

Impacts of heifer postweaning residual feed intake classification on reproductive and performance measurements of first, second, and third parity Angus beef females

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INTRODUCTION

Traditionally, feed efficiency in beef cattle has been expressed as the ratio of feed intake to body weight gained, expressed as feed to gain or gain to feed, but this measurement may be negatively correlated with average daily gain and mature size. As we select cattle that eat more and gain more, we are inadvertently selecting for cattle that often mature at a larger size, thus increasing our needed feed inputs in the future. In contrast, net feed efficiency (Byerly, 1941) or residual feed intake (RFI; Koch et al., 1963) is defined as the difference between an animal's actual feed intake and its expected feed requirements for maintenance and growth. RFI is calculated as the difference between actual feed intake and predicted feed intake with negative or smaller values being more desirable than positive or larger values (Crews, 2005). Cattle that are more efficient than their contemporary group have a lower RFI value with a feed intake being lower than predicted and cattle that are less efficient having a higher RFI value with feed intake being greater than predicted. RFI is an alternative measure of feed efficiency and is phenotypically independent of growth and body size. Crowley et al. 2010 reported that RFI is moderately heritable at 0.45, therefore selecting replacements for low RFI should produce energy-efficient cows and progeny.

However, there are questions related to the repeatability of RFI at different ages and stages of production and in different environments and on different diets (Manafiazar et al. 2015).

Most RFI studies have included energy-dense diets and rations focusing on feedlot performance (Lawrence et al., 2014) with limited published information pertaining to RFI in cattle offered forage-based diets (Arthur et al., 2005) and even fewer publications related to beef cows (Basarab et al., 2007; Meyer et al., 2008). Likewise, Manafiazar et al. (2015) suggest that more research is needed related to the lifetime performance of low and high RFI cattle.

The objectives of the following research were to evaluate the relationship of heifer postweaning RFI classification to subsequent cow performance data that includes reproductive efficiency as well as production traits that include cow body weight, body condition, and calf weaning weights in the absence of any selection pressure on RFI. We hypothesized that there is no difference between heifer postweaning RFI classification and reproductive performance and or production parameters in beef cattle through their third weaned calf.

MATERIALS AND METHODS

Black Angus females ($n = 347$; Table 1) from the Montana State University Northern Agricultural Research Center (NARC) located in Havre Montana were utilized for this study with RFI classification being the treatment. These females were managed

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as one contemporary group and are wintered at the NARC and summered at the Thackeray Ranch located south of Havre in the Bear Paw Mountains. All females were synchronized and time inseminated on 1 d in early June with exposure to cleanup bulls for an additional 45 d of natural service. Calves were weaned early fall, mid-September to mid-October, with dry pregnant cows remaining at the Thackeray ranch grazing dormant late season forages through early January. Weaned calves are returned to the experiment station to graze crop aftermath and dormant forages till the beginning of the GrowSafe residual feed intake trial beginning in late November. Following the GrowSafe intake trial heifer postweaning RFI was calculated and heifers were categorized as either low (>-0.50 SD from mean), or average (± 0.50 SD from mean) or high ($<+0.50$ SD from the mean) within year. After weaning, replacement heifers were used in a GrowSafe residual feed intake trial with a minimum of 70 d on trial with forage-based rations (GrowSafe DAQ 4000E; GrowSafe System Ltd., Airdrie, AG, Canada) and was covered under Montana State University AACUC #2017-AA12. Individual heifer postweaning RFI was calculated following previous parameters set forth by Archer et al. (1997) and Arthur et al. (2001). Heifers were categorized as either low (>-0.50 SD from mean) or average (± 0.50 SD from mean) or high ($<+0.50$ SD from the mean) within year. We analyzed lifetime performance categories comparing RFI classifications and production and reproduction parameters such as: birth, 205 d adjusted weaning and yearling weight, age and weight at first service breeding, Artificial Insemination (AI) vs. cleanup conception, pounds of calf weaned per year, annual body condition score, annual body weight, number of years in the herd and at what age and why each cow was culled. Females that were culled from the herd were categorized as either being culled for reproductive reasons (open) or other (structure, disposition, calf died, and cow died). All measured production and reproduction measurements were analyzed to see if RFI classification (low, average, or high), parity and

pregnancy number, and associated interaction are related or associated and which measurements are most related to RFI rankings.

