



The Roles Micronutrients Play in Bison Health

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EDUCATION

2020

Ph.D., Animal Science
Ruminant Nutrition/Muscle Biology
Texas Tech University

2017

M.S., Agriculture
Animal Nutrition Focus
Sam Houston State University

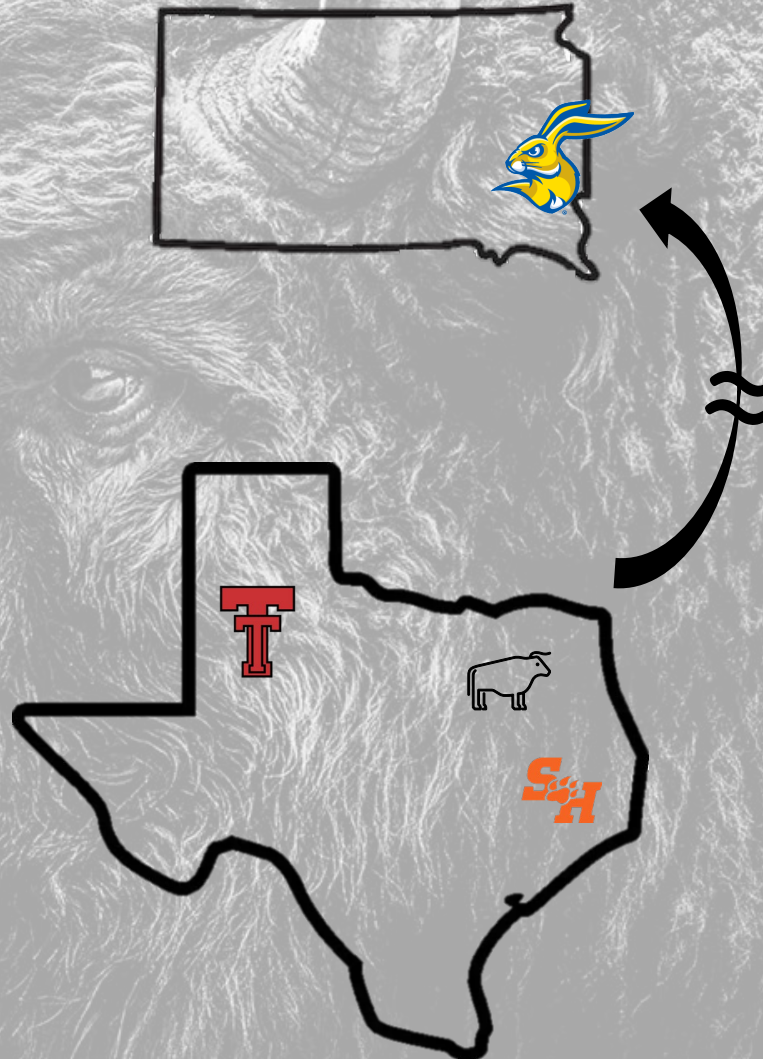
2015

B.S., Animal Science
Biology Concentration
Sam Houston State University

2011

Scurry, Texas

LIFE HISTORY



CURRENT TEACHING

- Introduction to Bison Mgmt
- Advanced Bison Production
- Study Abroad

PAST TEACHING

- Animal Feeds and Feeding
- Animal Nutrition
- Production Courses
- Many Wildlife Courses
 - Deer, Birds, and Fish
 - Research Related

INTERESTS



Macro Minerals

- Required in larger amounts (>100ppm)
 - Calcium
 - Phosphorus
 - Chlorine
 - Magnesium
 - Potassium
 - Sodium
 - Sulfur
 - Na, K, Cl = DCAD





