Mineral Status of Steers in Eastern Oregon

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SUMMARY

Liver, hair, and plasma mineral levels were monitored in range steers throughout a complete year to determine the influence of seasons and management practice on mineral status. Samples were taken from steers at two locations (Burns and Union) in eastern Oregon, starting shortly after weaning and at four times during the year, which represented times of major feed changes. Half of the steers at each location were fed a commercial trace mineralized salt mix, with those at Union receiving additional Se, and the other half were fed iodized salt (control). Weight gains were 345 and 367 pounds for the control group and trace mineralized salt group, respectively, at Burns; and 495 and 528 pounds at Union. Based on plasma and/or liver levels, marginal to deficient conditions existed for Cu, Zn, Co, and Se at various times at one or both locations, which are generally representative of western range areas. The mineral mix prevented deficiency of Se, Co, and at times Zn, but was not effective for Cu. There was little correlation between mineral content of hair samples and levels in the liver. Data showed that sampling at a single time was not sufficient to establish long-term mineral status.

INTRODUCTION

Trace mineral supplements recommended for grazing cattle in eastern Oregon are generally based on the mineral composition of forages. Copper (Cu) deficiency in beef cattle from different areas in Oregon has been suggested from plasma and liver Cu levels and from Cu and molybdenum (Mo) levels in feeds. Western Oregon has been classified as deficient in selenium (Se) while eastern Oregon is considered "variable" regarding the Se level of forages. Marginal zinc (Zn) deficiencies are considered a possibility in Oregon with the western United States (including Oregon) as an area adequate in cobalt (Co).

A purpose of this investigation was to evaluate the influence of the typical ranch management practices on the Cu, Se, Zn, Co, Mo, and manganese (Mn) status of growing cattle. Another objective was to monitor mineral status and needs on a year-round basis using mineral content in liver biopsy samples, in both pigmented and white hair and blood plasma as indicators. Although this study was conducted in eastern Oregon, it is anticipated it would serve as a model to assist in the evaluation of mineral status in cattle on range areas in many parts of the world.

MATERIALS AND METHODS

This investigation was conducted at the Eastern Oregon Agricultural Research Center. At Union, with a higher elevation and greater precipitation during the summer, the grass becomes green earlier and stays green longer than at Burns. Burns has a typical "high desert" vegetation in summer. At both locations, cattle were fed harvested forages during winter and allowed to graze on rangeland at other times.

Twenty-two crossbred Hereford steers (4 months old at Burns, 383 pounds; and 5 months at Union, 519 pounds) were used at each site. At each location, one-half (control) received iodized salt as a supplement and the other half a commercial trace mineralized salt (TM) fed free-choice in ground form, in mineral boxes. The TM salt contained (mg/kg) sodium chloride, 970 to 990; Zn, 3.5; Mn, 1.8; Magnesium (Mg), 3.7; iron (Fe), 2.0; Cu, 3.5; Co, .06; and iodine (I), .10. At Union the steers also were given Se (25 mg/kg) as sodium selenite mixed with the TM salt, because prior work suggested low Se content in forages at this location. Bone meal was provided on a free choice basis to the groups. The trial lasted from weaning in the fall through the end of the following summer. During the winter the steers were pen-fed ad libitum in groups according to treatment. Steers at Union were fed ad libitum a second-cut, rain-damaged alfalfa hay and at Burns they were fed meadow hay. During the other seasons the groups at each location grazed separate meadows with the carrying capacities controlled so as to be comparable. At Union the steers grazed tall fescue (*Festuca arundinacca*) pasture during fall and were on forested range the following spring and summer. Although the forage endophyte level was not determined, there has not been any indication from previous work that this is a problem. The forested range consisted of grand fir forest (*Abies grandis*) on the north slopes, with adjoining mixed conifer forest, wet meadow, and riparian zones. Dominant plant species were grand fir, Douglas fir (*Pesudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), nine bark (*Physearpus malvaceus*), ocean spray (*Holodisus discolor*), snowberry (*Symphoricarpos albus*), pine grass (*Calamagrostis rubescens*), elk sedge (*Carex geyeri*), and Kentucky bluegrass (*Poa pratensis*). At Burns, the steers grazed a meadow regrowth during the fall and pure stands of crested wheatgrass (*Agropyron desertorum*) during the spring and summer. The hay during the winter and forage in the fall included about 75 percent of the biomass as rushes (*Juncus* sp.) and sedges (*Carex* spp.). The principal species are rusty sedge (*Carex subjunca*) and baltic rush (*Juncus balticus*). The remaining 25 percent consisted of grass and shrub species. The most abundant grasses were Nevada bluegrass (*Poa nevadensis*), meadow barley (*Hordeum brachyanthorum*), meadow foxtail (*Alopecurus pratense*), and beardless wildrye (*Elymus triticoides*).

