Effects of selection for ultrasound intramuscular fat percentage in Angus bulls on carcass traits of progeny\textsuperscript{1,2}

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ABSTRACT: Angus bulls (n = 20) from three pure-bred herds in Georgia were acquired to determine the impact of selecting sires based on phenotypic yearling ultrasound intramuscular fat percentage (UIMF) or UIMF EPD on marbling score of steer progeny. Each year in each herd, pairs of bulls were selected to create large differences based on their age adjusted phenotypic yearling UIMF measurements. The average UIMF, weighted by number of progeny per sire, was 3.75\% (SD = 1.10\%) and 1.70\% (SD = 0.53\%) for high UIMF (HU) and low UIMF (LU) bulls, respectively. All available ultrasound measurements collected in the purebred cooperator herds were combined with other ultrasound records collected by the American Angus Association for the computation of genetic values for ultrasound fat thickness, ribeye area, and intramuscular fat percentage. Each year bulls were randomly mated to 14 to 30 commercial Angus females. Carcass weight, fat thickness at the 12th rib, ribeye area at the 12th rib, marbling score, yield grade, and quality-grade measurements were collected on 188 steer progeny. Carcass data were linearly adjusted to 480 d of age at slaughter. Steer progeny sired by HU bulls had higher age-adjusted marbling score and quality grade (P < 0.05), and smaller age-adjusted ribeye area (P < 0.05) than steer progeny sired by LU bulls. No significant differences between phenotypic UIMF lines were found for age-adjusted fat thickness (P = 0.84) and yield grade (P = 0.33) in the steer progeny. The regression of age-adjusted carcass marbling score and quality grade of the steer progeny on ultrasound intramuscular fat percentage EPD of the sires produced highly significant regression coefficients of 90.50 and 49.20, respectively. Thus, yearling Angus bulls selected for high-phenotypic UIMF and UIMF EPD can be expected to produce steer progeny with significantly higher amounts of marbling and quality grade. It also appears that marbling can be increased without corresponding increases in external fat thickness and yield grade.

Key Words: Beef Cattle, Carcass Quality, Selection, Ultrasound

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Introduction

Ultrasound as a means of predicting carcass merit is relatively inexpensive, has a shorter generation interval when compared with carcass sire progeny testing programs, and the data provided via ultrasound may be subject to less selection bias than carcass data collected via sire progeny testing programs. Studies have shown that ultrasound measures of fat thickness and ribeye area (Perkins et al., 1992; Herring et al., 1994; Bergen et al., 1996), and intramuscular fat percentage (Reverter et al., 2000; Hassen et al., 2001) are accurate predictors of their corresponding carcass traits in fed slaughter cattle. Average heritability estimates of seedstock cattle summarized from published literature for ultrasound measures of fat thickness, ribeye area, and intramuscular fat percentage are moderate-to-high (Bertrand et al., 2001). These moderate-to-high average heritabilities indicate that selecting seedstock animals based on ultrasound measurements has the potential to improve carcass traits in their progeny.

An important issue affecting the ultimate usefulness of live-animal ultrasound information as a tool for carcass genetic improvement is the genetic relationship between the live-animal measurements of seedstock cattle and the corresponding carcass measurements of their progeny (Baud et al., 1998). Researchers have shown the genetic correlation between ultrasound measurements of seedstock cattle and the
corresponding carcass measurements of fed cattle to be positive, but variable in magnitude (Moser et al., 1998; Devitt and Wilton, 2000; Reverter et al., 2000). Little information is available in the literature to assess the consequences of actual sire selection, based on ultrasound measures, on the carcass measures of their progeny. The objective of this study was to determine the impact of selecting sires based on phenotypic yearling ultrasound intramuscular fat percentage (UIMF) or UIMF EPD on marbling score of steer progeny.

**Materials and Methods**

**General**

Over 5 yr, Angus bulls (n = 422) born between 1992 and 1997 from three purebred herds in Georgia were scanned via real-time ultrasound at approximately 1 yr of age. Each year, either a Beef Improvement Federation-certified or an American Association of Ultrasound Practitioners-certified technician collected images using an Aloka 500V (Corometrics Medical Systems, Wallingford, CT) machine with a 17.2-cm linear probe. Three different sonographers were used during the project. Each year, the sonographer that collected the images also interpreted the images of ultrasound fat thickness and UIMF measurements that were obtained. Ultrasound ribeye area measurements during yr 2 to 5 were also collected and interpreted by the same sonographer; however, ultrasound ribeye-area measurements were not obtained during yr 1 of the project. The images taken to assess UIMF were interpreted using Beef Information Manager software, Version 3.0 (Critical Vision, Inc., Atlanta, GA). The ultrasound measurements for all traits were then linearly adjusted to 365 d according to regression coefficients proposed by Wilson et al. (1999) for yearling Angus bulls. Each year in each herd, pairs of bulls were selected to create large differences based on their age-adjusted phenotypic yearling UIMF measurements. Selection of bulls was based solely on age-adjusted phenotypic yearling UIMF measurements.

