Metabolizable protein supply while grazing dormant winter forage during heifer development alters pregnancy and subsequent in-herd retention rate

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ABSTRACT: Two studies were conducted to evaluate the effects of postweaning management of British crossbred heifers on growth and reproduction. In Exp. 1, 239 spring-born, crossbred heifers were stratified by weaning BW (234 ± 1 kg) and allotted randomly to 1 of 2 treatments. Treatments were fed at a rate equivalent to 1.14 kg/d while grazing dormant forage (6.5% CP and 80% NDF, DM basis) and were 1) 36% CP containing 36% RUP (36RUP) or 2) 36% CP containing 50% RUP (50RUP). Supplementation was initiated in February (1995 and 1996) or November (1997 and 1998) and terminated at the onset of breeding season (mid May). Heifers were weighed monthly up to breeding and again at time of palpation. After timed AI, heifers were exposed to breeding bulls for 42 ± 8 d. In Exp. 2, 191 spring-born, crossbred heifers were stratified by weaning BW to treatments. Heifer development treatments were 1) pasture developed and fed 0.9 kg/day of a 36% CP supplement containing 36% RUP (36RUP), 2) pasture developed and fed 0.9 kg/day of a 36% CP supplement containing 50% RUP (50RUP), and 3) corn silage-based growing diet in a drylot (DRYLOT). Heifers receiving 36RUP and 50RUP treatments were developed on dormant forage. Treatments started in February and ended at the onset of a 45-d breeding season in May. Heifer BW and hip height were taken monthly from initiation of supplementation until breeding and at pregnancy diagnosis. In Exp. 1, BW was not different ($P \geq 0.27$) for among treatments at all measurement times. However, 50RUP heifers had greater ($P = 0.02$; 80 and 67%) pregnancy rates than 36RUP heifers. In Exp. 2, DRYLOT heifers had greater ($P < 0.01$) BW at breeding than 36RUP or 50RUP developed heifers. However, BW at pregnancy diagnosis was not different ($P = 0.24$) for between treatments. Pregnancy rates tended to be greater ($P = 0.10$) for 50RUP heifers than 36RUP and DRYLOT. Net return per heifer was US$99.71 and $87.18 greater for 50RUP and 36RUP heifers, respectively, compared with DRYLOT heifers due to differences in pregnancy and development costs. Retention rate after breeding yr 3 and 4 was greatest ($P \leq 0.01$) for 50RUP heifers. Thus, increasing the supply of MP by increasing the proportion of RUP in supplements fed to heifers on dormant forage before breeding increased pregnancy rates, cow herd retention, and net return compared with heifers fed in drylot.

Key words: beef heifers, heifer development, longevity, pregnancy

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INTRODUCTION

Selection and development of replacement heifers can have major impact on the future productivity and longevity of the entire cowherd. Replacement heifers represent a significant cost to beef cow/calf producers. The primary cost associated with developing heifers managed under extensive conditions is purchased feed to augment diets for sufficient gains to achieve puberty before breeding (Roberts et al., 2009a). Considerable supplemental nutrient input may be necessary to achieve a target BW for heifers developed on poor quality forages. However, developing heifers to lighter target BW may be effective in reducing costs over time while achieving reproductive goals (Hawkins et al., 2000).

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Roberts et al. (2009a) suggested a potential economic advantage to developing heifers on a restricted level (80% of ad libitum) of feeding. In addition, Clanton et al. (1983) demonstrated that patterns of growth may be altered during the postweaning period without decreasing the ability of the heifer to conceive. However, the impacts of developing heifers on a restricted diet on the longevity and future productivity are not established. We hypothesized developing heifers in a low-input system on native range fed a high RUP supplement would not have a negative impact on heifer pregnancy rates and longevity. The objective of the first experiment was to determine effects of type of dietary protein (RUP or RDP) supplement on growth, development, reproductive performance, and implications on economic analysis of heifers grazing native dormant range. Objectives of the second experiment were to determine growth, reproductive performance, longevity, and economic efficiency of RUP or RDP supplemented heifers while grazing native dormant range or drylot developed heifer development.

MATERIALS AND METHODS

All experimental procedures described were approved by the New Mexico State University Animal Care and Use Committee.

Experiment 1

British crossbred heifers (234 ± 1 kg at weaning; n = 239) born in spring of 1994 to 1997 were used to compare 2 supplementation strategies for developing heifers on native dormant range at the New Mexico State University Corona Range and Livestock Research Center (**CRLRC**) located 13 km east of Corona, NM (34°15′36″ N, 105°24′36″ W). The CRLRC has an average elevation of 1,900 m and a mean annual precipitation of 397 mm, with more than one-half the rainfall typically received as short duration convectional thunderstorms between July and September. Vegetation was composed of a major overstory of moderate to dense woodlands consisting of Pinyon pine (*Pinus edulis*) and various juniper species (*Juniperus* spp.). Predominant grasses in these pastures included blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), hairy grama (*Bouteloua hirsuta*), sand dropseed (*Sporobolus cryptandrus*), common wolftail (*Lycurus phleoides*), threeawns (*Aristida* spp.), and black grama (*Bouteloua eriopoda*) with minor components of other grasses and annual forbs (Knox, 1998; Forbes, 1999).

