# Serial Measurements Using Real-Time Ultrasound to Evaluate Relative Changes in Fat Thickness and Ribeye Area of Feedlot Steers

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## ABSTRACT

**Feedlot steers representing two breed-X groups (Salers-X, n=46 and Brangus-X, n=50) were measured ultrasonically at 28 d intervals to evaluate changes in fat thickness (FTU1), and area of the longissimus muscle (REAU1) for the possible development of prediction equations for time and weight effects on ultrasonic measurements. The Salers-X group was also measured (FTU2 and REAU2) with an additional ultrasound unit. Individual ages were not available on the cattle studied, so date of measurement was used as the time effect. Body weights were taken at time of isonification. Initial weight means were 649.5 and 798.3 (pooled SE = 61.1) lb for Salers-X and Brangus-X groups, while final weights were 1093 and 1087.9 (pooled SE = 81.3) lb, respectively. Regression equations for the Salers-X group indicated linear relationships ($P < .01$) between FTU1 for both time and weight effects. Regression coefficients, b (and $R^2$ values) for the Salers-X group were: b=.00045 (.51), b=-.0000079 (.57) for FTU1 on weight and time, respectively. For the Brangus-X group, linear relationships existed ($P < .01$) between REAU1 on weight and time, respectively; b=.0091 (.51) and b=-.00012 (.36). For the Salers-X group, correlation coefficients between the two machines ranged from .802 to .928 for FTU and .361 to .738 for REAU. These data could be useful for development of adjustment procedures of ultrasonic measurements for prediction of carcass merit.**

KEY WORDS: Beef Cattle, Carcass Traits.

The use of ultrasonic techniques for prediction of fat thickness was initiated many years ago in beef cattle (Hazel and Kline, 1959; Stouffer, 1961) and in hogs (Panier, 1957). Advances in equipment and interest by beef industry groups has generated increasing amounts of research in the ultrasound field in recent years. Prediction of carcass attributes on the live animal through the use of ultrasonic imaging has been proposed as the method offering the most promise for incorporation of expected progeny differences for carcass merit into breed improvement programs

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(BIF, 1989). Much research has been done with ultrasound, primarily measuring fat thickness and ribeye area, as a means of predicting final carcass composition (Houghton, 1992). Little research has been done in evaluating changes in ultrasonic measures over the course of a feeding period. This information would be useful for standardizing measurements to constant time and weight endpoints for animal evaluation. Therefore, the objectives of this study were to develop prediction equations for time and weight effects on ultrasonic measurements and to measure relative change in ultrasonically predicted fat thickness and ribeye area in feedlot steers.

## MATERIALS AND METHODS

### Animals

The cattle used in the project were owned by the Bradley 3 Ranch and maintained at their facilities located at the ranch headquarters at Memphis, TX. Feedlot steers representing two breed-X groups (Salers-X, n=46 and Brangus-X, n=50) were used in the project. The Salers-X group calves were sired by Salers bulls while the Brangus-X group calves were sired by Brangus bulls. Both sire breed groups originated from a single producer and were calved from crossbred cows. The two groups were fed separately throughout the entire feeding period. After cattle arrived at the feedlot, they were processed and then allowed a 30 d adjustment period before the first ultrasonic image was taken. Thereafter, images were taken on 28 d intervals (8 measurements for the Salers-X and 6 measurements for the Brangus-X group) until slaughter. The animals were selected for slaughter based on individual merit as evaluated by the owner and operator of the feedlot resulting in uneven numbers per slaughter group. Selection was based on the evaluator's estimation that the animal would produce a carcass with a USDA quality grade (QG) of Choice or better with a USDA yield grade (YG) of less than 2.0.

