Ruminant Nutrition
The Art and the Science of Feeding

Scott Waltner  DVM, MS
Skagit Animal Clinic
Puget Sound Veterinary Nutrition Group, LLC

Metabolic Disease and Toxicology

Outline
- The Big Picture
- Diseases
  - Ketosis
  - Hypocalcemia
  - Hypophosphatemia
  - Hypomagnesemia
- Monitoring
- Investigation
- Summary

Transition Cow Health

- Between Dry Period and Initiation of Lactation
- Any feed transition can be a problem area
- The fewer transitions the better
- Heifers are often very predisposed
  - Social status
  - Competition for feed and water

Where are the mistakes made?

- Cow count
- Computers LIE
- Dry Matter Intake
  - Lack of Tracking Systems
- Overcrowding
  - Fresh cow and CU cow 90% density
- Farm formulation
  - Farmers change rations
- Forage Changes
Ketosis

**Host**

- Pathogen
- Environment

**Ketosis**

- Starvation – Negative Energy Balance
- Not Enough Groceries – Energy
  - Massive Fat Mobilization
  - Liver overwhelmed
  - Ketone Body Formation
    - Acetoacetate
    - β-hydroxybutyrate

**Signalment**

- High producing - Genetics
- Mature
- Over conditioned - BCS > 4/5
- Obese
- High parasite load
- Confined - lack of exercise
- Incidence 5 – 90%

**Clinical Signs**

- Digestive
  - Anorexia
  - Increased rumen motility
  - Massive decrease in milk production
  - Dry, firm, feces
  - Depressed
  - Often normal TPR

- Nervous
  - Digestive signs PLUS
  - Hyper-exitable
  - Ataxia,
  - Hypermetria
  - Excess salivation
  - Aggressive

**Time of Occurrence**

- Postpartum

<table>
<thead>
<tr>
<th>Clinical Characteristics</th>
<th>Postpartum Ketosis</th>
<th>Peak Lactation Ketosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine ketones</td>
<td>Moderate to High</td>
<td>High</td>
</tr>
<tr>
<td>Blood glucose</td>
<td>Low to Normal</td>
<td>Very Low</td>
</tr>
<tr>
<td>Blood NEFA</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Response to Therapy</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Time of Occurrence</td>
<td>6 – 10 days postpartum</td>
<td>3 – 6 weeks postpartum</td>
</tr>
</tbody>
</table>

**Clin. Path. and Ketosis**

Acetoacetate, β-hydroxy butyrate, acetone

- Hyperketonemia
  - > 100 mg / dl
- Hypoglycemia
  - Normal 40 – 60 mg /dl
  - Ketosis 10 – 30 mg/dl
- Lymphocytosis, neutropenia +/-
- Increased NEFA
- Ketoneria
Clin. Path. and Ketosis

- NEFA = Definitive Diagnosis
- Sample on every cow
  - Not so with urine
- Objective analysis
  - Put a number to the symptom

Ketone Tests

- Keto Stix – Ames Company
  - Used on urine or serum, does not work well with milk.
  - Sensitivity – 10 mg acetoacetate/dl
  - Must be kept very dry or they deteriorate and false negatives.

Ketone Tests

- Ross Test
  - Used on urine or serum
  - Sensitive at 2/5 mg/dl of acetone + acetoacetate (expressed as acetone equivalents).
  - Placed approximately one gram of a 1:100 mixture of sodium nitroprusside and ammonium sulphate in a test tube and add 5 ml of urine (or serum). Shake well and then add 2 cc of concentrated ammonium hydroxide. Look for purple color at liquid interface.

