

Essential Trace Minerals for Grazing Cattle in Florida¹

John D. Arthington²

Introduction

Pasture forage is the most significant contributor to the trace mineral nutrition of Florida's grazing beef cattle. Sandy, low-organic-matter soils have long been linked to the production of forages with low trace mineral content. In addition, the organic soils associated with the Okeechobee basin have been associated with the production of forages high in molybdenum, an antagonist of copper absorption. Consequently, Florida beef cattle producers recognize the importance of providing a supplemental source of trace mineral nutrition. Mineral supplementation in beef cattle can be divided into two broad categories, macro-minerals and micro-minerals (trace minerals). These categories are based on the amount of mineral required in the cow's diet. As a rule of thumb, micro-minerals are required in amounts less than 1 gram per day compared to macro-minerals, which are often required at levels greater than 1 gram per head per day. Multiple trace minerals are essential for basic physiological functions in beef cattle. In this review, we will discuss only those that are recognized as deficient in Florida grazing cattle and that are therefore important considerations in supplementation programs. The table below (Table 1) illustrates those minerals recognized as essential to

Florida grazing cattle.

Bahiagrass is the predominant pasture forage used in Florida. Recently, a review of bahiagrass mineral concentration was performed (Table 2). The results of the review help us to better address those minerals that are marginal to deficient in Florida pastures. However, these results only tell us the concentration of the mineral nutrient in a given amount of forage. Along with minerals, a forage must contain adequate dry matter in order to provide grazing cattle with the full complement of nutrient resources.

Review of Individual Trace Nutrients Essential to Grazing Florida Beef Cattle

Copper

Copper is one of the most common trace minerals found to be deficient in Florida beef cows. Copper is an important cofactor in approximately 30 enzyme systems. Deficiencies occur through the prolonged consumption of forages low in copper and/or the consumption of forages containing elevated concentrations of molybdenum, a natural

1. This document is AN086, one of a series of the Animal Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date November 20, 2000. Revised October, 2002; May, 2008. Visit the EDIS Web Site at <http://edis.ifas.ufl.edu>.

2. John D. Arthington, Associate Professor of Animal Science and Center Director-Beef Cattle Management, Range Cattle Research and Education Center, Ona, Florida 33865; Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

copper antagonist. Dietary sulfur is also an important component in the copper/molybdenum interaction. Researchers suspect that dietary sulfur levels greater than 0.35 % are highly likely to initiate copper deficiency (see mineral antagonist section below).

Blood copper concentrations are elevated during instances of stress, suggesting that stressed cattle may have a higher copper requirement. Use copper sulfate when supplementing copper: copper oxide is poorly absorbed and should not be used in grazing cattle supplements. Do not use boluses containing Cu oxide needles. This form of supplementation has been shown to depress forage digestibility and can cause copper toxicity in calves (see EDIS article AN111).

Signs of copper deficiency include:

- Immune suppression (failure to respond to vaccination)
- Rough, dull hair coat
- Anemia

Zinc

Like copper, zinc is also an important cofactor in many enzyme systems. In ruminant diets, zinc has been shown to be an important contributor to male fertility. In addition, diets fortified with adequate available zinc have been shown to improve hoof structural soundness in beef heifers. Copper and zinc are absorbed through similar pathways, indicating a competition for absorption sites. Therefore, mineral supplements should be formulated with a copper:zinc ratio of around 1:2 or 1:3. Use zinc sulfate when you supplement zinc.

Signs of zinc deficiency include:

- Connective tissue degeneration (compromised hoof integrity)
- Bull reproductive failure (especially young developing bulls)
- Anorexia and weight loss (notably in calves)

Selenium

A potential to develop selenium deficiency has been widely recognized in Florida cattle. Unlike most other essential trace nutrients, selenium can be difficult to supplement because it has a narrow range between deficiency and toxicity. In fact, many regions in the US are concerned with selenium toxicity in pasture forages. Selenium is essential for the maintenance of tissue integrity. One widely recognized deficiency symptom is the degeneration of tissue, resulting in a condition referred to as “white muscle disease.” Sodium selenite is a commonly used source of supplemental selenium. Because of the selenium-rich pasture forage problem in other regions of the country, selenium inclusion in supplemental feeds is federally regulated at a maximum inclusion level not to exceed 3 mg/d. Nevertheless, Florida cattle that achieve adequate mineral intake and are adequately supplemented with sodium selenite rarely develop selenium deficiencies.

