Effects of Metabolic Imprinting on Growth and Reproductive Performance of Early-weaned Beef Heifers[1]

P. Moriel[2], S. Johnson[3], J. Vendramini[2], M. Hersom[1], M. McCann[3], D. Gerrard[3], J. Arthington[2]

Metabolic imprinting increased growth performance and puberty rate, and hastened the age at puberty early-weaned beef heifers.

Summary

This study evaluated the effects of calf management following early weaning (EW) on growth and reproductive performance of beef heifers. On d 0, Brahman x British heifers (n = 40; body weight [BW] = 187 ± 37 lb; age = 69 ± 12 d) were stratified by age and BW, and randomly assigned to be normally-weaned on d 177 (NW), or 1 of 3 EW treatments: (1) EW and grazed on ryegrass pastures for 67 d then on bahiagrass pastures until d 177 (Ryegrass); 2) EW and limit-fed a high-concentrate diet in drylot until d 177 (Drylot); or 3) EW and metabolically imprinted by limit-feeding a high-concentrate diet for 94 d then grazed on bahiagrass pastures until d 177 (MI). Heifers were assigned to 1 of 2 pens per treatment. On d 177, heifers were grouped by treatment and grazed on bahiagrass pastures until the start of breeding season (d 335). Heifers on pastures were supplemented at 1.0 % BW until d 177 and 1.5 % BW from d 177 to 335. On d 177 and 335, Ryegrass heifers were lightest ($P < 0.01$) and Drylot heifers heaviest ($P < 0.001$) compared to all other treatments and NW and MI heifer BW did not differ ($P \geq 0.42$). Heifers placed on high-concentrate diets achieved puberty sooner ($P < 0.01$) than NW and Ryegrass heifers, with no differences ($P = 0.59$) on age at puberty between NW and Ryegrass heifers. On d 330, MI and Drylot treatments increased ($P = 0.002$) the percentage of pubertal heifers compared to NW and Ryegrass heifers, but did not affect ($P = 0.64$) the percentage of pregnant heifers. Thus, heifer management systems after EW result in significant differences on BW at the time of normal weaning and increased puberty achievement prior to the breeding season.

Metabolic imprinting is the process by which nutrition, during critical periods of life (such as, after early-weaning; EW), may permanently affect the metabolism and performance of livestock offspring (Lucas et al. 1998; Du et al., 2010). For example, placing early-weaned heifers (3 mo of age) on a high-concentrate diet increased the percentage of pubertal heifers prior to the beginning of the breeding season compared to heifers kept with the cows and normally weaned at 7 mo of age (Gasser et al., 2006). Little information exists related to management and nutrition of EW heifers, and its impact on reproductive performance. We hypothesized that a short period on a high-concentrate diet, following EW, would increase the reproductive performance of beef heifers. Therefore, our objectives were to evaluate the effects of nutrition, following EW, on growth and reproductive performance of beef heifers.

Materials and Methods

The study began on the day of EW (d 0; January 11, 2011), which corresponded with the start of the cow's breeding season. On d 0, 40 heifers (initial BW = 187 ± 37 lb; age = 69 ± 12 d) were stratified by age and randomly assigned to the normal weaning treatment (NW) on d 177, or to 1 of 3 EW treatments (n = 10 heifers/treatment). Normal weaning heifers remained with the cows without concentrate supplementation until d 177, whereas EW heifers remained in the cow pens for 7 d and were provided free choice access to stargrass hay, water and a preconditioning receiving ration (Purina; Land O' Lakes Purina Feed LLC, Gray Summit, MO: guaranteed analysis, as-fed:

[1]Department of Animal Sciences, University of Florida, Gainesville, FL
[2]Range Cattle Research and Education Center, University of Florida, Ona, FL
[3]Department of Poultry and Animal Sciences, Virginia Tech University, Blackburg, VA

