The importance of minerals in dairy cow nutrition: specific formulas for the farm

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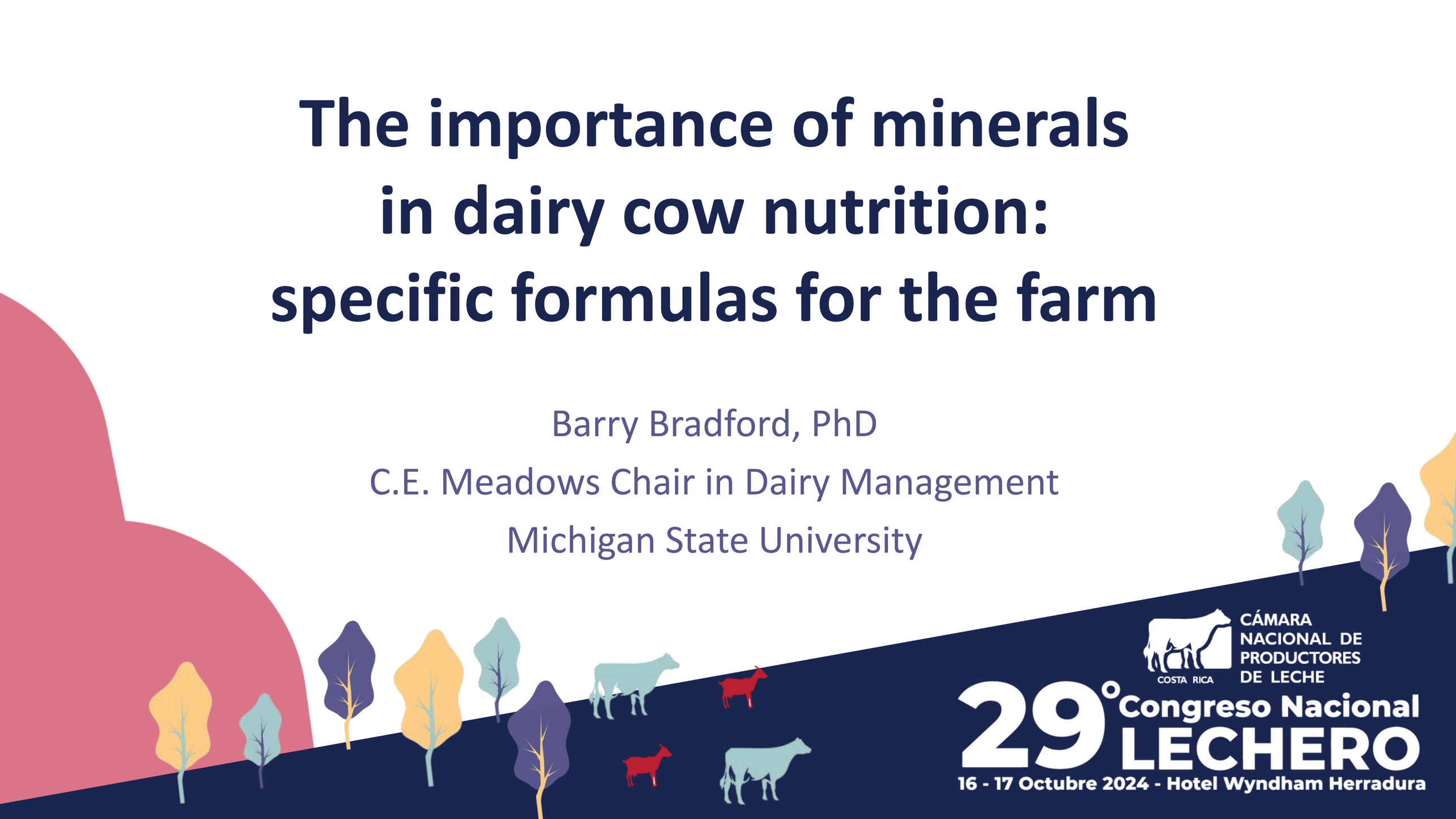


Overview

- A quick refresher on minerals and why they are important
- Approaches to meeting the mineral needs of ruminants
- Case studies:
  - Negative impacts of over-feeding trace minerals
  - Seasonal needs
  - Reconsidering copper nutrition
  - Managing postpartum calcium

Minerals

- Minerals are subdivided based on amounts added to the diet
- Macrominerals - kg/ton (0.1 to 5%)
- Microminerals (trace minerals)
  - ppm (mg/kg) or ppb (µg/kg)

Macrominerals

- **Calcium** **Ca**
- **Phosphorus** **P**

Mostly found in bone (hydroxyapatite)

- **Sodium** **Na**
- **Chlorine** **Cl**
- **Potassium** **K**

Electrolytes – regulate osmotic pressure

- **Magnesium** **Mg**
- **Sulfur** **S**

Microminerals / Trace Minerals

Cobalt	**Co**
Iodine	**I**
Zinc	**Zn**
Iron	**Fe**
Copper	**Cu**
Manganese	**Mn**
Selenium	**Se**

What is one part per million (ppm)?

- One drop of petrol in a 50-liter fuel tank
- One second in 11.5 days
- The square on the screen is about one millionth of the entire screen

What is one part per billion (ppb)?

