Effect of postweaning heifer development system on average daily gain, pregnancy rates, and subsequent feed efficiency as a pregnant heifer

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ABSTRACT: A 3-yr study utilized 300 Angus-based, spring-born heifers to evaluate postweaning heifer development systems on gain, reproductive performance, and feed efficiency as a pregnant heifer. Heifers were blocked by BW and randomly assigned to graze corn residue (CR), upland range (RANGE), or were fed 1 of 2 diets in a drylot differing in energy levels: high (DLHI) or low (DLLO). Heifers developed on DLHI and DLLO were managed within the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3. Heifers developed on RANGE grazed winter range for an equivalent amount of days each yr as the DLHI and DLLO heifers. Heifers assigned to CR grazed for 103 d in yr 1, 84 d in yr 2, and 97 d in yr 3 before being transported to graze winter range for the remainder of the treatment period. All heifers were managed as a single group following the treatment period. Artificial insemination and natural mating were utilized during breeding. Percent of mature BW prior to the breeding season was greater ($P = 0.02$) for DLHI (67%) compared with RANGE (59%) and CR (58%). Pregnancy rates to AI were not different

($P = 0.51$) among treatments ($59 \pm 6\%$), and final pregnancy rates were also not different ($87 \pm 4\%$, $P = 0.54$). A subset of AI-pregnant heifers from each treatment were placed in a Calan gate feeding system. Heifers were allowed a 20-d acclimation period before beginning the 90 d trial at approximately 170 d in gestation. Heifers were offered ad libitum hay; amount offered was recorded daily and orts collected weekly. Initial BW was not different ($P = 0.58$) among treatments (459 ± 11 kg). Body weight at the end of the trial (497 ± 17 kg) was also not different ($P = 0.41$). Intake was not different ($P = 0.33$), either as DMI (10.00 ± 1.07 kg) or residual feed intake (0.018 ± 0.190). There was no difference in ADG ($P = 0.36$, 0.42 ± 0.23 kg/d) among treatments. Although the total development cost was not different among treatments ($P = 0.99$), there was a \$41 difference ($P < 0.01$) between the mean of the most expensive diet (DLHI) and the mean of the two least expensive diets (CR and RANGE). Developing heifers to a greater pre-breeding BW did not influence subsequent AI or overall pregnancy rates or feed efficiency as a pregnant heifer.

Key words: beef heifers, feed conversion, heifer development

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INTRODUCTION

Retaining and developing replacement heifers present a significant expense to the cow-calf producer, only surpassed by feed expense. Developing *Bos taurus* heifers to a 10% to 15% lower target BW than previously recommended has reduced development cost, without reducing pregnancy rate (Feuz, 1992; Clark et al., 2005). Previous research comparing corn residue and drylot systems demonstrated heifers in the drylot gained more during the development period than on

corn residue (Summers et al., 2014). However, heifers developed on corn residue experienced increased post-AI ADG on summer range compared with drylot-developed heifers. The difference may be due to compensatory gain or retained learned grazing behavior as suggested by Summers et al. (2014). Recently, greater emphasis has been made in selection of feed efficient animals. However, selecting for greater efficiency in heifers may negatively impact reproduction. Heifers with low residual feed intake (RFI) calve later in the calving season compared with high RFI heifers (Donoghue et al., 2011). Additionally, low RFI heifers demonstrated decreased conception and pregnancy rates (Basarab et al., 2011). However, other research reports no significant differences in pregnancy

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rates between high and low RFI beef cattle (Arthur et al., 2005; Basarab et al., 2007). Limited research has demonstrated the effect of heifer development system on feed efficiency as a pregnant heifer or the impact of restricted growth in confinement on subsequent performance to elucidate a compensatory gain vs. learned behavior response. Therefore, objectives of the current study were to compare effects of postweaning heifer development system on ADG and pregnancy rates, as well as subsequent feed efficiency as a pregnant heifer.

MATERIALS AND METHODS

The University of Nebraska-Lincoln Institutional Animal Care and Use Committee approved all procedures and facilities used in this experiment.

