Relationship between eating patterns and performance of feedlot cattle


Current perceptions

- Feed Intake Variation
  - Increases incidence of acidosis
  - can decrease performance
  - increase time on feed
Feeding behaviour

- Diurnal pattern
- Very little known
- Influenced by many factors
  - (Stricklin, 1987; Hicks et al., 1989)

Factors affecting feeding behavior

- Social dominance
- Temperament
- Bunk space
- Amount/feed delivery times
- Weather
- Bunk management
Variables in relationship

**Performance**
- ADG
- Feed:Gain

**Behavior**
- bunk duration
- bunk frequency

**Intake**
- Daily variation
- Consumption

**Cattle**
- Charolais sired X-bred calves
- N = 81 (277±111 kg)
- Blocked by BW
- Diet- typical barley silage/barley grain
- 213 D trial
Variables
- Feeding duration (d)
- Intake (kg/d)
- Daily Variation in intake (kg/d)
- Visits

Feed:Gain category
- High (1.34-1.60)
- Avg (0.95-1.31)
- Low (0.60-0.94)

ADG category

<table>
<thead>
<tr>
<th>ADG category</th>
<th>ADG</th>
<th>Intake</th>
<th>D/var. (kg)</th>
<th>Freq.</th>
<th>Duration</th>
<th>Feed:gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>1.41</td>
<td>7.45</td>
<td>2.88</td>
<td>5.21</td>
<td>135.55</td>
<td>6.03</td>
</tr>
<tr>
<td>Avg</td>
<td>1.12</td>
<td>7.04</td>
<td>2.69</td>
<td>4.54</td>
<td>129.43</td>
<td>6.93</td>
</tr>
<tr>
<td>Low</td>
<td>0.87</td>
<td>6.72</td>
<td>2.63</td>
<td>4.52</td>
<td>124.16</td>
<td>8.12</td>
</tr>
</tbody>
</table>

Feed:Gain category

<table>
<thead>
<tr>
<th>Feed:Gain category</th>
<th>ADG</th>
<th>Intake</th>
<th>D/var. (kg)</th>
<th>Freq.</th>
<th>Duration</th>
<th>Feed:gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>1.33</td>
<td>6.24</td>
<td>2.93</td>
<td>4.36</td>
<td>125.64</td>
<td>5.88</td>
</tr>
<tr>
<td>Avg</td>
<td>1.14</td>
<td>7.13</td>
<td>2.67</td>
<td>4.59</td>
<td>129.81</td>
<td>6.87</td>
</tr>
<tr>
<td>Low</td>
<td>0.91</td>
<td>7.60</td>
<td>2.70</td>
<td>4.82</td>
<td>129.49</td>
<td>8.31</td>
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</table>

P value = 0.001
### Finishing

<table>
<thead>
<tr>
<th>ADG category</th>
<th>Intake</th>
<th>D/var. (kg)</th>
<th>Freq.</th>
<th>Duration</th>
<th>Feed: gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (1.61-1.72)</td>
<td>1.65</td>
<td>8.95</td>
<td>3.15</td>
<td>4.88</td>
<td>73.99</td>
</tr>
<tr>
<td>Avg (1.27-1.58)</td>
<td>1.43</td>
<td>8.55</td>
<td><strong>3.25</strong></td>
<td>4.63</td>
<td>81.79</td>
</tr>
<tr>
<td>Low (0.90-1.26)</td>
<td>1.18</td>
<td>8.13</td>
<td>3.17</td>
<td>4.70</td>
<td>86.69</td>
</tr>
</tbody>
</table>

**Feed:Gain category**

| High (4.35-6.10) | 1.63 | 8.04 | 3.21 | 4.42 | 74.28 | 5.62 |
| Avg (6.12-7.78) | 1.44 | 8.57 | 3.23 | 4.67 | 81.18 | 6.85 |
| Low (7.82-11.30) | 1.19 | 8.80 | 3.20 | 4.74 | 92.27 | 8.52 |

