Proceedings, Western Section, American Society of Animal Science
Vol. 40, 1989

SUPPLEMENTATION WITH INJECTABLE ZINC, COPPER AND SELENIUM AND THE EFFECTS ON AVERAGE DAILY GAIN AND PLASMA LEVELS OF WEANED STEERS[1]

T.O. Dill, H.A. Turner, D.W. Weber, and P.H. Whanger
Eastern Oregon Agricultural Research Center
Burns, Oregon 97720

Summary

A study was initiated to: 1) assess the efficacy of injectable zinc (Zn), copper (Cu) and selenium (Se) to correct deficiencies in two areas of eastern Oregon, and 2) determine the effect of Zn, Cu, and Se deficiencies on average daily gain (ADG) of weaned calves. The study was split into two phases based on area of mineral deficiency. In the Zn phase, steer calves were randomly assigned to either a Zn supplemented or a nonsupplemented treatment. The steers were from the Eastern Oregon Agricultural Research Center near Burns, Oregon. Zinc oxide suspended in corn oil (100 mg/ml) was injected at a rate of 1 ml/45.5 kg body weight. Weekly blood samples were collected and analyzed by flame atomic absorption spectrophotometry. Plasma Zn levels were maintained for 21 days following administration in the Zn supplemented group, while nonsupplemented steers remained deficient (.8 ppm). The ADG was not different (P>.05) between treatment groups for the 8-week study. The Cu and Se phase of the study was conducted at the Eastern Oregon Agricultural Research Center near Union, Oregon, where 20 steer calves were stratified by weight and randomly assigned to either: 1) Cu supplemented; 2) Se supplemented; 3) Cu+Se supplemented or; 4) nonsupplemented treatments. Weekly blood samples were collected and analyzed for Cu and Se plasma levels. Plasma Cu was analyzed by the same method as Zn. Se levels were analyzed by an automated fluorimetric method. Plasma Cu levels were maintained at adequate levels throughout the 8-week study in Cu supplemented groups and were deficient (0.6 ppm) in nonsupplemented steers on weeks 2, 3, and 4 only. Plasma Se levels were deficient in all groups with the exception of weeks 2 and 3 in the Cu+Se supplemented and weeks 2, 3, and 5 in the Se supplemented groups. Injections of Cu were able to correct a deficiency for the entire study period, while Se injections corrected the deficiency for only 21 days. There was no difference (P>.05) in ADG between the groups, however, a trend of higher ADG was observed in the Cu+Se supplemented group. Differences may have been observed in ADG if the study had been continued until spring.

Introduction

Trace minerals are known to be essential in the growth, reproductive performance and normal health of animals (Ammerman and Goodrich, 1983). Minor deficiencies lead to poor performance, while severe ones may lead to death. Zinc has been shown to be an essential mineral for cattle (Miller and Miller, 1960). Mayland et al. (1980) observed an improved rate of gain in calves supplemented with Zn. Supplementation of Zn has been accomplished through the use of drenching (Price and Wood, 1982), feed additives (Ammerman and Henry, 1986) and prepared mineral mixes (Mayland et al., 1980). Sheep have been supplemented in the same ways, as well as by injection. Mahmoud et al. (1985) used a subcutaneous injection of zinc chloride suspended in water and zinc oxide suspended in oil to correct Zn deficiencies in sheep. They found the zinc chloride suspension caused skin abscesses and ulcers at the injection site. Zinc oxide dust was also reported to be an effective treatment in correcting Zn deficiency in sheep (Lamand et al., 1980).

Copper has been known to be an essential mineral for hemoglobin formation since 1928 (Hart et al., 1928). Deficiencies in Cu have been reported to cause poor performance in yearling steers (Sankoh and Boila, 1987) and depressed milk production and general unthriftiness in cows (Haynes, 1985). Adequate levels of Cu have been obtained through various methods including, copper needles for sheep, soluble glass pellets and boluses, feed additives, and injectable solutions (Ammerman and Henry, 1986). Injectable Cu has been used to prevent or correct deficiencies in ruminants (Hemingway et al., 1970; Ishmael 1970). The complexes of Cu used tended to produce inflammation at the site of injection (Hemingway et al., 1970).

Selenium has been a concern as a toxin in animal production for over 50 years (Franke, 1934). White muscle disease was reported to be caused by Se deficiency in 1958 (Muth et al., 1958) and has since been found to be an essential mineral for normal growth (Doyle and Spaulding, 1978). Spears et al. (1986) increased adjusted calf weaning weights and decreased calf death losses with injections of Se + vitamin E. Sodium selenate has been effectively used to prevent several diseases in cattle and sheep (Doyle and Spaulding, 1978). Several forms of Se supplementation are used, including feed additives, mineral mixtures and injectables, with the most widely used, being injectables of Se + vitamin E mixtures. Weaned calves at Burns and Union, Oregon have been shown to be deficient in Zn and Se, respectively. Marginal plasma levels of Cu have been reported at Union (Whanger et al., 1987). Weaning is a time of high stress levels in calves and these minerals tend to decrease under stress (Maas, John (DVM) personal communication, 1988).

