TRACE MINERAL NUTRITION OF RUMINANTS ON FORAGE BASED SYSTEMS

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Sheep and cattle are complex biological factories. Outputs or products from these factories may be meat, milk, wool, developing fetus, etc. The inputs or raw products going into the system include oxygen, water, carbohydrates, proteins, vitamins and minerals. Production can be slowed down when any of the operating inputs is out of balance.

Some minerals are required in relatively large amounts and are known as the major elements. Others are required in much smaller amounts and generally function in various enzymatic reactions in the body. Minerals in this last group are referred to as trace elements and include cobalt (Co), copper (Cu), iron (Fe), iodine (I), manganese (Mn), selenium (Se), zinc (Zn), and molybdenum (Mo).

Trace mineral deficiencies that may occur in sheep and cattle on forage-based systems in Montana include iodine, copper, selenium, and zinc. A brief description for these essential elements is given below.

Element	Iodine
Distribution:	80% of total body I is in the thyroid.
Function:	Hormonal control of energy metabolism and protein synthesis.
Requirements:	0.15 mg/kg feed (2 mg/kg in presence of goitrogenic type feeds).
Signs of Deficiency:	Most obvious is enlargement of thyroid gland. Subclinical deficiencies result in small depressions in production.
Diagnosis:	Serum or plasma T_4 and T_5 by radioimmuno assay.
Forage Levels:	Deficient across Montana.
Supplementation:	Ethylenediamine dihyriodide is commonly incorporated into salt.
Interferences:	Goitrogens are found in soybean meal and most brassicas (turnips, rape).

Element:	Copper
Distribution:	40 - 70% of total body Cu is stored in liver.
Function:	Cu-enzyme responsible for cross-linkage formation in collagen and bone structure. It is necessary for the formation of constituents of the myelin sheath around the nerve fiber. Cu is active in the conversion of tyrosine to melanin, which provides the color ingredient in hair and wool. About 20% of the plasma Cu is in a loosely bound form, while the other 80% is associated with a protein called ferroxidase (ceruloplasmin). Ferroxidase oxidizes ferrous iron (Fe^{2+}) to ferric (Fe^{3}) allowing the mobilization of iron stores.
Requirements:	The coefficient of absorption of Cu varies according to age and dietary factors such as increasing levels of Mo and S. Provided that the availability of the Cu is not greatly influenced by dietary factors such as Mo and S, and the DM intakes are adequate, then pastures containing 5 to 6 mg Cu/kg DM and 7 to 10 mg Cu/kg DM should meet the Cu requirement of sheep and cattle, respectively. A Cu:Mo in forage of 2.0 or greater is desirable to avoid molybdenosis.
Interactions:	In grazing animals, increasing Mo and S levels are the most important dietary factors that can reduce the absorption or availability of Cu. The mechanism of the Cu x Mo x S is not fully understood, but insoluble complex salts such as Cu thiomolybdates can be formed in the rumen and thereby reduce the absorption of Cu and/or its utilization. Insoluble Cu compounds can also be formed in the blood reducing Cu activity.
Signs of Deficiency:	Visible signs are not usually seen in the adult sheep. Cu-deficient adult cattle are unthrifty, grow poorly, and have reproductive problems. The growth of calves is poor, while bone fractures and loss of coordination of the hind limbs have been reported. Sometimes a lightening of the coat color is associated Cu deficiency.
Diagnosis:	To assess the Cu status of a group of sheep or cattle samples of the liver from at least 6 to 14 animals should be taken either by liver biopsy or when the animals are slaughtered. If liver samples are not available, then blood samples should be taken.

In cattle, liver Cu levels below 3 mg Cu/kg wet tissue tissue (12 mg Cu/kg dry matter) and blood or plasma Cu levels below 0.5 mg/ℓ are indicative of Cu deficiency. In the case of sheep, liver Cu levels below 5 mg Cu/kg wet tissue (25 mg Cu/kg dry matter) are also indicative of Cu deficiency, but the situation with plasma Cu levels is not clearly defined. Generally, 100 to 300 mg Cu/kg dry matter in liver is adequate in both sheep and cattle. Sheep are very sensitive to high Cu intake, whereas cattle are able to excrete Cu and maintain a maximum level of about 500 ppm Cu in liver (dry basis).

Forage levels: Forage Cu concentrations vary from 4 or 5 ppm to values of 10 to 15 ppm. Sulfur and molybdenum interfere with the absorption of Cu. Concentrations of S range from about 10 to 40 mg S/g DM, while Mo can range from 1 to about 100 µg Mo/g. Note that Mo can vary by a factor of 100, while S can vary by 3 or 4X and Cu by 2 or 3X. This is an important fact when considering the Cu x Mo x S interaction.

