Interactions of health, disease, and nutrition in dairy calves

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Cornell University

Cow/Calf

Pathogen
(e.g. Salmonella)

Environment
(e.g. fecal contamination)

How are we doing with calves?
Not so good!
Why bother with good youngstock programs?

- Herd Growth if you want
- Animals to sell if you want
- Better culling decisions
- More milk
- We like calves
8% heifer death is average!
e.g. ~150 cow dairy losing ~5 calves/year

3% loss is very achievable!
e.g. 150 cow dairy losing 1-2 calves/year

---

PASSIVE TRANSFER!!
**Colostrum vs. Milk**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Colostrum</th>
<th>Transmition milk</th>
<th>Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (%)</td>
<td>2.25</td>
<td>1.95</td>
<td>1.72</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>4.7</td>
<td>3.8</td>
<td>2.7</td>
</tr>
<tr>
<td>Total solids (%)</td>
<td>5.4</td>
<td>4.8</td>
<td>3.8</td>
</tr>
<tr>
<td>Minerals (%)</td>
<td>1.0</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Sodium (mg/dl)</td>
<td>738</td>
<td>578</td>
<td>42</td>
</tr>
<tr>
<td>Calcium (mg/dl)</td>
<td>110</td>
<td>87.7</td>
<td>78</td>
</tr>
<tr>
<td>Phosphate (mg/dl)</td>
<td>26.5</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>Magnesium (mg/dl)</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Bicarbonate (mg/dl)</td>
<td>16.0</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>赖氨酸 (mg/dl)</td>
<td>900</td>
<td>700</td>
<td>500</td>
</tr>
<tr>
<td>蛋氨酸 (mg/dl)</td>
<td>85</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td>蛋氨酸-乙酰基 (mg/dl)</td>
<td>5.5</td>
<td>4.5</td>
<td>3.0</td>
</tr>
<tr>
<td>谷氨酰胺 (mg/dl)</td>
<td>9.0</td>
<td>6.0</td>
<td>4.0</td>
</tr>
<tr>
<td>乳酸 (mg/dl)</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
</tr>
</tbody>
</table>

**Monitoring Passive Transfer**

- Serum total proteins
- TP estimates IgG levels
- Frequency
  - Dependent on herd size & calving rate
  - 1x/month < 1,000 cows
  - 2x/month > 1,000 cows
- Red top tubes
- Clot and spin
- Sit for 24 hours
- Refractometer
  - $250
  - Group of 12 healthy calves
  - 24 hrs - 7 days of age
  - Goal: TP ≥ 5.2mg/dl in > 9/12 calves

**Agents associated with Calf Scours**

- Bacteria
  - *E. coli*, *Salmonella*, *Clostridium*, *Sarcina*, etc.
- Viruses
  - Rotavirus, Coronavirus, BVD, etc.
- Protozoa
  - *Cryptosporidium*, *Giardia*, etc.
Cattle agents that are zoonotic in North America

- Bacteria
  - *E. coli*, *Salmonella*, *Listeria*, etc.
- Viruses
  - None? (Rabies)
- Protozoa
  - *Cryptosporidium*, *Giardia*, etc.

Cryptosporidium

The pathogen most commonly diagnosed in association with calf scours

 Crypto Background Information

- Pathogenic Protozoa of Phylum Apicomplexa
- Worldwide Distribution
- Monoxenous life cycle
- Sporulated oocyst
- 4-5 micro meters
**Cryptosporidium parvum**

**Prevalence**
- USA
  - Garber, 1994
- BC
  - Olson, 1997
- Quebec
  - Ruest, 1998
- Ontario
  - Trotz-Williams
- Argentina
  - Del Cocco, 2008
- Switzerland
  - Uhde, 2008
- Norway
  - Gulliksen, 2009
- Sweden
  - Silverlas, 2009
- Netherlands
  - Barilis, 2010
- Belgium
  - De Graaf, 1999

- 60-95% Herds
- 20-80% Calves
- Up to 80% within herd prevalence

**Mechanism of disease**

PPP 4-7 d
Shed ~10 d

day 0 d2 d7 d17 d21
Mechanism of disease

Background Information

- Survivability
  - Fecal material: 100 – 400 d
  - Soil: >160 d
  - Water: >160 d
  - A portion remain viable after freezing

Background Information

- Disinfection
  - Resistant to:
    - bleach
    - Virkon
    - iodophores
    - 10% formalin works though?
  - Effective:
    - Pasteurization
    - Steam disinfection
Transmission:
Mostly fecal oral, but...

