Reproductive development and fertility traits among heifers in different residual feed intake groups[1]

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Transl. Anim. Sci. 2018.2:S175–S179
doi: 10.1093/tas/txy039

INTRODUCTION

Feed costs and reproductive failure represent major costs to beef operations (Hall, 2013), and early attainment of pregnancy results in a longer reproductive life span (Cushman et al., 2013). Methods to select cattle that are both feed efficient and reproductively sound warrant investigation.

Feed efficiency is moderately heritable. Residual feed intake (**RFI**) is a common method and offers advantages over other measures, such as being independent from average daily gain (ADG) and body weight (BW; Arthur and Herd, 2008).

Reproductive success is lowly heritable when considering pregnancy rate (**PR**; Cushman and Perry, 2012). However, traits reflecting potential fertility, such as reproductive tract scores (**RTSs**) and antral follicle counts (**AFCs**), are moderately heritable (Cushman and Perry, 2012). Feed efficiency may not be independent from fertility. When using conventional methods to assess RFI, efficient heifers are older at puberty (Basarab et al., 2011; Shaffer et al., 2011).

RTSs semi-objectively classify heifers as prepubertal, peripubertal, or pubertal based on uterine tone and ovarian structures (Martin et al., 1992). Scores of 1 to 5 assigned prior to breeding reflect development and cyclicity (Martin et al., 1992; Gutierrez et al., 2014).

Categories based on the number of antral follicles ≥3 mm are used to classify heifers as low (≤15 follicles), medium (16 to 24 follicles), and high (≥25 follicles; Ireland et al., 2008; Cushman et al., 2009). Heifers with a high AFCs are more likely to become pregnant (Cushman et al., 2009) and have longer reproductive life spans (Ireland et al., 2008; McNeel and Cushman, 2015).

The objective of this study was to investigate whether RTS, AFC, pubertal status at synchronization, and PR were different among RFI groups. Our hypothesis was reproductive competence as measured by RTS, AFC, pubertal status, and PR would be similar among RFI groups.

MATERIALS AND METHODS

All procedures in this study were approved by the University of Idaho Institutional Animal Care and Use Committee (Protocol # 2015–19).

[1]Research presented in this manuscript was supported by the Idaho Agricultural Experiment Station, UI Department of Animal and Veterinary Science, UI Nancy M. Cummings REEC and the Hatch Program project number IDA01493 of the National Institute of Food and Agriculture, U.S. Department of Agriculture. The authors would like to thank Wayne Smith, Jennifer Spencer, and Saulo Zoca for their help in this project.

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Received March 16, 2018.
Accepted April 14, 2018.

Feed Efficiency Trial

To evaluate feed efficiency, Angus, Hereford, and SimAngus crossbred heifers (n = 139; Age = 342.3 ± 1.4; Start BW = 320.7 ± 2.9 kg; End BW = 414.7 ± 3.0) were placed into four pens each equipped with five feeding nodes (GrowSafe, Calgary, Alberta, Canada) at the University of Idaho Nancy M. Cummings Research, Education and Extension Center. Pen assignment was by BW to ensure that heifers were in a pen with contemporaries of a similar BW. RFI was determined over a 77-d period. Heifers were weighed at the initiation and conclusion of the trial. Heifers were also weighed every 2 wk during the study. Ultrasound backfat was determined at the conclusion of the trial and used in RFI calculations. Heifers were fed a diet of 80% alfalfa hay, 10% wheat middlings, and 10% liquid supplement. All diets were prepared daily as a total mixed ration and fed for free choice intake. The liquid supplement contained protein, vitamins, minerals, and monensin. Nutrient analysis of heifer diet is provided in Table 1. Daily feed samples were composited into two time periods and components analyzed (Cumberland Valley Analytical Services, Inc., Waynesboro, PA) to give an estimate of diet quality.

Reproduction Data Collection and Estrous Synchronization

Ten days prior to estrous synchronization, RTSs were determined for all heifers (n = 139). AFC was determined for a subset of heifers (n = 80). RTSs were performed via palpation and verified by ultrasound (Martin et al., 1992). To determine AFCs, ovaries were scanned using an Ibex, EVO portable ultrasound with a 7.5 MHz linear probe. Videos were recorded of each ovary and later used to count follicles ≥3 mm as established by Ireland et al. (2008) and Cushman et al. (2009). Heifers were determined to be low (<15 follicles), medium (15 to 24 follicles), or high (≤ 25 follicles). Data from seven heifers was lost due to recording issues.

