NET FEED INTAKE OF GROWING BULLS AND RELATIONSHIPS WITH PERFORMANCE, FERTILITY AND ULTRASOUND COMPOSITION TRAITS

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Introduction

Feed efficiency has traditionally been measured as feed conversion ration (FCR), which is feed intake divided by weight gain. Feed conversion ratio is a gross measure of feed efficiency in that it does not attempt to account for differences in requirements for maintenance and growth (Brelin and Bannang, 1982; Mrode et al., 1990; Arthur et al., 2001a). An alternative method of measuring feed efficiency is net feed intake (NFI). This feed efficiency trait allows selection of more efficient cattle without the concurrent increases in mature size that would occur if selection pressure were applied against FCR (Bishop et al., 1991; Arthur et al., 2001a, b). Net feed intake measures the variation in feed intake beyond that needed to support maintenance and growth requirements, and is calculated as the difference between actual feed intake and the feed an animal is expected to consume based on its body weight (BW) and ADG. Cattle that eat less than expected for their BW and ADG have negative NFI, which equates to improved net feed efficiency. Objectives of this study were to characterize NFI in growing bulls, and to examine relationships between NFI and performance, fertility and body composition traits estimated by ultrasound.

Experimental Procedures

Experimental Animals and Design.

Bonsmara bulls (N = 62) provided by George Chapman (Amarillo, TX), were vaccinated with Bovashield 4 (Pfizer Animal Health) at weaning and again 3 wk later with Cattlemaster 4 (Pfizer Animal Health), Clostridial 7-Way with Haemophilus somnus and vitamin E. The 205-d adjusted weaning weights of the bulls were 403 ± 44 lb. Upon arrival at the McGregor Research Center, bulls were dehorned and given Cydectin pour-on (Fort Dodge Animal Health). At the start of the experiment, the bulls averaged 256 ± 5 d of age. Bulls were stratified by BW, randomly assigned to pens (four bulls per pen) equipped with Calan gate feeders, adapted to the experimental diet and trained to eat from Calan gate feeders for 35 days. The experimental diet consisted of 50% cottonseed hulls, 13.5% dry rolled corn, 13.5% ground milo, 14.5% cottonseed meal, 6% molasses, and 2.5% vitamin/trace mineral premix (1.7 Mcal/kg ME; 12.4% CP, DM basis). Following the adaptation period, weekly BW and DMI were measured for 70 d. Ultrasound measurements of 12th rib fat thickness (backfat), ribeye area (REA), and percent intramuscular fat (IM) were obtained on days 0 and 70. Scrotal circumference was measured on days 0 and 70, and breeding soundness examinations were performed for 70 d (Amarillo, TX), were vaccinated with Bovashield 4 (Pfizer Animal Health) at weaning and again 3 wk later with Cattlemaster 4 (Pfizer Animal Health), Clostridial 7-Way with Haemophilus somnus and vitamin E. The 205-d adjusted weaning weights of the bulls were 403 ± 44 lb. Upon arrival at the McGregor Research Center, bulls were dehorned and given Cydectin pour-on (Fort Dodge Animal Health). At the start of the experiment, the bulls averaged 256 ± 5 d of age. Bulls were stratified by BW, randomly assigned to pens (four bulls per pen) equipped with Calan gate feeders, adapted to the experimental diet and trained to eat from Calan gate feeders for 35 days. The experimental diet consisted of 50% cottonseed hulls, 13.5% dry rolled corn, 13.5% ground milo, 14.5% cottonseed meal, 6% molasses, and 2.5% vitamin/trace mineral premix (1.7 Mcal/kg ME; 12.4% CP, DM basis). Following the adaptation period, weekly BW and DMI were measured for 70 d. Ultrasound measurements of 12th rib fat thickness (backfat), ribeye area (REA), and percent intramuscular fat (IM) were obtained on days 0 and 70. Scrotal circumference was measured on days 0 and 70, and breeding soundness examinations were performed for 70 d.