Ruminally cannulated heifers were used to collect diet extrusa samples for analysis of CP (AOAC, 2000) and NDF (Van Soest et al., 1991) in February and April. Two rumen cannulated heifers grazed together alongside herd mates were used to obtain diet extrusa samples in each of 6 pastures. Extrusa samples were collected in April before breeding via the ruminal evacuation techniques described by Lesperance et al. (1960). Upon collection, ruminal extrusa samples were dried in a forced air oven at 55°C and mixed thoroughly every 12 h until completely dried and ground through a Wiley mill (Thomas Scientific, Swedesboro, NJ) to pass a 2 mm screen. Extrusa samples from the study pastures averaged (DM basis) 5.2 and 7.7% CP and 80.7 and 79.4% NDF for February and April, respectively.

Weaning occurred in late September/early October every year with the average heifer age at weaning at 190 ± 5 d. All heifers grazed the same pasture in common from weaning to initiation of treatments. Supplementation commenced in November (1995 and 1996) or February (1997 and 1998). Protocol was altered in 1997 and 1998 due to the lack of BW change from November to February in 1995 and 1996. In 1997 and 1998, heifers were fed 0.23 kg·heifer^{-1}·d^{-1} of 36% CP supplement until initiation of treatments in February. Duration of supplementation was 190, 195, 89, and 93 d for 1995, 1996, 1997, and 1998, respectively. Each year, heifers were stratified by BW at weaning and randomly assigned to 1 of 6 replications. Each replication was randomly assigned to 1 of 6 pastures. Treatments were randomly assigned to each pasture, resulting in 3 replications per treatment within each of the 4 yr. Pastures were 270 ha and contained approximately 400 kg/ha of standing forage. All pastures were stocked at a rate that was 50% less than the Natural Resources Conservation Service (NRCS) recommended rate so that forage availability was assumed not to limit heifer productivity (USDA-NRCS, 2002). Average stocking rate across years was 20 ha/heifer. Pastures were grazed each year of the experiment only during the experimental period.

Supplements were fed 3 d/wk at a rate equivalent to 1.14 kg·heifer^{-1}·d^{-1} to provide 1) 36% CP containing 50% RUP, 408 g/d of CP, 200 g/d of RUP, and 194 g/d of MP (**50RUP**; MP supply calculated from NRC, 2000) or 2) 36% CP containing 36% RUP, 408 g/d of CP, 146 g/d of RUP, and 148 g/d of MP (**36RUP**; MP supply calculated from NRC, 2000; Table 1). Supplements were commercially cubed and milled at Hi-Pro Feeds, Friona, TX. Supplements were formulated to be isoenergetic and were designed to supply adequate RDP to ensure comparable ruminal function and microbial protein synthesis and differed in RUP concentration. Supplementation occurred on Monday, Wednesday, and Friday at 1000 h. Heifers had unlimited access to water and a loose salt–mineral mix that was formulated to complement available forages.

Heifer development treatments were ended at the onset of the breeding season and heifers were then placed in a common pasture for a timed AI breeding season. Heifers were subjected to a conventional Syncro-Mate-B (Merial Ltd., Athens, GA) estrous synchronization protocol. This protocol consisted of an intramuscular (**i.m.**) injection (2 mL) containing 5 mg of estradiol valerate and 3 mg of norgestomet and a 6 mg implant in the ear containing norgestomet on d 0. After 9 d, implants were removed and heifers were AI 48 h after implant removal. No heifer was inseminated before the timed AI and the breading season started on the day of the timed AI. After the timed AI, all heifers were exposed to breeding bulls (1:20 bull:heifer ratio) for a period of 42 ± 8 d. During the breeding season, all heifers grazed in the same pasture and were fed 1.14 kg/d of 36RUP. Percent of mature BW at breeding was estimated by the average cow BW at 5 yr of age for each heifer development treatment. Heifers were diagnosed pregnant by rectal palpation in September to October. Shrunk BW were recorded once monthly from January until May (initiation of breeding) and at pregnancy diagnosis.

Table 1. Ingredients and nutrient composition of protein supplements (all units as fed) fed to range developed heifers in Exp. 1 and 2

Item	Treatment[1] 36RUP	50RUP
Ingredients, %		
Cottonseed meal	56.94	24.80
Wheat middlings	21.45	42.50
Hydrolyzed feather meal	–	20.00
Soybean meal	10.00	–
Molasses	9.00	9.00
Urea	1.20	0.70
Potassium chloride	0.95	1.70
Monocalcium phosphate	0.30	–
Vitamin A premix	0.08	0.08
Manganese sulfate	0.06	0.05
Trace mineral premix	0.02	0.02
Copper sulfate	0.01	<0.01
Nutrient composition, %		
DM	87.67	88.46
Ca	0.24	0.49
P	1.00	1.09
Mg	0.47	0.33
K	2.01	2.01
S	0.36	0.37
Na	0.09	0.38
Mm, mg/kg	210.49	210.57
Zn, mg/kg	109.19	199.13
Fe, mg/kg	176.43	233.46
Cu, mg/kg	49.82	50.45
Se, mg/kg	0.24	0.53
Co, mg/kg	0.44	0.38
I, mg/kg	1.23	1.25
Vitamin A, 1,000 IU/kg	33	33
TDN, %	65.64	64.98
CP, %	36.01	36.01
RDP. %	25.22	18.39
RUP, %	12.00	17.62

[1]36RUP = 36% CP cottonseed meal base supplement fed 3 d/wk supplying 36% RUP; 50RUP = 36% CP supplement fed 3 d/wk supplying 50% RUP.

