Quantification of climate impact for breeding and decision support at dairy farms

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Background and societal relevance

The frequency and severity of heat waves are expected to increase with the changing climate. As heat severely impacts dairy cows, climate change poses a risk on (dairy) **food security** and **animal welfare**.

Aim of the project

Heat stress impact on dairy cows is typically quantified based on loss in milk production, and secondarily, based on fertility, and mortality. With the increasing availability of high-frequency behavioural sensor data, it has become possible to characterize the impact of heat stress on cow behaviour. In this project, we studied **heat stress** effects on **milk production**, **activity** (step count) as a behavioural feature, and **developed a novel modelling technique** to investigate heat stress sensitivity of individual cows.

Materials and Methods

Daily milk production and activity from 11,650 lactations of 4,912 Holstein cows were used. The dataset represents 15 years of data from 13 farms from the Netherlands and Belgium.
Daily climatic parameters were calculated based on the hourly data collected from nearby weather stations.
We developed an iterative procedure based on the Nadaraya-Watson estimator, to fit several farm-, cow-, and weather-related effects, in order to overcome challenges of joint estimation of correlated effects (e.g., activity of a cow on consecutive days).

Main results

Heat stress should be expected not only in summer, but also in the **shoulder seasons** (spring and autumn), even under temperate climate. In spring and autumn, not only mild heat stress (temperature-humidity index [THI]: 68-72), but also moderate heat stress (THI 72-80) was observed. Severe heat stress (THI ≥ 80) occurred only in summer (**Figure R1**).
Mean temperature-humidity index (THI) of the **previous 3 days**, and the duration of high THI within a day were important predictors of **milk production**. Milk losses were observed above THI 65 (THI=70: -1.0%, THI=75: -2.1%, on average; **Figure R2**).
THI on the **same day** was an important predictor of **activity**.
Activity increased during heat stress (**Figure R3**). Activity increase was more than proportional (activity score +0.40 between THI 60 and 65, but +0.77 between THI 70 and 75).
Substantially reduced activity (as a potential sign of disease) was a predictor of reduced milk production (**Figure R4**).

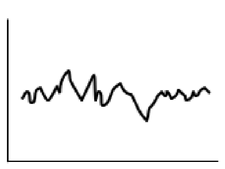
Conclusions and next steps

The behaviour of cows is affected days before changes in milk production could be observed. Therefore, behavioural changes are better suited than milk production where timely decision support is needed. For breeding purposes, further research is needed before changes in activity during heat waves can be used. The methodology developed in this project will be further improved (e.g., by considering compensatory behaviour) in other heat stress-related projects.

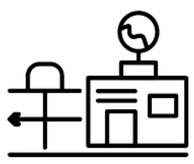
Data

13 dairy farms
(Netherlands, Belgium)