Heifers were estrous synchronized using the 14-d CIDR Split-Time AI protocol (Thomas et al., 2014). Briefly, on day 0, heifers received a Control Internal Drug Release (**CIDR**; Zoetis, Parsippany, NJ) device. Fourteen days later, the CIDR was removed. On day 33, heifers received $PGF_{2\alpha}$ (Lutalyse, 25 mg i.m.; Zoetis), and EstroTect patches (Rockway Inc., Spring Valley, WI) were applied. Between day 33 and 36, heifers were monitored for estrus using patches and visual observation three times daily by two trained observers. Sixty-six hours after $PGF_{2\alpha}$, all heifers displaying estrus were artificially inseminated by one of three inseminators. Heifers not expressing estrus were monitored for estrus and inseminated 24 h later. Heifers not displaying estrus by 90 h after CIDR removal received GnRH (Factrel, 100 µg i.m., Zoetis) at the time of AI. Bulls were placed with heifers 14 d after timed AI for the remainder of the 45-d breeding season. To determine AI and final PR, blood pregnancy-specific protein B levels were tested 25 and 30 d (BioPyrn; BioTracking, Inc., Moscow, Idaho) after AI, and pregnancy status determined via ultrasound monitoring at 42, 64, and 142 d after AI.

Table 1. Nutrient composition of diet fed to heifers during 77-d RFI trial

	Period	
Item	1[a]	2[a]
Diet, % dry matter	87.3	87.5
Nutrient analysis		
Crude protein[b]	15.3	13.6
Acid detergent fiber[b]	39.9	44.6
Neutral detergent fiber[b]	48.4	54.5
Total digestible nutrients[b]	55.1	56.3
Net energy maintenance, Mcal/kg	1.14	1.19
Net energy gain, Mcal/kg	0.57	0.62

[a] Period 1 = January 25, 2017 to March 11, 2017. Period 2 = March 12, 2017 to April 12, 2017.

[b] Values reported on a dry matter basis.

Progesterone Assay

To determine pubertal status at the initiation of synchronization, coccygeal venipuncture blood samples were collected into 10-mL vacutainer tubes 10 d before and immediately prior to CIDR insertion. Blood was allowed to clot for 24 h at 4 °C and was centrifuged at 2,500 × g (4 °C) for 30 min, and serum was collected and stored at −20 °C until a double antibody radioimmunoassay (RIA; MP Biomedicals, Costa Mesa, CA) was performed on samples in duplicate. The intra-assay coefficient of variation was 6.4%. Heifers with at least one sample with progesterone concentrations >1 ng/mL were considered pubertal.

Statistical Analysis

To determine RFI, actual individual daily dry matter intake was regressed against predicted intake based on ADG during the feeding period, using metabolic BW at midpoint and ultrasound

ribfat as adjustments. Heifers were ranked by RFI and classified as inefficient, average, or efficient based on the number of standard deviations from the mean of all heifers in the study (>0.5 SD above mean, ±0.5 within SD, and <0.5 SD, respectively).

Chi-square analysis using SAS Proc FREQ was used to test for differences in proportions of heifers in different RTS and AFC classifications, pubertal status, AI, and final PR among inefficient, average, and efficient heifers. Significance was declared at $P \leq 0.05$.

Reproductive tract scores tended to differ ($P < 0.10$) among heifers in different RFI groups. To further evaluate this difference, RTS categories were collapsed to prepubertal (1 to 3 score) and pubertal (4 or 5 score) and inefficient and efficient heifers compared by using a chi-square analysis (SAS Proc FREQ).

RESULTS

Heifers were ranked as inefficient ($n = 44$), average ($n = 55$), and efficient ($n = 40$). Reproductive development and fertility measures among RFI groups are presented in Figures 1 to 4. There was no difference in pubertal status among inefficient, average, or efficient heifers ($P = 0.65$, Figure 1); however, there tended to be a difference ($P = 0.09$) in RTSs (≥2 to 5) among RFI classifications (data not shown). When RTS categories were collapsed for further analysis, there tended to be a difference ($P = 0.08$) among groups with the inefficient group having more heifers with an RTS of 4 or 5 and the efficient group having more heifers with an RTS of 1, 2, or 3 (Figure 2). There was no difference in the proportion of heifers in low, medium, or high AFC categories among RFI classifications ($P = 0.59$, Figure 3). Pregnancy rate among heifers to AI ($P = 0.56$) and final PR ($P = 0.09$) was also not different among RFI classifications (Figure 4).

