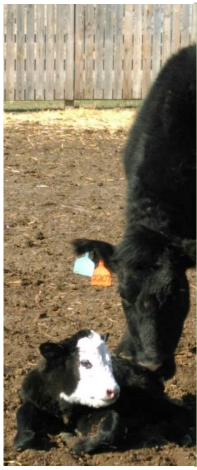

Vitamin and Mineral Supplementation and Rate of Gain in Beef Heifers: Effects of Concentration of Trace Minerals in Maternal and Fetal Liver at Day 83 of Gestation

Ana Clara B. Menezes[1], Kacie L. McCarthy[2], Cierrah J. Kassetas[1], Friederike Baumgaertner[1], James D. Kirsch[1], Sheri Dorsam[1], Tammi L. Neville[1], Alison K. Ward[1], Pawel P. Borowicz[1], Lawrence P. Reynolds[1], Kevin K. Sedivec[3], J. Chris Forcherio[4], Ronald Scott[4], Joel S. Caton[1] and Carl R. Dahlen[1]

[1] Department of Animal Sciences and Center for Nutrition and Pregnancy, NDSU

[2] Department of Animal Sciences, University of Nebraska-Lincoln

[3] Central Grasslands Research Extension Center, NDSU

[4] Purina Animal Nutrition LLC, Gray Summit, Mo.

The objective of this study was to evaluate the effects of feeding vitamin and mineral supplement and two different rates of gain during the first 83 days of pregnancy on trace mineral concentrations in the maternal and fetal liver. Our results show that providing a vitamin and mineral supplement resulted in increased concentrations of selenium (Se), copper (Cu), manganese (Mn) and cobalt (Co) in fetal liver. Increased trace mineral stores in the liver may be beneficial for offspring health and productive performance.

Summary

The objective of this study was to evaluate the effects of feeding vitamin and mineral (VTM) supplement and two different rates of gain during the first 83 days of pregnancy on trace mineral concentrations in the maternal and fetal liver. Thirty-five crossbred Angus heifers (initial body weight [BW] = 792.6 ± 15.7 pounds [lb.]) were assigned randomly to one of four treatments in a 2 × 2 factorial arrangement with main effects of vitamin and mineral supplement (VTM or NoVTM) and rate of gain (GAIN; low gain [LG], 0.62 lb./day, vs. moderate gain [MG], 1.74 lb./day).

The VTM treatment (113 grams (g)/heifer/day) was initiated at least 71 days before artificial insemination (AI). At breeding, heifers were maintained on their respective diets (target gain of 0.62 lb./day) or fed a starch-based protein/energy supplement (target gain of 1.74 lb./day).

Heifers were ovariohysterectomized on day 83 of gestation and samples of maternal and fetal liver were collected. Samples then were analyzed for concentrations of Se, Mn, Cu, Co, molybdenum (Mo) and zinc (Zn). In maternal liver, a VTM × GAIN was observed for Se (P = 0.02) and Mn (P = 0.03). Se concentrations were greater for VTM-LG than all other treatments, while Mn were greater for VTM-MG than VTM-LG heifers.

Further, maternal liver from VTM had increased concentrations of Cu (P < 0.01) and Co (P = 0.04), whereas GAIN affected concentrations of Mo, with greater concentrations (P ≤ 0.02) in MG heifers. Greater concentrations of Se (*P* < 0.01), Cu (*P* = 0.01), Mn (*P* = 0.04) and Co (*P* = 0.01) were observed in fetal liver from VTM than NoVTM, while Mo (*P* ≤ 0.04) and Co (*P* < 0.01) were impacted by GAIN, with greater concentrations in fetal liver from LG than MG.

In conclusion, concentrations of Se, Cu, Mn and Co were greater in fetal liver from VTM dams, while greater concentrations of Mo were observed in the liver of fetuses from LG dams. Concentrations of Zn were not affected by any of the nutritional strategies evaluated. These data provide insights into how nutritional management of beef heifers affect fetal liver stores of trace minerals, which may be beneficial for offspring health and productive performance.

Introduction

The first trimester of gestation is a critical period for fetal development; it is when the placenta and all vital organs are developed. Many producers do not realize that at this stage, not only the dam, but also the fetus, require proper trace mineral nutrition.

However, several biological processes, such as carbohydrate, protein and lipid metabolism, and hormone and DNA synthesis are dependent on trace minerals (Van Emon et al., 2020). Further, the fetus is completely dependent on the dam for trace mineral supply; thus, an inadequate maternal trace mineral consumption can compromise reproduction and negatively affect embryonic and fetal development (Hostetler et al., 2003), which can have long-term consequences on offspring health and performance.

Therefore, developing studies evaluating how maternal nutritional strategies can affect the supply of trace minerals to the fetus is important. The current experiment characterized a research model we developed to evaluate the effect of managerial inputs on maternal and fetal trace mineral concentration. The primary aim of this study was to test the hypothesis that vitamin and mineral supplementation and rate of gain during the first trimester of gestation would impact the concentrations of trace minerals in the maternal and fetal liver.

