Survey of Serum Trace Mineral Concentrations in Weaned Montana Ram Lambs

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IMPACT STATEMENT

Clinical and subclinical trace mineral deficiencies can limit productivity in western sheep production systems. The objective of the survey was to quantify trace mineral status among Montana ram lambs post weaning by examining blood serum mineral concentrations. Our results showed that selenium and zinc are the two most deficient and marginally deficient minerals in Montana ram lambs. On average Se levels were lower in animals reared in western Montana, while Zn was lower in animals sampled from operations located in the eastern half of the state. Producers and nutritionists can now use this data to formulate adequate mineral packages for their regions.

SUMMARY

Clinical and subclinical trace mineral deficiencies can limit productivity in western sheep production systems. The objective of the study was to quantify trace mineral status among Montana ram lambs post weaning. Based on prior research investigating forage trace mineral concentrations and trace mineral status in cattle, we hypothesized that clinical and subclinical deficiencies would be most prominent with Zn and Se. To test this hypothesis, serum samples (n = 201) were collected from ram lambs 8 to 10 mo of age (BW 52.8 ±16 kg) at 21 locations throughout Montana and analyzed for Co, Cu, Fe, Mn, Mo, Se, and Zn. The average concentration and range for each trace mineral analyzed in the serum samples were: Co (1.002 ng/mL; 0.09-6.22 ng/mL), Cu (0.837 µg/mL; 0.3-1.61 µg/mL), Fe (154.8 µg/dL; 26-350 µg/dL), Mn (2.562 ng/mL; 0.7-31.3 ng/mL), Mo (40.136 ng/mL; 2.8-456.5 ng/mL), Se (111.4 ng/mL; 16-197 ng/mL), and Zn (0.737 µg/mL, 0.3-1.74 µg/mL). The two most deficient and marginally deficient minerals across Montana were Se (19% of ranches deficient; 24% of ranches marginally deficient) and Zn (14% of ranches deficient; 52% of ranches marginally deficient). All Se deficient samples were obtained from western Montana. There was considerable variation in serum trace mineral concentrations within individual flocks. Given that Se and Zn play major roles in growth, fertility, and immunity, results suggest opportunities for more effective supplementation strategies. Producers and nutritionists alike can use these results to identify mineral deficient areas and develop cost effective mineral supplementation management practices.

INTRODUCTION

Forage mineral concentrations are variable throughout regions of the United States (Mortimer et al., 1999; Mathis et al., 2004). Seasonality, climate, plant maturity, along with other factors affect mineral availability in forages/feed, which are the main source of minerals, except in circumstances where there are excessive mineral concentrations in water (NRC, 2007).

With over 147,040 square miles of diverse geographic makeup, the variability of trace mineral concentration of Montana's forage is undoubtedly diverse. Montana has an estimated 230,000 sheep and lambs, 210,000 of those are breeding sheep ranking Montana 7th in breeding sheep numbers in the United States (USDA-

NASS, 2016). Even with a large sheep population and general knowledge of trace mineral deficiencies, specific research attempting to quantify trace mineral status in Montana sheep populations has not previously been examined.

The objective of this study was to quantify trace mineral status in ram lamb sub-populations to identify deficiencies during early post weaning periods of ram lamb development. We hypothesized that clinical and subclinical deficiencies are most prominent in regards to Se and Zn, based on prior research investigating forage trace mineral concentrations (Mortimer et al., 1999) and trace mineral status in Montana range cattle (Ricketts et al., 2002).

MATERIALS AND METHODS

From September 24, 2015 to November 23, 2015, serum samples were collected. Montana was divided into an east and west region at 48.5833˚ N longitudinal line. Ranches (n=21) involved in the survey were from a wide range of environments, 11 from the west and 10 from the east. The locations spanned from Dillon, Mt to Wolf Point, MT, representing a distance of approximately 805 km (**Figure 1)**.

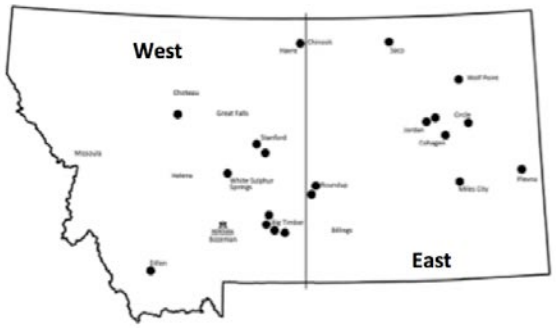

Figure 1: Map of sampling locations and longitudinal division of East and West regions.