Ketone Tests

- Denco Powder (Denver Chemical Manufacturing Co.) consists of sodium carbonate, ammonium carbonate, ammonium sulfate, and sodium nitroprusside in a granular form.
  - Can be used for milk, urine, or serum
  - Read at one minute rather than 15 to 30 sec. for other tests
  - Acetoacetate tends to turn powder pink, acetone turns it purple. Because acetone is usually present in smaller concentrations compared to acetoacetate, a pink reaction is read as a trace to +1 and a purple reaction is +2 to +4.
  - This test can be used as a screening test on milk for subclinical ketosis.
  - Does not work well on colostrum
  - Sensitive at 10 mg acetoacetate/dl

Ketone Tests

- Acetest – Tablet form - Ames Company
  - Used on serum or urine. Sensitive at 10 mg acetoacetate/dl

Metabolic Disposition of Mobilized Fat
Ketosis Therapy and Prevention

- Dextrose – d-glucose
  - 500cc at 50% solution IV
  - Effective time = 2 hours
- Glucocorticoids
  - 20mg Dexamethasone
  - Create hyperglycemia for 36 hours

Metabolic Disposition of Mobilized Fat

Ca Propionate
- Glucose precursor
- 1#
- Nutrical® - Not for Sheep
  - High copper

Propylene Glycol
- 8 oz.
- Over dosage will decrease DMI via CNS depression
Ketosis Therapy and Presentation

**Choline – Rumen Protected**
- Reashure®
- 2 oz/cow/day close-up and fresh
  - 21 to +30 days
- Increase VLDL formation
- Increase fat transport from the liver

Ketosis Therapy and Presentation

- Niacin
  - 6-12g/d PO
  - Decreased lipolysis

Ketosis Therapy and Presentation

- Methioine - Alimet
  - One of two limiting amino acids – First?
  - Addition to ration decreases CHO need for microbial protein production
  - Methyl donation
    - Donation of methyl groups from methionine may further enhance energy balance

**Metabolic Disposition of Mobilized Fat**

- Adipose triglycerides
- Liver
- NEFA
- Glucose
- VLDL
- Hepatocyte Storage
- Ketone Bodies
- Mammary Gland
- Milkfat
Ketosis Drench
- 8 oz Propylene Glycol
- 1 lb Ca Propionate
- 2 oz Rumen Protected Choline
- 1 oz Methionine - Alimet
- 2 oz Yeast
- 6 oz KCL
- qs 5 gal Water

Why Do Cows Get Fat?
Reproduction Failure

Ketosis Treatment and Prevention
Maximize DMI
- Bunk management
- Stocking density

Avoid Exogenous Ketones
- Forage quality
- Silage fermentation

Milk Fever
Hypocalcemia
* Low Serum Ca *

Characteristics and Tendencies
- Jersey > Holstein
- > Third Lactation
- Greater in BCS > 4/5
- 90% within 72 hours postpartum
  - Watch for 120 DIM Milk Fever
- Heritability

Three “Stages” of Milk Fever

I = Standing
Total Serum Ca  8 – 6.5 mg/dl

II = Down
Total Serum Ca  6.4 – 4.0 mg/dl

III = Dying
Total Serum Ca < 4.0 mg/dl
The Real World

**Diagnosis – Individual Cow**
- Down cow – just post partum
- Cold ears
- Lethargic

**Treatment – Individual Cow**
- 2 – 500ml – Ca f mg – IV
- Drench – PO
- FEED – at her level
- Water – at her level

Monitor Response

**Differential Dx**
- Injury
- Obturator paralysis
- Uterine Torsion
- Mastitis
- Grass Tetany
- Ketosis
- Hypophosphatemia
- Hemorrhage

Ca Endocrine Regulation

- **PTH – Low Serum Ca**
  - Increases GI Absorption – Vit D
  - Increased Renal P Excretion
  - Increased mobilization from bone
- **Calcitonin – High Serum Ca**
  - Increase Bone Deposition
  - Decrease GI Absorption

Ration Evaluation

*DCAD Calculations*

1. \( (0.15 \times \text{Ca meq}) + 0.15 + \text{Mg meq} + \text{K meq} + \text{Na meq} - (\text{Cl meq} \times 0.2 + 5 \times \text{meq} + 0.3 \times \text{P}) \)
   Target 400 to 500

2. \( (\text{Na meq} + \text{K meq}) - (\text{Cl meq} + 5 \times \text{meq}) \)
   Target – 50 to -150

Milk Fever – Herd

**Presentation and Treatment**

- **Urine pH**
  - Holsteins 6.2 – 6.8
  - Jerseys 5.8 - 6.2
  - pH < 5.8 = Acidosis
Milk Fever – Herd Diagnosis