Signs of selenium deficiency include:

- Muscle degeneration (white muscle disease)
- Reproductive failure
- Immune suppression

Manganese

Manganese has been shown to be an important trace mineral to ensure proper bone formation in young animals and to maintain optimal fertility in female cattle. Although dietary manganese absorption and retention in cattle is low, manganese deficiency in grazing cattle is uncommon. Considering the suspected effect of manganese on cow fertility and young calf development, it is most important to focus on optimal manganese nutrition prior to and following calving. Manganese sulfate is the most available form of manganese, but it is often difficult to find commercially. As an alternative, manganese oxide is an acceptable and widely used source of manganese supplementation.

Signs of manganese deficiency include:

- Bone abnormalities

- Reduced growth rate
- Reduced fertility

Iodine

Iodine is critical for the maintenance of proper thyroid function because it is essential to the regulation and synthesis of thyroid hormone. Thyroid hormones affect nearly every physiological process in mammals. Ethylenediamine dihydroiodide (EDDI), often provided in trace mineral supplements as a foot rot preventative, provides a quality source of available iodine. In addition, including iodized salt in the base mineral mix may provide adequate iodine supplementation in most cases.

Signs of iodine deficiency include:

- Reduced fertility
- Enlarged thyroid (goiter)
- Stillborn, weak, and/or hairless calves

Iron

Iron deficiency is seldom a problem in cattle consuming Florida forages. In fact, the antagonistic impact of dietary iron on copper absorption is often more of an issue when attempting to balance trace mineral nutrients. Further, many ingredient sources of other trace nutrients are naturally contaminated with iron. Because iron deficiency in cattle is unusual and because iron inhibits copper absorption in cattle, additional supplementation of iron to grazing Florida cattle is usually not recommended. Iron supplementation is sometimes necessary, however, because iron deficiency is occasionally an issue in young calves or in adult cattle suffering blood loss, usually as a result of parasite infestation. If you do determine that cattle need supplemental iron, bear in mind that the iron included in most trace mineral supplements is in the form of iron oxide. Iron oxide is used as a coloring agent, providing the classic dark red appearance of supplemental trace mineral products: it is basically *unavailable* to the animal. Use iron sulfate for iron supplementation.

Signs of iron deficiency include:

- Anemia
- Immune suppression
- Decreased calf weight gain

Cobalt

Cobalt is an essential nutrient for cattle because it enables the synthesis of vitamin B12 in the rumen. This metabolic process, unique to ruminants, allows us to virtually ignore the dietary supplementation of B-vitamins in cattle. In fact, since cobalt is poorly stored in body tissues, cobalt status in ruminants is commonly assessed via measurements of blood vitamin B12 concentrations. Multiple cobalt sources are included in mineral formulations, including carbonate, chloride, and sulfate.

Cobalt is the most over-supplemented trace mineral in grazing cattle supplements. It is not uncommon to find formulations providing over 1,000% of the cow's requirement. Recent studies have suggested that this over-supplementation may decrease reproductive performance. A salt-based supplement should not contain more than 0.01 % cobalt.

Signs of cobalt deficiency include:

- Loss of appetite leading to weight loss
- Listlessness and diarrhea
- Anemia

Clearly, many trace mineral deficiency symptoms overlap. This is best explained by the intricate interrelationships shared between many of the essential trace minerals. High levels of one element may induce a deficiency in another. Therefore it is essential that formulations take into account the impact of one nutrient upon another.

To further complicate the issue, animals with trace mineral deficiencies often show no clinical signs until they are severely deficient. Chronic, low-grade trace mineral deficiencies sometimes continue unchecked for many years, inhibiting performance and decreasing production without ever revealing themselves through classic clinical symptoms.

Sulfur – A Common Trace Mineral Antagonist in Florida

In Florida, the most recognized trace mineral antagonist is sulfur. Although it is an antagonist, sulfur is also an essential nutrient for cattle as a component of certain amino acids, vitamins, and other compounds. Sulfur deficiency in cattle is linked to a decrease in ruminal microorganisms and subsequent decrease in rumen function. This condition would lead to a decline in forage digestibility and ultimately a decrease in animal growth. Fortunately, sulfur deficiency is seldom a problem in well-managed grazing cowherds.