Experiment 2

Over 3 yr (2005 to 2007), 191 spring-born, British crossbred heifers (234 ± 1.1 kg BW at weaning) were used to compare 3 methods of heifer development on reproductive performance and retention rate on herd at CRLRC (using the same pastures as in Exp. 1). Each year, roughly 21 heifers were randomly assigned to each treatment group. In each year from November to January, all heifers were managed in a common pasture and were fed 0.23 $kg \cdot heifer^{-1} \cdot d^{-1}$ of a cottonseed meal-based 36% CP supplement. At weaning (September/October), heifers were stratified to treatments by weaning weight and assigned to 1 of 3 treatments groups. Heifer development treatments were 1) pasture developed and fed a 36% CP cottonseed-meal based containing 36% RUP (36RUP), 2) pasture developed and fed a 36% CP cottonseed-meal based containing 50% RUP (50RUP), and 3) fed a commercial concentrate growing diet in a dry lot (**DRYLOT**). Supplementation treatments were initiated in February and terminated at breeding (mid May). Pasture developed heifers were randomly assigned to 1 of 4 pastures, allowing for 2 replications per year for each pasture treatment. Protein supplements were fed 3 d/wk at a rate equivalent to 0.9 $kg \cdot heifer^{-1} \cdot d^{-1}$ to provide 1) 36% CP containing 327 g/d of CP, 109 g/d of RUP, and 119 g/d of MP (36RUP; MP supply calculated from NRC, 2000) or 2) 36% CP containing 327 g/d of CP, 160 g/d of RUP, and 155 g/d of MP (50RUP; MP supply calculated from NRC, 2000; Table 1). Supplements were commercially cubed and milled at Hi-Pro Feeds, Friona, TX. Protein supplements were formulated to be isoenergetic and designed to supply adequate RDP to ensure comparable ruminal function and microbial protein synthesis and differed in RUP concentration. Supplementation occurred on Monday, Wednesday, and Friday at 1000 h. Heifers had unlimited access to water and a loose salt–mineral mix that was formulated to complement available forages. Pastures were the same to those described in Exp. 1. Vegetation was composed of a major overstory of moderate to dense woodlands consisting of Pinyon pine (*P. edulis*) and various juniper species (*Juniperus* spp.). Predominant grasses in these pastures included blue grama (*B. gracilis*), sideoats grama (*B. curtipendula*), hairy grama (*B. hirsuta*), sand dropseed (*S. cryptandrus*), common wolftail (*L.

Table 2. Input prices used in the enterprise budget in Exp. 1 and 2

Treatment cost	Treatment[1] 36RUP	50RUP	DRYLOT
Heifer development supplement, $/heifer	35.62	42.56	126.00
Input prices			$/unit
Nonpregnant heifer price, kg			1.36
Pregnant heifer price, heifer			885.12
Weaned heifer purchase price, kg			2.27
Grazing fee, AUM[2]			12.30
Labor cost, AUM			2.43
Mineral and salt cost, heifer			4.40
Freight fee, heifer			6.00
Yardage fee, day			0.28

[1]36RUP = 36% CP cottonseed meal base supplement fed 3 d/wk supplying 36% RUP; 50RUP = 36% CP supplement fed 3 d/wk supplying 50% RUP; DRYLOT = corn silage diet fed in drylot to gain 0.68 kg/d.

[2]AUM = animal unit month.

Table 3. Growth and reproductive performance of heifers grazing native dormant pastures and fed 2 different protein supplements (Exp. 1)

Measurement	Treatment[1] 36RUP	50RUP	SEM	*P*-value
BW, kg				
Weaning[2]	237	234	1	0.27
Initial[3]	232	230	2	0.36
Breeding[4]	261	260	2	0.66
Pregnancy diagnosis[5]	356	354	2	0.61
ADG, kg/d				
Initial to breeding	0.29	0.29	0.01	0.77
Breeding to pregnancy diagnosis	0.69	0.68	0.01	0.49
Initial to pregnancy diagnosis	0.52	0.52	0.01	0.92
Percentage of mature BW[6], %	48	48	1	0.58
Pregnancy rate, %	67	80	4	0.02

[1]36RUP = 36% CP cottonseed meal base supplement fed 3 d/wk supplying 36% RUP; 50RUP = 36% CP supplement fed 3 d/wk supplying 50% RUP.

[2]Late September/early October every year at 190 ± 5 d of age.

[3]Initiation of heifer development treatments occurring in Nov (2 of 4 yr) or Feb (2 of 4 yr).

[4]Early May.

[5]Late September/early October.

[6]Estimated percentage of mature BW at breeding.

phleoides), threeawns (*Aristida* spp.), and black grama (*B. eriopoda*) with minor components of other grasses and annual forbs (Knox, 1998; Forbes, 1999).

The DRYLOT heifers were shipped to a drylot (442 km away from CRLRC) in February and were fed to gain approximately 0.68 kg BW/d before breeding when consuming a corn silage-based growing diet. The drylot diet consisted of 70% corn silage and 30% steam-flaked corn in yr 1 and 2 and 100% corn silage in yr 3. Composition of the drylot diet changed slightly over the years based on commercial availability and least cost consideration of ingredients. Heifers were limit fed to achieve an average BW gain of 0.68 kg/d. Upon arrival to the feedlot, heifers were divided into 3 replicate pens with 6 to 7 heifers/pen. Upon termination of the treatment feeding period (late April to early May), DRYLOT heifers were shipped back to CRLRC and all treatments were combined in a common pasture and fed 36RUP at a rate equivalent to 0.9 kg·heifer^{-1}·d^{-1}.

