Use of sensor data for detection and genetic evaluation of heat stress in dairy cattle

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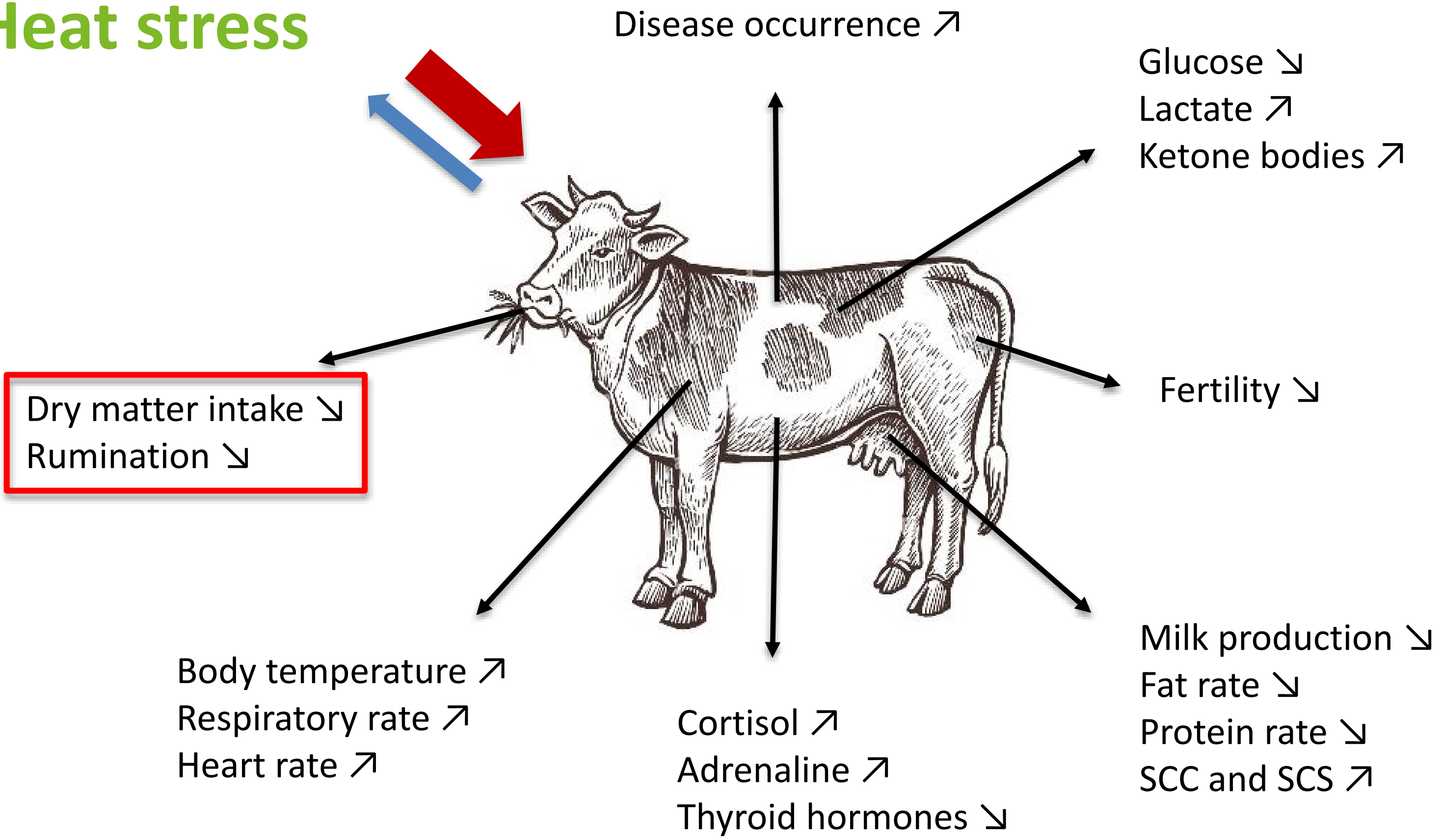
Heat stress