Postweaning Development

A 3-yr study conducted at the West Central Research and Extension Center (WCREC; North Platte, NE) utilized Angus-based crossbred, spring-born heifers. Heifers were received at WCREC each October ($n = 100/\text{yr}$) and allowed a 30-d acclimation period. After acclimation each year, heifers were blocked by BW and randomly assigned to 1 of 4 development treatments: graze corn residue (CR), graze upland range (RANGE), developed in a drylot consuming a high-energy diet (DLHI), or developed in a drylot consuming a low-energy diet (DLLO; Fig. 1). Each year, 25 heifers were assigned to a treatment, allowing for 75 heifers/treatment over the 3-yr study.

Heifers developed on CR grazed with pregnant heifers 100 km from WCREC on 1 corn residue field each year from mid-November and returned to WCREC mid-February to graze winter range. The irrigated CR field was approximately 40 ha and heifers were stocked at a rate of 2.5 heifer/ha during the grazing period. Fields were planted in April and harvested in October with an average annual yield of 12,544 kg/ha. Heifers grazed CR for 103 d in yr 1, 84 d in yr 2, and 97 d in yr 3. Weather dictated how many days were available for CR grazing each year. Following CR grazing, heifers were transported to winter range until the end of the treatment period. Corn residue heifers grazed winter range for 61 d in yr 1, 64 d in yr 2, and 63 d in yr 3.

Heifers developed on RANGE grazed winter range for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3. The stocking rate for RANGE heifers was approximately 0.70 heifer/ha with an average annual herbage production of 1,430 kg/ha. When grazing winter range or corn residue, each heifer received the equivalent of 0.45 kg/d of a 32% CP (DM), dried distillers grain-based supplement 3 times/wk containing 80 mg·animal⁻¹·d⁻¹ monen-

Figure 1. Time heifers grazed winter range (RANGE; black), grazed corn residue (CR; gray), were fed a higher energy drylot diet (DLHI; white), or fed a low energy drylot diet (DLLO; diagonal lines) during the 160-d treatment period (approximately mid-November to late April) between a 30-d receiving period and comingling in the drylot for estrous synchronization. Heifers on RANGE grazed winter range throughout the treatment period. Heifers on CR grazed corn residue for the first half of the treatment period and then were moved to winter range. Heifers on DLHI and DLLO were placed in the drylot for the duration of the treatment period.

sin (Rumensin; Elanco Animal Health, Indianapolis, IN) and vitamins and minerals with a 3.9 kg/d brome, rye, and prairie hay mixture (7.5% CP, 54.4% TDN, 0.58% Ca, 0.14% P) provided in times of deep snow. Range warm-season grass species consisted of little bluestem (*Schizachyrium scoparium* [Michx.] Nash.), big bluestem (*Andropogon gerardii* Vitman), side oats grama (*Bouteloua curtipendula* [Michx.] Torr.), blue grama (*Bouteloua gracilis* [Willd. ex Kunth] lag. Ex Griffiths), and switchgrass (*Panicum virgatum* L.). Primary cool-season grasses were Scribner's panicum (*Dichanthelium oligosanthos* [Schult.] Gould var. *scribnerianum* [Nash] Gould), western wheatgrass (*Agropyron smithii* Rydb.), and needle and thread (*Stipa comata* Trin. & Rupr.). Cheatgrass (*Bromus tectorum* L.), smooth brome grass (*Bromus inermis* L.), and Kentucky bluegrass (*Poa pratensis* L.) were introduced grass species.

The composition of the DLHI and DLLO diets for the duration of the study are shown in Table 1. Heifers assigned to DLHI and DLLO were fed according to their respective development treatment diet for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3. Drylot-high energy developed heifers were offered a diet formulated to target 65% of mature BW with DLLO developed heifers targeted to 60% of mature BW. Heifers assigned to DLHI received 1.31 kg/d wet corn gluten feed (WCGF) with 4.6 kg/d grass hay (DM), while DLLO heifers received 0.65 kg/d WCGF and 4.6 kg/d grass hay (DM). Mature BW was based on an average mature cowherd BW of 552 kg. Due to previous evidence of retained grazing behavior in corn residue and winter range-developed heifers, DLLO heifers were managed to mimic the ma-

ture BW of CR and RANGE heifers, thereby determining if DLLO heifers display a learned grazing behavior and similar performance postbreeding as previously documented (Funston and Larson, 2011; Summers et al., 2014). Heifers placed on the drylot treatments were fed once daily in the morning. Thirty-five d before AI, all heifers were combined, managed together, and received the DLHI diet in the drylot. Average daily gain during the development trial, post-development BW, and BW before breeding were measured.

