HEIFER INTAKE AND EFFICIENCY AS INDICATORS OF COW INTAKE AND EFFICIENCY

Daniel W. Shike[1], Chris J. Cassady[1], J. W. Adcock[1], and Keela M. Retallick[2]

[1]*Univeristy of Illinois at Urbana-Champaign*
[2] *California Polytechnic State University, San Luis Obispo*

Introduction

Feed costs account for over 60% of the total costs associated with maintaining a beef cow and are the largest detriment to profitability for beef producers (Miller et al., 2001). Approximately 60 – 70% of energy for beef production is required by the cow herd. Of the energy needed for the cow herd, approximately 70% goes to maintenance energy (Ferrell and Jenkins, 1982). Thus, nearly 50% of all energy required by the beef industry is used simply to maintain the cow herd. Although variation in maintenance energy appears to exist, maintenance requirements of cattle have shown little no change over the past 100 years (Johnson et al., 2003). Limited work has been done evaluating the relationship between heifer intake and performance during the postweaning growing period and cow performance and reproduction traits.

The objective of this study was to determine the relationship between residual feed intake (RFI), residual body weight gain (RG), and intake in heifers during the postweaning period and subsequent cow performance and reproduction as 2-year-old lactating and dry cows.

Materials and Methods

Postweaning heifer evaluation

A postweaning intake and performance evaluation was conducted on Angus and Simmental x Angus heifers (n=511) over a 5-yr period at the Beef Field Research Laboratory in Urbana, IL. Heifers were developed on a diet consisting of approximately 70% corn silage, 25% corn co-products, and 5% supplement each year. Heifer intake and performance were monitored for a minimum of 70 d each year; according to BIF standards. Individual intakes were recorded using the GrowSafe® automated feeding system. For years 1, 2, and 3, cattle were weighed on 2 consecutive days at the beginning and end of the test period, and ADG was calculated by dividing total BW gain by the number of days on test. Individual animal midtest metabolic weight (MWW) was determined by the average of the beginning and end weights of the test period. For years 4 and 5, cattle were weighed on 2 consecutive days at the beginning and end of the test and biweekly throughout. Heifer ADG was calculated by regressing each individual weight over all time points of the test. Individual MWW was determined by taking the mid-date test weight via the regression equation. Individual animal 12^{th} rib fat thickness (BF) was recorded via ultrasound on years 4 and 5.

Heifer RFI and RG were determined for each individual animal. For all years, animals were separated into contemporary groups, based on breed type and source of origin. For years 1, 2, and 3, RFI was assumed to represent the residuals from a multiple regression model regressing DMI on ADG and MWW, using pen as a random effect, and RG was assumed to represent the residuals from a multiple regression model regressing ADG on DMI and MWW, using pen as a random effect. For years 4 and 5, RFI was assumed to represent the residuals from a multiple regression model regressing DMI on ADG, MWW, and BF using pen as a random effect, and RG was assumed to represent the residuals from a multiple regression model regressing ADG on DMI, MWW, and BF using pen as a random effect.

Heifers were classified as low, medium, or high RFI, RG, or intake. Classification groups were established by calculation of the mean and SD of the heifers for RFI, RG, and intake. Heifers that were less than 0.5 SD below the mean were classified as "Low," heifers that were ± 0.5 SD of the mean were classified as "Med," and heifers that were more than 0.5 SD above the mean were classified as "High."

Heifers with structural soundness problems or very poor performance were culled annually prior to the breeding season. Heifers (n=366) kept as replacements were synchronized and AI. Heifers were exposed to clean-up bulls for 60 d following AI. Reproductive data were collected for first service AI conception and overall pregnancy rates. Calving data was recorded to determine age of cow (days) at first calving and calf birth weight.

2-year-old cow evaluation

Each year, cows were placed in the barns at the Beef Field Research Laboratory in Urbana, IL for two 14 d evaluation phases (60 d (lactating) and 240 d (dry) postpartum) where they were fed a common forage based diet (~60% TDN). During these evaluation periods, measurements were taken to characterize each individual cow relative to several production traits. At 60 d postpartum, twenty-four hour milk production estimates were determined using a 12-hr weigh-suckle-weigh technique (Beal et al., 1990). Individual intake was measured during each evaluation period by using the GrowSafe® automated feeding system. At the conclusion of each evaluation period, weights were taken on two consecutive days, hip height recorded, BCS scored (1-9 scale) by a trained technician, and cows were ultrasound for BF.