### Ultrasonic Images

Images were taken by two technicians on 28 d intervals. The last measure for each animal was obtained 24 h before slaughter. Both the Brangus-X and Salers-X group were isonified with Unit 1 (Aloka 210DX, Corometrics Medical Systems, Inc., Wallingford, CT 06492) equipped with a 3.0 $MH_z$, 102-mm scanning width, linear array transducer. In addition, Unit 2 (Tokyo Keiki LS 1000, Products Group International, Inc., Boulder, CO 80322) equipped with a 3.5$MH_z$, 102-mm scanning width, linear array transducer was used to isonify the Salers-X group. The transducer was placed at the 12th-13th rib interface lateral to the vertebrae and parallel to the rib. Both fat thickness and ribeye area images were taken at this site. To ensure proper contact between transducer and animal, corn oil (Mazola®) was placed on the animal at the isonification site and used as a couplant. At time of isonification, images were recorded on a high resolution tape with a video cassette recorder. Fat thickness was estimated on site with internal calipers available within the ultrasound unit. The recorded images were analyzed on a computer system using a software package (PlusMorph, Woods Hole Educational Associates, Woods Hole, MA 02543) to determine ribeye area. A problem was encountered with the VCR while recording the images for later analysis on d 140 for the Salers-X group resulting in a lack of data for that subclass.

### Carcass Data

Animals were slaughtered at B3R Country Meats, Childress, TX. All carcass information was collected 48 h post-mortem by trained personnel employed at the processing plant. Data collected included fat thickness (FTC) and ribeye area (REAC) measurements, YG (estimated by personnel), kidney pelvic and heart fat (KPH) and QG estimates.

### Statistical Analysis

All statistical analyses were computed using procedures of SAS (1990). Regression models were utilized to evaluate the linear and quadratic effects of time on feed and live weight. Pearson correlation coefficients were estimated among important variables. Variables analyzed were ultrasonic measurements of fat thickness and ribeye area, and carcass measures FTC, REAC, KPH, YG, and QG. Analyses were performed separately by breed-X group because the two groups were initially at different points on their growth curve, were placed on feed at different times, and a different technician measured each sire-breed group.

## RESULTS

The initial weight differences in the cattle are shown in Table 1. The Salers-X group was lighter when the project started but the final weight means are very similar which is attributable to the individual selection criteria the owner/operator implemented to select animals for slaughter. Also shown are FTC and REAC means for the two groups. The Salers-X group had a larger estimated ribeye area with less fat thickness.

Table 1. Descriptive means and standard errors for Salers-X and Brangus-X feedlot steers[a].

| Measurement | Salers-X | | Brangus-X | |
|---|---|---|---|---|
| | Mean | SE | Mean | SE |
| Initial wt, lb | 649.49 | (51.73)[b] | 799.31 | (69.53) |
| Final wt, lb | 1093.0 | (64.53) | 1097.9 | (97.62) |
| FTC, in | .2947 | (.0985) | .3679 | (.1157) |
| REAC, $in^2$ | 12.20 | (.9767) | 11.81 | (1.26) |
| Average days on feed | 163 | (20.6) | 107 | (27.5) |

[a]FTC = carcass fat thickness, REAC = carcass ribeye area.
[b]Mean (pooled SE).

Shown in Table 2 are the means and standard errors for FTU and REAU measurements by time period for both groups. As shown, there is a general upward trend for FTU for both groups while the REAU measurements reached a peak and then plateaued on the last few measurements. In addition, the Brangus-X group had a higher initial fat thickness that continued to be higher through each measurement date. The higher initial weight and fat thickness resulted in fewer days on feed for the Brangus-X group.

Table 2. Means and standard errors of ultrasonic measures by time of measure and breed group[a].

| | Salers-X | | Brangus-X | |
|---|---|---|---|---|
| Day | FTU(in) | REAU($in^2$) | FTU(in) | REAU($in^2$) |
| 0 | .11 (.04)[b] | 8.66 (1.09) | .17 (.03) | 8.78 (.99) |
| 28 | .16 (.04) | 9.39 (1.26) | .20 (.06) | 9.73 (1.45) |
| 56 | .22 (.05) | 9.51 (1.06) | .31 (.11) | 10.40 (1.18) |
| 84 | .25 (.07) | 8.98 (1.17) | .32 (.10) | 10.97 (1.24) |
| 112 | .25 (.07) | 11.12 (.70) | .32 (.08) | 11.52 (1.34) |
| 140 | .30 (.07) | | .28 (.07) | 11.27 (1.06) |
| 168 | .30 (.07) | 10.57 (1.11) | | |
| 196 | .30 (.08) | 10.74 (.757) | | |

[a]FTU = ultrasonic fat thickness, REAU = ultrasonic ribeye area.
[b]Standard errors in parentheses.

Presented in Table 3 are the means and standard errors of the carcass measures by slaughter group. As seen in this table, cattle were not slaughtered on exact 28 d intervals due to the individual selection criteria imposed by the operator. This resulted in a range in days on feed from 70 to 195 for the animals in the study and unbalanced subclasses between slaughter dates.