Summary

Net feed intake (NFI) is a moderately heritable feed efficiency trait that has been shown to be genetically independent of ADG and BW in beef cattle. Objectives of this study were to characterize NFI in growing bulls, and to examine phenotypic correlations between NFI and performance, body composition, and fertility traits. Net feed intake was positively correlated phenotypically with feed conversion ratio (FCR), but was phenotypically independent of BW and ADG. Bulls with low NFI (< 0.5 SD below mean) consumed 20% less feed than bulls with high NFI (> 0.5 SD above mean), even though both groups of bulls gained the same and had similar BW. Net feed intake was not correlated with longissimus muscle area, but tended to be positively correlated with subcutaneous fat thickness at the 12th rib and percent intramuscular fat of the longissimus muscle. Scrotal circumference and sperm motility traits measured in this study were not correlated with NFI, although scrotal circumference was positively correlated with FCR. These results suggest that NFI may be a useful trait to improve feed efficiency in cattle, independent of growth traits. NFI was not related to bull fertility traits in this study, but additional studies are warranted to confirm these results and to further examine the relationships between NFI and body composition and meat quality traits.
performed five and 61 days following the completion of the 70-day performance measurement period.

**Calculations and Statistical Analyses.**
Linear regression of weekly BW against time was used to derive ADG, initial and final BW, and mid-test BW^{.75} (mean of initial and final BW raised to the power of .75) for each bull. To calculate NFI, average dry matter feed intakes (DMI) were regressed on ADG and mid-test BW^{.75}. Individual NFI were calculated as the actual DMI minus DMI predicted from the regression equation. Feed conversion ratios were calculated as DMI divided by ADG. In addition to NFI and FCR, residual gain efficiency (RG) was also computed for each bull as described by Koch et al. (1963). Individual RG were calculated as the difference between actual and expected ADG. Expected ADG were determined by regressing ADG on mid-test BW^{.75} and DMI. Cattle that gain faster than expected for their BW and actual DMI will have positive RG and be more efficient.

Partial correlations were performed using the Proc CORR procedure of SAS (1999) to determine significant relationships between feed efficiency traits (NFI, FCR and RG), and performance traits, ultrasound measures of body composition, and fertility traits. To further characterize NFI, bulls were ranked by NFI and separated into low, medium and high groups that were < 0.5 SD, ± 0.5 SD, and > 0.5 SD, respectively, from the mean NFI of 0.0 ± 2.4 lb/day (mean ± SD). The least-squares mean option of the GLM procedure of SAS (1999) was then used to evaluate trait differences traits among RFI groups. The chi-square option of FREQ (SAS, 1999) was used to observe differences in extension of penis, semen concentrations, sperm abnormalities and breeding soundness classifications between RFI groups of bulls.

**Results and Discussion**
Overall ADG, DMI, and NFI during the 70-d trial were 3.89 (SD = 0.44), 24.4 (SD = 3.7), and 0.00 (SD = 2.40) lb/day, respectively. Dry matter intakes were phenotypically correlated (P < 0.001) with ADG (r = 0.66), initial BW (r = 0.56) and final BW (r = 0.71). As expected, NFI was not phenotypically correlated with initial BW, final BW, or ADG, as these traits are included as independent variables in the calculation of NFI. Feed conversion ratio tended (P = 0.15) to be negatively correlated with ADG (r = -0.18), although this correlation was considerably less than the phenotypic correlations (r = -0.72 to -0.74) reported in previous studies (Arthur et al., 2001a; Carstens et al., 2002). Negative correlations between FCR and ADG suggest that applying selection pressure against FCR may lead to larger cow mature size and increases in feed required for maintenance of the cow herd (Herd and Bishop, 2000).

Residual gain was positively correlated with ADG (r = 0.75) and negatively correlated with NFI (r = -0.51) and FCR (-0.78). As expected, RG was not correlated with initial or final BW or DMI.

Average NFI for bulls identified as having low (< 0.5 SD below the mean), medium (± 0.5 SD from the mean) and high (> 0.5 SD above the mean) NFI were -2.90, -0.07, and 2.44 ± 0.29 lb/d, respectively. Growth rate (Figure 1), initial BW, and final BW were not statistically different for low, medium, and high NFI bulls. However, bulls with low NFI (more efficient) consumed 20% less (P < 0.001) dry matter feed than bulls with high NFI (less efficient; Figure 1). Consequently, bulls with low NFI had FCR that were 21% lower compared to bulls with high NFI.