Materials and Methods

Zinc Phase: The Zn phase of the trial was conducted at Burns, Oregon on the Eastern Oregon Agricultural Research Center, where 10 steer calves were randomly assigned to either Zn supplemented (5 steers) or nonsupplemented (5 steers) treatments. One animal in the Zn supplemented group died. Following weaning steers were fed a diet of corn and native hay deficient in Zn (3.9 ppm). The steers were given an injection (3.25 ml) of zinc oxide suspended in corn oil (100 mg/ml oil) or corn oil on weeks 1 and 4 of the 8-week trial. Weekly blood samples were collected from all animals by jugular

[1] Oregon State University Agricultural Experiment Station Technical Paper No. 8853

venipuncture in vacutainers containing sodium heparin, centrifuged to obtain plasma and refrigerated until analyzed. Plasma Zn levels were measured by flame atomic absorption spectrophotometry. Baseline plasma levels were established by sampling 1 week prior to weaning. Weights were taken on day 1 and 50 and ADG was computed.

Copper and Selenium Phase: The Se and Cu phase of the trial was conducted at the Union Station of the Eastern Oregon Agricultural Research Center. Twenty steer calves were stratified by weight and randomly assigned to: 1) Cu supplemented; 2) Se supplemented; 3) both Cu and Se supplemented or; 4) nonsupplemented treatment groups. After weaning, steers were fed a diet of native hay with marginal levels of Cu (5.3 ppm) and deficient in Se (0.02 ppm). The steers were given injections of: 1) 2 ml cupric glycinate; 2) 1 ml per 90.9 kg of body weight of sodium selenite; 3) cupric glycinate + sodium selenite; or 4) normal saline solution on week 1 of the 8-week trial. Weekly blood samples were collected in vacutainers containing sodium heparin, centrifuged to obtain plasma and refrigerated until analyzed. Plasma Cu levels were measured using the same method as for the Zn samples. Plasma Se levels were measured by an automated fluorimetric method (Brown and Watkinson, 1977). Baseline Cu and Se levels were determined by sampling 1 week prior to weaning (week 1). Weights were taken on days 1 and 50 and ADG was computed.

Statistical analysis was conducted on treatment means using the General Linear Models procedures of the Statistical Analysis System (SAS, 1984).

Results and Discussion

Zinc Phase: Mean plasma Zn levels are listed in table 1. One-week prior to weaning (week 1) both supplemented and nonsupplemented groups had adequate plasma levels of Zn. At weaning (week 2), neither group had deficient plasma Zn levels (0.8 ppm), however, 1 week following weaning, the nonsupplemented group had deficient levels of plasma Zn and remained deficient throughout the remainder of the trial. Supplemented steers were deficient only on weeks 4 and 8. An injection of zinc oxide at a dose of 100 mg/45.5 kg of body weight was adequate to maintain Zn plasma levels for approximately 21 days. The ADGs were not different (P>.05) between treatment groups. Supplemented steers had ADGs of approximately one-half those of the nonsupplemented group (.162 kg and .311 kg, respectively (se=0.21)). There appears to be a trend toward higher ADG in nonsupplemented steers; however, this may be due to the short length and low animal numbers of this trial.

Copper and Selenium Phase: Mean plasma Cu and Se levels are reported in table 2,, and 3. Plasma Cu levels 1-week prior to weaning (week 1) were not deficient and only the nonsupplemented group had deficient (0.6 ppm) plasma Cu levels at any time throughout the trial. This occurred on weeks 2, 3 and 4 of the study, however, levels remained adequate for the final 4 weeks. Steers supplemented with either Cu or Cu+Se had higher (P<.05) plasma Cu levels than nonsupplemented steers throughout the trial except on weeks 1, 6, and 7. A single injection of cupric glycinate (2 ml) was adequate to maintain plasma Cu levels for the 8 weeks of the trial.

Plasma Se levels were deficient (0.03 ppm) in all treatment groups 1 week prior to weaning (week 1). Levels were adequate only on weeks 2 and 3 in the Cu+Se supplemented group and weeks 2, 3, and 5 in the Se only supplemented group. Plasma Se levels were deficient in supplemented groups at all other sampling dates. Nonsupplemented steers had deficient plasma Se throughout the entire study period. At the recommended dose (1 ml/90.9 kg of body weight) the Se injections failed to maintain adequate plasma Se levels for more than 21 days after administration. Plasma Se levels were higher (P<.05) in supplemented steers throughout the study period except on weeks 1 and 6, but they were still deficient on most of the sampling dates.

The ADGs were not different (P>.05) among the treatment groups. The ADGs of the Cu only, Se only, Cu+Se and nonsupplemented groups were .41 kg, .39 kg, .46 kg, and .41 kg, respectively (se=0.21). This suggests an additive effect of Se and Cu when both are adequately supplied in the diet. Injectable Zn, Cu, and Se were generally able to maintain adequate plasma levels in weaned steers, thereby correcting a deficiency, but they appeared to have little effect on ADGs.

Literature Cited

Ammerman, C.B. and P.R. Henry. 1986. Mineral supplementation for ruminants. Animal Health & Nutrition. April, pp. 24-28.

