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EFFECTS OF A LONG ACTING TRACE MINERAL RUMEN BOLUS UPON RANGE COW AND CALF TRACE MINERAL PROFILES [1]

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ABSTRACT: The objectives were to determine if strategic supplementation of range cows with a long acting (six mo) rumen bolus containing Cu, Se, and Co would alter liver Cu or Zn in cows, or blood Se, Cu, or Zn in cows and calves and exhibit differential response between cow breeds. Treatment and control cows used over three years consisted of 42 and 45 Composite (C) cows (25% Hereford, Angus, Gelbevieh, and Barzona), 35 and 41 Hereford (H) cows, and 44 and 44 Brahman (B) cross cows, respectively. Prior to administering the bolus in January, cows had liver and blood samples obtained. Liver and blood sampling was repeated for cows in May and blood sampling for calves in May and September. Data were analyzed using a restricted maximum likelihood-based mixed effects model appropriate for repeated measures with fixed effects of treatment, cow breed, month, year, and age of dam. Blood data included breed x bolus, bolus x year, and month x year interactions, and for cow Se, bolus x month x year. Liver data included breed x bolus as an interaction. Cow within breed by treatment was included as a random effect. Overall liver Cu was deficient ($P < 0.0001$) in control cows and adequate for treated cows. Liver Cu differed by year ($P < 0.01$). Blood Se was adequate for all cows except in January 2001 and 2002. There was no difference ($P > 0.05$) in Se between treatment groups in January but treated cows always had greater ($P < 0.10$) Se in May. Breed differences for Se existed for both treatment cows and calves ($P < 0.05$). Calves from treatment cows had greater Se than calves from control cows ($P < 0.0001$) and the concentration of calf Se dropped ($P < 0.0001$) from May to September. Cow and calf serum Cu and Zn differed ($P > 0.05$) by breed, month, and year but did not accurately reflect trace mineral status for cow liver. Strategic supplementation of copper and selenium via a long acting trace mineral bolus in late gestation was successful in increasing liver copper in cows and blood selenium in cows and calves, but varied by year for Cu and for Se, year and breed.

Key Words: Cattle, Minerals

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Introduction

Gooneratne and Christensen (1989) demonstrated that the developing fetus draws extensively from maternal liver stores of copper. Similarly, selenium efficiently passes from pregnant cows to the fetus through the placenta (Koller et al., 1984) and this maternal mode of transfer has been shown to more effective in improving selenium status in calves than through the milk of cows supplemented postpartum (Enjalbert et al., 1999).

Breed effects for efficiency in metabolizing copper have been well documented (Littledike et al., 1995); however, breed differences in selenium metabolism are not well understood.

The objective of this study was to determine if strategic supplementation of range cows during late gestation with a long acting (6 mo; Cosecure®, Telsol Ltd., Leeds, United Kingdom) rumen bolus containing Cu, Se, and Co would alter liver Cu and Zn in cows, or blood Se, Cu, or Zn in cows and calves and whether the response would vary by breed.

Materials and Methods

Range site. The study site for this experiment was at the V-V Ranch operated by the University of Arizona and located near Camp Verde, Arizona. The ranch ranges in elevation from approximately 975 m to 2195 m. Average yearly precipitation ranges from 40 cm at the lower elevations to 70 cm at the upper elevations. However, annual precipitation during the course of this trial was quite variable, with above average precipitation during the growing season in 2001, below average precipitation during the growing season in 2002, and above average precipitation during March and June 2000 and mostly below average summer precipitation in 2000.

Forage Sampling. Forage was sampled by hand clipping four times a year (January, April, June or August, and September) from four different locations on the ranch.

Forage Analyses. Prior to mineral analysis, forage samples were dried at 65º C for 48 to 72 h, then ground to pass through an approximately 2 mm screen using a Wiley mill (AOAC, 1995) by the AZ Veterinary Diagnostic Laboratory (**AZVDL**) in Tucson. For the determination of total Se, samples were first wet digested with a solution of nitric acid and magnesium nitrate followed by dry ashing at 500° C (Shimoishi, 1976). Selenium was selectively extracted from the digests as the 2-nitro piazselenol chelate and quantified by capillary gas chromatography with electron capture detection (Shimoishi, 1976). Forage samples were analyzed for copper and zinc by a commercial laboratory (Dairy One, Ithaca, NY) using inductively coupled plasma emission spectroscopy as described by Sirois et al. (1991).

