

Factors Influencing Bovine Maternal and Fetal Hepatic Mineral Concentrations

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Introduction

Studies have shown significant transference of mineral elements from the pregnant cow to the developing fetus. Maternal mineral status during pregnancy influences fetal and postnatal mineral status. Minerals are indirectly or directly associated with a tremendous variety of metabolic processes. Trace mineral deficiency diseases affect almost every physiologic function and include immune dysfunction (Cu, Zn, Se), developmental abnormalities (Cu, Mn, I), abortion (Cu, I, Se), retained placenta (Cu, Se, I) and metabolic disturbances (Co, Fe, Zn, I). Understanding the role of mineral nutrition in animal health has prompted a need for accurate assessment and interpretation of mineral status relative to disease potential. Diagnostic criteria for fetal hepatic mineral concentrations are not well established. Most laboratories use wet weight adult hepatic mineral concentrations for criteria to evaluate fetal hepatic mineral status. The aim of this study was to characterize parameters that influence bovine maternal and fetal hepatic mineral concentrations in an effort to improve diagnostic evaluation of fetal mineral status.

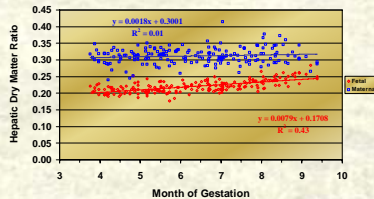
Materials and Methods

Liver samples were collected from 181 pairs of pregnant cows and their fetuses at an abattoir over a period of 13 months. Breed, sex, fetal numbers and measured crown-rump length were recorded at time of collection. Inductively coupled plasma atomic emission mass spectroscopy (ICP/MS) was used to assay 9 minerals (calcium, copper, cobalt, iron, magnesium, manganese, molybdenum, selenium, zinc) in all samples. Mineral concentrations were determined on a wet weight (WW) and converted to a dry weight (DW) basis. Liver dry matter (DM) content was determined by drying an aliquot sample in a convection oven. Fetal gestational age was estimated from measured crown-rump length. Paired T-test was used to determine differences between fetal and maternal mineral values. Regression and ANOVA were used to determine significant parameters influencing fetal and maternal hepatic mineral concentrations.

Results and Discussion

Of the 181 total paired samples, 78.5% and 21.5% were from dairy and beef cows, respectively. Mean (range) fetal age was 6.4 (3.8-9.4 months). Dairy cows were predominately Holstein breed, while beef cows were Hereford, Angus or crossbreds. Fetal age, sex, and breed varied by collection period as a result of available cattle at any point of time. Collection visit was used as a covariate where appropriate in statistical models to avoid biasing comparisons. Twin fetuses were found in 11 cows (10 dairy; 1 beef). Fetal sex and twin pregnancy did not influence hepatic mineral concentrations of either dam or fetus when adjusted for breed. Mean fetal (0.22 ± 0.018; range: 0.177 – 0.284) and adult (0.31 ± 0.024; range: 0.24 – 0.41) liver DM ratios were different (P<.0001). Fetal (P<.0001), but not maternal (P>.6), liver DM ratio increased with gestational age (Figure 1). The observed increasing DM content of the fetal liver is consistent with the desiccating process that is associated with fetal development and ultimately with aging. Maternal hepatic DM ratios are consistent with other observations suggesting a value between 30 and 33%. Fat infiltration of the liver can increase DM content in excess of 40%.

Figure 1. Gestational age effect on bovine hepatic dry matter ratio for the pregnant cow and her fetus.



Though maternal and fetal hepatic WW mineral concentrations spanned a similar range of values (Table 1), paired analysis showed these values are two different populations. Mean fetal-maternal pair differences for all mineral concentrations were different (<.0001) from zero, except selenium (WW) concentration across all data and within dairy breed samples. Within the beef cow samples, no differences between maternal and fetal concentrations were found for WW cobalt, copper or selenium and cobalt DW. Similarity of range in fetal and maternal wet weight hepatic

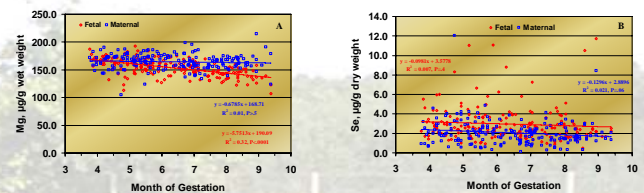
mineral concentrations may account for the use of adult wet weight mineral concentrations as reference values for fetal samples. Differences in DM content between fetal and maternal liver confound a direct comparison of mineral concentrations. Significant differences across paired maternal-fetal samples further suggest different hepatic mineral concentration populations. These data also imply some defined relationship between maternal and fetal hepatic mineral concentrations.

Table 1. Population statistics (n=181) for and comparison of bovine maternal and fetal hepatic mineral concentrations (µg/g wet weight basis).

Mineral	Fetal			Maternal			Paired Difference P < F	
	Median	STD	Range	Median	STD	Range	WW	DW
Calcium	49.65	14.15	28.1-133	46.0	11.132	23.5-94	< 0.0001	< 0.0001
Cobalt	0.015	0.006	0.015-0.08	0.078	0.14	0.015-1.94	< 0.0001	< 0.0001
Copper	89.5	25.09	27.5-161	130.0	95.0	0.92-463	< 0.0001	0.004
Iron	215.0	224.0	14.9-1470	69.0	60.685	31.3-384	< 0.0001	< 0.0001
Magnesium	156.0	15.5	107-193	165.0	14.2	105-215	< 0.0001	< 0.0001
Manganese	1.25	0.44	0.192-2.48	2.40	0.637	0.777-5.38	< 0.0001	< 0.0001
Selenium	0.584	0.38	0.286-2.68	0.587	0.38	0.036-2.95	0.69	< 0.0001
Zinc	169.5	72.91	15-463	54.80	43.9	26-285	< 0.0001	< 0.0001

Gestational month influenced fetal mineral concentrations more than maternal values and these effects were further influenced by breed. Within all fetuses, both WW and DW concentrations of magnesium decreased (P<.0001; Figure 2a) and manganese, molybdenum and zinc increased (P<.0001) with gestational age. Fetal WW and DW concentrations of iron, cobalt and selenium were not influenced by fetal age. In contrast, only maternal WW and DW selenium tended (P=.06) to decline with gestational age (Figure 2b). Age effects on fetal mineral concentrations reflects transfer efficiency, hepatic storage capabilities or their combination.

Figure 2. Gestational age effect on bovine maternal and fetal hepatic magnesium wet weight (A) and selenium dry weight (B) concentrations.



Breed (dairy or beef) influenced a number of mineral relationships. Both WW and DW concentrations of cobalt and zinc showed the most interactions with breed effects. Across fetal and maternal samples, hepatic iron WW (P=.02) and DW (P=.03) concentrations showed a gestational age by breed interaction. Maternal WW (P=.009) and DW (P.008), but not fetal, cobalt concentrations were influenced by breed. Breed (dairy or beef) effects may simply reflect differences in mineral supplementation practices, or may suggest differences in mineral metabolism.

Conclusions

These data show a number of factors that influence hepatic mineral concentrations. Though often considered a single population, maternal and fetal hepatic mineral concentrations are not equivalent. Hepatic mineral concentrations are further influenced by gestational age and breed effects and their interaction. Surprisingly, twin pregnancy status did not influence fetal or maternal hepatic mineral concentrations. Maternal and fetal hepatic DM differences suggest different criteria or values be converted to a DW basis for appropriate evaluation, though adjustments should be made for gestational age and breed.

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