The critical relationship between nutrition and immunity in ruminants

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Today’s goals

• Nutrition’s impact on the immune system
• Nutrient recommendations for ruminants
• Brief overview of the ruminant immune system
• Vaccination basics
• www.nwvetstanwood.com – Health Information - Presentations
NUTRIENT RECOMMENDATIONS

- Discussing nutrients involved with immunity. There are others we won’t have time to discuss today.
- The values I am giving are recommended for health and growth. These are not absolutes, you will see other recommendations and there are regional variations.
- More is not always better.
- Will need to do math. Metric system involved.
- The nutrient recommendation is usually given as a dietary concentration in feed.

NUTRITION TERMINOLOGY
NUTRIENT CONCENTRATION
IN DIET AND FEEDSTUFFS

- PPM = parts per million (mg/kg) – Selenium (Se) 0.3 ppm = 0.3 mg/kg feed
  - 1000 milligrams (mg) = 1 gram (gm)
  - 1000 grams = 1 kilogram (kg) = 2.2 pounds (lb.) – Convert kg into lbs.
- Percent; 1% = 10,000 milligram(mg)/kg feed
  - Move decimal 4 places to right to convert % to ppm
  - Copper(Cu) 0.05% = 500 mg/kg feed
  - Crude protein 16% = 16% of feed is protein.
- Vitamins
  - International Units (IU)
  - Listed as IU/lb. or kg feed – read the label
NUTRITION - NUTRIENTS

NUTRIENTS USUALLY LISTED AS DIETARY CONCENTRATIONS IN FEED

- Dry matter/as fed – (DM) – DM is moisture removed. Hay ~88-89%DM, grain ~90%DM
  - Example – Hay 88% dry matter, 14% protein, feeding 10 lbs. hay/head/day
  - 10lbs. × 0.88 × 0.14 = 1.23 lbs of protein in that amount of hay.
- Dry matter intake (DMI) directly related to forage quality – lbs. or kg, % of body weight
- Energy – Mcal/kg or lb. of feed =1000 Calories – DE, ME, NEg, NEm, TDN, NEI
- Protein – (CP) % of diet (DM)
- Fiber - % of diet, ADF%, NDF%

NUTRITION - NUTRIENTS

- Fat - % of diet
- Water - % BW, temperature dependent
- Macro minerals –% of feed, or grams/day
  - Calcium, Phosphorous, Sodium, Chlorine, Potassium, Magnesium, Sulfur

- Micro minerals – ppm = mg/kg feed, or mg/day
  - Cobalt, Copper, Iodine, Iron, Manganese, Molybdenum, Selenium, Zinc, Chromium

- Vitamins – IU/kg or lb. feed, or IU/day
  - Fat-soluble – A, D, E, K
  - Water-soluble – B’s, C
  - Vitamin A – RE (retinol equivalents)
NUTRITION – IMMUNITY INFLUENCE

• Energy & Protein
  • Overall animal health, growth and production
  • Immune component manufacturing
  • Colostrum production, quantity and quality
  • Parasites – protein depletion
    • coccidia – immune suppression

MINERALS & IMMUNE FUNCTION

• Copper (Cu) - phagocytic cells, antioxidant formation, antibody production
• Manganese (Mn) - antioxidant formation, phagocytic cell activity
• Zinc (Zn) - cellular antioxidant system, antibody production
• Iron (Fe) - cofactor antioxidant production
• Selenium (Se) - cellular antioxidant system, phagocytic cell function
• Iodine (I) – general immune function and energy production
• Chromium (Cr) – white blood cell function
VITAMINS & IMMUNE FUNCTION

• Fat soluble
  • Vitamin E - cellular antioxidant system
  • Vitamin A – Broad range of immune responses
  • Vitamin D - Broad range of immune responses

• Water soluble - adequate amounts made in healthy rumen
  • Vitamin C – Antioxidant
  • Vitamin B – Metabolism, production

RUMINANT NUTRIENT RECOMMENDATIONS

• Based on Animal Requirements
  • National Research Council – NRC - http://www.nationalacademies.org/nrc
  • Maintenance PLUS
    • Gender
    • Breed
    • Weight
    • Growth or body weight change – grams to pounds of gain/day
    • Lactating – pounds of milk/day, components (fat, protein)
    • Fiber Production
    • Age
    • Stage of Pregnancy + number of babies
    • Season – forage quality & environment
    • Interaction between different minerals
NUTRIENT RECOMMENDATIONS
RUMINANT NUTRITION STARTS WITH QUALITY FORAGE

- Grass Hay - Crude Protein %
  - Dry matter basis analysis
  - Excellent - 14% or above
  - Good - 12 – 13%
  - Fair - 9 – 10%
  - Poor - Below 8%
  - What cutting is the hay? 1st – 3rd

- Legume Hay – Crude Protein %
  - Dry matter basis analysis
  - Excellent - 18% or above
  - Good - 16 – 17%
  - Fair - 14 – 15%
  - Poor - Below 14%
  - What cutting is the hay? 1st – 3rd

- Not all hay is created equal.