Trace minerals

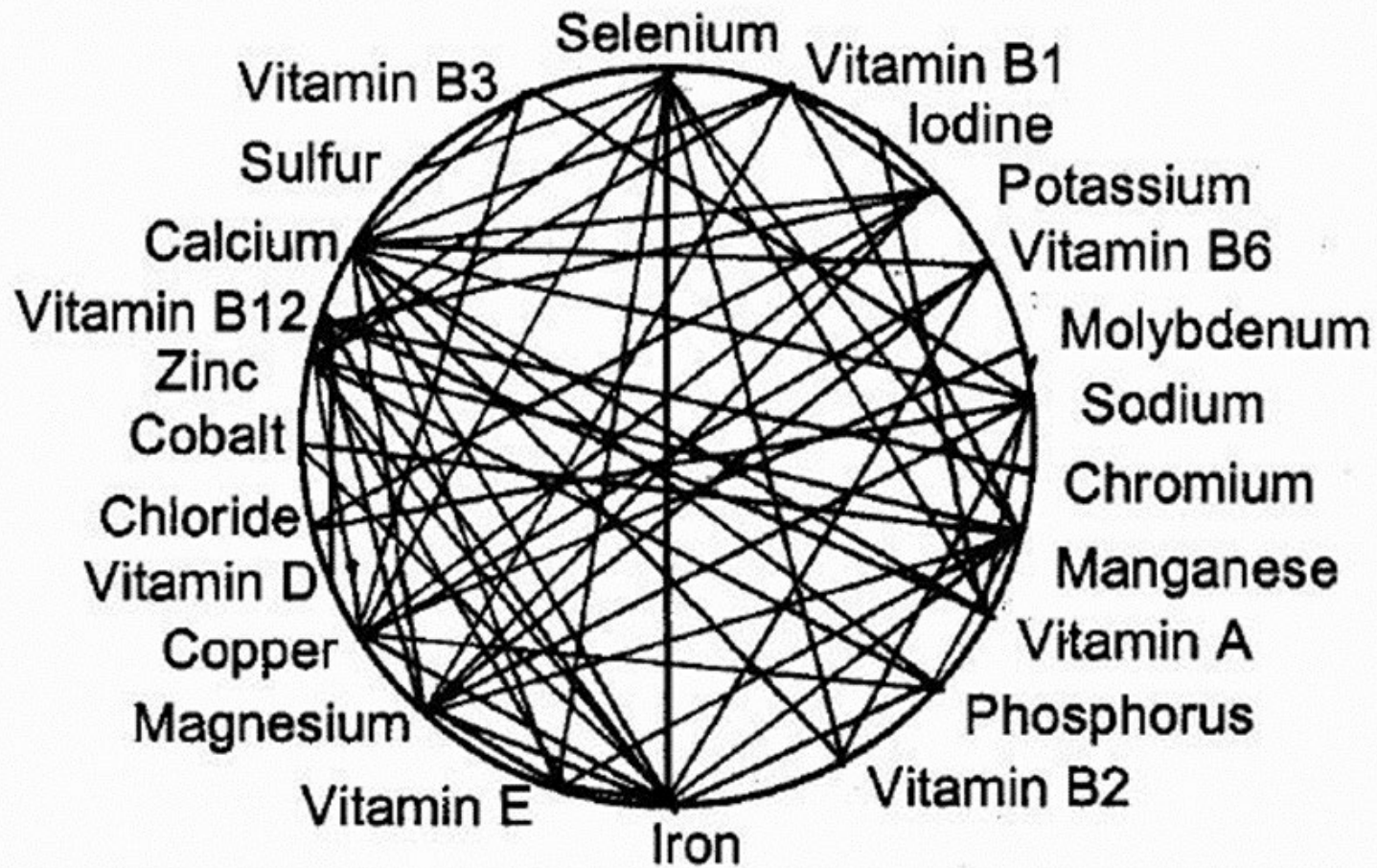
- A trace mineral is required in small amounts.
 - Less than <100 ppm or mg/kg
 - Iron
 - Iodine
 - Copper
 - Zinc
 - Manganese
 - Selenium
 - Chromium
 - Cobalt



Vitamins

- Some general rules
 - Organic in nature, but not CHO, Pro, or Lipid
 - Needed in very small amounts
 - Essential for normal metabolism
 - Inadequacy leads to issues
 - Cannot be normally synthesized
 - Except Vit D and C, Niacin
- Vitamin vs Provitamin vs Vitamer vs Quasivitamin

MINERAL AND VITAMIN INTERACTIONS



Omega-6 : Omega-3



Zinc : Copper



Potassium : Sodium



Calcium : Magnesium



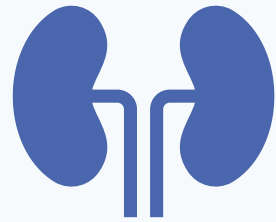
Iron : Copper



Calcium : Phosphorus



Calcium and Vitamin D



Parathyroid gland is key for absorption

PTH receptor

- Bone – Ca Resorption
- Kidney – Ca Reabsorption
- GIT – No Receptor

How to we absorb via GIT?

