Acutely Restricting Nutrition Causes Anovulation and Alters Endocrine Function in Beef Heifers

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Story in Brief

The effects of acutely restricting nutrition on ovulation and metabolic hormones were evaluated in Angus x Hereford heifers. Heifers were housed in individual pens in a barn and fed a diet supplying 1.2 of their maintenance requirements for protein and energy (1.2 M) for 10 d to allow time to adjust to the environment and diet. Heifers were then fed a diet supplying either .4 of their maintenance requirements (.4 M) or 1.2 M, and heifers were treated with prostaglandin F_{2a} so they would ovulate on d 14 of restriction. If heifers had plasma progesterone less than .5 ng/mL on d 15 to 28, they were classified as anovulatory. Seventy percent (7 of 10) of .4 M heifers did not ovulate on d 14 while all 1.2 M heifers had normal luteal function. Heifers fed .4 M had less plasma thyroxine and increased nonesterified fatty acid (NEFA) concentrations compared with 1.2 M heifers. Nutritional restriction decreased concentrations of insulin-like growth factor-I (IGF-I) in plasma. We conclude that acute nutritional restriction can alter plasma concentrations of NEFA, thyroxine, and IGF-I and induce anovulation in beef heifers.

Key Words: Beef Heifer, IGF-I, NEFA

Introduction

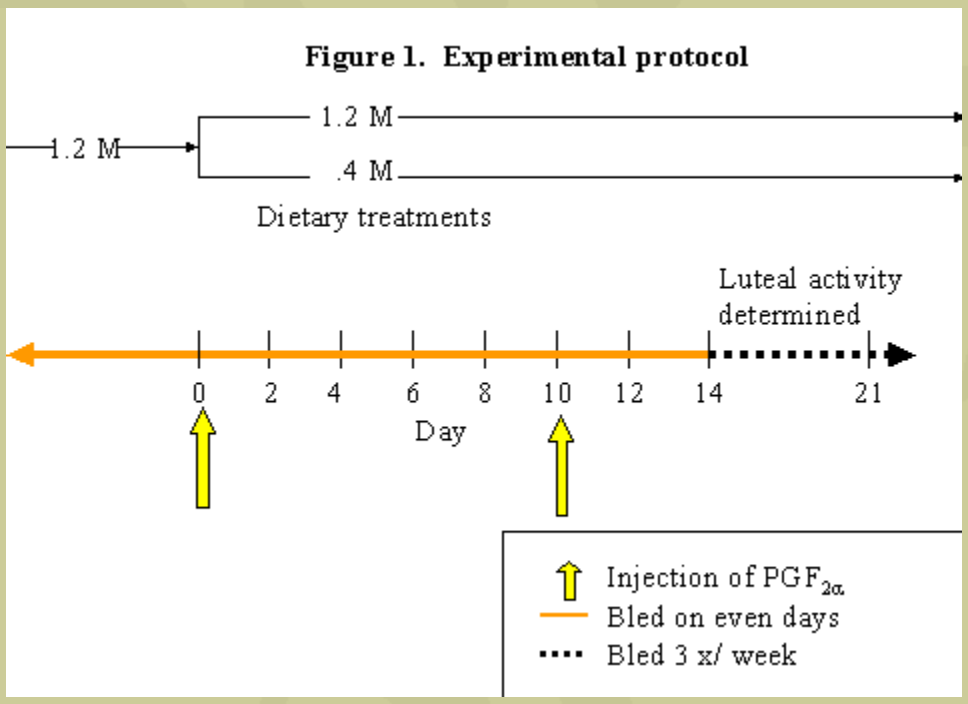
Nutrition regulates reproductive efficiency of cattle. Reducing energy intake of heifers delays puberty and prolongs the postpartum interval to ovulation in cows. Chronic restriction of nutrient intake causes cessation of estrous cycles in heifers and reduces follicular growth and concentrations of LH and estradiol in plasma (Bossis et al., 1999). An animal's energy status regulates reproduction, and metabolic hormones and energy metabolites are possible signals between nutrient intake and reproductive performance.

Restriction of nutrition to .4 of maintenance requirements for 14 d induced anovulation in 60% of heifers, reduced follicle size and growth, and inhibited the gonadotropin surge at ovulation (Mackey et al., 1999). Previous studies have not determined the effects of acute nutritional restriction on concentrations of metabolic hormones and metabolites. This study determined the effects of acute nutritional restriction on the ovulatory status of beef heifers and changes in metabolic hormones and energy metabolites that may serve as signals to control reproduction.