- Total Ca v. Ionized Ca
- Serum Ca on 10 Fresh Cows
  - > 2nd lactation?
- Ration Evaluation
  - Close up dry
- Urine pH

Milk Fever
Herd Prevention and Treatment

- Track DMI in Close Up Pen
- No Free Choice NaCl for dry cows
- 90% Stocking Density
- Feed Available to Cows During Parturition
- Treat All Suspected Milk Fever by a Protocol
- Monitor Response

Close Up Diet Formulation

K < 1.2% - No Acidification
K 1.2% - 1.5% - ?
K > 1.5% - Acidification

HCL Products
  - Soy Chlor 16-7
  - Nutri Chlor 18-8
True Anionic Salts
  - Ammonium Chloride
  - Magnesium Sulfate

Close Up Diet Formulation

Ca 180 g/d – 220 g/d
P 35 g/d
K < 1.2%
S .3 - .4%
Mg .4%
Vit E 2000 – 4000 IU/d
Vit D 65 KIU/d

Close Up Diet Ingredients

- Yeast – stabilize rumen health
- Ca Proprionate – energy and calcium
- Acidification Agent
  - DMI
- Molasses –
  - Some is good
  - Too much increases insulin and decreases DMI
- Bypass Fat – Energy Source
  - 25 lbs per cow per day
- Tallow ??
Grass Tetany
Hypomagnessemia

- Beef, Dairy, Sheep, Goats

Signalment
- Older ruminants
- Spring
  - Lush, fast growing pasture
  - Cereal crop – pasture / feed

Clinical Signs
- Down
- Twitching
- Hyper-aesthesia
- “Neurotic”
- Paralysis

Mg Flux

Why? - Pathogenesis
- Requirement ~ .2% Mg in DMI
- Dietary Mg has low availability
  - 7% - 35%
- High K reduces Mg availability
- High Na increases Mg excretion

Diagnosis – Real World
- Mature Beef Cow
- Down Post Calving – cold ears
- Spring Pasture
- Twitching / Neurotic
- Treat and Monitor

Treatment
- 500 ml 23% Ca borogluconate – IV
  - [15% Mg gluconate]
- Oral Mg
  - Enema
  - 60g Mg Cl₂ in 200 ml H₂O
Prevention

- Diet
- TMR + MgO – Mg to .4%
- Pasture + Mg Min block
- Grazing
  - Rotation
  - Fertilization
  - Limestone
  - Mixed legume - grass

Nutritional Investigation

- Step 1
  - Owners / management complaint
  - Owners / management goals
- Step 2
  - If the owner’s Chief Complaint and employee’s Chief Complaint are different then return to Step 1

Case 2 - Disease Investigation

- History – Poor Production, Some Mastitis
  - Nutritional
- Exam and Testing
  - Farm Visits – 3 – Interviewed all employees and owner
  - Visited with 2 nutritionists involved
  - Evaluated and balanced all rations
  - Attained written records from previous veterinarian
  - DHI Records
  - Weekly bulk tank milk samples for mastitis
  - Blood samples on all cows giving birth – Ca, P, Mg

Disease Investigation

- Results
  - Owner was paying on SPC – owner induced reproductive failure
  - Severe Mycoplasma mastitis outbreak – Contagious
  - Improper load mixing of feed
  - Severe mechanical dysfunction in milking parlor
  - Slight improper balancing of ration
History
- Owner, manager, employee
- Ensure it is a nutritional problem
- #1 Blame = Nutrition

Objective Information
- Production – DHI – Daily Weights
- Reproduction – Computer
- Disease – Treatment Lists, Computer

The Four Rations of the Farm
- The formulated – nutritionist
  - The Reformulated – on the farm
- The fed – DMI tracking
- The consumed – DMI tracking
- The metabolized – Milk weights

Ration Evaluation
- Don’t look for a Mn deficiency first
- DMI Limitation
  - Forage Quality
  - Water Quality
  - Poor Communication

Sample and Test
- NIR v. Wet Chemistry
- Table / Book Values
- Feed Tags
**Sampling / Testing**

- **Feed Samples** – Ingredient, TMR
  - Wet Chemistry
  - DM, CP, NE, ADF, NDF, Ca, P, Sol P, Nitrate, Fe, S, Mo

