Salt Institute Newsletter (STM) First Quarter 2014

TRACE MINERALS AND REPRODUCTION IN RUMINANTS

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INTRODUCTION

Reproductive efficiency is a major factor that affects profitability in ruminants. The reproductive process consists of the male producing viable sperm, the female exhibiting estrus and conceiving, and proper embryonic and fetal development that results in the birth of a live offspring. A number of trace minerals are important in maximizing reproductive performance. Even marginal trace mineral deficiencies can impair reproduction in animals showing few, if any, clinical signs of deficiency.

Pastures and other feedstuffs consumed by ruminants are often deficient in one or more trace minerals. In grazing animals it is important to provide a trace mineral salt or complete mineral supplement (phosphorus, calcium, and magnesium in addition to salt and trace minerals) to ensure that trace mineral requirements are met. This newsletter will discuss the role of trace minerals on reproduction in ruminants.

COPPER

Requirements for copper in ruminants can vary from approximately 4 ppm to well over 10 ppm in the diet. Copper requirements are increased by high levels of molybdenum, sulfur, and iron in the diet. In most instances copper deficiency results from the presence of other minerals in forages that interfere with copper utilization.

Copper deficiency resulting strictly from low levels of copper in forages does not appear to affect the occurrence of estrus or conception rate in cattle. However, when copper deficiency is due to high levels of molybdenum there is good evidence that reproduction can be adversely affected. Phillippo et al (1982) examined the relationship between serum copper concentrations and reproductive performance in 17 beef cattle herds in Scotland. When measured one month prior to breeding, average serum copper of the different herds varied from 0.16 to 0.92 mg/liter. No relationship was found between serum copper and conception rate despite the fact that over 50% of the herds studied had serum copper concentrations below the 0.60 mg/liter value that is considered to be indicative of copper deficiency. In a second field study one-half of the cows in four different herds were injected with 100 mg of copper at one month prior to breeding (Phillippo et al., 1982). Average serum copper concentrations were below 0.30 mg/liter in all herds. Injecting copper increased serum copper but did not affect conception rate or calving interval. On one farm where the molybdenum content of forage was high (3 ppm) copper injection reduced calving intervals in first calf heifers from 451 to 392 days.

As mentioned earlier there is evidence that low copper status caused by high molybdenum in the diet can reduce fertility. The addition of 5 ppm of molybdenum to a control diet containing 4 ppm of copper and 0.1 ppm of molybdenum caused infertility in heifers (Phillippo et al., 1987). Supplementing molybdenum to heifers starting at 13 to 19 weeks of age increased the age in which the heifers reached puberty by 8 to 12 weeks. Conception rate in heifers fed molybdenum was less than 20% compared with approximately 80% in heifers fed the control diet. Forages grown in some areas are naturally high (2 ppm or greater) in molybdenum. Adverse effects of molybdenum on reproduction in these areas can be prevented by adequate copper supplementation (Raisbeck et al., 2006).

MANGANESE

The manganese requirement is higher for reproduction than for growth. An early study in dairy heifers indicated that a diet containing 10 ppm of manganese was sufficient for growth but not for maximal reproduction (Bentley and Phillips, 1951) Heifers fed the low manganese diet were older in age when they showed signs of estrus than heifers supplemented with manganese, and they also exhibited lower conception rates. Later studies with cattle and sheep confirmed that lack of dietary manganese reduced conception rate in females (McDowell, 2003). Manganese may also be important in male reproduction. Male lambs fed a diet containing only 13 ppm of manganese had lower testicular growth than ram lambs supplemented with manganese (Masters et al., 1988).

The developing fetus is quite susceptible to manganese deficiency. Calves born to cows fed diets deficient in manganese exhibit skeletal abnormalities characterized by stiffness, twisted legs, enlarged joints, and short leg bones (McDowell, 2003). Dwarfism, unsteadiness, and shortening of the nasomaxillary bones, causing the lower jaw to appear extended, can also be seen in young calves (Hansen et al., 2006). Visually, shortening of the nasomaxillary bones results in the bottom row of teeth being exposed.

IODINE

Iodine functions as a component of the thyroid hormones. The thyroid hormones play an important role in energy metabolism, and are required for growth and development in young animals. The iodine requirements of ruminants are fairly low (approximately 0.5 ppm). However, forages and other feedstuffs produced in some areas are deficient in iodine. Goitrogens present in certain feeds (white clover, raw soybeans, and rapeseed meal) impairs iodine metabolism, and may increase iodine requirements by 2 to 4 fold (NRC, 2000).

