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EFFECT OF DEVELOPMENT SYSTEM ON GROWTH AND REPRODUCTIVE PERFORMANCE OF BEEF HEIFERS

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Introduction

Traditionally, replacement heifers have been developed to reach 60 to 65% of their mature body weight (BW) (Wiltbank et al. 1966; Short and Bellows 1971) by the onset of the breeding season (reviewed by Patterson et al. 1992). This approach has been used over several decades, primarily by feeding heifers in intensive drylot systems to achieve or exceed a target BW, in order to maximize heifer pregnancy rates. Recently, alternative extensive systems that use less feed and rely on compensatory gain have been evaluated (Funston and Deutscher 2004; Roberts et al. 2009). Other studies have demonstrated that heifers reaching less than 58% of mature BW by breeding do not display impaired reproductive performance (Martin et al. 2008; Funston et al. 2012; Mulliniks et al. 2012). In today's beef industry, exceeding heifer maintenance and gestation nutrient requirements will increase overall development costs and reduce net returns for beef producers. In western Canada, beef producers are moving from conventional drylot, where cattle are housed in pens during winter months, to the adoption of extensive wintering grazing systems (Van De Kerckhove et al. 2011; Kelln et al. 2011: Krause et al. 2013). The most commonly used extensive grazing system in western Canada is grazing forage bales in field paddocks (Kelln et al. 2011). The objectives of this study were to evaluate the effects of developing heifers to a pre-breeding target BW of 55% or 62% of mature BW, and managing heifers post-weaning in an extensive bale grazing system or drylot pen on estimated dry matter intake, heifer performance and reproductive efficiency, first- and second-calf performance and economic analysis.

Development System Management

The study was conducted at the Western Beef Development Centre located at Lanigan, Saskatchewan. Over two years, spring-born Black Angus heifers (n=174) were weaned (late October) approximately 21 days (d) before being randomly allocated by age and BW to 1 of 4 replicated (n=2) heifer development systems; (1) moderate gain (**MG**), fed to reach 775 lb at breeding (55% of mature BW) in an extensive bale grazing (**BG**) system; (2) moderate gain (55% of mature BW) in an intensive drylot (**DL**) feeding system; (3) high gain (**HG**), fed to reach 874 lb at breeding (62% of mature BW) in an extensive BG system; and (4) high gain (62% of mature BW) in an intensive DL feeding system; the high gain DL being a traditional system for developing replacement beef heifers in western Canada. Mature cow BW was calculated using adjusted dam BW and historical cow BW (1410 lb) from cows 5 years and older within the main WBDC herd.

The bale grazing site assigned for extensive grazing was divided into four (325×325 ft) paddocks located opposite each other with a centralized winter watering system. Two portable windbreaks (32×52 ft each) were supplied in each paddock for wind protection. Each replicated (n=2) BG paddock was where grass-legume [smooth bromegrass (*Bromus inermis* L.)-alfalfa (*Medicago sativa* L.)] round hay bales were set out on and heifers grazed the bales in field paddocks, with access to feed restricted for a 3 d period using portable electric fence. The intensive DL pen system was located 0.5 mile away where either MG or HG heifers were housed in four outdoor pens (165 × 400 ft) and fed grass-legume [smooth bromegrass (*Bromus inermis* L.)-alfalfa (*Medicago sativa* L.)] round bale hay in circular bale feeders, as the round bale is the most common method for preserving winter feed in western Canada. Each replicated (n = 2) DL pen was surrounded by wooden slatted fences with 20% porosity fencing and contained an open-faced shed (cattle shelter) and a round bale feeder and water was supplied to each pen in troughs.

All heifers received smooth bromegrass-alfalfa hay (56.9% TDN; 9.8% CP) as the base forage, along with supplemental barley (*Hordeum vulgare*) grain (85.1% TDN; 12.3% CP) as an energy source to reach the desired target BW pre-breeding. Daily supplemented barley grain was offered (1.5 to 5.0 lb/d depending on targeted gain). All heifers also had *ad libitum* access to a commercial 2:1 mineral supplement and cobalt-iodized salt over the course of the trial. Measures of BW were taken over two consecutive days at the beginning (November 12) and end (June 2) of the winter feeding (development) 202 d period. Heifer BW was also measured every 14 d during the winter, and feed amounts were adjusted to obtain the desired targeted BW gains. Ultrasound measurements of subcutaneous body fat (rib fat; mm) and *longissimus dorsi* area fat (rump fat, mm) were determined by a trained technician at the start and end of the development period using an Aloka 500V real-time ultrasound machine (3.5 MHz; Aloka Inc., Wallingford, CT) equipped with a 17-cm linear array transducer. Forage and supplement amounts offered to heifers during the winter feeding period were recorded for each group.

