WAGENINGEN
UNIVERSITY & RESEARCH

Impact of climate change on dairy cow welfare using high-frequent behavioral sensor data

Marjaneh Taghavi, Roxann Rikkers, István Fodor, Ines Adriaens

Background

High-producing dairy cows are highly susceptible to heat stress, affecting animal production, health and welfare. Current climate change increases the frequency and intensity of extreme weather events. Quantification of behaviour and production changes during heat waves allows to better grasp their impact on animal welfare and health. This can be studied best by looking at temperature-humidity.

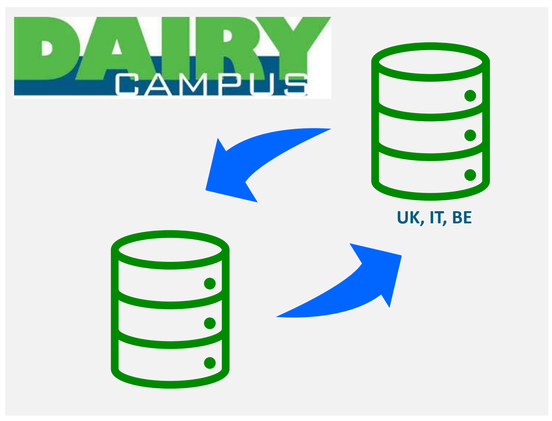
Objective

We aimed to (1) develop a data-driven methodology to quantify the effects of heat stress in dairy herds from multiple on-farm sensors and (2) study their long-term (up to weeks after the stress-event) impact on production, fertility and health of dairy cows. With this knowledge at hand, research can focus on developing timely management actions from the farmer in the short term, and improved breeding programs targeting heat stress resilience in the long term.

Data

For this study, we use datasets from different farms across Europe. These datasets contain:

- Spatial (position) data, measured with UWB technology
- Activity data, measured with accelerometers
- Milk production data
- Health and fertility information
- Weather and location data



Materials & Methods

Acquisition of large dataset of multiple herds across Europe & the UK
Analysis of individual behavioural time series (for 2 farms separately)

- Preprocessing steps: data selection for completeness, outlier removal, etc.
- Group-level visualisations
- Statistical modelling: linear mixed model + residual analysis

1) $BEH = \beta X + bZ + \varepsilon$
with $X = [\mathbf{1}\ \boldsymbol{COW\ THI\ PAR\ LS}]$,
$Z = [\mathbf{1}\ \boldsymbol{THI}]$,
$b \sim N(0, \Sigma)$, $\Sigma = \begin{bmatrix} \sigma_0 & COV(0, THI) \\ COV(THI, 0) & \sigma_{THI} \end{bmatrix}$,
$\varepsilon \sim N(0, \sigma)$

Parameter	Interpretation
β	Group-level changes in behaviour ~THI Differences across lactation stages, parities
b	$b_{i,0}$ = individual baseline in behaviour compared to group $b_{i,THI}$ = difference in susceptibility to THI
Σ	Relation between individual baseline and susceptibility
$\varepsilon \mid cow\ i, t$	Expressed in function of TIME per individual animal: time-lagged effects, duration, etc.

2) Express errors in function of time per animal

per cow: $RES_{i,t} = BEH_{i,t} - \widehat{BEH_{i,t}}$ ➡ Residual analysis, autocorrelation, patterns | time, ...

Conclusions

- Comprehensive dataset acquired
- Data exploration, visualisation and pre-processing for herd-level effects of high temperature and heat stress
- Model developed, result interpretation is WIP.

Acknowledgements

We acknowledge the Livestock Technology group at KU Leuven (BE), University of Padova (IT), and RAFT Solutions Ltd. (UK) for sharing the datasets.

Results – spatial data

- Higher THI (heat stress):
  - Time spent at drinking through increases
  - Less time spend at lying cubicles, more time spend in walking area
- High variation between cows is starting point for further in-depth analysis of behaviour over time