Materials and Methods

Fourteen-month-old Hereford x Angus heifers were housed in individual pens in a barn and fed a diet supplying 1.2 of their maintenance requirements of protein and energy (1.2 M) for 10 d to allow adjustment to the environment and diet. Prior to treatment, heifers weighed 317 ± 1.7 kg, had a body condition score of 5.7 ± .1 (1=emaciated, 9=obese), and had normal luteal activity. Then heifers were individually fed (d 0) either 1.2 M (n=9) or.4 M (n=10) for 14 d (d 0 to d 14; Figure 1). Heifers were blocked by body weight, body condition score, and randomly assigned

to treatment. Estrous cycles were synchronized by treatment with prostaglandin F_{2a} (Lutalyse®; Pharmacia & Upjohn



Company, Kalamazoo, MI) on d -10, 0, and 10 and weight and body condition score were determined on d 0 and 14.

Blood plasma was collected prior to feeding on alternate days until d 14 and three times per week thereafter. Concentrations of plasma progesterone were quantified by radioimmunoassay, and heifers with progesterone less than .5 ng/mL on d 15 to 28 were identified as anovulatory. Concentrations of IGF-I and thyroxine were quantified with radioimmunoassay and NEFA were determined by a colorimetric procedure.

The effects of treatment on metabolic hormones were determined with a completely randomized design with seven repeated measurements. Results were analyzed by analysis of variance using Proc Mixed, SAS (SAS Inst. Inc., Cary, NC), with diet (1.2 or .4 M), time (d 0 to d14), and diet x time as fixed effects and cow (diet) a random effect.

Results and Discussion

Nutritional restriction for 14 d did not affect BSC, but heifers fed .4 M lost an average of 15 kg of BW. Diets altered ovarian function (Table 1), and restricting heifers to .4 M induced anovulation in 70% of heifers, while all 1.2 M heifers ovulated. Beef cows and heifers fed to lose 1% of BW per week ceased to ovulate, after 26 (Richards et al., 1991) and 32 wk (Bossis et al., 1999), respectively. In heifers synchronized with an intravaginal progesterone-releasing device,

restriction of diet to .4 of their maintenance requirements caused 60% of heifers to become anovulatory in 15 d (Mackey et al., 1999).

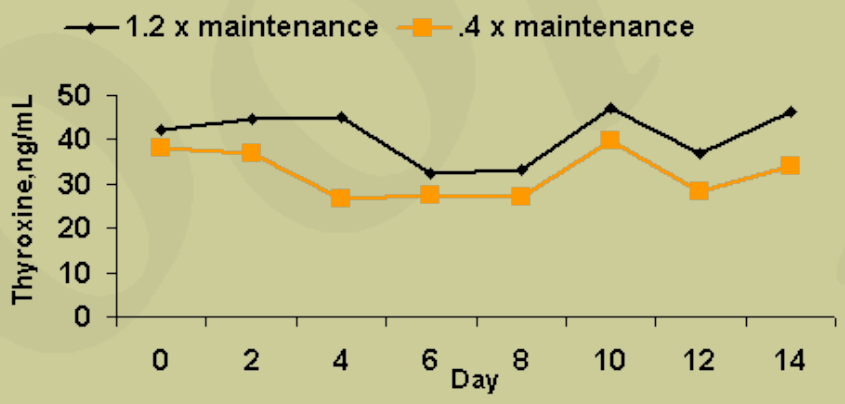
Table 1. Effects of feeding 1.2 of maintenance (M) or .4 M on BCS, BW, and percentage of heifers that ovulated on d 14 of treatment

	Treatments			
	1.2 M		.4 M	
	Day 0 [a]	Day 14	Day 0	Day 14
Heifers, no	9	9	10	10
BCS	5.7[b]	5.4[b]	5.7[b]	5.3[b]
BW, kg	320[b]	323[b]	314[b]	299[c]
Ovulatory, %	100[b]	100[b]	100[b]	30[c]

[a]Day (d) of treatment

[b,c]Means in the same row without a common superscript differ ($P < .001$).

Figure 2. Least squares means of plasma thyroxine concentrations for heifers fed either .4 or 1.2 M (Diet; P < .005).



