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Calf Note #244 – Mineral and Vitamin Requirements for Calves, Part 2

Introduction

This is part 2 of the series of Calf Notes discussing mineral and vitamin nutrition in young calves. Previous Calf Notes on the topic (#243, and #242) are available at Calf Notes.com. In this Calf Note, I'll discuss some aspects of water soluble vitamin nutrition for calves.

Water-soluble Vitamins

Water soluble vitamins are not normally considered essential in ruminant diets as rumen microbiota normally produce sufficient amounts of B-vitamins in excess of the animal's requirements. However, in the case of young calves prior to weaning, it is assumed that there is insufficient microbial synthesis, and, consequently, supplementation is necessary. The 2021 NASEM Committee recommended inclusion of water soluble vitamins in CMR as in Table 4. The Committee recommended water-soluble vitamins in CMR only.

B-vitamin supply in young calves is a combination of dietary supply and production by microbiota in both the rumen and intestine. Because colostrum contains significant amounts of B-vitamins (Foley and Otterby, 1978; Duplessis et al., 2015), blood levels of most B-vitamins are elevated in the first few days after birth (Figure 1, Smith and Allen, 1954). These levels generally decline to a nadir at approximately two to four weeks of age, then either increase (vitamin B12, thiamine) or remain constant or decline with advancing age (riboflavin, niacin, pantothenic acid).

In the 1950's and 1960's researchers documented changes in ruminal, intestine, and blood concentrations of selected B-vitamins in calves in the first four months of life (Kesler and Knodt, 1951; Conrad and Hibbs, 1954; Smith and Allen, 1954; Hibbs and Conrad, 1958). Interestingly, changes in concentrations in rumen and intestine were not always related to intake or age of calf (Figures 2-4). Also, Buziassy and Tribe (1960) reported that concentrations of thiamine, riboflavin, and nicotinic acid in the rumen of grazing lambs increased sharply in the first three weeks of life, but did not change markedly thereafter. After weaning (8 wk of age), the concentrations of vitamins were more stable, though concentrations of nicotinic acid declined. Synthesis of B-vitamins may be significant, as indicated in Figures 2-4. Also, Miller et al. (1986) reported that the intestine is the major site of biotin synthesis suggesting that intestinal microbial B-vitamin production may be significant.

An additional consideration regarding B-vitamin supplementation is effect of diet on rumen vitamin synthesis. Conrad and Hibbs (1954) found that changing % forage from 100% to 0% of the total ration DM changed concentration of thiamine and riboflavin in the rumen fluid of calves as 12 weeks of age. Also, it has been reported that adult cattle may experience subclinical thiamine deficiency when fed high grain diets (Karapinar et al., 2010; Pan et al., 2018), suggesting that high grain diets may be dilatory to adequate synthesis of B-vitamins in the rumen. Because calves are typically fed diets containing 90% or more of concentrate, it is possible that B-vitamin synthesis may not be optimal when calves are fed high concentrate diets.

Vitamin C may be important to calf health under certain circumstances. I summarized the role of vitamin C in immune response in Calf Note #242.

Summary and recommendations

We consider rumen synthesis of B-vitamins to be important to B-vitamin supply. The NASEM Committee considered supplementation of B-vitamins only necessary in CMR. However, I think relative maturity of the rumen is a better indicator of potential B-vitamin synthesis and supply. Data from Quigley et al., (2019a, b) provide an indirect indication of relative maturity; digestion of nutrients approached that of mature ruminants when calves consumed a total of 15 kg of non-fiber carbohydrate (Quigley et al., 2019b). This approach requires B-vitamin supplementation in CMR and calf starter formulations. Inclusion of B-vitamins in calf starters (products intended to be fed for the first two months of life) at levels in Table 4 are recommended. No supplementation is needed in calf grower feeds, as the transition from starter to grower feeds usually occurs at the time at which rumen fermentation is relatively mature. Inclusion of ascorbic acid in stress packs and/or CMR for stressed calves for the first 3 weeks of life as outlined in Table 1 is recommended.

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Table 1. Recommended concentrations of B-vitamin concentrations in calf milk replacer (CMR) from 2021 NASEM. Values are on a DM basis.*

Nutrient	mg/kg
Biotin	0.10
Choline	1,000
Folic acid	0.5
Niacin	10
Pantothenic acid	13
Pyridoxine	6.5
Riboflavin	6.5
Thiamine	6.5
Vitamin B_{12}	0.007

*During periods of stress, inclusion of ascorbic acid at 3 g/d for 7 d, then 2 g/d for 7 d, then 1 g/d for 7 d is recommended. If included in CMR, the recommended vitamin C inclusion is 0.15% of DM.