- NEFA – Non- Esterified Fatty Acid
  - Indicates insufficient energy intake - Ketosis

**Body Condition Scoring**

- **Dairy / Beef**
  - Subjective measure of body fat
  - 1-5 scale / 1-9 scale
  - 1 = emaciated
  - 5 / 9 = obese
  - Change in condition within the life cycle is often more critical than the condition at 1 point in time

**Rumen Fluid Analysis**

- pH > 6
- pH 5.5 to 6 borderline
- pH < 5.5 = Acidosis
  - 4 hr post feeding
- Microscopic Evaluation
  - Protozoal activity
- Rumen Cl
  - High rumen Cl = GI stagnation

**Analysis of Information**

- Categorize History, Exam, Diagnostics
- Multiple categories
  - Multi path / multi disease
- Utilize objective information

**Summary**

- Find simple solutions to complex problems
- Think in the trenches – cause / the "why"
- Keep them eating
- Promote a simple feeding program
  - Easy to implement
  - Easy to manage
Classification of Forage Trace Elements

<table>
<thead>
<tr>
<th>Trace Mineral</th>
<th>Deficient, ppm</th>
<th>Marginal, ppm</th>
<th>Adequate, ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>&lt;4.0</td>
<td>4.1 – 7.0</td>
<td>&gt;7.0</td>
</tr>
<tr>
<td>Manganese</td>
<td>&lt;20</td>
<td>20 – 40</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Zinc</td>
<td>&lt;20</td>
<td>20 – 40</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Selenium</td>
<td>&lt;0.1</td>
<td>0.1 – 0.2</td>
<td>0.2 – 0.3</td>
</tr>
<tr>
<td>Cu:Mo ratio</td>
<td>&lt;4.1</td>
<td>4.0 – 5.1</td>
<td>6 – 10:1</td>
</tr>
</tbody>
</table>

**Protein Overfeeding The Consequences**

- $$$ Loss
- Poor Reproduction
- Metabolic Inefficiency

**Diagnosis of Protein Over Feeding**

- BUN
- MUN
- Manure Scoring
- Ration Evaluation

**MUN**

<table>
<thead>
<tr>
<th>MUN Grade</th>
<th>Low MUN (&lt;12 mg/dl)</th>
<th>Normal MUN (12-16 mg/dl)</th>
<th>High MUN (&gt;16 mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>low SSC +/- or NEL, low SIP +/- or DIP +/- or UIP</td>
<td>SIP, DIP, UIP, AAA in balance, low CHO +/- or NEL</td>
<td>Excess SIP +/- or DIP relative to CHO/NEL, excess UIP or imbalance in AAA</td>
</tr>
<tr>
<td>3.0 – 3.2</td>
<td>low SIP +/- or DIP +/- or UIP</td>
<td>Balanced SIP, DIP, UIP, AAA, and CHO/NEL</td>
<td>Excess SIP +/- or DIP relative to CHO/NEL, imbalance</td>
</tr>
<tr>
<td>&gt;3.2</td>
<td>low SIP +/- or DIP +/- or UIP, AAA balanced, excess CHO/NEL</td>
<td>Balanced SIP, DIP, UIP, AAA, and CHO/NEL</td>
<td>Excess SIP +/- or DIP relative to CHO, excess of UIP vs NEL or AAA imbalance</td>
</tr>
</tbody>
</table>

**NPN Toxicosis**

- ≠ Nitrate Toxicosis
- Ruminants Hydrolyze ammonia
- Predispose by Low CHO Diets
- Generally Due to Mixing Error
- Failure of Use of NH₃, y
  - NH₃ → NH₄⁺ → H⁺
  - NH₄⁺ Alkalizes the Rumen
  - TCA Inhibited → Acidosis
  - Acidosis Creates Hyperkalemia
  - Hyperkalemia = Death
**NPN Toxicosis**

