Effect of Skeletal Frame Size and Forage-Based Stair-Step Development System On Growth and Reproductive Performance in Replacement Heifers

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Abstract

One hundred small (**SF**; n = 50; mature weight 1220 lbs) and large (**LF**; n = 50; mature weight 1470 lbs) frame heifers were developed to breeding weight with an extensive forage-based heifer development program designed for May-June calving. Energy was managed using a stair-step procedure in which dietary energy was restricted during the 209-day period from October weaning to early-May by grazing unharvested corn and corn residue plus supplemental average-quality hay. Dormant season energy restriction was followed by an elevated energy diet from grazing spring and early-summer crested wheatgrass pasture followed by an 85-day drylot growing/breeding period, when alfalfa and a co-product supplement were fed.

During the 209 day period between October weaning and early-May, ADG for the SF and LF heifers was 0.56 and 0.47 lb/day (P = 0.187). In May, when the heifers were moved to crested wheatgrass pasture, the SF heifers weighed 596 lb (49% of mature BW) and the LF heifers weighed 687 lb (47% of mature BW). By the start of the breeding season on August 11, the SF heifers weighed 705 lb (58% of mature BW) and the LF heifers weighed 841 lb (57% of mature BW). Based on the mature cow body weight of cows in the small and large frame cow herds at the Dickinson Research Extension Center, the SF and LF heifers were estimated to have attained 57.8 and 57.2% of their mature body weight by the start of the breeding season.

Following the 209-day restricted energy period after weaning, 18.0% of the SF heifers were pubertal and 40.0% of the LF heifers had reached puberty; however, by the start of the breeding season 93 days later, 90.0% of the SF heifers and 96.0% of the LF heifers had attained puberty based on progesterone assay.

Heifer growth, feed efficiency, and live animal carcass traits were measured during the 85-day growing and breeding period in drylot. Small framed heifers consumed 20.1% less feed than the LF heifers (P = 0.0008), but the amount of feed required/lb of gain did not differ (P = 0.406), and feed cost/lb of gain did not differ (P = 0.413). Ribeye area was greater among the LF heifers in May (P = 0.002) and October (P = 0.039), but the ratio of ribeye area/hundredweight was greater among the SF heifers in May (P = 0.079) and October (P= 0.027). Although feed efficiency was similar, the SF heifers consumed less total feed overall resulting in a drylot development cost that was 16.2% less than the LF heifers.

Breeding cycle pregnancy rates did not differ for 1st cycle (SF 62.0%; LF 70.0%), 2nd cycle (SF 16.0%; LF 10.0%), 3rd cycle (SF 8.0%; LF 4.0%), and total pregnancy percentage (SF 86.0%; LF 84.0%).

These data suggest that developing replacement heifers to 57-58% of mature body weight using a stair-step energy management regime grazing low and high quality forages can be used successfully to attain high first breeding cycle and total pregnancy rate in both SF and LF heifers.

Introduction

Heifer development methods vary from intense high energy nutrition management to extensive lower-cost lower-energy residue grazing, and a stair-stepped approach that manages dietary energy to create a compensatory flushing effect.

Traditional development procedures recommend that heifers be grown to attain 60-65% of mature body weight using high energy inputs and the premise that high pregnancy rates are dependent on early puberty onset (Short and Bellows, 1971), and multiple estrous cycles before breeding (Byerley et al., 1987). In previous research using the stair-step method, dietary energy is restricted resulting in low rates of gain for 6-8 weeks followed by a period of rapid growth rate for 6-8 weeks prior to onset of breeding, which has been shown to improve conception and pregnancy rates compared to constant rates of gain (Fox, et al., 1988; Patterson, et al., 1992; Marston, et al., 1995; Lynch et al., 1996; Poland and Ringwall, 2001). More recently, a less intense approach reduces the breeding target weight goal to 53-58% of mature cow body weight and utilizes lower-cost, lower-energy, winter range and corn residue grazing (Funston and Deutscher, 2004), and

Freely et al. (2011), reported that for *Bos Taurus* that the proportion of mature BW at puberty was 56-58%, and attainment of this proportion of mature BW was a better predictor of age at puberty than absolute weight or age.

