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LIÈGE université Gembloux Agro-Bio Tech

Development of a global heat stress assessment for genetic evaluation in dairy cattle

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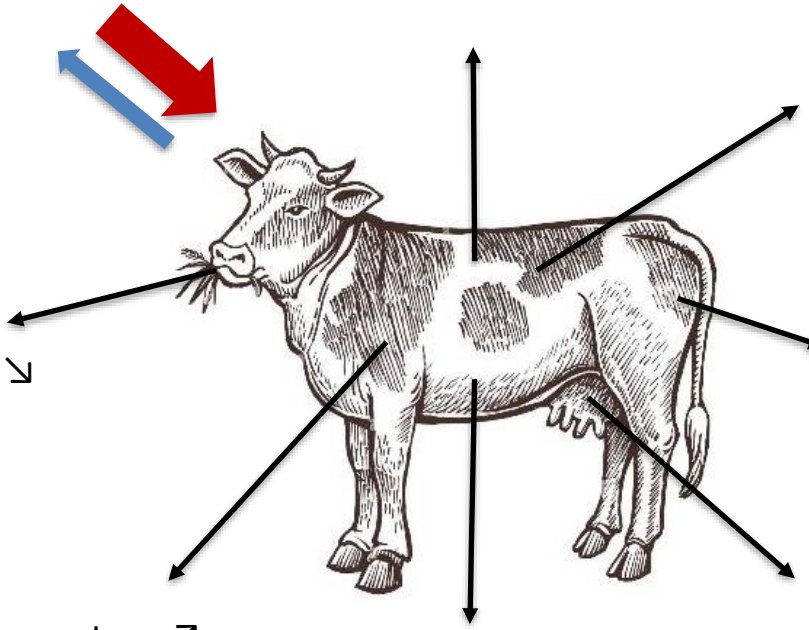
Heat stress



Disease occurrence ↗

Glucose ↘
Lactate ↗
Ketone bodies ↗

Dry matter intake ↘
Rumination ↘

Fertility ↘

Body temperature ↗
Respiratory rate ↗
Heart rate ↗

Cortisol ↗
Adrenaline ↗
Thyroid hormones ↘

Milk production ↘
Fat rate ↘
Protein rate ↘
SCC ↗

Objectives

- Be able to perform genetic evaluation for heat tolerance for a variety of traits
- Combine these traits to obtain a global heat stress assessment
- Evaluate the possibility to implement the assessment in selection

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Genetic evaluation

Data

- Milk recording (milk yield, fat %, protein % and SCC)
  - FPCM: milk yield * (0.337 + 0.116 * fat % + 0.06 x protein %)
  - SCS: $[\log_2 (SCC/100000)] + 3$ with minimum=0.1

→ 1740 Walloon Holstein cows from 2015 to 2022 in six herds

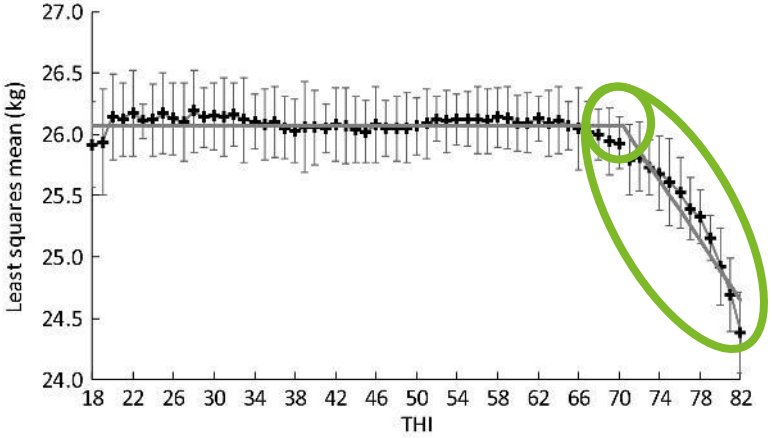
- Sensors (activity, rumination and eating time)

→ 459 Walloon Holstein cows from October 2019 to July 2022 in six herds

- Meteorological data
  - THI: $((1.8 \times T) + 32) - [(0.55 - 0.0055 \times RH) \times ((1.8 \times T) - 26)]$

Method

- Reaction norm model on the THI



Hagiya et al., (2019), *Animal Science Journal*, *90*(5), 613-618.