Females receiving inadequate iodine during gestation can give birth to offspring with goiter (enlarged thyroid gland). Iodine deficiency can also cause abortion, or result in offspring being born hairless, blind, weak, or dead (McDowell, 2003). In adult females iodine deficiency is characterized by irregular cycling, low conception rate, and retained placenta. Iodine supplementation of sheep increased the number of lambs born to ewes by 14 to 21% and reduced lamb mortality rate over a 2-year period (Sargison et al., 1998).

SELENIUM

Selenium requirements in ruminants are relatively low (0.1 to 0.3 ppm). However, forages and other feedstuffs produced in many areas of the world are deficient in selenium. Selenium supplementation is needed in these areas to prevent economic losses in animal production. Selenium deficiency in sheep results in high embryonic death, and reduced number of ewes becoming pregnant when exposed to rams (Underwood and Suttle, 1999). In Australia, selenium supplementation prior to breeding reduced the number of ewes failing to lamb from 16 to 9% on 14 sheep farms with low selenium pastures (Wilkins and Kilgour, 1982). Increased incidence of retained placenta is common in dairy cows receiving inadequate selenium. Cows with retained placenta have a higher incidence of uterine infections following calving. Selenium supplementation of dairy cows reduced the incidence of retained placenta from 38% to 0 in a study in Ohio (Julien et al., 1976). Reduced viability of sperm has been seen in selenium-deficient bulls (Underwood and Suttle, 1999).

ZINC

Zinc is required by over 70 enzymes in the body. Because of its involvement in so many enzymes, zinc is critical for energy and protein metabolism. Zinc requirements of ruminant animals vary from 30 to 50 ppm, and are highest in lactating dairy cows. Severe zinc deficiency caused by feeding sheep diets low in zinc (less than 5 ppm) impairs reproduction in males (Underwood and Somers, 1969) and females (Apgar and Fitzgerald, 1985). Testicular growth is greatly impaired in ram lambs (Underwood and Somers, 1969) and bull calves (Miller and Miller, 1962) fed diets extremely deficient in zinc (less than 3 ppm). Growing ram lambs fed a zinc deficient diet for 20 - 24 weeks were incapable of producing sperm. Ram lambs fed a diet marginal in zinc (17 ppm) during development also had reduced testicular growth and sperm production compared with rams fed adequate zinc (32 ppm; Underwood and Somers, 1969).

Severe zinc deficiency is rare under practical conditions. However, marginal zinc deficiency is more likely to occur in ruminants. Zinc supplementation of ewes grazing pastures containing approximately 20 ppm of zinc increased the number of lambs produced by 14% (Masters and Fels, 1980). Lamb birth weights were higher for zinc-supplemented lambs, and zinc supplementation improved lamb survival rate in one of two studies.

CHROMIUM

Chromium functions by enhancing the action of insulin in the body. Insulin is an important hormone involved in regulating energy metabolism, and as a result can affect reproduction. In beef cows, grazing pastures and being fed harvested forages in the winter, chromium supplementation increased pregnancy rate in cows 5 years of age or younger (Stahlhut et al., 2006). In this study chromium was provided in a free choice mineral where salt was used to regulate mineral consumption. The improved pregnancy rate was associated with much lower plasma fatty acid concentrations at approximately 21 and 79 days after calving in chromium-supplemented cows. Lower plasma fatty acid concentrations would suggest that chromium-supplemented cows were mobilizing less body fat to support milk production. Consistent with the lower plasma fatty acid concentrations, chromium supplementation reduced body weight loss in young cows (2 and 3-year olds) after calving. Chromium supplementation in a free choice mineral also reduced the interval from calving to first estrus and tended to improve pregnancy rate in young Zebu cows in Brazil (Aragon et al., 2001.

Summary

A number of trace minerals are important in maximizing reproductive performance in female and male ruminant animals. Trace mineral deficiencies can affect the occurrence of estrus, conception rate, and fetal development in females. In males a deficiency of certain trace minerals can reduce testicular development, and sperm production and viability. Trace minerals that may be inadequate in the diet can be supplied by providing trace mineral salt or a complete mineral supplement free choice, or by adding a trace mineral supplement directly to the feed.

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