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 and SCS ↗

Objectives

- Evaluate the potential value of adding sensor data for **genetic evaluation** of heat tolerance in dairy cattle
- Evaluate the potential value of sensor data for **detection** of heat stress in dairy cattle

Data

- Milk recording (milk yield, fat %, protein % and SCC)
  - **FPCM** (fat- and protein- corrected milk)

milk yield * (0.337 + 0.116 * fat % + 0.06 x protein %)

  - **SCS** (somatic cell score)

$[\log_2 (SCC/100000)] + 3$ with minimum=0.1

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

- Sensors (activity, rumination and eating time)

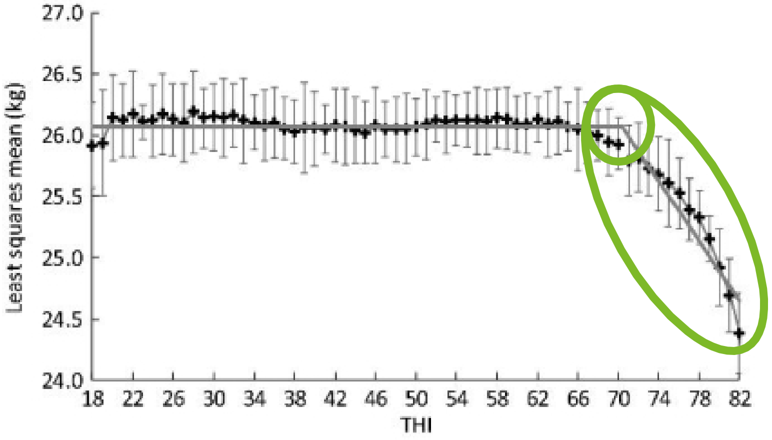
→ 453 Walloon Holstein cows from October 2019 to July 2022 in six herds

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

Genetic evaluation

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

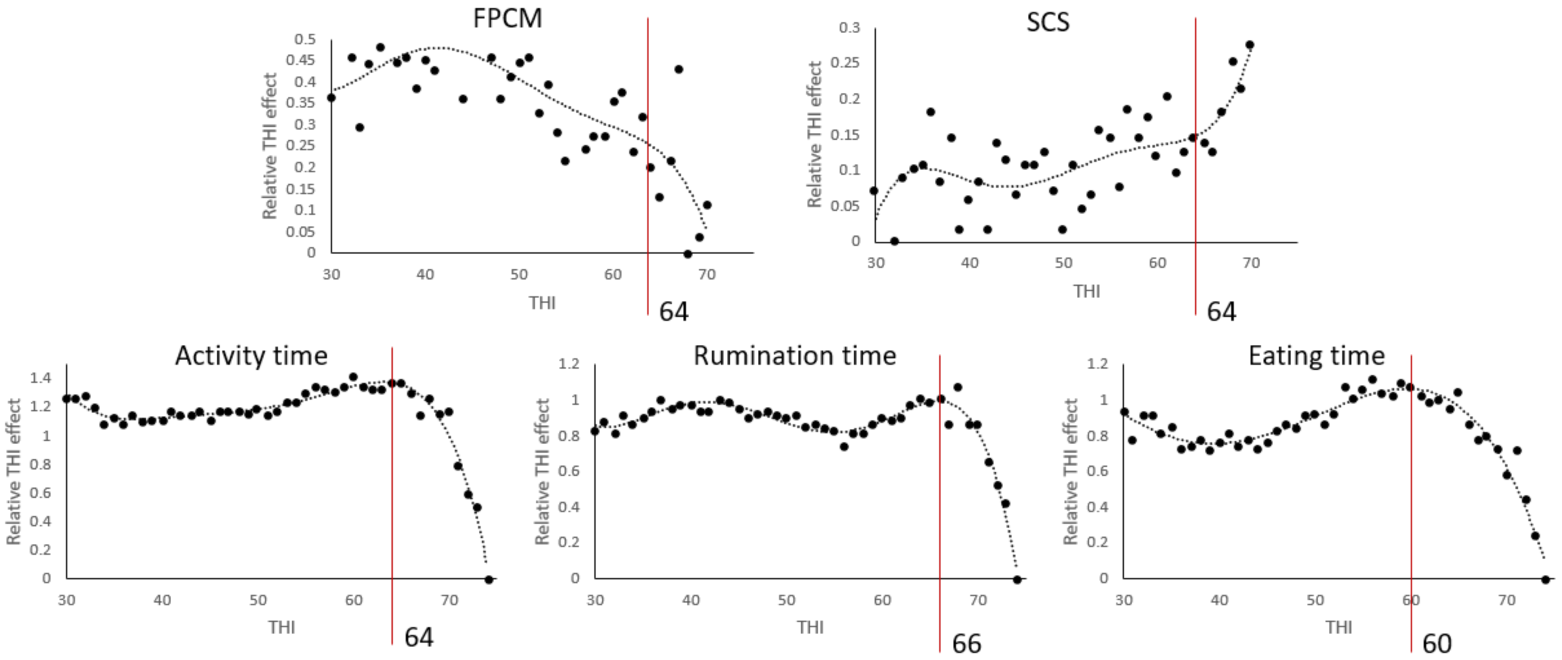
- **THI**: Temperature-humidity index
- **HY**: Herd year
- **DIM-s**: Combination of day in milk and season of calving
- **lact**: Lactation number
- **age**: Age at calving

