Effect of Nutrient Restriction during Early Gestation on Postnatal Growth, Carcass, and Organ Weights of Beef Steers

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Story in Brief

Decreased nutrient intake of beef heifers during early gestation resulted in decreased gestation length and no effect on birth weight. There was no difference in the growth of the calves before or after weaning or in the feedlot. At harvest the steers had similar empty body weight and organ weights except for lungs and trachea which were 16 percent smaller for Low steers (dams fed 55 % of NRC recommendations for NEm from d 32-115 of gestation) compared to Moderate steers (dams fed in excess of 100 % NRC recommendations). Muscle from steers from nutrient restricted dams had greater concentrations of DNA and tended to have lower protein to DNA ratio. Low prenatal nutrition changed muscle tissue in the mature animal.

Key Words: Beef Heifers, Calves, Growth, Prenatal Nutrition

Introduction

Reduced nutrient intake during early pregnancy has resulted in decreased fetal weight of calves compared with controls at 125 d of gestation (Ford et al., 2005). Inadequate nutrient intake during late gestation increased bovine placenta weight and decreased fructose in amniotic fluid (Rasby et al., 1990). Inadequate nutrition from d 30 to 125 of gestation increased caruncular surface capillary density at 250 d of gestation and decreased cotyledonary surface capillary density compared with cows fed adequate nutrition (Vonnahme et al., 2007). The number of myofibers and diameter of muscle fibers may be influenced by early prenatal nutrition in cattle and sheep (Du et al., 2005; Zhu et al., 2006). Exposure of lambs to low nutrition from d 28 through 78 of gestation increased growth rate postnatally (Ford et al., 2007). Similarly, average daily gains and feed efficiency were increased when steers were exposed to inadequate nutrient intake during d 31 to 120 of gestation (Underwood et al., 2006). The objective of this experiment was to determine the effect of nutrient restriction during early gestation on postnatal growth and DNA and protein in tissues of steers.

Materials and method

Animals. Angus x Hereford heifers at 15 mo of age were artificially inseminated with semen from an Angus sire. At 32.0 ± 0.5 d after AI, pregnancy was diagnosed by transrectal ultrasonography. Pregnant heifers were stratified by weight and BCS and allotted to either low nutrition (L, n=10, 3.71 Mcal of MEm/ heifer/d, 7 lb of prairie hay and 1 lb of a 40% CP supplement; 55% of NE for maintance requirments; NRC) in a drylot or moderate nutrition (M, n=10 with ad libitum native grass pasture; 100% NRC). After 83 d, heifers were commingled on native grass pasture and supplemented with 40% CP protein and grass hay to meet NRC (2000) requirements.

Heifers calved over a 31-d period beginning on January 31, 2005. All bull calves were castrated at birth. There were five heifer and five steer calves in each of the two treatments. Calves were weaned at approximately 230 d of age and all calves were maintained as a single group after weaning. At approximately 16 mo of age; steers were transported 9 miles and placed into two adjacent pens and fed a high concentrate diet for 135 d.

Slaughter and Sample Collection. Steers were transported to the Oklahoma Food and Agriculture Products Research and Technology Center abattoir the day before slaughter. All steers were stunned with a captive bolt, exsanguinated and viscera removed. The weight of blood, feet, ears, hide, head, hot carcass, lungs, trachea, heart, spleen and empty alimentary tract were recorded to calculate empty body weight. Tissue samples were taken from the heart (left ventricle), kidney, liver (right lobe), pancreas, and muscle (Complexus) within 2 hr after exsanguination. All tissue samples were snap frozen in liquid nitrogen and then stored at - 80ºC.

Analysis of Tissue Samples. Dry matter of tissue was determined (AOAC, 1990). Protein concentrations were determined by a Leco Nitrogen Analyzer (model FP-428; Leco Corp., St. Joseph, MI). DNA concentrations were determined by Hoechst Dye 33258 (Argos Organics; New Jersey) in a flourospectrometer (ND-3300, Nanodrop technologies, wavelength excitation 365 nm and emission 450 nm) (LaBarca and Paigen, 1980).

Statistical Analysis. Maternal BW change and weight of organs at slaughter were analyzed using the GLM procedure of SAS with treatment in the model. Birth weight, postweaning growth, and gestation length were analyzed with the Mixed procedure of SAS with treatment, sex, and the interaction in the model. DNA and protein were analyzed using the Mixed procedure of SAS with laboratory assay block as a random variable.