- Define the threshold

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

- Evaluate the animals

y = HTD + (DIM-s) + lact + age + a + α [f(THI)] + pe + π [f(THI)] + e

Method

Model adapted from McWhorter et al., 2022

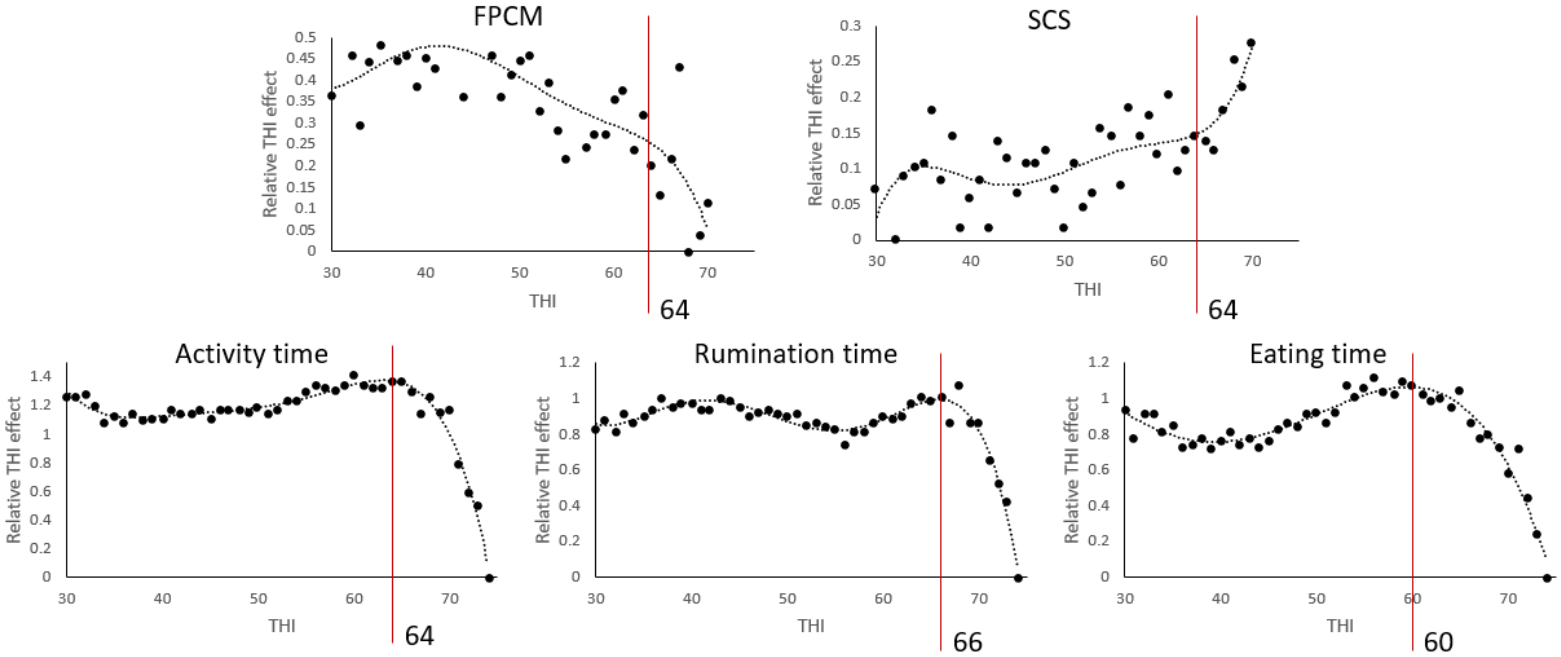
y = THI + HY + (DIM-s) + lact + age + a + pe + e

Fixed effects
- **THI**: Temperature-humidity index
- **HY**: Herd year
- **DIM-s**: Combination of day in milk and season of calving
- **lact**: Lactation number
- **age**: Age at calving

Random effects
- **a**: additive genetic
- **pe**: permanent environment

THI thresholds

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



Method

Model adapted from McWhorter et al., 2022

If $THI < THI_{threshold}$: $f(THI) = 0$
If $THI \geq THI_{threshold}$: $f(THI) = THI - THI_{threshold}$

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

Fixed effects
- **HTD**: Herd test-day
- **DIM-s**: Combination of day in milk and season of calving
- **lact**: Lactation number
- **age**: Age at calving

Random effects
- **a**: additive genetic
- **pe**: permanent environment
- **α**: slope of the regression on THI for additive genetic
- **π**: slope of the regression on THI for permanent environment

Evaluation

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

	FPCM	Activity	Rumination	Eating	SCS
h^2 threshold	0.15 ± 0.02	0.14 ± 0.06	0.19 ± 0.05	0.12 ± 0.05	0.08 ± 0.02
h^2 THImax	0.08 ± 0.18	0.31 ± 0.25	0.17 ± 0.29	0.09 ± 0.21	0.09 ± 0.12

