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INCREASING GLUCOGENIC PRECURSORS IN RANGE SUPPLEMENTS IMPROVES REPRODUCTIVE EFFICIENCY AND PROFITABILITY IN YOUNG POSTPARTUM RANGE COWS IN YEARS 2000 TO 2007

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ABSTRACT: Reproductive efficiency in young beef cows is often compromised due to a mismatch of physiological demands and suboptimal environmental conditions. Studies conducted at the Corona Range and Livestock Research Center from 2000 to 2007 evaluated 3 postpartum supplement strategies increasing in glucogenic precursors (**GP**). Reproductive variables, milk production, and serum metabolites were used to assess supplement effectiveness and economics associated with young beef cow production (n = 379) on native range. Supplements were individually fed 2×/wk at 1135 g/d (2003-2004) or 908 g/d (all other yr) and provided: 1) 327 g CP, 109-118 g undegradable intake protein (**UIP**), 44-47 g GP (**CON**); 2) 327-341 g CP, 142-157 g UIP, 57-70 g GP (**BP**); 3) 327 g CP, 151-173 g UIP + 40 – 100 g of propionate salt (NutroCal, Kemin Industries, Inc.), 93-141 g GP (**P**). Blood samples were collected 1×/wk (2000) or 2×/wk (2001-2007) for progesterone analysis to estimate days to first estrus. Cows were exposed to bulls for 60 d or less and pregnancy was confirmed by rectal palpation at weaning. Number of days to first estrus after calving decreased and pregnancy rates increased linearly ($P \leq 0.02$) with increasing supplemental GP. Milk production exhibited a quadratic ($P = 0.04$) response to increasing GP with cows fed BP producing the most amount of milk (5920, 6812, and 6217 ± 421 g/d for CON, BP, and P, respectively). Total kg of calf weaned per cow exposed for the supplemental year and subsequent year was greater ($P = 0.07$) for cows fed P than the other supplements (418, 410, and 435 ± 40 kg for CON, BP, and P, respectively). These data suggest feeding young cows additional GP in the form of propionate salts allows for repartitioning of nutrients away from milk production and towards reproduction.

Key Words: Beef Cow, Supplementation, Reproduction

INTRODUCTION

Achieving reproductive efficiency in a beef cow herd is a critical factor for beef cow/calf producers to be sustainable. Reproduction is the primary cause limiting production efficiency in most herds, in which failure to conceive represents the single most important factor reducing net calf crop (Dziuk and Bellows, 1983). Furthermore, reproduction is associated with five times more economic value than traits associated with milk production or calf growth (Trenkle and Willham, 1977).

In a beef cow herd a lower percentage of successful rebreedings of young cows is a large cost and an obstacle to profitability. One reason for a lower rebreeding rate in young cows is their inability to consume enough energy for maintenance, lactation, and growth due to their immature body weight. Decreased efficiency in young beef cows can be due to reduced forage quality coupled with higher energy demands (Hawkins et al., 2000). Glucose requirements are increased dramatically due to nutrient demands of lactation plus a grazed dormant native range that yields low quantities of glucogenic precursors, specifically ruminal propionate. Therefore, the supply of glucose precursors becomes increasingly important for reproductive competence when forage quality is low (Hawkins et al., 2000). Knox (1998) found that young cows fed protein supplements increasing in glucogenic precursors coming from differing amounts of bypass protein had an 18% increase in pregnancy rates than cows fed a low bypass supplement. Therefore, the objective of this experiment were to compare measures of reproductive efficiency such as pregnancy rate, days to first estrus, and calf weight per cow exposed as impacted by 3 different postpartum supplementation strategies increasing in glucogenic potential and to assess economic viability of these supplementation strategies for 2- and 3-yr-old cows grazing native range.

MATERIALS AND METHODS

Studies were conducted over 8 years at New Mexico State University's Corona Range and Livestock Research Center (CRLRC). The data were compiled from three independent studies: 1) Waterman et al., 2006 (2000-2001), 2) Endecott et al., 2006 (2003-2004), and 3) Mulliniks et al., 2008 (2005-2007). A study did not occur during 2002 because of drought conditions. The ranch's average elevation is 1,900 m with an average rainfall of 380 mm, most of which occurs in July and August (Waterman et al., 2006). Forages at this study site were primarily blue grama (*Bouteloua gracilis*), threeawns (*Aristida* spp.), and wolftail (*Lycurus phleoides*). All animal handling and experimental procedures were in accordance with guidelines set by the New Mexico State University's Institutional Animal Care and Use Committee.

