Effect of lactation number on the respiratory rate of dairy cows on hot days

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Study Background

“Optimized animal specific barn climatisation facing temperature rise and increased climate variability – OptiBarn” (ERANET)

Consortium: 6 institutes from 4 countries + Associated partner from Australia
Content

1. Motivation and Hypotheses
2. Material and Methods
3. Results
4. Conclusion and Outlook
1.1. Stress levels factors for dairy cattle

Environmental
- Barn
- Climate

Climate change

Behavior
- Dry matter intake
- Water intake
- Feeding time/frequency
- Lying time
- Rumination

Production
- Milk Yield
- Reproduction/conception rate

Physiology
- Body temperature
- Heart frequency
- Blood parameters
- Respiratory rate

Ambient temperature and Relative Humidity = THI

Later indicator

Early indicator

Early indicator

Stress levels

Environmental
- Barn climate
- Genotypes

Date: 12.10.2016
1.2. Temperature Humidity Index (THI)

NRC, 1971

\[ \text{THI} = (1.8 \times T_{\text{db}} + 32) - (0.55 - 0.0055 \times \text{RH}) \times (1.8 \times T_{\text{db}} - 26.8) \]

Where \( T_{\text{db}} \) is the dry bulb temperature in \(^{\circ}\text{C}\) and \( \text{RH} \) is the relative humidity in percent [%].

| Luft Temp. °C | THI 20%  | THI 25%  | THI 30%  | THI 35%  | THI 40%  | THI 45%  | THI 50%  | THI 55%  | THI 60%  | THI 65%  | THI 70%  | THI 75%  | THI 80%  | THI 85%  | THI 90%  | THI 95%  | THI 100% |
|---------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| 20            | 64       | 64       | 64       | 65       | 65       | 65       | 66       | 66       | 66       | 66       | 66       | 67       | 67       | 67       | 68       | 68       |
| 21            | 65       | 65       | 65       | 66       | 66       | 66       | 67       | 67       | 67       | 67       | 67       | 68       | 68       | 68       | 69       | 69       |
| 22            | 66       | 66       | 66       | 67       | 67       | 67       | 68       | 68       | 68       | 68       | 68       | 69       | 69       | 69       | 70       | 70       |
| 23            | 67       | 67       | 67       | 68       | 68       | 68       | 69       | 69       | 69       | 69       | 69       | 70       | 70       | 70       | 71       | 71       |
| 24            | 68       | 68       | 68       | 69       | 69       | 69       | 70       | 70       | 70       | 70       | 70       | 71       | 71       | 71       | 72       | 72       |
| 25            | 69       | 69       | 69       | 70       | 70       | 70       | 71       | 71       | 71       | 71       | 71       | 72       | 72       | 72       | 73       | 73       |
| 26            | 70       | 70       | 70       | 71       | 71       | 71       | 72       | 72       | 72       | 72       | 72       | 73       | 73       | 73       | 74       | 74       |
| 27            | 71       | 71       | 71       | 72       | 72       | 72       | 73       | 73       | 73       | 73       | 73       | 74       | 74       | 74       | 75       | 75       |
| 28            | 72       | 72       | 72       | 73       | 73       | 73       | 74       | 74       | 74       | 74       | 74       | 75       | 75       | 75       | 76       | 76       |
| 29            | 73       | 73       | 73       | 74       | 74       | 74       | 75       | 75       | 75       | 75       | 75       | 76       | 76       | 76       | 77       | 77       |
| 30            | 74       | 74       | 74       | 75       | 75       | 75       | 76       | 76       | 76       | 76       | 76       | 77       | 77       | 77       | 78       | 78       |
| 31            | 75       | 75       | 75       | 76       | 76       | 76       | 77       | 77       | 77       | 77       | 77       | 78       | 78       | 78       | 79       | 79       |
| 32            | 76       | 76       | 76       | 77       | 77       | 77       | 78       | 78       | 78       | 78       | 78       | 79       | 79       | 79       | 80       | 80       |
| 33            | 77       | 77       | 77       | 78       | 78       | 78       | 79       | 79       | 79       | 79       | 79       | 80       | 80       | 80       | 81       | 81       |
| 34            | 78       | 78       | 78       | 79       | 79       | 79       | 80       | 80       | 80       | 80       | 80       | 81       | 81       | 81       | 82       | 82       |
| 35            | 79       | 79       | 79       | 80       | 80       | 80       | 81       | 81       | 81       | 81       | 81       | 82       | 82       | 82       | 83       | 83       |
| 36            | 80       | 80       | 80       | 81       | 81       | 81       | 82       | 82       | 82       | 82       | 82       | 83       | 83       | 83       | 84       | 84       |
| 37            | 81       | 81       | 81       | 82       | 82       | 82       | 83       | 83       | 83       | 83       | 83       | 84       | 84       | 84       | 85       | 85       |
| 38            | 82       | 82       | 82       | 83       | 83       | 83       | 84       | 84       | 84       | 84       | 84       | 85       | 85       | 85       | 85       | 86       |
| 39            | 83       | 83       | 83       | 84       | 84       | 84       | 85       | 85       | 85       | 85       | 85       | 86       | 86       | 86       | 86       | 87       |
| 40            | 84       | 84       | 84       | 85       | 85       | 85       | 86       | 86       | 86       | 86       | 86       | 87       | 87       | 87       | 88       | 88       |