And rodents?

Quantify risk calves pose:
- Study Design:
  - 478 dairy calves recruited from a longitudinal study
  - 4-21 days old
  - 37 farms in New York
  - Oocysts enumerated by sugar flotation and microscopy

Number of *Cryptosporidium parvum* oocysts or *Giardia* spp cysts shed by dairy calves after natural infection

Daryl V. Nield, DVM; Susan E. Wade, PhD; Stephanie L. Schoof, BA; Husain O. Mohamed, BVSc, MPOV, PhD

1912 AJVR, Vol 62, No. 10, October 2001
Quantify risk calves pose

• Computation:

\[ \int_a^b \left( (32105.2 \text{ age}) - (1398.6 \text{ age}^2) \right) \, dx \]

a=age at onset
b=age at termination

Example:

- Calf sheds from 8 to 10 days old
- Model predicts 350,388 oocysts/g
- Data: 5.4 kg/day

Conclusion:

- 189,095,200 oocysts shed by average infected calf
- This is a significant number of oocysts with potential for environmental contamination and transmission to susceptible hosts
- ID_{50} = 132 oocysts for seronegative people
- Calves infected with as few as 50 oocysts consistently create scouris with 6000 oocysts
Do people get Crypto from cows?

- Short Answer: YES
- Long Answer: SOMETIMES
- Need to talk about nomenclature and genotyping

Cryptosporidium species / genotypes

- C. parvum
  - Genotype H (1); C (2)
    - C. hominis, C. parvum
- C. hominis
- C. andersoni (muris)
- C. muris
- C. felis
- C. serpentis
- C. etc.

Species / Genotyping

Cattle often implicated as source of C. parvum oocysts in drinking-water outbreaks

At least 2 species that infect humans

- C. hominis
- C. parvum
Objective

Determine the potential risk of *Cryptosporidium parvum* and *C. hominis* in dairy herds in the NYC Watershed

Risk of infection with *Cryptosporidium parvum* and *Cryptosporidium hominis* in dairy cattle in the New York City watershed

Drs. S. Nyamai, DVM, PhD; Goldberg, H. Lecon, MD, PhD; Creamer, J. L. Smith, MD, PhD; Schaff, E. Schaff, RA; Wiede, E. W.; Hamid, O. Mohammed, BVSc, MPVM, PhD

JAV, Vol. 84, No. 3, March 2006

New York City’s Water Supply System
Materials and Methods

Study Design:
- Target Population: Dairies in 5 counties in NYCW
- 27 randomly selected farms; weighted proportional sampling of calves at risk
- Human fecal samples from outbreaks and sporadic cases
- C. parvum oocysts detected by quantitative concentration flotation

Public Health Concerns and Genotyping

437 isolates, 95% Confidence

638 bp
331 bp
57 bp

Conclusions

Cattle in the NYCW have only the C. parvum genotype

Cattle may not be the 1st source of human drinking water outbreaks
Discussion

Review of North American drinking water outbreaks; all but 1 associated with H genotype (C. hominus)

Cattle are not the likely source of waterborne outbreaks which are of the H genotype (C. hominus) at least in North America

In Europe waterborne outbreaks have been associated with C. parvum type 2 / C. hominus??

Treatment/Prophylaxis

- Allicin
- Trimethoprim-sulfa, sulfadimidine, sulfadimethoxine
- Amprolium
- Ionophores?
  - Effective dose ~ LD₅₀

- Azithromycin
  - ~$20/g
  - 1g/day for 7 days → $140

- Decoquinate?
  - 5x dose suggested (2.5mg/kg)
  - 2 trials indicate limited effect

- Paromomycin?
  - Aminoglycoside?, $60/day
Treatment /Prophylaxis

- Halofuginone?
  - 3 European studies indicating some effectiveness
  - Canadian study:
    - No difference in daily gain or intakes
    - Did delay shedding and decrease amount shed
  - Not currently available in North America (except emergency approval)
  - Estimated at $10 - 15/ treated calf

Objective of our study...

...to perform a randomized, blinded, controlled study evaluating the effect of nitazoxanide (NTZ) on cryptosporidiosis in experimentally challenged neonatal dairy calves.