Heifers were moved from winter grazing (BG) sites or wintering (DL) drylot pens on June 2 and placed on summer pasture prior to breeding. Heifers were exposed to fertile Angus bulls for a 63 d breeding season at a ratio of one bull to 25 heifers. During the breeding season and until pregnancy diagnosis (October), heifers were managed as a single group on mixed (crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.; smooth bromegrass (*Bromus inermis* Leyss.) grass pastures. For the period from pregnancy determination to calving, pregnant heifers grazed in field paddocks on swathed barley (69.3% TDN; 10.8% CP) from November 1 to February 15, followed by drylot feeding free choice grass-legume hay (86.6% DM, 9.7% CP, 58.5% TDN) with a daily supplemented range pellet (6 lb/d; 13.6% CP, 79.5% TDN) from February 15 to May 30. The winter and calving diets were designed to meet NRC (1996) recommended protein and energy requirements for pregnant beef heifers similar to the animals used in the current study.

Reproductive data collected included pregnancy rate, calf birth weight and calving date. Body weight and body condition score (1 to 5 scale) of the first-calf heifers was also recorded at calving. The 2-yr old cows were exposed to bulls for 63 d at the end of June for re-breeding. At the end of September, 2nd pregnancy diagnosis was performed and calves were weaned. All pregnant 2-yr old cows were managed together. Birth, weaning, reproductive, and calving data for 2nd pregnancy, were collected similar as the first year.

Results, Discussions, and Recommendations

Forage Intake and Heifer Performance

Hay intake was lower for heifers bale grazing (10 lb/d), compared with heifers in the drylot (11.7 lb/d) system, whereas MG heifers had greater hay intake (11.5 lb/d), compared with HG heifers (10.4 lb/d) (**Table 1**).

Table 1. Average forage and supplement intake (lb/d, DM basis)

	MG[1]		HG	
Item	BG[2]	DL	BG	DL
Mixed grass-legume hay	11.6	12.4	9.3	11.0
Barley grain	2.0	1.5	5.3	4.6

[1]Targeted BW; moderate gain = 55% of mature BW at start of breeding; high gain = 62% of mature BW at start of breeding season.
[2]BG = bale graze, heifers developed in field paddocks bale grazing and supplemented barley grain; DL = drylot, heifers developed in drylot pens and supplemented barley grain.

By design, MG and HG heifers were supplemented at different levels in BG or DL systems, which accounted for differences in DM intake (Table 1). According to the NRC (1996) a medium framed, 565 lb heifer, targeted to gain 1.2 lb/d, needs TDN and CP intakes of 7.7 and 1.3 lb/d, respectively with a total DMI of 13.5 lb/d. In the current study, calculated DM and nutrient intakes of all heifers targeted at either moderate or high gain were meeting NRC (1996) recommended requirements.

A review by Moore et al. (1999), on the effects of energy supplementation of cattle consuming forages *ad libitum*, concluded voluntary forage DMI was decreased when supplemented energy intake was greater than 0.7% of BW and forage TDN:CP ratio was less than seven. This was observed in the current study, where increased level of barley supplement to either BG or DL heifers resulted in a reduced DMI of mixed hay. The reduced forage intake observed in BG system may have been the combined effects of extreme cold temperatures, snow depth and naive animals. Studies conducted in Montana (Adams et al., 1986) and Saskatchewan (Kelln et al., 2011) revealed adverse weather can reduce both grazing activity and subsequent DMI for less-experienced animals. During February in the current study, snow depth was greater compared with the 30-yr average for the Lanigan area, potentially affecting accessibility to forage. Beef cattle in an extensive grazing system require 18 to 21% more energy than cattle fed in a drylot system because of the increased requirements associated with walking, environmental stress and activities involved in foraging (McCartney et al., 2004; Kelln et al., 2011; Kumar et al., 2012).

Heifer performance during winter and first pregnancy rates are presented in Table 2. There was no difference (P = 0.08) in initial BW between systems; however, differences were detected for winter ADG, pre-breeding BW, summer ADG and pregnancy diagnosis BW between MG and HG systems (**Table 2**). The targeted pre-breeding BW was based on an average mature BW of 1410 lb, and targeted to be 775 and 874 lb for MG and HG heifers, respectively. Heifers developed to 62% of mature BW gained approximately 0.4 lb/d more than heifers developed to 55% of mature BW (1.5 vs. 1.1 lb/d; **Table 2**) during the study. High gain heifers had greater final BW (1056 vs. 994 lb), compared with MG heifers (**Table 2**).