- Vit D



Contributions to Ca Homeostasis

Metabolic Alkalosis

Hypomagnesemia

Calcium and Vitamin D



Milk Fever (Periparturient Hypocalcemia)

Non-lactating to lactating at calving

- Low Ca in blood
- Lose nerve and muscle contraction
 - Lost ability to rise
 - Lose rumen motility
 - Decreased teat contraction
 - Mastitis
- Impairs immune response



Treatment

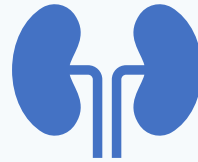
2 g Ca/100 kg BW given 1 g/min

Magnesium and Potassium



Withdraw PTH

- ↑ Mg reabsorption
- ↓ Mg in plasma



With PTH, and 1,25 DHCC

- ↑ Mg absorption (Rumen)
- ↓ Mg in reabsorption (Kidney)
- Mg resorption



Mg passively absorbed in rumen

- K is antagonist
- Higher pH decrease A_{Mg} (5 ↓ 80%; 7 ↓ 20%)

Magnesium and Potassium

- K and Grass Tetany
 - Prominent in cool season grasses
 - K complexes and inhibits Mg
 - Young grasses
 - High in protein
 - Deaminate = \uparrow in NH_3
 - Increase pH



Sodium/Potassium /Chlorine

- Osmotic skeleton
 - Need these three to sustained
- \uparrow Na intake = \uparrow Water consumption
- Na/K homeostasis in kidneys
- Can you estimate cost based on Sodium?
 - 400 kg bull
 - 1 kg/d ADG
 - DMI = 7.5 kg/d
 - Na requirement = 0.65 g of Na/kg of DM
 - Mineral Supplement label = 18% NaCl

Na Problem

- First, determine % of Na in NaCl
 - Na = 22.987, Cl = 35.453; Na + Cl = 58.44
 - $22.987 / 58.44 = 39.34\%$ Na in NaCl
- Next, determine Na intake
 - $7.5 \text{ kg DMI} \times 0.65 \text{ g Na} = 4.875 \text{ g of Na}$
 - $4.875 \text{ g of Na} / 0.3934 = 12.4 \text{ g of NaCl/hd/d}$
- Take that number back to the supplement you are feeding
 - $12.4 \text{ g of NaCl} / 0.18 = 68.91 \text{ g of supplement/hd/d needed}$
- What if you have more head?
 - $68.91 \text{ g of sup/hd/d} \times \# \text{ of hd} = \text{Total supp needed}$
- Can you figure cost from here?
 - Total supp \times Cost



Sulfur

- Affects DCAD
- Requirement = 0.5 – 2% BW
- Sulfur amino acids
- TSI
 - Sulfates
 - DDGs
 - Low quality water
- Polioencephalomalasia
 - Excess sulfur in the diet

