

The “how and why” of assessing micronutrient levels in beef cow-calf systems

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Introduction

Matching the nutritional resources of protein, energy, minerals, trace minerals and vitamins to requirements of the beef cow at various times of the year is likely the most challenging aspect of meeting the production goals in a cow-calf production system. While each system will have different goals, commonly accepted goals are 95% of females pregnant in 60 days, 65% of the cows calving in the first 21 days, and a 90 % weaned calf crop based on number of cows exposed.¹⁸ If goals are not being met, the obvious question is “why?” and a careful evaluation of the entire system should be undertaken as many times these problems are multifactorial. It is not uncommon to find nutrition playing a significant role in these problems whether they be reproductive, neonatal health or weaning health (Figure 1).

The “why” of micronutrient assessment

Energy and protein are the nutritional components of primary concern in cow-calf operations. Body condition score (BCS) provides a reasonable assessment of the adequacy of energy and

protein intake. Cows should be in a BCS of 5-5.5 and heifers 5.5-6.0 going into calving in order for them to produce adequate colostrum and return to estrus in an acceptable manner. Evaluation of body condition score should be included as part of the diagnostic workup if problems such as neonatal diarrhea, respiratory disease at weaning, or reproductive inefficiency is occurring in a herd.

Consideration should also be given to the micronutrient status of the herd, particularly in herds with excessive calf losses (mortality greater than 5.0% of calves born).²¹ Copper, manganese, selenium and zinc play a significant role in the immune responses as well as reproduction, yet are the most common trace mineral deficiencies observed in beef herds.⁷ The impact of vitamin A on immunity and reproduction has become apparent in recent years as drought conditions have affected the Great Plains and the western United States. Deficiencies of these micronutrients manifest themselves as subclinical disease and have been referred to as “production disease”.²¹ This impact on immunity and reproduction occurs prior to the appearance of the classical micronutrient deficiency (Figure 2).²¹

Figure 1: Factors influencing production in cow-calf systems.