J. Dairy Sci. 92:1643-1648
DOI 10.3168/jds.2008-1474

Effect of nitazoxanide on cryptosporidiosis in experimentally infected neonatal dairy calves

E. L. Wilcox, D. V. Rutish, B. L. Leonard, M. L. Balfour, T. C. Linden, and T. J. Divens

Department of Translational Sciences, Box 20, College of Veterinary Medicine, Cornell University, Ithaca, NY 14853

Department of Pediatrics and Diagnostic Sciences, Box 20, College of Veterinary Medicine, Cornell University, Ithaca, NY 14853

Department of Microbiology and Immunology, CS-VTH VMC, College of Veterinary Medicine, Cornell University, Ithaca, NY 14853
Materials & Methods

- Clean delivery
- Rapid transport to isolation facility
- 23 Holstein bull calves
- 32 Feeding follow up

Materials & Methods

- Feeding
  - Non-medicated milk replacer
  - 1.5 lbs dry matter/day
  - Twice daily
- Cleaning
  - New bedding daily
  - Separate equipment
  - High pressure, hot water between calves

Materials & Methods

- Challenge Model
  - $1 \times 10^6$ *C. parvum* oocysts
  - 1 hr after feeding #3
  - Serum protein $\geq 5$ mg/dl
- Outcomes measured:
  - Body weight
  - Health score
  - Fecal score
  - Oocyst count
Materials & Methods

Health Scoring
1) Normal
2) Depressed
3) Very depressed
4) Moribund or dead

Materials & Methods

Fecal Scoring
1) Normal
2) Mild diarrhea
3) Severe diarrhea

Materials & Methods

Treatment Criteria
- Feeding ≥ #11
- Fecal score ≥ 2

Dose
- 1.5 g NTZ PO BID x 5 days
- Equivalent to 4.7 g commercial NTZ paste
Materials & Methods

- Oocyst counting
  - IFA
- Data analysis
  - Wilcoxon Rank Sum
  - Survival Analysis
  - Chi Square Analysis

Results

- 13 NTZ treated calves
- 7 placebo treated calves
- Diarrhea
- Palatable
- Easily administered
- Non-toxic

<table>
<thead>
<tr>
<th></th>
<th>Treatment (median)</th>
<th>Control (median)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Protein at feeding 3</td>
<td>5.4 g/dl</td>
<td>5.40 g/dl</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Body Weight at feeding 3</td>
<td>117 lbs</td>
<td>110 lbs</td>
<td>0.8</td>
</tr>
<tr>
<td>Onset Oocyst Shedding</td>
<td>7 days</td>
<td>7 days</td>
<td>1.0</td>
</tr>
</tbody>
</table>

![Image: Cryptosporidium parvum 01.jpg](http://commons.wikimedia.org/wiki/Image:Cryptosporidium_parvum_01.jpg)
The Effect of Nutritional Plane on Health and Performance of Dairy Calves After Experimental Infection with *C. parvum*

TL Ollivett, DV Nydam, TC Linden, DD Bowman, M. Van Amburgh
Objective of our study...

to evaluate the effect of nutritional plane on health and performance of dairy calves after experimental infection with C. parvum.

Materials & Methods - Acquisition

- Clean delivery
- Immediate isolation
- 29 Holstein bull calves
- 42 Feeding (21d) follow up

Feeding Strategies

- Calves randomized at birth
- Conventional (CN) v. High Plane of Nutrition (HPN)
- Commercially available milk replacers
- Feeding rates based on metabolic body weight (MBW) (body mass that significantly contributes to metabolism)
  - MBW = (kg)^0.7
Current Feeding Standards

- “female calves in the US destined for herd replacements should be fed restricted amounts of milk or milk replacer (typically 8-10% of birth weight) to encourage early consumption of calf starter”

- “growth rates... and feed efficiency is lower than that in the young of other farm animals allowed to consume milk ad libitum”
  - NRC, 2001

Amount of MR/Milk DM to meet Maintenance Requirements and Gain 1lb/day

<table>
<thead>
<tr>
<th>Body weight, lbs</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>-5</td>
</tr>
<tr>
<td>60</td>
<td>1.1</td>
</tr>
<tr>
<td>80</td>
<td>1.2</td>
</tr>
<tr>
<td>100</td>
<td>1.4</td>
</tr>
<tr>
<td>120</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Environment Effects Maintenance Requirements

- Thermoneutral zone for calves <21d is 59 – 80 F
- In New York, ~160 d below 59 F
- For calves >21 days the lower critical temp = 42 F
Feeding Calculations