Animals and Supplementation. Cows were 2- and 3-yr-old (n = 379) and were primarily Angus breeding with some Hereford influence. Management before calving was similar in all years and among all cows. Cow/calf pairs

were moved to a common pasture within 10 d of calving. In all years, cows were stratified by calving date and were randomly assigned to treatments. Initiation of supplementation occurred approximately 10 d after parturition. A 60-d breeding season was utilized in all years and was initiated in early or mid May. Cows were moved to an ungrazed pasture prior to the initiation of breeding in all years.

On supplementation days, cows were gathered and calves were sorted off after the morning grazing bout. Strategically, cows were individually fed supplement for an average of 90 d (2000), 100 d (2001), 72 d (2003), 65 d (2004), 74 d (2005), 120 d (2006), and 80 d (2007). Duration of supplementation was dictated by environmental conditions and the onset of BW gain. Supplements were cubed and milled at Hi-Pro Feeds, Friona, TX (2000-2006) and Alderman Cave, Roswell, NM (2007). Supplements were fed at a rate of 908 g/d in 5 of the 7 years, while cows were fed 1135 g/d in 2003 and 2004. However, the amount of CP supplied was similar each year, regardless of differences in supplementation rate. Composition of the supplements changed slightly over the years; however, supplements consisted mostly of cottonseed meal or wheat middlings and either fish meal and/or hydrolyzed feather meal as the bypass protein source. Supplements were designed to increase in glucogenic potential (**GP**) and provided: 1) 327 g CP, 109-118 g UIP, 44-47 g GP (**CON**); 2) 327-341 g CP, 142-157 g UIP, 57-70 g GP (**BP**); 3) 327 g CP, 151-173 g UIP + 40 – 100 g of propionate salt (NutroCAL™, Kemin Industries, Inc.), 93-141 g GP (**P**). Supplement P was the only supplement to be fed all 7 years; whereas, CON and BP were only fed 5 and 4 years out of 7, respectively. Glucogenic potential of the supplements was calculated by the equation of Preston and Leng (1987), where 40% of the UIP is considered glucogenic (Overton et al., 1999). NutroCAL™ contains 80% propionate, which has been shown to be 95% glucogenic (Steinhour and Bauman, 1988). All supplements were fortified with macro- and microminerals and vitamin A. Cows and calves had year-long access to a loose salt-mineral mix formulated to complement available forages.

Sampling and Measurements. Blood samples were collected once weekly (2000; Friday) or twice weekly (2001 – 2007) on supplementation days (Monday and Friday) via coccygeal venipuncture beginning 35 to 55 d postpartum for progesterone to estimate days to return of estrus (2 or more consecutive progesterone concentrations $\geq$ 1.0 ng/mL). Blood was collected immediately after cows received supplement. Samples were analyzed for progesterone by solid-phase radioimmunoassay (Coat-A-Count, Diagnostic Products Corp., Los Angeles, CA) as described by Schneider and Hallford (1996). Serum samples were also analyzed for insulin, glucose, non-esterified fatty acid (**NEFA**), serum urea nitrogen (**SUN**) to evaluate nutrient status of each cow. Serum samples were composited by cow within 3 productive peridods: 1) pre-breeding; 2) breeding-end of supplementation; 3) end supplementation-end of breeding. Samples were analyzed using commercial kits for NEFA (Wako Chemicals, Richmond, VA), SUN (Thermo Electron Corp., Waltham, MA), and glucose (enzymatic endpoint, Thermo Electron Corp., Waltham, MA). Insulin was analyzed by solid-phase RIA (DCP kit, Diagnostic Products Corp., Los Angeles, CA). Inter- and intra-assay CV were less than 10% for all serum metabolites.