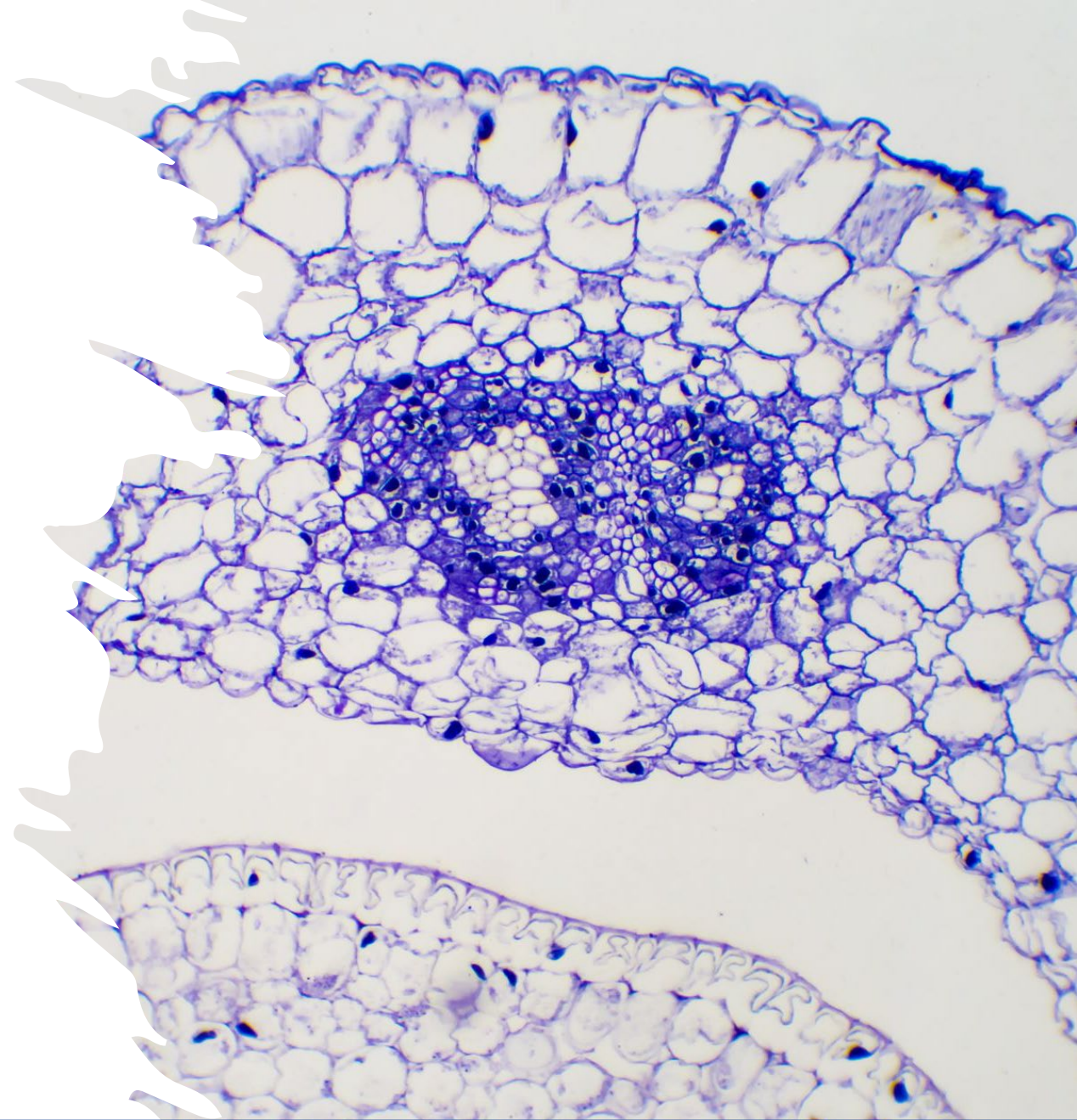


Vitamin A

- Animal sources
 - Retinol
- Plant sources
 - Beta-carotene
 - Can be complexed by lignin or phytates
- Important roles in vision

Vitamin E /Selenium/Vitamin C

- Free radicals and lipid oxidation
 - Lipid peroxidation
 - Aging
 - Cell membrane integrity
 - Cancer
- 3 main sources
 - Normal oxidative metabolism
 - Mitosomal cytochrome
 - Stimulated phagocytes



Vitamin E/Selenium/Vitamin C



Vit E

Only synthesized by photogenic pathway
Tocopherols



Vit C

Almost all plants
Animals can synthesize from glucose



Selenium

Component of iodothyronine
Glutathione Peroxidase

B Vitamins

B_1 = Thiamin

- Important for glucose metabolism
- Glucose in brain

B_2 = Riboflavin

B_3 = Niacin

B_5 = Pantothenic Acid

B_6 = Pyridoxal

- Never supplement to ruminants
- Transamination and AA metabolism
- Glycogen utilization

B_7 = Biotin

- Works with Mn and is essential for energy to leave to mitochondria
- Fatty liver syndrome

B_{12} = Cobalamine

- TCA in mitochondria

Cobalt

- Important component of Vitamin B₁₂
- Ruminants can synthesize B₁₂ with cobalt present
 - Bacterial byproduct
- Monogastrics need supplementation
- Deficiency
 - Anemia