Steers were weighed and plasma, liver biopsy, and pigmented and non-pigmented hair samples were taken at weaning, at the end of the fall grazing period (November), at the end of winter (April), at the end of spring (July), and at the end of the summer grazing period (September). Newly grown hair was collected from the jaws and neck or from the forehead (white hair) and side just behind the right shoulder (colored hair) each time blood or liver samples were collected. This was done by clipping the hair with coarse clippers and subsequently with a fine-head clipper. Random samples of feed and forage were also collected for mineral analysis throughout the experimental period (Table 1). Forage samples during the grazing times were collected at times indicated in Table 1 by walking diagonally across each meadow and clipping them at ground level. Cored samples from at least 20 bales of hay were taken to be analyzed.

A Jarrell Ash atomic absorption spectrophotometer was used to measure Cu and Zn concentrations on diluted plasma samples and in the feed and livers after acid digestion. The

Table 1. The mineral composition of the forages consumed by the steers at Union and Burns (mg/kg DM).

	Union						Burns					
Season	Cu	Mo	Se	Zn	Co	Mn	Cu	Mo	Se	Zn	Co	Mn
Fall (B)	2.7	-	0.01	14.1	0.07	43	3.2	1.6	0.21	28.3	0.04	68
Winter (C)	9.5	9.6	0.03	18.2	0.28	-	3.5	2.3	0.22	26.7	0.08	53
Spring (D)	5.7	-	0.02	08.8	-	38	4.5	-	0.02	19.1	-	-
Summer (E)*	5.2	-	0.02	23.6	-	-	1.2	-	0.01	12.0	0.09	21
	2.6			23.4	0.10	61	1.1	6.9	0.02	11.8	0.17	31
	1.9	3.7	0.03	21.3	0.07	92	0.9	5.1	0.02	10.9	0.24	40
	1.5	4.6	0.2	27.0	0.14	64	1.2	5.3	0.01	10.3	0.18	32

*The four sampling dates during the summer were 6/10, 7/15, 8/14, and 9/17 at Union and 7/21, 8/20, 9/22, and 10/13 at Burns

Co levels in the feed and liver, Mo and Mn levels in feed, liver, and plasma, and Zn, Cu, Mo, Mn, and Co in hair digest were determined using a Perkin Elmer atomic absorption spectrophotometer. Selenium in the feed, tissues, and hair was determined by a fluorometric procedure. Mineral content of liver and hair is expressed on a dry-weight basis. A bovine liver reference standard (NBS) was used in all mineral analyses.

RESULTS AND DISCUSSION

Weight Gains

The average daily gains (ADG) of steers during each phase of the trial are presented in Table 2. Unexpectedly, the ADG was less in steers given TM at Burns during spring than in those not given TM. During the summer, however, both groups lost weight, presumably because of the nutrient content of the typical "high desert" vegetation in summer at Burns. However, those given TM lost less weight. During the winter the TM group at Union gained more weight than the group receiving iodized salt. ADG for the entire study for steers fed iodized salt and TM salt was, respectively, .88 and .95 pounds at Burns, and 1.36 and 1.45 pounds at Union. The average total weight gain per animal for the year for steers fed iodized salt and TM salt were, respectively, 345 and 367 pounds at Burns, and 495 and 528 pounds at Union (data not shown). This response to TM could be due to a single mineral or a combination of several. Young growing animals are most likely to show a response in live-weight gain to Cu supplementation while grazing a Cu-deficient pasture. Prior studies here suggested that Se could also account for some of this response.

