Reproduction of Heifers Sired by High or Low Residual Feed Intake Angus Bulls

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Introduction

Residual feed intake (RFI) has gained popularity as a selection tool for improving feed efficiency in beef cattle. RFI is the difference between what an animal consumes and what it is predicted to consume based on size and growth rate. Animals with low or negative RFI eat less than predicted and are more efficient. Although RFI is being used by the industry, research on the impact of selection for RFI on female fertility is lacking. The objective of this study is to evaluate the reproductive performance of heifers that have been selected for RFI.

Experimental Procedures

This study was conducted under guidelines established by the Kansas State University Institutional Animal Care and Use Committee. Angus-based commercial cows were bred to sires with high or low estimated breeding values for RFI as published by the Angus Society of Australia (Armidale, New South Wales, Australia) in two consecutive breeding seasons. Table 1 shows the sire estimated breeding value and the distribution of heifers by sire. Heifers born in 2006 were tested in two groups (Test 1 and Test 2) using Calan gates (Northwood, New Hampshire), and heifers born in 2007 were tested in one group (Test 3) using a GrowSafe system (Airdrie, Alberta, Canada). In all three tests, heifers were allowed a 14-day warm-up period to adjust to the equipment. Test 1 and 2 heifers were measured for feed intake for 42 days and for gain for 58 days. Test 3 heifers were measured for both feed intake and gain for 57 days. All heifers were allowed *ad libitum* consumption of a high roughage complete diet (approximately 2.63 Mcal ME/kg dry matter in for Test 1 and Test 2 and 1.9 Mcal ME/kg dry matter for Test 3). Heifers were synchronized and bred by artificial insemination (AI) one time then exposed to natural service sires. Diagnoses for pregnancy status were performed approximately 60 days after the breeding season. Heifers were determined to have conceived to first service (AI), to have conceived to natural service, or to be open at fall pregnancy check. RFI was calculated within each test group. Body weights were collected every 14 days and used to calculate mid-test body weight and average daily gain. Actual dry matter intake was regressed on mid-test metabolic body weight and average daily gain to calculate an expected dry matter intake 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 average daily gain of animal i, WT_i is mid-test metabolic body weight of animal i, and e_i is the error. Expected dry matter intake was calculated within each contemporary (test) group separately. RFI was calculated by subtracting the expected intake from the actual intake. Calving day was defined as the relative day of calving season when the heifer calved. For example, within year, the first heifer that calved received a calving day of 1, heifer(s) that calved the next day received a calving day of 2, and so on.

Effects of sire RFI-estimated breed value group

Pregnancy and first service pregnancy were analyzed as categorical variables, with test group within year, heifer's sire RFI group (efficient versus inefficient), service sire within year, and breeding treatment (synchronization protocol) as fixed effects and heifer birth date as a covariate. The model for analysis of calving day and age at first calving included fixed effects of test group within year, heifer's sire RFI group, service sire within year and breeding treatment, and random effect of heifer's sire. Heifer birth date was included as a covariate in the analysis of calving day, but not age at first calving. If age at first calving is adjusted for birth date of the heifer, it becomes the same trait as calving day. The model for analysis of calf birth weight included year, calf sex, calf sire within year, and dam's sire RFI group as fixed effects; dam's sire as a random effect; and dam's birth date as a covariate.

Effects of phenotypic RFI

The model to determine whether pregnant and open heifers had different phenotypic RFI included fixed effects of test within year, breeding treatment, service sire within year and pregnancy, and the covariate of heifer birth date. The continuous variables calving day, age at first calving, and calf birth weight were regressed on phenotypic RFI. For calving day and age at first calving, fixed effects included test within year, breeding treatment, and service sire of the heifer with covariates of heifer birth date and phenotypic RFI. For calf birth weight, fixed effects included year, calf sex, and calf sire within year with covariates of heifer birth date and phenotypic RFI.

To further examine the relationship of phenotypic RFI and other traits, heifers were divided into high and low groups based on their phenotype for RFI. The model to determine the relationship between phenotypic RFI group and pregnancy, first service pregnancy, and calving day included the fixed effects test within year, breeding treatment, service sire within year, and phenotypic RFI group with heifer birth date as a covariate. The same model was used to determine the relationship between age at first calving and RFI except that heifer birth date was not included. The model for calf birth weight included year, calf sex, calf sire within year, and phenotypic RFI group with heifer birth date as a covariate.

