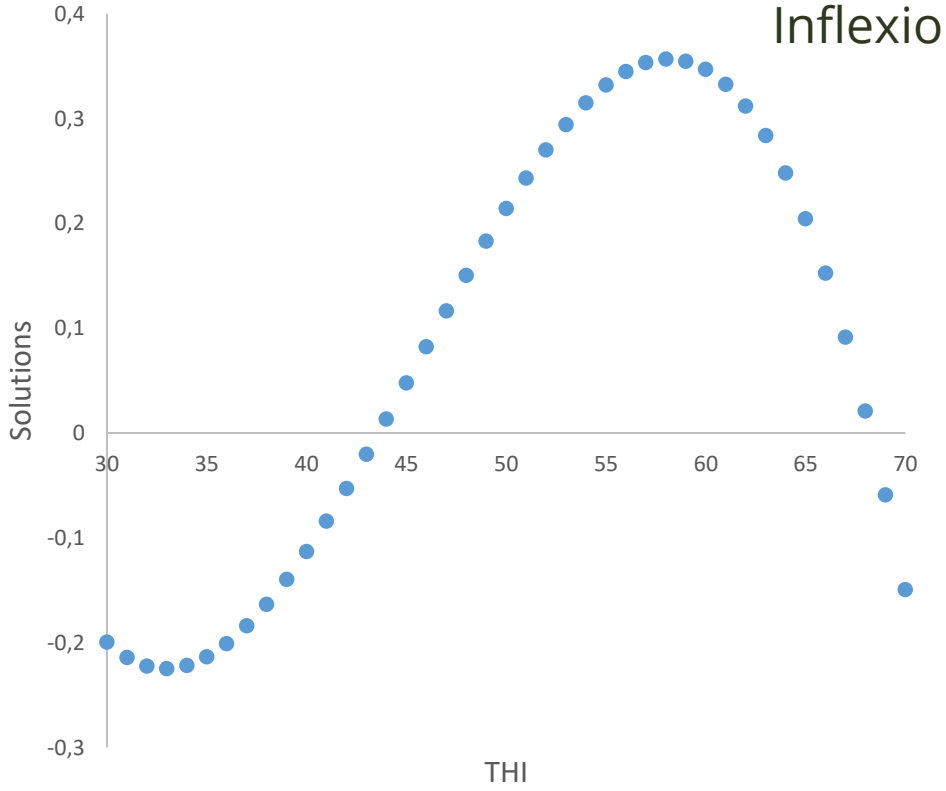
a : additive genetic
pe : permanent environment

} Random effects

Determine the threshold

The same threshold for every trait → facilitates the comparison

Highest threshold → Milk



Regression on THI

$$y = HTD + (DIM\text{-}s) + lact + age + a + \alpha\,[f(THI)] + pe + \pi\,[f(THI)] + e$$

HTD : Herd test-day
→ 'Combination of HY and THI'
DIM-s : Day in milk-season of calving
lact : Lactation number
age : Age at calving

Fixed effects

a : additive genetic
α : additive genetic regression
pe : permanent environment
π : permanent environmental regression