Mineral Intake from Supplement and Composition of Feed.

Intake of TM mix (Tables 3 and 4) at Union was significantly higher than that at Burns. Since steers at Union were heavier than those at Burns, the relative differences

Table 2. Seasonal differences in average daily gains (lb/d) of steers at two Oregon locations.

Seasons	Union		Burns	
	Salt	TM[a]	Salt	TM[a]
Fall	.86	.99	.92	.95
Winter	.77	1.03	1.14	1.28
Spring	2.00	2.00	2.11	1.65
Summer	2.09	1.96	-.64	-.33
Overall	1.36	1.45	.88	.95

[a]Trace mineralized salt.

between mineral requirements and mineral intake from the supplement were greater there. Supplemental Cu intake was 15 to 30 percent of requirements at Union and about 50 percent of requirements at Burns. The TM supplement supplied 40 to 80 percent of the Se requirements at Union. About 50 percent of the Mn requirement was supplied through the TM mix at Burns, while below 50 percent of the Mn required was supplied at Union. Supplemental Co intake was in excess of requirements at both locations.

Copper content in the feeds (Table 1) decreased from fall to the next summer at Burns while Mo levels increased. At Union, the Cu and Mo levels in the winter feed were much higher than those during grazing. Over 100 percent of the Zn required was supplied by the TM supplement at Burns, and over 50 percent was supplied at Union. The Zn level of the feed from Burns was lower in the spring and summer grass than in the roughage fed to steers in fall and winter, but the opposite occurred at Union. Cobalt in feed at Burns increased from .04 mg/kg in fall and winter to > .09 mg/kg in spring and summer. The Se level in feed at Burns was higher during fall and winter than in the other seasons, and also higher than at Union.

A "good" free-choice mineral supplement is one that supplies at least 25 to 50 percent of the requirements for the mineral to the animal, or 100 percent in a region of known deficiency. Any response to the mineral supplementation should be evaluated in terms of the proportions of total needs supplied and the levels of these minerals in the available feed relative to the needs of the animal.

Minerals in Liver and Plasma

Copper. The Cu concentration in livers (Figure 1, top) of steers in Burns decreased from weaning in the fall to levels of between 10 to 20 µg/g liver during the other seasons, with slight recovery in summer. The same trend was observed in plasma Cu levels (Figure 1,

Table 3. Body weights of steers and estimated daily mineral requirements of the steers at Union and amounts supplied by the trace mineralized supplement during the different seasons of the trial.

			Copper		Selenium		Zinc		Cobalt		Manganese	
Season	Body weight end of season, lb	Estimated[a] feed intake, lb	Required[b] in diet, mg	Supplied by mix, mg	Required[b] in diet, mg	Supplied by mix, mg	Required[b] in diet, mg	Supplied by mix, mg	Required[b] in diet, mg	Supplied by mix, mg	Required[b] in diet, mg	Supplied by mix, mg
Fall	579	11.7	42	12.4	1.06	0.88	159	124	0.53	2.1	212	64
Winter	722	14.5	53	11.2	1.32	0.80	198	112	0.66	1.9	264	57
Spring	882	17.6	64	15.6	1.60	1.12	240	156	0.80	2.7	320	80
Summer	1042	20.9	76	11.2	1.90	0.80	285	112	0.95	2.6	380	68

[a]Estimated as 2% body weight

[b]Cu, 8 mg/kg; Se, 0.2 mg/kg; Zn, 30mg/kg; Co, .1 mg/kg; Mn, 40 mg/dg [NRC (23), Table 4].