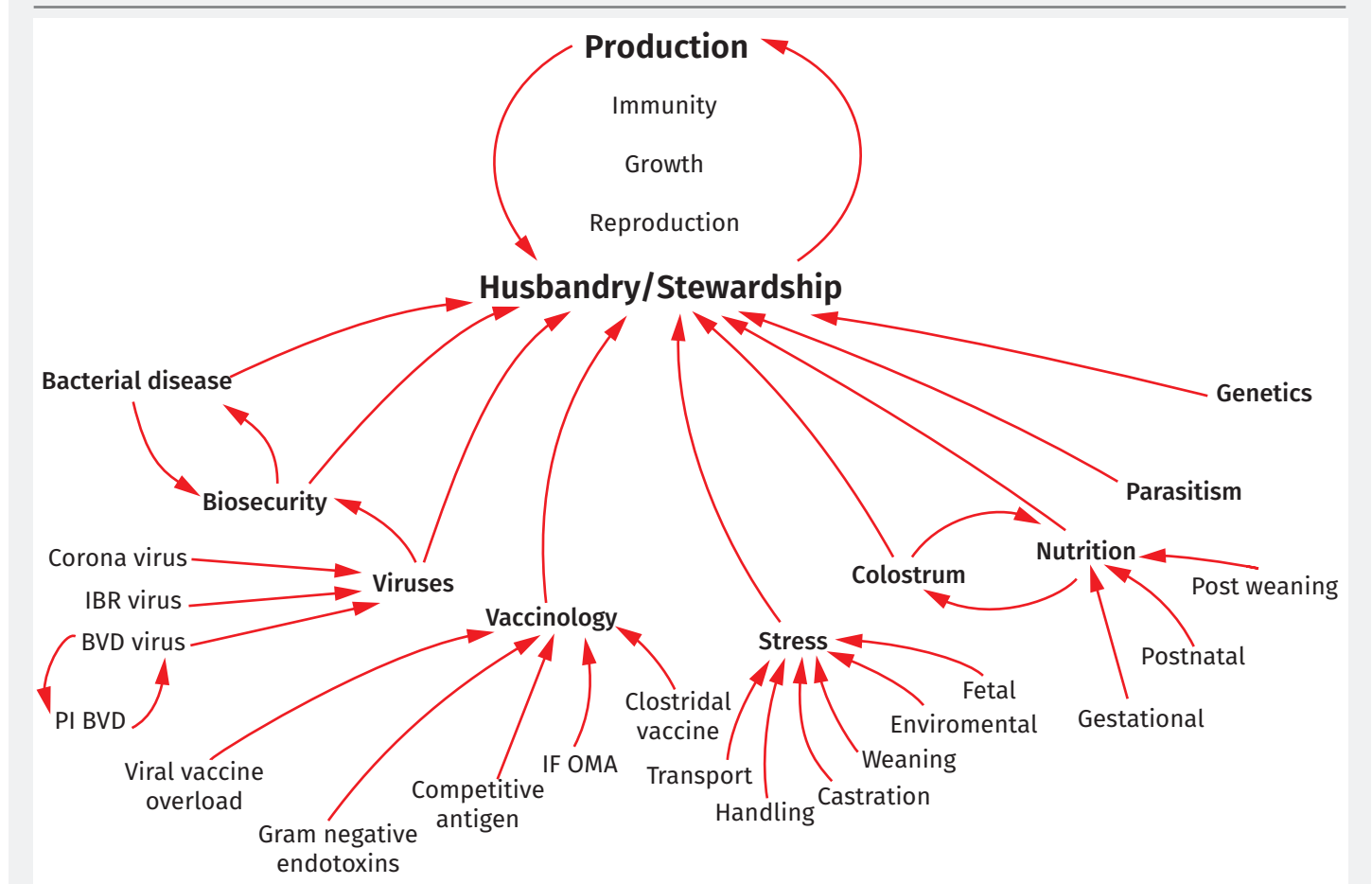
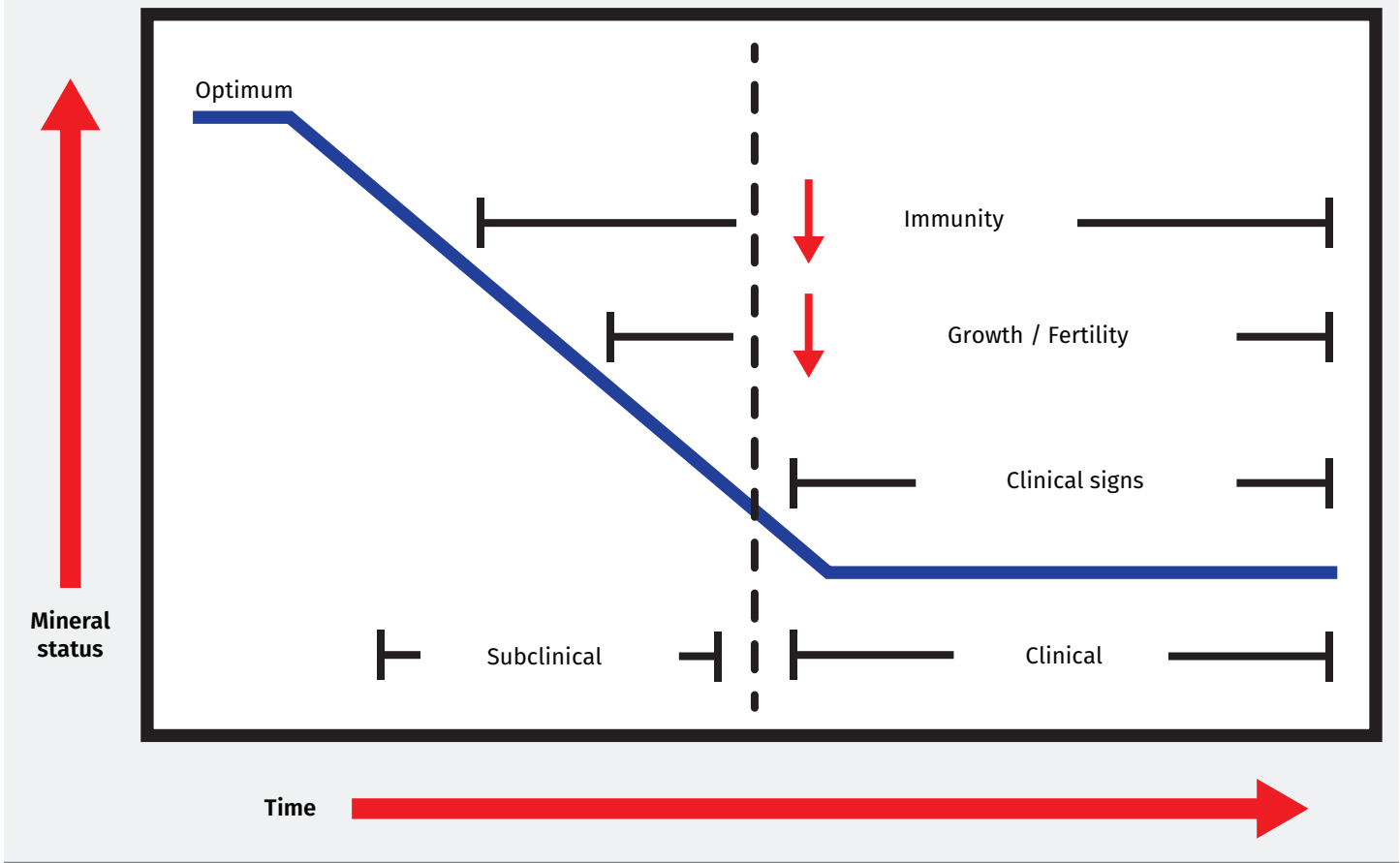