Net feed intake was not correlated with REA, but there was a tendency (P ≤ .10) for NFI to be correlated with final backfat (r = 0.20) and final IM fat (r = 0.23) (Table 1). Bulls with low NFI tended (P = 0.10) to have less IM fat (2.60 vs 2.78 ± 0.07%) and less backfat (0.21 vs 0.23 ± .006 inches) than bulls with high NFI, although REA was similar among NFI groups. Feed conversion ratio was correlated with IM fat (r = 0.25; P < .05), but not with backfat or REA. Residual gain was not correlated with backfat or IM fat, but was positively correlated with REA (r = 0.26).

Scrotal circumference was not correlated with NFI on day 0, 70 or 61 d following the 70-d performance study. In contrast, scrotal circumference on day 0 of the study was positively correlated with FCR and negatively correlated with RG (Table 1). This would suggest that selection for improved feed efficiency based on FCR (lower FCR) or RG (higher RG) might lead to smaller scrotal circumference and potentially later maturing calves. Arthur et al. (2001a), however, did not observe significant genetic correlations between scrotal circumference and NFI or FCR feed efficiency measurements in Angus bulls. In the present study, sperm motility measured five and 61 days following the 70-d performance study was not correlated with either of the feed efficiency traits. Chi-square analysis revealed no significant differences (P > 0.20) between NFI groups in penile extension, semen concentration, sperm abnormalities, or overall breeding soundness. These results suggest that breeding soundness of bulls was not related to feed efficiency traits.

**Implications**
Results from this study demonstrate that NFI is an alternative measure of feed efficiency that may provide opportunities to identify more efficient cattle independent of growth traits. Increased leaness may have contributed to the improvement in feed efficiency of bulls with low net feed intake; however, the magnitude of this contribution was small. Scrotal circumference and sperm motility traits were not related to NFI in this study. Additional studies are warranted to further examine the relationship between NFI and bull fertility
traits to confirm that selection for improved feed efficiency using NFI will not compromise bull fertility.

**Literature Cited**


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**Figure 1.** Growth rate and dry matter intakes for bulls with low (< 0.5 SD below mean), medium or high (> 0.5 SD above mean) net feed intakes. There were 17, 24 and 21 bulls in the low, medium and high NFI groups, respectively. Standard errors for ADG and DMI were 0.11 and 0.75.
Table 1. Phenotypic correlations between feed efficiency and performance traits, scrotal circumference measured on day 0, and ultrasound traits measured on day 70 of the performance study

<table>
<thead>
<tr>
<th>Trait</th>
<th>NFI</th>
<th>FCR</th>
<th>RG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial (day 0) BW</td>
<td>0.00</td>
<td>0.41**</td>
<td>-0.18</td>
</tr>
<tr>
<td>Final (day 70) BW</td>
<td>0.00</td>
<td>0.26*</td>
<td>0.14</td>
</tr>
<tr>
<td>Dry matter intake</td>
<td>0.65**</td>
<td>0.62**</td>
<td>0.00</td>
</tr>
<tr>
<td>Average daily gain</td>
<td>0.00</td>
<td>-0.18</td>
<td>0.75**</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>0.85**</td>
<td>--</td>
<td>-0.78**</td>
</tr>
<tr>
<td>12th rib backfat</td>
<td>0.20†</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>Ribeye area</td>
<td>-0.01</td>
<td>0.15</td>
<td>0.26</td>
</tr>
<tr>
<td>Intramuscular fat percent</td>
<td>0.23†</td>
<td>0.25*</td>
<td>-0.12</td>
</tr>
<tr>
<td>Scrotal circumference</td>
<td>0.10</td>
<td>0.39**</td>
<td>-0.33**</td>
</tr>
</tbody>
</table>

aNFI = net feed intake; FCR = feed conversion or feed:gain ratio; RG = residual gain efficiency.

†P < 0.10.
*P < 0.05.
**P < 0.01.