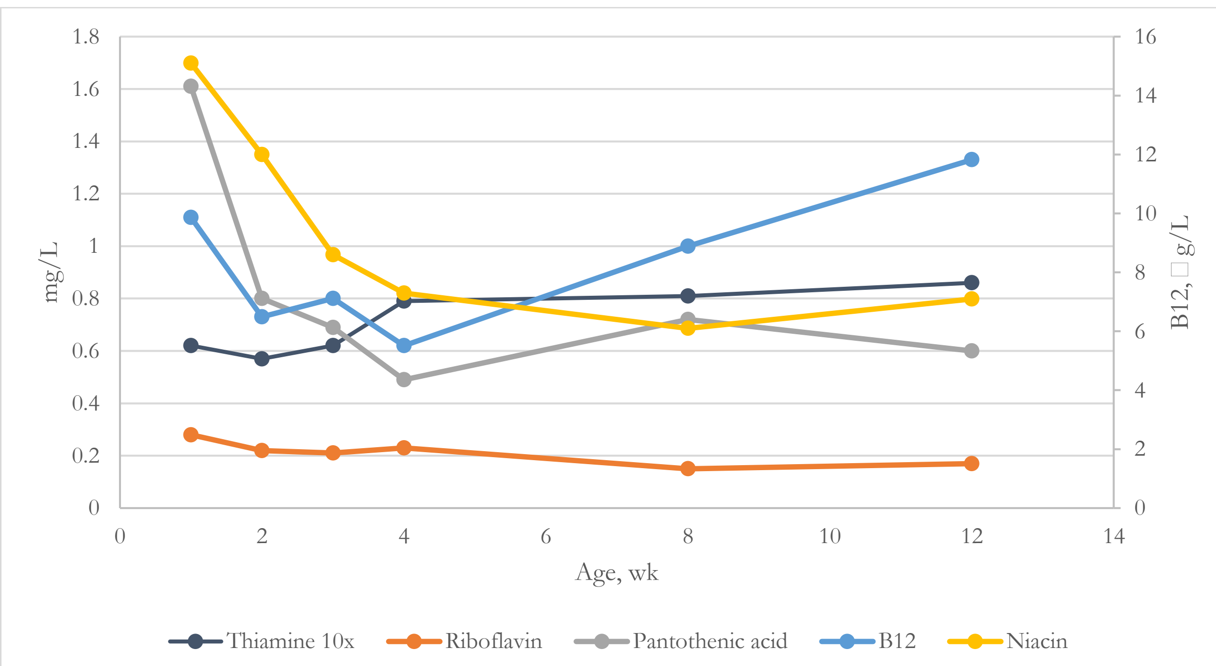

Figure 1. Serum concentrations of selected B-vitamins in Holstein calves. From: Smith and Allen, 1954.