Figure 2: The effects of micronutrient deficiency on the health and performance of cows and calves.



The energy, protein, mineral, trace mineral and vitamin status of cattle serves to modulate nearly all physiological processes in the body, including the immune system.^{1,12} This immune modulation serves to influence the health and reproductive performance of cattle. Micronutrients modulate immune responses through their role in enzymatic processes, thus a micronutrient deficiency or excess can alter immune system function. These abnormalities can alter antibody responses, cell-mediated immunity, and natural killer cell activity.¹²

Copper

Copper is necessary in numerous enzyme systems associated with energy metabolism, immune function, and reproduction. Additionally, it is involved in antioxidant defense mechanisms, connective tissue development and iron metabolism.⁷ Impairments in the immune system that are associated with copper deficiency occur in the humoral immune system as well as the cellular immune system. These impairments include decreased antibody production, decreased cytokine production, altered immune cell maturation, and altered immune cell function.¹ Reproductive effects of copper deficiency are observed as decreased conception rate, infertility, anestrus and fetal resorption.³

Hypocuprosis can be primary (low copper intake) or secondary (associated with antagonism). In areas of high molybdenum, this trace mineral will act as antagonist. Sulfur, iron and selenium can also act as copper antagonists.

Manganese

Manganese plays a significant role in enzyme systems that impact growth, bone and joint development, reproduction, and antioxidant defense systems.⁷ Manganese deficiency has been associated with skeletal abnormalities such as contracted tendons and abortion.⁶ Other reproductive effects include cystic ovaries, silent heats and low conception rates.⁸ Poor growth has been associated with this deficiency as well as testicular atrophy and impaired ovulation.¹³ Chondrodysplastic fetuses and neonates have been observed with manganese deficiency.¹¹ These calves have a dwarf-like appearance with tendon laxity. Manganese does not preferentially accumulate in the fetal liver in the same manner as copper, zinc and selenium.¹³