In each of the 5 yr, bulls were individually mated to 14 to 30 commercial Angus females at the Northwest Georgia Branch Experiment Station (Calhoun, GA). Females were randomly assigned to sires. Four bulls were used in yr 1 of the project. Four new bulls entered the project in yr 2 and 4 of the project. Two and six new bulls entered the project in yr 3 and 5, respectively. Bulls were used for only 1 yr, except for two of the original four bulls, one high-UIMF (HU) and one low-UIMF line (LU) bull, that remained throughout the entire project. Females were exposed to bulls in early April each year for approximately 90 d. Progeny were born in 1995 to 1999.

Actual birth and weaning weights were recorded on all calves. Bull calves were castrated at birth and implanted with 36 mg of zeranol (Ralco; Schering-Plough Animal Health Corporation, Terre Haute, IN). Cows were grazed on Fescue pasture and consumed minerals ad libitum while the calves were at their sides. Calves remained with their dams until weaning. Steer calves were implanted with 100 mg of progesterone and 10 mg of estradiol benzoate (Synovex C; Syntex Animal Health Inc., Des Moines, IA) at 3 to 4 mo of age and again at weaning. After weaning, steer calves were developed on Fescue pasture and received additional supplementation of approximately 50% rolled barley, 35% rolled corn, and 15% whole rolled soybeans at 1% of the steer’s body weight daily (as-fed basis). Steers also consumed fescue hay on an ad libitum basis. Steer calves were shipped to the feedyard at approximately 12 to 15 mo of age. Steers were implanted with 200 mg trenbolone acetate and 28 mg of estradiol benzoate (Synovex Plus; Syntex Animal Health Inc.) at the start of the finishing period. In yr 1 of the project, steer progeny were fed and harvested at University of Georgia facilities. After yr 1, steer progeny were shipped to a commercial feedlot for finishing and harvested by a commercial packer. Average age at slaughter was 392 d for yr 1 and a range of 514 to 576 d for yr 2 to 5. Trained University of Georgia personnel evaluated carcasses during yr 1 for USDA yield and quality-grade factors; during yr 2 to 5 the same factors were evaluated on carcasses by USDA graders in the packing plants. The final data used in the analysis included 188 steer carcass records. Traits analyzed were carcass weight, fat thickness, ribeye area, marbling score, yield grade, and quality grade. The numerical marbling score was a subjective scoring system related to the amount of observable intramuscular fat in the ribeye.

**Statistical Analyses**

Phenotypic UIMF measurements adjusted to 365 d were used to group bulls into HU and LU lines. The number of progeny and the average age-adjusted phenotypic UIMF measurement, weighted by number of progeny per sire, for HU and LU line bulls are listed in Table 1. Carcass weight, fat thickness, ribeye area, and marbling score were linearly adjusted to 480 d of age at slaughter using the adjustment factors published for the Angus breed in the American Angus Association (AAA) fall 2001 carcass evaluation (Wilson, 2001b). Age-adjusted ribeye area, fat thickness, and carcass weight were used to calculate age-adjusted yield grade, and age-adjusted marbling score was used in the computation of age-adjusted quality grade. The age-adjusted carcass traits were analyzed using the MIXED procedure of SAS, version 6.12 (SAS Inst. Inc., Cary, NC). The model used for analyses of all carcass traits measured in the progeny included fixed effects for birth year of calf, phenotypic UIMF line of sire, and interaction between year and line. Sire, nested within year and line, was included as a random effect.
The available ultrasound measures of all yearling bulls that were collected in the purebred cooperator herds during the 5 yr of the project were combined with other ultrasound records collected by AAA. These data were then used to compute genetic values for ultrasound fat thickness, ribeye area, and intramuscular fat percentage during June 2001. The analysis procedures for the computation of ultrasound genetic values were outlined by Wilson (2001a). The current genetic evaluation of ultrasound traits by AAA adjusts fat thickness and ribeye area for weight and age at the time of scanning. Because a large proportion of the bulls had missing scan weights, the genetic evaluation was conducted adjusting all ultrasound traits for age only. All bull ultrasound measurements were adjusted to 365 d and heifer ultrasound measurements were adjusted to 390 d and to a bull equivalent. The average UIMF EPD, weighted by number of progeny per sire, for HU and LU line bulls is listed in Table 1.

