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CASE STUDY: Feed Intake and Performance of Heifers Sired by High- or Low-Residual Feed Intake Angus Bulls

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Case Study: Feed Intake and Performance of Heifers Sired by High- or Low-Residual Feed Intake Angus Bulls[1]

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ABSTRACT

The objective of this project was to investigate the effects of selecting sires for residual feed intake (RFI) on the performance of their daughters. Bulls with low or high estimated breeding values (EBV) for RFI were selected from the Angus Society of Australia sire summary and mated to Angus cross commercial cows at the Kansas State University Cow-Calf Unit in 2005 and 2006. The average EBV of low- and high-RFI bulls were −0.55 and 0.27 kg DM, respectively. Heifers born in 2006 were tested for feed intake in 2 groups ($n = 24$, $n = 26$), and heifers born in 2007 ($n = 42$) were sent to a commercial bull test facility for feed intake and BW gain tests. Body weights were collected every 14 d and used to calculate midtest BW and ADG. Actual feed intake was regressed on midtest metabolic BW and ADG to calculate an expected feed intake for each heifer. Residual feed intake was calculated by subtracting the expected intake from the actual intake. There were no significant differences between heifers sired by low- or high-RFI EBV bulls in RFI, feed intake, G:F, or BW gain ($P > 0.05$). Heifers in this study were being developed on a less energy-dense diet than the diet used to rank their sires. Genetic differences in RFI calculated in growing bulls may not have been expressed on the lower plane of nutrition of these developing heifers.

Key words: beef heifer, breeding value, residual feed intake

INTRODUCTION

Feed costs continue to be a large portion of the total expenses of a beef cattle operation. Much of the focus of genetic improvement in beef cattle has focused on improved quantity and quality of outputs of the production system, such as increased growth rate and carcass quality. Feed continues to be a major cost to the cow-calf, stocker, and feedlot sections of the industry, and there has been much recent interest in improving the feed efficiency of beef production.

Koch et al. (1963) first proposed using residual feed intake (**RFI**) as a measure of efficiency in beef cattle. Residual feed intake is defined as the difference between actual feed intake and predicted feed intake based on BW and growth. Animals with negative RFI eat less than is expected for their size and level of production, and are more efficient. Residual feed intake appears to be moderately heritable, with literature estimates for Angus cattle ranging from 0.39 to 0.51 (Arthur et al., 2001a; Moore et al., 2003, 2005). After one generation of selection in an Australian study, bulls, heifers, and steers from the high-RFI ($n = 27$) and low-RFI ($n = 30$) lines had differences in RFI ($P < 0.05$) and in actual intake ($P < 0.05$), showing response to selection in one generation (Herd et al., 1997; Richardson et al., 1998). The performance of animals selected for RFI has not been evaluated outside Australia, so the objective of this study was to investigate the effects of selecting for RFI on the feed efficiency and performance of beef heifers in a typical Midwestern US beef production system.

MATERIALS AND METHODS

This study was conducted under guidelines established by the Kansas State University Institutional Animal Care and Use Committee. In 2005 and 2006, Angus-based commercial cows at the Kansas State University

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Cow-Calf Unit were bred to Angus sires that had RFI estimated breeding values (**EBV**) published by the Angus Society of Australia (Armidale, New South Wales, Australia). The distribution of progeny by sire is shown in Table 1. The sires used had a combination of progeny with feed intake phenotypes and IGF-1 phenotypes. Accuracy of sire EBV ranged from 0.34 to 0.78 at the time they were used. One sire was used only in yr 1, whereas 4 sires were used only in yr 2, and 4 sires were used in both years. Heifers born in 2006 were tested in winter and spring of 2007 using Calan gates (American Calan, Northwood, NH) in 2 groups (n = 24, test 1; n = 26, test 2). In 2008, heifers that were born in 2007 were tested in the spring in a GrowSafe system (Airdrie, Alberta, Canada) in one group (n = 42, test 3). Heifers were removed from the study for failure to train to the equipment, morbidity, pregnancy, and death. After a 14-d adjustment period, feed intake was measured for 42 d, BW gain was measured for 58 d in 2007, and both intake and BW gain were measured for 57 d in 2008, following the recommendations of Archer et al. (1997) and Wang et al. (2006). These studies showed that 35 d was an adequate time to obtain accurate measurements of feed intake, whereas BW gain should be measured for approximately 60 d. In both years, heifers were allowed ad libitum intake of a high-roughage, complete diet [approximately 2.63 Mcal ME/kg DM (11.00 MJ ME/kg DM) in 2007 and 1.9 Mcal ME/kg DM (7.95 MJ ME/kg DM) in 2008]. Test 1 and 2 heifers were scanned by ultrasound for body composition at the end of the BW gain test. Residual feed intake was calculated by the method of Arthur et al. (2001b) within each test group. Body weights were collected every 14 d and used to calculate midtest BW and ADG. Actual DMI was regressed on midtest metabolic BW and ADG to calculate an expected DMI for each heifer. The model for expected feed intake was