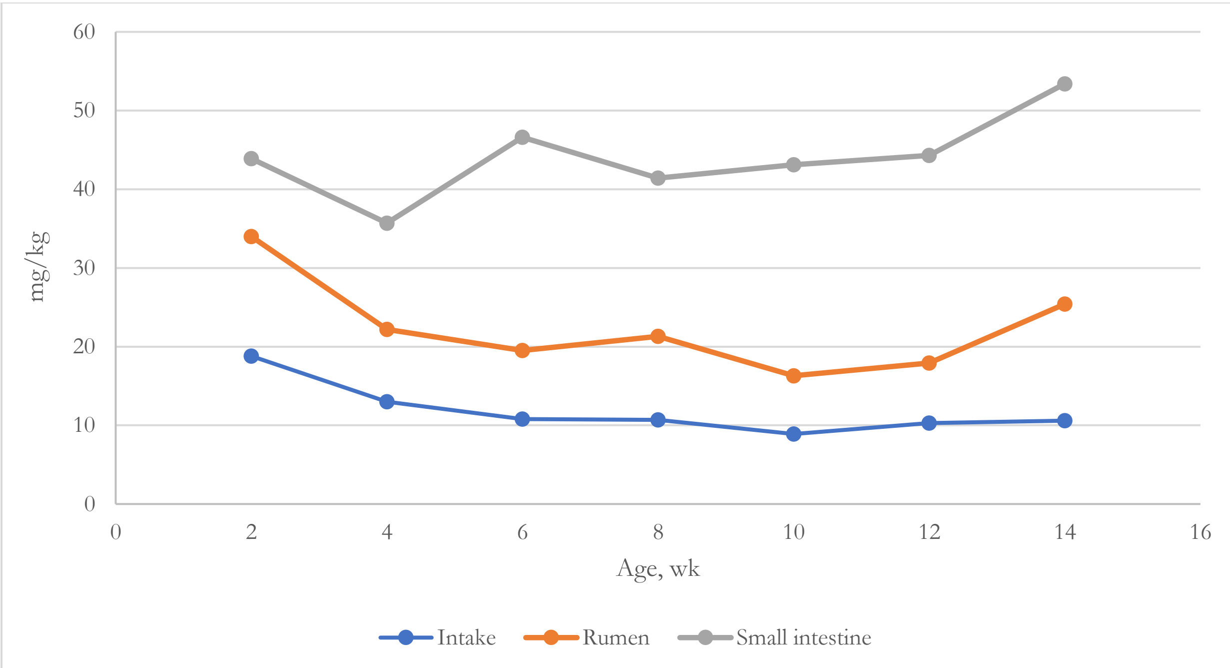

Figure 2. Concentrations of riboflavin in rumen and small intestine of calves. Source: Kesler and Knodt, 1951.

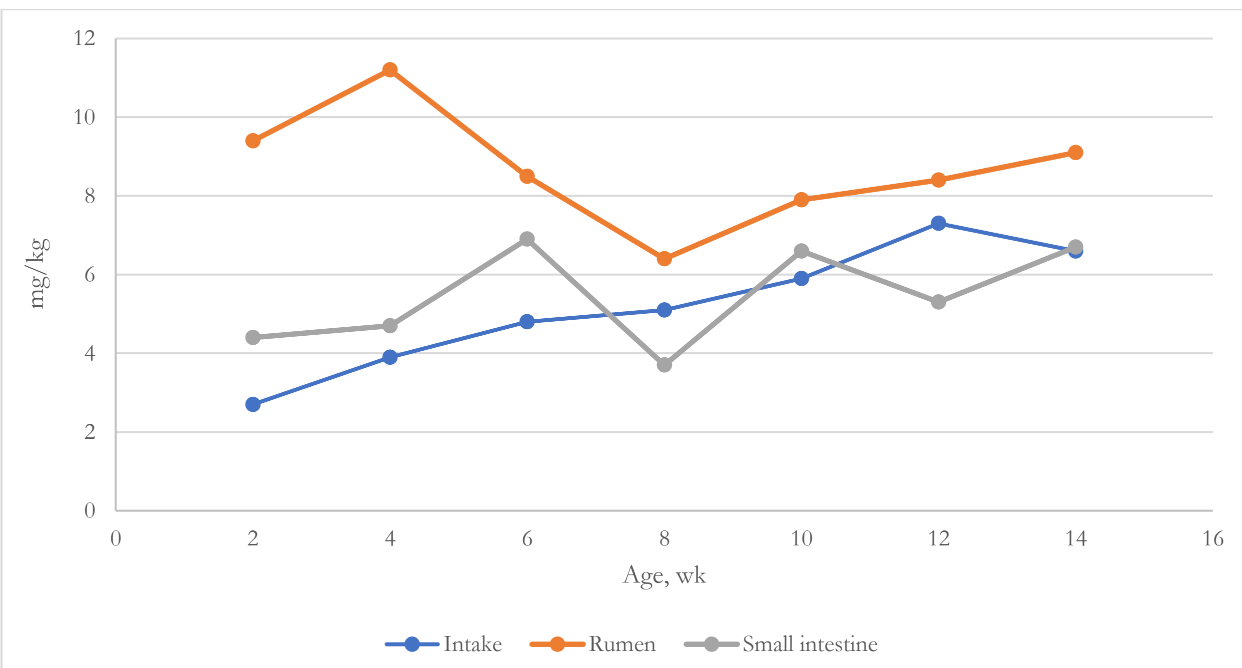

Figure 3. Concentrations of thiamine in rumen and small intestine of calves. Source: Kesler and Knodt, 1951.