Table 2. Growth and reproductive performance of beef heifers from start of development period to first pregnancy diagnosis

	MG[1]		HG	
Item	BG[2]	DL	BG	DL
Initial BW, lb	565	555	558	554
Final BW, lb	787	771	875	873
ADG[3], lb	1.1	1.1	1.5	1.5
Pregnancy diagnosis BW, lb	998	989	1054	1058
Pregnancy diagnosis BCS	2.6	2.6	2.8	2.8
ADG[4], lb	2.0	2.0	1.5	1.6
1st pregnancy rate, %	84	88	91	85

[1]Targeted BW; moderate gain = 55% of mature BW at start of breeding; high gain = 62% of mature BW at start of breeding season.
[2]BG = bale graze, heifers developed in field paddocks bale grazing and supplemented barley grain; DL = drylot, heifers developed in drylot pens and supplemented barley grain.
[3]ADG during November to June (202 d) winter development period.
[4]ADG during June to September (117 d) summer grazing to pregnancy diagnosis.

Heifer 1st and 2nd Calving Performance

Heifer performance at first and second calving and reproductive data are presented in **Tables 2** and **3**. Animal performance from all development systems was similar for the first pregnancy rate (avg. 87%; **Table 2**), condition score (2.4; **Table 3**) at calving, calf birth weight (77 lb; **Table 3**), and calf 205-d weaning weight (501 lb; Table 3). In addition, 77 % of heifers from all treatment groups calved in the first 42 d of the calving season. Furthermore, the second calving cow body weight (1253 lb), percentage of MBW (89%), body condition (2.4), second pregnancy rate (avg. 95%), calving interval (380 d), and calf birth weight (avg. 86.9 lb) did not differ between cows treated by different nutrient level when they were heifers (**Table 3**). Majority of pregnant heifers (93%) of all treatment groups calved in the first 42 d of calving season. Overall, neither MG nor the extensive field grazing (BG) systems had a negative effect on heifer reproductive performance in first and second reproduction cycle in the current study. Other recent studies (Lynch et al., 1997; Funston and Larson, 2011) suggest less of a negative impact from delayed puberty on pregnancy rates. Evidenced by the finding in the current study, decreased winter BW gain of MG heifers in the extensive BG system resulted in greater BW gain during the breeding season (referred to as compensatory gain), which may explain overall pregnancy rates.

A major reason heifer reproductive performance has not been affected when developing to reduced percent of mature BW before breeding, may be related to genetic progress of beef heifers' age at puberty (Funston et al., 2012). Earlier studies have indicated heifers should exhibit 2 or 3 estrous cycles before the start of the breeding season, as Byerley et al. (1987), reported first estrus pregnancy rate was 21% lower compared with heifers bred on the third estrus.

The 63 d breeding season may have allowed more heifers to achieve puberty and become pregnant, however percentage of heifers pregnant after 45 d (98 and 95% for MG and HG, respectively (data not shown) of the breeding season in the current study, is similar to other studies where heifers were exposed to bulls for a 45 d breeding season (Martin et al., 2008).

Table 3. Growth, reproductive and calf performance of beef heifers from first calving through re-breeding as 2-yr-old cows

	MG[1]		HG	
Item	BG[2]	DL	BG	DL
Pre-calving BW, lb	1065	1074	1085	1112
Pre-calving BCS	2.4	2.3	2.4	2.4
1st calf birth BW, lb	78.1	77.0	76.0	77.6
1st calf 205-d weaning BW, lb	498	502	492	512
2nd pregnancy diagnosis BW[5], lb	1178	1219	1222	1224
2nd pregnancy rate, %	95	95	97	95
Cow BW, lb	1206	1280	1234	1291
Cow BW, % of MBW	85.9	91.2	87.9	92.0
Cow BCS	2.3	2.4	2.4	2.4
Calving interval, d	382	385	370	384
2nd calf birth BW, lb	86.9	88.4	89.7	82.9
2nd calf 205-d weaning BW, lb	592	606	579	586
Pregnancy diagnosis BW[5], lb	1295	1345	1305	1334
3rd pregnancy rate, %	94	94	90	97
3-yr-old retention, %	77.1	76.7	75.8	76.1

[1]Targeted BW; moderate gain = 55% of mature BW at start of breeding; high gain = 62% of mature BW at start of breeding season.
[2]BG = bale graze, heifers developed in field paddocks bale grazing and supplemented barley grain; DL = drylot, heifers developed in drylot pens and supplemented barley grain.