Experimental Procedures

All procedures were approved by the North Dakota State University Institutional Animal Care and Use Committee.

Thirty-five crossbred Angus heifers (initial BW = 792.6 ± 15.7 lb.) were assigned randomly to one of four treatments in a 2 × 2 factorial arrangement with main effects of vitamin and mineral supplementation (VTM or NoVTM) and rate of gain [GAIN; low gain (LG) 0.62 lb./day or moderate gain (MG) 1.74 lb./day]. Briefly,

Table 1. Nutrient composition of total mixed ration and supplements provided to beef heifers during the first trimester of gestation.

Chemical Composition	Total Mixed Ration[1]	Supplements		
		NoVTM[2]	VTM[3]	Starch-based protein/energy[4]
Dry matter (DM), %	53.0	86.6	89.6	87.7
Ash, % DM	11.5	5.3	25.1	2.4
Crude protein, % DM	9.9	15.6	14.8	17.5
Neutral detergent fiber, % DM	65.9	41.9	27.6	19.4
Ether extract, % DM	1.5	-	-	9.1
Nonfiber carbohydrates, % DM	11.1	37.2	32.5	51.6
Mineral Content				
Calcium, g/kg DM	5.74	2.47	50.62	0.30
Phosphorus, g/kg DM	2.05	8.94	22.82	4.59
Sodium, g/kg DM	0.26	0.12	19.44	0.24
Magnesium, g/kg DM	2.83	4.47	5.20	1.96
Potassium, g/kg DM	15.81	14.22	13.15	6.05
Sulfur, g/kg DM	2.25	2.41	4.84	2.57
Manganese, mg/kg DM	121.2	103.9	953.4	26.0
Cobalt, mg/kg DM	0.36	0.14	3.38	0.05
Copper, mg/kg DM	4.8	13.7	285.8	3.6
Selenium, mg/kg DM	0.3	0.4	7.0	0.3
Zinc, mg/kg DM	28.4	130.2	1051.8	35.0

[1]Proportion of ingredients: prairie grass hay (55%), corn silage (38%) and dried distillers grains plus solubles (7%).

[2]NoVTM: No vitamin mineral supplement was a pelleted product fed at 0.99 lb./heifer/day with no added vitamin and mineral supplement.

[3]VTM: Vitamin mineral supplement was a pelleted product fed at 0.99 lb./heifer/day (consisting of 113 grams [g] of a vitamin and mineral supplement [Purina Wind & Rain Storm All-Season 7.5 Complete, Land O'Lakes Inc., Arden Hills, Minn.] and 337 g of a carrier).

[4]An energy/protein supplement formulated with a blend of ground corn, dried distillers grains plus solubles, wheat midds, fish oil and urea; targeting gain of 1.74 lb./day for moderate-gain and 0.62 lb./day for low-gain heifers.

the VTM supplement was initiated at least 71 days before artificial insemination.

At breeding, heifers were maintained on their respective diets (LG) or fed a starch-based protein/energy supplement (MG). This resulted in the following treatment combinations: 1) No vitamin and mineral supplement, low gain (NoVTM-LG; n = 9); 2) No vitamin and mineral supplement, moderate gain (NoVTM-MG; n = 9); 3) Vitamin and mineral supplement, low gain (VTM-LG; n = 9); 4) Vitamin and mineral supplement, moderate gain (VTM-MG; n = 8). Heifers were fed individually in Calan gates, and supplements were top dressed over the total mixed ration (Table 1).

Heifers were ovariohysterectomized on day 83 ± 0.27 of gestation. Liver biopsies were obtained from all heifers at surgery day. Following ovariohysterectomy, fetuses were harvested and dissected, and samples of fetal liver were collected. Samples were placed in 2 milliliter microtubes and snap frozen on dry ice and stored at minus 80 C for subsequent trace mineral analysis.

Concentrations of Se, Mn, Cu, Co, Mo and Zn were determined via inductively coupled plasma mass spectrometry at the Veterinary Diagnostic Laboratory of Michigan State University. Data were analyzed using the MIXED procedures of SAS for effects of VTM, GAIN and a VTM × GAIN interaction. Differences were considered significant at a P- value ≤ 0.05.

Results and Discussion

In the maternal liver (Table 2), a VTM × GAIN interaction was observed for Se (P = 0.02) and Mn (P = 0.03). Se concentrations were significantly greater for VTM-LG than all other treatments, while Mn were significantly greater for VTM-MG than VTM-LG heifers. Further, maternal liver from VTM had increased concentrations of Cu (P < 0.01) and Co (P = 0.04), whereas GAIN affected concentrations of Mo, with greater concentrations (P ≤ 0.02) in MG heifers.

In the fetal liver (Table 3), greater concentrations of Se (P < 0.01), Cu (P = 0.01), Mn (P = 0.04) and Co (P = 0.01) were observed in the fetal liver from VTM than NoVTM dams, while Mo (P ≤ 0.04) and Co (P < 0.01) were impacted by GAIN, with greater concentrations in the fetal liver from LG than MG dams.