Calves were weaned at approximately 6 mo of age. Weaning weights were recorded and submitted to the American Angus Association and American Simmental Association. An adjusted weaning weight was then calculated by the associations. As a measurement of cow efficiency during the lactating period, a cow RFI value was calculated for each cow. Cow RFI was assumed to represent the residuals from a multiple regression model regressing DMI on metabolic weight (MW), BF, and 24-hour milk production.

Statistical Analysis

The MIXED procedure of SAS was used to test the effect of heifer intake and efficiency classification on cow production traits. The model used included the fixed effect of RFI, RG, or intake classification group (high, medium, and low.) The GLIMMIX procedure of SAS was used to test the effect of heifer intake and efficiency classification on reproductive traits (binomial data). The model used included the fixed effect of RFI, RG, or intake classification group (high, medium, and low). Mean values were considered to be significantly different when $P < 0.05$ and considered a tendency when $P > 0.05$ and < 0.10.

Results and Discussion

Heifers were classified into Low, Med, or High RFI groups, and the effects of the RFI classification on female reproductive and performance traits are presented in table 1. There were no differences in percentage of females kept as replacements, first AI conception rate, overall pregnancy rate, or age at calving between the RFI classifications. The heifer RFI classification did not affect calf birth weight or weaning weight. Heifer RFI classification did not affect cow BW, hip height, BF or milk production at 60 d postpartum, but there was a trend ($P = 0.08$) for cows from the Med RFI group to have decreased BCS at 60 d postpartum compared to cows from the High RFI group. Cows classified as Med or High RFI had greater ($P < 0.01$) DMI than cows in the Low RFI group

Table 1. Effects of RFI classification on female reproductive and performance traits					
	Heifer RFI Category				
Item	Low	Med	High	SEM	*P*-value
Reproductive traits					
Retained as replacement, %	69	76	71	-	0.36
First AI conception rate, %	45	50	42	-	0.50
Overall pregnancy rate, %	86	83	85	-	0.80
Cow age at first calf, d	736	734	741	3	0.16
Calf performance[1]					
Calf birth weight, lb	73	73	75	1	0.51
Calf weaning weight, lb	598	586	618	12	0.12
2-year-old cows (lactating)[2]					
Cow BW, lb	1270	1257	1272	14	0.68
Cow hip height, in	52.6	52.8	52.9	0.2	0.54
Cow BCS	5.7^{xy}	5.6^{x}	5.7^{y}	0.1	0.08
Cow BF, in	0.25	0.24	0.25	0.01	0.91
24 h milk production, lb	18	17	18	1	0.70
Cow DMI, lb	32.4^{a}	35.9^{b}	36.9^{b}	1.1	<0.01
Cow RFI, lb	-1.67^{a}	0.56^{b}	1.09^{b}	0.65	<0.01
2-year-old cows (dry)[3]					
Cow BW, lb	1378	1368	1384	14	0.67
Cow hip Height, in	53.5	53.5	53.5	0.2	0.99
Cow BCS	5.8	5.8	5.9	0.1	0.81
Cow BF, in	0.27	0.27	0.28	0.01	0.55
Cow DMI, lb	29.0^{x}	30.9^{xy}	33.4^{y}	1.3	0.06
^{a,b} Row means that do not have a common superscript differ, $P < 0.05$					
^{x,y} Row means that do not have a common superscript tend to differ, $P > 0.05$ and < 0.10					
[1] Progeny of 2-year-old cows					
[2] 2-year-old cow traits measured at 60 d postpartum					
[3] 2-year -old cow traits measured at 240 d postpartum					

at 60 d postpartum. Cows classified as Med and High RFI heifers had greater Cow RFI than cows that were classified as Low RFI heifers; heifers that ate less than predicted during the postweaning evaluation also ate less than predicted as 2-year-old lactating cows. There were no differences in cow BW, hip height, BCS, or BF at 240 d postpartum among heifer RFI classification groups; however, there was a trend ($P = 0.06$) for cows from the High RFI group to have increased DMI compared to cows from the Low RFI group.

There has been limited work done evaluating the effects of efficiency during the postweaning period on cow performance and reproduction. Shaffer et al. (2011) reported that High RFI heifers tended ($P = 0.06$) to reach puberty at a younger age than Med or Low RFI but this did not result in any differences among RFI classifications for conception rate or pregnancy. Crowley et al. (2011) reported a negative genetic correlation between RFI in growing males and cow age at first calving but did not find any correlations with fertility or calving difficulty. Crowley et al. (2011) also found a negative genetic correlation between growing male RFI and cow BW but reported no correlation between RFI and maternal weaning weight. Black et al. (2013) found that heifers classified as Med or High RFI had greater DMI as cows than heifers classified as Low RFI.