Heifers were estrous synchronized using the megestrol acetate-prostaglandin $F_{2\alpha}$ (MGA-PG) protocol (Vraspir et al., 2013). Synchronization began in late April with each heifer receiving 0.5 mg/d MGA pellets in the diet (Zoetis, Florham Park, NJ) for 14 d. Nineteen days following MGA withdrawal, PG (25 mg, Lutalyse; Zoetis) was injected i.m. and estrous detection aids applied (Estroject; Rockway Inc, Spring Valley, WI). Heat detection followed for 5 d after injection twice daily from 0600 h to 0800 h and 1800 h to 2000 h. Heifers with greater than 50% of the Estroject coating removed were considered to have expressed estrus. Heifers in standing estrus were randomly AI by 3 technicians to 1 of 4 bulls approximately 12 h later; thus, AI sire was not included in statistical analysis. Heifers not expressing estrus received a PG injection 6 d following the first PG injection and placed with bulls. Inseminated heifers were combined with the non-AI heifers and bulls 10 d following AI on upland range at a 1:50 bull to heifer ratio for 60 d. Pregnancy diagnosis was conducted via transrectal ultrasonography (ReproScan, Beaverton, OR) 45 d following AI. Forty-five d after bull removal a second pregnancy diagnosis determined final pregnancy rate. Body weight was recorded at AI and final pregnancy diagnosis, and ADG during the breeding season was calculated. Calving rate and the proportion of heifers calving in the first 21 d was also recorded.

Pregnant Heifer Feed Efficiency

In mid-October, following final pregnancy diagnosis, a subset of randomly selected AI-pregnant heifers from each treatment were placed in a covered Calan Broadbent (American Calan, Northwood, NH) individual feeding system (CALAN). Three replicates utilized a total of 36 RANGE, 28 CR, 28 DLHI, and 23 DLLO heifers to evaluate AI-pregnant heifer feed efficiency. Heifers were allowed a 20-d acclimation period before beginning a 90-d trial at approximately gestational d 170. Initial acclimation period diet consisted of 15% WCGF and 75% grass hay (DM basis) ad libitum. During the acclimation period, WCGF was slowly removed from the diet until heifers were receiving only grass hay before the feeding trial. The efficiency period

Table 1. Drylot diet composition (DM basis) offered to replacement heifers

Ingredient, %	DLHI ¹	DLLO ²
Hay	74	83
Wet corn gluten feed	21	12
Heifer supplement ³	5	5

¹DLHI = heifers received a high-energy diet in the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3.

²DLLO = heifers received a low-energy diet in the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3.

³Supplement (DM basis) = ground corn (81.35%), limestone (11.11%), iodized salt (5.55%), trace mix (1.39%), Rumensin-90 (0.37%), and Vitamins A-D-E (0.22%).

began on gestational d 170 to allow time prior to the calving season. Pregnant heifers that did not acclimate to the Calan Broadbent feeding system were removed from the feed efficiency trial. Heifers were offered an ad libitum brome, rye, and prairie grass hay mixture (8.3% CP, 56.4% TDN, 0.62% Ca, 0.16% P, DM); individual amounts offered were recorded daily and orts collected by hand weekly. The chopped hay included water to control dust. Diet was tested for nutrient analysis 30 d following initiation of feed efficiency trial. Initial and final BW, ADG, DMI, RFI, and G:F were measured. Residual feed intake was calculated as actual DMI minus predicted DMI. Following the trial period, pregnant heifers grazed winter range. The remaining heifers in the study (STALK, $n = 185$) grazed corn residue throughout the fall. Body weight prior to calving was recorded. Calf birth BW, calving ease, calf vigor, dystocia, and calf sex was measured at parturition. A calving ease scoring system of 1 to 5 was utilized with 1 representing no assistance and 5 indicating a Caesarean section. Calf vigor was determined with a 1 to 5 scoring system where 1 referred to the calf nursing immediately and 5 signified dead on arrival. Dystocia rate was characterized as a calving ease score of 2 and greater. Proportion of bull calves was recorded as calf sex can influence dystocia rate (Summers et al., 2014).