Table 4. Body weights of steers and estimated daily dietary mineral requirements of the steers at Burns and amounts supplied by the trace mineralized supplement during the different seasons of the trial.

			Copper		Zinc		Cobalt		Manganese	
Season	Body weight end of season, lb	Estimated[a] feed intake, lb	Required[b] in diet, mg	Supplied by mix, mg	Required[b] in diet, mg	Supplied by mix, mg	Required[b] in diet, mg	Supplied by mix, mg	Required[b] in diet, mg	Supplied by mix, mg
Fall	427	8.6	31	19.6	117	196	0.39	3.4	156	101
Winter	678	13.0	47	19.6	177	196	0.59	3.4	236	101
Spring	779	15.6	57	29.1	213	291	0.71	5.0	284	149
Summer	750	15.0	54	29.1	204	291	0.68	5.0	272	149

[a]Estimated at 2% body weight, except for actual average intake of hay during winter.

[b]Cu, 8 mg/kg; Zn, 30 mg/kg; co, .1 mg/kg; Mn, 40 mg/kg [NRC (23), Table 4].

bottom), although the lowest level was reached in winter with a subsequent increase to levels of .7 mg/L at the end of summer. This was similar to that at weaning in the fall. TM supplementation did not have a consistent effect on plasma Cu levels, although in winter and spring they were higher in the group fed the TM supplement than in the controls. At Union, liver Cu levels increased in winter above levels (10 to 20 mg/kg) observed at weaning in the fall and further decreased in the spring. In summer, Cu levels increased to above 25 mg/kg. Plasma Cu dropped from a level of .65 mg/L to between .45 and .55 mg/L in winter and spring, and increased again to .7µg/ml in summer. There were no significant increases in plasma and liver Cu concentrations associated with the Cu supplementation, except in the plasma of steers at Burns at the end of spring.

The Cu requirements for beef cattle have been estimated to range from 4 to 10 mg/kg. However, the concentrations of ingredients such as Mo and S can have a major influence on the minimum level of Cu required in a ruminant feed. Based on calculation of available Cu in pastures, this resulted in a very low availability of cu in the feed at Union and Burns. Although forage levels of Cu are helpful to evaluate Cu status, hepatic and plasma levels are more useful. Hepatic Cu concentrations below 20 mg/kg or 25 mg/kg DM have been suggested as indicative of Cu deficiency in growing cattle, but other work revealed that grazing livestock with hepatic Cu levels ranging from 8 to 32 mg/kg showed no clinical signs of Cu deficiency. At Union, the liver Cu levels in animals given the TM salt mix were 25 mg/kg dry matter (DM) or below during all time periods except winter. The high level of Cu in livers of both groups in Union, during winter could be a "systemic effect" due to the Cu x Mo x S interaction of high Mo intakes, but plasma Cu levels would also have been expected to be high.

The plasma with liver Cu levels support the conclusion that 3.5µg Cu/g in the TM supplement used at Union and Burns was insufficient to completely overcome Cu deficiency in the steers. This agrees with conclusions of other studies under different environmental conditions. Unless higher levels are used in TM mixes, the use of Cu injections or slow-releasing Cu products in the rumen may be more effective in overcoming the Cu deficiency in steers.

Molybdenum. Liver Mo levels of steers at Burns (Figure 2) remained fairly constant throughout the trial. Plasma Mo levels of steers were not determined because of insufficient plasma sample size. At Union, plasma and hepatic Mo levels of steers were higher at the end of the winter feeding period than at any other time. The Mo concentrations in tissues of ruminants tend to correspond with daily Mo intakes, provided all other conditions remain constant. In our investigation, the Mo levels in the plasma and livers fluctuated between about 3 and 12 mg/kg in the livers and .16 and 1.60 mg/L plasma (Union), and appeared to be influenced by the Mo concentration in the feeds.

Selenium. At Burns, where no Se supplementation was done, Se levels in the liver and plasma (Figure 3) were higher at the end of fall and winter than at any other time. At Union, Se supplementation of steers resulted in a significant positive response in plasma and liver Se concentrations at all stages of the trial except at weaning. When no Se was fed to steers, the Se levels remained fairly constant at .2 mg/kg in the liver and .02 mg/L in plasma.