14% crude protein, 2% non-protein nitrogen, 1.0% fat, 18% fiber, 0.75% Ca, 0.40% P, and 0.40% NaCl). Average consumption of preconditioning concentrate gradually increased and reached 2 lb/calf daily on d 7. On d 7, EW heifers were allocated to their respective treatments which consisted of 1) heifers grazed on ryegrass pastures for 67 d then on bahiagrass pastures until d177 (Ryegrass), 2) heifers limit-fed a high-concentrate diet in drylot until d 177 (Drylot), or 3) heifers metabolically imprinted by limit-feeding a high-concentrate diet for 94 d then grazed on bahiagrass pastures until d 177 (MI). Within each treatment, heifers were assigned to 1 of 2 pens or pastures (5 steers/pen or pasture).

During the drylot phase, MI and Drylot heifers were limit-fed a high-concentrate diet at 3.5% of BW (as-fed basis: 21% soybean hulls, 15.7% cottonseed meal, 15% cottonseed hulls, 8.8% wheat middlings, 8% dry distillers grains + solubles, 8% citrus pulp, 7.8% cracked corn, 7.8% corn meal, 5.4% soybean meal, 2% sugarcane molasses, 0.05% TM vitamins, 0.02% Vit E 50 and 0.04% Bovatec 90; dry matter basis: 23.7% crude protein, 38.6% neutral detergent fiber, 75% total digestible nutrients, 0.98% Ca and 0.63% P). Same concentrate offered in drylot was provided at 1% of BW from d 7 to 177 and 94 to 177 for Ryegrass and MI heifers, respectively. On d 177, heifers were grouped by treatment and allocated into 1 of 8 bahiagrass pastures, and supplemented at 1.5% of BW with same drylot concentrate until the end of the breeding season (d 390).

All heifers were weighed every 28 d following a 6-h period of feed and water withdrawal. During the breeding season (d 335 to 390), each treatment group was placed with 1 yearling bull. Bulls were rotated among treatments every 10 d. Further, blood samples from jugular vein were taken every 10 d from d 177 to 390, to determine the plasma concentrations of progesterone, and consequently, attainment of puberty. Heifers were considered to be pubertal if 2 consecutive samples had concentrations of progesterone equal or greater than 1.5 ng/mL.

Data was analyzed using the MIXED procedure of SAS. Monthly shrunk BW, percentage of pubertal and pregnant heifers, age at puberty and BW at puberty was tested for the effects of treatment using MIXED procedure of SAS. Pen (or pasture) was the experimental unit, whereas pen(trt) was used as a random effect. All means were separated using PDIFF and reported as Least Squares means

Results

From d 0 to 94, heifers limit-fed the high-concentrate diet (Drylot and MI) had greater ($P < 0.0001$) ADG, and consequently, were heavier than heifers grazed on pasture (Table 1). Gain to feed conversion rate of EW heifers placed on high-concentrate diets were about 0.23, indicating that EW calves can achieve highly efficient BW gain. Further, Ryegrass and NW heifers had similar ($P \geq 0.42$) ADG and BW on d 94, which supports previous results from our research group (Arthington, 2003). Also, no health problems were reported on calves following EW.

From d 94 to the time of normal weaning (177), when MI heifers were transferred from the feedlot to bahiagrass pastures and supplemented at 1% of BW, ADG decreased ($P < 0.01$) compared to Drylot heifers, but it was similar ($P = 0.83$) compared with Ryegrass heifers. During this period, NW heifers had greater ($P \leq 0.01$) growth performance compared to MI and Ryegrass heifers (Table 1). Consequently, Drylot heifers were heaviest and Ryegrass heifers lightest, whereas MI and NW heifers had similar BW on d 177 (normal-weaning). Therefore, placing EW calves on a high-concentrate diet for 94 d is a good alternative for calf management system following EW.