In grazing cattle, too much sulfur is typically more of a concern than too little. High dietary sulfur can lead to a reduction in copper and selenium absorption as well as a neurological disease called polioencephalomalacia, which is common in feedlot cattle consuming high sulfur diets. The maximum tolerable concentration for sulfur is estimated to be 0.40% of the total diet. Dietary concentrations exceeding 0.30% are sufficient for the antagonism of copper absorption. Therefore, a reasonable upper limit for daily sulfur intake would be approximately 32 g daily (Table 3). Dietary sulfur can be derived from a variety of sources, with the major contributors coming from forage, supplement, and water. For ease of explanation, the following sections and tables illustrate some common sources and sulfur concentrations available to cattle in Florida.

Forage Sulfur

Because forage intake constitutes the greatest amount of total daily dry matter intake, forage sulfur concentrations tend to be the leading provider of dietary sulfur. Our experiences suggest that a common range for pasture bahiagrass is 0.15 to 0.25 % sulfur. The sulfur in pasture forage comes from natural concentrations of sulfur in soil, sulfur provided from nitrogen fertilizers containing ammonium sulfate, and to a lesser extent, sulfur in animal manure.

Our research has found that repeated annual applications of ammonium sulfate as a source of nitrogen can result in plant sulfur concentrations as great as 0.50%. Cows grazing these pastures were

found to have lower liver copper concentrations at the end of the grazing season compared to cows grazing unfertilized pastures or pastures fertilized with ammonium nitrate (see EDIS article AN112).

Supplemental Feeds

Supplemental feeds provided to grazing cattle can be another significant source of dietary sulfur. Common Florida feeds may vary greatly in their sulfur content (Table 4). Although their contribution to total dietary sulfur intake may be significant, these feeds are typically only provided during the winter season, which may last from 3 to 6 months depending on the region of Florida being considered. The two trace minerals commonly impacted by sulfur antagonisms (copper and selenium) can be stored in liver tissue and called upon during instances of deficiency. Although sulfur excesses may reduce copper and selenium stores during periods of winter supplementation, well-managed cattle will likely have adequate reserves to handle short periods of trace mineral loss. Be cautious, however, to provide high-sulfur supplemental feed during only a few months throughout the year to ensure cattle have an opportunity to replenish these tissue losses.

Trace Mineral Supplementation

Supplementation of trace minerals may occur through a variety of means, including free-choice loose mineral mixes, trace mineral blocks, and fortified energy and/or protein supplements.

Free-Choice Loose Mineral Supplements

This form of mineral supplementation is by far the most common supplementation strategy in Florida beef herds. An example of a quality salt-based mineral supplement is provided in Table 5. In nearly all cases, this formula will provide an effective, cost-efficient means of delivering adequate mineral supplementation. Although formulations vary greatly, the common base mix should contain approximately 20 to 25% salt. Intake is often targeted at two to four ounces per head daily. Unfortunately, not all animals achieve this target intake. Several animals within a herd will consume very little to no mineral at all. However, on the average, mineral consumption usually meets the desired intake levels.

It is this averaging effect, over time, which allows free-choice mineral supplements to be the most practical choice for most Florida producers.

Seasonal variation in free-choice mineral intake can occur. During the wetter summer months, cattle readily consume salt-based mineral supplements. In contrast, during the drier winter months, free-choice intake may be reduced by 15% or more. To avoid over consumption in the summer, offer mineral every 10 to 14 days at a level slightly exceeding the target intake. It is acceptable for the feeder to remain empty for a few days before the next scheduled day of mineral offer. In the winter when consumption is often reduced, try blending your mineral with your winter supplement (described below). If you do not use winter supplements, try mixing your salt-based loose mineral mix with cottonseed meal or soy hulls at a 1 to 1 ratio. Remember to double your offer and monitor intake. Increase or decrease the ratio of mineral to meal or hulls to control intake to your desired level.