The NRC recommended a dietary concentration of .20 mg/kg as the minimum Se required by beef cattle while others propose a level of .1 mg Se/kg feed. Provision of Se supplement was consequently effective in significantly increasing plasma and liver Se levels, and the response in weight gain could be due to Se. The plasma and liver Se contents at Burns reflected the adequate content of forage Se during fall and winter. During spring and summer, however, the feed Se level was reduced to .02 mg/kg, accompanied by a drop in the plasma and liver Se levels in the steers.

Zinc. At Burns and Union, hepatic Zn concentrations decreased after weaning and remained fairly constant (Figure 4) at 80 to 90 mg/kg during the other seasons, with a slight increase in steers at Burns at the end of summer. The TM mix did not significantly influence the liver Zn concentration at either location. Plasma Zn levels decreased after weaning, reaching minimum levels at the end of fall at Burns and at the end of winter at Union, reflecting low forage levels, e.g., 10.3 mg/kg in summer at Burns (Table 1). At the end of winter and spring, the plasma Zn level was higher in the supplemented steers than in the control animals.

Research indicates 10 to 14 mg Zn/kg feed as sufficient to maintain serum Zn levels between .8 to 1.0 mg/L in animals; however, calves would require higher Zn levels in their feed, 18 to 43 mg/kg under most practical situations. A range of 20 to 40 mg Zn/kg feed has been recommended for beef cattle. Research has suggested the critical level for Zn in serum was between .6 and .8 μg/ml, which is consistent with Idaho studies where calves with .84 mg/L plasma gained 6 percent more weight when Zn was added to their diet. Thus, it would appear that a marginal Zn deficiency existed at both locations. Unfortunately, there are no effective biochemical measures for determining a borderline deficiency of Zn in livestock.

Cobalt. Except at weaning and at the end of summer, a significant response was obtained in Co concentration in the livers of steers (Figure 5) at Burns due to TM supplementation. At Union, Co levels in the liver stayed relatively constant throughout the experimental period with no difference between the salt mix and the TM supplement fed to steers.

A concentration of .1 mg Co/kg feed is considered adequate for beef cattle, with ranges from .05 to .07 mg Co/kg given as critical. The Co levels of the forages at Union fluctuated at near-adequate levels during the experimental period, yet the liver Co increased in steers given the TM salt treatment. The low Co level in the feed during fall and winter at Burns is potentially deficient and resulted in the winter hepatic Co concentration of .065 mg/kg in the TM salt-fed steers there. At both locations, the TM mix supplied amounts of Co well above that required by the steers (Tables 2 and 3). Liver Co levels are not considered a very sensitive measure of Co status, but vitamin B_{12} levels appear to be better indicators of such status in ruminants. Our results, combined with the feed analyses, indicated a possibility of marginal Co deficiency at Burns.

Minerals in Hair. Although Zn, Cu, Se, Mo, Mn, and Co were determined in hair, only the Cu, Zn, and Se levels are presented to indicate the difficulty involved in assessing mineral status by this method (Table 5). Cu levels were significantly higher in the white hair than the colored, but in contrast the Se levels were higher in the colored hair. There were no significant correlations between hair levels of Zn, Cu, Se, Mo, Mn, or Co with the content of these minerals in the liver or plasma, except for plasma Cu and liver and plasma Se.

The use of hair mineral content as an indicator of mineral status does not appear feasible, since the mineral levels (Zn, Mn, Fe, Na, Ca, Cu, and K) of hair are affected by season, breed, hair color within and between breeds, age, and body location. Although our study indicates a possible relationship between plasma Cu and hair Cu (Table 4, Figure 1), this is not supported by the work of others. Moreover, we found that the Cu content of white and colored hair was different, which is inconsistent with other observations. Our results and

Table 5. Average mineral concentration of colored versus white hair from steers µ/g).