**P value = 0.001**

### Overall

<table>
<thead>
<tr>
<th>ADG category</th>
<th>N</th>
<th>ADG means</th>
<th>Intake</th>
<th>D/var. (kg)</th>
<th>Freq.</th>
<th>Duration</th>
<th>Feed: gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (1.47-1.60)</td>
<td>9</td>
<td>1.54</td>
<td>8.69</td>
<td><strong>3.08</strong></td>
<td>4.88</td>
<td>99.99</td>
<td>5.76</td>
</tr>
<tr>
<td>Avg (1.21-1.45)</td>
<td>52</td>
<td>1.34</td>
<td>8.04</td>
<td><strong>2.94</strong></td>
<td>4.63</td>
<td>102.04</td>
<td>6.13</td>
</tr>
<tr>
<td>Low (0.98-1.20)</td>
<td>13</td>
<td>1.12</td>
<td>7.66</td>
<td>2.72</td>
<td>4.70</td>
<td>102.79</td>
<td>6.91</td>
</tr>
</tbody>
</table>

**Feed:Gain category**

| High (4.85-5.22) | 11 | 1.43 | 7.55 | **3.28** | 4.44 | 106.52 | 5.04 |
| Avg (5.25-6.28) | 50 | 1.33 | 8.05 | **2.85** | 4.90 | 106.63 | 5.69 |
| Low (6.37-7.07) | 13 | 1.22 | 8.50 | 2.90 | 4.93 | 110.21 | 6.62 |

**P value = 0.001**
High ADG steer

Intake (kg/dm)

Day 0 | Backgrounding phase | Day 213 | Finishing phase

High ADG = 1.55 kg
Low ADG = 1.08 kg
Feed delivery
High ADG steer

Intake (kg/dm)

D-0 D-21

17.3 kg
9.2 kg
6.7 kg

Implications

• Acidosis
• Consumption patterns
• Current beliefs based upon average animals?
Effect of uniformity of feed delivery on feeding behavior, ruminal pH and growth performance of feedlot cattle

K. Schwartzkopf-Genswein¹, T.A. McAllister², D. J. Gibb², K. A. Beauchemin² and M. Streeter³

BUNK MANAGEMENT

• Controlling intake
• Improving FE
• Transition
Variation in Intake

Large variations in intake may cause digestive disturbance and reduce performance

- Fulton et al., 1979
- Britton and Stock, 1987
- Stock, 1995
- Galyean et al., 1992

Intake and rumen pH

- Over consumption
- High pH
- Reduced intake
- Low pH

Milton, 2000
Intake variation and performance (Galyean et al., 1992)

- 380 kg calves, program fed
- 10% daily, or weekly fluctuations (DMI = between groups)
- Constant feeding resulted in:
  - 6% higher average daily gain
  - 7% improvement in feed efficiency
  - Acidosis ??

Intake variation and acidosis

- Summary of trials that found no difference
  - Zinn, R.A., 1994
  - Stock et al., 1995
  - Soto-Navarro et al., 1997
  - Cooper et al., 1998
Objectives

- Experiment 1 - Determine effects of fluctuation in quantity of feed delivered
  - Intake, Rumen pH

- Experiment 2 - Determine effects of fluctuation and time of feed delivery
  - Intake, ADG, FE, Feeding behavior

Methods - Experiment 1

- 6 cannulated steers (797 kg)
- Barley grain/silage finishing diet
- *ad libitum* DMI determined (10.3 kg/d)
- Record feed offered and refused
Methods - Experiment 1

Treatment

C = Constant feed delivery (ad libitum intake)

F = 10% above and below A (3d)

Continuous measurement of pH

- Electrodes calibrated daily
- Data collected every 5 s
- Average over 15 min
## pH Data

- Daily each steer, each period
  - mean pH
  - Max
  - Min
  - Amount and % time pH below 5.8 -5.5