- 1 second in 31.7 years
- You among all people in North & South America
- The point: Incredibly small amounts of nutrients can affect animal health

Trace mineral sources

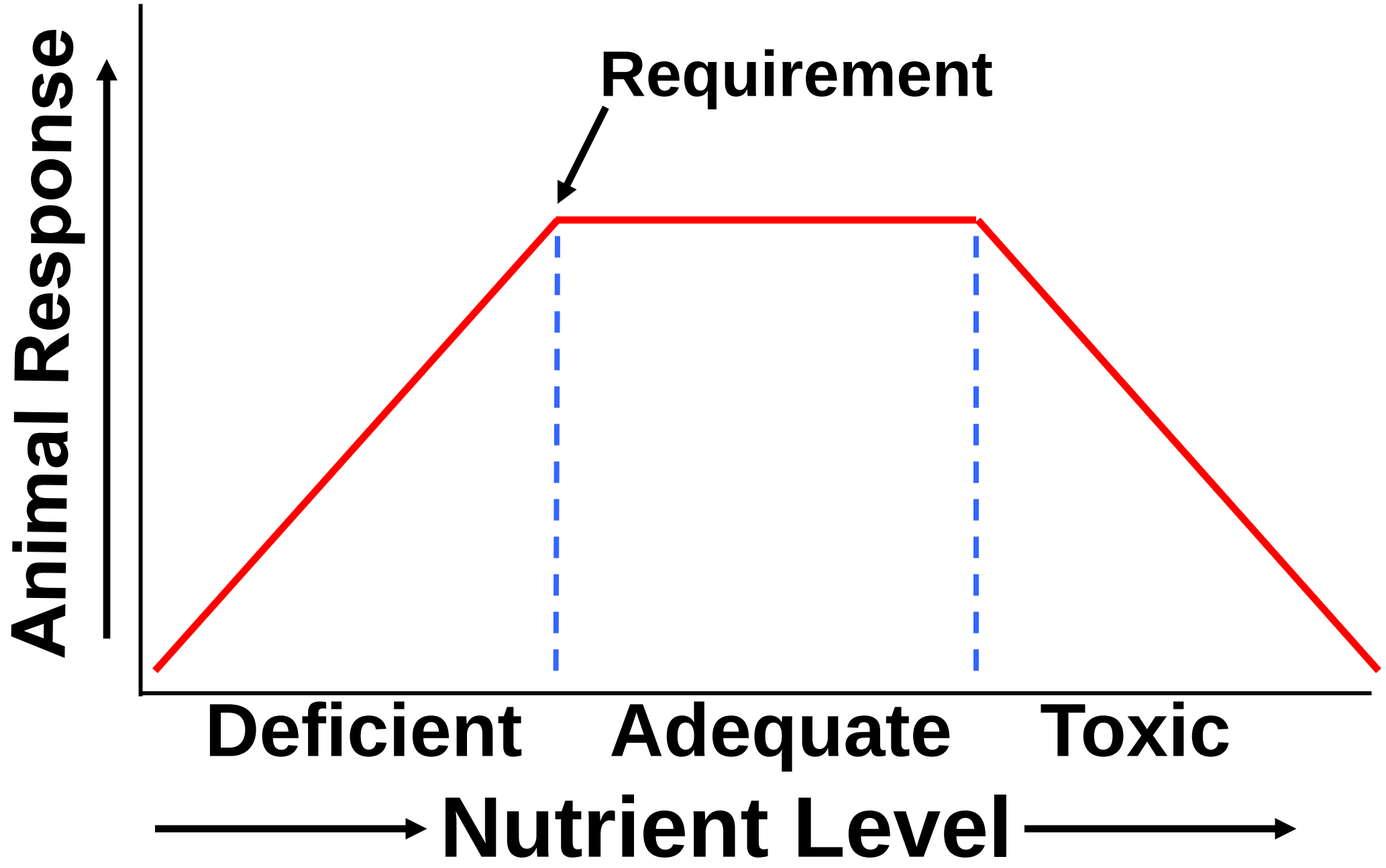
- Trace minerals can be provided in several forms
  - Sulfates
  - Oxides
  - Chelates - (organic)
- Differences relate to cost and availability of the minerals
- Sulfate forms may play a small role in odor of manure

Organic trace minerals

- Organic forms often show higher bioavailability
- The cost is typically much greater

- Cost/benefit is hard to determine for an individual farm
  - Depends on importance of that mineral in that environment

Response to Essential Nutrients



Typical approach to livestock mineral nutrition

1. Assume that book values are accurate for micromineral content of main feed ingredients
2. Add macrominerals to reach requirements, with perhaps 50% extra
3. Ignore all trace minerals in main feed ingredients, add in supplemental form to provide 150 – 300% of the requirement