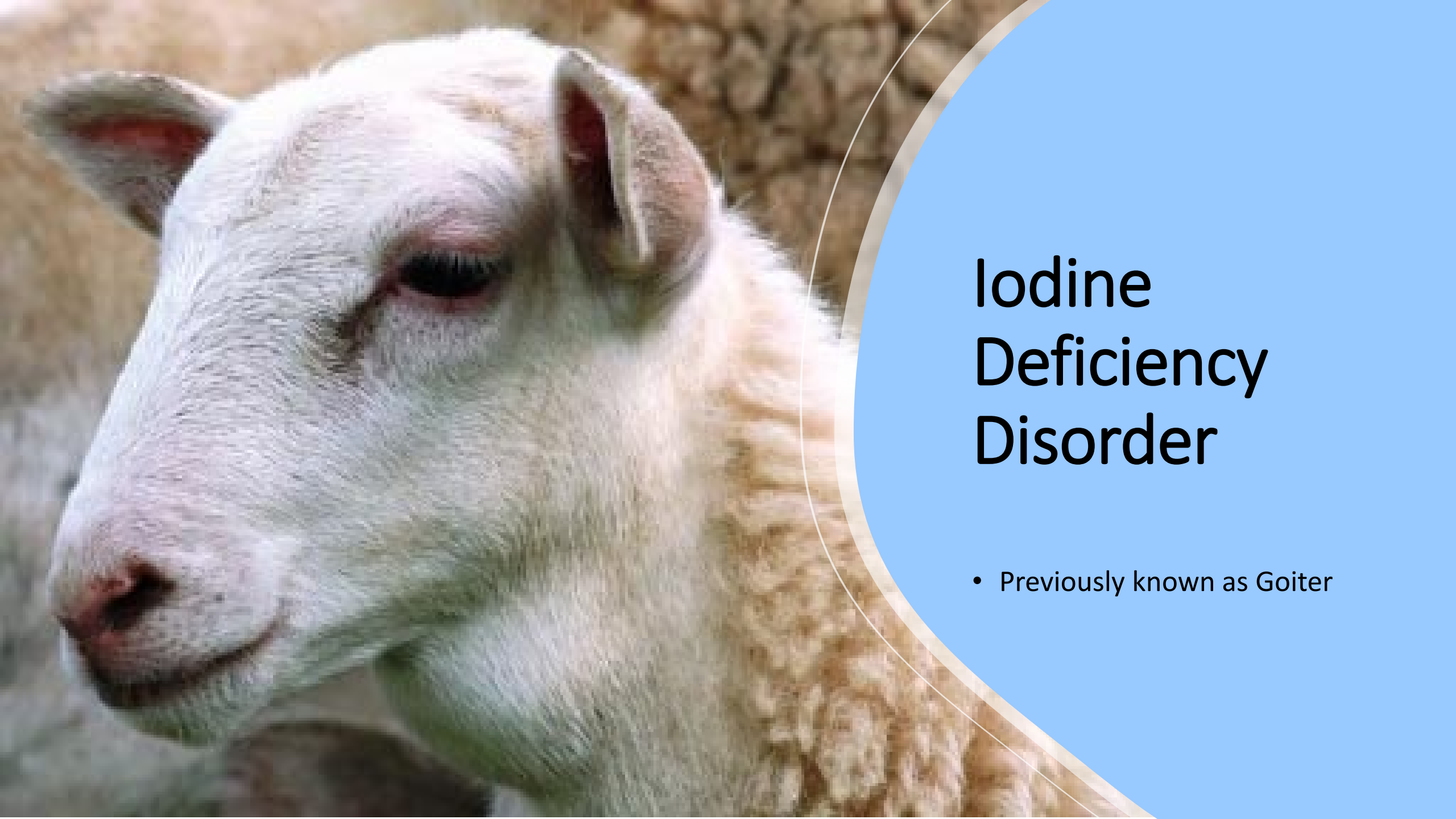
Iron

- Mostly present in hemoglobin and myoglobin
 - Important component of O₂ transfer
- Deficiency
 - Anemia
 - Most prominent in young animals