DISCUSSION

The purpose of this study was to investigate possible differences in reproductive development and fertility among heifers in different RFI groups. We observed a tendency in differences among RTS between inefficient and efficient heifers, indicating that efficient heifers may have delayed reproductive development. This is supported by research conducted by Basarab et al. (2011) and Shaffer et al. (2011); both studies detected delayed pubertal attainment in efficient heifers when using conventional methods to determine feed efficiency. The current study did not detect a statistical difference in pubertal status at the initiation of synchronization using serum progesterone, possibly due to the limited number of heifers in each RFI group. A higher percentage of efficient heifers were determined pubertal by serum progesterone samples than by RTS assigned before synchronization. It is possible that recently ovulated heifers received an RTS 3 because of the lack of a dominant follicle or prominent corpus luteum (Gutierrez et al., 2014). Another possibility is efficient heifers classified as RTS 3 may have become pubertal by the second progesterone sample. This is further supported by the fact that reproductive evaluation in this study occurred around the age most heifers from this herd reach puberty. Reproductive development is a low priority for nutrient partitioning (Short and Adams, 1988). At the time of the feed trial, efficient heifers may have been partitioning more nutrients to muscle and bone development compared with inefficient heifers. Inefficient heifers may have been at a later stage of development, therefore reaching reproductive maturity sooner than efficient heifers (Basarab et al., 2011; Shaffer et al.,

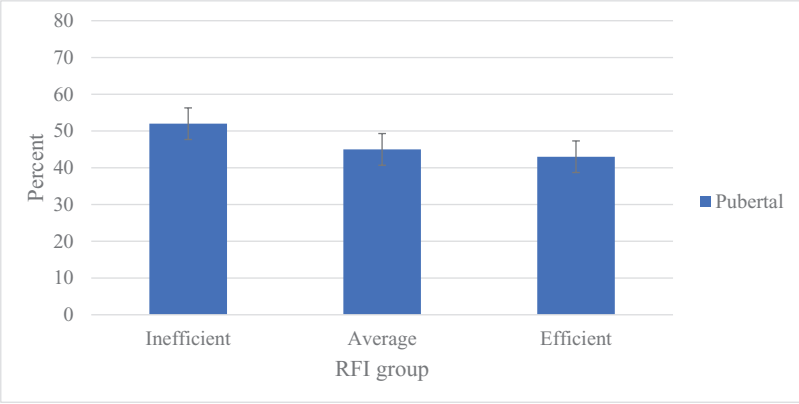

Figure 1. Percent of heifers pubertal in different RFI groups at the start of synchronization. The percent of heifers pubertal before synchronization was not different ($P = 0.65$) among RFI groups based on serum progesterone levels.

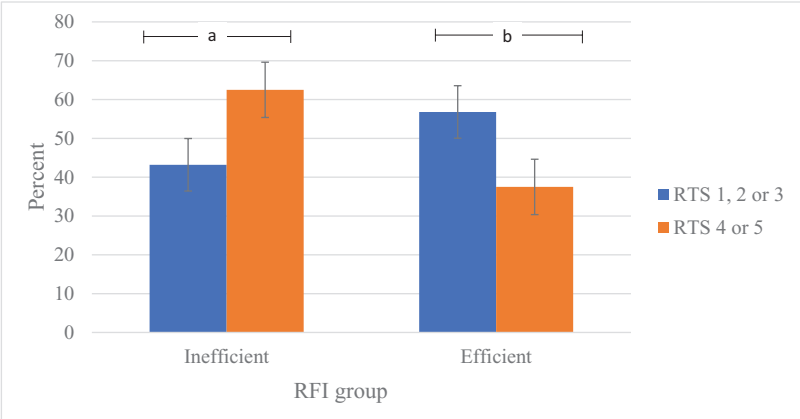

Figure 2. RTSs of heifers in different RFI groups. Heifers were assigned RTSs at the start of synchronization. There tended to be a difference in the occurrence of RTS ≤ 3 and RTS ≥ 4. More heifers ($P = 0.08$) ranked as inefficient had an RTS ≥ 4 than heifers ranked as efficient.