Trace Mineral Blocks

In most grazing situations, trace-mineral-containing salt blocks cannot provide sufficient trace mineral intake to meet nutritional needs. Cattle are often unable to consume enough of the product (which is formulated in a hard, salt-based block) to achieve their necessary level of trace mineral supplementation. Nevertheless, some grazing situations dictate the need for this type of supplementation. When producers are physically unable to provide regular loose mineral or fortified supplements, trace-mineral-fortified salt blocks provide an opportunity to offer long-term mineral supplementation, therefore lessening the potential for trace mineral deficiency.

Fortified Energy / Protein Supplements

One of the most effective management strategies for addressing trace mineral nutrition in beef cows involves the mineral fortification of energy and/or protein supplements. Simply fortify your traditional supplements with your current free-choice trace mineral supplement. Some producers fortify their winter supplement and return cows to free-choice products during months when supplement is not

offered. This strategy is effective in decreasing the variability in free-choice trace mineral intake and in bolstering trace mineral tissue stores during the winter supplementation period. Using mineral-fortified winter supplements lessens the risk of poor winter mineral intake compared to relying on free-choice, salt-based mineral supplements alone.

When supplementing trace minerals, it is important to realize that cattle *do not* have the nutritional wisdom to consume trace minerals as needed. We have all heard the statements, "My cattle are not consuming mineral, so they must not need it," or, "My cows are eating four times their normal level; I guess they really need it." Cattle only possess the ability to consume salt at the level of their requirement. Consequently, by altering the salt inclusion in mineral mixes, we can either encourage or discourage mineral intake. Remember that the majority of trace mineral intake beyond that nutritionally required by the animal is excreted in urine and feces. When cattle are over-consuming mineral, consider adding stock salt directly into the trace mineral mixture. Once mineral intake has normalized, lessen or remove the additional salt. *Do not provide stock salt and trace mineral supplement separately.* Because cattle are attracted only to salt, this strategy will decrease trace mineral intake and may lead to a deficiency state.

Analysis of Herd Trace Mineral Status

If you suspect a trace mineral deficiency, you may wish to conduct an evaluation of herd trace mineral status. With today's technologies, this task is fairly simple and cost efficient. Consider the following steps to evaluate herd trace mineral status and the effectiveness of your trace mineral supplementation program.

A. Rule Out Other Influential Factors

The first step in identifying a trace mineral deficiency is to attempt to rule out other more directly contributing factors. For instance, if average cow body condition score is less than 4, chances are far greater that decreases in reproductive performance and/or immune function are a result of energy/protein deficiency versus trace mineral deficiency. Also, be

sure to evaluate the basics of your current supplementation program. Does the product provide a balanced mineral profile using quality ingredients? Are the cattle being provided with a consistent supply of fresh mineral? Are the cattle consuming the mineral at an appropriate level?

B. Forage Trace Mineral Concentrations

Grazing cattle selectively consume forage with 25 to 30% more crude protein than hand-clippings of the same pasture; therefore pasture samples often underestimate the quality of forage consumed by the animal. The same concept does not apply to trace minerals. In a field study, we attempted to collect the same forage being consumed by rumen-cannulated steers. During controlled grazing periods, we attempted to clip that forage which the steers were consuming. Later, the rumen of each animal was emptied and the consumed forage collected. Even though we attempted to clip exactly the forage being consumed, the steers selected forage higher in crude protein (30.0%), calcium (52.6%), and phosphorus (36.8%), compared to hand-clipped samples. However, no differences occurred in the trace mineral content of steer-selected vs. clipped forage, suggesting that hand-clipped forage samples are a good reflection of the trace mineral concentration of animal-selected forage.

When collecting forage samples for trace mineral analysis it is important to collect the sample from areas where animals are grazing (selecting). Do not collect from non-selected forage areas and be careful not to contaminate your sample with weeds or dirt. Before you conduct your collection, contact a laboratory that will test forage for trace mineral levels. Many commercial laboratories offer an analysis package containing a group of trace minerals, usually for a cost of about \$15 to \$30 per sample. The laboratory will provide directions for collecting, handling, and shipping your samples. It is important to test for copper, zinc, selenium, cobalt, and manganese. It is also important to include antagonistic trace minerals, which may interfere with the normal absorption of other minerals. Three commonly recognized antagonists in Florida forages are molybdenum, iron, and sulfur.