Heifers fed .4 M had less thyroxine in plasma than 1.2 M heifers (Figure 2; P<.005). Concentrations of thyroxine in plasma were not influenced by day of restriction (P>.1). Nutritional intake also influenced concentrations of NEFA and IGF-I in plasma. In restricted heifers, concentrations of NEFA increased daily, but heifers fed 1.2 M had similar amounts of NEFA throughout the experiment (Figure 3; P<.01). On d 14, restricted heifers had 43% more NEFA in plasma than 1.2 M heifers.

Figure 3. Least squares means of plasma NEFA concentrations for heifers fed either .4 or 1.2 M. (Diet x day P < .01).

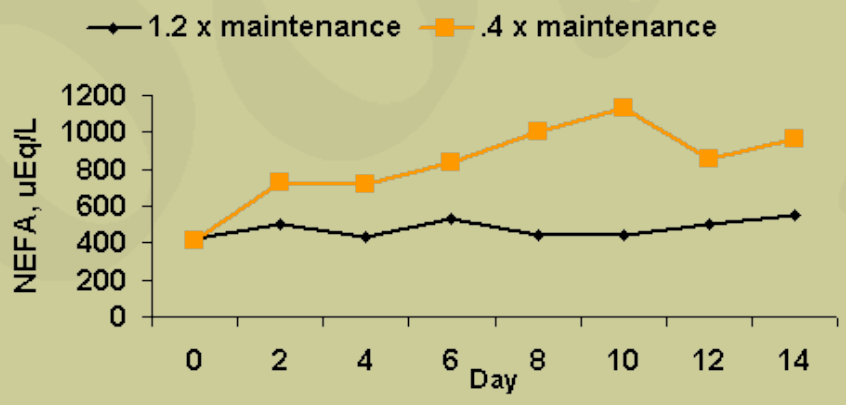
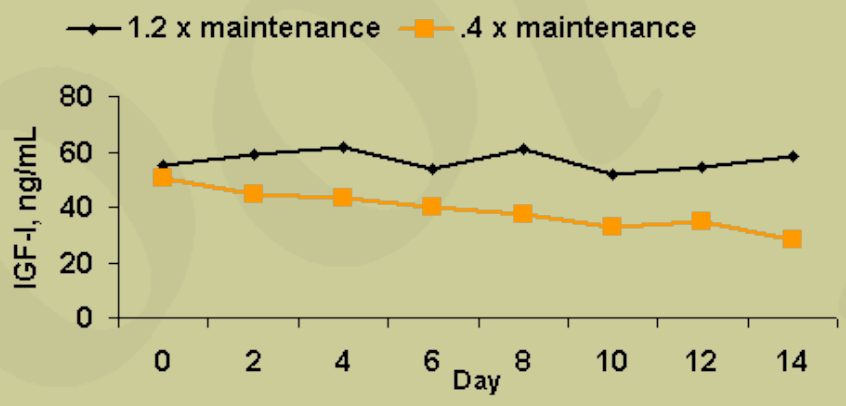


Figure 4. Least squares means of plasma IGF-I concentrations for heifers fed either .4 or 1.2 M. (Diet x day P < .0001).



Heifers fed .4 M had decreased plasma IGF-I when compared with 1.2 M heifers (Figure 4; P<.01). Similar to our study, limiting energy intake increased blood NEFA concentrations in beef heifers (Mackey et al., 2000) and cows (Richards et al., 1989; Vizcarra et al., 1998). Chronic and acute nutrient deprivation also decreased plasma IGF-I concentrations in heifers (Bossis et al., 1999; Mackey et al., 2000), and IGF-I may regulate nutritional effects on reproduction in cows. In conclusion, 70% of heifers fed a diet supplying .4 of maintenance requirements for 14 d did not ovulate while all heifers fed 1.2 of maintenance requirements had normal ovarian function. Acute nutritional restriction reduced concentrations of IGF-I and thyroxine in plasma, and heifers fed a restricted diet had increased plasma concentrations of

NEFA. Acute nutritional restriction induces anovulation in beef heifers, and IGF-I and NEFA may be metabolic signals which regulate reproduction.

Implications

Restricting nutrient intake for 14 d prevented ovulation in beef heifers without altering body condition. Heifers should be managed to avoid short-term nutrient restriction to maintain normal estrous cycles. Acute nutritional restriction decreased plasma concentrations of IGF-I and increased concentrations of NEFA, which may serve as metabolic signals that link the energy status of an animal and reproduction.

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