Hair Color	Union			Burns		
	Cu	Zn	Se	Cu	Zn	Se
Colored	5.1	129	0.34	5.1	142	0.53
White	6.5	148	0.24	6.3	153	0.34

those of others indicate that hair Se levels might give a rough estimate of Se status, but the disadvantages of using hair, i.e., the need for thorough washing to remove foreign contamination and finding a reproducible location on the animal would appear to outweigh the advantages. Others agree that because of many factors that cause variation in mineral content of hair, hair analyses are not likely to be precise indicators of the mineral status of animals.

CONCLUSIONS

This study was conducted in two locations in Oregon which are reasonably representative of the Great Basin and other range areas. Results indicate that accurate assessment of the mineral status of livestock requires that multiple samples must be taken throughout the year. The other obvious lesson is that the mineral content of the plasma does not always reflect that in the liver. For example, the plasma Cu levels at the end of the winter feeding period were lowest, but the hepatic levels were highest compared to other time periods in the cattle at Union (Figure 1). This could reflect a higher Mo concentration at this time in both plasma and liver than at any other time (Figure 2). This trend for Cu is the opposite of expected results from other work and further work is necessary to explore this apparent paradox. Furthermore, the trace mineral supplements used did not provide enough Cu to prevent deficiencies (Figure 1) and did not produce any consistent significant increase of Cu in liver or plasma. Neither does the Zn level in the TM mix appear to be high enough to result in adequate Zn status. Thus, the TM mix composition should be revised for areas similar to eastern Oregon.

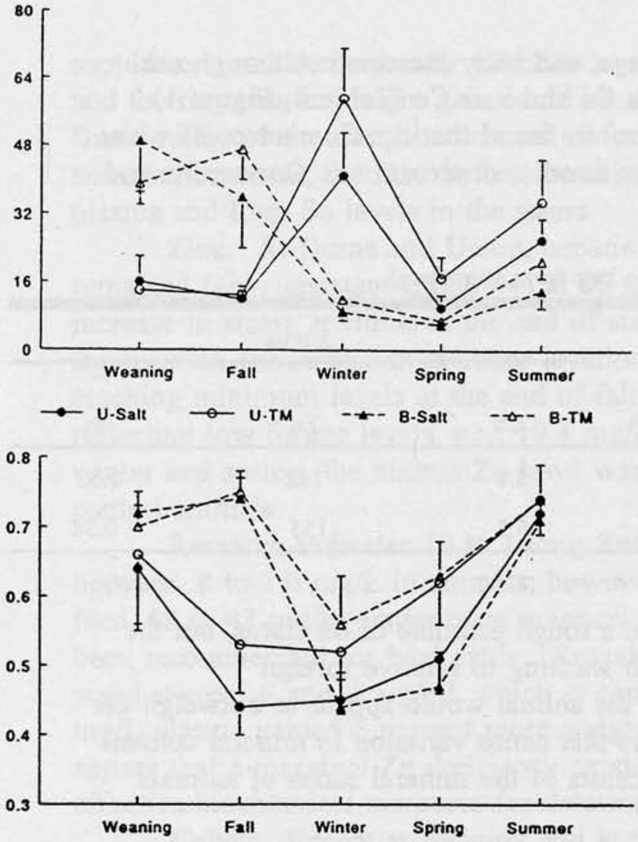

Figure 1. **Liver and plasma copper levels in steers at Union (U) and Burns (B) at weaning and at the end of fall, winter, spring, and summer when receiving a salt or a trace mineralized (TM) supplement. Vertical bars represent standard deviations.**