When evaluating the correlation coefficients between ultrasonic measurements and final carcass measurements for fat thickness using unit one, a trend of improvement in accuracy occurred for the Salers-X group when moving from d 0 to 196 (Table 4). However, there was no visible trend in accuracy of ultrasonic measurement of ribeye area. One possible explanation for this result is that the sample sizes were smaller in the later measurement dates, however this also would hold true for the fat thickness measurements. The smaller groups at final measurement can be attributed to the selection process imposed by the feedlot operator. Correlation coefficients for the Brangus-X group indicated the same general tendencies as those from Salers-X's. There was a general trend of improvement in accuracy for fat thickness measurements and a general improvement trend for the ribeye area measurements except for the final measurement date, possibly due to the increased experience of the technicians. When evaluating the correlation coefficients for unit two, there was a noticeable trend of improvement for FTU2 and a range of unfavorably low correlations for REAU2 ($r=.00$ to $r=.38$).

Table 3. Means and standard errors of carcass measures by slaughter group[a]

| DAY | N | WT(lb)[b] | FTU1(in) | REAU1($in^2$) | FTC(in) | REAC($in^2$) |
|---|---|---|---|---|---|---|
| 70 | 6 | 1135 (63.6) | .47 (.07) | 11.1 (1.35) | .40 (.07) | 11.8 (1.15) |
| 84 | 10 | 1022 (79.1) | .47 (.06) | 11.2 (1.12) | .41 (.09) | 11.0 (.85) |
| 105 | 5 | 1198 (58.4) | .34 (.07) | 11.7 (1.26) | .33 (.09) | 12.4 (1.08) |
| 111 | 6 | 1173 (60.9) | .43 (.09) | 11.4 (1.36) | .36 (.15) | 12.6 (1.43) |
| 118 | 5 | 1081 (56.6) | | | .39 (.04) | 12.0 (1.15) |
| 125 | 3 | 1189 (48.2) | .40 (.07) | 11.2 (.5) | .35 (.07) | 12.5 (.08) |
| 139 | 7 | 1130 (41.9) | .35 (.09) | | .38 (.08) | 11.7 (1.24) |
| 153 | 10 | 1088 (38.8) | .40 (.07) | 10.5 (.70) | .29 (.05) | 12.0 (.70) |
| 153 | 7 | 1055 (109) | .38 (.11) | 10.2 (1.41) | .31 (.16) | 11.7 (1.14) |
| 166 | 15 | 1085 (58.8) | .31 (.07) | 10.3 (2.91) | .22 (.15) | 9.8 (5.0) |
| 195 | 9 | 1049 (52.7) | .30 (.07) | 10.7 (.71) | .26 (.09) | 12.7 (.32) |

[a]WT = live weight, FTU1 = ultrasonic fat thickness from Unit 1, REAU1 = ultrasonic ribeye area from Unit 1, FTC = carcass fat thickness, REAC = carcass ribeye area.
[b]Standard errors in parentheses.

Correlations between estimates from the two machines are also shown. For the fat thickness measurements, the correlations were high between machines for all days of measurement. The ribeye area correlations were moderate on all days except d 112. This low correlation resulted from the relative inaccuracy of the Tokyo Keiki unit on that measurement date. The comparison of the two machines indicates that both measured the traits similarly. However, Unit 1 had higher correlation coefficients for fat thickness in the early measurement dates while Unit 2 had higher correlations for ribeye area in the early measurements. In addition, there were differences in ease of operation with Unit 1 being lighter weight and more portable with internal calipers that were easier and quicker to use.

Expressed in Table 5 are the regression coefficients and $R^2$ values for weight and time on feed effects for both breed groups. For the Salers-X group, there was a linear effect ($P < .01$) of weight on FTU1 and time on feed on REAU1 with $R^2$ values of .51 and .18, respectively. In addition, time on FTU1 had a quadratic effect ($P < .01$) for the Salers-X group with an $R^2$ value of .57. The Brangus-X group had linear effects ($P < .01$) for weight on FTU1 and weight on REAU1 with $R^2$ values of .36 and .51, respectively. Quadratic effects ($P < .01$) were detected for time on FTU1 and time on REAU1 with .37 and .36 $R^2$ values respectively.