Beef cattle production characteristics (e.g., calf birth and weaning weight, calf weaning weight ratio) were analyzed using ANOVA with a mixed model including RFI classification, cow cohort, calf number (parity) and the interaction of parity with RFI classification as fixed effects and individual cow as the random effect. Least square means were separated using pairwise comparison when $P < 0.05$. Data were plotted and log-transformed if needed to satisfy assumptions of normality and homogeneity of variance. Beef cattle reproductive characteristics eliciting a binomial response (e.g., conception rate) were analyzed using generalized linear models following a binomial distribution in an ANOVA framework. An alpha ≤ 0.05 was considered significant. All statistical analyses were performed in R (R Core Team, 2017).

RESULTS AND DISCUSSIONS

Julian birth day of heifers with differing RFI classification displayed both a linear ($P = 0.05$) and quadratic ($P = 0.02$) response with high RFI calves being born earlier in the calving season (71.2 vs. 75.3 d) than average RFI calves but not different than low RFI calves (Table 2). Calf birth weight (BW) differed relative to RFI classification ($P = 0.03$). In contrast, cow weights and body condition at weaning across three calf crops did not differ related to RFI classification ($P > 0.05$).

Parity number differed ($P < 0.01$) related to pregnancy weight (Table 3) with third parity pregnancy weights being heavier than second and first, and second parity pregnancy weights being heavier than first but lighter than third parity. Calf BW differed by parity ($P < 0.01$) with first parity BW being lighter than second and third parity BW. Calf adjusted 205 d weights differed by parity classification ($P = 0.03$) with adjusted 205 d weights being lighter in first parity females than second or third parity. Calf adjusted 205 d weaning weight ratio differed by

Table 1. Five years of cow cohorts with 5 years of cow data and 3 years of calf production ($n = 347$)

Year born	Yearling			Parity 1			Parity 2			Parity 3		
	Low	Ave	High	Low	Ave	High	Low	Ave	High	Low	Ave	High
2010	26	36	33	22	31	33	19	26	29	17	21	21
2011	26	28	27	19	21	19	14	21	16	12	19	14
2012	22	18	23	10	10	7	9	8	17	8	6	15
2013	14	20	11	12	20	7	10	18	7	10	15	6
2014	20	26	17	14	21	12	13	21	11	13	18	7

Table 2. The influence of RFI on beef cattle weight, body condition, and production parameters for 5 years of cow cohorts and three weaned calf crops

Category	RFI				Preplanned contrast		
	Low	Ave	High	SE ¹	P-value		
					RFI	Linear	Quadratic
Cow birth Wt. Kg	37.4	36.0	35.5	2.55	0.27	0.27	0.76
Cow Julian birth day	74.0 ^{ab}	75.3 ^b	71.2 ^a	0.99	<0.01	0.05	0.02
Cow wean wt., kg	239.3	237.4	240.6	5.39	0.14	0.77	0.43
Cow yearling wt., kg	488.1	501.2	504.4	13.70	0.17	0.08	0.49
Cow yearling BCS ¹	5.86	5.82	5.90	0.06	0.55	0.59	0.35
Cow pregnancy wt., kg	586.1	585.7	586.6	4.22	0.83	0.93	0.89
Cow pregnancy BCS	5.20	5.27	5.29	0.03	0.91	0.20	0.57
Calf birth wt., kg	39.0	39.3	39.3	0.70	0.03	0.78	0.88
Calf weaning wt., kg	276.9	281.0	281.0	2.93	0.23	0.36	0.55
Calf weaning wt., ratio ²	0.476	0.483	0.483	0.007	0.56	0.52	0.66
Calf Julian birth day	84.4	83.6	83.0	1.12	0.65	0.38	0.93
Calving interval, d	365	366	366	2.17	0.72	0.71	0.79
Postpartum interval, d	85.2	84.0	85.2	1.75	0.96	0.98	0.56

Means within rows lacking common superscript differ ($P < 0.05$).