Results and Discussion

Restriction of nutrient intake of heifers to 55% of NRC (Low nutrient) during 32 to 115 d of gestation resulted in a loss of body weight (-139 lb; Figure 1) and BCS (4.3 vs 5.5; Figure 2) compared with heifers on 100% NRC (Moderate nutrition). Gestation length was shorter ($P<.05$) for heifers exposed to Low nutrition from d 32 to 115 of gestation compared with the Moderate nutrition (Figure 3). Birth weight were similar ($P>.10$) for both groups (Table 1).

Average daily gains from birth to 33 wk of age (weaning), 33 to 72 wk of age (stockering), and from 72 to 88 wk (finishing) of age were not influenced by treatment ($P>.10$, Table 1). Empty body weight at harvest was not influenced by prenatal nutrition (1114 ± 60, 1087 ± 49 lbs; Low, Mod, respectively, Table 2). The lung and trachea of the low steers were lighter ($P=.05$) than the lungs and trachea of Moderate steers (11.9 ± 1.1, 13.9 ± 1.8 lbs; Low, Mod, respectively). Weights of all other organs were not influenced by treatment (Table 3). Characteristics of carcasses were not influenced by prenatal nutrition (Table 2). Muscle from the Low steers had greater ($P<.05$) mg DNA per g of tissue than muscle from Moderate steers. There was a tendency for reduced ($P<.10$)

protein to DNA ratio for muscle from Low steers compared with Moderate steers (Table 3). Muscle of steers exposed to low prenatal nutrition had increased nuclei per unit of muscle and a decreased amount of cytoplasm per nuclei. Nutrient intake from d 32-115 of gestation did not influence growth or carcass measurements of steers.

