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CHARACTERIZATION OF FORAGE TRACE MINERAL CONCENTRATION BY SEASON IN DIETS OF BEEF COWS GRAZING NATIVE RANGE IN EASTERN COLORADO[1]

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ABSTRACT: Concentrations of Se, Cu, Co, Fe, Mn, Mo, and Zn in diets of cows grazing native sandhills range in Eastern Colorado were characterized during a 21-month period in 2001 and 2002. After rumen evacuation and short-term grazing (approximately 30 min.), rumen grab-samples were collected from 2 fistulated beef cows. Samples were collected 27 times (once or twice monthly) and represented 4 seasons during each yr: winter (Nov. to Mar.), spring (April to May), summer (June to Aug.), and fall (Sept. to Oct.). Samples (n = 54) were analyzed for trace mineral concentration. In most (> 90%) samples, Co and Mo concentrations could not be quantified because they were below detection limits (0.5 and 1.0 mg/kg DM, respectively). Overall mean (± SD) concentrations (mg/kg DM) were: Se, 0.26 ± 0.097; Cu, 3.9 ± 1.84; Fe, 428.1 ± 530.06; Mn, 67.7 ± 25.05; and Zn, 18.3 ± 6.43. There was a tendency ($P = 0.10$) for a yr × season interaction for Mn concentration, but no yr × season interaction ($P > 0.48$) for Se concentration, so data were pooled across yr for Mn and Se. Concentration of Se tended to be greater in spring vs. summer ($P = 0.11$) and fall ($P = 0.06$), and Mn concentration tended ($P = 0.09$) to be greater in winter than spring. There were yr × season interactions for Cu ($P < 0.01$), Fe ($P < 0.05$), and Zn ($P < 0.001$) concentrations. In Yr 1, Cu concentration was greater ($P < 0.05$) in winter vs. summer and fall, and tended ($P < 0.09$) to be lower in fall vs. spring and summer. In Yr 2, Cu concentration was lower ($P < 0.05$) in winter vs. all other seasons. Concentration of Fe in Yr 1 was greater ($P < 0.05$) in winter than all other seasons. Winter Zn concentration in Yr 1 tended ($P = 0.08$) to be greater than spring, and was greater ($P < 0.05$) vs. summer and fall. Concentration of Zn was lower ($P < 0.05$) in winter vs. all other seasons in Yr 2, and greater ($P < 0.05$) in fall compared to all other seasons. Results suggest that beef cow diets in parts of eastern Colorado contain inadequate Cu and Zn concentrations, and concentrations of some trace minerals may differ by season.

Key words: Beef Cows, Native Range, Trace Minerals

Introduction

Trace minerals are necessary for normal growth, reproduction, and immune response in beef cattle (McDowell, 1992). During most of the year, native range forages provide the primary source of trace minerals for the majority of beef cows throughout the western U.S. As range forages mature during the summer and fall, nutrient content (fiber, protein, etc.) and digestibility undergo substantial changes. Thus, in many situations, nutrient supplementation to cattle is necessary in order to avoid deficiencies and maintain production. A major challenge faced by western beef cow/calf operators is determining when and how to supplement (Bohnert and DelCurto, 2004).

The ability of a beef cow to perform on western rangelands depends on 3 primary factors: 1) nutrient concentration and availability in forage, 2) forage intake, and 3) nutritional needs of the animal (Adams and Short, 1988). Nutrients required by beef cattle are well documented (NRC, 1996); however, information on the amount of minerals in beef cow diets is limited. Without these data, development of a low-cost trace mineral supplementation strategy to provide necessary trace minerals and reduce supplementation costs can be difficult.

Sprinkle and others (2000) documented that trace mineral concentrations in hand-clipped forages vary significantly at different stages of the growing season in Arizona. Similarly, year-to-year, month-to-month, and species-specific patterns of mineral concentration in 7 northern Great Basin rangeland grasses, also collected via clipping, are quite variable (Ganskopp and Bohnert, 2003). Earlier researchers using Texas native range evaluated the effect of plant selection by grazing livestock on the resulting concentration of macro minerals in the diet (Pinchak et al., 1989). The authors suggested that selection of live tissue vs. whole plants would result in a diet with maximum macro mineral concentrations.

Therefore, the objective of this study was to characterize seasonal effects on the forage concentrations of Se, Cu, Co, Fe, Mn, Mo, and Zn consumed by cows grazing native sandhills range in Eastern Colorado in order to determine if trace mineral supplementation strategies should be adjusted seasonally by beef cattle producers.

Materials and Methods

General procedures. Two mature, ruminally-fistulated beef cows were used during a 21-month period (January 2001 through September 2002) to collect masticated diet samples from native sandhills range at the Eastern Colorado Research Center (Akron, Colorado). The native range consisted primarily of blue grama (*Bouteloua gracilis*), prairie sandreed (*Calamovilfa longifolia*), and needle-and-thread grass (*Stipa comata*), which collectively comprised approximately 80% of the vegetation.