Selenium

Selenium is essential for immune function, reproduction, and iodine metabolism in addition to its role in supporting antioxidant enzymes.⁷ Necrosis and scarring of cardiac and skeletal musculature, referred to as white muscle disease, is associated with selenium deficiency.⁸ Deficiencies of vitamin A and vitamin E can increase the expression of selenium deficiency because of the antioxidant activity of these vitamins.⁶ Reductions in growth rates, feed efficiency, immune function and reproductive performance are also associated with deficiencies of this trace mineral.⁸ Areas of excessive selenium exist in the Great Plains. This toxicosis affects the immune system, musculoskeletal system and reproductive system. Additionally, it acts as an antagonist to the absorption of copper and zinc.⁹

Zinc

Zinc plays a role in the activity of more than 300 enzymes involved in metabolism, growth, reproduction, immune function and epithelial health.^{1,7} It is involved in humoral, and cell mediated immunity, thus a deficiency is associated with reduced T-cell function and antibody responses. Immunosuppression has been reported as a result of excessive zinc.¹ Zinc in conjunction with vitamin A plays a role in the integrity of tight junctions in epithelial surfaces throughout the body including the respiratory tract, intestinal tract, testicle, uterus and mammary gland in addition to many others. Zinc dependent enzyme systems are involved in the conversion of beta carotene and retinyl to retinol in the intestinal mucosa.¹⁵ An increased frequency of zinc deficiency has been observed in grazing cattle during and for 1-2 years following severe drought.⁸ Some cattle with low normal zinc levels have responded to zinc supplementation.⁸

Vitamin A

Vitamin A is a fat-soluble vitamin that serves as an antioxidant in addition to being involved in the immune system and reproduction. Deficiency is observed as reduced growth, immune function and reproductive performance. It is also associated with a high incidence of neonatal diarrhea.⁸ In synergy with zinc, it plays a role in tight junctions of essentially every epithelial surface in the body. Humoral immunity and cellular immunity both benefit from this vitamin due to its effect on essentially all immune cells. Reproductively, vitamin A is necessary for placental, testicular and ovarian function.¹⁴ Abortion has been associated with this deficiency. Bony changes of the optic foramen create a stenosis of the optic nerve resulting in night blindness of young animals.⁵

Transfer of micronutrients to the neonate

The transfer of trace minerals, especially copper, zinc and selenium, from the dam to the fetus during the third trimester of pregnancy is essential for the immune system of the neonatal calf to function efficiently.^{19,20} If cows do not receive adequate levels of these trace minerals during late pregnancy due to either inadequate levels in the provided mineral, the absence of mineral supplementation or cutting the provided mineral with salt in order to reduce intake, the immune system of the neonate will not function efficiently during the first 50-60 days of life. Additionally, deficiency in the cow can impact her immune function and decrease colostral antibody production. These deficiencies make the calves especially prone to neonatal diarrhea and/or respiratory disease. This shortfall may actually impact the calves their entire life.

Vitamin A does not cross the placenta well. A very small amount will cross the placenta but it is not enough to meet the requirement of the neonate. Colostrum is the primary source vitamin A. Adequate dietary vitamin A intake can be a challenge when the cows are consuming brown forage for an extended period of time, such as occurs in moderate to severe drought conditions. Corn silage, corn by-products, and stored grass hay are also low in vitamin A, making supplementation of vitamin A essential when these feedstuffs are the primary forage in the diet. Body condition scores should be monitored during late gestation to ensure adequate fat in the colostrum to transfer the the vitamin A as well as provide brown fat to serve as an energy source for the newborn calf. Zinc levels tend to be marginal under drought conditions which could also alter vitamin A metabolism (Figure 3).