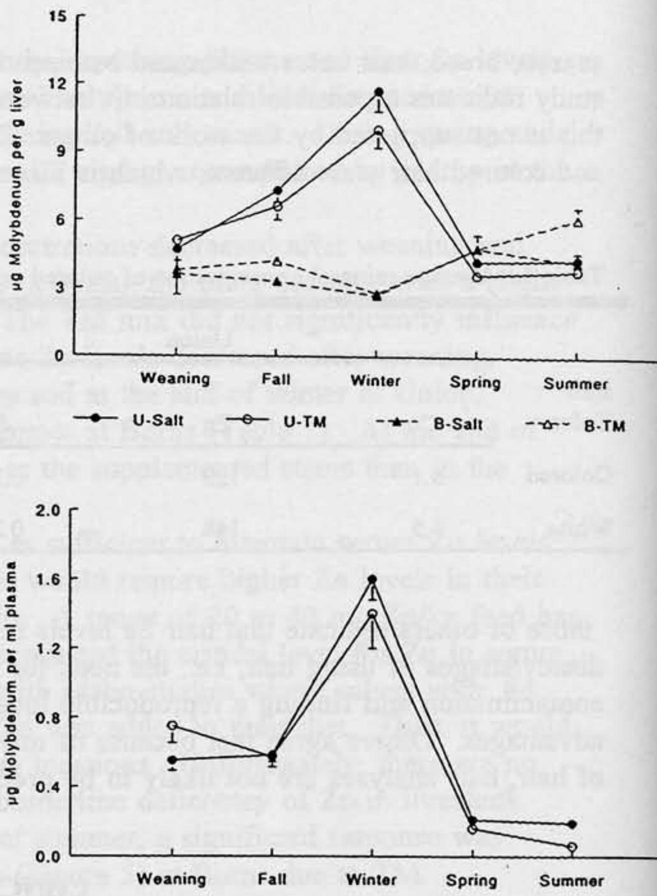

Figure 2. **Liver molybdenum levels in steers at Union (U) and Burns (B) and plasma molybdenum levels in steers at Union at weaning and at the end of fall, winter, spring, and summer when receiving a salt or trace mineralized (TM) supplement. Vertical bars represent standard deviations.**