Table 5. Regression coefficients and R-squared values for weight and time effects on ultrasonic measurements[a].

| Variables | Salers-X b(Linear) | Salers-X b(Quadratic) | $R^2$ |
|---|---|---|---|
| FTU1 on WT. | 00045(.000079)[b] | NS | .51 |
| REAU1 on WT | NS | NS | |
| FTU1 on TIME | | -.0000079 (.000001) | .57 |
| REAU1 on TIME | .0102 (.0015) | NS | .18 |
| FTUCWT1 on TIME | | -.0000000056 (000000) | .30 |
| REAUCWT1 on TIME | | .000000178(.00000003) | .40 |

| Variables | Brangus-X b(Linear) | Brangus-X b(Quadratic) | $R^2$ |
|---|---|---|---|
| FTU1 on WT | .0005 (.00005) | NS | .36 |
| REAU1 on WT | .0091 (.0006) | NS | .51 |
| FTU1 on TIME | | -.000016 (.000003) | .37 |
| REAU1 on TIME | | -.00012 (.00005) | .36 |
| FTUCWT1 on TIME | | -.000000015 (000000) | .23 |
| REAUCWT1 on TIME | NS | | |

[a]FTU1 = ultrasonic fat thickness from unit 1, REAU1 = ultrasonic ribeye area from unit 1, WT = live weight, TIME = days on feed.
[b]Standard error of regression coefficients.

Table 6. Prediction equations for weight and time effects on ultrasonic measurements[a].

| Variables | Equations | SEE[b] | $R^2$ |
|---|---|---|---|
| Salers-X | | | |
| FTU1 on WT | $Y= -.1676 + .00045(x)$* | .0018 | .51 |
| REAU1 on WT | Non Significant | | |
| FTU1 on TIME | $Y= .1061 +.0023(x)-.0000079(x)^2$** | .0035 | .57 |
| REAU1 on TIME | $Y= 8.7795 + .0102(x)$* | .08 | .18 |
| FTUCWT1 on TIME | $Y=.0002+.000002(x)-.000000006(x)^2$** | .000004 | .30 |
| REAUCWT1 on TIME | $Y=.013-.00005(x)+.00000018(x)^2$** | .00000003 | .40 |
| Brangus-X | | | |
| FTU1 on WT | $Y= -.2073 + .0005(x)$* | .0025 | .36 |
| REAU1 on WT | $Y= 1.765 + .0091(x)$* | .32 | .51 |
| FTU1 on TIME | $Y= .1584 +.0033(x)-.000016(x)^2$** | .0055 | .37 |
| REAU1 on TIME | $Y= 8.8009 +.0368(x)-.00012(x)^2$** | .082 | .36 |
| FTUCWT1 on TIME | $Y=.0002+.000003(x)-.00000002(x)^2$ | .0000 | .23 |
| REAUCWT1 on TIME | Non Significant | | |

[a]FTU1 = ultrasonic fat thickness from Unit 1, REAU1 = ultrasonic ribeye area from Unit 1, WT = live weight, TIME = days on feed.
[b]Standard error of estimate.
*Linear effects ($P < .01$).
**Quadratic effects ($P < .01$).

Shown in Table 6 are the prediction equations derived from the regression coefficients expressed in Table 5. Only the significant equations are presented with their respective standard errors of the estimates and $R^2$ values. The Y represents the predicted fat thickness or ribeye area measurement derived from X. The X represents either the weight of the animal or number of days on feed. These equations could be beneficial in predicting final fat thickness and ribeye area measurements but in some cases need to be used with caution due to low to moderate $R^2$ values. Graphical representation of the prediction equations for FTU on time and REAU on weight are shown in Figures 1 and 2, respectively.

Another way of expressing the ultrasonic measurements over time is to express the FTU1 and REAU1 on a per hundred weight basis (FTU1CWT and REAU1CWT). Figure 3 shows the visual trend for FTU1. When moving from d 0 to 196, there was a general upward trend followed by a plateau for both breed groups. The plateau may have been caused by the selection criteria imposed by the operator. The curve could possibly have continued on an upward movement instead of plateauing early.