Supplementation: Subcutaneous injections of copper glycinate or the feeding of copper sulfate in the salt mix are the options presently available to us in the U.S. Producers in other countries are using copper oxide wire or needles, phosphate based soluble glass boluses containing Cu and other trace minerals as needed, or subcutaneous CuCa edetate. Some animal deaths have been associated with the use of the edetate formulation.

Interferences: Molydenum, sulfur, and to a much lesser extent, iron and manganese interfere with the absorption of Cu from the rumen. Quite likely Mo and S reduce the availability of the total Cu in the blood by forming compounds that are insoluble in trichloroacetic acid (TCA).

The following equation was developed from several studies to relate Cu absorption or availability (Y) to the Mo concentration (mg/kg feed) and S concentration (g/kg feed).

$$\text{Log } Y = -1.15 - 0.0019\ \text{Mo} - 0.0755\ \text{S} - 0.013\ (\text{Mo} \times \text{S})$$

Copper in cured hay or grass is more available than is Cu in fresh grass or silage.

Element: <u>Selenium</u>

Distribution: An adult sheep contains 2.5 to 3 mg Se which is widely distributed in the body. The kidney and liver normally have the highest concentrations of Se.

Function: Se is an integral part of the enzyme glutathione peroxidase (GSH-Px) which catalyzes the reduction of peroxides, thereby protecting tissues against oxidative damage. Vitamin E acts by preventing peroxide formation.

Requirements: In many areas sheep and cattle grow normally on pastures containing no more than 0.03 mg Se/kg and show no evidence of a deficiency. In other areas WMD can occur, especially in lambs, where pastures contain as much as 0.05 mg Se/kg. A value of 0.1 is often used as a critical level, but this should be evaluated on a basis of animal performance.

Interactions: As S and Se are similar, it has been suggested that at least S will compete for uptake of Se by plants and animals. Forage production systems on which irrigation or sulfur containing fertilizers are applied may increase yields and often produce forage containing significantly lower Se concentrations than occurred before the introduction of these practices.

Signs of Deficiency: A number of diseases of sheep and cattle are caused by a deficiency of Se. Lambs and calves with congenital white muscle disease (WMD) are born dead or die suddenly within a few days of birth. A delayed form of WMD occurs in young animals and another is identified as ill-thrift in animals of all ages. Again, overall animal performance is probably the best monitor.

Supplementation: Oral or parental administration of Se are routes currently permitted in the U.S. Some experimentation is evaluating the use of a Se bullet or bolus made from 10% metallic Se and 90% iron. Another form of Se, now marketed in Great Britain, is a soluble glass bolus containing slowly released Se.

Element <u>Zinc</u>

Distribution: Zinc occurs widely and in relatively high concentrations throughout the body. The Zn concentrations in plasma of sheep and cattle range from 0.6 to 1.2 mg Zn/ℓ and 0.8 to 1.2 mg Zn/ℓ, respectively.

Function: Zinc is a constituent of a large number of metalloenzymes involved in biochemical processes essential to nucleic acid and carbohydrate metabolism, as well as protein synthesis. It is associated with appetite, growth, male sexual development, and wound healing. There are no significant stores of body Zn, and the animal must rely on a daily supply to meet requirements.

Requirements: An accurate determination of Zn requirements of ruminants is not available, although the level of 20 to 25 mg Zn/kg DM is consistent with results obtained from grazing experiments.

Signs of Deficiency: Clinical signs of Zn deficiency include excessive salivation, deterioration and loss of hair or wool, and stiff joints. Cracks may appear above the coronary border of the hoof, and the skin around the nostrils, neck and scrotum. The teats become thickened, scaly and dry and crack easily. The skin changes are known as "parakeratosis." No visual signs of Zn deficiency have been identified in grazing livestock in the U.S. Weight gain responses by grazing livestock to Zn supplementation were achieved with no clinical signs of the deficiency evident and very small differences in blood plasma Zn levels.

Diagnosis: At the present time there is no reliable index of Zn status of ruminants except production performance.

Forage levels: Zinc concentrations may be as high as 30 µg Zn/kg DM, but this concentration declines rapidly as forage matures, with many values falling between 15 and 20 µg Zn/kg DM.

Supplementation: Zinc oxide in salt mixes and zinc methionine are satisfactory sources of Zn for the grazing animal. However, do not supplement unless a production response is measured from animal trials. Zinc foot baths have been used in other countries to provide effective control of footrot in sheep. Drenching of Zn, though touted by some to reduce footrot, has not been supported by most research. Zinc supplementation of dairy cows may be effective in countering facial eczema in New Zealand. This relationship is now being tested.

Interferences: Moderate to high intakes of Zn will depress the Cu status of the animal.

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