Ranches were chosen that currently had ram lamb populations being developed for breeding purposes. Blood samples were drawn within 2 mo post weaning when the approximate age of the animals were 8 to 10 mo (BW 52.8 ± 16 kg). A total of 340 serum samples were initially collected across the 21 locations, however 201 serum samples were randomly subsampled for analysis thereafter to reflect a minimum of 15% of the ram lamb population at each ranch location.

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. Samples were put on ice until they were centrifuged at 2800 rpm for 15 min to decant serum, and 2 aliquots were taken from each sample. Aliquots were kept at -20˚C until sent for analysis at Michigan State University Diagnostic Center for Population and Animal Health. Serum trace mineral analysis included Co, Cu, Fe, Mn, Mo, Se, and Zn concentrations. Ranch (n = 21) was the experimental unit and data was analyzed using the MEANS, UNIVARIATE and FREQ procedures of SAS.

RESULTS AND DISCUSSION

Reference ranges for sheep serum trace mineral concentrations were provided by T. Herdt at the Michigan State University Diagnostic Center for Population and Animal Health (Herdt, 2000). Results from the survey suggested adequate serum trace mineral concentrations for Co, Cu, Fe, and Se (**Table 1**). Average serum Mn and Mo concentrations (**Table 1**) were greater than adequate (> 0.5 ng/mL), but were not determined to be toxic. Average serum Zn concentrations were found to be deficient (< 0.6 µg/mL) in Montana ram lambs.

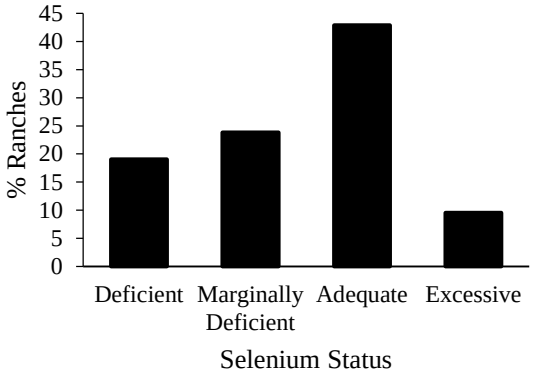

Figure 2: Distribution of Se status across 21 Montana sheep operations. Deficient: < 50 ng/mL; Marginally deficient: 50 to 90 ng/mL; Adequate: 110 to 160 ng/mL; and Toxic: > 160 ng/mL (Herdt, 2000).

Cobalt. Cobalt concentrations were adequate, with average and range 1.002 ng/mL and 0.09-6.22 ng/mL. A concentration of 0.1 ng/mL and above is thought to be adequate in ram lamb serum samples

Copper. Cu serum concentration average and range was 0.837 µg/mL and 0.3-1.61 µg/mL. The average was within an adequate range 0.7-2.0 µg/mL. Authors acknowledge that liver biopsies would have been a superior indicator of Cu status but due to the collection of samples from privately owned sheep, liver biopsies were not feasible.

Iron. Fe serum concentration average and range was 154.8 µg/dL and 26-350 µg/dL, with an adequate range being between 116-222 µg/dL. Fe is the most abundant trace mineral in the body and approximately 60% of it is found in hemoglobin as an essential part to oxygen and carbon dioxide transportation (NRC, 2007)

Manganese. Mn serum concentration average and range was 2.562 ng/mL and 0.7-31.3 ng/mL. An adequate range for serum Mn is between 0.5-2.0 ng/mL. Although the Mn serum concentration average across the state is higher than what is found to be adequate concentration range, Mn is low in toxicity even at high levels (NRC, 2007). An antagonistic relationship exists between Fe and Mn, enabling a minimum level of Mn to reduce appetite and growth rate in some weaned lambs (NRC, 2007)

Molybdenum. Mo serum concentration average and range was 40.136 ng/mL and 2.8-456.5 ng/mL. Mo serum concentrations have been reported to range between 12-30 ng/mL in healthy sheep, however accurate reference ranges have only recently been established (T. Herdt, MSU Diagnostic Center for Population and Animal Health personal communication). A larger database is needed to determine true adequate ranges and make accurate comparisons to the current data set.

Selenium. Se serum concentration average and range was 111.4 ng/mL and 16-197 ng/mL, with an adequate range of 110-160 ng/mL. Selenium status across MT ranches is shown in **Figure 2**. Results suggest the mean serum selenium concentrations are within adequate reference ranges yet approximating marginal status. Clinical signs of Se deficiency are often manifest as nutritional myopathy (white muscle disease,) but can also result in production losses in subclinical instances. Marginal deficiencies can cause impairments in growth performance, loss of milk yield, decreased reproductive performance and loss of wool production but can be remedied with Se supplementation (Slen et al, 1961; Gabbedy, 1971; McDonald, 1975; Suttle, 2010).