Economic Analysis

Due to price fluctuations during this study, an average of prices from 2010 to 2014 was used for economic analysis. Heifer value was obtained for the wk heifers were received (USDA-AMS, 2015). Pasture values were calculated as half the cost of a cow-calf pair in the southwest region of Nebraska and obtained from the Nebraska Farm Real Estate Market Highlights (Johnson et al., 2010, 2011, 2013; Johnson and Van Newkirk, 2012; Jansen and Wilson, 2014). Wet corn gluten prices were obtained from the USDA-AMS for the third wk in September using Kansas City values

(USDA-AMS, 2015). Hay prices were also obtained for the third wk of September in the Platte Valley from the Nebraska and Iowa Hay report (USDA-AMS, 2015). Actual supplement costs, both drylot and cube, were used. Other expenses include interest (6.5% of heifer value), vaccine, yardage, trucking for CR heifers, breeding expenses, and other miscellaneous expenses. Cull values of nonpregnant heifers were obtained for the wk of final pregnancy diagnosis (USDA-AMS, 2015). The net cost of 1 pregnant heifer was calculated using the procedure defined by Feuz (1992). The value of 1, nonpregnant heifer was divided by 1 minus pregnancy rate to determine the value of cull heifers per pregnant heifer. This value was subtracted from the total development cost. Finally, the adjusted development cost was divided by pregnancy rate to determine the net cost of 1 pregnant heifer.

Statistical Analysis

Treatment (RANGE, CR, DLHI, and DLLO) within yr was considered the experimental unit, with development treatment fitted as a fixed effect to measure BW, ADG, and reproductive performance during and after the development treatment period. Therefore, 3 replications per treatment represented this study, and power tests were necessary for AI pregnancy rate and calving rate. Data were analyzed using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC). Pregnant heifer feed efficiency analyses included pen as a random effect to evaluate BW, ADG, DMI, RFI, and G:F. The interaction of development treatment $\times$ winter treatment was included in the initial model for assessing calving performance and first-calf characteristics. The interaction was not significant and thus removed from the model. A P -value ≤ 0.05 was considered significant, with P -values between 0.05 and 0.1 considered tendencies. Pregnancy rate, calving rate, pubertal status, the proportion of heifers that calved in the first 21 d, and sex of calves represent binomial distribution and were analyzed using an odds ratio. Least squares means and SE of the proportion were obtained using the ILINK function.

RESULTS AND DISCUSSION

Postweaning Development

Heifer BW, ADG, and reproductive performance are summarized in Table 2. During development, ADG was greater ($P = 0.01$) for DLHI heifers (0.75 ± 0.05 kg/d) compared with RANGE and CR (0.44 and 0.40 ± 0.05 kg/d, respectively) resulting in post-development BW differences where DLHI heifers were heavier than RANGE and CR heifers ($P = 0.01$), but not different from DLLO

heifers. At prebreeding, BW and percent of mature BW was greater ($P = 0.02$) for DLHI heifers compared with RANGE and CR heifers. Synchronization ADG from the start of MGA delivery to BW taken before breeding did not differ ($P = 0.44$) among treatments. Average daily gain following AI to the first pregnancy diagnosis was greater ($P < 0.01$) for RANGE and CR heifers when compared with DLHI heifers. Funston and Larson (2011) noted an increased ADG in the period between the first breeding service and final pregnancy diagnosis in extensively developed heifers when compared with drylot-developed heifers. Furthermore, the increased ADG in RANGE and CR heifers may be due to a learned grazing behavior in addition to compensatory gain. Perry et al. (2013) found heifers with less grazing experience to have lost BW the first week following AI when moved to graze forage. This is also supported by the response seen in the DLLO heifers where postbreeding ADG was less ($P < 0.05$) than CR heifers despite similar development ADG ($P = 0.16$) and prebreeding ($P = 0.26$) weights. Pregnancy rates to AI ($64, 57, 61, 45 \pm 8\%$; RANGE, CR, DLHI, DLLO; $P = 0.47$), and final pregnancy rates ($83, 87, 88, 91 \pm 4\%$; RANGE, CR, DLHI, DLLO; $P = 0.54$) did not differ. Due to the range in AI pregnancy values between RANGE and DLLO, a power test was conducted. To achieve a statistical difference in AI pregnancy rate between RANGE and DLLO heifers, an additional 3 yr with 25 heifers/treatment each yr would be necessary. Previous research has reported similar final pregnancy rates in heifers restricted in ADG postweaning (Funston and Deutscher, 2004; Martin et al., 2008). Although DLHI heifers had the lowest ADG following AI, BW at first pregnancy diagnosis was greatest ($P = 0.03$) for DLHI heifers compared with RANGE and CR. However, final pregnancy diagnosis BW was not different ($P = 0.16$) among treatments. Calving rate was not different ($P = 0.32$) among treatments; however, there is a numerical difference between RANGE and the other groups. Therefore, a power test was performed. To observe a detectable difference between RANGE and the other treatments, an additional 2 yr with 25 heifers per treatment each yr is needed. Eborn et al. (2013) reported similar pregnancy rates for heifers developed on high- or low-gain diets from 8 mo to d 21 of the breeding season. However, a greater proportion of high-gain heifers became pregnant in the first 21 d of the breeding period, whereas in the current study the proportion of heifers calving within the first 21 d did not differ ($P = 0.12$) among heifers.