Co-products, i.e. distiller's dried grains, barley malt sprouts, and wheat midds are readily available in North Dakota and can be used effectively in dietary energy management for heifer development, because co-products contain highly digestible fiber fractions, and high oil content in the case of DDGS. Distiller's dried grains with solubles are an excellent source of energy and undegradable intake protein (UIP), and the high unsaturated fat content of DDGS may provide a potential reproductive benefit independent of the energy contribution (Wiley, et al., 1991; Williams and Stanko, 1999).

The beef cattle industry is gradually moving toward a more moderate cow size; therefore, the purpose of this research was to evaluate the effect of a forage-based development system on the reproductive performance of small and large framed heifers using the principles of restricted and enhanced energy management.

Using the energy management principles of the stair-step system as a heifer development model, an extensive forage-based heifer development program was designed for small and large frame May-June calving heifers. The restricted energy environment was created grazing unharvested corn, corn residue and supplemental hay during the 209 day period between October 2010 (weaning) and May 2011. The compensating higher energy component of the stair-step system was created grazing spring and early-summer crested wheatgrass pasture until July, when heifers in the study were moved into drylot and fed an alfalfa/co-product supplement during breeding.

Materials and Methods

Animals and Treatments

The experimental protocol was approved by the North Dakota State University Animal Care and Use Committee.

One hundred heifer calves originating from two separate frame size cow herds were weaned the 2nd week of October 2010 and assigned to either small (**SF** ≤ 4.5 Frame Score) or large (**LF** ≥ 4.5 Frame Score) frame development groups.

Diets

During the 209 day period between weaning (October 2010) and May 10, 2011, the heifers were managed as a single group grazing unharvested corn and corn residue plus supplemental medium-quality hay. On May 10, the heifers were weighed off corn residue grazing and supplemental hay, and base-line ultrasound body measurements were collected. At the same time, the 1st of two bleedings for serum recovery were collected10 days apart from each heifer to determine the percentage of heifers that had attained puberty. After the two bleedings were completed, the heifers were moved to crested wheatgrass pasture until July 6, 2011 when the heifers were sorted into treatments and pen replicates for a 35-day heifer development feeding and 50-day breeding period. The 85 day feeding period was from July 6 to September 29, 2011 and breeding began on August 11 and ended September 29 for mid-May calving. The ad libitum diet consisted of 80.0% alfalfa hay (18.4% CP) and 20.0% of a co-product supplement (Table 1). The diet was calculated to provide the SF and LF heifers with 8.99 and 10.8 Mcal NEg/Day, respectively.

Data Collection and Assay Procedures

Measurements of heifer performance included changes in postweaning grazing growth, drylot breeding period growth performance, and feed efficiency. Non-invasive ultrasound was used to estimate changes in live animal carcass traits (ribeye area, ribeye area/cwt, 12th rib fat depth, and percent intramuscular fat) and reproductive performance.

The number of heifers cycling at the end of the wintering period and at the start of the 50-day breeding season on August 11 was based on the circulating progesterone concentration derived from two blood serum samples collected 10 days apart. Circulating concentrations of progesterone were analyzed in all serum samples using methodology described by Engel et al. (2008). Intra- and interassay CV for progesterone assays were 2.47 and 5.9%. A progesterone concentration greater than 1 ng/mL in either sample was interpreted to indicate attainment of puberty. Heifers in the study were bred naturally and breeding cycle pregnancy rate and overall pregnancy rate were determined using transrectal ultrasound cranial width measurement taken 30 days after the end of the 45-day breeding season.

Statistical Analysis

The data was analyzed using the generalized least squares MIXED analysis procedure of SAS (2002-2008). Main effects included dietary treatments and pen served as the experimental unit. During the higher energy drylot phase, each treatment group of 50 heifers consisted of 5 pen replicates of 10 heifers per replicate.