Animals. The trial commenced in January 2000 and concluded in September 2002. Treatment and control cattle were randomly allocated at the onset and each yr cattle were chosen from within these groups for a total of 42 and 45 Composite (**C**) cows (25% Hereford, Angus, Gelbevieh, and Barzona or Senepol), 35 and 41 Hereford (**H**) cows, and 44 and 44 Brahman (**B**) cross cows, respectively. Cows ranged in age from 3 to 8 yr for C, 3 to 11 yr for H, and 5 to 15 yr for B.

Cows in the treatment group were orally dosed each January with two 100 gram Cosecure® boluses consisting of 0.30% (wt/wt) selenium as sodium selenate, 13.4% (wt/wt) copper, and 0.5% (wt/wt) cobalt. According to company literature validated with rumen fistulated cattle on a silage and concentrate ration, boluses dissolved in 175 d and released 156, 5.9, and 3.4 mg/d of Cu, Co, and Se, respectively.

Cattle remained in a common herd without any type of oral trace mineral supplement for the three years of the trial except for free choice white iodized salt blocks. In the winter of 2002, from early February to late April 2002, cows were provided free pasture access to protein blocks (27% crude protein; Eagle Milling Co., Inc., Casa Grande, AZ) containing 17 ppm Cu, 149 ppm Zn, and 0.301 ppm Se. At an average daily intake of 0.88 kg of protein supplement, it was estimated that cattle received 15 mg/d Cu, 131mg/d Zn, and 0.26 mg/d Se from the protein supplement.

Data Sampling for Cattle. During the three-yr study, liver and blood samples were obtained from cows in January and May (except that liver samples were not collected in January 2000), and blood samples were collected from calves in May and September. Blood samples were collected via tail venapuncture for cows and by jugular venapuncture for calves using trace mineral free Vacutainers (Becton-Dickinson, Inc., Franklin Lakes, NJ) and stored on ice during transport to the laboratory. Whole blood samples were used for Se (except for May 2000 calves, for which serum was used) and blood serum for Cu and Zn. Blood serum for calves was used for Se analysis in May 2000 due to whole blood samples accidentally getting frozen. Blood samples were centrifuged at 2,400 x g for 20 min and serum collected and stored at -20˚C. Whole blood samples were stored at 5˚C. Liver samples were collected using a Schackelford-Courtney Liver Biopsy Instrument (Sontec Instruments, Englewood, CO) according to the technique described by Rogers et al. (2001) and stored at -20˚C until analyses.

Mineral Analyses. Selenium analyses of whole blood were determined at the AZVDL using the same methods as previously described for forage samples. Serum samples were shipped overnight to the Animal Nutrition and Growth Lab, Department of Animal Science, Texas A & M University, College Station, TX and analyzed for Cu and Zn by flame atomic absorption spectroscopy (Model S11, Thermal Jarrel Ash Corp.). Serum samples were diluted 1:1 with double-distilled, deionized water, and standards prepared in a 15% (vol/vol) glycerol solution. Liver samples (approximately 0.1 g wet tissue) were freeze dried for 24 h and then predigested with 5 ml of nitric acid for three d. Following addition of 1 ml of hydrogen peroxide, samples were digested in a MSP 1000 microwave sample preparation unit (CEM Corp.) for 2 h at 100˚C. Digested liver samples were diluted with double distilled water, and Cu and Zn analyses conducted as described above. Atomic absorption standards were prepared in 2% nitric acid solution.

Missing Data. Due to the extensive nature of the V-V Ranch (31,161 ha), we were not able to gather all the cattle for the May sampling period in 2002 (78 total cows gathered). In May 2001, 15 cows failed to calve by the time the liver biopsy was obtained (4 B, 5 C, and 6 H), so these cows were not included in data analyses. There were 77 calves sampled in May 2000, 78 in September 2000, 69 in May 2001, 81 in September 2001, 73 in May 2002, and 67 in September 2002. There were 34 calf serum samples which froze in September 2002 and had to be eliminated from analyses due to excessive hemolysis.