Pregnant Heifer Feed Efficiency

Pregnant heifer feed efficiency data are reported in Table 3. In the feed efficiency trial, initial and final BW was not different ($P \geq 0.41$). Intake did not differ

Table 2. Effect of development system on heifer gain and reproductive performance

Item	RANGE ¹	CR ²	DLHI ³	DLLO ⁴	SEM	P-value
<i>n</i> ⁵	3	3	3	3		
Initial BW, kg	231	233	231	231	5	0.93
Post development BW, ⁶ kg	301 ^b	297 ^b	349 ^a	321 ^{a,b}	9	0.01
Development ADG, ⁷ kg	0.44 ^b	0.40 ^b	0.75 ^a	0.57 ^{a,b}	0.05	0.01
Prebreeding BW, kg	324 ^b	322 ^b	372 ^a	347 ^{a,b}	9	0.02
Percent of mature BW, ⁸ %	59 ^b	58 ^b	67 ^a	63 ^{a,b}	2	0.02
Synchronization ADG, ⁹ kg	0.63	0.69	0.62	0.69	0.07	0.44
AI pregnancy diagnosis BW, kg	364 ^b	365 ^b	394 ^a	376 ^{a,b}	6	0.03
Final pregnancy diagnosis BW, kg	432	432	455	437	12	0.16
Breeding ADG, ¹⁰ kg	0.77 ^{a,b}	0.83 ^a	0.44 ^c	0.58 ^{b,c}	0.13	< 0.01
AI pregnancy, %	64	57	61	45	8	0.47
Final pregnancy, %	83	87	88	91	4	0.54
Calving rate, ¹¹ %	73	84	81	85	5	0.32
Calved in first 21 d, %	82	69	76	56	11	0.12

¹RANGE = each heifer received the equivalent of 0.45 kg/d of a distillers-based supplement while grazing winter range for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 before entering the drylot for estrous synchronization and AI.

²CR = each heifer received the equivalent of 0.45 kg/d of a distillers-based supplement while grazing corn residue for 103 d in yr 1, 84 d in yr 2, and 97 d in yr 3 and winter range for 61 d in yr 1, 64 d in yr 2, and 63 d in yr 3 before entering the drylot for estrous synchronization and AI.

³DLHI = heifers were developed in the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 and through estrous synchronization and AI on a high-energy diet.

⁴DLLO = heifers received a low-energy diet in the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 and through estrous synchronization and AI.

⁵Represents number of replications; 1 yr = 1 replication.

⁶BW at the time of blood collection prior to estrous synchronization.

⁷ADG during the 160-d treatment period.

⁸Percent of mature BW at breeding based on mature cow size of 552 kg.

⁹ADG between estrous synchronization and prebreeding.

¹⁰ADG between prebreeding and first pregnancy diagnosis.

¹¹Percentage of heifers that calved.

^{a-c}Means in a row with different superscripts differ ($P \leq 0.05$).

either as DMI ($P = 0.33$) or as residual feed intake ($P = 0.74$). There was no difference ($P \geq 0.35$) in ADG or G:F among development treatments. Recent emphasis on genetic selection for feed efficient cattle in the feed yard has led to the discussion of increased feed efficiency in the cow herd. Although increased feed efficiency may reduce feed costs, reproductive performance could be compromised. In the current study, development treatment did not impact feed efficiency as a pregnant first-calf heifer. Future studies investigating how heifer development impacts lifetime feed efficiency and longevity are needed.