## pH Results

<table>
<thead>
<tr>
<th></th>
<th>Fluctuating</th>
<th>Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean pH</td>
<td>5.63&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.73&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Min pH</td>
<td>5.04</td>
<td>5.17</td>
</tr>
<tr>
<td>Max pH</td>
<td>6.53</td>
<td>6.45</td>
</tr>
<tr>
<td>Time pH &lt; 6.2 (h)</td>
<td>18.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time pH &lt; 5.8 (h)</td>
<td>14.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.5&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time pH &lt; 5.5 (h)</td>
<td>11.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.0&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a,b P < .15</sup>  
<sup>c,d P < .05</sup>  

Proc Mixed SAS
DMI Results

F - 8.81 +/- 1.01
C - 8.66 +/- .84       P = .15

• C feeding did not eliminate day-day var.

• 99% of variation = 2.5 kg or 29% of DMI

• Risk of acidosis not related to intake

Methods - Experiment 2

• 240 cross bred steers (310 +/- 23 kg)

• Treatments
  C - Constant feed delivery
  F - Fluctuating feed delivery (10% above and below)

• 209 d trial
Methods - Experiment 2

- 16 pens -15hd/pen - 8 pens/treatment
- 209 d trial - backgrounding and finishing
- Barley grain / barley silage diet
- Weighed and vaccinated on arrival

Performance Data

- Weights - 21d intervals
- ADG
- Feed Efficiency - F:G ratio
- Intake - Feed delivered daily - feed refusals for pen
Feeding Behavior

60 steers - 4 pens

Bunk attendance (frequency and duration)

Global system overview

Constant vs Fluctuating Feeding

<table>
<thead>
<tr>
<th>Treatment</th>
<th>C</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steers, no. (pens)</td>
<td>120 (8)</td>
<td>120 (8)</td>
</tr>
<tr>
<td>Daily gain, kg</td>
<td>1.23</td>
<td>1.20</td>
</tr>
<tr>
<td>Daily DMI, kg/steer</td>
<td>7.35</td>
<td>7.39</td>
</tr>
<tr>
<td>Feed Efficiency</td>
<td>6.22</td>
<td>6.41</td>
</tr>
<tr>
<td>Bunk attendance, min/d</td>
<td>23.40</td>
<td>23.25</td>
</tr>
<tr>
<td>Frequency, visits/d</td>
<td>10.22&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.82&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a,b</sup> P <.01 Proc Mixed
Conclusions

- Risk of ruminal acidosis was increased with fluctuation feed delivery but increased risk did not impair performance.

- Feedlot cattle on finishing diets appear to adapt to fluctuations in intake with little effect on performance.
Effect of rapid vs. gradual adaptation to a high concentrate diet on rumen pH and fermentation of feedlot cattle

D.W. Bevans, K.S. Schwartzkopf-Genswein, T.A. McAllister, K.A. Beauchemin and J.J. McKinnon

Grain adaptation

- Abrupt dietary change from forage to concentrate can result in acidosis (Goad et al., 1998; Coe et al., 1999)

- Acidosis results in reduced feed intake and performance (Owens et al., 1998)
Step-up programs
• Dietary concentrate is typically increased in a step-up manner
  • Series of sequential diets with increasing grain concentration
  • Many variations exist

• Common Goal
  • To achieve a high level of concentrate intake as rapidly as possible without causing significant acidosis

Step-up programs - Acidosis
• Even with step-up programs some acidosis is prevalent during grain adaptation (Burrin and Britton, 1986)

• All cattle experience some level of acidosis during grain adaptation (Klopfenstein et al., 2003)
Objectives

- To determine effects of rapid vs. gradual adaptation to a high grain diet on rumen pH and fermentation

Methods

- 12 cannulated heifers (384 ± 25 kg)
- Adapted from 40 to 90% concentrate
- Rapid or gradual adaptation
Ruminal pH – Continuous data