Statistical Analyses. Data were analyzed using a restricted maximum likelihood-based mixed effects model appropriate for repeated measures (SAS Inst., Inc., Cary, NC) with fixed effects of treatment, cow breed, month, year, and Beef Improvement Federation (BIF, 1990) age of dam. An unstructured correlation structure was used to model within subject error. Blood data included breed x bolus, bolus x year, and month x year interactions, and for cow Se, bolus x month x year. Liver data included breed x bolus as an interaction. Cow within breed by bolus was included as a random effect. Yearly concentrations of forage were analyzed using a restricted maximum likelihood-based mixed effects model appropriate for repeated measures with fixed effects of plant species, year, month, and plant species x year. Pasture was included as a random effect. An unstructured correlation structure was used. Treatment means for blood and liver data and yearly forage concentrations of Cu, Se, and Zn were separated using all pairwise tests using unprotected least squares difference tests.

Results and Discussion

Overall Forage Trace Mineral Concentrations. Concentrations of Cu in forage were nearly adequate (10 ppm; NRC, 1996) in 2000 (9.2 ± .46 ppm), marginally deficient in 2002 (4.9 ± .45 ppm), and severely deficient in 2001 (3.9 ± .46 ppm), a year with more favorable precipitation during the growing season. The concentrations of Se in acted in an opposite fashion to that of Cu, being 0.042 ± .006 ppm in 2000, 0.079 ± .006ppm in 2001, and 0.045 ± .006 ppm in 2002), though the concentrations of Se were always deficient in forage (< 0.1 ppm; NRC, 1996). Concentrations of Zn in forage were severely deficient in 2001 (16.0 ± 1.04 ppm) and 2002 (15.1 ± 1.03 ppm) and marginally deficient (20.2 ± 1.04 ppm) in 2000.

Ganskopp and Bohnert (2003) found that the concentrations of Cu in forage decreased in wetter years and they related this phenomenon to a dilution effect with increased biomass in favorable years. Conversely, from the data we have presented, it appears that increased moisture on semi-arid rangelands may in fact increase Se translocation in forage.

Trace Mineral Values in Cattle. Tables 1 and 2 present the least squares means for cow and calves, respectively. Liver Cu for control cows was deficient (Corah and Dargatz, 1996) at 73 ± 4.8 ppm while liver Cu was adequate (121 ± 4.8 ppm) for cows receiving the Cosecure® boluses. There were no significant (P = 0.17) breed effects detected for liver Cu, but concentrations varied by year (P < 0.0001), being 122 ± 7.6 ppm in 2000, 78 ± 3.3 ppm in 2001, and 91 ± 5.3 ppm in 2002 when pooled over all cows. The levels of liver Cu corresponded to forage concentrations of Cu, but did not correlate well to cow serum Cu levels. There was no difference between treated and control cows (P = 0.42) for serum Cu (Table 1) and these data add to a growing body of evidence (Radostits et al., 1994) that serum Cu is not a good indication of trace mineral status until levels approach deficient levels.

Concentrations of liver Zn never fell below adequate levels (80 to 90 ppm; Corah and Dargatz, 1996), though they declined (P < 0.0001) from January (133 ± 3.0 ppm) to May (116 ± 2.1 ppm). These data indicate that dietary levels recommended for grazing beef cattle by NRC (1996) may not accurately match dietary needs for range cattle in central AZ. Liver Zn and serum Zn did not differ (P = 0.79; Table 1) between treatment groups and was to be expected since the cattle in this study did not receive any supplemental Zn.

Serum Cu and Zn did not differ (P > 0.0585) by treatment for calves (Table 2), though serum Cu concentrations for both treated and control calves fell below what is considered adequate (0.60 ppm; Puls, 1994) in 2000. As noted for serum Cu data for cows, serum Cu data for calves in this study are questionable.