We would expect greater concentrations of all trace minerals in the maternal and fetal liver in response to vitamin and mineral supplementation. However, that was not the case for two of the six trace minerals

Table 2. Concentrations of trace minerals in the liver of beef heifers at day 83 of gestation as influenced by vitamin and mineral (VTM) supplementation and rate of gain (GAIN; low rate, 0.62 lb./day [LG] or moderate rate, 1.74 lb./day [MG]) in early gestation.

Mineral concentration, ug/g dry	NoVTM[1]		VTM[2]		SEM[4]	*P*-value		
	LG	MG[3]	LG	MG[3]		VTM	GAIN	VTM × GAIN
Selenium	1.64[c5]	1.54[c]	2.87[a]	2.26[b]	0.11	<0.01	<0.01	0.02
Copper	39.35	27.35	196.27	184.21	14.64	<0.01	0.39	0.99
Manganese	9.94[ab]	9.86[ab]	8.46[b]	10.85[a]	0.58	0.66	0.04	0.03
Cobalt	0.20	0.19	0.24	0.21	0.01	0.04	0.26	0.41
Molybdenum	3.58	3.85	3.39	3.95	0.17	0.76	0.02	0.36
Zinc	119.49	120.73	121.95	123.93	6.04	0.63	0.78	0.95

[1]NoVTM: No vitamin and mineral supplement was a pelleted product fed at a 0.99 lb./heifer/day with no added vitamin and mineral supplement.

[2]VTM: Vitamin mineral supplement was a pelleted product fed at a 0.99 lb./heifer/day (consisting of 113 g of a mineral and vitamin supplement, formulated to deliver similar levels of vitamins and minerals that were fed pre-breeding, and 337 g of a carrier).

[3]Heifers fed a pelleted blend of ground corn, dried distillers grains plus solubles, wheat midds, fish oil and urea, targeting a gain of 1.74 lb./day.

[4]NoVTM-LG (n = 9); NoVTM-MG (n = 9); VTM-LG (n = 9); VTM-MG (n = 8).

[5] Means within a row and without a common superscript differ significantly (P ≤ 0.05) with respect to VTM × GAIN interaction.

Table 3. Concentrations of trace minerals in fetal liver at day 83 of gestation as influenced by maternal vitamin and mineral (VTM) supplementation and rate of gain (GAIN; low rate, 0.62 lb./day [LG] or moderate rate, 1.74 lb./day [MG]) in early gestation.

Mineral concentration, ug/g dry	NoVTM[1]		VTM[2]		SEM[4]	*P*-value		
	LG	MG[3]	LG	MG[3]		VTM	GAIN	VTM × GAIN
Selenium	4.23	4.25	6.25	6.39	0.46	<0.01	0.86	0.89
Copper	246.01	277.84	298.21	348.91	22.75	0.01	0.08	0.68
Manganese	5.09	4.78	5.19	6.03	0.32	0.04	0.39	0.07
Cobalt	0.07	0.05	0.09	0.06	0.01	0.01	<0.01	0.27
Molybdenum	0.37	0.33	0.36	0.33	0.02	0.79	0.04	0.81
Zinc	440.61	448.24	541.2	563.76	85.35	0.21	0.85	0.93

[1]NoVTM: No vitamin and mineral supplement was a pelleted product fed at 0.99 lb./heifer/day with no added vitamin and mineral supplement.

[2]VTM: Vitamin mineral supplement was a pelleted product fed at 0.99 lb./heifer/day (consisting of 113 g of a mineral and vitamin supplement, formulated to deliver similar levels of vitamins and minerals that were fed pre-breeding, and 337 g of a carrier).

[3]Heifers fed a pelleted blend of ground corn, dried distillers grains plus solubles, wheat midds, fish oil and urea, targeting a gain of 1.74 lb./day.

[4]NoVTM-LG (n = 9); NoVTM-MG (n = 9); VTM-LG (n = 9); VTM-MG (n = 8).

evaluated, Mo and Zn; those concentrations were not affected by VTM supplementation.

Interestingly, heifers with moderate rates of gain had greater liver concentrations of Mo than LG heifers, but the opposite relationship was observed in the fetal liver. We may speculate that the protein/energy supplement provided to MG heifers already was providing enough minerals to reach fetal requirements, therefore, unsupplemented heifers (LG) had to mobilize more nutrients to the developing fetus to ensure an adequate supply and consequently liver storage.

Fetal liver stores of trace minerals are important for the neonate because the bovine milk is poor in essential trace minerals (Abdelrahman and Kincaid, 1993). Additionally, an adequate trace mineral reserve is crucial in early life to maintaining health status (Van Emon et al., 2020).

In conclusion, concentrations of Se, Cu, Mn and Co were greater in the fetal liver from VTM dams, while greater concentrations of Mo were observed in the liver of fetuses from LG dams. Concentrations of Zn were not affected by any of the nutritional strategies evaluated. These data provide insights into how nutritional management of beef heifers affect fetal liver stores of trace minerals, which may be beneficial for offspring health and productive performance.

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