Calving Performance

Calving performance and first-calf characteristics are presented in Table 4. Precalving BW of pregnant heifers did not differ ($P = 0.34$) among development treatment; however, CALAN heifers had a greater ($P < 0.01$) precalving BW compared with STALK heifers during the winter treatment. Calf birth BW did not differ ($P = 0.35$) among development or winter treatments. Additionally, calving ease, calf vigor score, and dystocia rate were not different ($P \geq 0.44$) among treat-

Table 3. Effects of heifer development system on pregnant heifer feed efficiency measured from d 170 to 260 of gestation

Item	RANGE ¹	CR ²	DLHI ³	DLLO ⁴	SEM	P-value
<i>n</i> ⁵	3	3	3	3		
Initial BW, kg	450	454	467	463	11	0.58
Mid BW, kg	468	474	488	482	10	0.49
Final BW, kg	486	495	508	500	17	0.41
DMI, kg	9.76	10.00	10.20	10.03	1.07	0.33
ADG, kg	0.39	0.45	0.44	0.41	0.23	0.36
RFI, ⁶ kg	0.088	0.118	-0.058	-0.077	0.190	0.74
G:F	0.040	0.046	0.043	0.042	0.022	0.35

¹RANGE = each heifer received the equivalent of 0.45 kg/d of a distillers-based supplement while grazing winter range for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 before entering the drylot for estrous synchronization and AI.

²CR = each heifer received the equivalent of 0.45 kg/d of a distillers-based supplement while grazing corn residue for 103 d in yr 1, 84 d in yr 2, and 97 d in yr 3 and winter range for 61 d in yr 1, 64 d in yr 2, and 63 d in yr 3 before entering the drylot for estrous synchronization and AI.

³DLHI = heifers were developed in the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 and through estrous synchronization and AI on a high-energy diet.

⁴DLLO = heifers received a low-energy diet in the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 and through estrous synchronization and AI.

⁵Represents number of replications; 1 yr = 1 replication.

⁶Residual feed intake.

Table 4. Effect of heifer development system and winter treatment on calving performance and first calf characteristics

Item	Development Treatment				SEM	P-value	Winter Treatment		SEM	P-value
	RANGE ¹	CR ²	DLHI ³	DLLO ⁴			STALK ⁵	CALAN ⁶		
n ⁷	3	3	3	3			3	3		
Precalving BW, kg	460	465	483	469	15	0.34	477	497	6	< 0.01
Calf birth BW, kg	31.4	30.5	31.9	31.4	0.6	0.35	31	31	0.5	0.75
Sex of calves, % bulls	51	53	58	50	7	0.80	50	57	5	0.26
Calving ease ⁸	1.14	1.24	1.20	1.24	0.08	0.81	1.22	1.19	0.05	0.59
Calf vigor ⁹	1.15	1.27	1.25	1.16	0.1	0.72	1.22	1.19	0.07	0.74
Dystocia, ¹⁰ %	11	18	18	16	5	0.71	17	14	3	0.44

¹RANGE = each heifer received the equivalent of 0.45 kg/d of a distillers-based supplement while grazing winter range for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 before entering the drylot for estrous synchronization and AI.

²CR = each heifer received the equivalent of 0.45 kg/d of a distillers-based supplement while grazing corn residue for 103 d in yr 1, 84 d in yr 2, and 97 d in yr 3 and winter range for 61 d in yr 1, 64 d in yr 2, and 63 d in yr 3 before entering the drylot for estrous synchronization and AI.

³DLHI = heifers were developed in the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 and through estrous synchronization and AI on a high-energy diet.

⁴DLLO = heifers received a low-energy diet in the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 and through estrous synchronization and AI.

⁵STALK = each pregnant heifer received the equivalent of 0.45 kg/d of a distillers-based supplement while grazing corn residue following pregnancy diagnosis.

⁶CALAN = AI-pregnant heifers placed in Calan Broadbent individual feeding system and offered ad libitum hay following pregnancy diagnosis.

⁷Represents number of replications; 1 yr = 1 replication.

⁸Calving ease scoring system: 1 = no assistance, 2 = easy pull, 3 = mechanical pull, 4 = hard mechanical pull, and 5 = Caesarean section.