C. Herd trace Mineral Status

Often, it is possible to establish a reasonable plan of action by addressing points A. and B. However, in some instances it may be important to further explore a potential trace mineral deficiency by examining animal blood and/or liver mineral status. For two of Florida's most troublesome trace minerals, copper and selenium, liver samples provide the most reliable indicator of actual animal stores. Blood samples are an unreliable approach for the measurement of these elements unless the cattle are severely deficient. Modern laboratory technology allows for the use of very small tissue samples for the analysis of multiple trace elements. Today's liver biopsy collection technique is simple, and will cause very little stress to the animal.

Table 1. Mineral Requirements of Beef Cows¹

Macro-minerals, % ²	Gestation	Lactation	Micro-minerals, ppm ²	
Potassium (K)	0.60	0.70	Copper (Cu)	10.00
Magnesium (Mg)	0.12	0.20	Iron (Fe)	50.00
Sodium (Na)	0.06 – 0.08	0.10	Manganese (Mn)	40.00
Sulfur (S)	0.15	0.15	Zinc (Zn)	30.00
Phosphorus (P)	16 – 33 g / d ²	—	Cobalt (Co)	0.10
Calcium (Ca)	13 – 24 g / d ²	—	Iodine (I)	0.50
			Selenium (Se)	0.10

¹ Data taken from Nutrient Requirements of Beef Cattle, National Research Council, 1996. Dietary requirements vary by stage of production, with the highest requirement during the first 3 months post-calving.

² Macro-mineral requirements listed as % of total diet on a dry matter basis. Micro-minerals listed as ppm, or mg per kg of diet on a dry matter basis

Table 2. Average Mineral Concentration of South Florida Bahiagrass¹

Macro-Minerals	Concentration, %	Micro-Minerals %	Concentration, ppm
Phosphorus	0.27	Zinc	51.4
Potassium	0.74	Copper	6.4
Calcium	0.43	Manganese	54.8
Magnesium	0.33	Iron	77.4

¹ Samples collected from 9 counties in south Florida. Samples collected monthly from March to December. Pastures fertilized in March (60 lb nitrogen / acre).

Table 3. Amount of sulfur derived from pasture forage containing a range of sulfur concentrations^a

Forage sulfur, %	DM Intake, lb/d	Sulfur Intake, g/d
0.15	20	14
0.20	20	18
0.25	20	23
0.30	20	27
0.35	20	32

^a Assumes a 1000-lb cow consuming 2.0% of body weight in DM daily. Cow/calf producers should target sulfur intakes to not exceed 32 g/d.

Table 4. Amount of sulfur derived from feedstuffs commonly supplemented to cowherds in Florida^a

Item	Intake, lb/d	Sulfur, % as-fed	Sulfur provided, g/d
Molasses (heavy mill run) ^b	5	0.70	16
Molasses, 32% ^b	3.5	0.70	11
Brewer's grains ^b	5	0.36	8
Distiller's grains ^b	5	0.40	9
Corn gluten feed ^b	5	0.23	5
Soy hulls ^b	5	0.10	2
Citrus pulp ^b	5	0.07	1.5

^a Daily intake values are selected estimates for commonly used supplementation rates. If your supplement rate differs, then actual sulfur intakes will also differ.

^b Liquid molasses values provided by United States Sugar Corporation, Clewiston, Fla. for molasses derived from sugarcane processing (06/18/07). Dry feed values derived from the National Research Council, 1996

Table 5. Example: Salt-based mineral supplement for grazing cattle in Florida^a

Mineral	Inclusion, %	Intake / d
Calcium	12.00	6.8 g
Phosphorus	0 to 9 ^b	5.1 g
Copper	0.15	85.05 mg
Cobalt	0.005	2.84 mg
Manganese	0.05	28.35 mg
Zinc	0.30	170.10 mg
Iodine	0.02	11.34 mg
Selenium	0.004	2.27 mg

^a Mix should contain 20 to 25% salt with a targeted intake of 2 oz/hd/d (57 g).

^b Phosphorus is the most expensive ingredient in a free-choice mineral product. Grazing Florida beef cattle often do not require additional phosphorus, especially if they are receiving winter supplements fortified with phosphorus.