A subsample of cows (n = 24 in 2000; n = 36 in 2001; n = 29 in 2003; n = 20 in 2004; n = 0 in 2005; n = 29 in 2006; and n = 24 in 2007) were milked with a portable milking machine at approximately 57 d postpartum on a day following supplementation using a modified weigh-suckle-weigh technique described by Appeddu et al. (1997). Milk subsamples were collected into preservative-coated vials for analysis of milk components by an independent laboratory (Pioneer Dairy Laboratories, DHIA, Artesia, NM). Milk weights were calculated for a 24 h milk production.

After calving, cows were weighed once every two weeks (2000 and 2001) or weekly (2003-2007) until the termination of the breeding season, and at weaning. Days to BW nadir was calculated from the lowest BW after calving. Body condition scores (BCS; 1 = emaciated, 9 = obese) were assigned to each cow by visual observation and palpation at initiation of the study, at branding, and at weaning by a trained technician. Calves were weighed at branding and weaning in each year. Branding weights and weaning weights were adjusted for a 55-d branding and 205-d weaning weight with no adjustments for sex of calf or age of dam. Weaning weight for the year following supplementation was not adjusted to show differences in weight caused by variation in calving date and/or conception date.

Economic Analysis. A hypothetical model was developed to compare three 100-cow herds in a two year partial budget of the 3 postpartum supplements using the results from 2000 to 2007. All calves were valued at time of weaning based on a base price in the New Mexico Weekly Weighted Average Feeder Cattle Report (USDA CB LS 795) with no value difference between steers and heifers. In the model, second-year weaning weights were adjusted for calving date by results from days to first estrus and using the weaning weight and days to first estrus for CON as the base. Therefore, weaning weights were adjusted by 0.91 kg for each day decreased in postpartum interval. Calf crop was determined by using the average calf loss according to the SW Cow-Calf Standardized Performance Analysis (SPA) data.

Statistical Analysis. Years were characterized as being either above (**AA**) or below (**BA**) an 18-yr average rainfall for CRLRC. Consequently, year served as the experimental unit for rainfall. However, response to rainfall was not significant and the results were not included. Within each year, there were either two or three supplemental groups. A mixed model accounted for correlations within year and supplement group within year and allowed for appropriate comparison of supplements even though some supplements did not appear in every year. SAS PROC MIXED (ver 9.1.3) was used to analyze the mixed model with cow as the experimental unit and with the fixed effects of supplement, rain, supplement × rain. Year with rain and year within year × supplement were used as the random effects. The Kenward-Roger

degrees of freedom method was used to adjust standard errors and calculate denominator degrees of freedom. Two preplanned contrast statements were used to test for linear and quadratic effects of increasing amounts of glucogenic precursors. The GENMOD procedure of SAS was used to analyze pregnancy rates. Significance was determined at $P \leq 0.10$.

RESULTS AND DISCUSSION

Cows fed P returned to estrus earlier over the 7 years than cows fed any other supplement. A linear decrease (P = 0.02) in days to first estrus was found with increasing amount of GP (Table 1). This earlier return to estrus increases the probability that conception will occur earlier in the breeding season (Randel, 1990), which can result in older and heavier calves the following year at weaning. Along with calving earlier the next year, cows will have an opportunity to remain in the herd by becoming reproductively competent sooner and cycling before the initiation of the breeding season. Pregnancy rates increased (P = 0.01; 84, 88, and 95% for CON, BP, and P, respectively) with increasing supply of GP in the supplements.

Cow BW and BCS were similar across all treatments at all measurement times ($P \geq 0.16$; Table 1). Treatments did not affect body weight realimentation and therefore, any improvement in reproduction was not associated with a difference in BW gain. Cows reached BW nadir at similar (P = 0.79) days postpartum in all supplement groups. However, a linear decrease (P = 0.07) in days from BW nadir to first estrus was found with increasing consumption of glucogenic precursors. Once cows reached a positive energy balance, cows fed P required less days to return to estrus.