A logical occurrence appears when REAU1CWT is presented graphically in Figure 4. As time increased, REAU1CWT gradually decreased for the Salers-X group probably due to a decrease in lean gain and increase in fat gain due to physiological maturing. However, the Brangus-X group did not decrease but had a flatter trend. This can be explained by their lesser time on feed from a physiologically maturer initial point.

## DISCUSSION

The use of ultrasound allowed for moderate accuracy in monitoring the change in fat thickness and ribeye area during the feeding period. However a much larger sample size is needed for development of accurate prediction equations. Relationships with time and weight indicated that these factors should be standardized when comparing animals on the basis of ultrasonic measures. It is realized that weight and time on feed are highly related in these data. However, the evaluation of time effects above those associated with weight alone were felt to be important. This agrees with data presented by Turner et al. (1990) which indicated that age adjusted ribeye area and ribeye area per hundred weight are not suitable as singular traits but ribeye area should be used in combination with age, weight and fat thickness. With $R^2$ values in excess of 50% in the best-fit models, these data suggest that ultrasonic data obtained from animals varying in weight and age could be standardized using linear effects of weight or quadratic effects on time.

Due to the strong relationship between weight and measures of ribeye area ($R^2$= 51% in Brangus-X data), some researchers have suggested that weight is a better predictor of ribeye area than ultrasound. Changes in REAUCWT and FTUCWT shown in this work illustrate that evaluation of weight alone does not allow for detection of differences in degree of muscling and fatness, either static or across time. There is still considerable variability left after removing time effects from the FTUCWT and REAUCWT measures (coefficient of variation = 26.59% and 12.25% for FTUCWT and REAUCWT, respectively, in the Salers-X group).

The feedlot operator would be able to apply fat thickness equations like those derived in this study for a method of sorting cattle. Sorting feeder cattle by frame and backfat when entering the feedyard could result in more appropriate d on feed

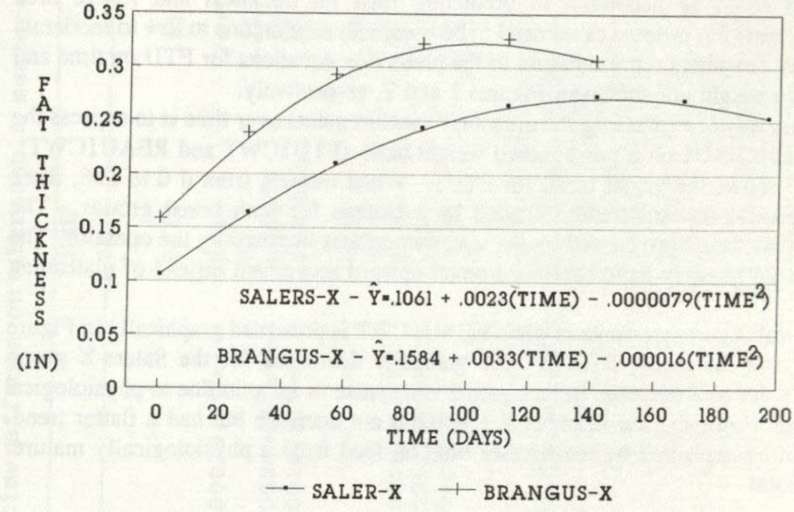


Figure 1. Regression of fat thickness on time.

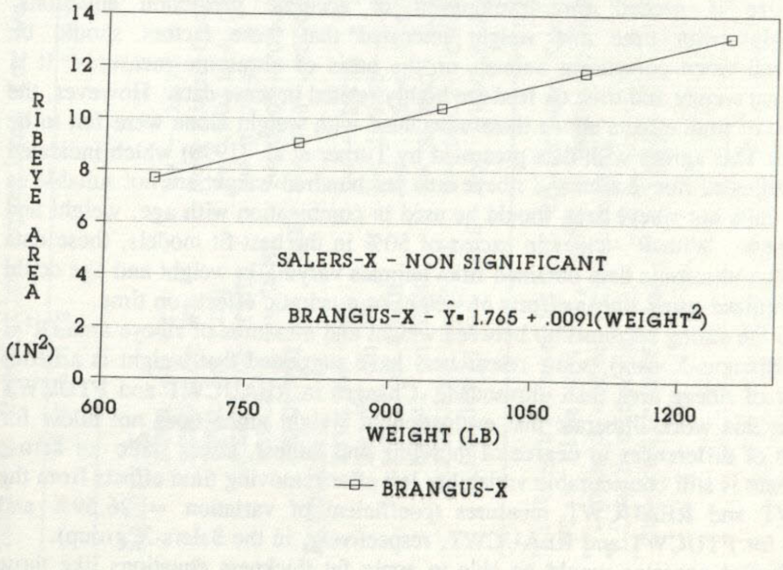


Figure 2. Regression of ribeye area on weight.