Ammerman, C.B. and R.D. Goodrich. 1983. Advances in mineral nutrition in ruminants. J. Anim. Sci. 57:519.

Brown, M.W. and J.H. Watkinson. 1977. An automated fluorimetric method for the determination of nanogram quantities of selenium. Analytica Chimica Acta. 89:29.

Doyle, J.J. and J.E. Spaulding. 1978. Toxic and essential trace elements in meat-a review. J. Anim. Sci. 47:398.

Franke, K.W. 1934. A new toxicant occurring naturally in certain samples of plant foodstuffs. I. Results obtained in preliminary feeding trials. J. Nutr. 8:597.

Hart, E.B., H. Steenbook, J. Waddell, and C.A. Elvehjem. 1928. Iron in nutrition. VII. Copper as a supplement to iron for hemoglobin in the rat. J. Biol. Chem. 77:797.

Haynes, N.B. 1985. Deficiency diseases. In: Keeping Livestock Healthy, A veterinary Guide. Storey Comm., Inc. Pownal, Vermont. pp. 272-279.

Hemingway, R.G., A. MacPherson, and N.S. Richie. 1970. Improvement in the copper status of ewes and their lambs resulting from the use of injectable copper compounds. In: Trace Mineral Metabolism in Animals. E. and S. Livingstone. Edinburgh-London. p. 264.

Ishmael, J. 1970. In: Trace Mineral Metabolism in Animals. E. and S. Livingstone. Edinburgh-London. p. 267.

Lamand, M., C. Lab. and J.C. Tressol. 1980. Interet compare de la zincemie et de la phosphatase alcaline dans le diagnostic de la subcarence en zinc chez le mouton. Annales de Recherches Veterinanine. 11:47

Mahmoud, O.M., A.O. Bakeit, and F. Elsamani. 1985. Treatment of zinc deficiency in sheep by zinc injections. In: Trace Elements in Man and Animals. Proceedings of the Fifth International Symposium on Trace Elements in Man and Animals.

Mayland, H.F., R.C. Rosenau, and A.R. Florence. 1980. Grazing cow and calf responses to zinc supplementation. J. Anim. Sci. 51:966.

Miller, J.K. and W.J. Miller. 1960. Development of zinc deficiency in Holstein calves fed a purified diet. J. Dairy Sci. 63:1854.

Muth, O.J., J.E. Oldfield, L.F. Remmert, and J.R. Schubert. 1958. Effects of selenium and vitamin E on white muscle disease. Science 128:1090.

Price, J. and D.A. Wood. 1982. Zinc responsive parakeratosis and ill-thrift in a Friesian calf. Vet. Record. 110:478.

Sankoh, F. A-R. and R.J. Boila. 1987. Injectable copper and zinc for grazing yearling steers. Canadian J. Anim. Sci. 64:1033.

SAS. 1984. SAS Institute, Inc., Box 8000, Cary, N.C.

Spears, J.W., R.W. Harvey, and E.C. Segerson. 1986. Effects of marginal selenium deficiency and winter protein supplementation on growth, reproduction and selenium status of beef cattle. J. Anim. Sci. 63:586.

Whanger, P.D., J.B. J van Ryssen, H.A. Turner, and I.J. Tinsley. 1987. Influence of routine management practices at Burns and Union, Oregon, on selenium, copper, zinc and cobalt status of cattle. Special Report 801. Agricultural Experiment Station, Oregon State University. pp 9-15.

TABLE 1. MEAN PLASMA ZINC LEVELS (PPM) OF WEANED STEERS.

	Week							
Treatment	1[a]	2	3	4[a]	5	6	7	8
Zn injected	.97	.84	.87	.73	.81	.94	1.00	.75
Oil injected	1.07	1.02	.75	.62	.73	.80	.73*	.69
Standard error	.07	.08	.09	.09	.04	.08	.09	.05

[a] Week of treatment applications.
* Values differ from others in the same column (P<.05).

TABLE 2. MEAN PLASMA COPPER LEVELS (PPM) OF WEANED STEERS.

	Week							
Treatment	1[a]	2	3	4	5	6	7	8
Cu injected	.71	.89*	1.05*	.87*	.84*	.97	.94	.96*
Cu+SE injected	.63	.79*	.98*	.81*	.82*	.96	.90	.95*
Saline injected	.65	.53	.57	.57	.62	.81	.76	.76
Standard error	.17	.22	.03	.13	.14	.11	.27	.20

[a] Week of treatment administration
* Values differ from the saline injected in the same column (P<.05)

TABLE 3. MEAN PLASMA SELENIUM LEVELS (PPM) OF WEANED STEERS.

	Week							
Treatment	1[a]	2	3	4	5	6	7	8
Se injected	.008	.038*	.039*	.026*	.032*	.022	.019*	.016*
Cu+Se injected	.010	.038*	.034*	.026*	.021*	.023	.021*	.016*
Saline injected	.010	.010	.011	.010	.009	.017	.011	.010
Standard error	.007	.031	.010	.008	.022	.024	.004	.002

[a] Week of treatment administration.
* Values differ from the saline injected in the same column (P<.05).