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Blood serum mineral element concentrations of weaned Montana ram lambs and their relationship with water quality characteristics

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ABSTRACT

Clinical and subclinical trace mineral deficiencies can limit productivity in western sheep production systems. The objective of this research was to determine the proportion of ranches that supplemented with trace minerals and to quantify serum trace mineral concentrations in ram lambs after weaning across Montana with particular emphasis on Se and Zn. Serum samples (n = 214) were collected from ram lambs 8 to 10 mo of age (52.8 ± 16 kg) at 21 ranches throughout Montana and analyzed for Co, Cu, Fe, Mn, Mo, Se, and Zn. Ranches were classified as deficient, marginally deficient, adequate, or excessive by flock mean serum trace mineral concentrations. Additionally, water samples were analyzed for pertinent characteristics. The median and interquartile range of serum concentrations for each trace mineral across ranches were as follows: Co (0.41 ng/mL; 0.90 ng/mL), Cu (0.79 μg/mL; 0.24 μg/mL), Fe (153 μg/dL; 52 μg/dL), Mn (1.70 ng/mL; 0.80 ng/mL), Mo (15.3 ng/mL; 19.3 ng/mL), Se (115 ng/mL; 97.5 ng/mL), and Zn (0.70 μg/mL, 0.19 μg/mL). Of ranches surveyed, 67% provided a trace mineral supplement. Ranches that provided supplementary trace mineral had greater serum Se concentrations ($P < 0.001$). The 2 most commonly deficient and marginally deficient minerals across Montana were Se (19% of ranches deficient; 23.8% of ranches marginally deficient) and Zn (9.5% of ranches deficient; 57.1% of ranches marginally deficient). Regionally, Se serum samples classified as deficient were all located in western Montana. Of ranches sampled, 40 and 35% of water samples exceeded upper desired concentrations for Na and sulfates, respectively.

Key words: Montana, ram lamb, selenium, sheep, zinc

INTRODUCTION

Sheep operations in the western United States rely on rangelands as their primary feed source, which could lead to clinical or subclinical trace mineral deficiencies and limit animal productivity. Minerals perform essential functions including structural, physiological, catalytic, and regulatory roles (Suttle, 2010). Forage trace mineral concentrations are highly variable across rangelands because they are largely influenced by soil geochemistry and plant stage of maturity (Mathis and Sawyer, 2004; Smith et al., 2014; Jones and Tracy, 2015).

Montana consists of 380,832 km^2 of diverse geography, resulting in a high potential for variability of trace mineral concentrations of rangelands and feedstuffs. Additionally, Montana has an estimated 200,000 total breeding sheep, which was the fifth largest inventory in the United States (USDA-NASS, 2017). Previous research reported Se and Zn concentrations in forages across the western United States were less than adequate for animal health and performance (Dargatz and Ross, 1996; Mathis and Sawyer, 2004). Mineral deficiencies in sheep, particularly Se and Zn, have negative effects on reproductive performance and longevity (Suttle, 2010), which may present potential production losses. Additionally, selection programs have resulted in increased growth performance and greater mature BW (Notter, 1998; Burton et al., 2015), which may necessitate greater precision in trace mineral nutrition management.

No previous study has quantified trace mineral status in western US breeding sheep populations. Therefore, the objective of this research was to quantify serum trace mineral concentrations in Montana ram lambs after weaning with particular emphasis on Se and Zn. It was hypothesized that mineral supplementation strategies and serum trace mineral concentrations would vary across flocks sampled, and Se and Zn serum concentrations would be less than adequate.

MATERIALS AND METHODS

Experimental Design

The experimental protocol for this study was approved by the Agricultural Animal Care and Use Committee of Montana State University (2016-AA04). This study was conducted from September 24 to November 23, 2015.

The authors declare no conflict of interest.