Random effects

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

THI thresholds

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

(Co-)variance components

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

→ Genetic correlations for thermotolerance

	FPCM (Fat- and protein-corrected milk)	Activity	Rumination	Eating
Activity	**0.45 ± 0.62**			
Rumination	**-0.02 ± 0.46**	**0.73 ± 0.66**		
Eating	**0.28 ± 0.70**	**-0.01 ± 0.18**	**-0.12 ± 0.36**	
SCS	**-0.40 ± 0.18**	**-0.39 ± 0.18**	**-0.10 ± 0.43**	**0.06 ± 0.55**

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(Co-)variance components

→ Direction of variation

Principal component	Explained variance	FPCM	Activity	Rumination	Eating	SCS
1	42 %	0.42	0.65	0.47	0.03	-0.43

→ Are sensor data able to explain FPCM and SCS variation during heat stress ?

Genetic effects of sensor data used	FPCM	SCS
Thermotolerance effects	51 %	23 %
+ general effects	59 %	31 %

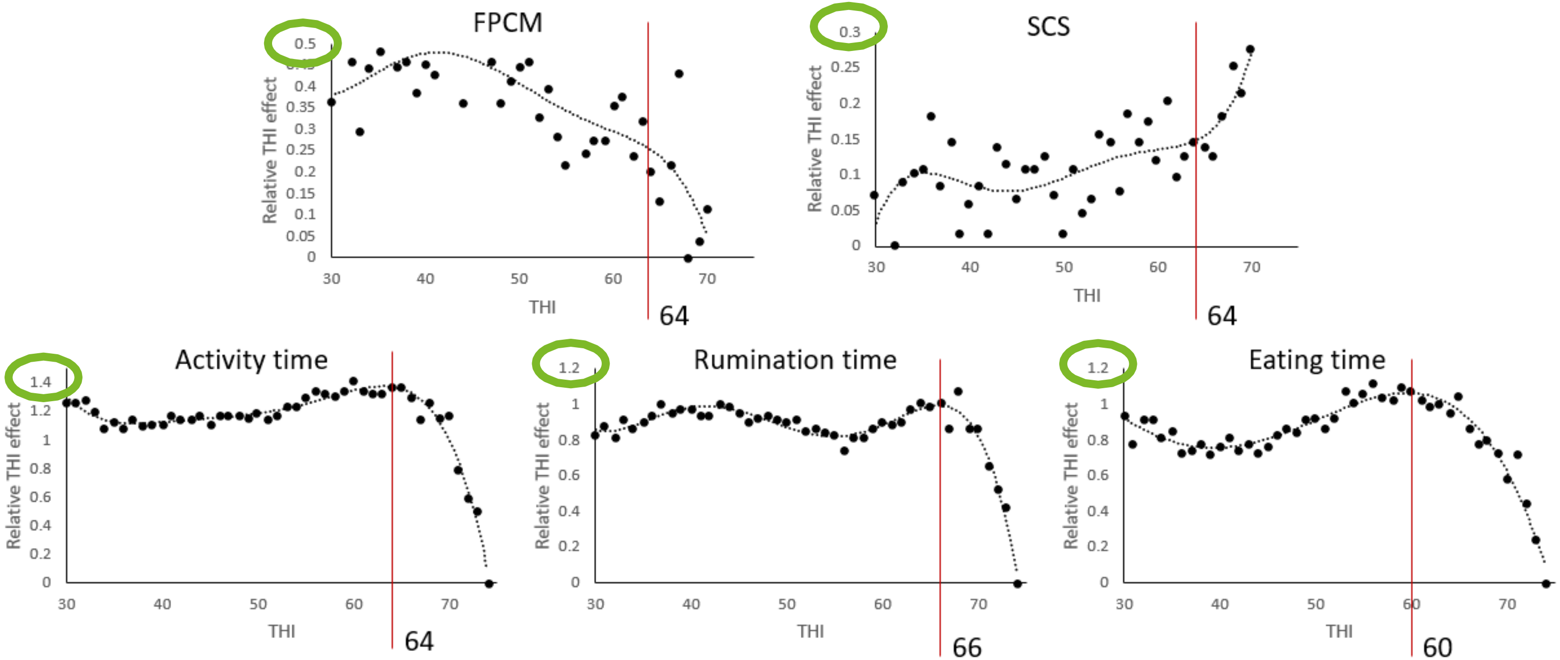
Advantages of sensor data for genetic evaluation of heat tolerance

- Daily recording
- Favorable genetic correlations and direction of variation
- Part of the variation of performance traits explained by variation of sensor data
- Usable on non-lactating animals

Detection

Variation with the THI

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



(Co-)variance components