Typical approach to livestock mineral nutrition

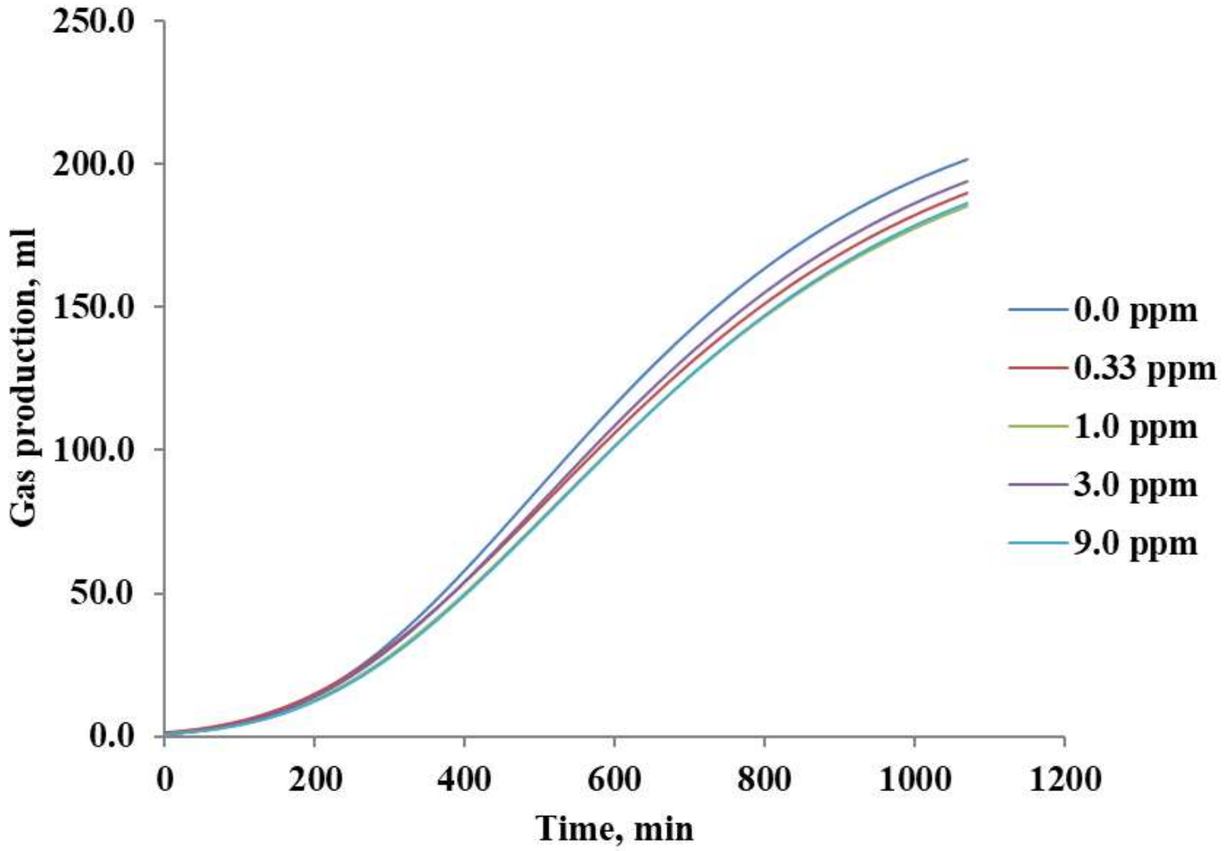
Advantages of this approach:

1. You can use the same trace mineral mix for all farms
2. No need to spend money on mineral analyses

Are there problems
with this approach?

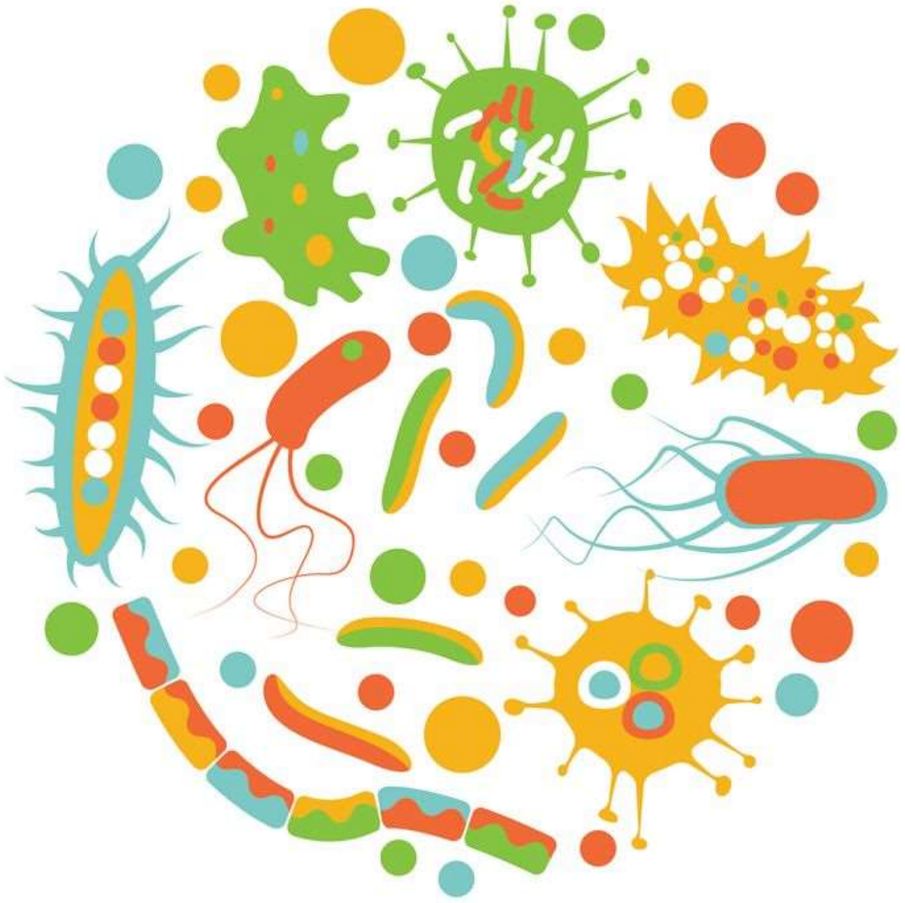
#1: Feeding excess trace minerals has a cost

- Cobalt was added to in vitro ruminal incubations over 24 h with gas production monitored as a proxy for microbial activity
- Requirement is about 0.02 ppm; but many feed > 2 ppm
- The highest doses of Co decreased gas production by about 6%



Vargas-Rodriguez and Bradford, 2015

#1: Feeding excess trace minerals has a cost



- Fiber digestion is entirely dependent on microbial activity in the rumen and hind-gut
- Although trace minerals are essential for animal health and productivity, some are quite toxic to some commensal bacteria (e.g., Cu sulfate)
- Need to balance meeting animal needs vs. harm to bacteria

#1: Feeding excess trace minerals has a cost

- Does trace mineral source of Cu, Zn and Mn affect NDF and DM digestibility or dry matter intake?
- “Hydroxy” trace minerals may be less available in the rumen; do they minimize harm to bacteria?