The regression of steer carcass data on ultrasound EPD of sires was used to determine the impact of ultrasound EPD on progeny carcass measures. The carcass data were analyzed using the GLM procedure of SAS, version 6.12 (SAS Inst. Inc.). The model used for the regression of age-adjusted carcass traits on ultrasound EPD of sires included the fixed effect for birth year of calf and the covariate of ultrasound EPD of sire, in which the carcass traits were adjusted to 480 d of age at slaughter using the adjustment factors published for the Angus breed in the AAA fall 2001 carcass evaluation (Wilson, 2001b).

**Results and Discussion**

Overall means for 188 steer progeny by phenotypic UIMF line of sire are listed in Table 2. Year of birth was highly significant for carcass weight, ribeye area, marbling score, and quality grade and significant for yield grade. Year × line interaction was only significant for ribeye area.

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### Table 1. Phenotypic ultrasound intramuscular fat percentage line weighted average age-adjusted UIMF and UIMF EPD

<table>
<thead>
<tr>
<th>Item</th>
<th>Phenotypic UIMF line</th>
<th>UIMF EPD, %</th>
<th>BA*</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. sires</td>
<td>High</td>
<td>9</td>
<td>—</td>
<td>3.75</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>96</td>
<td>92</td>
<td>1.10</td>
</tr>
<tr>
<td>No. progeny</td>
<td>High</td>
<td>11</td>
<td>—</td>
<td>1.70</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>92</td>
<td>92</td>
<td>0.53</td>
</tr>
<tr>
<td>UIMF, %</td>
<td>High</td>
<td>3.49</td>
<td>0.82</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>3.49</td>
<td>0.82</td>
<td>—</td>
</tr>
</tbody>
</table>

*Breed average, breed average for Angus cattle evaluated in the AAA fall 2001 body composition evaluation (Wilson, 2001a). UIMF = phenotypic ultrasound intramuscular fat percentage.

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*Analyses by Phenotypic Ultrasound Intramuscular Fat Percentage Lines*

Least squares means for progeny carcass traits of the 20 bulls are listed by line in Table 3. Marbling score and quality grade were higher ($P < 0.05$) for HU calves than LU calves. In the steer progeny, ribeye areas of LU line were larger than HU line in 4 of the 5 yr, smaller than HU line in 1 of the 5 yr, and the overall effect of line was significant for ribeye area with HU having smaller ribeye area compared to LU. The genetic correlation, summarized from published literature, between UIMF percentage and ultrasound ribeye area (range of $-0.12$ to $-0.01$) averaged $-0.07$ (Bertrand et al., 2001). Bertrand et al. (2001) also reported an average genetic correlation of $-0.01$ (range of $-0.37$ to $0.51$) between carcass ribeye area and marbling score from 10 published literature reports. The fact that the ribeye area was significantly larger for progeny sired by LU bulls compared with progeny sired by HU bulls may suggest that the correlation between ribeye area and marbling is more antagonistic than the literature suggests. Similarly, Gwartney et al. (1996) reported a tendency for ribeye areas to be larger in heifers and steers sired by bulls in a low marbling-score EPD group compared with heifers and steers sired by bulls in a high marbling-score EPD group when carcass traits were adjusted for days on feed, carcass weight, fat thickness, and marbling score.

No significant differences between phenotypic UIMF lines were found for fat thickness ($P = 0.84$) and yield grade ($P = 0.33$) in the steer progeny. The summarized genetic correlation from published literature between UIMF and ultrasound fat thickness averaged 0.08 (range of $-0.02$ to 0.17) and between carcass fat thickness and marbling score (range of $-0.13$ to 0.44) averaged 0.10 (Bertrand et al., 2001). The magnitude of these correlations suggests that selection for increased marbling can be obtained without increasing external fat. The results of this study also indicate that intramuscular fat percentage can be increased without increasing external fat. Our finding that neither fat thickness or yield grade was significantly different when selecting for increased marbling concurs with Gwartney et al. (1996) and Vieselmeyer et al. (1996). Both studies found that when sires were selected based on high and low marbling-score EPD, fat thickness and yield grade in heifer and steer progeny were similar across the two marbling score EPD lines.
Table 2. Phenotypic means and SD for steer progeny by phenotypic ultrasound intramuscular fat percentage line of sire