Sample collection was done as described by Olson (1991). Briefly, prior to sample collection, each rumen was completely evacuated by hand and the liquid portion was removed via a modified wet/dry vacuum cleaner. Each cow was then allowed to graze for approximately 30 min. in a designated 40 hectare pasture. After grazing, a diet sample (approximately 2 kg) was collected from each cow and frozen for later analysis. After grazed forages were sampled, each rumen was refilled with its original contents.

Samples were collected at 27 different times (once or twice monthly) during the trial, and represented 4 seasons during each yr: winter (Nov. to Mar.), spring (April to May), summer (June to Aug.), and fall (Sept. to Oct.). After freeze-drying, samples (n = 54) were ground to pass through a 2 mm screen and analyzed for trace mineral concentration via inductively coupled plasma atomic emission spectroscopy.

Data analyses. With animal as the experimental unit, data were analyzed using a restricted maximum likelihood-based, mixed effects model repeated measures analysis (PROC MIXED, SAS Inst. Inc., Cary, NC) to determine the effect of growing season on trace mineral concentration. Season and rumen-cannulated cows were the independent variables and concentration of trace mineral was the dependant variable.

Results and Discussion

In most (> 90%) of the samples, Co and Mo concentrations could not be quantified because they were below detection limits (0.5 and 1.0 mg/kg DM, respectively). Only 4 samples had Co concentrations above 0.5 mg/kg DM, and none were greater than 2.0 mg/kg DM. Similarly, of the 3 samples where Mo was quantified, the highest Mo concentration was 1.27 mg/kg DM. Based on these apparent low Mo concentrations, any antagonistic effect of Mo on Cu in a ruminant's diet would most likely be minimal (NRC, 1996).

For the other minerals, overall mean (± SD) concentrations (mg/kg DM) were: Se, 0.26 ± 0.097; Cu, 3.9 ± 1.84; Fe, 428.1 ± 530.06; Mn, 67.7 ± 25.05; and Zn, 18.3 ± 6.43. Relative to NRC (1996) recommendations for beef cows, mean trace mineral concentrations in masticate diet samples collected at the 27 sampling times were adequate for Se and Fe every time, adequate in Mn 26 times, and adequate in Zn only 2 times. Mean copper concentration was not adequate at any of the collection times.

In terms of the effect of season on trace mineral concentration, there was a tendency ($P = 0.10$) for a yr × season interaction for Mn concentration, but no yr × season interaction ($P > 0.48$) for Se concentration, so data were pooled across yr for both Mn and Se (Table 1). Concentration of Se tended to be greater in spring vs. summer ($P = 0.11$) and fall ($P = 0.06$). In contrast, Mn concentration was not affected by season, but tended ($P = 0.09$) to be greater in winter than spring.

Mean Cu, Fe, and Zn concentrations are reported in Table 2. There were yr × season interactions for Cu ($P < 0.01$), Fe ($P < 0.05$), and Zn ($P < 0.001$) concentrations, and therefore data are reported by yr. In Yr 1, Cu concentration was greater ($P < 0.05$) in winter vs. summer and fall, and tended ($P < 0.09$) to be lower in fall vs. spring and summer. In Yr 2, Cu concentration was lower ($P < 0.05$) in winter vs. all other seasons. Concentration of Fe in Yr 1 was greater ($P < 0.05$) in winter than all other seasons. In Yr 2, Fe concentrations were not different among the 4 seasons. Winter Zn concentration in Yr 1 tended ($P = 0.08$) to be greater than spring, and was greater ($P < 0.05$) vs. summer and fall. Concentration of Zn was lower ($P < 0.05$) in winter vs. all other seasons in Yr 2, and greater ($P < 0.05$) in fall compared to all other seasons. Interestingly, mean fall Zn concentration in Yr 2 was the only season during the entire experiment when dietary Zn concentration was adequate relative to NRC (1996) recommendations for beef cows.

Results for Zn, Cu, Fe and Mn in the current experiment are similar to those reported in a large survey by Corah and others (1996) where 352 forage samples collected from 18 states (including Colorado) were evaluated for trace mineral concentration. In general, relative to beef cow dietary needs, the authors reported widespread deficiencies of Se and Zn, marginal Cu deficiency and elevated concentrations of Cu antagonists (Fe, Mo, and S), and adequate concentrations of Mn and Fe.