In May of each year, estrus was synchronized using a CO-Synch protocol plus a controlled internal progesterone-releasing device (**CIDR**; Eazi-Breed, Pfizer Animal Health, New York, NY). Heifers were administered a single 2-mL i.m. injection of GnRH (Cystorelin, Merial, Iselin, NJ), and a CIDR was inserted. After 7 d, the CIDR was removed and all cows received a single 5-mL i.m. injection of $PGF_{2\alpha}$ (Lutalyse, Pfizer Animal Health). Approximately 66 h after CIDR removal, all heifers were artificially inseminated and were administered a single 2-mL i.m. injection of GnRH (Cystorelin, Merial). All heifers were then managed together with a bull for a 45-d breeding season. Heifers were evaluated for pregnancy by rectal palpation in October. In each year, shrunk BW and hip heights were recorded once monthly from January to May and at pregnancy diagnosis. Percent of mature BW at breeding was estimated by the average cow BW at 5 yr of age for each heifer development treatment. Body weight-to-height ratios were calculated at initiation of supplementation, before breeding, and at pregnancy diagnosis. Percent of heifers becoming pregnant and remaining in the herd at start of each breeding season was recorded to determine retention rate. Females were removed from the study herd if they failed to wean a calf.

Economic Analysis

Hypothetical enterprise budgets were used to evaluate the economic returns generated by developing 100 heifers in each development method using the pregnancy rates and BW from both experiments. In the enterprise budget, Exp. 1 and 2 were considered only 1 yr scenarios. The heifer development segment was considered a separate enterprise from the cow–calf operation. Inputs used in the enterprise budgets are listed in Table 2. A grazing fee was assigned based on average leased price ($12.30/animal unit month) of private rangeland in New Mexico for the year 2008 (National Agricultural Statistics Service, 2008). Animal unit equivalents used for heifers was suggested by Vallentine (1990). Cost of supplementation and mineral supplements were calculated to the cost delivered to the ranch during the last year of each experiment. Costs associated with developing heifers in the feedlot included freight to and from the feedlot, yardage, and feed. Returns generated from sale of nonpregnant heifers were included in the budget. Pregnant heifers were retained, however, for the purpose of the analysis; a sale value was assigned using a 10-yr average market value for both nonpregnant and pregnant heifers (Cattle Fax, 2008).

Statistical Analysis

Normality of data distribution was evaluated using PROC UNIVARIATE procedure (SAS Inst. Inc., Cary, NC). Continuous data were analyzed using the MIXED procedure of SAS with pasture (or pen) as the experimental unit within a completely randomized design. The model included the fixed effects of treatment, year, and treatment × year. Results from the main effect of year were not reported because year effects do not meet the objectives of the study. The Kenward-Roger degrees of freedom method was used to adjust SE and calculate denominator degrees of freedom. Binomial data (pregnancy and retention rate) were analyzed with PROC GLIMMIX using a model that included the fixed effects of treatment, year, and treatment × year. Means were separated using least significant difference. The default variance component structures (type = VC) of SAS were assumed for all analysis. Significance was considered if $P \leq 0.05$ and as a tendency if $P > 0.05$ and $P \leq 0.11$.

RESULTS AND DISCUSSION

Experiment 1

Treatment × year interaction was not detected ($P > 0.10$) for any measurement. Initial BW at weaning and at the initiation of supplementation was similar ($P \geq 0.27$; Table 3) between treatments. In addition, heifer BW was similar ($P \geq 0.27$) at breeding and diagnosis of pregnancy. Likewise, Lalman et al. (1993) reported no differences in BW or ADG during supplementation of prepuberal heifers with supplements comparable to treatments in this study. However, Silva et al. (1995) reported BW gain and increased ADG in heifers fed a RUP supplement compared with heifers fed a RDP supplement.

Heifers fed 50RUP had greater ($P = 0.04$; Table 3) pregnancy rates than 36RUP heifers. Likewise, Martin et al. (2007) reported an increase in AI conception rates with RUP supplementation in beef heifers compared with greater ruminal degradable supplement. Ruminally undegradable protein has been suggested to enhance pituitary release of LH and FSH (Bays et al., 1994), decrease GH (Hunter and Magner, 1988), and increase IGF-I (Strauch et al., 2001) and insulin (Petersen et al., 1992).

Economic Analysis. Effects of management decisions on profitability of cow/calf enterprises are illustrated by an enterprise budget (Table 4). Because all heifers were developed with the same protocol other than differences in type of protein supplementation before breeding, any differences found in the net return is expected to be caused by differences in pregnancy rates and cost of supplementation. Pregnancy rates were 13% greater for the 50RUP heifers than the 36RUP heifers, resulting in an increased total gross return for 50RUP heifers than 36RUP. However, development cost was greater for the 50RUP heifers by $12.09/heifer due to protein supplement cost differences. Nevertheless, net return ($/heifer) was $40.60/heifer greater for the 50RUP heifers compared with 36RUP.