Micronutrient sources and bioavailability

Trace minerals can be supplemented using inorganic or organic sources. The inorganic forms can be sulfate, chloride, oxide, or hydroxyl forms with the bioavailability being the major difference. The bioavailability of the sulfates is generally regarded to be superior to that of the oxides and chlorides but there are some exceptions.¹⁷ The ionic bonds of these salts are readily broken down in the less acidic environment of the rumen making the minerals susceptible to antagonists such as molybdenum, iron, sulfur, and selenium that are free in the rumen. The hydroxyl minerals are a mineral metal that is bound to a hydroxy group by a bond that is not broken in the rumen but can be broken in the abomasum. This mechanism greatly reduces the antagonism by other metals, thus increasing bioavailability. The organic forms of trace minerals can be true amino acid chelates, amino acid complexes, proteinates, or saccharide complexes and are protected from ruminal interferences as they are not soluble in the rumen. The bond of this molecule is not broken down in the rumen reducing the risk of antagonism.¹⁷ Some thought exists that the bond on certain forms of organics is not broken in the abomasum and the intact molecule is absorbed as an amino acid in the small intestine and the bond is broken after absorption.^{4, 10,16,17} The bioavailability of chelated minerals and hydroxyl minerals is superior to that of the inorganic sulfates, oxides, and chlorides (Figure 4).

The “how” of micronutrient assessment

While liver and serum can both be used for trace mineral assessment, liver is the preferred sample. Serum does not consistently reflect the liver stores of a mineral such as copper. It is possible to have normal serum values for copper, yet the liver values are deficient. Use of serum to assess selenium is acceptable. It is necessary to use tubes such as blue top serum tubes when testing serum in order to avoid false results on minerals such as zinc. Serum should be removed from the clot as soon as possible. Liver samples can be from liver biopsies or collected as post-mortem samples. Post-mortem samples should not be taken from animals that were chronically ill as disease processes will alter hepatic copper and zinc levels. These samples should be frozen soon after collection.

Liver and serum are both appropriate samples when assessing vitamin A or E status. Serum should be separated from the clot as soon as possible, protected from heat and light, and frozen. Liver samples should be from fresh deads and frozen. Current technology does not allow for using liver biopsies to assess vitamin status on a routine basis.

Liver biopsy

Liver biopsy is a relatively simple procedure used to collect a sample to be used for trace mineral analysis. It is performed in the right 10th intercostal space at the level of a line drawn from the tuber coxae to the point of the shoulder (Figure 5).

After clipping the area, a surgical prep is done on the site followed by injection of 5-10 ml of lidocaine. A stab incision is made using a number 10 scalpel blade taking care to avoid the caudal aspect of the 10th rib. The biopsy needle is inserted through the intercostal muscles and the cutting chamber extended. The needle is directed approximately 15 degrees down and 15 degrees forward. After the needle is inserted 1-2 inches

Figure 3: Vitamin A metabolism in the cow. Adapted from: *Vitamins in Animal and Human Nutrition*. Vitamin A Chapter, 2000.