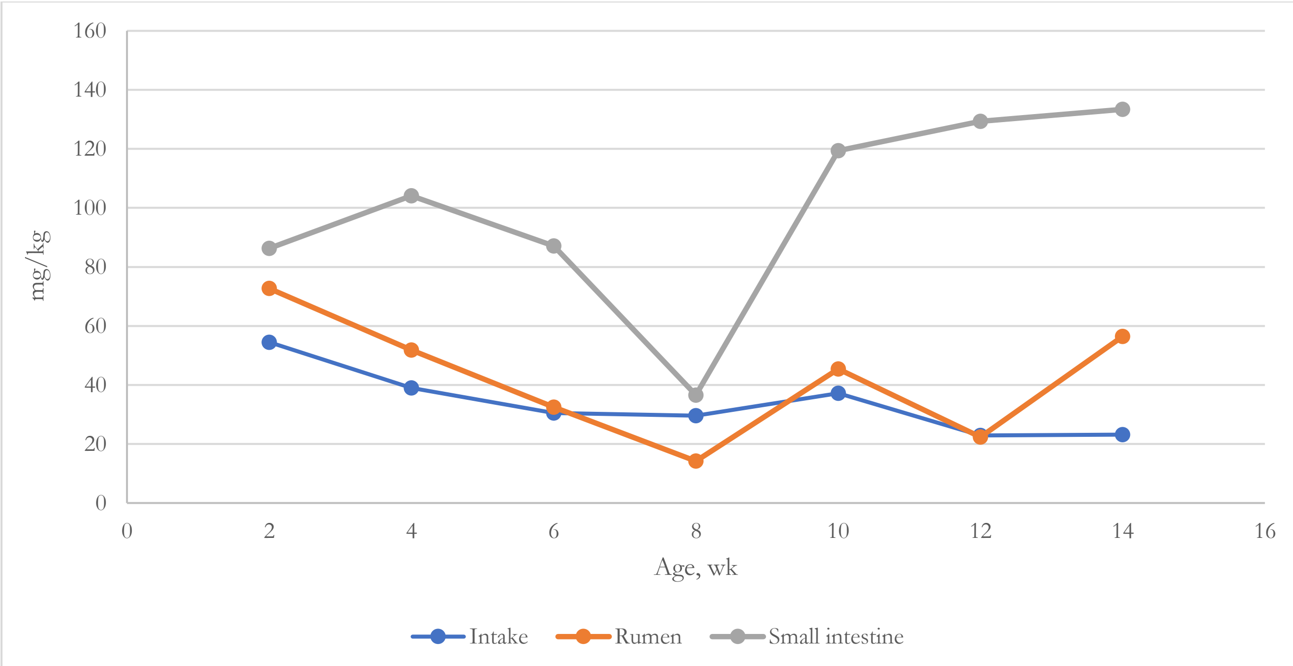

Figure 4. Concentrations of nicotinic acid in rumen and small intestine of calves. Source: Kesler and Knodt, 1951.