Results and Discussion

This heifer development evaluation was designed to take advantage of a lower input development system to evaluate the response among small frame (SF) and large frame (LF) heifers that were predicted to weigh 1220 and 1470 pounds as mature cows. Based on this historical mature body weight of cows in the Dickinson Research Extension Center herds, heifer weight at the start of breeding was estimated to be 57.8 and 57.2% for SF and LF heifers, respectively.

At weaning, SF heifers weighed 111 lb less than the LF heifers and during the 209 day wintering period, gain and ADG did not differ, and the weight differential between the two groups in May remained about the same, e.g. 91 lb (Table 2). Heifer growth during the wintering period was restricted naturally grazing lower quality corn residue, which was supplemented with average-quality hay. Winter gain and the percentage of heifers that had attained puberty by the end of the wintering period was low; however, while ADG did not differ (P = 0.187), a greater percentage of LF heifers had attained puberty (P = 0.0196) (Table 4).

After grazing crested wheatgrass for approximately 40 days following the second May bleeding, the heifers were confined in drylot on July 6 and fed alfalfa hay and the fiber-based co-product supplement shown in Table 1 as a flushing diet prior to and during the 50-day breeding period that began August 11. Progesterone assay at the start of the breeding season August 11 indicated that the percentage of heifers attaining puberty by the start of the breeding season was 90.0 and 96.0% for the SF and LF heifers, respectively. Energy restriction grazing low quality corn residue plus supplemental hay followed by grazing crested wheatgrass and alfalfa/co-product in drylot provided a high forage-based plane of nutrition that very effectively initiated the onset of puberty.

Heifer growth, feed efficiency, and live animal carcass traits measured during the drylot breeding period are shown in Table 3. Small framed heifers consumed 20.1% less feed than the LF heifers (P = 0.0008), but the amount of feed required/lb of gain did not differ (P = 0.406), and feed cost/lb of gain did not differ (P = 0.413).

Non-invasive live animal carcass traits measured with ultrasound are shown in Table 3. Ribeye area was greater among the LF heifers in May (P = 0.002) and October (P = 0.039), but the ratio of ribeye area/hundredweight was greater among the SF heifers in May (P = 0.079) and October (P= 0.027).

Development system reproductive performance, summarized in Table 4, was excellent for both frame size treatment groups and no differences were identified for 1st (P = 0.528), 2nd (P = 0.402), 3rd (P = 0.486), and total pregnancy rate (P = 0.622). The percentage of non-breeding heifers also did not differ (P = 0.622).

The results of this experiment agree with results reported by Funston and Deutscher, (2004), Martin et al., (2008), and Freetly et al., (2011) indicating that heifers reaching 55-57% of mature body weight by the start of the breeding season have similar pregnancy rates as heifers grown to 60-65% of mature body weight. In the present experiment, SF and LF heifers had identical reproductive performance. Although feed efficiency between the two frame size groups was similar, the SF heifers consumed less total feed overall resulting in drylot development cost that was 16.2% less than the LF heifers.

These data imply that a stair-stepped heifer development system that uses crop residues such as corn residue with supplemental hay as a way to naturally restrict energy, followed by elevated energy supplied by grazing spring and early summer crested wheatgrass, and a forage-based drylot breeding period can be used to obtain superior reproductive performance.

Table 1. Heifer Development System: Co-Product Supplement Composition and Nutrient Analysis

Composition		**Nutrient Analysis**		
Ingredient	**Dry Matter (%)**	**Nutrient**	**Dry Matter (%)**	**Mcal/lb**
Distillers Dried Grain	30.23	Dry Matter	89.41	-
Barley Malt Sprouts	30.00	Crude Protein	20.39	-
Wheat Midds	15.00	ADF	13.88	-
Soybean Hulls	7.75	NDF	36.65	-
Fat	7.5	TDN	86.49	-
Beet Molasses	5.00	Crude Fat	13.14	-
Sodium Phosphate	3.25	Fiber	11.85	-
Salt	0.75	Starch	5.99	-
Urea (281%)	0.35	Calcium	0.19	-
Trace Mineral Pre-Mix[a]	0.15	Phosphorus	1.56	-
Vitamin Pre-Mix[b]	0.025	NEm	-	0.939
		NEg	-	0.638

[a] Trace Mineral Content: Potassium, % 0.77, Sodium, % 1.33, Chloride, % 0.64, Magnesium, % 0.19, Sulfur, % 0.41, Manganese, ppm 169.13, Iron, ppm 103.22, Copper, ppm, 106.01, Zinc, ppm 377.64, Cobalt, ppm 1.81, Iodine, ppm 8.86.