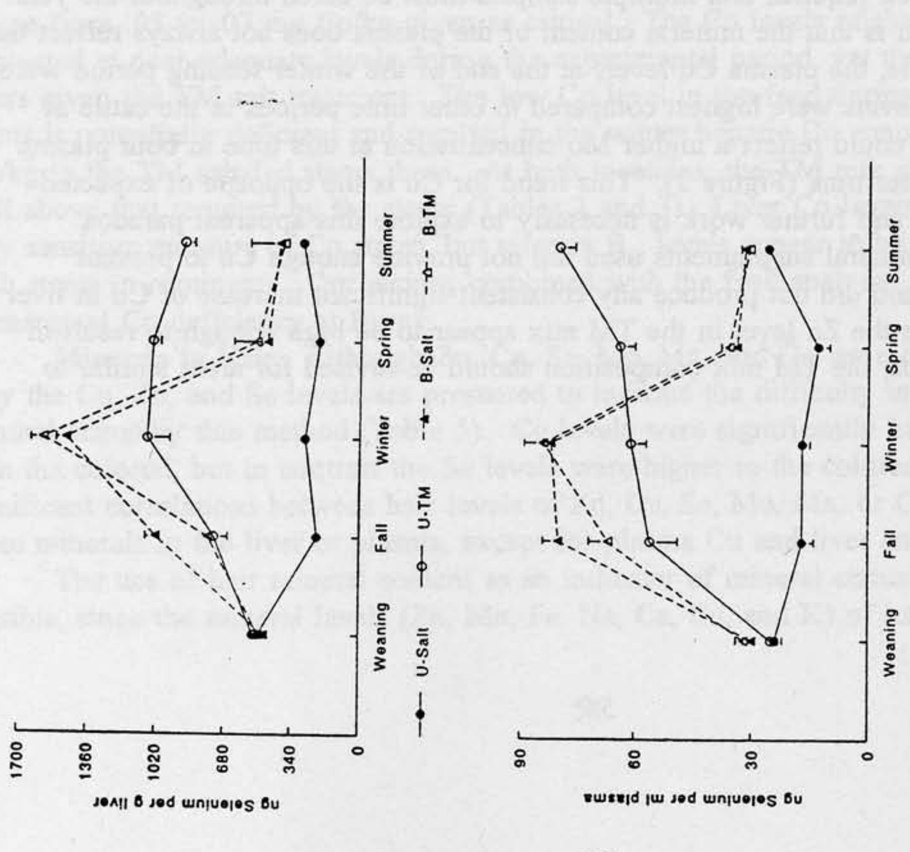

Figure 3. **Liver and plasma selenium levels in steers at Union (U) and Burns (B) at weaning and at the end of fall, winter, spring, and summer when receiving a salt or a trace mineralized (TM) supplement. Vertical bars represent standard deviations.**

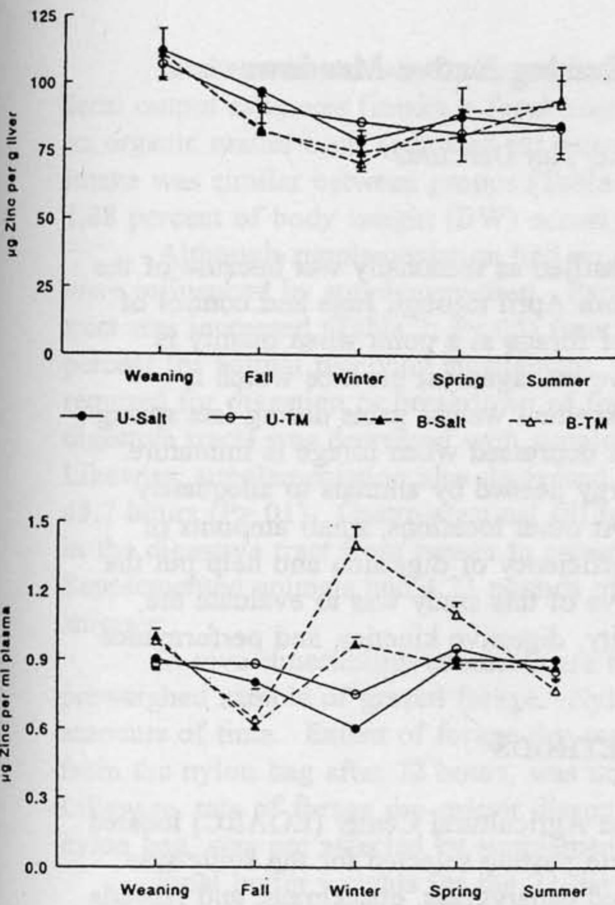

Figure 4. **Liver and plasma zinc levels in steers at Union (U) and Burns (B) at weaning and at the end of fall, winter, spring, and summer when receiving a salt or trace mineralized (TM) supplement. Vertical bars represent standard deviations.**

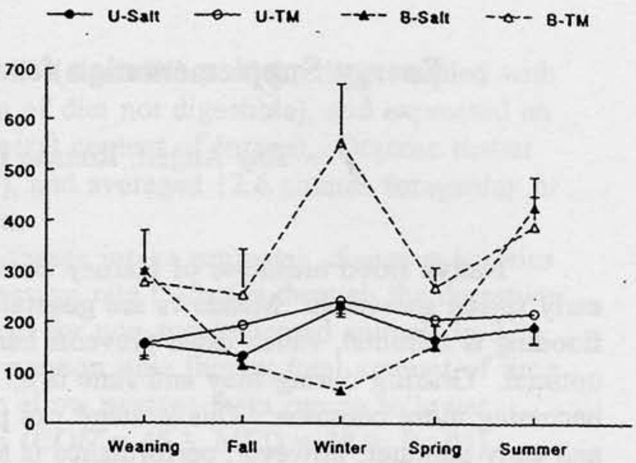

Figure 5. **Liver cobalt levels in steers at Union (U) and Burns (B) at weaning and at the end of fall, winter, spring, and summer when receiving a salt or a trace mineralized (TM) supplement. Vertical bars represent standard deviations.**