THI ≤72: Comfort zone
THI 73 – 78: Mild stress
THI 79 – 84: Danger
THI ≥85: Emergency

1.3. Overview Indicators – Why respiratory rate?

- Non invasive animal measurement
- Visual measurement is less dependent on housing facilities
- Early & sensitive indicator
- Commonly used as heat stress indicator in cattle

1.4. Objectives

- Aim: Assess the effect of lactation number on the respiratory rate of dairy cows on high temperature days
1.5. Hypotheses

- The cows individually differ in the respiratory rate based on cow-related factors under heat stress conditions.

- The respiration frequency in lactating cows differs between early morning and afternoon.
2.1. Variables

- Two different groups

**Climate related variables**
- Ambient temperature, relative humidity
- Temperature Humidity Index (THI) (NRC, 1971)

**Cow related variables**
- Holstein 1st – 8th lactation
- Heart Rate (HR)
  - Stethoscope
- Heart Rate Variability (HRV)
  - eMotion HRV® / Faros 90°
- **Respiratory rate (RR)**
  - visually 30 seconds
- Rectal Temperature (RT)

- Measurement time from 07:00h to 15:00h
2.2. Data collection
2.3. Experiment 1

- 15 cows (≥ 2nd lactation);
- morning and afternoon measurements of RR (HR, HRV, RT)
- 17 days: Jun – Aug
2.4. Experiment 2 & 3

- 30 cows (2\textsuperscript{nd} – 8\textsuperscript{th} lactation);
- RR (HR, RT) once in the morning and in the afternoon
- 12 days: Jun – Aug

- 15 cows (1\textsuperscript{st} – 8\textsuperscript{th} lactation);
- RR every hour
- 7 days: Aug
2.5. Data analysis

- Data of all experiments for morning (07:00 h – 10:00 h) and afternoon (11:00 h – 15:00 h)

- Test: Effect of animal factors on RR - significance level of 0.05 (p < 0.05)

- Fixed effects: body posture, lactation number, test day, co-variable temperature
3.1. Mean of temperature & rel. humidity during the trial period

- 36 days: June – August 2015

<table>
<thead>
<tr>
<th>Time of the Day</th>
<th>Mean Ambient Temperature (°C)</th>
<th>Standard Deviation</th>
<th>Mean Relative Humidity (%)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>19.2</td>
<td>2.52</td>
<td>77.1</td>
<td>11.69</td>
</tr>
<tr>
<td>Afternoon</td>
<td>25.1</td>
<td>4.36</td>
<td>57.4</td>
<td>14.20</td>
</tr>
</tbody>
</table>
3.2. Influence of the barn temperature on the respiratory rate

Increase in barn temperature leads to increase in respiratory rate.
3.3. Behavior

- Cows spend more time standing with increasing barn temperatures

Morning

Afternoon
3.4. Daily respiratory rate morning and afternoon

N=30-38, one measurement per morning and noon

- RR increase in the afternoon in comparison of morning
3.5 Difference of respiratory rate between afternoon and morning

N=30-38, one measurement per morning and noon

Respiratory rate difference per 30 sec

Big range of RR -differences shows the cows’ individuality, and difference between afternoon and morning.
3.6. Respiratory rate of each cow morning and afternoon - (group level)

N=30-38, one measurement per morning and noon

RR of cows in the morning are more compact, and in the afternoon are higher and diverge.
3.7. Respiratory rate of three cows within two days (individual level)

- High variability between and within cows independent of barn temperature;
- Temperature increase leads to higher respiratory rate
### 3.8. Mean and confidence interval of respiratory rate in different body posture and parity

<table>
<thead>
<tr>
<th>Effect</th>
<th>Mean Respiratory rate /30 sec</th>
<th>Limits of the 95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Body posture</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lying</td>
<td>22.4</td>
<td>21.6</td>
</tr>
<tr>
<td>Standing</td>
<td>19.0</td>
<td>18.5</td>
</tr>
<tr>
<td>Parity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>20.1</td>
<td>18.9</td>
</tr>
<tr>
<td>2</td>
<td>19.9</td>
<td>19.2</td>
</tr>
<tr>
<td>3+</td>
<td>21.9</td>
<td>21.3</td>
</tr>
</tbody>
</table>

Means in different colors differ significantly (t-Test, ±=0.05).
3.9. Daily respiratory rate during standing and lying

Respiratory rate per 30 sec

- RR of lying cows was higher than that of standing cows;
- High variability of RR in lying cows.
4.1. Conclusion

The respiratory rate of lactating dairy cows is influenced by cow-related factors (e.g. lactation number and body posture) as well as climate-related variables (e.g. ambient temperature).
4.2. Next steps


Consider other vital and production parameters
4.2. Next steps

Measurements: Israel – August 2016

Measurements: Spain – June 2016

Comparison between respiratory rate and THI, in other climate zones and different seasons
Thank you for your Attention!