Heritability values

Genetic correlations

Regression

Constant

	FPCM	Activity	Rumination	Eating	SCS
FPCM		**0.45 ± 0.62**	**-0.02 ± 0.46**	**0.28 ± 0.70**	**-0.40 ± 0.18**
Activity	*-0.38 ± 0.30*		**0.73 ± 0.66**	**-0.01 ± 0.18**	**-0.39 ± 0.18**
Rumination	*0.32 ± 0.16*	*0.27 ± 0.31*		**-0.12 ± 0.36**	**-0.10 ± 0.43**
Eating	*0.29 ± 0.28*	*0.29 ± 0.64*	*0.32 ± 0.36*		**0.06 ± 0.55**
SCS	*-0.19 ± 0.14*	*-0.27 ± 0.28*	*0.22 ± 0.20*	*-0.33 ± 0.35*	

Evaluation

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

→ Combination : « phenotypic reaction »

« Phenotypic » correlations

Regression

Constant

	FPCM	Activity	Rumination	Eating	SCS
FPCM		**0.50 ± 0.31**	**0.20 ± 0.26**	**0.10 ± 0.20**	**-0.42 ± 0.09**
Activity	*-0.02 ± 0.05*		**0.56 ± 0.14**	**0.12 ± 0.08**	**-0.35 ± 0.12**
Rumination	*0.20 ± 0.05*	*-0.12 ± 0.05*		**0.25 ± 0.10**	**-0.05 ± 0.20**
Eating	*0.19 ± 0.05*	*0.10 ± 0.05*	*0.07 ± 0.05*		**0.14 ± 0.20**
SCS	*-0.17 ± 0.03*	*-0.04 ± 0.05*	*0.08 ± 0.05*	*-0.10 ± 0.05*	

Global assessment

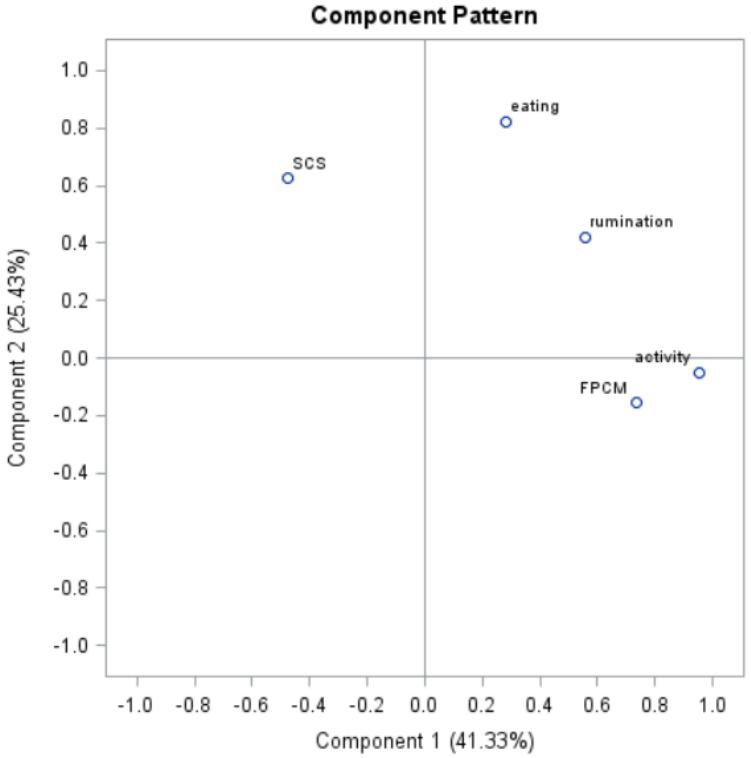
Combination of traits

- G+P
  - FPCM
  - Activity time
  - Rumination time
  - Eating time
  - SCS

PCA

Eigenvector of component 1				
FPCM	Activity	Rumination	Eating	SCS
0.51	0.66	0.39	0.19	-0.33