NUTRITION – RECOMMENDED LEVELS

- Handout & Additions
  - Energy – Camelid - Growing&Pregnant 0.60-0.65; Lactating 0.65-0.70
  - Protein – Sheep – Pregnant 10-12%
  - Selenium – Camelid – 0.3ppm or 1mg/45kg/day
  - Cobalt & Chromium – * = No recommendation found but make sure some is on mineral/grain tag.
  - Rained on? Mold? How long in field?
NUTRITION CALCULATING DAILY INTAKES - SHEEP

Nutrient | Analysis | 0.125 lbs/d | 0.25 lbs/d
---|---|---|---
Copper (Cu) | 0 ppm |  |  
Iodine (I) | NL |  |  
Manganese (Mn) | 2,000 ppm | 114 mg | 227 mg  
Selenium (Se) | 35 ppm | 1.99 mg | 3.98 mg  
Zinc (Zn) | 616 ppm | 35 mg | 70 mg  
Vitamin A | 125,000 IU/Lb. | 15,625 IU/d | 31,250 IU/d  
Vitamin D-3 | NL |  |  
Vitamin E | NL |  |  

Sheep loose mineral mix
Feeding rate: 2 – 4 ounces/head/day

1. 2 ounces/16 ounces/lb. = 0.125 lbs.
2. Zinc 616 ppm = 616 mg/kg feed
   a) 616 mg/2.2 lbs/kg = 280 mg/lb. feed
   b) 280 mg x .125 = 35 mg/day
   c) 280 mg x .25 = 70 mg/day
3. Vitamin A
   a) 125,000 x .125 = 15,625 IU/day
   b) 125,000 x .25 = 31,250 IU/day

NUTRITION CALCULATING DAILY INTAKES - BEEF

Nutrient | Analysis | 0.3 lbs/d | 0.75 lbs/d
---|---|---|---
Copper (Cu) | 500 ppm | 68 mg | 170 mg
Iodine (I) | 25 ppm | 3 mg | 9 mg
Manganese (Mn) | 2,000 ppm | 273 mg | 682 mg
Selenium (Se) | 8.8 ppm | 1 mg | 3 mg
Zinc (Zn) | 1,500 ppm | 205 mg | 511 mg
Vitamin A | 100,000 IU/Lb. | 30,000 IU/d | 75,000 IU/d
Vitamin D-3 | 10,000 IU/Lb. | 3,000 IU/d | 7,500 IU/d
Vitamin E | 100 IU/Lb. | 30 IU | 75 IU

Beef cattle loose mineral mix
Feeding rate: 0.3 – 0.75 lbs./head/day

- Cu - 500 ppm = 500 mg/kg feed = 500/2.2 lbs = 227.27 mg/lb. feed
- 227.27 x 0.3 = 68 mg/day
- 227.27 x 0.75 = 171 mg/day
- Vitamin E
  - 100 x 0.3 = 30 IU/day
  - 100 x 0.75 = 75 IU/day
### NUTRITION CALCULATING DAILY INTAKES

**GOATS**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Analysis</th>
<th>0.25oz./d</th>
<th>0.5oz./d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper (Cu)</td>
<td>1350 ppm</td>
<td>9.6 mg</td>
<td>19.2 mg</td>
</tr>
<tr>
<td>Iodine (I)</td>
<td>NL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>2,750 ppm</td>
<td>19.5 mg</td>
<td>39 mg</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>12 ppm</td>
<td>0.9 mg</td>
<td>.17 mg</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>5,500 ppm</td>
<td>39 mg</td>
<td>78 mg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>300,000 IU/Lb</td>
<td>4,480 IU/d</td>
<td>9390 IU/d</td>
</tr>
<tr>
<td>Vitamin D-3</td>
<td>30,000 IU/Lb</td>
<td>468 IU/d</td>
<td>939 IU/d</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>400 IU/Lb</td>
<td>6.24 IU</td>
<td>12.5 IU</td>
</tr>
</tbody>
</table>