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Meta-analysis of the effects of sulfate versus hydroxy trace mineral source on nutrient digestibility in dairy and beef cattle

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Ibraheem et al., 2023

#1: Feeding excess trace minerals has a cost

- Meta-analysis of 12 comparisons in the literature as of 2012 revealed a 1.5% unit improvement in NDF digestibility for cattle fed hydroxy-TM vs. sulfate forms (equal concentrations)

Table 2. Simple least squares means estimates of responses to replacing sulfate trace minerals (TM) with hydroxy TM and test of response heterogeneity

Outcome	Comparisons (n)	Mean response	SEM	*P*-value (treatment means)	Q	*P*-value (Q)
DM digestibility (%)	12	+0.50	0.27	0.11	22.5	0.02
NDF digestibility (%)	12	+1.51	0.49	0.02	33.1	<0.001
DMI (kg/d)	9	+0.30	0.35	0.43	26.3	<0.001
DMI (% of BW)	9	+0.04	0.049	0.44	24.7	<0.01

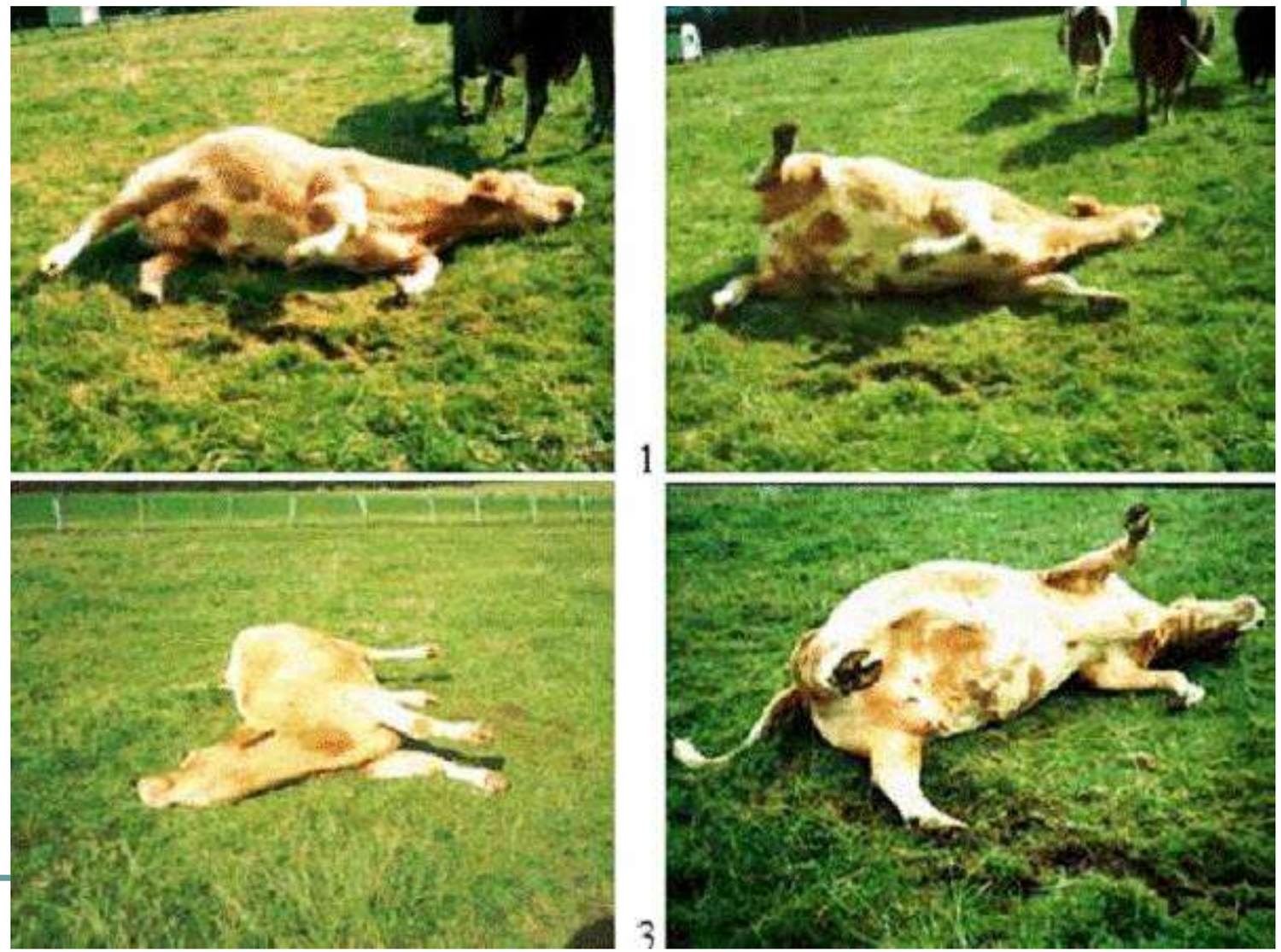
Ibraheem et al., 2023

#1: Feeding excess trace minerals has a cost

- Negative effects of excess TM on fiber digestibility demonstrates the value of more careful formulation
- May need to consider basal ingredient contributions to trace mineral supply, or at least limit supplementation to 100% of requirement

#2: There are specific seasonal mineral needs

- **Grass tetany**
- Rapidly-growing grass accumulates K faster than Mg
- Mg deficiency: loss of muscle control
- In the US, this typically occurs with cool-season grasses in early spring