$$y_i = b_0 + b_1ADG_i + b_2WT_i + e_i,$$

where ADG_i is the ADG of animal i, WT_i is the midtest metabolic BW of animal i, and e_i is the error. Expected DMI was calculated within each contemporary (test) group separately. Residual feed intake was calculated by subtracting the expected intake from the actual intake. Data were analyzed using SAS software (SAS Institute Inc., Cary, NC). The model for differences between high- and low-RFI sire groups included test group as a fixed effect and sire within RFI group as a random effect. For analysis of ultrasound traits, test group was a fixed effect, sire within RFI group was a random effect, and sire EBV for the ultrasound trait was included as a covariate. The model for regression of heifer RFI phenotype on sire RFI EBV included the fixed effect of test group. For both sire RFI EBV group and test group, Levene's test for homogeneity of variance was performed on RFI, ADG, DMI, and G:F. To further investigate the relationship between diet and RFI, the differences between sire groups were analyzed within test group. For analysis within group, sire within RFI group was included as a random effect.

Table 1. Sire residual feed intake (RFI) group (I = inefficient, E = efficient), estimated breeding value (EBV), and number of daughters

Sire	Sire RFI group	EBV, kg DM	Daughters, no.
1	I	0.29	18
2	I	0.26	10
3	I	0.30	3
4	I	0.31	21
5	I	0.19	4
6	E	−0.54	8
7	E	−0.72	7
8	E	−0.41	7
9	E	−0.51	14

RESULTS AND DISCUSSION

Least squares means for daily RFI, ADG, daily DMI, and G:F for the sire groups within test groups are shown in Table 2. There was no difference between the 2 lines for feed intake or RFI either within or across tests. The phenotypic variances between sire groups and test groups were equal ($P > 0.1471$) for RFI, ADG, DMI, and G:F (Table 3). The weighted averages of sire RFI EBV were 0.29 kg for inefficient sires and −0.40 for efficient sires. Therefore, we would expect the progeny groups from these sires to differ in RFI by 0.35 kg (difference in EBV divided by 2). The actual difference in phenotypic RFI between heifers sired by low- or high-RFI EBV bulls was 0.12 kg. The regression of heifer RFI on sire RFI EBV was 0.17 ± 0.32 kg. Theoretically, this value is expected to be 0.5 because half the breeding value of the sire is passed to progeny. These results are in contrast with previous results from the Australian selection experiment. After one generation of selection, they found significant differences ($P < 0.05$) in feed intake and RFI between high and low selection lines in bulls, heifers, and steers (Herd et al., 1997; Richardson et al., 1998). Herd et al. (1997) reported significant differences in intake, of 1,262 ± 25 kg for the low-RFI line and 1,354 ± 24 kg for the high-RFI line, and total RFI of −19 ± 10 kg for the low-RFI line and +49 ± 9 kg for the high-RFI line. Richardson et al. (1998) found significant differences in daily DMI, of 9.22 ± 0.18 for the low-RFI line and 9.78 ± 0.16 for the high-RFI line, and daily RFI of −0.20 ± 0.11 for the low-RFI line and + 0.17 ± 0.10 for the high-RFI line. There may be an effect of plane of nutrition and growth rate of the cattle on RFI. In the Australian stud-

Table 2. Least squares means for residual feed intake (RFI), ADG, daily DMI, and G:F for heifers by sire RFI group (I = inefficient, E = efficient) within and across test groups

Test and sire RFI group	n	RFI, kg/d	ADG, kg/d	DMI, kg/d	G:F, kg/kg
Test 1					
E	12	−0.37	1.46	10.05	0.150
I	12	0.47	1.55	10.82	0.146
P-value		0.2580	0.3344	0.3031	0.7975
Test 2					
E	9	0.03	0.98	12.31	0.079
I	17	−0.02	0.89	11.57	0.077
P-value		0.8888	0.6830	0.2702	0.9220
Test 3					
E	15	0.12	0.68	11.63	0.059
I	27	−0.17	0.70	11.46	0.061
P-value		0.5612	0.8434	0.7355	0.7796
All groups					
E	36	−0.07	1.02	11.30	0.095
I	56	0.05	1.06	11.26	0.096
P-value		0.6749	0.5210	0.9015	0.9113

ies, animals were on high-concentrate diets [10.5 MJ/kg DM (Herd et al., 1997) and 10.7 MJ/kg DM (Richardson et al., 1998)] and were on relatively high rates of BW gain (between 1.17 and 1.35 kg/d, depending on the study and group).