No treatment effects were detected on ADG from d 177 to 335. Therefore, at the start of the breeding season (d 335), Drylot heifers were still heaviest and Ryegrass heifers lightest, whereas MI and NW heifers were intermediate. However, MI and Drylot heifers achieved puberty sooner ($P \leq 0.01$) than NW and Ryegrass heifers, with no differences ($P = 0.59$)

on age at puberty between NW and Ryegrass heifers. This response was achieved despite the fact that MI and NW heifers had similar BW and ADG from d 177 to 335. Other researchers (Gasser et al., 2006) reported that EW heifers placed on high-concentrate diets following EW had enhanced follicular development and achieved puberty sooner than EW heifers fed diets to achieve lesser ADG.

Although MI heifers achieved puberty at older ages ($P < 0.01$) compared to Drylot heifers, the percentage of pubertal heifers at the start of the breeding season was similar ($P = 0.30$) between these treatments, but greater ($P \leq 0.04$) than NW and Ryegrass heifers. These results indicate that a 90-d period on high-concentrate diet, following EW, was sufficient to enhance reproductive performance of EW beef heifers. Further, it supports the concept of metabolic imprinting, by which nutrition early in life may permanently affect the metabolism and/or physiology of the animal.

No differences were detected ($P = 0.64$) on percentage of pregnant heifers following a 60-d breeding season, which can be attributed to the small number of heifers in each treatment.

In conclusion, the early-weaned, heifer management systems evaluated in this study resulted in differences in BW at NW and at the start of breeding season. Further, limit-feeding a high-concentrate diet for 90 d anticipated puberty achievement and increased the percentage of EW heifers cycling at the start of the breeding season.

References

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Table 1. Growth and reproductive performance of beef heifers developed on different calf management systems from the time of early weaning (d 0) until the time of normal weaning (d 177).

	Treatments[1]					
Item	NW	Ryegrass	Drylot	MI	SEM	*P*-value
BW[2,3], lb						
d 94	306[a]	297[a]	361[b]	376[b]	8.1	<0.0001
d 177	467[a]	392[b]	577[c]	476[a]	14.1	<0.0001
d 335	712[a]	643[b]	800[c]	720[a]	17.5	<0.0001
ADG[3], lb/d						
d 0 - 94	1.33[a]	1.23[a]	1.92[b]	2.07[b]	0.088	<0.01
d 94 - 177	1.94[a]	1.15[b]	2.58[c]	1.18[b]	0.125	0.001
d 177 - 335	1.52	1.60	1.36	1.54	0.058	0.15
Age at puberty, d	429[a]	418[a]	298[b]	358[c]	14.9	<0.0001
BW at puberty, lb	753[a]	674[b]	629[b]	643[b]	26.2	0.09
Pubertal heifers on d 335, % of total heifers	30[a]	40[a]	100[b]	80[b]	13.2	0.002
Pregnant heifers, % of total heifers[4]	60	50	78	70	15.6	0.64

[a,b]Whithin a row, means without common superscript differ ($P \leq 0.05$).

[1]NW = heifers remained with cows until the time of normal weaning (d 177); Ryegrass = heifers early-weaned on d 0, grazed on ryegrass pastures + concentrate supplementation at 1% of BW for 67 d, then grazed on bahiagrass pastures with concentrate supplementation at 1% of BW until d 177; Drylot = heifers early-weaned and limit-fed a high-concentrate diet (3.5% of BW) in drylot until d 177; and MI = heifers early-weaned on d 0, metabolically imprinted by limit-feeding a high-concentrate diet (3.5% of BW) for 94 d, then grazed on bahiagrass pastures with concentrate supplementation at 1% of BW until d 177.

[2]Shunk BW after a 6-h period of feed and water withdrawal.

[3]From d 177 to the start of the breeding season (d 335), heifers were grouped by treatment and rotated among bahiagrass pastures every 10 d, and were provided concentrate supplementation at 1.5% of BW.

[4]Determined by ultrasound scanning on d 480.