**Notes:**
- Goats loose mineral mix
- Feeding rate: 0.25 – 0.5 oz./head/day

**Calculations:**
- Mn – 2,750ppm=2750mg/kg feed = 2750/2.2lbs=1,250mg/lb. feed
- 0.25oz=0.25/16oz/lb.=0.0156lzs.
- 1,250 X 0.0156 = 19.5 mg/day
- 1,250 X 0.0313 = 39 mg/day
- Vitamin E
  - 400 X 0.0156 = 6.24 IU/day
  - 400 X 0.0313 = 12.5 IU/day

### NUTRITION CALCULATING DAILY INTAKES

**CAMELIDS**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Analysis</th>
<th>0.3oz./d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper (Cu)</td>
<td>27 ppm</td>
<td>0.23 mg</td>
</tr>
<tr>
<td>Iodine (I)</td>
<td>30 ppm</td>
<td>0.26 mg</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>1,500 ppm</td>
<td>12.8 mg</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>70 ppm</td>
<td>0.6 mg</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>5,000 ppm</td>
<td>77 mg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>250,000 IU/Lb</td>
<td>30,000 IU/d</td>
</tr>
<tr>
<td>Vitamin D-3</td>
<td>30,000 IU/Lb</td>
<td>3,000 IU/d</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>7,000 IU/Lb</td>
<td>132 IU</td>
</tr>
</tbody>
</table>

**Notes:**
- Alpaca loose mineral mix
- Feeding rate: 0.3 ounces/head/day

**Calculations:**
- Zn – 9,000ppm=9,000mg/kg feed = 9,000/2.2lbs=4,091 mg/lb. feed
- 0.3oz.=0.3oz./16oz./lb.=0.0188lbs
- 4,091 X 0.0188 = 77 mg/day
- Vitamin E
  - 7000 X 0.0188 = 132 IU/day
NUTRITION CALCULATING DAILY INTAKES

• Example 1400 lbs pregnant cow
  • Assume all copper comes from mineral
  • Cu 10 - 15ppm = 10 - 15mg/kg feed DM
  • DMI = 2% X(1400/2.2) = 12.7 kg DMI
  • Mineral supplies 68 – 170 mg Cu
  • Mineral = 68/12.7 = 5.4 mg/kg (ppm)
  • Mineral = 170/12.7 = 13.4 mg/kg (ppm)

• Example 200 lb lactating ewe
  • All selenium comes from mineral
  • Se 0.3ppm = 0.3mg/kg feed DM
  • DMI = 3.5% X (200/2.2) = 3.2 kg DMI
  • Mineral supplies 2 - 4 mg Se
  • Mineral = 2/3.2 = 0.63 mg/kg (ppm)
  • Mineral = 4/3.2 = 1.25 mg/kg (ppm)

TESTING FOR NUTRIENT LEVELS

• WA Animal Disease Diagnostic Laboratory - WADDL
  • Plasma – Selenium, Cobalt, Molybdenum
  • Liver – Chromium, Cobalt, Copper, Manganese, Molybdenum, Selenium, Sulfur, Zinc
  • Serum – Copper, Zinc, Vitamin E

• Serum Chemistry –Veterinary Clinic
  • Calcium, Chloride, Magnesium, Phosphorous, Potassium, Sodium, Proteins

• Forage Analysis
  • National Forage Testing Association - www.foragetesting.org
  • Dairy One Forage Lab, Dairyland Laboratories, Custom Dairy Services
MINERAL INTERACTIONS

- Copper  {Sulfur – Molybdenum – Iron – Zinc}
- Calcium – Phosphorous - Vitamin D - Manganese
- Iron – {Calcium – Zinc – Copper – Manganese}
- Selenium – Vitamin E – White Muscle Disease
- Sulfur – Thiamine – polioencephalomalacia (PEM)
QUESTIONS

IMMUNITY – TWO BASIC TYPES

- Innate
  - Built-in
  - First Line of Defense – Skin and Mucous Membranes
  - Second Line – Phagocytes (White Blood Cells), Anti-bacterial proteins (Interferons, Complement), Natural Killer Cells (T-cells), non-specific