In this study during 2007, both test 1 and test 2 heifers were fed for a high rate of BW gain. However, test 2 was later in the year (immediately preceding breeding), and the heifers had reached a more advanced stage of maturity, as indicated by the ADG of 1.50 kg/d for test 1 and 0.93 kg/d for test 2. In 2008 (test 3), heifers were developed on a lower plane of nutrition and gained 0.69 kg/d. In test 1, when heifers were gaining faster, the results for RFI were more similar to those from the Australian selection experiment than in tests 2 and 3, in which the heifers had a slower rate of BW gain. It may be that RFI calculated on faster gaining animals on a higher plane of nutrition is not the same trait as RFI calculated on slower gaining animals on a lower plane of nutrition. This supports the results of other studies that have reported genetic correlations between RFI on growing rations and RFI on finishing rations of 0.59 ± 0.17 (Animal Genetics and Breeding Unit, 2007) and 0.55 (Crews et al., 2003), indicating that they are not the same trait. In addition, the Australian experiment was selecting both sires and dams for RFI. This study used commercial dams that were not selected for RFI.

There were no differences between sire RFI groups for G:F or ADG. Herd et al. (1997) also reported no difference between selection lines for ADG or G:F. Richardson et al. (1998) found no difference between lines in ADG, but the low- and high-RFI lines had significantly different feed conversion ratios, of 6.97 ± 0.23 kg/kg and 7.60 ± 0.20 kg/kg, respectively. Low- and high-RFI-sired heifers were similar for birth weight, adjusted weaning weight, and adjusted yearling weight ($P > 0.05$). Because RFI is calculated to be independent of growth, there should be no difference in growth potential between high- and low-RFI-sired heifers.

Least squares means for body composition traits of test 1 and 2 heifers by sire group are shown in Table 4. There were no differences between RFI groups for rump fat, rib fat, ribeye area, or intramuscular fat. In bulls and heifers, Herd et al. (1997) found no differences in rib fat or ribeye area between the low- and high-RFI lines. However, in steers, Richardson et al. (1998) found that low-RFI-line steers had less rib fat and ribeye area ($P < 0.05$), which is in contrast to the present results. Neither Herd et al. (1997) nor Richardson et al. (1998) measured intramuscular fat. The phenotypic correlations between heifer RFI and rump fat, rib fat, ribeye, and intramuscular fat were 0.01 ($P = 0.9312$), 0.13 ($P = 0.3761$), 0.16 ($P = 0.2712$), and 0.18 ($P = 0.2107$), respectively. Arthur et al. (2001a) and Robinson and Oddy (2004) both found a higher phenotypic correlation between RFI and rump fat, of 0.11. Similar correlations between RFI and rib fat in Angus cattle were reported by Arthur et al. (2001a; 0.14), Lancaster et al. (2006; 0.13), and Lancaster et al. (2008; 0.20). Literature reports of the phenotypic correlation between RFI and ribeye area in Angus cattle are inconsistent and are lower than

Table 3. Phenotypic variances for residual feed intake (RFI), ADG, daily DMI, and G:F for heifers by sire RFI group (I = inefficient, E = efficient) and by test groups

Item	n	RFI, kg^2/d	ADG, kg^2/d	DMI, kg^2/d	G:F, kg^2/kg^2
Sire RFI group					
E	36	1.42	0.16	2.39	0.0025
I	56	1.64	0.17	2.08	0.0016
P-value		0.7382	0.8023	0.7367	0.3308
Test group					
Test 1	24	2.27	0.04	2.35	0.0012
Test 2	26	0.54	0.07	1.40	0.0005
Test 3	42	1.82	0.05	1.98	0.0004
P-value		0.1471	0.4153	0.6042	0.1537

Table 4. Least squares means for rump fat, rib fat, ribeye area, and intramuscular fat for heifers by sire residual feed intake (RFI) group (I = inefficient, E = efficient)

Sire RFI group	n	Rump fat, cm	Rib fat, cm	Ribeye area, cm^2	Intramuscular fat, %
E	21	1.18	0.96	66.34	4.56
I	29	0.98	0.83	64.16	3.97
P-value		0.2260	0.2900	0.5104	0.2489

found in this study, ranging from −0.07 (Lancaster et al., 2006) to 0.09 (Lancaster et al., 2008). Similarly, phenotypic correlations between RFI and intramuscular fat in Angus cattle in the literature are small and inconsistent in direction, ranging from −0.09 (Lancaster et al., 2006) to 0.04 (Lancaster et al., 2008). Results from this study indicate that selection for RFI should not significantly affect fat, ribeye area, or intramuscular fat.

IMPLICATIONS

The lack of difference in RFI between heifers sired by high- or low-RFI EBV bulls in this study is in contrast to results found in previous studies. Although the number of observations in this study was somewhat limited, the RFI of high- and low-RFI EBV-sired heifers was virtually identical. This lends support to the idea that RFI measured on finishing cattle is not the same trait as RFI measured on growing or developing cattle. Beef breed associations and genomics companies are increasingly adopting RFI as a measure of feed efficiency for selection. It is important to understand the relationships between diet, growth rate, body composition, and RFI in heifers before producers invest in measuring cattle phenotypically or genomically for RFI. Estimated breeding values or EPD calculated from data on growing bulls may not result in better feed efficiency in developing heifers. More research is needed to better understand these relationships as selection for RFI becomes used more by the industry.

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