Experiment 2

Heifer BW at weaning and at initiation of the supplementation period did not differ ($P \geq 0.97$; Table 5) among treatments. At breeding, DRYLOT heifers were heavier ($P < 0.01$) than 36RUP and 50RUP heifers due to increased ($P < 0.01$) ADG from initiation of the study to breeding. Likewise, overall ADG was greater ($P < 0.01$) in DRYLOT heifers than either 36RUP or 50RUP heifers. Heifers developed on pasture (36RUP and 50RUP) had greater ($P < 0.01$) ADG from the time of breeding to pregnancy diagnosis. Heifers developed on low-quality winter range may compensate for the minimal prebreeding ADG and gain more BW during the breeding season than heifers fed in a drylot due to decreased maintenance requirements and the ability to respond to a seasonal improvement in forage quality (Marston et al., 1995; Ciccioli et al., 2005).

Similar to BW, heifer hip height at initiation of supplementation was not different ($P = 0.29$; Table 5)

Table 4. Enterprise budget for cost and return from developing heifers on dormant, low-quality native range fed 2different protein supplements (Exp. 1)

Item	Treatment[1]	
	36RUP	50RUP
Gross return, $		
Nonpregnant heifers	15,958.80	9,721.60
Pregnant heifers	59,303.04	70,809.60
Total	75,261.84	80,531.20
Cost, $		
Heifer purchase cost at weaning	53,148.00	53,663.00
Heifer development cost		
Grazing	4,419.00	4,419.00
Supplement	3,561.60	4,256.00
Mineral and Salt	620.00	620.00
Total	61,748.60	62,958.00
Net returns, $	13,513.24	17,573.20
Net returns, $/heifer developed	135.13	175.73

[1]36RUP = 36% CP cottonseed meal base supplement fed 3 d/wk supplying 36% RUP; 50RUP = 36% CP supplement fed 3 d/wk supplying 50% RUP.

among treatments. However, hip height change from initiation of supplementation to breeding was greater ($P = 0.01$) in 36RUP and 50RUP heifers compared with DRYLOT heifers, resulting in a greater ($P < 0.01$) hip height at breeding in the 50RUP and 36RUP heifers. However, hip height change from breeding to pregnancy diagnosis and overall hip height change were greater ($P < 0.01$) in DRYLOT heifers. This increase in height from breeding to pregnancy diagnosis did not result ($P = 0.18$) in greater overall hip height in the DRYLOT heifers. Hip heights at pregnancy diagnosis were not different among the 3 methods; therefore, mature size was not expected to be impacted in heifers managed in a restricted environment. Previous research has reported that level of energy intake does not affect heifer hip height (Buskirk et al., 1995; Roberts et al., 2007). Dietary protein supplementation increased peak bone mass acquisition in energy-restricted growing rats (Mardon et al., 2009). Protein supplemented heifers grazing dormant forage may prioritize nutrients to skeletal growth instead of body composition (lean muscle and fat) growth. Initial BW to hip height ratio was similar ($P = 0.94$); however, when compared at breeding and at pregnancy diagnosis DRYLOT heifers had increased ($P \leq 0.01$) BW to hip height ratio. The difference found in BW to hip height ratio at breeding and pregnancy diagnosis was due to an increased BW in DRYLOT heifers because 50RUP and 36RUP had greater hip height at breeding and no difference at palpation. In agreement, Roberts et al. (2007) reported that heifers developed on a restricted diet had decreased BW to hip height ratio with no difference in hip height.

Recommended guidelines have been to achieve 60 to 65% of mature BW in beef heifers at breeding to optimize reproduction (Patterson et al., 1992). In contrast, Martin et al. (2008) reported that heifers achieving 50% of their mature size before a 45-d breeding season had pregnancy rates of 88.4%. Heifers BW at breeding were 51, 51, and 58% ($P < 0.01$; Table 5) of mature BW for 36RUP, 50RUP, and DRYLOT heifers, respectively. However, pregnancy rates tended to be greater ($P = 0.10$) in 50RUP heifers compared with DRYLOT and 36RUP heifers. In addition, calving date as a 2 yr old was not different ($P = 0.89$) between heifer development treatments. Previous research developing heifers at similar prebreeding target BW has reported pregnancy rates from 88 to 90% after a 60- (Funston and Deutscher, 2004) or 45-d breeding season (Martin et al., 2008), respectively. In addition, Funston and Larson (2011) reported no difference in final pregnancy rates between heifers developed in a drylot and those grazing corn residue or winter range. Thus, these studies indicate that heifers can be developed to a lighter target BW before breeding but maintain adequate pregnancy rates and thus effectively reduce developmental feed costs.

The greatest concern with developing heifers on a restricted diet with slow rate of BW gain is decreasing heifer pregnancy rates and increased calving difficulties that may result in decreased longevity and productivity in the cow herd. Lesmeister et al. (1973) indicated that nutritionally restricted heifers had decreased pregnancy rates and those that are bred generally calve later, which leads to a decrease in lifetime productivity. Moriel et al. (2012) suggested that replacement beef heifers consuming low-quality forages should receive low-starch energy supplements daily to enhance their reproductive development. However, developing heifers on lower levels of nutrient input (80% of ad libitum intake) has been suggested to improve efficiency and enhance longevity in the cow herd (Roberts et al., 2009b). Furthermore, results

Table 5. Growth and reproductive performance of heifers grazing native dormant range with protein supplementation (36RUP and 50RUP) or fed a growing diet in a drylot (Exp. 2)[1]