¹BCS = body condition score.

²Ratio of calf weaning weight to cow body weight.

Table 3. The influence of parity on beef cattle weight, body condition, and reproductive parameters for 5 years of cow cohorts and three weaned calf crops

Category	Parity			SE	P-value
	1	2	3		
Cow wt. at weaning, kg	538.2 ^a	564.8 ^b	627.9 ^c	3.36	<0.01
Cow BCS ¹ at weaning	5.20	5.17	5.39	0.05	0.28
Calf birth wt., kg	33.8 ^a	40.9 ^b	42.5 ^b	1.10	<0.01
Calf weaning wt., kg	271.9 ^a	286.0 ^b	281.3 ^b	4.82	0.03
Calf wean wt., %	50.4 ^a	48.7 ^a	45.3 ^b	0.72	<0.01
Calf Julian birth day	83.6	83.5	83.9	1.05	0.28
Calving interval, d	NA	365	366	1.50	0.08
Postpartum interval, d	87.2 ^a	86.5 ^a	80.6 ^b	1.60	0.03

Means within rows lacking common superscript differ ($P < 0.05$).

¹BCS = body condition score.

Table 4. The influence of RFI classification on beef cattle conception probability and AI probability and cow longevity and reason culled due to pregnancy status through four breeding seasons and three weaned calf crops

Category	RFI				P-value			Preplanned contrast	
	Low	Ave	High	SE	RFI	Pregnancy	RFI X pregnancy	Linear	Quadratic
Cow conception probability, %	94.0	93.7	93.3	1.8	0.75	0.05	0.02		
Pregnancy 1	80.2	90.6	88.3	3.3				0.11	0.14
Pregnancy 2	89.5	98.0	96.5	2.3				0.09	0.14
Pregnancy 3	95.2	90.8	88.2	3.2				0.15	0.68
Pregnancy 4	97.6	89.3	96.2	3.0				0.70	0.07
Cow AI conception probability, %	55.0	59.5	59.5	3.27	0.81	<0.01	0.32	0.36	0.55
Years in herd/production	3.70	3.91	3.79	0.1	0.48			0.65	0.31
Present at 5 years, %	52.4	51.6	48.4	5.0	0.66			0.58	0.85
Culled due to pregnancy status, %	33.4	37.3	37.3	4.8	0.44			0.59	0.30

parity ($P < 0.01$) with weaning weight ratio decreasing with increasing parity. Cow postpartum interval differed by parity ($P = 0.03$) with third parity females having fewer days between calving and conception than first and second parity females.

Cow overall probability of conceiving following a 45 d breeding season (Table 4) exhibited a pregnancy ($P = 0.05$) as well as an RFI X pregnancy interaction ($P = 0.02$). Within breeding season, second calf low RFI heifers tended ($P = 0.09$) to have lower conception rates with a linear increase in conception with increasing RFI. In contrast, cow's conception for the fourth calf tended ($P < 0.07$) to display a quadratic response with average RFI cows having lower conception than low or high RFI cows.

Cow AI conception probability differed by pregnancy ($P < 0.01$) but not to RFI classification with probability of becoming pregnant following one synchronized timed AI breeding increasing with increasing pregnancies, with females having a lower chance of becoming pregnant following one synchronized timed AI breeding their first and third breeding seasons (48.3% and 54.3%, respectively) than their second and fourth breeding seasons (62.4% and 66.5 % respectively). RFI classification did not impact ($P > 0.05$) cow longevity, the probability of remaining in the herd at the age of 5 or for culling reasons related to pregnancy status (Table 4).

IMPLICATIONS

These results provide strong evidence that heifer postweaning RFI classification, though important in the growing and finishing sector, has limited application to commercial cow calf management as it exhibited limited statistical significance related to cow production or reproduction parameters. However, no selection pressure was placed on RFI while selecting replacement heifers or semen or bulls during this trial. We believe further research is needed to investigate the relationship of heifer postweaning RFI classification with pasture utilization, foraging behavior, and supplement intake as well as the relationship between heifer postweaning RFI classification and mature cow forage intake.

Conflict of interest statement. None declared.

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