Iodine

- Component of thyroid hormones
 - Tyrosine and Iodine
- Regulates basal metabolism
- Deficiency
 - Iodine deficiency disorder (formerly known as goiter)
 - Hairlessness at birth
- Goitrogens
 - Inhibitory of Thyroid Peroxidase
- Other requirements: Se and Mg



Iodine Deficiency Disorder

- Previously known as Goiter

Copper

Many interactions with other minerals

- Mo, S, and Fe

Achromotrichia – loss of pigment

- Coenzyme for Tyrosinase
- Tyrosine → Melanin

Synthesis of connective tissue

- Lysil oxidases

Oxidation protection

- CuSOD

Zinc

- Constituent of metalloenzymes
- Zinc fingers
- Appetite control
 - CCK expression
- Fat absorption
 - Phospholipase A2
- Antioxidant
 - ZnSOD

Manganese

Important for bone formation

Metalloenzyme

Deficiency

- Altered glucose metabolism
- Poor bone growth

Selenium

Oxidation protection

- Glutathione peroxidase
- Vitamins E and C

Deficiency

- Nutritional muscular dystrophy
- White Muscle Disease

Toxicity

- Blind staggers
- Soil = 0.5ppm
- Diet = 4ppm

Chromium

- Impacts glucose uptake
 - Affects insulin receptor stability
 - Translocation of GLUT4
- Increase ATP Citrate Lyase activity
- Decrease stress via cortisol reduction
- Organic vs Inorganic forms?

Implications in Animal Health

- Cu – Increased susceptibility to bacterial infections
- Co – Poor parasitic resistance
- Se – Antioxidant defense, thyroid, immune function, reproduction, and production efficiency
- Zn – Immune function, performance efficiency, reproduction
- Mn – Activation of metalloenzymes that affect lipid and carb metabolism, reproduction
- Toxic elements
 - As, Cd, Pb, Hg

Current Mineral Data (Liver)

Sex	n	Cu (mg/kg)		Mg (mg/kg)		Se (mg/kg)		Zn (mg/kg)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Bulls	57	181.8	66.99	322.63	49.69	0.72	0.42	179.82	69.98
Cows	62	195.75	64.9	326.36	53.62	0.87	0.48	186.06	73.21
Heifer	94	191.2	72.72	328.19	53.22	0.8	0.44	187.75	73.71

Current Vitamin Data

Location	n	Vit A (ug/100g)		Vit E (α) (mg/100g)		Vit E (γ) (mg/100g)		Vit K (ug/100g)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Kidney	94	398.57	45.06	0.21	0.04	0.02	0.01	ND	ND
Muscle	94	0.89	0.14	0.04	0.01	0.01	<0.001	2.01	0.12
Liver	73	3450.43	871.08	0.31	0.06	0.05	0.02	82.19	6.63