	Treatment				
Measurement	36RUP	50RUP	DRYLOT	SEM	*P*-value
BW, kg					
Weaning[2]	223	224	224	3	0.97
Initial[3]	255	256	255	3	0.98
Breeding[4]	276	276	315	4	<0.01
Pregnancy diagnosis[5]	402	393	403	5	0.24
ADG, kg/d					
Initial to breeding	0.27	0.26	0.69	0.02	<0.01
Breeding to pregnancy diagnosis	0.85	0.80	0.61	0.01	<0.01
Initial to pregnancy diagnosis	0.62	0.58	0.64	0.01	<0.01
Hip height, cm					
Initial[3]	116.64	116.38	116.13	0.53	0.80
Breeding[4]	120.88	120.80	118.49	0.46	<0.01
Pregnancy diagnosis[5]	124.76	123.80	124.82	0.56	0.32
BW:hip height ratio, kg/cm					
Initial[3]	2.19	2.20	2.19	0.02	0.94
Breeding[4]	2.28	2.28	2.65	0.01	<0.01
Pregnancy diagnosis[5]	3.20	3.16	3.21	0.02	0.14
Hip height change, cm					
Initial to breeding	4.27	4.42	2.34	0.30	<0.01
Breeding to pregnancy diagnosis	3.89	2.97	6.32	0.36	<0.01
Initial to pregnancy diagnosis	8.13	7.39	8.66	0.38	<0.01
Percentage of mature BW[6], %	51	51	58	0.62	<0.01
Reproductive performance					
Pregnancy rate, %	88	94	84	3	0.10
Calving date[7], Julian date	66	65	63	4	0.89

[1]36RUP = 36% CP cottonseed meal base supplement fed 3 d/wk supplying 36% RUP; 50RUP = 36% CP supplement fed 3 d/wk supplying 50% RUP; DRYLOT = corn silage diet fed in drylot to gain 0.68 kg/d.

[2]Late September/early October every year at 190 ± 5 d of age.

[3]Initiation of heifer development treatments occurring in Nov (2 of 4 yr) or Feb (2 of 4 yr).

[4]Early May.

[5]Late September/early October.

[6]Estimated percentage of mature BW at breeding.

[7]Calving date as 2 yr old.

of a 10-yr study (Hughes et al., 1978) suggest an advantage in retention rate of beef cows on a lower plane of nutrition (77% retention rate) compared with greater levels (63 and 67% retention rate for high and very high nutrition). In addition, Pinney et al. (1972) suggested that differences in retention rate are established rather early in the life of a cow and its longevity is maintained thereafter. In this study, heifers fed 50RUP tended to have greater retention rate in breeding yr 1 ($P = 0.10$; heifer pregnancy rate) and 2 ($P = 0.08$) whereas 50RUP had the greatest retention rate in breeding yr 3 and 4 than 36RUP and DRYLOT cows ($P < 0.01$; Fig. 1). Retention rates were similar for 36RUP and DRYLOT heifers from heifer development to breeding yr 4. A retention rate of cows around 42 and 41% after 4 breeding seasons in the DRYLOT and 36RUP heifers, respectively, can be considered low. If 4 yr of 80 to 90% pregnancy rate occur, retention rates of 40% can be very common, especially in the limited nutritional and high drought occurring environment as in the current study. Roberts et al. (2009b) also indicated that retention rate of heifers up to 5 yr of age can be as low as 40%. The retention differences between the current study and Hughes et al. (1978) are due to the criteria to cull a cow. Hughes et al. (1978) culled cows after not being pregnant for 2 consecutive breeding seasons; however, in the current study, cows were culled for failing to wean a calf, either from being nonpregnant or from losing a calf before weaning. Currently, there is limited data suggesting why heifers developed on a low-quality native range and fed a high RUP supplement has an increased retention rate up to 5 yr of age.

Table 6. Enterprise budget for costs and returns from each heifer development (Exp. 2)

	Treatment[1]		
Item	36RUP	50RUP	DRYLOT
Gross returns, $			
Nonpregnant heifers	6,576.96	3,214.08	8,799.04
Pregnant heifers	77,890.56	83,201.28	74,350.08
Total	84,467.52	86,415.36	83,149.12
Costs, $			
Heifer purchase cost	50,264.00	50,264.00	50,264.00
Developing ranch heifers			
Grazing	4,419.00	4,419.00	
Supplement	3,561.60	4,256.00	
Mineral and salt	620.00	620.00	
Developing feedlot heifers			
Freight			600.00
Feed			12,600.00
Yardage			2,800.00
Total	58,864.60	59,559.00	66,264.00
Net returns, $	25,602.92	26,856.36	16,885.12
Net returns, $/heifer developed	256.03	268.56	168.85

[1]36RUP = 36% CP cottonseed meal base supplement fed 3 d/wk supplying 36% RUP; 50RUP = 36% CP supplement fed 3 d/wk supplying 50% RUP; DRYLOT = corn silage diet fed in drylot to gain 0.68 kg/d.

Economic Analysis. Developmental costs, fees, and values used in the enterprise budget are listed in Table 2. Differences reported in net return or profit are directly correlated with development feed cost and pregnancy rates. An enterprise budget comparing the 3 heifer development methods on their economic impacts is illustrated in Table 6. Gross returns were greatest for the 50RUP heifers and lowest in DRYLOT heifers, resulting from an increase in pregnancy rate for 50RUP. Feed costs for DRYLOT heifers were greatest compared with heifers developed on dormant forage. Therefore, with lower gross returns and greater feed costs, DRYLOT developed heifers had decreased net returns compared with 50RUP and 36RUP heifers. Net return was $99.71 and $87.18 per heifer greater for 50RUP and 36RUP, respectively, compared with DRYLOT. The increase in net return for pasture-developed heifers was due to increased pregnancy rates and decreased development costs. Likewise, restricting BW gain during development by limiting DMI (Roberts et al., 2009a) or developing to a lighter target breeding BW (Martin et al., 2008) also reported economic advantages in low-cost heifer development methods compared with developing heifers at greater rate of BW gain to achieve a certain BW. However, the additional benefit of increased retention rate was not considered in the enterprise budget, which would have further increased the revenue of developing heifers on pasture.