#2: There are specific seasonal mineral needs

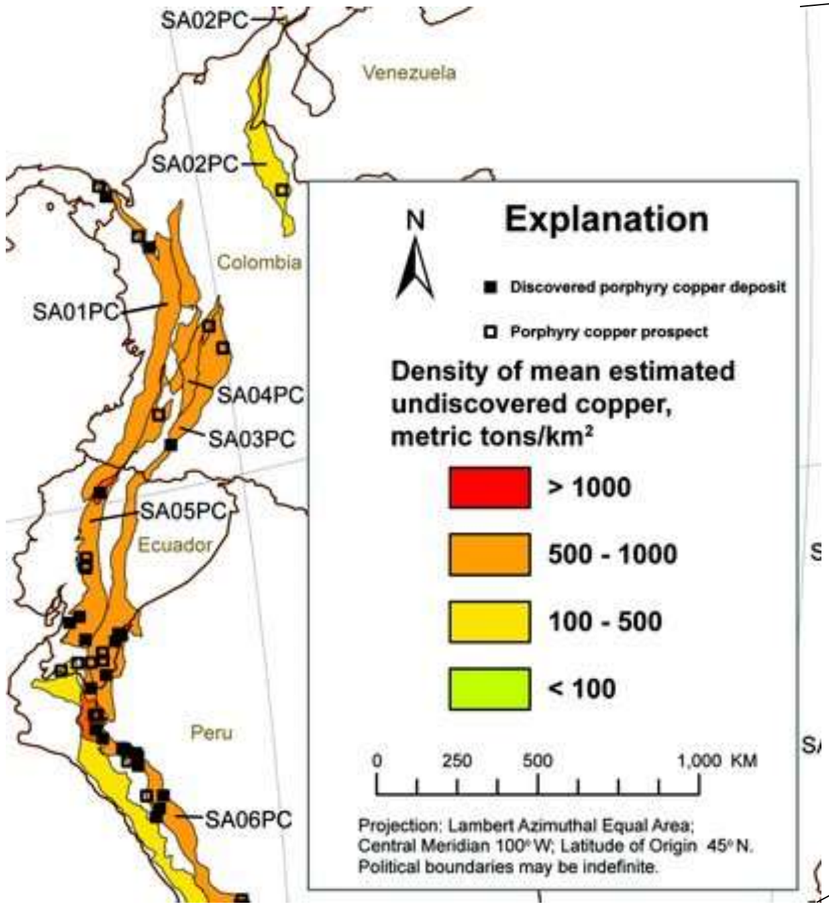
Grass tetany prevention strategies

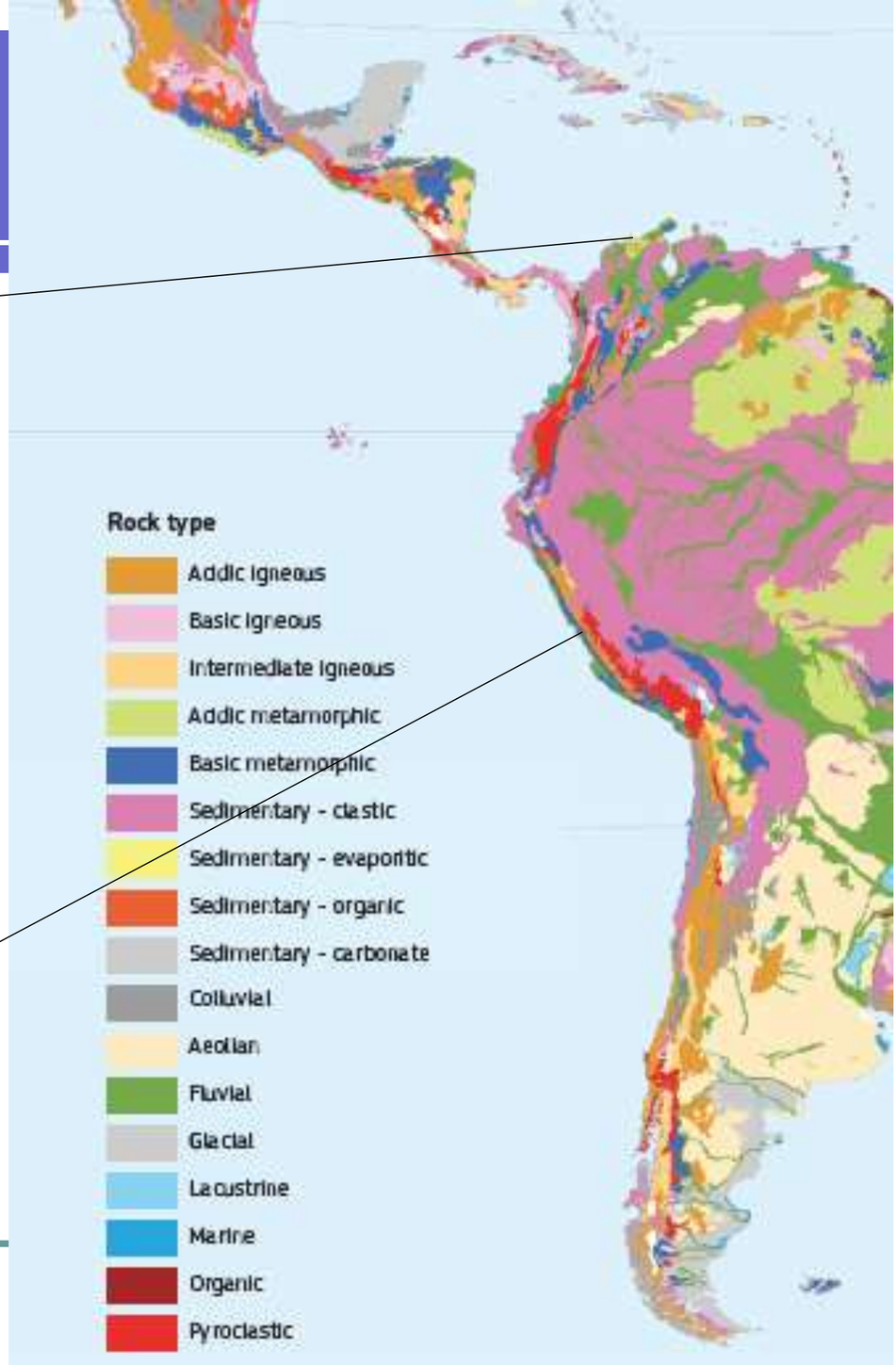
- Supplementing extra Mg!
- Pasture management solutions:
  - Slow growth by moderating N application
  - Avoiding applying K
  - Do not graze during the period of fastest growth
  - Once growth slows, plants recover Mg