Mineral deficiencies



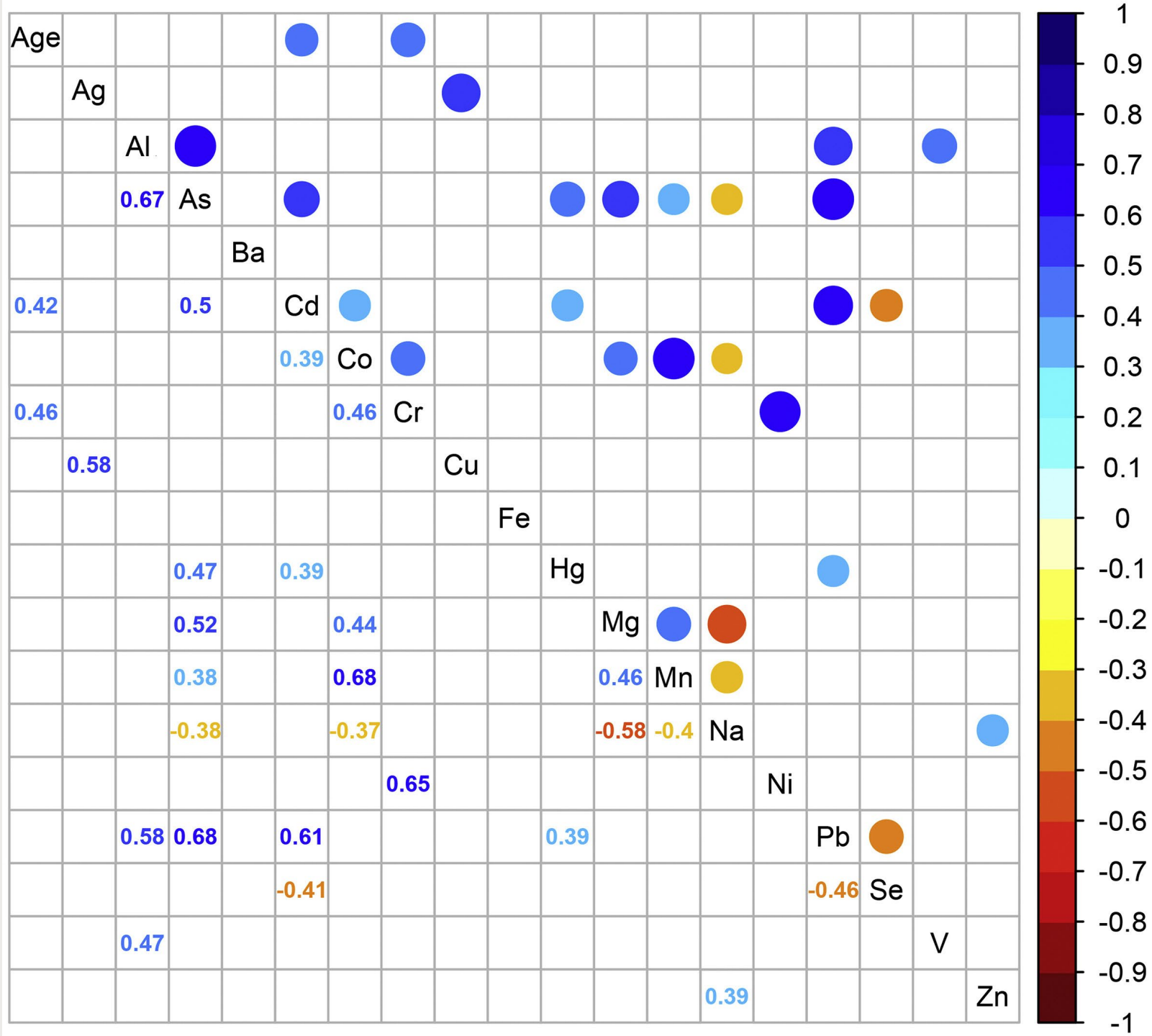
47 Silver Ag 107.87	13 Aluminum Al 26.982	33 Arsenic As 74.922	56 Barium Ba 137.33	56 Beryllium Be 9.0122	48 Cadmium Cd 112.41	27 Cobalt Co 58.933	24 Chromium Cr 51.996	29 Copper Cu 63.546
80 Mercury Hg 200.59	12 Magnesium Mg 24.305	25 Manganese Mn 54.938	11 Sodium Na 22.990	18 Nickel Ni 58.693	82 Lead Pb 207.2	34 Selenium Se 78.96	90 Thorium Th 232.04	
81 Thallium Tl 204.38	92 Uranium U 238.03	23 Vanadium V 50.942	30 Zinc Zn 65.39					

27 Cobalt Co 58.93	25 Manganese Mn 54.938	11 Sodium Na 22.990	30 Zinc Zn 65.39
29 Copper Cu 63.546	34 Selenium Se 78.96		

Fot. Maria Sobczak

Correlations of minerals in European Bison Liver

Spearman rank correlation coefficients between trace elements in the liver of the European bison ($n = 30$). The color and size of the circle indicate the level of correlation: with 1 indicating positive correlation (dark blue) and -1 indicating the negative correlation (dark red). Numerical values of correlations are presented in the lower left part of the matrix. For clarity, non-significant values ($p > 0.05$) are not shown.