Serum concentration of glucose increased (P = 0.02) linearly with increasing GP in the diet and also decreased ($P < 0.01$) with advancing physiological periods coinciding with improved forage quality. A supplement × physiological period interaction ($P < 0.01$; Table 2) occurred for serum insulin, NEFA, and SUN. Serum insulin concentrations were higher for cows fed BP and P than cows fed CON before breeding season and early in the breeding season. The increase in serum glucose and insulin may have had a positive effect on the restoration of LH pulse frequency as seen by Chagas (2003), who reported decreased days to first estrus and increased pregnancy rates in grazing dairy cows with supplementation of glucogenic precursors. Serum NEFA were higher in the first 2 physiological periods which follows the same trend of cow's weight loss after calving. Cows fed BP tended to have higher SUN concentrations until the last physiological period in which BP had the lowest SUN concentrations compared to cows fed CON and P.

Twenty-four hour milk production exhibited a quadratic response (P = 0.04; Table 1) to increasing consumption of GP. A quadratic response was also observed for milk protein, lactose, solids non-fat, and butterfat ($P \leq 0.05$). The additional GP in the BP supplement seemed to be used to promote higher milk production. Supplement P contained the same amount of UIP as the BP supplement, but cows fed P tended to shift nutrients away from milk production and toward reproduction. The increase in 24-h milk production in the BP group agrees with other finding that UIP-supplemented cows produce more milk (Appeddu et al., 1997). The contradicting results between BP and P supplements may be explained by the cows fed BP in our study may not have received enough glucogenic precursors to overcome the effects of insulin insensitivity and passively partitioned nutrients towards lactation. Milk production differences did not alter calf BW at branding (P = 0.82). Calf weaning weight followed the same quadratic milk production response (P = 0.07) with calves from BP cows having the heaviest weaning weight.

A ranch's productivity can be described as pounds of calf weaned per exposed female (Ramsey et al., 2005). Increasing total kilograms of calf weaned per cow exposed to a bull is a crucial criterion for beef cattle producers and is primarily controlled by reproductive efficiency and calf death loss. Feeding young lactating beef cows supplement P decreased days to first estrus and increased pregnancy rates providing the opportunity to wean older/heavier and more calves the next year. Total kg of calf weaned for the supplemental year and the subsequent year was greater (P = 0.07; Table 1) for P fed cows than the other supplements.

Economic Analysis. An evaluation of potential revenue from three 100-cow herds was conducted with a 2-yr partial budget of the 3 postpartum supplements using the results from 2000 to 2007 (Table 3). Feed costs for the supplemental period were $22.26, $26.95, and $33.18/cow for CON, BP, and P, respectively. In yr 1, total revenue was $21.35 and $6.44 per cow higher for BP and P, respectively compared to CON. This higher revenue in yr 1 was due to an increase in calf weaning weight in the BP and P cow herds. Pregnancy rates across the 7 yr averaged for the supplement year (yr 1) were 84%, 88%, and 95% for CON, BP, and P, respectively. Consequently, cows fed P in yr 1 had an increase in total revenue of 15.3% compared to CON-fed cows and 7.2% compared to BP-fed cows in yr 2. This increase in revenue is the sum of an increase in pregnancy rates and to a lesser extent a decrease in days to first estrus which offset the higher postpartum feed costs for the year.

IMPLICATIONS

Increasing glucogenic precursors in range supplements decreased days to first estrus and improved pregnancy rates in 2- and 3-yr-old cows by apparently repartitioning nutrients away from lactation. Additionally, the increase in pregnancy rates for cows fed propionate salts offset the higher cost of the supplement by increasing calf crop the following year which increased ranch revenue compared to the other supplements fed in this study.

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Table 1. Effect of postpartum supplementation on reproductive measurements, cow body weight and change, body condition score, milk production, and calf weight change for 2- and 3-yr-old cows grazing native range in 2000-2007.