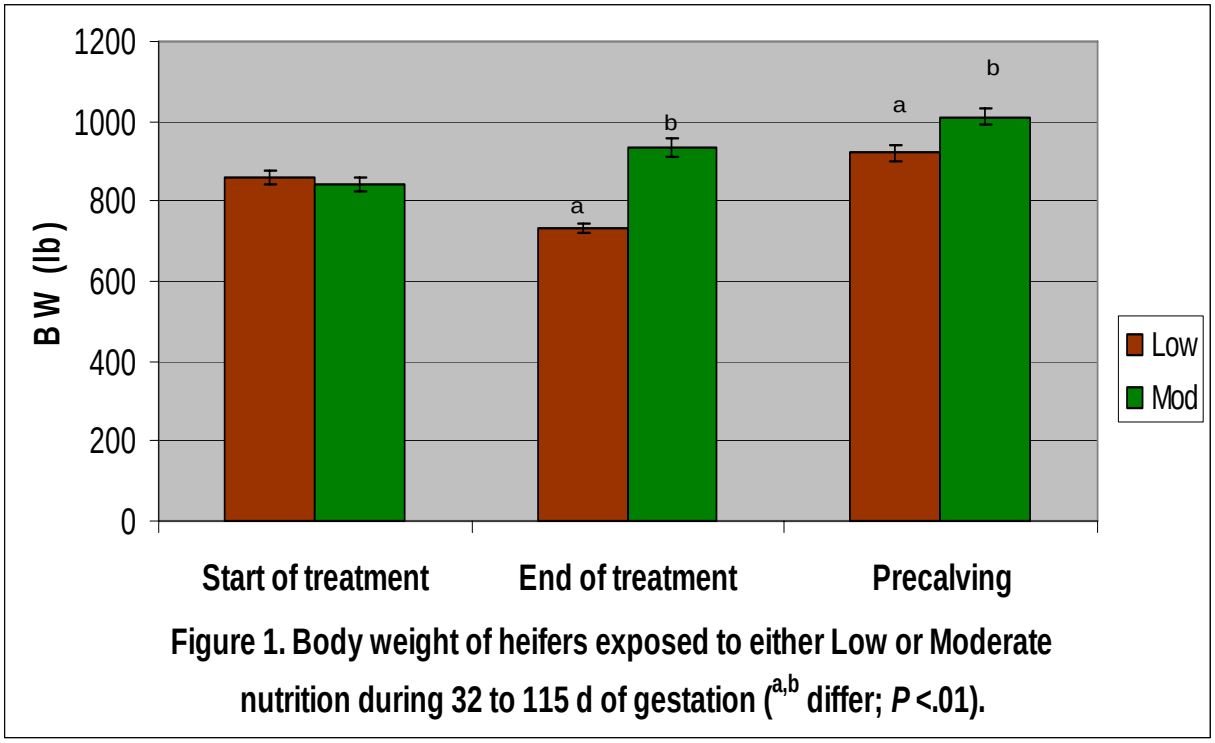

Figure 1. Body weight of heifers exposed to either Low or Moderate nutrition during 32 to 115 d of gestation (^{a,b} differ; P <.01).

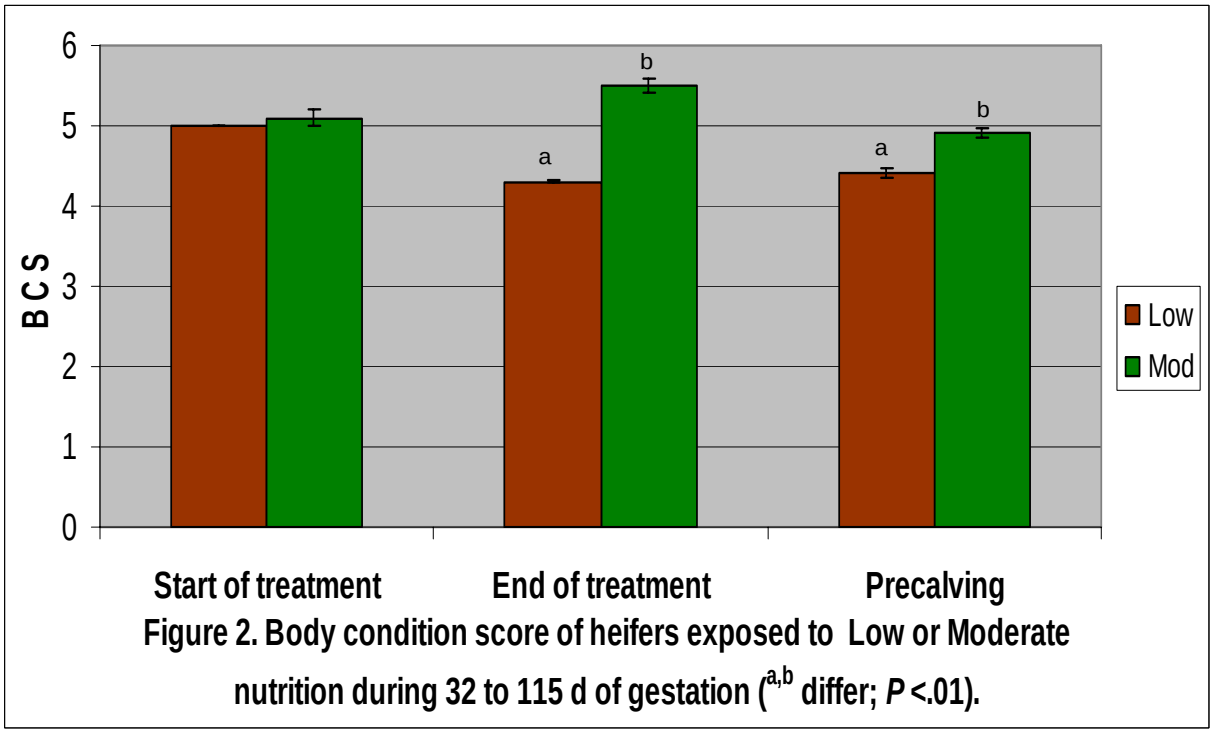

Figure 2. Body condition score of heifers exposed to Low or Moderate nutrition during 32 to 115 d of gestation (^{a,b} differ; P <.01).