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

→ « Phenotypic » correlations for thermotolerance

	FPCM (Fat- and protein-corrected milk)	Activity	Rumination	Eating
Activity	**0.50 ± 0.31**			
Rumination	**0.20 ± 0.26**	**0.56 ± 0.14**		
Eating	**0.10 ± 0.20**	**0.12 ± 0.08**	**0.25 ± 0.10**	
SCS	**-0.42 ± 0.09**	**-0.35 ± 0.12**	**-0.05 ± 0.20**	**0.14 ± 0.20**

Advantages of sensor data for detection of heat stress

- Daily recording
- Usable on non-lactating animals
- Clear thresholds and high variation with the THI
- Favorable « phenotypic » correlations with performance traits

Activity time

- Highest genetic and « phenotypic » correlations with FPCM and lowest with SCS
- Highest variation with the THI

→ Supported by Poppe et al. (2022)

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Development of resilience indicator traits based on daily step count data for dairy cattle breeding

Marieke Poppe[1,3*], Han A. Mulder[1], Mathijs L. van Pelt[2], Erik Mullaart[3], Henk Hogeveen[4] and Roel F. Veerkamp[1]

Conclusion

- Sensor data presents several advantages for genetic evaluation of heat tolerance
- Sensor data could help heat stress detection in farms
- Activity time seems to be the most interesting sensor trait in the context of heat stress

Thank you for your attention

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