<table>
<thead>
<tr>
<th>Calf ID</th>
<th>BW, KG</th>
<th>MBW</th>
<th>Feeding rate</th>
<th>Mcal/d</th>
<th>MR, Mcal/kg</th>
<th>MR, kg/d</th>
<th>MR, lb/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>18.80</td>
<td>0.130</td>
<td>2.444</td>
<td>4.040</td>
<td>0.409</td>
<td>1.080</td>
</tr>
</tbody>
</table>

HPN for days 1-7

<table>
<thead>
<tr>
<th>Calf ID</th>
<th>BW, KG</th>
<th>MBW</th>
<th>Feeding rate</th>
<th>Mcal/d</th>
<th>MR, Mcal/kg</th>
<th>MR, kg/d</th>
<th>MR, lb/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>50</td>
<td>18.80</td>
<td>0.230</td>
<td>4.325</td>
<td>5.000</td>
<td>0.655</td>
<td>1.550</td>
</tr>
</tbody>
</table>

Maintenance requirement = 1.75 Mcal/day

(Thermoneutral zone; no pathogen load)

Feeding Summary

<table>
<thead>
<tr>
<th>CN</th>
<th>HPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 20% protein 20% fat</td>
<td>• 28% protein 20% fat</td>
</tr>
<tr>
<td>• 1 lb dry matter (DM) per day</td>
<td>• 2.5 lbs DM per day</td>
</tr>
<tr>
<td>• 2.4 Mcals/day</td>
<td>• 5.6 Mcals/day</td>
</tr>
</tbody>
</table>

Materials & Methods - Infection

- Serum protein > 5 g/dl
- 1 x 10⁶ C. parvum oocysts
- 1 hr after feeding 5

PPP ~3 d  Shedding ~10d

F0  F5  F11  F32  F42
Materials & Methods - Outcomes

- Health score
- Fecal score
- Oocyst count
- Packed Cell Volume
- Dry matter intake (DMI)
- Average daily weight gain (ADG)
- Feed Efficiency

Materials & Methods - Analysis

- Oocyst counting
  - IFA
- Data analysis
  - Wilcoxon Rank Sum
  - Regression Analysis
  - Chi-Square
  - Survival Analysis

Results

<table>
<thead>
<tr>
<th></th>
<th>HPN (median)</th>
<th>CN (median)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Protein at feeding 5</td>
<td>5.5g/dl</td>
<td>5.3g/dl</td>
<td>0.4</td>
</tr>
<tr>
<td>Body Weight at feeding 5</td>
<td>103 lbs</td>
<td>104 lbs</td>
<td>0.8</td>
</tr>
<tr>
<td>Packed Cell Volume at feeding 5</td>
<td>30%</td>
<td>32%</td>
<td>0.15</td>
</tr>
</tbody>
</table>

- 11 HPN calves
- 9 CN calves
- 100% Diarrhea
- 0 Treatments
Results

No Difference
(P>0.7)

- Peak shedding
- Total shedding
- Onset of shedding
- Duration of shedding

Packed Cell Volume

<table>
<thead>
<tr>
<th>Age (d)</th>
<th>Median PCV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CN</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>10</td>
<td>34</td>
</tr>
<tr>
<td>12</td>
<td>36</td>
</tr>
<tr>
<td>14</td>
<td>38</td>
</tr>
<tr>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td>18</td>
<td>42</td>
</tr>
</tbody>
</table>

- D8: HPN vs CN P=0.3
- D8 HPN vs D21 HPN P=0.5
- D8 CN vs D21 CN P=0.04

Resolution of diarrhea

- Regression Analysis
  - HPN slope = -0.1
  - CN slope = -0.01
  - P = 0.03

- Interpretation
  - FS improve 10x per day
Conclusions

- HPN reduces the effect of disease due to *C. parvum* in neonatal dairy calves
- Calf behavior should be predominant factor affecting calf feeding; not fecal consistency

**Effect of nutritional plane on health, performance and muscle metabolism in neonatal dairy calves**

- Theresa L. Ollivett, DVM
- Daryl Nydam, DVM, PhD; Mike VanAmburgh, PhD;
- Joe Wakshlag, DVM, PhD, DACVN
Questions

- Important?
- Characterize?
  - Hydration status?
  - Lipolysis?
  - Muscle wasting?