- Acquired
  - Passive – First milk
    - Colostrum – 90% of newborn’s immunity comes from colostrum
    - Replacers and supplements (Majority are bovine origin)
    - Serums and antibody products
  - Active – Exposure via disease or vaccine
    - Cell-mediated immunity – T cells
    - Humoral immunity – Antibody production
IMMUNE SYSTEM - INNATE

• Built-in
• First Line of Defense – Skin and Mucous Membranes
• Second Line – Phagocytes (White Blood Cells), Anti-bacterial proteins (Interferons, Complement), Natural Killer Cells (T-cells)

IMMUNE SYSTEM - ACQUIRED

• Passive – First milk
  • Colostrum – 90% of newborn’s immunity comes from colostrum
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• Active – Exposure via disease or vaccine
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PASSIVE IMMUNITY - COLOSTRUM

Colostrum Key Points

1. **Quantity** – Newborn needs a minimum of 10% to 15% of body weight in colostrum (1 pint = 1 pound = 480 ml or 30 ml/ounce = 16 ounces).
2. **Quality** – Multiparous (multiple births) mothers usually have better colostrum than primiparous (1st time) dams. Females on a poor plane of nutrition will have lower quality colostrum.
3. **Timing** – Newborn needs all of colostrum within 24 hours. Should start nursing within 2 hours. There is decreased absorption over time with intestinal closure complete at 24 hours. Ideal is for newborn to have total colostrum within 12 hours.
4. **Environmental** – Newborn stress will decrease colostrum absorption by early closure of intestinal channels (i.e., delayed birth, cold, wet, etc.)

PASSIVE IMMUNITY

• **Colostrum Replacers & Supplements**
  - **Quantity** – Use if newborn does not nurse frequently within first 24 hours, or if dam does not appear to have much milk.
  - **Quality** – Use if colostrum quality is suspect – dam - poor body condition, dam had another animal nursing prior to parturition.
  - **Timing** – Use if newborn does not nurse well within 4 hours, or if needed for a bottle baby.
  - **Environment** – Use if the birth is delayed and newborn is slow to start, or if born in a cold or dirty environment.

• **Antibody products**
  - Use tetanus antitoxin for banding
  - Clostridium C/D (enterotoxaemia) antitoxin for newborn, if dams are not vaccinated.
  - Farm specific diseases – Antibody products for newborn diarrhea.
ACTIVE IMMUNITY – HUMORAL/CELL-MEDIATED

**HUMORAL**
- B cells
- Plasma cells
- Antibodies
- Memory B cells

**CELL-MEDIATED**
- Cytotoxic T cells
- Helper T cells
- Memory Helper T cells
- Memory Cytotoxic T cells
- Active Cytotoxic T cells

2nd exposure - vaccination

1. Increased duration of immunity
2. Increased immune response

Adapted from Biology by Campbell and Reece © 2000 Pearson Education, Inc.

ACTIVE IMMUNITY - VACCINATION

http://www.bbc.co.uk/bitesize/intermediate2/biology/guide/003_bite/humoral_cell-mediated_immunity active_immunity.png

![Graph showing antibody concentration over time](http://www.bbc.co.uk/bitesize/intermediate2/biology/guide/003_bite/humoral_cell-mediated_immunity active_immunity.png)

- Antibody concentration
- Time (days)
- Primary
- Secondary
- First vaccination or infection
- Second vaccination or infection
VACCINATION

- Four reasons to vaccinate
  - Survival
  - Reproductive protection
  - Protect newborn
  - Provide a barrier

- Routes
  - Intramuscular = IM
  - Subcutaneous = SubQ
  - Intranasal = IN
  - Oral = PO

- Most vaccines NEED a booster within 2-4 weeks.
- Anamnestic response
  - Immune response is greater and develops memory.
VACCINE TYPES

• Viral
  • Modified-Live (MLV)
    • Usually have to mix
    • Caution in pregnant animals
    • Longer immunity
  • Killed
    • Shorter duration of immunity
    • Multi-dose bottle

• Bacterins – Bacteria
• Toxoids – Toxins produced by bacteria
• Antiserum/antibodies
  • Passive immunity
  • Tetanus antitoxin, C/D antitoxin, Rota & Corona virus, E. coli

VACCINATION

• Effectiveness
  • Age – Young & Old
  • Passive immunity – Maternal antibodies block
  • Which pathogen is involved
  • Stress
  • Disease location
  • Exposure level
  • Vaccine efficacy
  • Schedule

• Handling
  • Refrigerate
  • Out of sunlight
  • Expiration date
  • Contamination
  • Meat withdrawal
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