

# Evaluation of Ultrasound Measurement of Fat Thickness and Ribeye Area, II. Repeatability of Measurements.

## A.S. Leaflet R1330

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### Summary

**Data from two feeding trials were used to evaluate repeatability of ultrasound measurements of fat thickness and ribeye area. In each trial, steers were scanned three or four times by one technician. Two beef improvement federation (BIF)-certified technicians with different levels of experience interpreted images from the last scan. Each technician interpreted the image of an individual steer twice on two different days. Repeatability was evaluated as an intra-class correlation. Additional statistics used to evaluate repeatability were the slope and intercepts from a regression analysis, RMSE, and ESD. Ultrasound measurements of fat thickness and ribeye area were repeatable both within and across technicians. The only exception was the across-technician measurements of ribeye area, where an apparent difference in variances of measurements was observed.**

### Introduction

Several reports indicate a wide variability in the relative accuracy of ultrasound estimates of fat thickness and ribeye area. Although accuracy varies with the species of animal under consideration, type of instrument, technician, and the technician's level of previous experience are among the crucial factors.

The use of real-time ultrasound imaging has now led to a more precise estimation of fat thickness and ribeye area. Therefore, rigorous evaluation and improvement of image capture and interpretation will make the technology more reliable. The objective of this study was to evaluate the repeatability of ultrasound measurements of fat thickness and ribeye area of steers measured under feedlot conditions.

### Materials and Methods

Sources and method of data collection are discussed in the first part of our report. Briefly, data for this analysis were from two feeding trials. In Trial I, data were collected on 164 cross-bred steers of uniform age (10-12 months at the start of

feeding). The steers were fed in two separate groups with different treatments and duration of feeding (148 to 168 days).

Trial II involved 144 11-12 month-old cross-bred (Simmental and Charolais crosses) steers with an average weight of 395 Kilograms at the start of the experiment. Steers in this experiment were randomly assigned to eight different treatments and fed 140 days (see R1235).

During each trial, steers were scanned ultrasonically three or four times by one technician locating the transducer laterally between the 12<sup>th</sup> and 13<sup>th</sup> ribs. Measurements were made by Aloka 500V unit (Corometrics Medical System, Inc., Wallingford, Connecticut), equipped with a 3.5 Mhz, 17 cm linear-array transducer. Each image was assigned a specific animal identification number, and all images were saved on VHS video tape for interpretation.

Two technicians (Technicians A and B) interpreted the images of the last scan from both trials. Both technicians were beef improvement federation (BIF)-certified; however, Technician A had more experience at the time of the study. Each image was traced twice by each technician on two different days. Neither technician was involved in the image collection process.

Preliminary evaluation of repeatability was made by observing the scatter of data points from the two measurements made on each animal. The relationship was then evaluated by fitting a linear regression of the second measurement on the first measurement for each animal within technician. The degree of fit was evaluated by testing the intercept and the slope of the regression line against 0 and 1, respectively.

The variance of interpreting a particular image was partitioned into variance due to technician, day of measurement, animal, and residual. The between-animal variance refers to variation associated with differences among measurements of different steers, and is therefore the covariance between repeated measurements on an individual steer. Technician variance represents variation associated with differences in image interpretation by the two technicians. Day of measurement variance refers to differences in interpretation associated with the two days of measurements. In all cases, variances were estimated according to SAS (version 6.09, 1989) VAR COMP procedure REML.

Repeatability may be defined as the correlation between repeated measures on the same animal. This correlation may be evaluated between repeated measurements of a steer within technician or between repeated measurements of a steer across technicians. Accordingly, sub-models with varying random effects were used to evaluate repeatability within technician and within day of measurement across technicians. In all cases, repeatability was calculated as an intra-class correlation

with the between-animal variance divided by the appropriate total variance. The pooled repeatability was calculated as,

$$t = \sigma_a^2 / (\sigma_{int}^2 + \sigma_a^2 + \sigma_m^2 + \sigma_e^2),$$

$\sigma_a^2$  = between-animal variance,

$\sigma_{int}^2$  = technician variance,

$\sigma_m^2$  = variance of day of measurement, and

$\sigma_e^2$  = residual variance,

Other measures of repeatability were RMSE and ESD,

$$RMSE = \sqrt{\sum(X_2 - X_1)^2 / n}$$

$$ESD = \sqrt{\sum[(X_2 - X_1) - (\bar{X}_2 - \bar{X}_1)]^2 / (n-1)}, \quad \text{and}$$

where,  $X_1$  and  $X_2$  are the first and the second measurements on the same animal.