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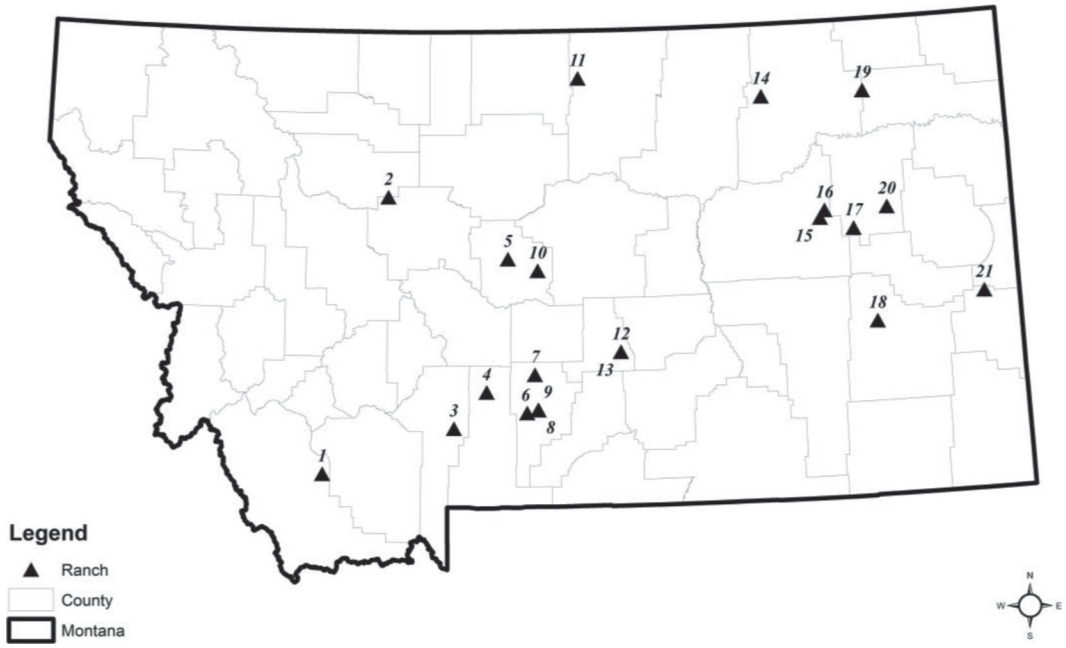

Figure 1. Map of sampling locations across Montana.

Twenty-one seedstock operations located across 15 counties and a wide range of production environments in Montana were sampled. Locations spanned from Dillon (45.2158° N, 112.6342° W) to Wolf Point (48.0914° N, 105.6425° W), representing a distance of approximately 805 km (Figure 1).

Participating ranches were selected for sampling based on their intent for developing and marketing rams to commercial operations. A homogeneous age group of 8- to 10-mo-old rams (52.8 ± 16 kg) were sampled within 2 mo after weaning to broadly assess trace mineral status across the state. This subpopulation of ram lambs was sampled due to similar developmental stage at a time of year when dietary trace mineral consumed came from late-season forages or harvested feedstuffs. A total of 214 rams were randomly sampled across ranches for analysis. Breed composition of the rams included Targhee (n = 95), Rambouillet (n = 47), Columbia (n = 20), Suffolk (n = 12), Hampshire (n = 15), other fine-wool breeds (n = 5), and various crosses (n = 20). Within each ranch, at least 15% of the ram lamb population was sampled, following recommendations for adequate sample size by Herdt and Hoff (2011).

All blood samples were collected via jugular venipuncture into 13 × 100 mm trace mineral royal blue top vacutainer tubes (Covidien, Mansfield, MA) without any additives. Blood was centrifuged at 1,573 × *g* at 20°C for 15 min approximately 4 h after collection (Herdt and Hoff, 2011), and serum was decanted into 2 aliquots in 2-mL tubes and stored at −20°C for later analyses. Samples that had a significant amount of hemolysis were not used in the laboratory analysis. Serum samples were shipped on ice overnight for trace mineral analysis at a commercial laboratory (Michigan State University Diagnostic Center for Population and Animal Health, East Lansing). Cobalt, Cu, Fe, Mn, Mo, Se, and Zn concentrations in serum were quantified using an ionized coupled plasma mass spectrometry method (Wahlen et al., 2005).

Operators at each location were surveyed on whether ram lambs were offered a trace mineral supplement to evaluate supplementation effects on serum trace mineral concentrations. Instances where ranches only provided a source of NaCl and not a trace mineral supplement were classified as unsupplemented. If supplementation occurred, there was no attempt to distinguish consumption or supplementation levels. Due to logistical and financial limitations, basal dietary trace mineral concentrations were not collected or analyzed from harvested feedstuffs or rangeland plant communities. Serum trace mineral concentrations were classified as deficient, marginally deficient, adequate, and excessive based on reference ranges established at Michigan State University, Diagnostic Center for Population and Animal Health (Table 1).

Samples (500 mL) were collected from the water source used by ram lambs at each ranch and analyzed by a commercial laboratory (Midwest Laboratories Inc., Omaha, NE) for livestock suitability (package W1 livestock suitability). Water characteristics included Ca, Cu, Fe, Mg, Na, chloride, nitrate-nitrogen, sulfate, and total dissolved solid content as well as pH and conductivity. Water characteristics were quantified using a light emission technique where prepared samples are injected into a high energy plasma that forces the elements in the injected sample to emit light wavelengths that are specific to each metal present. Ions of aqueous samples are separated and measured for conductivity.