Heifers were also classified into Low, Med, or High RG groups, and the effects of the RG classification on female reproductive and performance traits are shown in table 2. There were no differences in percentage of females kept as replacements, first AI conception rate, overall pregnancy rate, or age at calving between the RG classifications. The RG classification also did not affect calf birth weight or weaning weight. Heifer RG classification did not affect cow BW, BCS, BF, milk production, DMI, or cow RFI at 60 d postpartum, but there was a trend ($P = 0.06$) for cows from the High RG group to have increased hip heights compared to the cows from the Low RG group. There were no differences in cow BW, hip height, BCS, BF, or DMI at 240 d postpartum among heifer RG classification groups.

Crowley et al. (2011) found that RG in growing males was genetically correlated to age at first calving. Crowley et al. (2011) also reported that growing male RG was genetically correlated to cow BW and maternal weaning weight (0.67 and 0.57, respectively).

Heifers were also classified into Low, Med, or High intake groups, and the effects of the intake classification on female reproductive and performance traits are shown in table 3. There were a greater ($P < 0.01$) percentage of heifers retained as replacements from the groups classified as Med or High Intake heifers compared to the heifers classified as Low Intake. Heifers were culled prior to breeding for either structural soundness problems or very poor performance. We speculate that that the difference in percentage of heifers retained as replacements is likely a reflection of some of the low intake heifers being the smaller, poorer gaining heifers. There were no differences in first AI conception rate or overall pregnancy rate; however, heifers classified as Low Intake were younger ($P = 0.04$) at calving then the heifers classified as High Intake. Cows that were classified as High Intake heifers had calves with greater ($P < 0.01$) birth weights than cows that were classified as Low or Med Intake heifers. However, there were no differences in calf weaning weights among cows from different heifer intake classification groups. Cows from the Med and High Intake groups had greater ($P = 0.02$) BW at 60 d postpartum than cows from the Low Intake group. Cows from the High Intake group had increased ($P < 0.01$) hip height than cows from the Low Intake heifer group, and cows from the Med Intake heifer group were intermediate. Heifer intake classification did not affect milk production, BCS, or BF at 60 d postpartum. Cows from the High Intake group had increased ($P < 0.01$) DMI compared to cows from the Low Intake group, and cows from the Med Intake group were intermediate. Cows from the High Intake group also had greater ($P = 0.04$) cow RFI than the cows from the Low Intake group. Results at 240 d postpartum were very similar to results at 60 d postpartum. Cows from the Med and High Intake groups again had greater ($P < 0.01$) BW at 60 d postpartum than cows from the Low Intake group. Cows from the High Intake group also again had increased ($P < 0.01$) hip height than cows from the Low Intake group, and cows from the Med Intake group were intermediate. Heifer intake classification did not affect BCS or BF at 240 d postpartum either. Similar to 60 d postpartum, cows from the High Intake heifer group had increased ($P = 0.02$) DMI compared to cows from the Low Intake group, and cows from the Med Intake group were intermediate.

Crowley et al. (2011) reported a negative correlation between growing male concentrate intake and cow age at first calving. Crowley et al. (2011) also found a positive correlation between growing male concentrate intake and calving difficulty, cow BW, and maternal weaning weight.

Conclusions

Results from this study suggest that heifers that are more efficient based off of RFI will consume less DMI as cows with no differences in cow or calf performance or reproduction. There were no differences detected between RG and cow performance or reproductive traits. Heifers that have greater DMI calve at an older age, have larger BW and greater hip height as 2-year-old cows, and have increased DMI as cows. Further evaluation of the relationship of heifer intake and efficiency measures on cow production traits after 2 years of age is needed.

Literature Cited

Beal, W. E., D. R. Notter, and R. M. Akers. 1990. Techniques for estimation of milk yield in beef cows and relationships of milk yield to calf weight gain and postpartum reproduction. *J. Anim. Sci.* 68:937-943.

Table 2. Effects of RG classification on female reproductive and performance traits					
	Heifer RG Category				
Item	Low	Med	High	SEM	*P*-value
Reproductive traits					
Retained as replacement, %	71	71	74	-	0.80
First AI conception rate, %	46	44	47	-	0.91
Overall pregnancy rate, %	86	83	85	-	0.72
Cow age at first calf, d	71	71	74	-	0.80
Calf performance[1]					
Calf birth weight, lb	73	74	74	1	0.84
Calf weaning weight, lb	596	600	601	12	0.94
2-year-old cows (lactating)[2]					
Cow BW, lb	1261	1256	1280	14	0.42
Cow hip height, in	52.5^{x}	52.7^{xy}	53.0^{y}	0.2	0.06
Cow BCS	5.7	5.6	5.6	0.1	0.91
Cow BF, in	0.26	0.24	0.24	0.01	0.45
24 h milk production, lb	18	17	18	1	0.47
Cow DMI, lb	35.1	35.0	35.2	1.1	0.99
Cow RFI, lb	0.92	-0.30	-0.54	0.63	0.21
2-year-old cows (dry)[3]					
Cow BW, lb	1372	1359	1398	14	0.12
Cow hip height, in	53.3	53.4	53.7	0.2	0.14
Cow BCS	5.9	5.8	5.8	0.1	0.83
Cow BF, in	0.28	0.27	0.27	0.01	0.67
Cow DMI, lb	29.6	31.7	31.9	1.3	0.36

