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Relationship between Beef Heifer Residual Feed Intake and Productivity as Cows

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ABSTRACT: The effect of heifer residual feed intake (RFI) (n=451) on subsequent lifetime productivity as cows was measured over an 8 year period (2005-2013, mating opportunities=1081) at Lacombe, Alberta, Canada. Most probable producing ability for birth weight (MPPAbw) and weaning weight (MPPAww) were calculated as measures of cow productivity. RFI was negatively correlated (P=0.02) to MPPAbw, but was not significant when RFI was adjusted for backfat thickness (P=0.08) or backfat thickness and feeding activity (P=0.10). No significant correlations were found between RFI or adjusted RFI and MPPAww (P=0.64). Lifetime productivity (LTP) was calculated for cows culled from the herd (n=108) over the eight-year period. RFI and LTP were not correlated (P=0.10). Selection for feed efficient, low RFI replacement heifers appears to have no impact on their productivity as cows.
Keywords: Beef Cattle; Residual Feed Intake; Cow productivity

Introduction

In beef cattle production, one of the major costs for cattle producers is feed. In western Canada feed costs have a major impact on the competitiveness of beef production since 63% of the total cost of production for cow-calf production is associated with feed, bedding and pasture (Larson, 2010). As 65-75% of total feed energy is used for maintenance in cattle (Ferrell and Jenkins 1985), increasing feed efficiency within the herd could be economically beneficial for the operation. Residual feed intake (RFI) is defined as the difference between an animal's actual feed intake and its expected feed requirements for maintenance and growth (Basarab et al. 2005). Residual Feed Intake is independent of body weight and average daily gain, compared to feed to gain ratio, which has been previously used to measure feed efficiency. Low RFI heifers eat less than high RFI heifers for the same level of growth and body size or weight (Archer et al. 1997; Basarab et al. 2003; Nkrumah et al. 2007). Seedstock producers internationally are rapidly increasing their capacity to test potential breeding stock for RFI (Basarab et al. 2005; Crews et al. 2006). Replacement heifers are being selected on the basis of low RFI, as progeny from low RFI bulls or from direct RFI measurement and there is a limited understanding of its effects on herd fertility and cow lifetime productivity (Basarab et al. 2011).

Reproductive efficiency is another factor that has a major impact on profitability in beef production. The greatest economic value to commercial cow-calf producers is increased weaning rate (maternal and reproductive characteristics) and weaning weight (Kluyts et al. 2003). The overall objective of this study was to determine the relationship between heifer RFI and various measures of cow productivity which include both calf growth traits as well as herd lifetime productivity.

Materials and Methods

Over 450 beef replacement heifers, either British breed cross (Angus and Hereford) or Continental-British cross (Charolais-Maine Anjou x Red Angus), had feed intake measured using the GrowSafe™ System from 2006 to 2012. Many of these heifers were kept as replacements, resulting in 1081 subsequent mating opportunities. The management of the cow herd has previously been described in Basarab et al. (2007). Growth, feeding behavior, live animal body composition, fertility and their calf productivity traits were recorded. All animals were maintained at the Agriculture and Agri-Food Canada Lacombe Research Centre and were cared for according to the guidelines of the Canadian Council on Animal Care (1993).

Three measures of residual feed intake were determined for each heifer. The first measure, RFI1, was calculated as the difference between standardized dry matter intake (SDMI) and its expected feed intake (EFI1). Standardized DMI (SDMI) of each animal within contemporary group was regressed on ADG (kg/d) and metabolic MIDWT ($kg^{0.75}$) to estimate EFI1 using PROC GLM (SAS Institute, Inc. 2009), using the following model:

$$Y_i = b_0 + b_1 ADG_i + b_2 \, MIDWT^{0.75}{}_i + e_i,$$

where Y_i is the SDMI for animal i, b_0 is the regression intercept, b_1 is the partial regression coefficient of SDMI on average daily gain, b_2 is the partial regression coefficient of SDMI on metabolic mid-weight, and e_i is the random error term. A second and third model were developed to estimate EFI that adjusted RFI for back fat thickness, BF, measured at the end of the feeding period (RFI2), and back fat thickness and average feeding event frequency during the test, FEF (RFI3) in addition to ADG and metabolic mid-weight. Heifers were classified into High [+] and Low [-] RFI groups for some of the analyses.