	Supplement					Contrast	
Measurement	CON	BP	P	SEM	*P*-value	Linear	Quadratic
Reproductive Measurements							
Days to First Estrus	88	87	82	9	0.07	0.02	0.85
Days to Nadir	52	54	52	8	0.87	0.99	0.59
Nadir to Estrus	36	33	29	12	0.19	0.07	0.85
Pregnancy, %	84	88	95	--	0.01	--	--
Cow Wt, kg							
Initial	431	435	436	12	0.60	0.40	0.71
Begin of Breeding	376	374	379	10	0.66	0.39	0.71
Nadir	345	345	348	11	0.80	0.51	0.88
End of Breeding	407	404	410	10	0.54	0.32	0.57
Weaning	444	439	447	12	0.49	0.31	0.48
Body Condition Score							
Initial	4.6	4.7	4.7	0.3	0.40	0.34	0.38
Brand	3.9	4.1	4.0	0.1	0.16	0.23	0.16
Weaning	4.6	4.7	4.7	0.1	0.42	0.31	0.44
Milk, g/d							
24 h Production	6,272	7,136	6,461	441	0.12	0.93	0.04
Protein	164	189	174	13	0.15	0.70	0.05
Fat	215	273	226	21	0.02	0.82	0.01
Lactose	313	358	321	23	0.09	0.82	0.03
SNF	530	611	553	40	0.09	0.93	0.03
Calf Weights, kg							
Branding Wt	66	67	66	4	0.82	0.82	0.56
Weaning Wt	209	218	215	12	0.07	0.15	0.10
kg weaned	207	188	215	25	0.28	0.17	0.32
2 yr total kg weaned	418	410	435	40	0.18	0.07	0.58

Table 2. Supplement × physiological period interactions for serum insulin, non-esterified fatty acid (NEFA), and serum urea nitrogen (SUN) of 2- and 3-yr-old postpartum cows grazing native range and fed supplements increasing in glucogenic precursors in 2000-2007.

		Supplement			
Measurement	Period	CON	BP	P	SEM
Serum Metabolite					
Insulin, ng/mL	Prebreeding	1.34^{x}	1.39^{x}	1.61^{x}	0.54
	Breeding - End Supplementation	1.40^{x}	1.65^{y}	1.73^{y}	0.54
	End Supplementation - End Breeding	1.28^{x}	1.18^{z}	1.38^{z}	0.54
NEFA, µmol/L	Prebreeding	362^{ax}	437^{bx}	408^{bx}	57
	Breeding - End Supplementation	374^{ax}	318^{by}	396^{ax}	57
	End Supplementation - End Breeding	253^{ay}	278^{ay}	255^{ay}	57
SUN, mg/100 mL	Prebreeding	9.76^{ax}	11.07^{bx}	9.72^{ax}	1.35
	Breeding - End Supplementation	8.97^{ax}	10.98^{bx}	9.14^{ax}	1.35
	End Supplementation - End Breeding	12.67^{ay}	10.51^{bx}	12.13^{ay}	1.35

[a,b] For each interaction, means in rows with different superscripts differ ($P < 0.10$).

[x,y,z] For each interaction, means in columns with different superscripts differ ($P < 0.10$)

Table 3. A model results comparing cost and revenue for 3 postpartum supplementation strategies for three 100-cow herds for 2 consecutive years. Data from 2- and 3-yr-old cow postpartum supplementation studies (2000-2007) at NMSU's Corona Range and Livestock Research Center were used to construct the 2-year partial budget.

Year 1	**CON**	**BP**	**P**
No. of Cows	100	100	100
Cost of supplement, $/ton	318	364	474
Days of Postpartum Supplementation	70	70	70
Cost of supplement/day	0.318	0.385	0.474
Postpartum supplement cost/cow	22.26	26.95	33.18
Weaning Weight, kg	209	218	215
Price of calves, $/45.4 kg	124	124	124
Weaned calf value, $	569.16	595.2	586.52
Minus Feed Cost, $	546.90	568.25	553.34
Total Revenue/100 hd, $	54,690	56,825	55,334
Difference, $	--	**2,135**	**644**
Pregnancy rates, %	84	88	95
Calving death loss based on exposed females, %	2.8	2.8	2.8
Calf Crop, %	81.2	85.2	92.3
Year 2			
No. of Cows	81	85	92
Estimated Calving Interval, d	365	364	359
Cost of supplement, $/ton	318	385	474
Days of Postpartum Supplementation	70	70	70
Cost of supplement/day	0.318	0.385	0.474
Postpartum supplement cost/cow	22.26	26.95	33.18
Adjusted Weaning Weight for calving date, kg	209	219	220
Price of calves, $/45.4 kg	124	124	124
Weaned calf value, $	569.16	597.68	601.4
Minus Feed Cost, $	546.90	570.73	568.22
Total Revenue/cow herd, $	44,298.90	48,512.05	52,276.24
Difference, $	--	**4,213.15**	**7,977.34**