- Dx – Rumen pH > 8
  - Ration evaluation
  - Feed samples

**Clinical Signs**

- Ab Pain
- Muscle Tremor
- Ataxia
- Bloat
- Violent Death

**Nitrate Toxicosis**

- NO3 Reduction NO2
  - Hb NO2 Met Hb

- Source
  - Oats, Pigweed
  - Stressed Grasses

- Testing
  - NO3 or NO3-N (multiply by 4.4)
  - < .3% Nitrate (DM) Dairy
  - .5% Nitrate (DM) Beef
  - .8% Acute Toxicity

**Clinical Signs**

- Dyspnea
- Poor Reproduction
- Abortion
- Decreased Milk Production

**Treatment – Methylene Blue**

- 5 – 15 g / kg IV

**Protein Overfeeding**

- $$$ Loss
- Poor Reproduction
- Metabolic Inefficiency

**Diagnosis of Protein Over Feeding**

- BUN
- MUN
- Manure Scoring
- Ration Evaluation
MUN

<table>
<thead>
<tr>
<th>Milk Crude Protein %</th>
<th>Low MUN (&lt;12 mg/dl)</th>
<th>Normal MUN (12-16 mg/dl)</th>
<th>High MUN (&gt;16 mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>Low NSC +/- NEL. Low SIP +/- DIP +/- UIP</td>
<td>SIP, DIP, UIP, AAA in balance. Low CHO +/- NEL</td>
<td>Excess SIP +/- DIP relative to CHO/NEL, Excess UIP or imbalance in AAA.</td>
</tr>
<tr>
<td>3.0 – 3.2</td>
<td>Low SIP +/- DIP +/- UIP</td>
<td>Balanced SIP, DIP, UIP, AAA, and CHO/NEL</td>
<td>Excess SIP +/- DIP relative to CHO/NEL balanced</td>
</tr>
<tr>
<td>&gt;3.2</td>
<td>Low SIP +/- DIP +/- UIP, AAA balanced, Excess CHO/NEL</td>
<td>Balanced SIP, DIP, UIP, AAA, Excess CHO/NEL</td>
<td>Excess SIP +/- DIP relative to CHO, Excess of UIP vs NEL or AAA imbalance</td>
</tr>
</tbody>
</table>

NPN Toxicosis

- Dx – Rumen pH > 8
  - Ration evaluation
  - Feed samples

Nitrate Toxicosis

- NO3 Reduction NO2
  - Hb NO2 Met Hb

Source
- Oats, Pigweed
- Stressed Grasses

Testing
- NO3 or NO3-N (multiply by 4.4)
  - .3% Nitrate (DM) Dairy
  - .5% Nitrate (DM) Beef
  - .8% Acute Toxicity

NPN Toxicosis

- Clinical Signs
  - Dyspnea
  - Poor Reproduction
  - Abortion
  - Decreased Milk Production

Nitrate Toxicosis

- Clinical Signs
  - Methylene Blue
    - 5 – 15 g / kg IV
Rumenal Acidosis
- Treatment – Individual Cow
  - Antibodies
  - Anti-inflammatory agents
  - Mineral oil PO
  - Charcoal PO
- Treatment – Herd
  - Yeast
  - Bicarb / Sesquicarbonate
  - Ration Evaluation
  - Particle Separation Evaluation
  - Forage Evaluation

Excess CHO Intake
- **Ruminal Acidosis**
  - Excess CHO = *Strep bovis* proliferation
  - *Strep bovis* produces Lactic Acid
  - Reduction in Rumen pH until *Strep bovis*
  - Enables Bactobacilles Growth
  - Lactobacilles Produces D-Lactate
    - D-Lactate cannot be metabolized to propionate

Rumenal Acidosis
- Clinical signs
  - Diarrhea – Hindgut fermentation
  - Ab Pain
- Diagnosis
  - Rumen pH
    - 5.0 - 5.8 = subclinical
    - <5 = Clinical

Dietary Urea Levels
- < 3% of Concentrate
- < 1% Total Diet
- 0.1% /cow/d is common with corn silage diets
- Ensure adequate CHO

**Treatment of Urea Toxicity**
- Treat early and fast
- Large quantity COLD H₂O
  - 7 – 10 gal in adult cattle
  - Dilutes NH₄
- 2-6 Liters Vinegar (cattle)
  - Reduces pH
  - Reduces NH₄ absorption