#3: Soil-related toxicity concerns

- When we supplement 100 – 300% of trace mineral needs without considering basal diet contributions, we can sometimes risk mineral toxicity.
- Soils can be extremely variable in trace mineral content, and plant trace mineral content reflects that, to some extent.
- Ruminants often consume feeds grown mostly on the local soil.

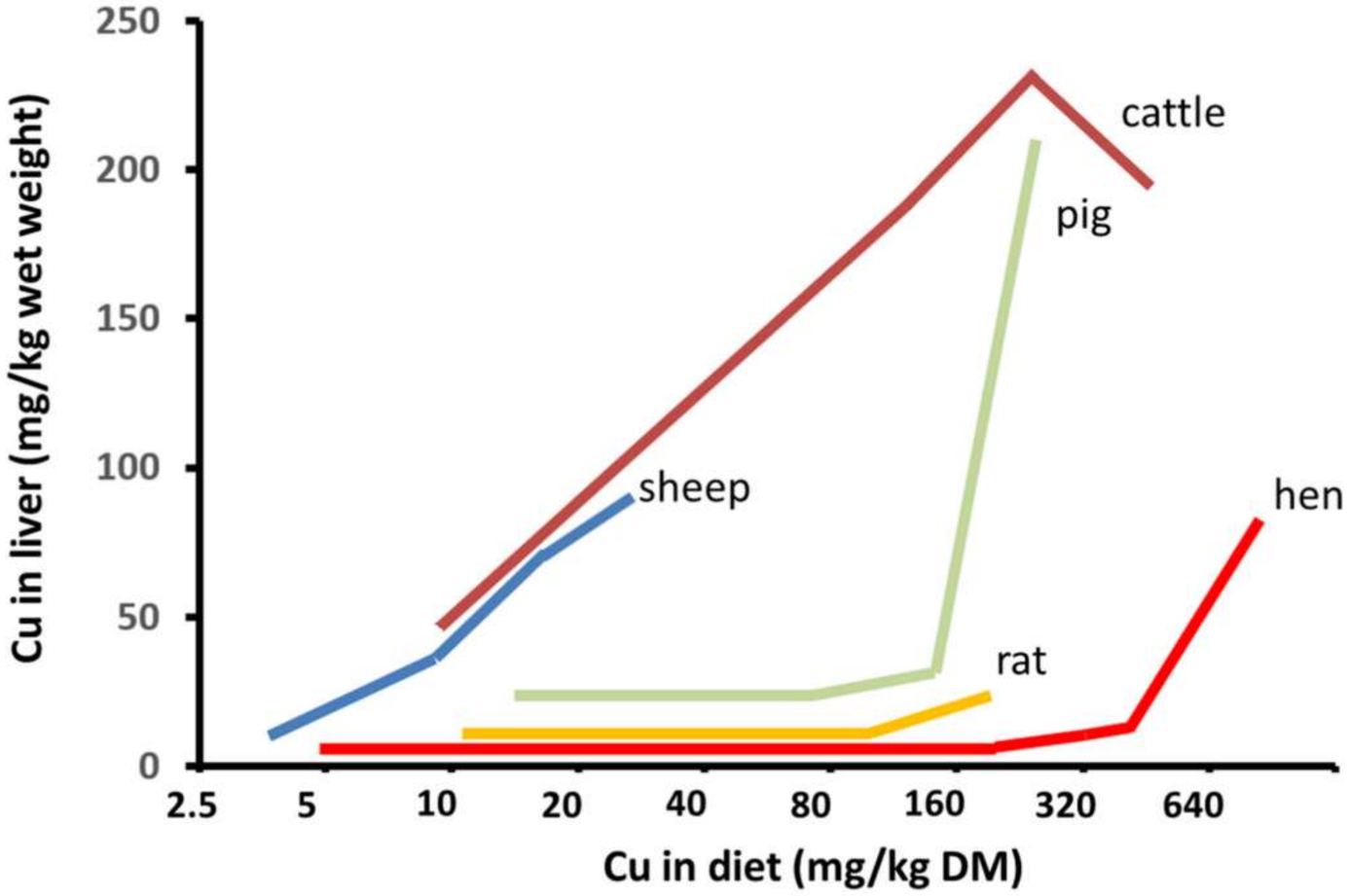
#3: Soil-related toxicity: copper



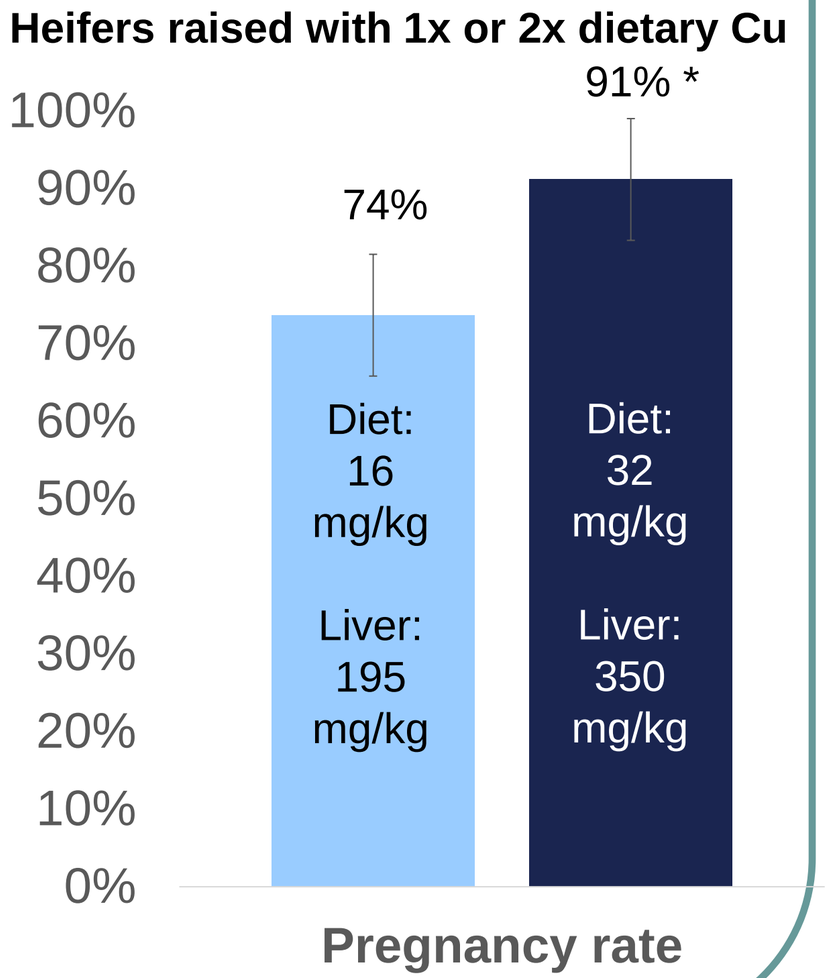


U.S. Geological Survey, 2008

#3: Soil-related toxicity concerns: copper



Lopez-Alonso and Miranda, 2020



McCaughern et al., 2024