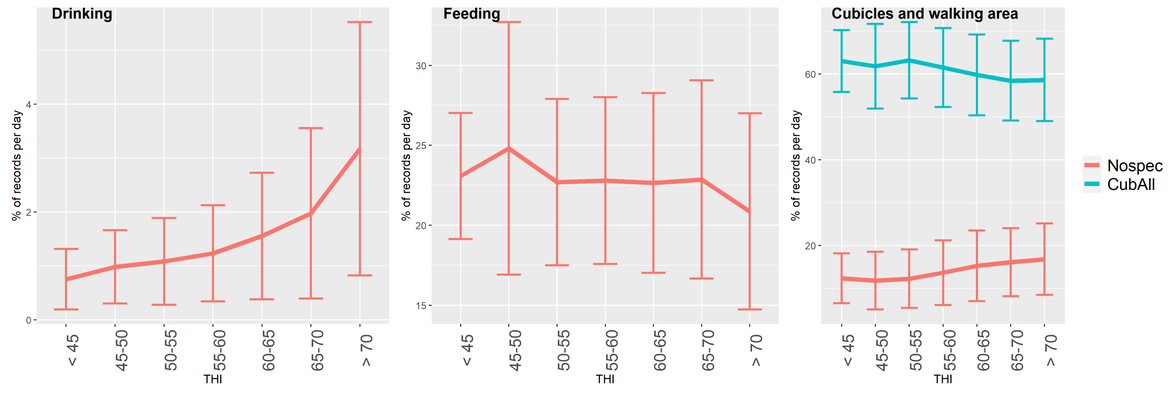


Figure 1. Percentage of records per day per area and daily mean temperature-humidity index categories. Nospec = no specific area/walking area, CubAll = lying area.

Results – activity data

The visualization of overall activity in the summer of 2019 in the morning and afternoon, indicates the higher activity when THI increased.

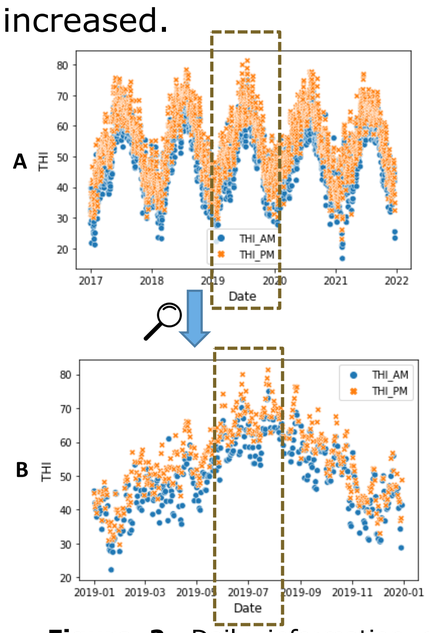


Figure 2. Daily information of climatic data from (A) 2017 to 2022, (B) 2019

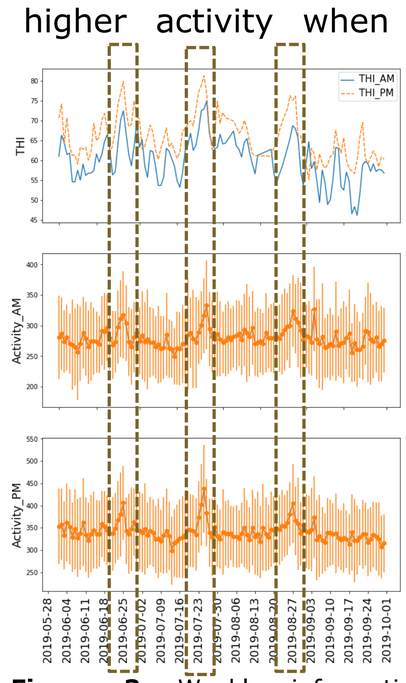


Figure 3. Weekly information of climatic and activity data in the warmest weeks of 2019

Results – milk production

First results show that higher daily mean THIs are **more detrimental** to milk production at **higher parities**, and especially in **early lactation**. Milk yield starts to drop at **<72 THI** units. Using **THI load** (total amount of heat >56 THI within a day) leads to the same conclusions.

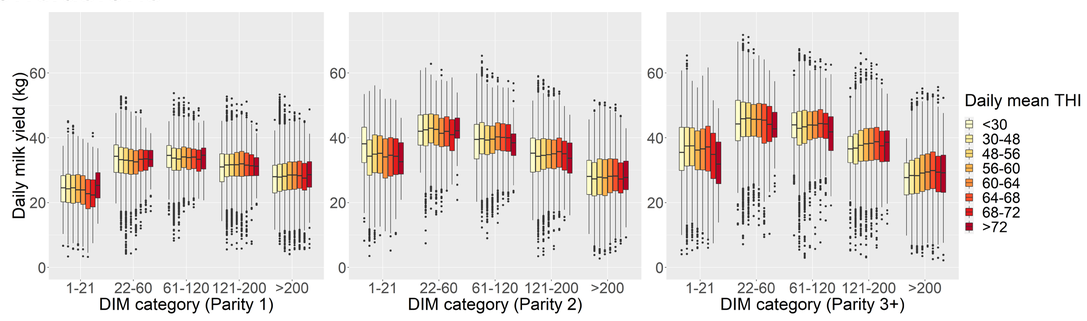


Figure 4. Daily milk yield (kg) by parity, lactation stage (days in milk; DIM), and daily mean temperature-humidity index categories

Wageningen University & Research
P.O. Box 123, 6700 AB Wageningen
Contact: name.surname@wur.nl
T + 31 (0)317 12 34 56, M +31 (0)6 12 34 56 78
www.wur.nl/xxxxx