In a regional experiment, a smaller-scale survey conducted to quantify forage trace mineral concentrations in New Mexico (Mathis and Sawyer, 2004) via hand-plucked samples reported similar results. The authors observed that overall trace mineral concentrations varied greatly, based on more than a ninefold range in concentrations for all minerals evaluated. When compared to NRC (1996) recommendations for beef cows, forage samples were inadequate in Cu (40% of samples), Mn (16%), Se (92%), and Zn (77%) concentration. However, unlike the current experiment, trace mineral concentrations were higher in fall than late winter in most cases.

Also in agreement with our results, Sprinkle et al. (2000) reported that hand-clipped range forage samples in Arizona were marginally deficient in Cu (7.0 mg/kg DM) and Zn (20.5 mg/kg DM). Although, in contrast to our results, the authors observed that Se was deficient (0.05 mg/kg DM) throughout the 2-yr study. In that experiment, which evaluated how Cu, Se, and Zn varied by season, only Cu and Zn concentrations varied during the yr, apparently due to winter and summer precipitation levels.

Consistently low Cu (1.75 mg/kg DM) and Zn concentrations (12.1 mg/kg DM) have also been reported in northern Great Basin grasses sampled monthly over a 2-yr period (Ganskopp and Bohnert, 2003). Also, Fe concentration was adequate and Mn concentration was generally adequate (38.6 mg/kg DM). However, Mn was the only trace mineral that varied by season by increasing as grass matured.

Grings et al. (1996) also observed widespread inadequate concentrations of Zn and Cu and adequate concentrations of Mn for beef cattle. In that experiment, northern Great Plains mineral concentrations were characterized in clipped range samples by plant species, date, and tissue class (live vs. dead). Similar variability in mineral concentration to the current experiment was observed, as well as low and mostly-undetectable Mo concentrations (< 1.0

mg/kg DM) that did not exceed 2.0 mg/kg DM. In general, the authors reported no obvious patterns of mineral concentration change during the growing season.

In conclusion, results of the current experiment indicate that beef cow diets in areas of eastern Colorado contain very low concentrations of Mo and Co, inadequate Cu and Zn concentrations, and adequate concentrations of Fe, Mn, and Se. In addition, trace mineral concentrations in beef cow diets can differ by season, but not consistently across years or minerals. It should be noted that trace mineral values reported are from masticate samples, and the digestibility of the trace minerals within the masticate samples was not determined. Therefore, caution should be taken when formulating trace mineral supplements based on masticate trace mineral analysis or, for that matter, any forage sample.

Implications

Limited information is available on the concentrations of trace minerals in diets of beef cows grazing western range. However, data suggest that trace mineral concentrations vary substantially due to several variables. In general, among beef cows in the western U.S., researchers have consistently shown that copper and zinc concentrations are widely inadequate, manganese and iron concentrations are mostly adequate, and selenium concentrations are extremely variable. In addition, seasonal variation in trace mineral concentration does occur, but does not follow a consistent pattern. Therefore, site-specific forage collection and analysis at more than one time during the year is warranted prior to development of a trace mineral supplementation program.

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Table 1. Least squares means for Se and Mn concentrations (± SE) in beef cow diets on native range in Eastern Colorado[a]

Season of year	Se concentration (mg/kg DM)	SE	Mn concentration (mg/kg DM)	SE
Winter	0.26	0.024	75.1	6.129
Spring	0.32	0.030	58.1	7.661
Summer	0.26	0.020	68.2	5.082
Fall	0.22	0.040	63.3	10.279

[a] There was no yr × season interaction for Se concentration ($P = 0.48$), and a tendency ($P = 0.10$) for a yr × season interaction for Mn concentration; therefore, data were pooled across yr for Se and Mn.

Table 2. Least squares means for Cu, Fe, and Zn concentrations (± SE) in beef cow diets on native range in Eastern Colorado[a]

Season of year	Cu concentration (mg/kg DM)	SE	Fe concentration (mg/kg DM)	SE	Zn concentration (mg/kg DM)	SE
Year 1						
Winter	5.38[b]	0.506	937.8[b]	153.99	21.93[b]	1.680
Spring	4.10[bc]	0.653	232.1[c]	198.80	17.08[bc]	2.168
Summer	3.86[c]	0.506	140.7[c]	153.99	15.75[c]	1.680
Fall	2.19[c]	0.800	199.5[c]	243.48	15.35[c]	2.656
Year 2						
Winter	1.87[b]	0.653	318.3	198.80	12.42[b]	2.168
Spring	4.20[c]	0.800	536.3	243.48	20.93[c]	2.656
Summer	3.71[c]	0.462	434.0	140.57	19.84[c]	1.533
Fall	4.84[c]	1.131	440.0	344.33	30.25[d]	3.756

[a] There was a yr × season interaction for Cu ($P < 0.01$), Fe ($P < 0.05$), and Zn ($P < 0.001$) concentration; therefore data are reported by yr for Cu, Fe, and Zn.
[b,c] Within a year for each mineral, values in the same column without common superscripts are different ($P < 0.05$).