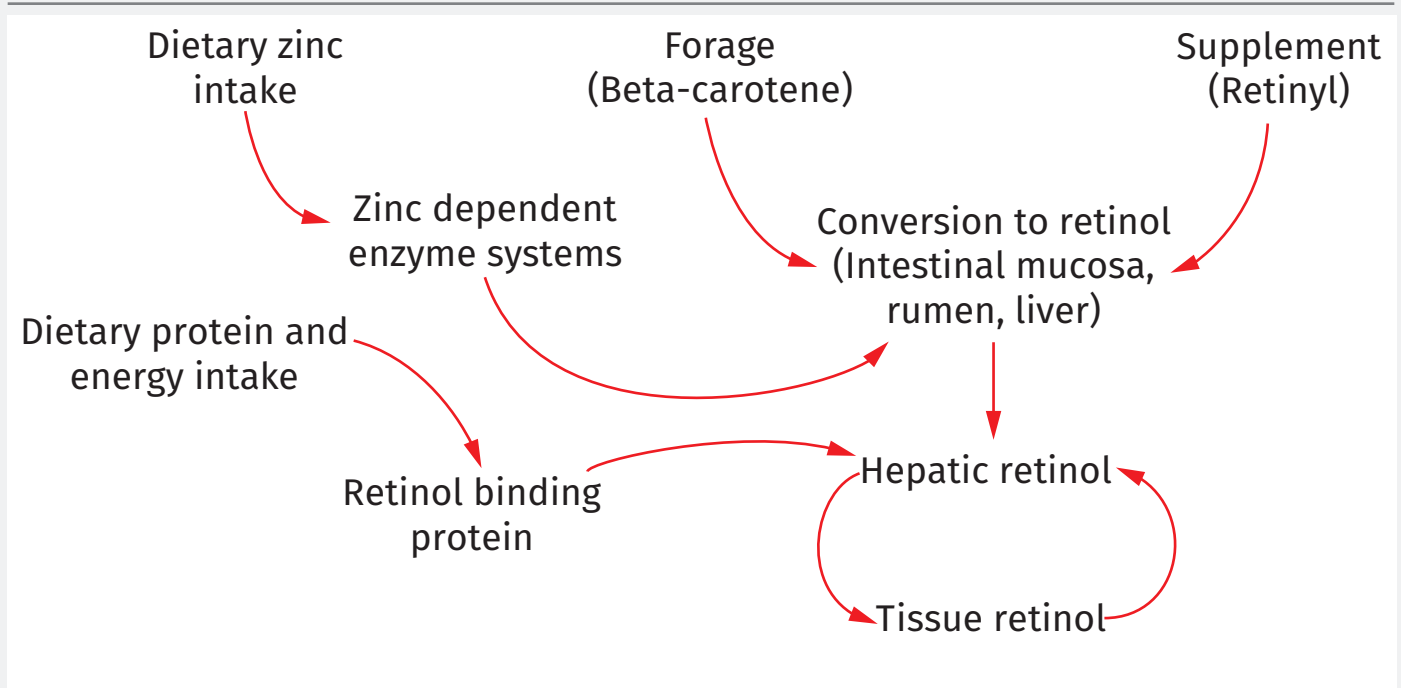


Figure 4: Relative Trace Mineral Bioavailability. Adapted from: Jeffery Hall, *Common Vitamin/Mineral Problems and Diagnoses in Cattle Herds of North America*, American Association of Bovine Practitioners 2023.