<table>
<thead>
<tr>
<th>Item</th>
<th>High</th>
<th>SD</th>
<th>Low</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. progeny</td>
<td>96</td>
<td>—</td>
<td>92</td>
<td>—</td>
</tr>
<tr>
<td>CW, kg&lt;sup&gt;a&lt;/sup&gt;</td>
<td>344.58</td>
<td>41.30</td>
<td>341.28</td>
<td>38.56</td>
</tr>
<tr>
<td>FAT, cm</td>
<td>1.55</td>
<td>0.41</td>
<td>1.55</td>
<td>0.43</td>
</tr>
<tr>
<td>REA, cm&lt;sup&gt;2&lt;/sup&gt;</td>
<td>75.90</td>
<td>7.06</td>
<td>78.43</td>
<td>9.15</td>
</tr>
<tr>
<td>MS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>430.89</td>
<td>86.40</td>
<td>400.41</td>
<td>75.02</td>
</tr>
<tr>
<td>YG, %</td>
<td>3.55</td>
<td>0.64</td>
<td>3.40</td>
<td>0.72</td>
</tr>
<tr>
<td>QG&lt;sup&gt;c&lt;/sup&gt;</td>
<td>598.19</td>
<td>43.78</td>
<td>580.91</td>
<td>46.61</td>
</tr>
</tbody>
</table>

<sup>a</sup>CW = carcass weight; FAT = fat thickness; REA = ribeye area; MS = marbling score; YG = yield grade; QG = quality grade, where the carcass traits were linearly adjusted to 480 d of age at slaughter; UIMF, ultrasound intramuscular fat percentage.

<sup>b</sup>300–399 = slight, 400–499 = small, 500–599 = modest.

<sup>c</sup>500–599 = Select, 600–699 = Choice.

Analyses Using Ultrasound Expected Progeny Difference

The regression of carcass marbling score of steer progeny on ultrasound intramuscular fat percentage EPD of sires produced a highly significant regression coefficient of 90.50. The regression of carcass quality-grade of steer progeny on ultrasound intramuscular fat percentage EPD of sires produced a highly significant regression coefficient of 49.20.

Direct selection using EPD has been demonstrated to improve growth traits (Hough et al., 1985; Mahrt et al., 1990), birth weight (Arnold et al., 1990; Lykins et al., 2000), and carcass traits (Gwartney et al., 1996; Vieselmeyer et al., 1996; Bertrand et al., 1997) in beef cattle. Traditional carcass evaluation programs have utilized carcass data produced from a structured sire progeny testing program. As elucidated by Wilson (1992), carcass progeny testing programs are costly in time and expense. Therefore, Wilson (1992) proposed that yearling live-animal ultrasound measurements of carcass traits in seedstock cattle be included in national cattle evaluation programs to decrease cost and generation interval. The usefulness of ultrasound for improving carcass merit will be dependent on the magnitude of the genetic relationship between ultrasound measures of carcass traits in seedstock cattle and the corresponding carcass measures in fed slaughter cattle. Reports by Bertrand et al. (2001) and Devitt and Wilton (2000) reported genetic correlations between ultrasound intramuscular fat percentage in seedstock cattle and marbling score in fed slaughter cattle of 0.70 and 0.88, respectively. Reverter et al. (2000) used data from Australian Angus and Hereford cattle to estimate within-breed genetic parameters between carcass measures from steers and heifers and 15-mo ultrasound measures from bulls and heifers. Near-infrared spectroscopy was used to measure intramuscular fat percentage in slaughter cattle in the abattoir. The genetic correlation for Angus carcass and ultrasound bull measures for intramuscular fat percentage was 0.47, and the same correlation involving Hereford carcass and ultrasound bull measures for intramuscular fat percentage was 0.28. The same genetic correlation involving carcass and seedstock ultrasound measures for intramuscular fat percent-

Table 3. Least squares means for carcass traits of steer progeny by phenotypic ultrasound intramuscular fat percentage line of sire