[b] Vitamin Content: Vitamin E, IU/Lb 22.12, Vitamin A, IU 22.12, Vitamin D_3 2.21, Thiamine, Mg/Lb 1.98.

Table 2. Heifer Development System: Postweaning Growth: October 2010 to May 2011

	Small Frame	Large Frame	SE	P-Value
No. Heifers	50	50		
October 2010 Weaning to May 2011, Days	209.5	208.86	0.6571	0.5105
Mid-October 2010 Weaning Wt., lb	477	588	22.52	0.0019
May 10, 2011 Wt., lb	596	687	21.02	0.0027
Gain, lb	118.4	98.9	9.67	0.1914
ADG, lb	0.5644	0.4733	0.04464	0.1871

Table 3. Heifer Development System: Frame Size, Growth Performance, Feed Efficiency, and Live Animal Body Measurements

		Small Frame	Large Frame	SE	P-Value
Number of Heifers		50	50		
Heifer Frame Score		3.50	5.56	0.3314	<0.0001
Growth Performance:					
Drylot Feeding/Breeding Period (7-6 to 9-29), days		85	85		
Start Wt., lb		655	765	22.46	0.0013
Start Breeding (8-11), lb		705	841	24.33	0.0002
End Wt., lb.		813	944	28.68	0.0009
Gain, lb		158	179	8.63	0.0873
ADG, lb		1.86	2.11	0.1025	0.0872
Feed Efficiency:					
Alfalfa-Grass Hay (DM), lb		1379	1657	48.95	0.0008
Co-Product Supplement (DM), lb		392	471	13.73	0.0008
Feed/Heifer (DM), lb		1770	2128	62.76	0.0008
Feed/Head/Day (DM), lb		20.82	25.0	0.74	0.0008
Feed/Lb of Gain (DM), lb		11.19	11.85	0.476	0.4060
Feed Cost/Heifer, $		135.18	157.12	5.004	0.0248
Feed Cost/Day, $		1.5906	1.913	0.05613	0.0008
Feed Cost/Lb of Gain, $		0.8650	0.9102	0.0369	0.4126
Live Animal Ultrasound Body Measurements:					
Ribeye Area, cm	May	5.44	5.87	0.1386	0.0018
	Oct.	7.20	7.85	0.1574	0.0387
	Change	1.76	1.98	0.1136	0.187
Ribeye Area/Cwt, cm	May	0.916	0.856	0.0215	0.0797
	Oct.	0.887	0.833	0.0193	0.0272
	Change	-.0291	-.0236	0.01367	0.7787
May 12th Rib Fat Depth,	May	0.08640	0.09340	0.0113	0.6730
	Oct.	0.185	0.180	0.0079	0.631
	Change	0.09826	0.0866	0.01368	0.4759
May Intramuscular Fat, %	May	2.225	2.2026	0.007448	0.0652
	Oct.	3.22	3.13	0.129	0.591
	Change	0.995	0.927	0.1279	0.6758

Table 4. Effect of Frame Score on Reproductive Performance

	Small Frame	Large Frame	SE	P-Value
May 10 , 2011 Heifer Wt., lb	595.6	687.1	21.02	0.0027
% Heifer Cycling (Progesterone Assay)	18.0	40.0	7.55	0.0196
August 11, 2011 Heifer Wt., lb	704.9	841.1	24.33	0.0002
% Heifer Cycling (Progesterone Assay)	90.0	96.0	2.828	0.0705
Breeding Cycle Pregnancy:				
First Cycle	62.0	70.0	9.327	0.5275
Second Cycle	16.0	10.0	4.795	0.4021
Third Cycle	8.0	4.0	3.873	0.486
Total	86.0	84.0	5.566	0.6215
Open	14.0	16.0	5.566	0.6215

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