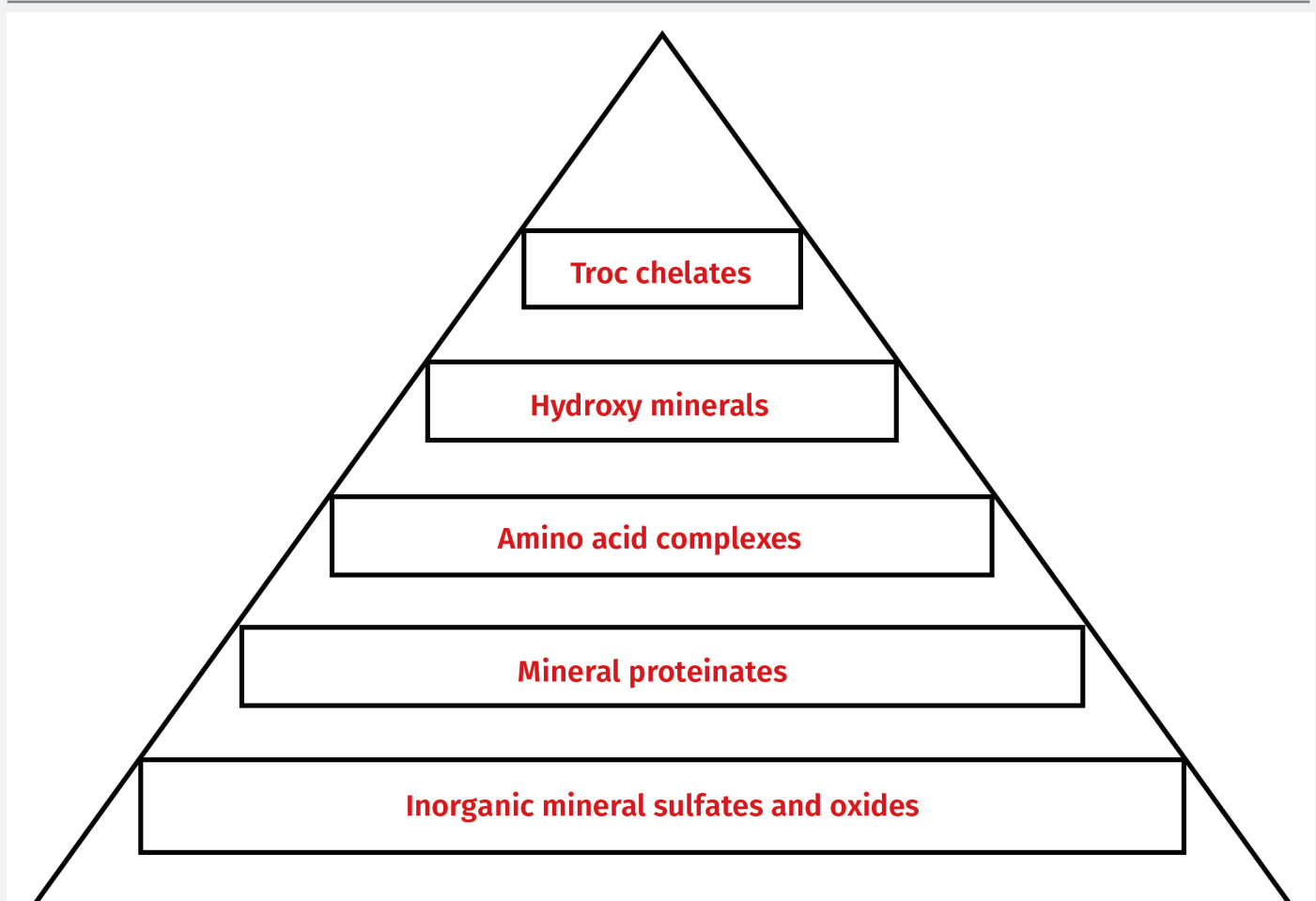
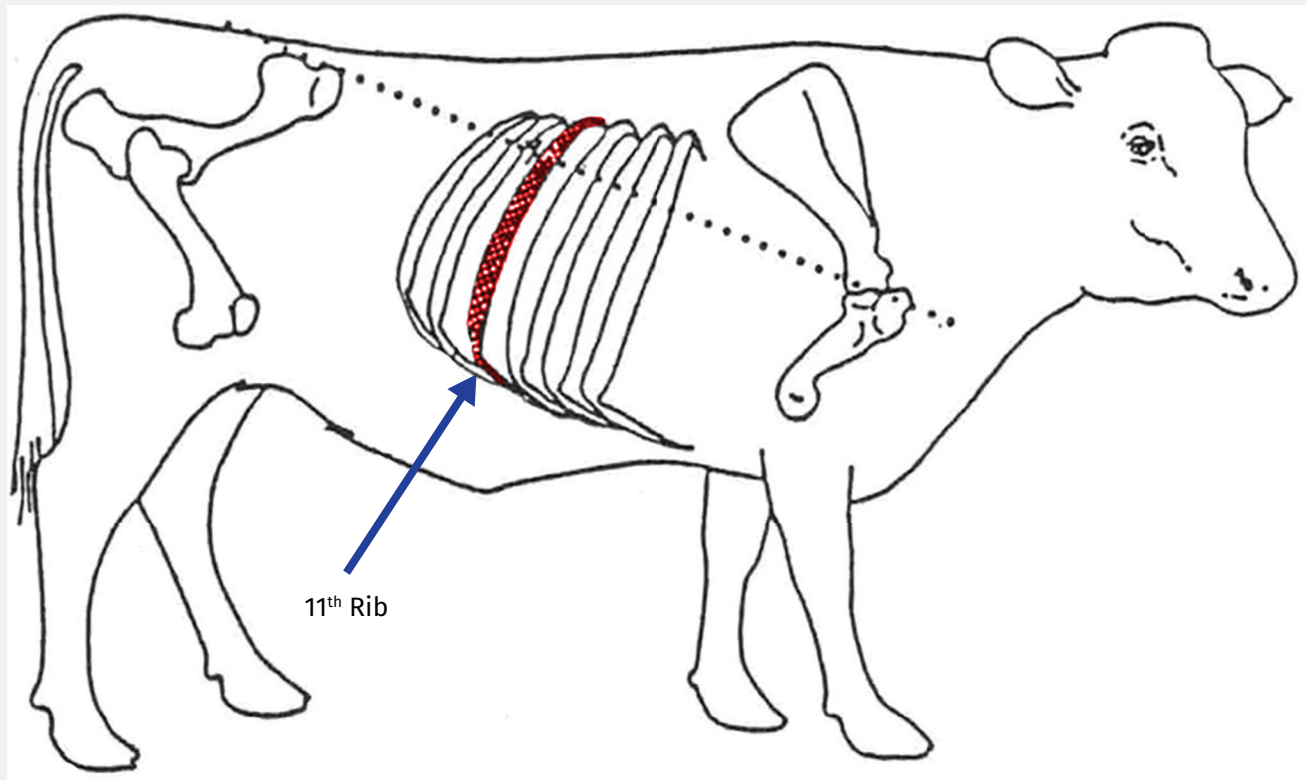