Neither the MG nor extensive BG systems had a negative effect on heifer reproductive performance during the first and second reproduction cycle in the current study. Calf birth BW in current study (77.6 lb) was slightly greater than the suggested birth BW (77.1 lb) for Angus breed cattle (NRC, 1996). High gain heifers had greater pre-calving BW than MG heifers, (1056 vs. 995 lb; SEM = 5.4), and a greater percent mature BW (78.3 vs. 75.5%; SEM = 0.74) at pre-calving. However, there was no difference for calf birth BW (1st or 2nd calf; Table 3) or proportion of heifers calving in first 21 d (data not shown). The proportion of heifers exposed to bulls that calved within the initial 45 d of the calving season was not affected by targeted BW, and was 78% for MG and 86% for HG heifers, with 82% of pregnant heifers from all development systems calved in the first 45 d of the first calving season. Heifers calving early during their first calving season have greater lifetime calf production than those calving late and are more likely to become pregnant sooner at 2 yr of age (Lesmeister et al., 1973). Heifer development treatment did not affect first calf pregnancy rate or number of heifers calving in the first 21 d, nor did it affect second calving performance of cows. Calf 205-d adjusted weaning weight (496 ± 11 lb) was not different between MG and HG heifers (Table 3). At weaning, first-calf heifer BW was similar between heifers previously developed in BG or DL, HG or MG systems (**Table 3**).

No system or targeted BW effects were detected for second calving, cow BW, BCS, or re-breeding performance measured parameters (Table 3). At second calving, cow BW (1253 ± 15 lb), percentage of MBW (89.2 ± 1.3%), second pregnancy rate (95.3 ± 6.7%), second calf birth BW (86.9 ± 1.3 lb), second calf 205-d adjusted weaning BW (589 ± 7 lb) and third pregnancy rate (93.8 ± 5.1%) were not different between cows exposed previously to the different development systems as heifers. The proportion of 2nd calvers exposed to bulls that calved within the initial 45 d of the calving season was not affected by development targeted BW, and was 88.1% for cows developed in MG and 96.8% for cows developed in HG system. Finally, the proportion of 2nd calvers exposed for breeding as yearlings remaining in the herd as pregnant 3-yr-olds was similar between systems, averaging 76.9 and 75.9% for MG and HG systems, respectively (**Table 3**).

Economic Analysis

The economic analyses of winter development from weaning to breeding are summarized in Table 4. Total costs were calculated using development system costs for feed, bedding, labour, equipment, depreciation, repair and manure for 2010 and 2011.

Table 4. Economic analysis of winter heifer development from weaning to breeding ($/heifer/d)

	Targeted BW[1]			
	Moderate gain		High gain	
Item	BG[2]	DL	BG	DL
Total feed cost	0.68	0.72	0.96	0.99
Labor	0.15	0.18	0.15	0.20
Other[3]	0.20	0.16	0.20	0.16
Manure cleaning	0.00	0.03	0.00	0.03
Total cost	1.03	1.09	1.31	1.38
Total development costs, 202 d	208.06	220.18	264.62	278.76
Average	214.12		271.69	

[1]Targeted BW (TBW); moderate gain = 55% of mature BW at start of breeding; high gain = 62% of mature BW at start of breeding season.
[2]BG = bale graze, heifers developed in field paddocks bale grazing and supplemented barley grain; DL = drylot, heifers developed in drylot pens and supplemented barley grain.
[3]Other = bedding, equipment, repairs and depreciation.

Total feed and daily costs were lower for the MG than the HG system. Comparatively, BG heifers had a small economic advantage (6% lower) over DL heifers during development. However, when compared over a 202 d development period, developing heifers in the HG system increased total costs $58/head (21% higher) mainly due to an increase in feed and labour costs (Table 4). Developing heifers to attain a target BW of 55% of mature BW is a practical method for reducing heifer development cost. This agrees with other studies (Funston and Deutscher, 2004; Roberts et al., 2009; Martin et al., 2008; Larson et al., 2011), who demonstrated that developing replacement heifers to lighter target BW ranging from 50% to 57% of mature BW before breeding, reduced development costs but had no negative effect on reproductive performance or subsequent calf performance. Funston and Larson (2011) reported developing heifers on corn residue or winter range, reduced development costs by $45/pregnant heifer. The advantages of developing heifers in extensive winter grazing systems are decreased stored feed requirements, direct deposition of manure nutrients on the wintering site and reduced yardage costs (Jungnitsch et al., 2011; Kelln et al., 2011).

Summary

The results of this study provides additional evidence post-weaning development of heifers to achieve 55% of mature BW before breeding does not affect reproductive performance during first and second calving compared with developing heifers to achieve 62% of mature body weight. Similarly, developing heifers to 55% of mature BW can save nearly $60 per heifer compared with developing to 62% in drylot. The study further suggests that bale grazing systems are viable alternatives to decrease ($12/head) heifer development cost. Nevertheless, environmental conditions (snowfall, temperature) may limit forage intake in winter bale grazing systems. Therefore, careful management and supplementation practices must be considered when using extensive grazing systems during the winter season in western Canada. Finally, this study which evaluates the influence of nutrition on heifer development contributes to the limited number of long term studies about the impacts of heifer development strategies on cow longevity.

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