#4: Preventing milk fever (periparturient pariesis)

#4: Milk fever is a disorder of calcium metabolism

- Blood calcium drops < 5 mg/dL (normally 9-10 mg/dL), leading to muscle and nerve problems
- Clinical cases develop in ~6% of U.S. dairy cows
- Sub-clinical cases limit productivity of many more cows
- Can be treated with calcium infusion

Anionic diets can be fed before calving to prevent milk fever

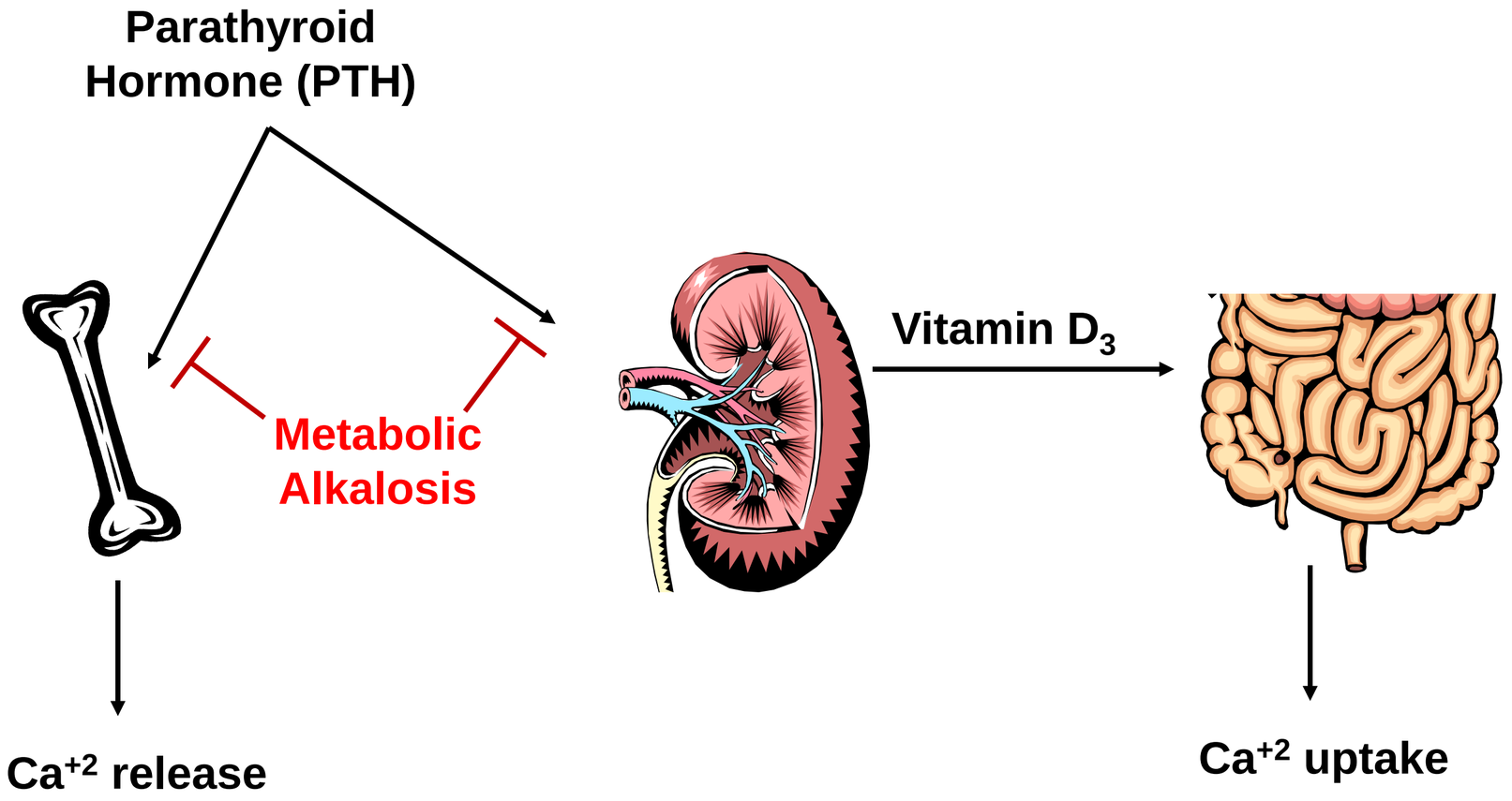
- DCAD = Dietary cation-anion difference
  - Cations: positive charge, positive DCAD
  - Anions: negative charge, negative DCAD
- DCAD4 = (Na + K – Cl – S), all in mEq/100 g

