Circadian metabolomic profile of beef heifers and associations with feed efficiency

Alaina Macdonald¹, Ian Burton⁴, Tobias Karakach⁴, Stephanie Lam¹, Ananda Fontoura¹, Stéphanie Bourgon², Stephen Miller³, Yuri Montanholi²
- 13 million beef cattle
- $20 billion annually
- export to 70 countries
$ Feed costs

Environmental sustainability

FAO 2013:

- Livestock sector $\rightarrow$ 7.1 gigatonnes of greenhouse gas emissions/year
- Beef cattle production $\rightarrow$ largest contributor $\rightarrow$ feed production and processing
FEED EFFICIENCY

Inefficient

Efficient
Introduction

Materials & Methods

Results & Discussion

Conclusion

**FEED EFFICIENCY**

- 112-day performance test
  - body weight, body composition

- Automated feeding equipment
  - feed intake
• **Acetate**  
  *(Gonano et al., 2014)*

• **Glucose**  
  *(Bauman and Currie 1980)*

• **Glycine, glutamate**  
  *(Karisa et al., 2014)*
• **Metabolomics** = study of the metabolome

• **Metabolite** = end product or intermediary → small molecule

http://takingstock.asas.org/?p=3023
Hypothesis:
Blood plasma metabolomic profiles display a circadian pattern and are associated with feed efficiency and physiological stage in beef heifers.

Objectives:
Using metabolomics, evaluate variation...
1. over the circadian period
2. across physiological stages
3. related to feed efficiency
• 36 open yearling beef heifers (63.4 % Angus, 24.3 % Simmental, 12.3 % other *Bos taurus* breeds)

• Performance test

• Blood collected every hour for 24 hours
Open
• 367 d old

Early gestation
• 542 d old
• 82 d in gestation

Late gestation
• 704 d old
• 244 d in gestation
**RFI determination:** dry matter intake = $\beta_0 + \beta_1$

(age) + $\beta_2$ (weight gain) + $\beta_3$ (body weight) + $\beta_4$ (back-fat thickness) + $\beta_5$ (rump-fat thickness) + $\beta_6$ (ribeye area) + $\beta_7$ (marbling) + residue

$R^2 = 0.34$
• **Metabolomic analysis: Bruker Avance III spectrometer**

• **Nuclear Magnetic Resonance (NMR)**
700MHz spectrum of a sample of bovine plasma
Statistical Analysis

• 36 heifers x 3 physiological stages x 24 hours

• Spectral data pre-processed and exported to MATLAB

• Test for normality

• Repeated measures
  → Proc mixed in SAS
  → Predictive values for circadian variation, physiological stage and feed efficiency classes

• Metabolite = \( \mu + \text{Age} + \text{stage} + \text{RFI group} + \text{hour} + \text{heifer} + \text{error} \)
<table>
<thead>
<tr>
<th>Time of the day (h)</th>
<th>Relative concentration</th>
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<tbody>
<tr>
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<tr>
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</table>

**Gonano et al., 2014**

**Colorimetric assay**
Lactate concentration over time.

<table>
<thead>
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</table>
Bell and Bauman, 1997

### Results & Discussion

<table>
<thead>
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<th>Time of Day (h)</th>
<th>Relative Concentration</th>
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<tr>
<td>0:00</td>
<td>0.058</td>
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<td>4:00</td>
<td></td>
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</tbody>
</table>

Introduction

Materials & Methods

Conclusion

Open

Early gestation

Late gestation

Bell and Bauman, 1997

[Graph showing IDGU (μmol/(kg.min)) vs. Plasma insulin (pmol/L)]
**Results & Discussion**

**Alanine**

- **Open**
- **Early gestation**
- **Late gestation**

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**Bauman and Currie, 1980**
Introduction

Materials & Methods

Results & Discussion

Conclusion

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**Lactate**

- **Open**
- **Early gestation**
- **Late gestation**

**Time of day (h)**

8:00, 12:00, 16:00, 20:00, 0:00, 4:00

**Relative concentration**

0.027, 0.0295, 0.032, 0.0345, 0.037

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**Bell and Ehrhardt, 2000**
Gonano et al., 2014

Colorimetric assay

- Open
- Early gestation
- Late gestation

**Figure (a)**

- **Acetate (μg/mL)**
  - 75
  - 70
  - 65
  - 60
  - 55
  - 50
  - 45
  - 40
  - 35
  - 30
  - 25

- **Time of the day (h)**
  - 8:00
  - 12:00
  - 16:00
  - 20:00
  - 0:00
  - 4:00

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Acetate concentration (μg/mL)</th>
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</thead>
<tbody>
<tr>
<td>Early gestation</td>
<td>0.00002, 0.00006, 0.0001, 0.00014, 0.00018</td>
</tr>
<tr>
<td>Late gestation</td>
<td>0.00002, 0.00006, 0.0001, 0.00014, 0.00018</td>
</tr>
</tbody>
</table>
Karisa et al., 2014

Metabolite level, μM

Available metabolites:
- Creatine
- Histidine
- Succinate
- Oxobutyrate
- 4H-butyrate
- Hippurate
- T-4-H-L-P
- Proline
- Allantoin
- Glutamine
- Uridine
- Carnitine

Significant metabolites

Low RFI  High RFI

Karisa et al., 2013

Introduction
Materials & Methods
Results & Discussion
Conclusion
• Acetate and lactate demonstrate circadian fluctuations

• Acetate, lactate, glucose and alanine differ across physiological stages

• Metabolites did not differ between feed efficiency groups

Further work needed
Acknowledgements

• Dr Yuri Montanholi

• Jasper Munro

• Ellen Crane

• Tim Caldwell

• 44+ staff and volunteers
Cardiovascular function and anatomy in relation to feed efficiency in beef cattle

Jasper Munro¹, Stephanie Lam², Alaina Macdonald², Peter Physick-Sheard², Flávio Schenkel², Stephen Miller²,³, Yuri Montanholi¹