- 20 d of rumen pH
  - Summarized for each day as
    - Mean
    - Minimum
    - Maximum
    - Area < pH 6.2, 5.6, 5.2
    - Time pH < 6.2, 5.6, 5.2

pH results – 65% concentrate

- d 1, d 2, d 3
  - pH variable means did not differ ($P > 0.14$)
- 3 d combined
  - Area pH < 5.6 tended to be greater for rapid adaptation ($P = 0.08$)
### pH results - 65% concentrate (d 1)

<table>
<thead>
<tr>
<th></th>
<th>Rapid</th>
<th>Gradual</th>
<th>Equality of variance (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean pH</td>
<td>5.86 ± 0.42</td>
<td>5.97 ± 0.12</td>
<td>0.02</td>
</tr>
<tr>
<td>Min pH</td>
<td>5.29 ± 0.37</td>
<td>5.36 ± 0.17</td>
<td>0.12</td>
</tr>
<tr>
<td>Area pH &lt; 5.6 (pH x h)</td>
<td>2.43 ± 2.64</td>
<td>0.62 ± 0.70</td>
<td>0.01</td>
</tr>
<tr>
<td>Time pH &lt; 5.6 (h)</td>
<td>7.96 ± 7.56</td>
<td>3.88 ± 2.91</td>
<td>0.06</td>
</tr>
<tr>
<td>Area pH &lt; 5.2 (pH x h)</td>
<td>0.28 ± 0.45</td>
<td>0.01 ± 0.03</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Time pH &lt; 5.2 (h)</td>
<td>2.47 ± 3.45</td>
<td>0.18 ± 0.44</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

(diff. between means \( P > 0.14 \))

### pH results - 90% concentrate

- d 1, d 2, d 3, d 4 and combined 3 d
- pH variable means did not differ \((P > 0.15)\)
pH results - 90% concentrate (d 1)

<table>
<thead>
<tr>
<th></th>
<th>Rapid</th>
<th>Gradual</th>
<th>Equality of variance (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean pH</td>
<td>5.62 ± 0.30</td>
<td>5.70 ± 0.23</td>
<td>0.54</td>
</tr>
<tr>
<td>Min pH</td>
<td>5.01 ± 0.29</td>
<td>5.10 ± 0.16</td>
<td>0.22</td>
</tr>
<tr>
<td>Area pH &lt; 5.6 (pH x h)</td>
<td>4.27 ± 4.08</td>
<td>2.72 ± 1.92</td>
<td>0.12</td>
</tr>
<tr>
<td>Time pH &lt; 5.6 (h)</td>
<td>11.99 ± 6.55</td>
<td>10.19 ± 5.20</td>
<td>0.62</td>
</tr>
<tr>
<td>Area pH &lt; 5.2 (pH x h)</td>
<td>1.11 ± 1.69</td>
<td>0.24 ± 0.33</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Time pH &lt; 5.2 (h)</td>
<td>4.58 ± 5.28</td>
<td>2.18 ± 1.19</td>
<td>0.04</td>
</tr>
</tbody>
</table>

(diff. between means P > 0.15)

Rumen fermentation

- Ruminal sampling on days of grain increase
  - 0, 8, 18 h post-feeding
- Measured
  - VFA
  - Lactate
  - Osmolality
- Means did not differ between treatments (P < 0.05)
  - 65 and 90% concentrate
Feed intake

- DMI and DMI variation was not affected by treatment on any day of feeding 65 or 90% concentrate
- Overall DMI was less on d 2 of each diet than on d 1 ($P < 0.05$)

Rumen pH – Individual animal variation
Implications

- Extreme variation exists in ability of cattle to deal with grain adaptation
- Rapid adaptation to high concentrate diets results in increased risk of acidosis for some individuals
- Management of grain adaptation must be tailored to the most susceptible animals if acidosis is to be prevented

Role of feed choice in reducing acidosis
Feeding techniques to improve welfare of cattle fed high grain diets

- Determine optimal forage: concentrate ratio in finishing diets based on animal choice, health and performance.