### Results

The scatter diagram for the two measurements made on each steer by technician are indicated on Figures 1 and 2. For fat thickness measurements, significant difference was not observed when the intercept and the slope of the regression line were tested against 0 and 1, respectively. This would indicate a strong relationship between the repeated measurements within technician. In case of ribeye area, data points seem to be a bit scattered (Figures 3 and 4) and the slope and the intercept were both significantly different ( $p < .05$ ) from 0 and 1, respectively. However, a test of these regression parameters at 10% level of significance did not show a true difference of these parameters from their expected value for measurements made by Technician A. These preliminary results suggest a higher degree of repeatability of fat thickness measurements within technician than for ribeye area. Additionally, Technician A performed better than Technician B in measuring ribeye area.

The pooled repeatability of measurements across technicians and days of measurement ranged from 0.42 for ribeye area to 0.92 for fat thickness. Evaluation of repeatability by technician and measurement day provides a more explicit explanation of results than a pooled estimate. Repeatability of fat thickness measurement across the two days was 0.97 and 0.96 for Technicians A and B, respectively (Table 1). Repeatability of ribeye area measurement over the two days was higher for Technician A (0.92) than for Technician B (0.79). The total variance of ribeye area measured by Technicians A and B was 82 cm<sup>2</sup> and 43 cm<sup>2</sup>, respectively, and that of the error variance for measurements of Technician B (22%) was nearly three times that of the errors from measurements by Technician A (7.8 %). Therefore, this proportionally higher error variance may account for the difference in repeatability.

Repeatability of ribeye area and fat thickness measurements made by the two Technicians on the 1<sup>st</sup> and 2<sup>nd</sup> days of measurement also are indicated in Table 1. Fat thickness measurements were highly repeatable between Technicians both for the 1<sup>st</sup> and the 2<sup>nd</sup> day of measurement. However, the opposite was true for ribeye area. It should be noted that repeatability measured as intra-class correlation is highly dependent on sample variances. Further, in using repeatability, equal variances between measurements are assumed. However, the total variance between measurements of Technicians A and B is far from the same; 82.3 cm<sup>2</sup> for Technician A vs 43.39 cm<sup>2</sup> for Technician B. The between-animal variance in the measurements of Technician B were almost half as much as that of Technician A-measured data (34 cm<sup>2</sup> vs 75.2 cm<sup>2</sup>). Perhaps the limited experience of Technician B was manifested through the unnecessary adjustment of variability in ribeye area among animals. Under such circumstances, the results for across-Technician repeatability for ribeye area may not provide an accurate description of measurements.

Evaluation of repeatability values, independent of sample variances, through the use of RMSE and ESD has demonstrated a similarly high repeatability for the within-technician measurements of fat thickness. While RMSE and ESD were the same for fat thickness measurements, these values differed between the two technicians for the measurement of ribeye area, indicating more repeatable measurements for data produced by Technician A. Despite the differences between the two Technicians, the overall result regarding repeatability of fat thickness and ribeye area within technician was higher than in many other reports. Evaluation of repeatability across Technicians using RMSE and ESD showed a relatively higher repeatability of fat thickness measurements across Technicians and a lower repeatability for ribeye area.

### Implication

**The results of this analysis indicate that ultrasonic measurements of ribeye area and fat thickness are repeatable within technicians and between technicians, with the exception of repeatability of ribeye area measurements across Technicians. There was a clear difference in the magnitude variance of components for measurements of ribeye area between the two Technicians. This may be due to the difference in the level of previous experience acquired by the technicians.**

Fig 1. The relationship between ultrasound fat thickness measurements made on day 1 (Ufat1) and day 2 (Ufat2) for Technician A.