<table>
<thead>
<tr>
<th>Item</th>
<th>High</th>
<th>Low</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. progeny</td>
<td>96</td>
<td>92</td>
<td>—</td>
</tr>
<tr>
<td>CW, kg&lt;sup&gt;a&lt;/sup&gt;</td>
<td>335.58 ± 5.08</td>
<td>337.90 ± 4.36</td>
<td>-2.32 ± 6.70</td>
</tr>
<tr>
<td>FAT, cm</td>
<td>1.54 ± 0.06</td>
<td>1.53 ± 0.05</td>
<td>0.02 ± 0.08</td>
</tr>
<tr>
<td>REA, cm&lt;sup&gt;2&lt;/sup&gt;</td>
<td>74.89 ± 0.85</td>
<td>77.86 ± 0.72</td>
<td>-2.97 ± 1.11*</td>
</tr>
<tr>
<td>MS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>452.36 ± 11.76</td>
<td>408.16 ± 10.15</td>
<td>44.19 ± 15.53*</td>
</tr>
<tr>
<td>YG, %</td>
<td>3.50 ± 0.09</td>
<td>3.38 ± 0.08</td>
<td>0.12 ± 0.12</td>
</tr>
<tr>
<td>QG&lt;sup&gt;c&lt;/sup&gt;</td>
<td>607.97 ± 6.25</td>
<td>585.09 ± 5.39</td>
<td>22.87 ± 8.26*</td>
</tr>
</tbody>
</table>

<sup>a</sup>CW = carcass weight; FAT = fat thickness; REA = ribeye area; MS = marbling score; YG = yield grade; QG = quality grade, where the carcass traits were linearly adjusted to 480 d of age at slaughter; UIMF, ultrasound intramuscular fat percentage.

<sup>b</sup>300–399 = slight, 400–499 = small, 500–599 = modest.

<sup>c</sup>500–599 = Select, 600–699 = Choice.

*P < 0.05.
age within the same breed was 0.46 for Angus heifers and 0.93 for Hereford heifers.

To our knowledge, no previous report has shown that selection of yearling bulls based on phenotypic intramuscular fat percentage produces marbling score differences in their steer progeny. Our findings indicate that for every 1% difference between the intramuscular fat percentage EPD of bulls a 90.50 marbling score difference in the progeny results. The range in ultrasound intramuscular fat percentage EPD for all animals was −0.59% to 0.78% in the AAA fall 2001 body composition evaluation (Wilson, 2001a). This range in intramuscular fat percentage EPD would equate to a possible range of 124 marbling score unit difference in the resulting progeny. It is interesting to note that the range in marbling score EPD (~0.66 to 7.77) of sires in the AAA fall 2001 carcass evaluation program (Wilson, 2001b) would equate to a possible range of 143 marbling score unit difference in the resulting progeny. This may imply that UIMF EPD predicted from yearling seedstock data provides similar genetic potential for changing marbling score in slaughter progeny when compared with marbling score EPD predicted from actual carcass data.

The regression of carcass yield grade of steer progeny on ultrasound fat thickness EPD of sires produced a significant regression coefficient of 2.70. Carcass fat thickness of steer progeny regressed on ultrasound fat thickness EPD of sires produced a regression coefficient of 1.19 ($P = 0.13$). Bertrand et al. (1997) expressed concerns that small differences in ultrasound fat thickness EPD could translate to far larger external fat differences in steer progeny. The regression estimate found in this study does not support this concern. However, this concern could still be valid for breeds that have lower amounts of external fat thickness in yearling bulls compared with Angus. The range in fat thickness EPD of sires in the AAA fall 2001 carcass evaluation (Wilson, 2001b) was 0.46 cm. The range in ultrasound fat thickness EPD of all animals from the AAA fall 2001 body composition evaluation (Wilson, 2001a) was also 0.46 cm. Again, this may imply that fat thickness EPD predicted from yearling seedstock data provides similar genetic potential for changing external fat in slaughter progeny when compared with fat thickness EPD predicted from actual carcass data.

Carcass ribeye area of steer progeny regressed on ultrasound ribeye-area EPD of sires produced a regression coefficient of 0.40. However, it may be difficult to draw definite conclusions from this result because bulls measured in yr 1 of the project had no ultrasound ribeye-area measurements. This resulted in four bulls, including the two bulls that were used each year of the project, which had a pedigree only ultrasound ribeye-area estimate. It is encouraging that the regression coefficient is positive, thus suggesting that ultrasound ribeye-area EPD would improve ribeye area in slaughter progeny.

**Implications**

Yearling Angus bulls selected for high-phenotypic ultrasound intramuscular fat percentage or phenotypic ultrasound intramuscular fat percentage expected progeny difference can be expected to produce steers with significantly higher amounts of marbling and quality grade. Apparently, marbling can be increased without corresponding increases in external fat thickness and yield grade. This implies that ultrasound intramuscular fat percentage should be included in genetic evaluation programs to allow producers to select animals that can influence degree of marbling in slaughter progeny at a younger age.

**Literature Cited**