Figure 5: Liver biopsy landmarks.



the sample is collected, the needle is withdrawn. Two samples should be collected for analysis. Samples should be placed in the bottom of a small conical tube and frozen for shipping. Minimal after care is required for the incision site.

Several different biopsy needles are available. The Tru-cut needle has been used for many years but requires a moderate learning curve. More recently, the SurgiVet needle has come on the market. It is spring loaded and eliminates the learning curve associated with the Tru-cut. Sontec Instruments makes a heavy duty, reusable instrument that collects a much larger sample. Bone marrow trephine needles can be modified to serve as a reusable instrument.

Two YouTube videos are available as a resource for learning the liver biopsy technique. One is available from Kansas State Veterinary Diagnostic Lab (KSVDL) and the other is from Utah State University.

Conclusion

“Cattle simply need stronger immunity at the time they leave their farm or ranch of origin, and this problem is more about producer education and implementation than it is about technology or know-how.” - Tom Brink, Beef Improvement Federation 2016

All of us associated with cow-calf segment of the beef industry should pause and ask what we could do differently to improve immune function in cattle at the ranch level, the stocker/back-grounder level, and the feedyard. A nutrition plan that evaluates energy, protein, minerals, trace minerals, and vitamins beginning conception plays a major role in optimal immune system function.

Body condition score at the beginning of calving is a major indicator of health and reproduction in a cow herd. If cows are thin and micronutrient deficient, correcting the micronutrient deficiency alone will not correct the problem. Energy and protein must be corrected in addition to correcting the micronutrient deficiency. Assessing and recording individual BCS at the time of pregnancy diagnosis and evaluating by age is a good starting point for evaluating energy and protein. This is also a good time to evaluate micronutrient status if a problem is suspected. By evaluating BCS at pregnancy diagnosis, one has time to start to correct, if necessary, prior to calving. BCS should then be re-evaluated 30 days prior to calving.

- The “nutritional perfect storm” can occur in the calf 30-90 days post-partum without an adequate mineral program in the cow calf herd.²
- What you decide to implement today will have an effect on the cows and calves 60-90 days later and to realize it then is too late.²

In conclusion, I challenge each of you to learn to look at the entire system. Ask numerous questions. Listen to understand rather than listening to respond. Look for the arrow and the measuring spoon in the Fed Ex logo (look for the small details).

Sell yourself. Build relationships by building trust. Show people that you care. People don't care what you know until they know how much you care.

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