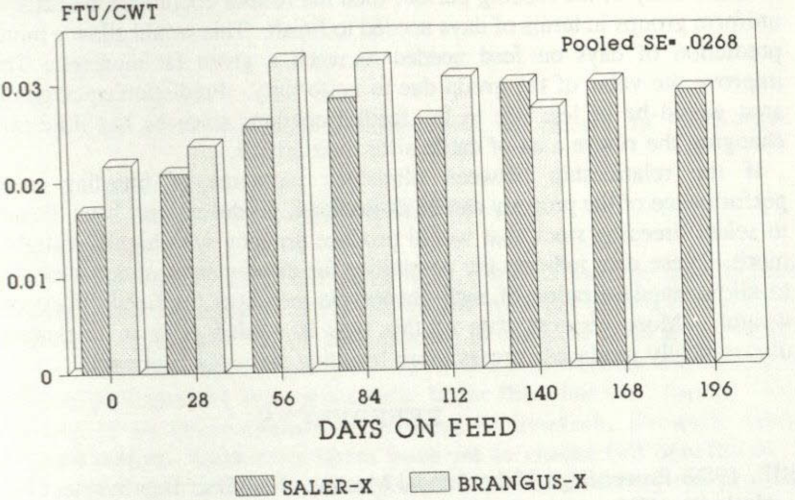


Figure 3. Fat thickness ultrasonic measurement means by day on per hundred weight basis for the Salers-X and Brangus-X groups.

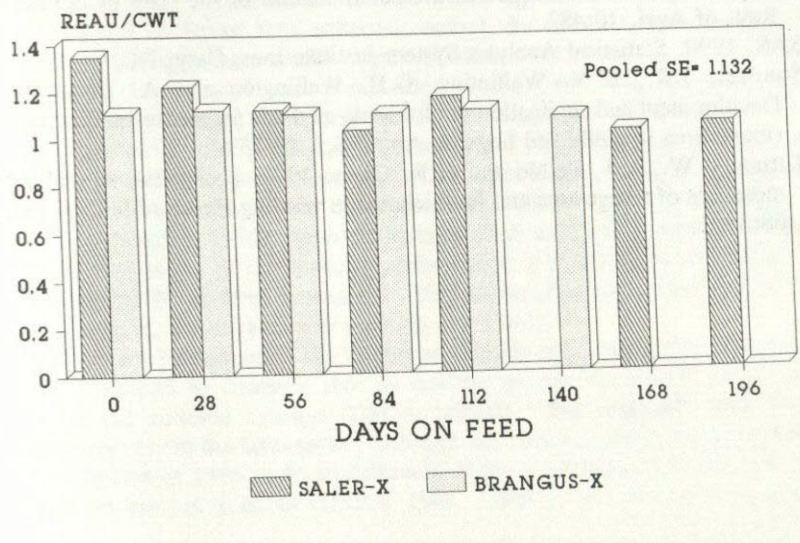


Figure 4. Ribeye area ultrasonic measurement means by day on per hundred weight basis for the Salers-X and Brangus-X group.

for cattle of different body types while achieving consistent and acceptable yield and quality grades across body type (Houghton, 1990). If a fat thickness measurement is taken early in the feeding period, then the feedlot could sort the cattle into more uniform groups in terms of days needed to finish. This would allow a more accurate prediction of days on feed needed to reach a given fat thickness. This should improve the value of the group due to uniformity. Prediction equations for ribeye area would be of less use to the feedlot operator since he has little influence in changing the ribeye area of cattle after their arrival.

If the relationship between ultrasonic measures of breeding animals and performance of the progeny can be determined, producers may have the opportunity to select breeding stock that would produce progeny with highly desirable carcass merit. These data indicate the possibility for development of adjustment equations to allow standardization of such phenotypic measures for fixed effects of age and weight. More research data of this type is needed prior to implementation of ultrasonically produced carcass merit breeding values in beef cattle.

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