Random effects

Regression on THI

h^2 = VarG/VarT

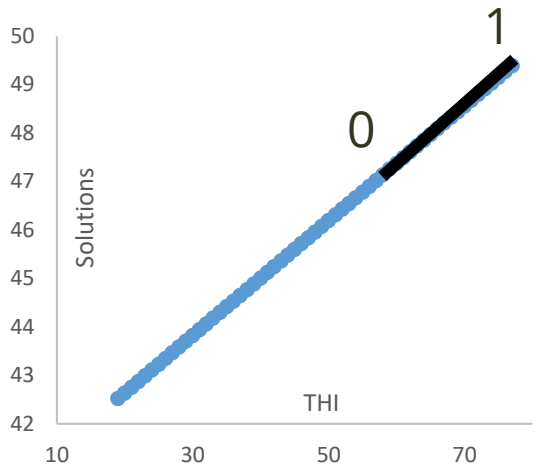
c^2 = VarP/VarT

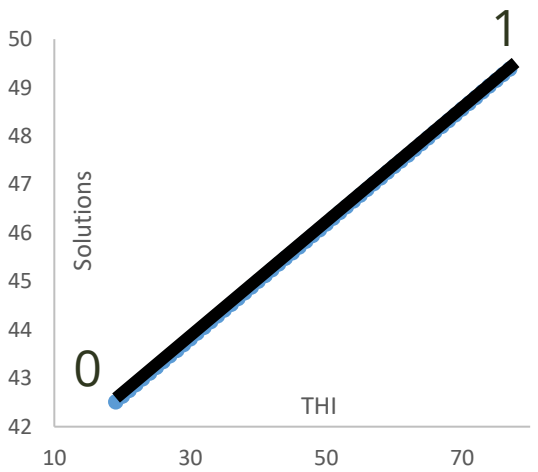
	Milk	SCS	Fat	Protein	Indicator
$h^2_{\text{threshold (58)}}$	0.20	0.11	0.37	0.37	**0.33**
$h^2_{\text{THImax (77)}}$	0.13	0.13	0.27	0.28	**0.30**
$c^2_{\text{threshold (58)}}$	0.21	0.24	0.08	0.09	**0.10**
$c^2_{\text{THImax (77)}}$	0.35	0.33	0.19	0.22	**0.15**
$VarG_{regression}/VarT$	0.052	0.019	0.073	0.100	**0.089**
$VarP_{regression}/VarT$	0.32	0.15	0.18	0.25	**0.14**

→ Model adapted to classical traits → alternative for the novel indicator ?

Different alternative models …

$$\text{if THI} < 58\text{: f(THI)} = 0$$
$$\text{if THI} \geq 58 : \text{f(THI)} = \frac{58 - THI}{58 - THImax}$$



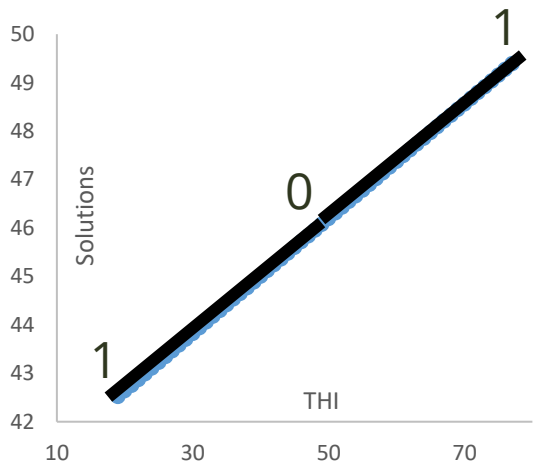


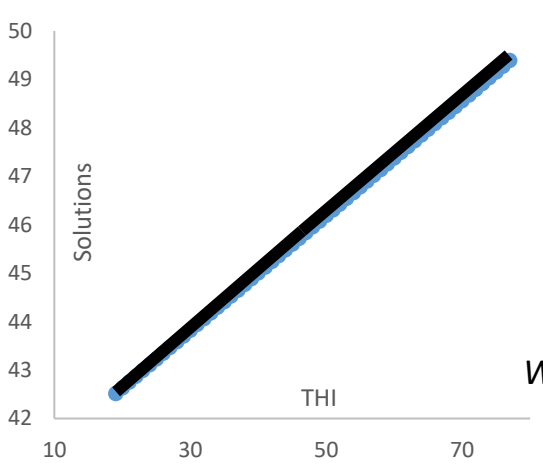
$$\text{f(THI)} = \frac{THImin - THI}{THImin - THImax}$$

$$\text{if THI} < 50\text{: f(THI)} = 0$$
$$\text{if THI} \geq 50 : \text{f(THI)} = \frac{50 - THI}{50 - THImax}$$

AND

$$\text{if THI} > 50\text{: f(THI)} = 0$$
$$\text{if THI} \leq 50 : \text{f(THI)} = \frac{50 - THI}{50 - THImin}$$





$$\text{if THI} = \text{Ki: Ci} = 0$$
$$\text{if THI } \textit{is between } \text{Ki and Ki}_{+1}\text{:}$$
$$\text{C}_\text{i} = \frac{(K_{i+1}) - THI}{(K_{i+1}) - K}$$

and $C_{i+1} = 1 - C_i$

Where K is the knot and C is the covariate

•••

Conclusion and Perspectives

→ Interesting Indicator:

- Combination of MIR spectral traits (absorbance at a given wavenumber)
- High variation along the THI scale
- Heritable

→ Perspectives:

- Determine which model is the best
- Additional genetic studies (e.g., correlations with other traits)

Conclusion and Perspectives

→ Application in routine :

Milk recording BUT no pedigree

Nguyen et al., 2017 : 2 steps → implementation of phenotypes and then genetics

→ HappyMoo

Milk composition to evaluate welfare in routine

Heat stress Indicator → also a welfare indicator

Thank you!

Interreg North-West Europe HappyMoo

Avec le soutien de la Wallonie

http://www.happymoo.eu

@HappyMooProject

Presenter Pauline Lemal (Pauline.lemal@uliege.be)