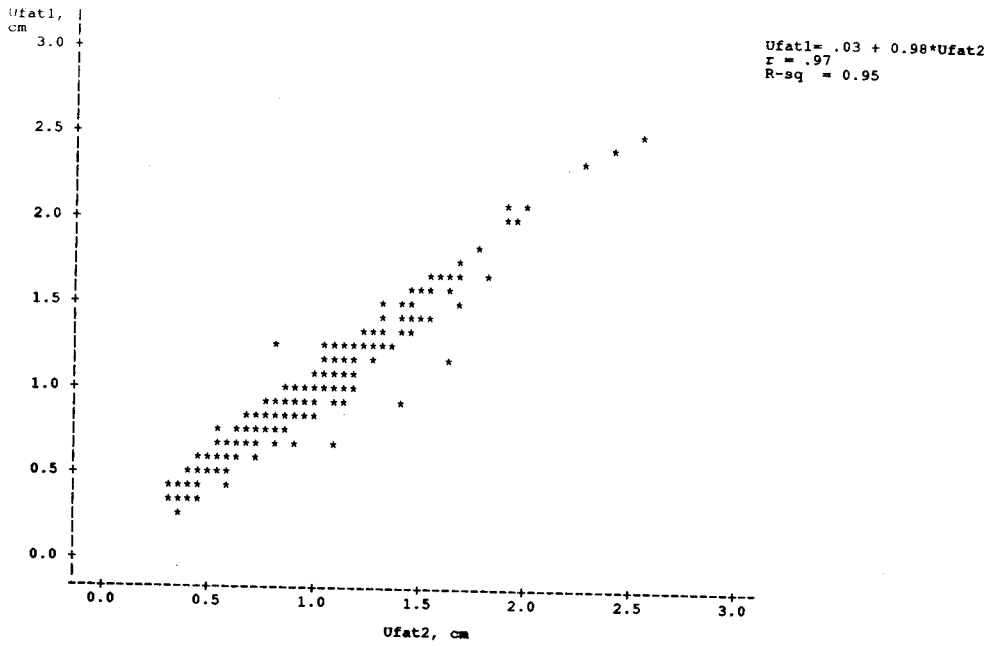


Fig 2. The relationship between ultrasound fat thickness measurements made on day 1 (Ufat1) and day 2 (Ufat2) for Technician B.

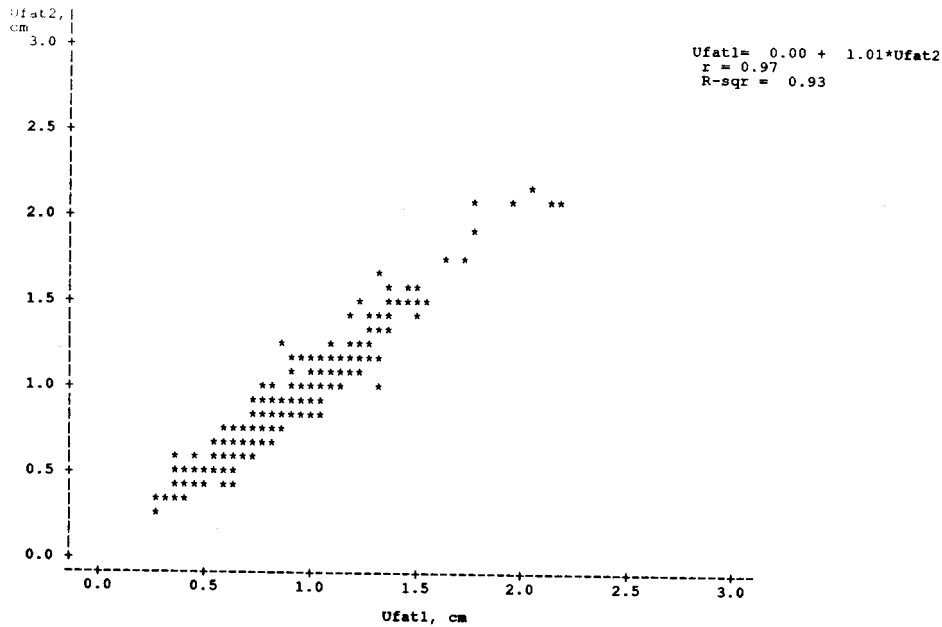


Fig 3. The relationship between ultrasound ribeye area measurements made on day 1 (Ureal) and day 2 (Urea2) for Technician A.