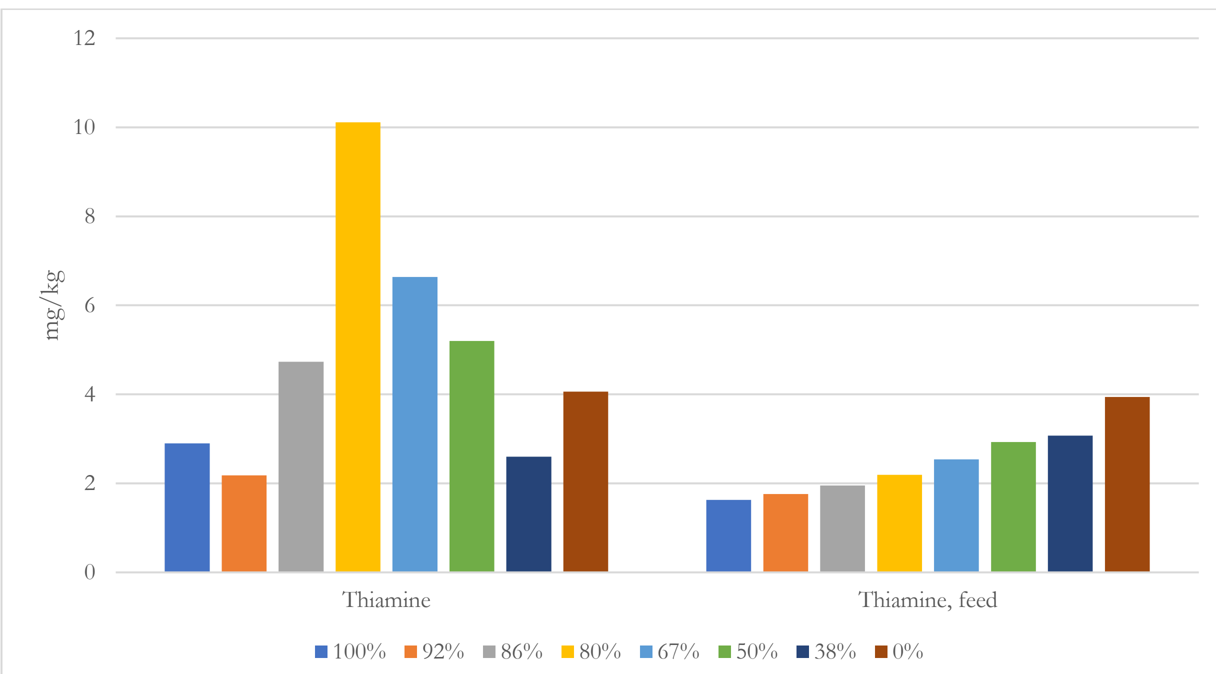

Figure 5. Concentration of thiamine in rumen liquid and feed intake in calves fed diets with varying % forage in the ration. Source: Conrad and Hibbs, 1954.

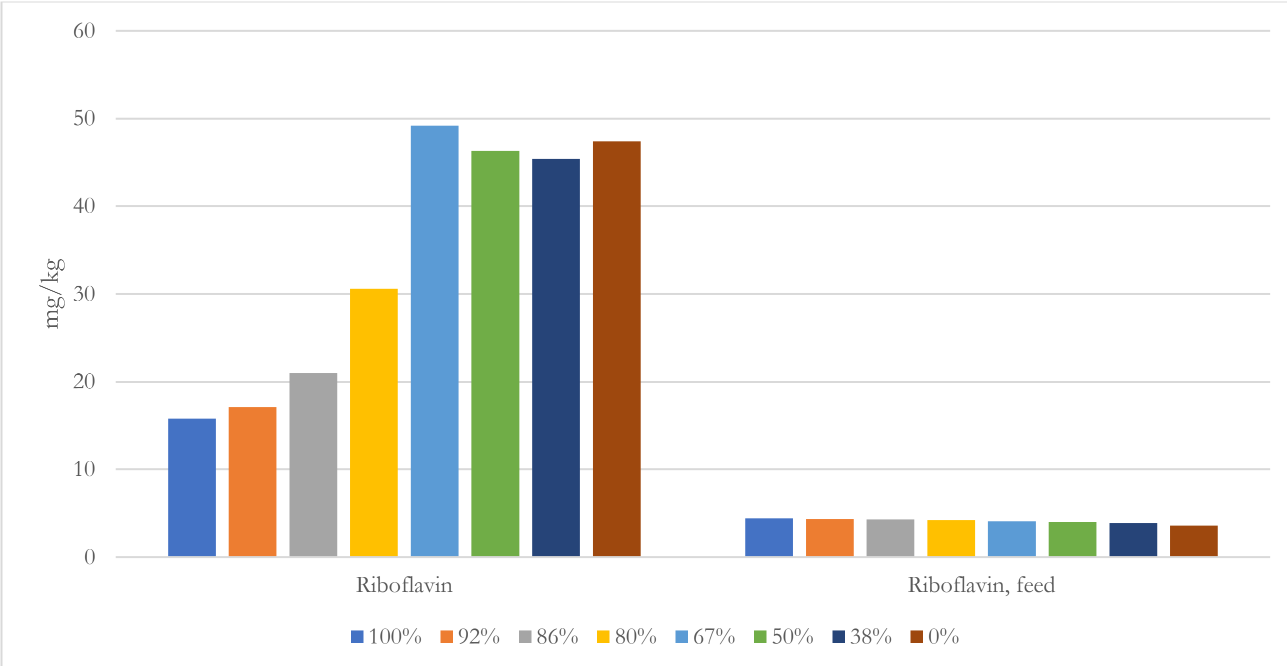

Figure 6. Concentration of riboflavin in rumen liquid and feed intake in calves fed diets with varying % forage in the ration. Source: Conrad and Hibbs, 1954.

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