- Typical lactation diet: +20 to +40
- Dry period recommendations: < 0
- This is usually achieved both by selecting low K forages and by supplementing anionic salts (e.g., ammonium chloride)

Anionic diets cause mild metabolic acidosis

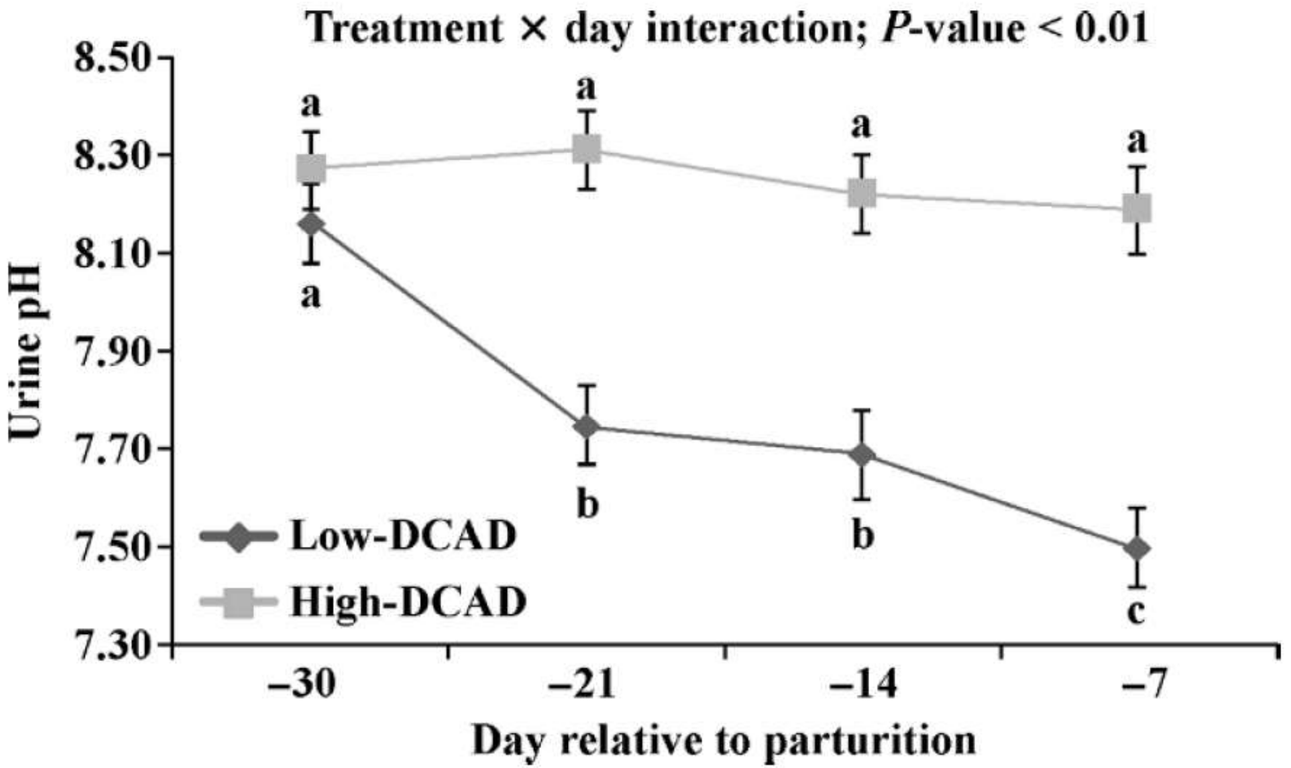
- Absorbed anions decrease blood pH
- Effects on urine pH are much more dramatic and easier to measure
- Target urine pH: 5.5 – 6.5

Metabolic acidosis triggers early calcium adaptations



#4: Application of farm-specific anionic hay

- Timothy hay field fertilized with $CaCl_2$
- Hay DCAD was +2 vs. +21 for control
- Hay was fed as 63% of the diet for the last 30 d before calving



Penner et al., 2008

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Item	Treatment: Low DCAD	Treatment: High DCAD
Number of cows per treatment	20	21
Retained placenta, %	5.0	19.0
Displaced abomasums, %	5.0	9.5
Subclinical hypocalcemia,[1] %	35.0	66.7

[1]Ionized calcium concentration in blood <1 m*M*.

Penner et al., 2008

Recommendations for mineral nutrition

- Analyze macrominerals in forage sources – these can often be run with NIR, which is not expensive
- Track trace minerals in forages raised on a specific farm every 4-5 years. These are expensive and should be analyzed by “wet” chemistry.
- Include basal diet minerals when formulating, and do not exceed 200% of requirements, especially for copper.

Thank you!

<u>Questions/comments:</u>

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