**Calf Weight By Age**

- HPN
- CN

- Median Weight (kg)

- Age

- 4.3% HPN
- 8.5% CN

**Questions**

- Important?
- Characterize?
  - Hydration status?
  - Lipolysis?
  - Muscle wasting?

- PCV, TP, Creatinine
- NEFA
- Markers of muscle metabolism
Objective

- evaluate the effect of nutritional plane on health, performance and muscle metabolism in neonatal dairy calves
Materials & Methods - Acquisition

- Clean delivery
- Immediate isolation
- 20 Holstein calves (M & F)
- 28 Feeding (14d) follow up

Materials & Methods - Treatment

- Treatment Groups

  - Conventional Nutrition (CN)
  - Higher Plane Nutrition (HPN)

<table>
<thead>
<tr>
<th>ID</th>
<th>BW, kg</th>
<th>MBW (kg)</th>
<th>Feeding rate</th>
<th>Mcal/d</th>
<th>MR, Mcal/kg</th>
<th>MR, lb/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>18.80</td>
<td>0.13</td>
<td>2.44</td>
<td>4.90</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Maintenance energy requirement = 1.75 Mcal/day
(thermoneutral zone; no pathogen load)

<table>
<thead>
<tr>
<th>ID</th>
<th>BW, kg</th>
<th>MBW (kg)</th>
<th>Feeding rate</th>
<th>Mcal/d</th>
<th>MR, Mcal/kg</th>
<th>MR, lb/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>50</td>
<td>18.80</td>
<td>0.23</td>
<td>4.33</td>
<td>5.06</td>
<td>1.88</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ID</th>
<th>BW, kg</th>
<th>MBW (kg)</th>
<th>Feeding rate</th>
<th>Mcal/d</th>
<th>MR, Mcal/kg</th>
<th>MR, lb/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>50</td>
<td>18.80</td>
<td>0.30</td>
<td>5.64</td>
<td>5.06</td>
<td>2.45</td>
</tr>
</tbody>
</table>
Materials & Methods - Outcomes

- Health score
- Fecal score
- Packed Cell Volume
- Serum Total Protein
- NEFA, creatinine
- Body Weight
- Muscle biopsy*


Materials & Methods - Analysis

- Atrogin
- Western blot
- Densitometry

Data
- Wilcoxon Rank Sum
- Regression Analysis
- Chi-Square

Results

<table>
<thead>
<tr>
<th></th>
<th>HPN (median)</th>
<th>CN (median)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Wt</td>
<td>42.75 kg</td>
<td>42.25 kg</td>
<td>1.0</td>
</tr>
<tr>
<td>TP day 3</td>
<td>5.9 g/dL</td>
<td>5.7 g/dL</td>
<td>0.40</td>
</tr>
<tr>
<td>TP day 14</td>
<td>5.6 g/dL</td>
<td>5.6 g/dL</td>
<td>0.88</td>
</tr>
<tr>
<td>PCV day 1</td>
<td>36%</td>
<td>35%</td>
<td>0.88</td>
</tr>
<tr>
<td>PCV day 14</td>
<td>32%</td>
<td>28%</td>
<td>0.07</td>
</tr>
<tr>
<td>NEFA day 1</td>
<td>0.095</td>
<td>0.29</td>
<td>0.05</td>
</tr>
<tr>
<td>NEFA day 7</td>
<td>0.25</td>
<td>0.27</td>
<td>0.20</td>
</tr>
<tr>
<td>Creat day 1</td>
<td>2.5</td>
<td>2.5</td>
<td>0.50</td>
</tr>
</tbody>
</table>

- n=10 HPN
- n=10 CN
- 3 treated dehydration
- 1 died Abomasitis
Feed Efficiency

<table>
<thead>
<tr>
<th>ADG:DMI (kg/kg)</th>
<th>HPN</th>
<th>CN</th>
</tr>
</thead>
<tbody>
<tr>
<td>P &lt; 0.0001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusions

- Upregulation of proteolytic pathway (atrogin) occurs in well fed neonatal calves
  - Likely due to muscle turnover during growth

- Early weight loss is preventable
  - Not solely related to hydration status, fat mobilization, or muscle wasting
Acknowledgements
• Tom Earleywine, PhD
• Tom Linden, BS
• FAME 2009
  • Josh Boyden, Blake Nguyen, Molly Hurley, Karen James, Matt Chuff, Steve Furst, Desiree Gentile, Lindsay Goodale

Questions?