The ranches from the eastern half of Montana were 0% deficient, 10% marginally deficient, 60% adequate, and 30% excessive based on average serum Se concentrations. Ranches in the western half of Montana were 36.4% deficient, 36.4% marginally deficient, 27.3% adequate, and 0% in excess based on average serum Se concentrations. Montana as a whole had 100% of Se deficient cases and 80% of marginally deficient ranches occur in the western half of the state.

Zinc. Zinc serum concentration average and range was 0.737 µg/mL and 0.3-1.74 µg/mL with an adequate range of 0.8-1.2 µg/mL. Zinc status of ram lambs is located in **Figure 3**. Zinc is difficult to analyze because there is no one well-defined storage area in the body but serum levels seem to be the best indicator of Zn status in the animal (Herdt et al., 2000). Zinc is the next abundant trace mineral in the body second to iron (Herdt et al., 2000). Therefore, Zn plays significant roles in the immune system, reproductive capabilities, and growth

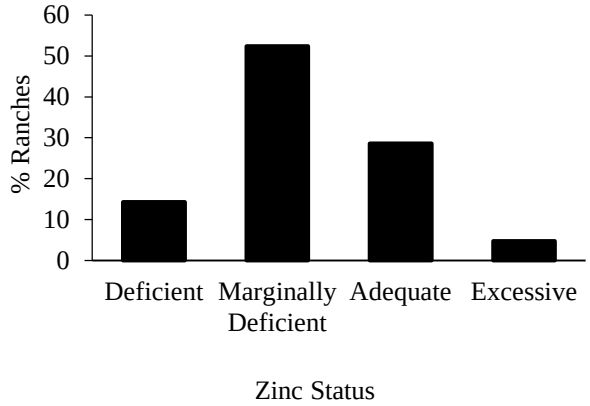

Figure 3: Distribution of Zn status across 21 Montana sheep operations. Deficient: < 0.6 µg/mL; Marginally deficient: 0.6 to 0.8 µg/mL; Adequate: 0.8 to 1.2 µg/mL; and Toxic: > 1.2 µg/mL (Herdt, 2000).

characteristics by influencing enzyme activity and gene expression of proteins (NRC, 2007). The ranches from the eastern half of Montana were 20% deficient, 50% marginally deficient, 30% adequate, and 0% excess based on average serum Zn concentrations. The western half of Montana ranches were 9.1% deficient, 54.6% marginally deficient, 36.4% adequate, and 0% in excess based on average serum Zn concentrations. Montana as a whole had 66% of Zn deficient and 45.5% of Zn marginally deficient ranches found on the eastern half of the state. Approximately 2/3 of ranches sampled were categorized as deficient or marginally deficient in serum Zn concentration. Studies have shown that variability in mineral consumption exists in flocks that are provided mineral ad libitum (Ragen et al., 2015). This could account for the variability that we witnessed within flocks in this study. Surprisingly, 20% of ranches sampled described their mineral supplementation strategies as inconsistent, and sporadic throughout the year. Deficiencies and marginal deficiencies in trace mineral status may be a result of both mineral inclusion rate, and bioavailability of the chemical form in the mineral supplement (oxide vs. chelated source), and delivery method (block vs. granulated). Mineral content of water sources and ram trace mineral status is currently being evaluated to identify antagonistic relationships across ranches sampled.

IMPLICATIONS

Trace mineral deficiencies exist among ram lamb populations in Montana and should be taken into account when determining sheep management practices and mineral supplementation strategies. Variability exists among individual flocks, likely because of varied consumption and other factors. On average selenium levels were lower in animals reared in western Montana, while zinc was lower in animals sampled from operations located in the eastern half of the state.

Future research will look at the most effective and economical way to adequately supplement essential trace minerals for sheep populations across Montana with an immediate emphasis on Zn source an it's effects on growth, fertility, and immune function in developing rams.

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Table 1. Minimum, maximum, mean, median and standard error of serum trace mineral concentrations from Montana ram lambs (n = 201)

Trace Mineral	Minimum	Maximum	Mean	Median	Standard Error
Se, ng/mL	16.00	197.00	111.42	122.00	3.310
Zn, µg/mL	0.30	1.74	0.73	0.71	0.015
Co, ng/mL	0.09	6.22	1.00	0.50	0.079
Cu, µg/mL	0.30	1.61	0.84	0.80	0.016
Fe, µg/dL	26.00	350.00	154.85	149.00	3.682
Mn, ng/mL	0.70	31.30	2.56	1.80	0.225
Mo, ng/mL	2.80	456.50	40.14	15.40	5.001