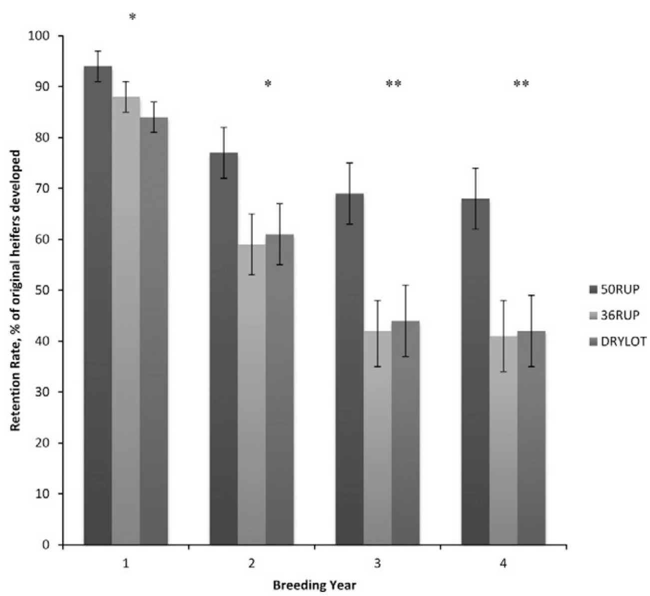

Figure 1. Retention rate of heifers grazing native dormant range with 2 types of protein supplementation (36RUP and 50RUP) or fed a growing diet in a drylot (Exp. 2). Values shown in breeding yr 1 are heifer pregnancy rates. Breeding yr 2 through 4 are a proportion of the original heifers treated that were remaining at end of breeding in yr 2, 3, and 4. Retention tended (*$P > 0.08$) to differ among treatments in breeding yr 1 and 2 but was greater for 50RUP than 36RUP and DRYLOT cows in breeding yr 3 and 4 (**$P < 0.01$). 36RUP = 36% CP cottonseed meal base supplement fed 3 d/wk supplying 36% RUP; 50RUP = 36% CP supplement fed 3 times/wk supplying 50% RUP; DRYLOT = corn silage diet fed in drylot to gain 0.68 kg/d.

In conclusion, heifers developed on native range fed high RUP supplements may increase retention and productivity with a lower cost of development. This study demonstrates that heifers can be developed at a slow rate of BW gain on semiarid rangelands with limited supplementation, which results in pregnancy rates similar to heifers in a moderate to high rate of BW gain. Developing heifers on native range with supplemental RUP enhanced retention rates based on reproductive success.

LITERATURE CITED

AOAC. 2000. Official methods of analysis. 17th ed. Association of Official Analytical Chemists, Gathersberg, MD.

Bays, T. R., D. E. Hawkins, and M. K. Petersen. 1994. Protein and exogenous insulin in postpartum beef cows: I. Effects on metabolic hormones and pituitary stores of LH and FSH. Proc. West. Sec. Am. Soc. Anim. Sci. 45:263–265.

Buskirk, D. D., D. B. Faulkner, and F. A. Ireland. 1995. Increased postweaning gain of beef heifers enhances fertility and milk production. J. Anim. Sci. 73:937–946.

Cattle Fax. 2008. US average heifer price. http://www.cattle-fax.com. (Accessed 2 November 2008.)

Ciccioli, N. H., S. L. Charles-Edwards, C. Floyd, R. P. Wettemann, H. T. Purvis, K. S. Lusby, G. W. Horn, and D. L. Lalman. 2005. Incidence of puberty in beef heifers fed high- or low-starch diets for different periods before breeding. J. Anim. Sci. 83:2653–2662.

Clanton, D. C., L. E. Jones, M. E. England. 1983. Effect of rate and time of gain after weaning on the development of replacement beef heifers. J. Anim. Sci. 56:280–285.

Forbes, A. C. 1999. Taxonomy of the flora of the Corona Range and Livestock Research Center. M.S. Thesis. New Mexico State University, Las Cruces, NM.

Funston, R. N., and G. H. Deutscher. 2004. Comparison of target breeding weight and breeding date for replacement beef heifers and effects on subsequent reproduction and calf performance. J. Anim. Sci. 82:3094–3099.

Funston, R. N., and D. M. Larson. 2011. Heifer development systems: Dry-lot feeding compared with grazing dormant winter forage. J. Anim. Sci. 89:1595–1602.

Hawkins, D E., M. K. Petersen, M. G. Thomas, J. E. Sawyer, and R. C. Waterman. 2000. Can beef heifers and young postpartum cows be physiologically and nutritionally manipulated to optimize reproductive efficiency?. J. Anim. Sci. 77:1–10.

Hughes, J. H., D. F. Stephens, K. S. Lusby, L. S. Pope, J. V. Whiteman, L. J. Smithson, and R. Totusek. 1978. Long-term effects of winter supplement on the productivity of range cows. J. Anim. Sci. 47:816–827.