To study the relationship of RFI and cow productivity, most probable producing ability (MPPA) for birth

weight and weaning weight were calculated as traits of the cow (Bourdon 2000). Most probable producing ability is a prediction of the performance of future calves from a given cow and it includes both cow maternal and direct genetic effects, as well as permanent environmental effects. Most probable producing ability was calculated for each heifer kept as a herd replacements using PROC MIXED (SAS Institute, Inc. 2009), using the following model:

$$Y_{ijkl} = \mu + Year_i + b_1 Cowage_{ijkl} + b_2 Cowage_{ijkl}^2 + S_j + Cow_k + e_{ijkl},$$

where Y_{ijkl} is the individual animal observation for either birth weight (BW) or weaning weight (WW) of the l'th calf born to the k'th cow of the j'th sex and born in the i'th year, $Year_i$ is the effect of the i'th calving year, $Cowage_{ijkl}$ is age of cow at calving, b_1 and b_2 are regression coefficients for linear and quadratic effects of Cowage on calf weight traits, S_j is the effect of calf gender, Cow_k is the effect of the k'th cow and e_{ijkl} is the deviation due to the ijkl'th calf. The model for WW did not include adjustment for calf age so that weaning weight differences among calves will include differences in birth date and thus differences in breeding dates of their dams. This will be important in the calculation of a lifetime productivity value for a cow. For both models, Cow and error effects were considered random effects while all other terms were considered fixed. The MIXED procedure (SAS Institute, Inc. 2009) was used to produce BLUP estimates of MPPA for either BW or WW, produced as estimates of Cow_k effects. Breed cross was not included in these models since they were not significant effects.

Repeatability (r) for BW was calculated using cow variance (σ^2_{cow}) and error variance (σ^2_e) components and used in the MPPA calculation. In our data, $r_{BW} = \sigma^2_{cow} / (\sigma^2_{cow} + \sigma^2_e) = 4.00/(4.00 + 14.17) = 0.22$. For WW, σ^2_{cow} =255 kg^2, σ^2_e= 563 kg^2, giving an r_{WW}=0.31.

A lifetime productivity measure (LTP) was then calculated for those cows culled from of the herd. These culled cows were considered to be animals that had an opportunity to express a lifetime of production. Animals were culled on the basis of temperament or infertility (open). Lifetime productivity was calculated as the MPPAww multiplied by number of calves weaned in the lifetime of the cow.

Results and Discussion

Table 1 shows a summary of the number of RFI-tested replacement heifers over the eight test years. The number of calvings in each year is also shown, and illustrates the increase in herd size as more and more RFI-tested animals are incorporated into the herd. Means and standard deviations for RFI1, BW and WW are also shown. As noted above, the repeatabilities for BW and WW were found to be 0.22 and 0.36, respectively. These compare to values of 0.2 and 0.4, respectively, as summarized by Bourdon (2000). These repeatability estimates were an implicit part of the calculation of MPPAbw and MPPAww in the Mixed procedure (SAS Institute, Inc. 2009).

Table 1. Animal numbers in the herd over 8 years, with trait means for residual feed intake (RFI1) measured on heifers, as well as birth weight (BW) and weaning weight (WW) of calves.