For cows, whole blood Se differed between treatment groups, by month, year, month within year, and by age of dam (P < 0.0001), as well as by breed (P = 0.0058). In spite of the low concentrations of Se in forage, cow blood Se levels were adequate for both treatment groups (> 0.1 ppm; Radostits et al., 1994) for all time periods except in January 2001 and 2002 when they were marginally (0.05 to 0.1 ppm; Radostits et al., 1994) deficient (Table 1). There were no differences in blood Se for control vs treated cows in January (P > 0.05; Table 1), but bolused cows had greater Se in May 2000 and 2002 (P < 0.0001) and tended to have greater blood Se in May 2001 (P = 0.0611).

Calves nursing bolused cows had greater (P = 0.0002) whole blood Se than did calves nursing control cows (Table 2). The concentration of Se for calves dropped from May (0.137 ± .003 ppm) to September (0.103 ± .003 ppm) and was to be expected as stores of Se acquired prenatally declined. The much lower Se observed in 2000 (Table 2) was an artifact related to the necessity of using serum Se instead of whole blood Se in May.

Figures 1 and 2 illustrate breed effects we observed for whole blood Se for cows and calves, respectively. Among treatment cows, Se was greater for B than for C (P = 0.0133) cattle and tended to be greater (P = 0.0532) than that observed for H cattle. Control calves from H cows had less (P = 0.0100) Se than did C cattle and tended (P = 0.0737) to have less Se than did B cattle. In reviewing data for both cows and calves, it is apparent that H cattle benefit from supplemental Se when grazing Se deficient rangelands.

Implications

Strategic supplementation of copper and selenium via a long acting trace mineral bolus in late gestation was successful in increasing liver copper in cows and blood selenium in cows and calves, but varied by year for Cu and for Se, year and breed. When favorable growing season moisture occurs, it is critical to evaluate Cu status in forage and supplement accordingly. Brahman cross cattle in this study appeared to be more efficient at metabolizing supplemental Se. Hereford cattle appeared to have a greater need for supplemental Se than did Brahman cross and Composite cattle when grazing Se deficient rangelands. Serum Cu was not a good indicator of trace mineral status and should be avoided when assessing Cu status of range cows except when cattle are known to be severely deficient in Cu. Suggested dietary requirements for zinc for range cows may need to be reevaluated.

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Table 1. Effects of a long acting trace mineral bolus upon cow liver copper, liver zinc, whole blood selenium, serum copper, and serum zinc[a]

Item	No Bolus		Bolus		SE	*P*-value
Liver Cu, DM ppm						
Pooled over all months and all years	73		121		4.8	0.0001
Liver Zn, DM ppm						
Pooled over all months and all years	124 ± 2.4		125 ± 2.5			0.7873
Serum Cu, DM ppm						
Pooled over all months and all years	0.78		0.79		0.015	0.4216
2000, pooled over mo	0.95		0.97		0.023	0.6568
2001, pooled over mo	0.78		0.79		0.017	0.4527
2002, pooled over mo	0.60 ± .022		0.61 ± .020			0.6063
Serum Zn, DM ppm						
Pooled over all months and all years	0.92		0.92		0.015	0.8986
2000, pooled over mo	1.00 ± .022		1.00 ± .023			0.9354
2001, pooled over mo	1.03		1.04		0.022	0.7576
2002, pooled over mo	0.73 ± .022		0.72 ± .020			0.6279
Whole blood Se, DM ppm						
Pooled over all months and all years	0.124		0.141		0.003	0.0001
2000, pooled over mo	0.144		0.161		0.004	0.0014
2001, pooled over mo	0.123		0.135		0.005	0.0793
2002, pooled over mo	0.106		0.129		0.004	0.0001
	January	May	January	May		
2000, mo within yr	0.130 ± .004 [b]	0.157 ± .005 [c]	0.127 ± .004 [b]	0.194 ± .005 [d]		
2001, mo within yr	0.088 ± .004 [b]	0.158 ± .008 [c]	0.091 ± .004 [b]	0.178 ± .008 [c]		
2002, mo within yr	0.066 ± .004 [b]	0.146 ± .005 [c]	0.069 ± .003 [b]	0.189 ± .005 [d]		

[a]Cosecure® trace mineral boluses had an expected life of approximately 175 d and provided approximately 156 mg/d Cu, 5.9 mg/d Co, and 3.4 mg/d Se.

[b,c,d] Within a row, means lacking a common superscript letter differ ($P < 0.05$).