Behaviour



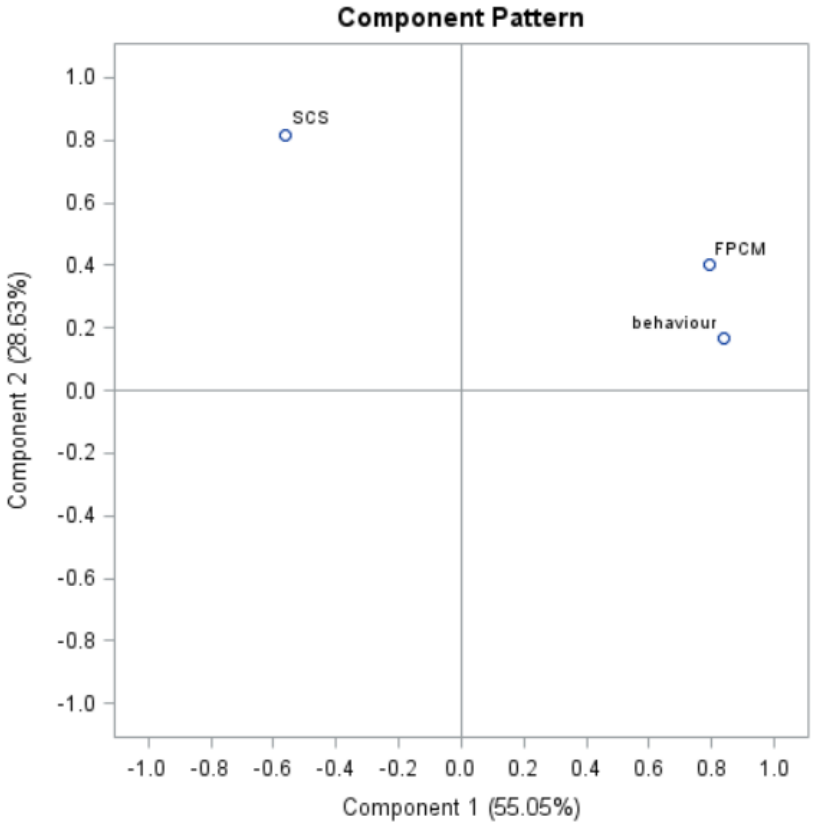
Combination of traits

- G+P
  - FPCM
  - Behaviour
  - SCS

PCA

Eigenvector of component 1		
FPCM	Behaviour	SCS
0.62	0.65	-0.44

Global assessment → Pseudo-phenotype



Implementation

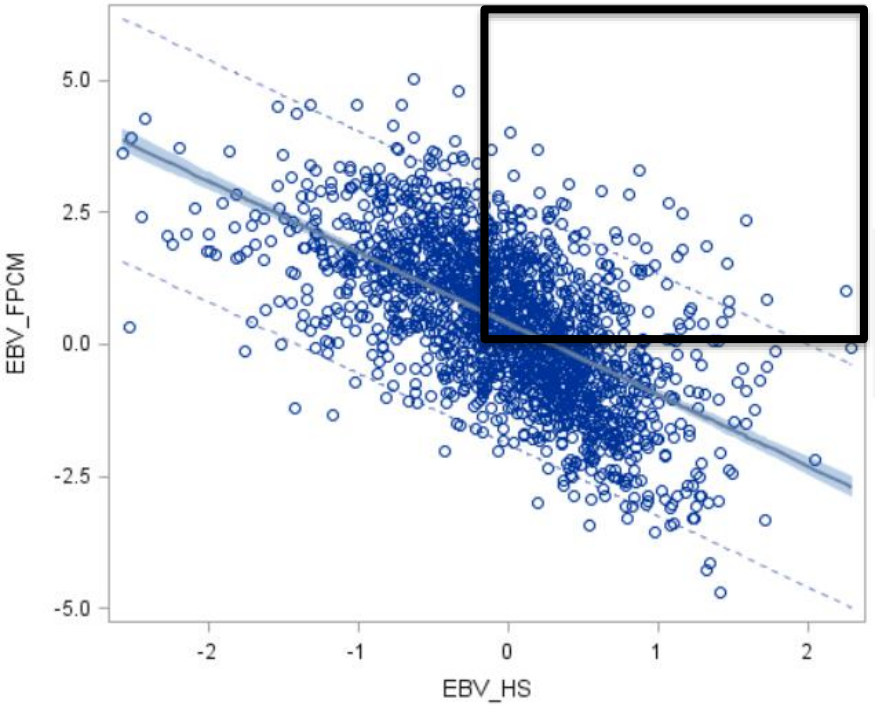
Usable in selection ?

Pseudo-phenotype

- **y = a + e**

- Heritability : 0.44
- Correlations with production

→ -0.60



Conclusion

- All traits adapted to routine
- Heat stress assessment based on production, health and behaviour
- Potentialy implementable in routine genetic evaluation

Thank you for your attention

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