4,912 Holstein cows

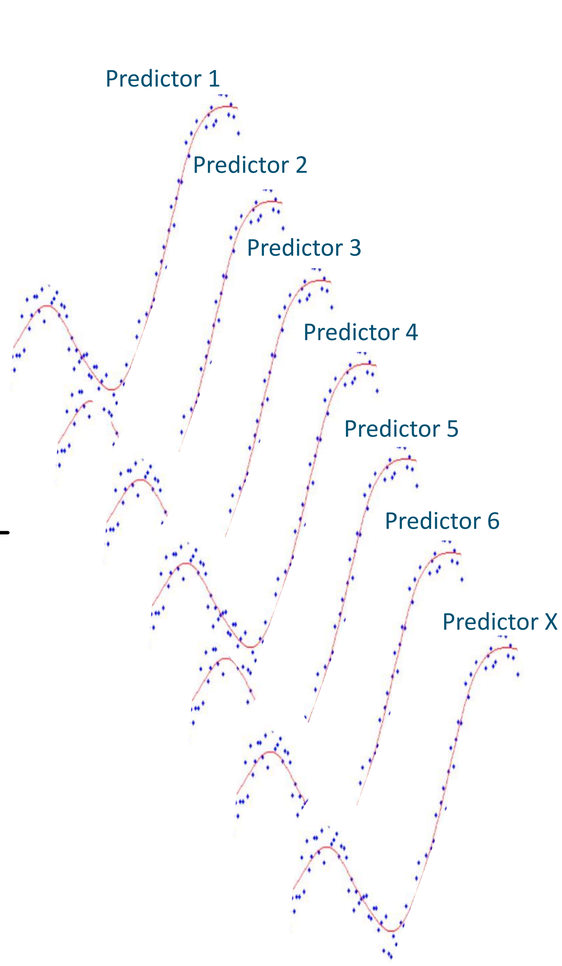


Daily milk production and activity from 11,650 lactations



Weather data from nearby weather stations

Methods



Iterative fitting
with Nadaraya-Watson estimator

Results

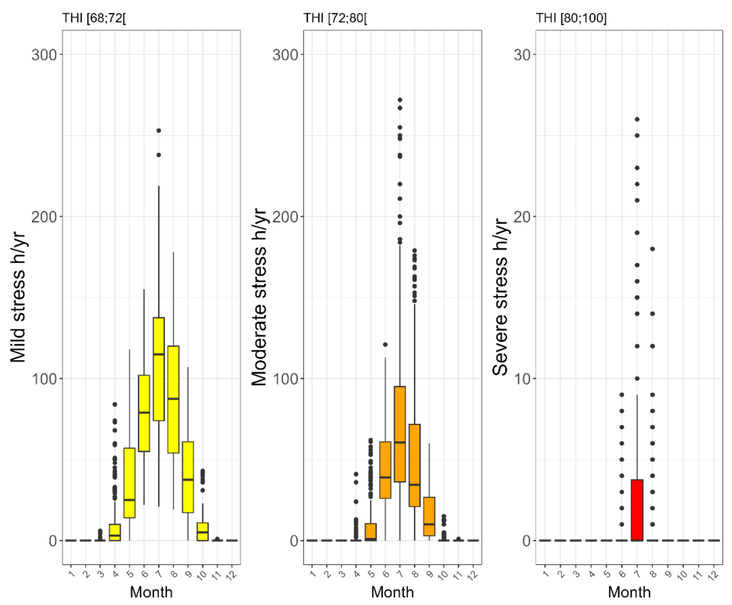


Figure R1.

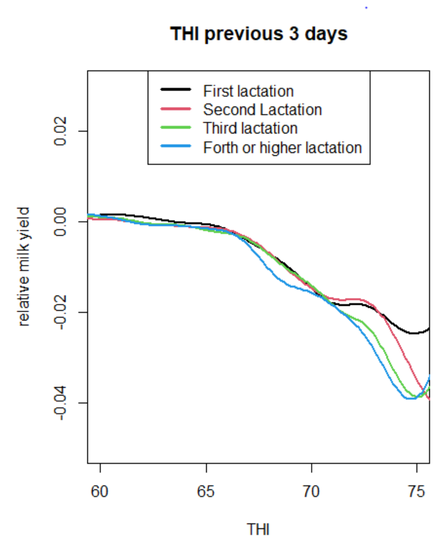


Figure R2.

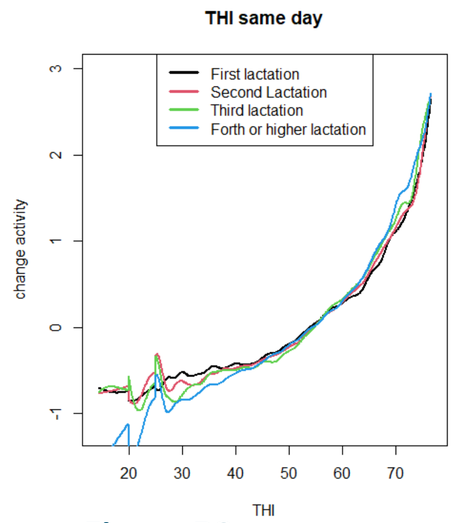


Figure R3.

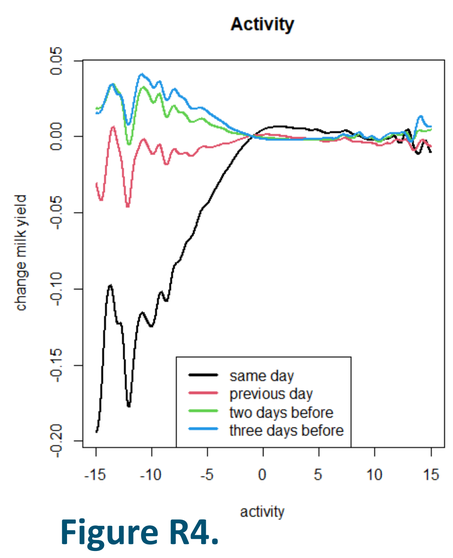


Figure R4.

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