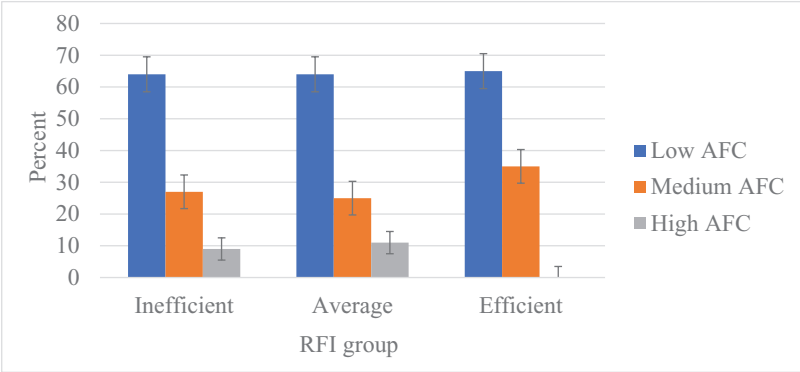

Figure 3. AFC of heifers in different RFI groups. AFC was determined at the start of synchronization. There was no difference ($P = 0.59$) in occurrence of heifers with low (≤15 follicles), medium (16 to 24 follicles), and high (≥25 follicles) AFC in different RFI groups.

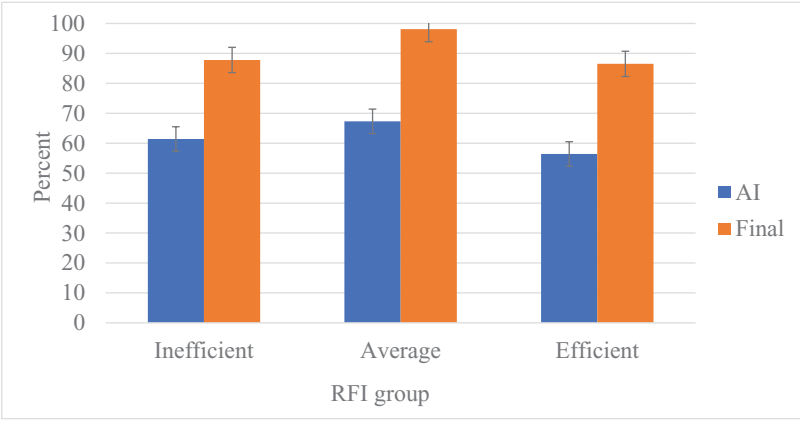

Figure 4. Pregnancy rate to timed AI and final pregnancy rate in heifers of different RFI groups. Heifers were bred by timed AI and natural service during a 45-d breeding season. There was no difference in AI pregnancy rate ($P = 0.56$) or final pregnancy rate ($P = 0.09$) among RFI groups.

2011). However, further studies on the magnitude of the relationship between feed efficiency and reproductive development are warranted. It is possible selecting for feed efficiency may delay puberty and conception and result in less pounds of calf weaned and sold (Larson et al., 2010).

There was no difference in AFC among RFI groups in our study. This possibly indicates that there may be no relationship between AFC and feed efficiency. Compared with other reports of AFC, our data did not show the same distribution of heifers in the medium and high categories. It is not clear why we saw this difference. The relationship between feed efficiency and AFC as well as other fertility traits, such as serum levels of anti-Müllerian hormone (Jimenez-Krassel et al., 2015), requires further research.

We also did not observe a difference in AI or final PR among RFI groups. The use of a CIDR

synchronization protocol may have induced puberty in peripubertal heifers by the time of AI (Lucy et al., 2001). Alternatively, the lack of difference in pubertal status at the time of synchronization may have resulted in heifers responding similarly to estrous synchronization, regardless of RFI. Therefore, it is difficult to make inferences on the effect of RFI on PR from our study.

In summary, our results support that selecting for feed efficiency may influence reproductive development as measured by RTS. Reproductive tract scoring is a viable method of evaluating potential fertility in heifers (Gutierrez et al., 2014). However, we did not observe differences in the other measures of fertility used in this study. Because of the importance of heifer fertility to profitability (Cushman et al., 2013), the impact of selection pressures for feed efficiency on time of conception and reproductive longevity require further investigation.

IMPLICATIONS

This study indicates that selecting replacement heifers for feed efficiency may not have an impact on reproduction and fertility. The differences in RTS between efficient and inefficient heifers detected in this study indicate that development and cyclicity may be impacted or delayed in efficient heifers. Therefore, extreme selection for feed efficiency in replacement heifers should be done with caution. Further research regarding feed efficiency and fertility would be valuable to the beef industry.

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