Results and Discussion

Effects of sire RFI-estimated breeding value group

Overall pregnancy rates and first service conception rates are shown in Table 2. Least squares means for calving day, age at first calving, and calf birth weight by sire RFI group are shown in Table 3. Heifers sired by efficient RFI bulls tended ($P<0.10$) to calve earlier in the season than heifers sired by inefficient RFI bulls. No difference occurred between sire RFI groups in age at first calving or calf birth weight.

Effects of phenotypic RFI

No difference was present in phenotypic RFI between heifers that were pregnant or open after first service or at the end of the breeding season ($P>0.70$). However, when first service conception rates and overall pregnancy rates of heifers with high and low phenotypic RFIs were compared, low (feed-efficient) RFI heifers tended to have lower first service conception rates (Table 4). Overall pregnancy rates were similar between heifers with high and low phenotypic RFI groups.

No correlation exists between calving day and age at first calving and phenotypic RFI of heifers (P>0.40). Calving day and age at first calving were similar between heifers with high and low phenotypic RFIs (Table 5). Calf birth weight and phenotypic RFI of the heifers were inversely related (-0.79; P<0.09), indicating a tendency for feed-efficient heifers to have heavier calves at birth. Phenotypic correlations between heifer RFI and calving day, age at first calving, and calf birth weight were small and insignificant (Table 6).

Implications

The beef industry is emphasizing selection for RFI as a method to improve feed efficiency. However, very little information exists about potential effects of selection for RFI on other traits, particularly in the female. In our study, pregnancy rates did not differ, but a favorable relationship emerged between RFI and calving date for calves sired by efficient sires. In contrast, a previous Australian study showed an unfavorable relationship. As more animals are measured and selected for RFI, further research should examine relationships between RFI and female fertility traits.

Table 1. Sire residual feed intake group[1], residual feed intake estimated breeding value, and number of daughters

Sire	Sire group	Estimated breeding value, lb	Daughters
1	I	0.64	18
2	I	0.58	10
3	I	0.66	3
4	I	0.69	21
5	I	0.42	4
6	E	-1.19	8
7	E	-1.58	7
8	E	-0.90	7
9	E	-1.06	14

[1] I = inefficient, E = efficient.

Table 2. Overall conception rate and first service conception rate for heifers sired by efficient residual feed intake (RFI) estimated breeding value bulls (E) and inefficient RFI estimated breeding value bulls (I)

Sire group	n	Overall conception rate, %	First service conception rate, %
E	36	77.8	38.9
I	56	82.1	48.2
P-value		0.89	0.84

Table 3. Number of animals and least squares means for calving day and age at first calving of heifers and birth weight of their calves by efficient residual feed intake (RFI) estimated breeding value bulls and inefficient RFI estimated breeding value bulls

Sire group	Calving day, days[a]	Age at first calving, days	Calf birth weight, lb
Number	55	55	79.2
Efficient	12.88	733.36	74.14
Inefficient	20.53	751.66	76.604
P-value	0.0964	0.21	0.48

[a] Calving day was defined as the relative day of the calving season when the heifer calved. See Experimental Procedures.

Table 4. Overall conception rate and first service conception rate for heifers that had high or low phenotypic residual feed intake (RFI)

RFI group	n	Overall conception rate, %	First service conception rate, %
High	46	82.6	52.2
Low	46	78.3	37.0
P-value		0.68	0.06

Table 5. Number of animals and least squares means for calving day and age at first calving of heifers, and birth weight of their calves for heifers that had high or low phenotypic residual feed intake (RFI)

RFI	Calving day, days[a]	Age at first calving, days	Calf birth weight, lb
Number	55	55	79.2
High	18.26	738.93	73.41
Low	18.51	744.94	77.31
P-value	0.95	0.34	0.17

[a] Calving day was defined as the relative day of the calving season when the heifer calved. See Experimental Procedures.

Table 6. Phenotypic correlations between heifer residual feed intake (RFI) and calving day, age at first calving, and calf birth weight

	Correlation (P-value) with phenotypic RFI
Calving day, days[a]	0.04 (0.78)
Age at first calving, days	-0.11 (0.42)
Calf birth weight, lb	-0.19 (0.27)

[a] Calving day was defined as the relative day of the calving season when the heifer calved. See Experimental Procedures.