Year	Heifers RFI1 N	Cows Calving N	Calves Weaned N
2005	21	-	-
2006	19	17	14
2007	61	26	26
2008	68	70	67
2009	61	114	104
2010	40	139	119
2011	94	139	132
2012	87	156	153
2013	-	145	144
Trait Summary Across Years			
	Heifer RFI1, kg DM d^{-1}	Calf BW, kg	Calf WW, kg
N	451	806	759
Mean (SD)	0.00 (0.38)	39.9 (4.9)	257.6 (31.9)

Table 2 shows the phenotypic correlations between replacement heifer RFI (RFI1), RFI adjusted for backfat thickness (RFI2) and for backfat thickness and feeding event frequency (RFI3) and MPPA for birth weight (MPPAbw) and weaning weight (MPPAww) and LTP. A significant correlation was observed between RFI1 and MPPAbw, but not when RFI was adjusted for backfat thickness and feeding activity. The adjustments giving RFI2 and RFI3 were made in an attempt to account for effects of sexual development of replacement heifers on feeding activity. Correlations between all RFI measures and MPPAww or LTP were not significant. Least squares means for MPPAbw, MPPAww and lifetime productivity for [-] and [+] RFI heifers were not significantly different (Table 2). These results are comparable to those of Basarab et al. (2011) who found no differences in calf birth weight, pre-weaning growth, actual weaning weight, 200-day weaning weight, and kg calf weaned per heifer exposed to breeding between low and high RFI ranked heifers. Similarly, Donoghue et al. (2011) found no differences in a study that look at reproductive performance over two production cycles between low or high RFI heifers for calf birth weight or kg of calf born per female exposed to breeding.

Table 2. Phenotypic correlations between heifer RFI, MPPA for birth and weaning weights and cow lifetime productivity.

Trait	RFI2	RFI3	MPPAbw	MPPAww	LTP
RFI1	0.98*	0.93*	-0.13*	-0.03	-0.15
N	451	451	299	289	108
RFI2		0.95*	-0.10	-0.04	-0.17
N		451	299	289	108
RFI3			-0.10	-0.02	-0.14
N			299	289	108
MPPAbw				0.24*	0.34*
N				292	108
MPPAww					0.92*
N					108

*P<. 05
RFI1: Residual Feed Intake (RFI) (kg DM d^{-1}) measured as a replacement heifer;
RFI2: RFI adjusted for backfat thickness;
RFI3: RFI adjusted for backfat and feeding activity;
MPPAbw: Most Probable Producing Ability (MPPA) for birth weight (kg);
MPPAww: MPPA for weaning weight (kg);
LTP of culled cows from the herd, based on MPPA for weaning weight (kg);

Table 3. LSMeans for heifers that were below average [-] and above average [+] in their RFI1, and their MPPA values for birth weight, weaning weight, and lifetime productivity as cows.

Trait	LOW [-]	SE	HIGH [+]	SE	P-Value
N	226		225		
RFI1, kg DM d^{-1}	-0.29	-0.11	0.30	-0.11	<.0001
N	140		159		
MPPAbw, kg	0.11	0.11	-0.11	0.10	0.120
N	137		152		
MPPAww, kg	0.33	0.98	-0.62	0.93	0.485
N	51		57		
LTP, kg	2.93	5.31	-6.12	5.03	0.219

These studies suggest that RFI is not correlated to lifetime productivity traits in cows, and selection for low RFI replacement heifers will not negatively impact productivity in a beef herd. The correlations measured in the present study are phenotypic correlations. The data structure did not allow for the calculation of genetic correlations, which would give a definitive answer to this question of the effects of selection of low RFI heifers. What the present study does show however is that heifers selected for low RFI would, in their lifetime, have no detrimental effects on their productivity.

Conclusion

Animals ranked as high or low RFI have no significant differences in MPPA values for birth weight and weaning. A significant negative phenotypic correlation was found between RFI and MPPA for birth weight, but this relationship was no longer evident when RFI was adjusted for backfat thickness and feeding activity. These results suggest that selection for feed efficient, low RFI replacement heifers will have no impact on their productivity as mature cows.

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