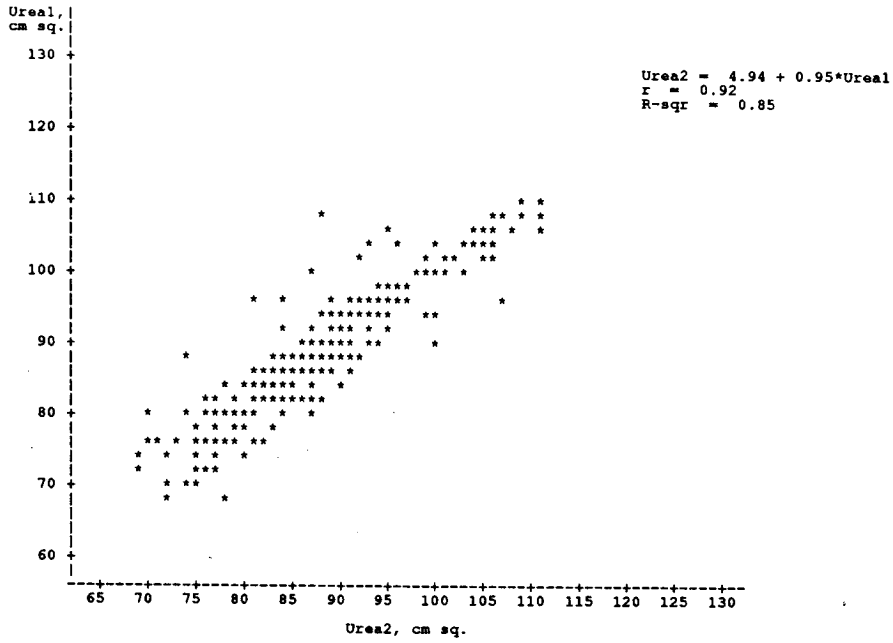
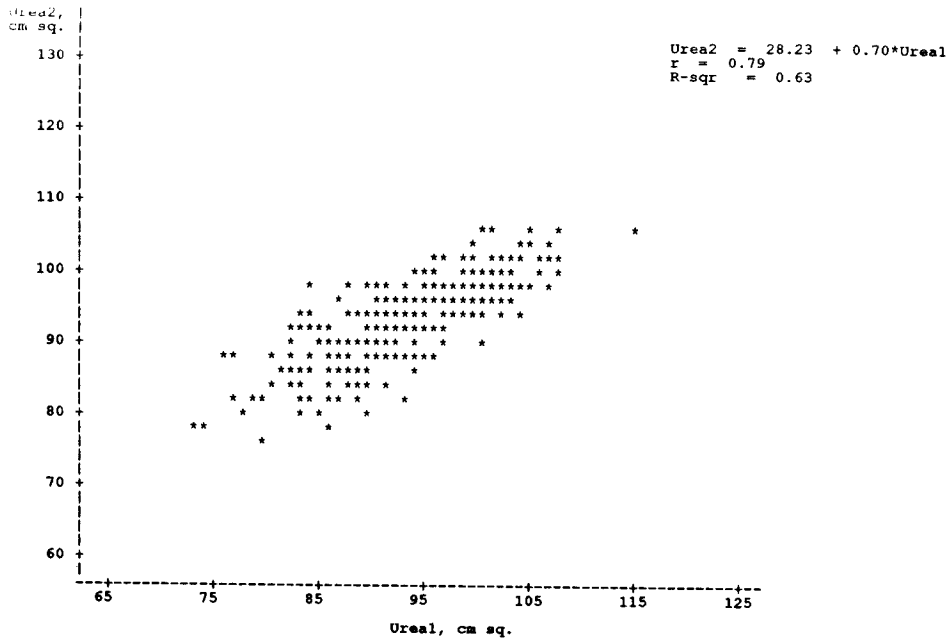


Fig 4. The relationship between ultrasound ribeye area measurements made on day 1 (Ureal) and day 2 (Urea2) for Technician B.



**Table 1. Simple measures of repeatability.**

	<b>t</b>	<b>RMSE</b>	<b>ESD</b>
<b>Int A</b>			
<i>Ufat</i>	0.97	0.09	0.09
<i>Uarea</i>	0.92	3.62	3.59
<b>Tech. B</b>			
<i>Ufat</i>	0.96	0.09	0.09
<i>Uarea</i>	0.79	4.32	4.32
<b>Day 1</b>			
<i>Ufat</i>	0.90	0.16	0.14
<i>Uarea</i>	0.22	10.57	9.81
<b>Day 2</b>			
<i>Ufat</i>	0.91	0.15	0.14
<i>Uarea</i>	0.27	9.97	9.29