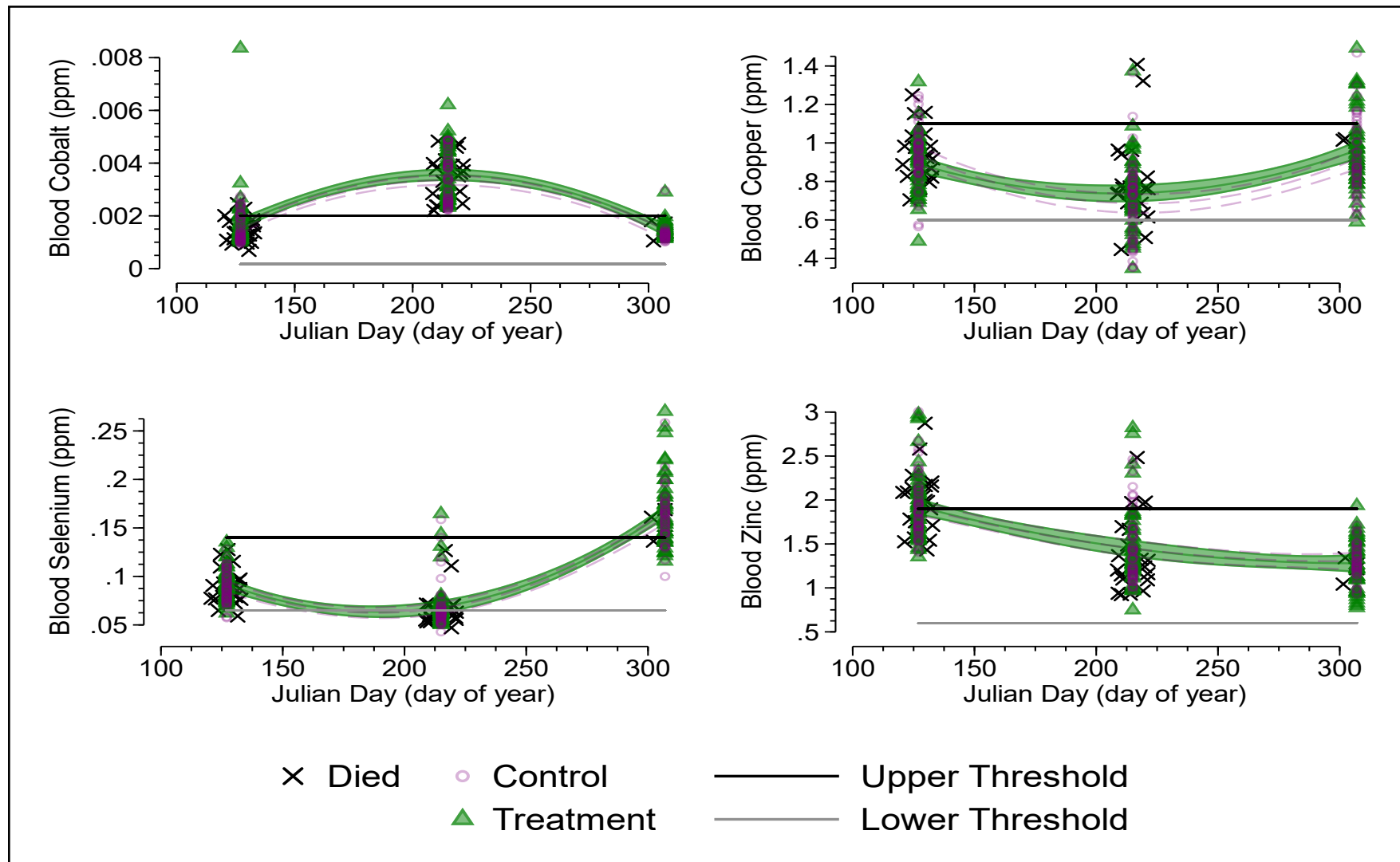


Figure 1. Blood serum mineral concentrations for Cobalt (upper left), Copper (upper right), Selenium (lower left), and Zinc (lower right) over the duration of the 2021 supplementation study (Julian Day) by treatment (filled green triangle) and control (open purple circle) groups of bison ($n = 1,295$ with those that died by the end of the study indicated with black 'x'; (these are 'jittered' around the day of year to show density). Individuals present above the upper black threshold line indicate possible toxicities and those below the lower gray threshold line indicate possible deficiencies.

Where do we go from here?

- Vit/Min study census studies
 - Eastern United States
 - Custer State Park
 - Turner Institute
- Requirement studies
 - Comparative slaughter
- Curriculum
 - Bison undergraduate and graduate courses at SDSU
 - Focus on production/management



Questions