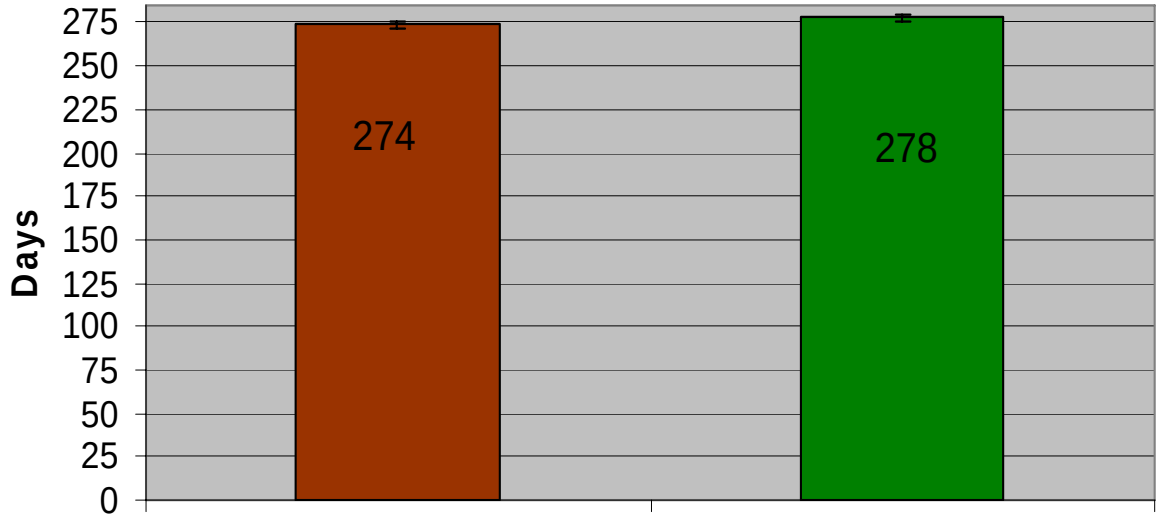

Figure 3. Gestation length of heifers exposed to either Low or Moderate nutrition during 32 to115 d of gestation (*P* =.04).

Table 1. Birth weight and average daily gain of steers exposed to Low or Moderate nutrition during 32-115 d of gestation.

	Treatment		P value
	Low	Moderate	
Birth weight in lb	69.2 ± 2.4	70.8 + 2.9	.31
Average daily gain			
Birth to 33 wk in lb/d	1.79 + .09	1.85 + .04	.38
33 to 72 wk in lb/d	.97 + .07	.93 + .04	.25
72 to 88 wk in lb/d	4.95 ± .29	4.65 + .24	.40

Table2. Influence of Low or Moderate prenatal nutrition on carcass characteristics of steers at 1257 lb			
	Treatment		
	Low	Moderate	P value
	n = 5	n = 5	
Empty body weigh. lb	1114 ± 60	1091 ± 49	.2
Dressing %	59.95 ± 1.71	61.67 ± 2.88	.28
Yield grade	2.48 ± .43	2.74 ± .27	.28
Quality grade	Choice -	Select +	.24
Ribeye area in^2	13.5 ± .5	12.8 ± .9	.18
12th rib Fat thickness in	.41 ± .10	.41 ± .07	1.00

Table 3. Influence of Low or Moderate prenatal nutrition on steers at 88 weeks of age (1257 lb)		
	Treatment	
	Low	Moderate
	n = 5	n = 5
Muscle (Complexus)		
DNA in mg	.85 ± .02 [a]	.52 ± .02 [b]
Protein in mg/g	189.9 ± 3.24	190.6 ± 4.02
Protein:DNA	331 ± 15 [c]	370 ± 15 [d]
Heart		
Weight in kg	2.46 ± .27	2.38 ± .22
DNA in mg	.51 ± .03	.49 ± .03
Protein in mg/g	177.7 ± .9	177.2 ± 2.1
Protein:DNA	347 ± 27	367 ± 27
Liver		
Weight in kg	8.74 ± .98	8.6 ± .49
DNA in mg	3.07 ± .39	3.25 ± .39
Protein in mg/g	197.7 ± 1.9 [a]	184.0 ± 3.5 [b]
Protein:DNA	53 ± 7	49 ± 7

[a,b] Means within a row with different superscripts differ ($P < 0.05$)

[c, d] Means within a row with different superscripts differ ($P < 0.1$)

Conclusion

Restricted nutrient intake of heifers during early gestation did not influence postnatal growth of their calves. Concentrations of DNA in muscle were increased and protein: DNA tended to be decreased when dams received 55% of NRC recommended energy requirments during early gestation.

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