Table 2. Whole blood selenium, serum copper, and serum zinc for calves nursing cows administered a long acting trace mineral bolus[a]

Item	No Bolus	Bolus	SE	*P*-value
Serum Cu, DM ppm				
Pooled over all months and all years	0.64	0.63	0.012	0.4025
2000, pooled over mo	0.41	0.45	0.014	0.0905
2001, pooled over mo	0.81	0.79	0.017	0.2838
2002, pooled over mo	0.69 ± .019	0.65 ± .017		0.0585
Serum Zn, DM ppm				
Pooled over all months and all years	1.05 ± .016	1.06 ± .018		0.4493
2000, pooled over mo	0.96 ± .033	0.97 ± .034		0.8196
2001, pooled over mo	1.20 ± .026	1.20 ± .027		0.8938
2002, pooled over mo	0.98 ± .025	1.01 ± .024		0.3635
Whole blood Se, DM ppm[b]				
Pooled over all months and all years	0.113	0.128	0.003	0.0002
2000, pooled over mo	0.058 ± .002	0.065 ± .003		0.0366
2001, pooled over mo	0.138	0.156	0.006	0.0478
2002, pooled over mo	0.142	0.163	0.005	0.0030

[a]Cosecure® trace mineral boluses had an expected life of approximately 175 d and provided approximately 156 mg/d Cu, 5.9 mg/d Co, and 3.4 mg/d Se.

[b]Selenium concentrations for May 2000 were determined with blood serum instead of whole blood.

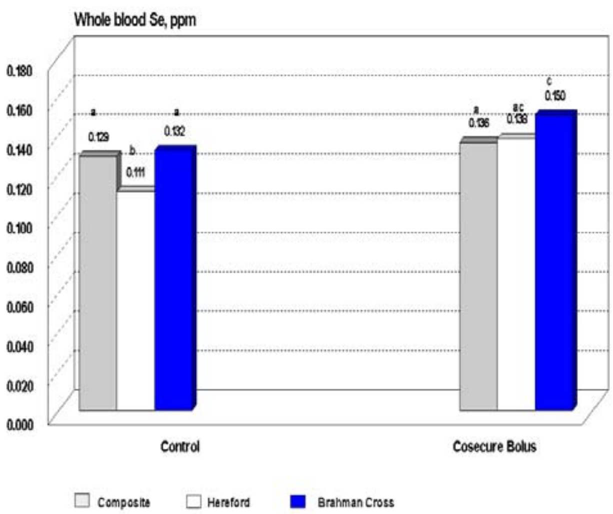

Figure 1. Whole blood selenium concentrations pooled over all years and months for cow beef breeds administered a long acting (6 mo) trace mineral bolus. The SE was .004 ppm for Hereford cattle and Composite control cattle, and .005 ppm for bolused Composite cattle and Brahman cattle. [abc] Means lacking a common superscript differ ($P < 0.05$).

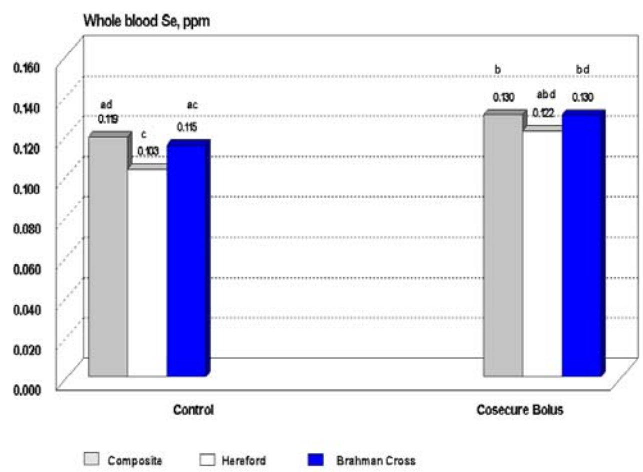

Figure 2. Whole blood selenium concentrations pooled over all years and months for calves nursing cow beef breeds administered a long acting (6 mo) trace mineral bolus. The SE was .004 ppm for calves from bolused Hereford cattle and control Composite control cattle, and .005 ppm for calves from all the other cattle. [abcd] Means lacking a common superscript differ ($P < 0.05$).