^{x,y} Row means that do not have a common superscript tend to differ, $P > 0.05$ and < 0.10

[1] Progeny of 2-year-old cows

[2] 2-year-old cow traits measured at 60 d postpartum

[3] 2-year -old cow traits measured at 240 d postpartum

Table 3. Effects of intake classification on female reproductive and performance traits					
	Heifer Intake Category				
Item	Low	Med	High	SEM	*P*-value
Reproductive traits					
Retained as replacement, %	57[a]	80[b]	76[b]	-	<0.01
First AI conception rate, %	51	44	45	-	0.62
Overall pregnancy Rate, %	84	84	86	-	0.87
Cow age at first calf, d	731[a]	738[ab]	741[b]	3.1	0.04
Calf performance[1]					
Calf birth weight, lb	71[a]	73[a]	77[b]	1.4	<0.01
Calf weaning weight, lb	605	590	607	13.8	0.47
2-year-old cows (lactating)[2]					
Cow BW, lb	1225[a]	1273[b]	1285[b]	16.2	0.02
Cow hip height, in	52.1[a]	52.8[b]	53.2[c]	0.2	<0.01
Cow BCS	5.6	5.7	5.7	0.1	0.75
Cow BF, in	0.24	0.26	0.24	0.01	0.25
24 h milk production, lb	18	18	17	0.8	0.73
Cow DMI, lb	30.2[a]	35.4[b]	38.4[c]	1.2	<0.01
Cow RFI, lb	-1.24[a]	-0.20[ab]	1.19[b]	0.74	0.04
2-year-old cows (dry)[3]					
Cow BW, lb	1305[a]	1377[b]	1409[b]	18.6	<0.01
Cow hip height, in	52.9[a]	53.5[b]	53.9[c]	0.2	<0.01
Cow BCS	5.7	5.8	5.9	0.1	0.24
Cow BF, in	0.27	0.27	0.29	0.01	0.44
Cow DMI, lb	27.3[a]	30.7[ab]	33.1[b]	1.5	0.02
[a,b,c] Row means that do not have a common superscript differ, $P < 0.05$					
[1] Progeny of 2-year-old cows					
[2] 2-year-old cow traits measured at 60 d postpartum					
[3] 2-year -old cow traits measured at 240 d postpartum					

Black, T. E., K. M. Bischoff, V. R. G. Mercadante, G. H. L. Marquezini, N. DiLorenzo, C. C. Chase, Jr., S. W. Coleman, T. D. Maddock and G. C. Lamb. 2013. Relationships among performance, residual feed intake, and temperament assessed in growing beef heifers and subsequently as 3-year-old, lactating beef cows. *J. Anim. Sci.* 91:2254-2263.

Crowley, J. J., R. D. Evans, N. McHugh, D. A. Kenny, M. McGee, D. H. Crews, Jr., and D. P. Berry. 2011. Genetic Relationships between feed efficiency in growing males and beef cow performance. *J. Anim. Sci.* 89:3372-3381.

Ferrell, C. L., and T. G. Jenkins. 1982. Efficiency of cows of different size and milk production potential. Pages 12–24 in USDA, ARS, Germplasm Evaluation Program Progress Report No. 10.MARC, Clay Center, NE.

Johnson, D. E., C. L. Ferrell, and T. G. Jenkins. 2003. The history of energetic efficiency research: Where have we been and where are we going? *J. Anim. Sci.* 81:E27–E38

Miller, A. J., D. B. Faulkner, R. K. Knipe, D. R. Strohbehn, D. F. Parrett, and L. L. Berger. 2001. Critical control points for profitability in the cow-calf enterprise. *Prof. Anim. Sci.* 17:295-302.

Shaffer, K. S., P. Turk, W. R. Wagner, and E. E. D. Felton. 2011. Residual feed intake, body composition, and fertility in yearling beef heifers. *J. Anim. Sci.* 2011:1028-1034.