Total Mixed Ration (TMR)
Hypothesis

- If calves have access to grain and forage separately they will select a diet that best maintains rumen health and prevents acidosis and liver abscesses.

Treatments

- 120 heifers (585 ± 39 kg)
- 8 pens - 15 animals/pen
Methods

• 0900, 1300 and 1500 to accommodate *ad libitum* appetite

• 68 d trial

• Weighed every 2 wks

• Weigh backs collected daily

Methods

Individual animal information

• Intake
• ADG
• Feed efficiency
• Feeding behaviour
• Carcass - warm carcass weight, fat cover, ribeye area marbling quality

• Liver Abscess scores
  0 –no abscess
  3 –severe abscess  1 abscess > 2.5 cm in diameter
### Results

<table>
<thead>
<tr>
<th></th>
<th>Choice</th>
<th>TMR</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heifers</strong></td>
<td>60</td>
<td>59</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pens</strong></td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Initial wt</strong></td>
<td>593.2</td>
<td>593.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DMI (kg)</strong></td>
<td>7.6</td>
<td>10.3</td>
<td>0.21</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td><strong>Barley % DMI</strong></td>
<td>80.4</td>
<td>87.7</td>
<td>0.83</td>
<td>.0008</td>
</tr>
<tr>
<td><strong>ADG (kg)</strong></td>
<td>1.34</td>
<td>1.39</td>
<td>.07</td>
<td>.636</td>
</tr>
<tr>
<td><strong>FE gain:feed kg</strong></td>
<td>.17</td>
<td>.13</td>
<td>.005</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

#### Graph

- **CH Barley %**
- **TMR Barley %**

- **Week 1-2**: 
  - CH: **
  - TMR: 

- **Week 3-4**: 
  - CH: **
  - TMR: 

- **Week 5-6**: 
  - CH: **
  - TMR: 

- **Week 7-8**: 
  - CH: **
  - TMR: 

- **Week 9-10**: 
  - CH: **
  - TMR: 

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**Notes**: 
- **CH Barley %** and **TMR Barley %** are compared across different weeks. The graph indicates a statistical significance indicated by **, **, and *** marks.
Results

<table>
<thead>
<tr>
<th></th>
<th>Choice</th>
<th>TMR</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm carcass wt (kg)</td>
<td>396.0</td>
<td>397.7</td>
<td>1.48</td>
<td>.450</td>
</tr>
<tr>
<td>Fat Cover (mm) 1</td>
<td>15.9</td>
<td>16.8</td>
<td>.36</td>
<td>.186</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>13.4</td>
<td>.64</td>
<td>.583</td>
</tr>
<tr>
<td>Grade fat</td>
<td>12.9</td>
<td>13.0</td>
<td>.56</td>
<td>.861</td>
</tr>
<tr>
<td>Average fat</td>
<td>14.1</td>
<td>14.6</td>
<td>.46</td>
<td>.489</td>
</tr>
<tr>
<td>REA cm²</td>
<td>94.4</td>
<td>94.7</td>
<td>.59</td>
<td>.790</td>
</tr>
<tr>
<td>Marbling Quality</td>
<td>2.8</td>
<td>2.7</td>
<td>.08</td>
<td>.209</td>
</tr>
<tr>
<td>Marbling level</td>
<td>38.2</td>
<td>45.2</td>
<td>3.49</td>
<td>.229</td>
</tr>
<tr>
<td>Salable meat %</td>
<td>56.8</td>
<td>56.1</td>
<td>.57</td>
<td>.461</td>
</tr>
<tr>
<td>Liver score</td>
<td>.59</td>
<td>.50</td>
<td>.16</td>
<td>.697</td>
</tr>
</tbody>
</table>
Conclusions

- Choice do not over consume grain
- Select diet with less grain then current industry practice
- Overall performance id the same or better (FE)
- Trend towards reduced liver abscess
- Atwood et al. (2001) found that producing animals on a free-choice diet could reduce costs by almost 25 %