Hunter, R. A., and T. Magner. 1988. The effects of formaldehyde-treated casein on the partitioning of nutrients between cow and calf in lactating *Bos indicus* × *Bos taurus* heifers fed a roughage diet. Aust. J. Agric. Res. 39:1151–1162.

Knox, L. A. 1998. The responses of beef cattle grazing native rangeland to management decisions. M.S. Thesis. New Mexico State University, Las Cruces, NM.

Lalman, D. L., M. K. Petersen, R. P. Ansotegui, M. W. Tess, C. K. Clark, and J. S. Wiley. 1993. The effects of ruminally undegradable protein, propionic acid, and monensin on puberty and pregnancy in beef heifers. J. Anim. Sci. 71:2843–2852.

Lesmeister, J. L., P. J. Burfening, and R. L. Blackwell. 1973. Date of first calving in beef cows and subsequent calf production. J. Anim. Sci. 36:1–6.

Lesperance, A. L., V. R. Bohman, and D. W. Marble. 1960. Development of techniques for evaluating grazed forage. J. Dairy Sci. 43:682–689.

Mardon, J., A. Trzeciakiewicz, V. Habauzit, M. Davicco, P. Lebecque, S. Mercier, J. Tressol, M. Horcajada, C. Demigné, and V. Coxam. 2009. Dietary protein supplementation increases peak bone mass acquisition in energy-restricted growing rats. Pediatr. Res. 66:513–518.

Marston, T. T., K. S. Lusby, and R. P. Wettemann. 1995. Effects of postweaning diet on age and weight at puberty and milk production of heifers. J. Anim. Sci. 73:63–68.

Martin, J. L., K. W. Creighton, J. A. Musgrave, T. J. Klopfenstein, R. T. Clark, D. C. Adams, and R. N. Funston. 2008. Effect of prebreeding body weight or progestin exposure before breeding on beef heifer performance through the second breeding season. J. Anim. Sci. 86:451–459.

Martin, J. L., A. S. Cupp, R. J. Rasby, Z. C. Hall, and R. N. Funston. 2007. Utilization of dried distillers grains for developing beef heifers. J. Anim. Sci. 85:2298–2303.

Moriel, P., R. F. Cooke, D. W. Bohnert, J. M. B. Vendramini, and J. D. Arthington. 2012. Effects of energy supplementation frequency and forage quality on performance, reproductive, and physiological responses of replacement beef heifers. J. Anim. Sci. 90:2371–2380.

National Agricultural Statistics Service. 2008. Lease prices of private land in New Mexico. http://www.nass.usda.gov. (Accessed 10 December 2008.)

NRC. 2000. Nutrient requirements of beef cattle. 7th rev. ed. Update 2000. Natl. Acad. Press, Washington, DC.

Patterson, D. J., R. C. Perry, G. H. Kiracofe, R. A. Bellows, R. B. Staigmiller, and L. R. Corah. 1992. Management considerations in heifer development and puberty. J. Anim. Sci. 70:4018–4035.

Petersen, M. K., D. M. Hallford, D. V. Dhuyvetter, D. Gambill, M. Ward, J. Cambell, E. Perez-Eugia, J. Rubio, and J. D. Wallace. 1992. The effects of supplemental feather, blood and/or cottonseed meal on metabolic hormones and serum metabolites in ewe lambs fed blue grama hay. Proc. West. Sec. Am. Soc. Anim. Sci. 43:560–654.

Pinney, D. O., D. F. Stephens, and L. S. Pope. 1972. Lifetime effects of winter supplementation feed level and age at first parturition on range beef cows. J. Anim. Sci. 34:1067–1074.

Roberts, A. J., T. W. Geary, E. E. Grings, R. C. Waterman, and M. D. MacNeil. 2009a. Reproductive performance of heifers offered ad libitum or restricted access to feed for a one hundred forty-day period after weaning. J. Anim. Sci. 87:3042–3052.

Roberts, A. J., E. E. Grings, M. D. MacNeil, R. C. Waterman, L. Alexander, and T. W. Geary. 2009b. Implications of going against the dogma of feed them to breed them. Proc. West. Sec. Anim. Sci. 60:85–88.

Roberts, A. J., S. I. Paisley, T. W. Geary, E. E. Grings, R. C. Waterman, and M. D. MacNeil. 2007. Effects of restricted feeding of beef heifers during the postweaning period on growth, efficiency, and ultrasound carcass characteristics. J. Anim. Sci. 85:2740–2745.

Silva, P. J., D. E. Hawkins, M. K. Petersen, and D. M. Hallford. 1995. The effects of ruminally undegradable intake protein and(or) fat on secretion of growth hormone and insulin in beef heifers. Proc. West. Sec. Amer. Soc. Anim. Sci. 46:510–513.

Strauch, T. A., E. J. Scholljegerdes, D. J. Patterson, M. F. Smith, M. C. Lucy, W. R. Lamberson, and J. E. Williams. 2001. Influence of undegraded intake protein on reproductive performance of primiparous beef heifers maintained on stockpiled fescue pasture. 2001. J. Anim. Sci. 79:574–581.

USDA USDA-NRCS. 2002. Ecological site description: Loamy [R070XC109NM]. http://esis.sc.egov.usda.govesdreport/fsReport.aspx?approved=yes&id=R070CY109NM. (Accessed 20 December 2009.)

Vallentine, J. F. 1990. Grazing management. Academic Press, Inc., San Diego, CA.

Van Soest, P. J., J. B. Roberston, and B. A. Lewis. 1991. Methods of dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 86:3583–3597.