⁹Calf vigor scoring system: 1 = nursed immediately, 2 = nursed on own, took some time, 3 = required some assistance to suckle, 4 = died shortly after birth, and 5 = dead on arrival.

¹⁰Percentage of females with a calving ease score of 2 or greater.

Table 5. Economic analysis of heifer development systems using averaged prices from 2010 to 2014

Item	RANGE ¹	CR ²	DLHI ³	DLLO ⁴	SEM	P-value
Heifer value, \$/heifer	876	876	877	877	138	1.00
Feed cost						
Receiving diet, ⁵ \$/heifer	32	32	32	32	3.43	1.00
Treatment diet, \$/heifer	113 ^a	109 ^a	152 ^b	137 ^c	4.87	< 0.01
Summer pasture, ⁶ \$/heifer	68	68	68	68	3.69	1.00
Other expenses ⁷ , \$/heifer	311	319	311	311	8.96	0.91
Total development cost ⁸	1401	1404	1440	1425	152	0.99
Less: cull heifer value	228 ^a	127 ^b	100 ^{b,c}	69 ^c	19	< 0.01
Net cost	1173	1277	1340	1356	137	0.77
Net cost per pregnant heifer, ⁹ \$	1420	1413	1447	1432	150	1.00

¹RANGE = each heifer received the equivalent of 0.45 kg/d of a distillers-based supplement while grazing winter range for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 before entering the drylot for estrous synchronization and AI.

²CR = each heifer received the equivalent of 0.45 kg/d of a distillers-based supplement while grazing corn residue for 103 d in yr 1, 84 d in yr 2, and 97 d in yr 3 and winter range for 61 d in yr 1, 64 d in yr 2, and 63 d in yr 3 before entering the drylot for estrous synchronization and AI.

³DLHI = heifers were developed in the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 and through estrous synchronization and AI on a high-energy diet.

⁴DLLO = heifers received a low-energy diet in the drylot for 166 d in yr 1, 150 d in yr 2, and 162 d in yr 3 and through estrous synchronization and AI.

⁵Heifers received a common receiving diet for 30 d prior to the initiation of the treatments.

⁶Summer pasture was calculated as half the cost of 1 cow-calf pair.

⁷Other expenses included breeding expense, interest (6.5% of heifer value), yardage, trucking for CR heifers, vaccinations, and other miscellaneous health expenses.

⁸Comprises fixed and variable costs of initial heifer value, feed, supplement, transportation for CR heifers, and breeding.

⁹Calculated using the equation defined by Feuz (1992).

^{a-c}Means in a row with different superscripts differ ($P \leq 0.05$).

ments. The proportion of bull calves born did not differ ($P \geq 0.26$) across development or winter treatment.

Economic Analysis

Economic analysis for the 4 heifer development treatments are presented in Table 5. Heifers began development with the same value and receiving diet expense. Diet cost was different ($P < 0.01$) among treatments except for RANGE and CR, which were similar ($P = 0.56$). The most expensive diet, DLHI, and the mean of the 2 least expensive diets, RANGE and CR, differed by \$41/heifer. Summer pasture and additional expenses did not differ across treatments. Numerical differences in pregnancy rates and BW at pregnancy diagnosis caused cull heifer value to differ ($P < 0.01$) among treatments where RANGE heifers, with the numerically lowest pregnancy rate, had the greatest cull heifer value. These data differ from previous studies reporting similar cull heifer value with intensive and extensive heifer development systems (Funston and Larson, 2011; Summers et al., 2014). Numerically higher final pregnancy rates resulted in a lower cull value for DLHI and DLLO heifers. Net cost per pregnant heifer was not different ($P = 1.00$) among treatments using 5 yr average prices. This magnitude of difference in development cost was similar to previous data suggesting extensive development reduced cost by \$45 per pregnant heifer (Funston and Larson, 2011). The lack of statistical difference in the current study may be due to the extreme feed price fluctuation in the years (2010 to 2014) this experiment was conducted.

In the current experiment, heifer development system did not impact AI or final pregnancy rates. Development cost per pregnant heifer was not different among treatments. Pregnant heifer feed efficiency was not impacted by development system. Furthermore, wintering system as a pregnant heifer did not impact calving characteristics. These results indicate a variety of heifer development systems may be utilized with no detriment to pregnancy rates, feed efficiency as first-calf heifers, or first-calf calving characteristics.

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