Effects of Initial Fat Thickness, Hip Height, and Concentration of Dietary Energy on Growth of Area of the *Longissimus dorsi* Muscle and Subcutaneous Fat of Yearling Steers

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Summary
Steers were sorted into four groups based on hip height and fat cover at the start of the finishing period. Each group of sorted steers was fed diets containing 0.59 or 0.64 Mcal NEg per lb. of diet dry matter. Steers with less initial fat cover (0.08 in.) compared with those with more (0.17) had less carcass fat cover 103 days later. The steers with less fat cover accumulated fat at a faster rate, but this was not apparent prior to 80 days. Accretion of fat was best predicted by an exponential growth equation, and was not affected by the two concentrations of energy fed in this study. Steers with greater initial height accumulated fat cover at a slower rate than shorter steers. This difference was interpreted to mean that large-frame steers accumulate subcutaneous fat at a slower rate than medium-frame steers. Increase in area of the ribeye was best described by a linear equation. Initial fat cover, hip height, and concentrations of energy in the diet did not affect rate of growth of this muscle. Predicting carcass fat cover from the initial ultrasound measurement of fat thickness found 46 of the 51 carcasses with less than 0.4 in. of fat cover. Twelve carcasses predicted to have less than 0.4 in. of fat cover had more than 0.4 in. Five carcasses predicted to have more than 0.4 in. actually had less than that. Accurate initial measurements of initial fat thickness with ultrasound might be a useful measurement to sort cattle for specific marketing grids.

Introduction
The meat industry is evolving into a market-based system driven by consumer preferences. There are many different beef consumers with variable tastes and preferences. Marketing systems are being developed to supply beef for these specific markets. Value of cattle varies among these systems depending upon what is specified. Cattle producers need to be more aware of what their cattle are producing to effectively participate in these evolving marketing systems. It frequently is said that cattle are too variable and inconsistent, but some difference in cattle is needed to satisfy the variable consumer demands. To optimize returns from value-based marketing systems, cattle need to be more predictable. When beef is marketed as a commodity, packers sort the carcasses after weight and grades have been determined. If producers knew how their cattle would grade and yield, they could select marketing grids that would optimize economic returns to their cattle. The primary objective of this study was to determine if yearling steers could be sorted into outcome groups based on initial measurements of hip height and fat cover. A second objective was to study the effects of different concentrations of dietary energy on accretion of muscle and fat during the finishing period.

Materials and Methods
Ninety-five crossbred steers with an average weight of 1,000 lbs had been fed a diet containing 0.57 Mcal NEg/lb. for 28 days in a prior study before being allotted to pens for this study. The steers were sorted into two groups based on hip height, and each of those groups was further divided into two groups based on fat thickness. The steers were predominantly black, red, and white in color. The steers were scanned between the 12th and 13th ribs with a Pie Scanner 210 using a 3.5 MHz 18-cm linear array transducer to measure fat thickness and area of ribeye prior to the initial 28-day study. Steers from each of the four subgroups were then allotted to pens of five steers. There were eight pens of shorter steers and eleven pens of taller steers. Within the shorter group, there were four pens each of steers with less and more initial fat cover. Within the taller group, there were four pens of steers with less initial fat and seven pens with more initial fat.

Two pens of cattle in each of the subgroups were fed corn-based diets containing 0.59 or 0.64 Mcal NEg/lb. of dry matter. All steers were implanted with Revalor S® at the beginning of the experiment. The steers were housed in an open-front shed with feed bunks under the roof of the shed. The steers were weighed individually in the morning, before feeding, on two days at the start, and also when the cattle were sold and at 28-day intervals throughout. The cattle were scanned for fat thickness, and ribeye area at approximately four-week intervals during the study. The steers were fed for 75 days following the initial 28-day study.

Table 1. Mean and range of measurements.

	Average	Minimum	Maximum
Shorter steers with less fat cover (20 head)			
Initial hip height, in.	49.6	47.0	52.5
Initial fat cover, in.	.07	.04	.12
Initial ribeye area, sq. in.	8.9	6.4	11.1
Starting weight, lb.	850	737	970
Final weight, lb.	1254	1112	1254
Carcass weight	756.0	641.3	843.4
Carcass fat cover, in.	0.33	0.16	0.59
Carcass ribeye area, sq. in.	13.1	11.6	15.1
Shorter steers with more fat cover (20 head)			
Initial hip height, in.	49.3	46.8	50.5
Initial fat cover, in.	.15	.12	.27
Initial ribeye area, sq. in.	9.3	7.8	10.9
Starting weight, lb.	910	787	1083
Final weight, lb.	1297	1144	1498
Carcass weight	793	718	913.7
Carcass fat cover, in.	.49	.28	.79
Carcass ribeye area, sq. in.	13.5	11.7	16.6
Taller steers with less fat cover (22 head)			
Initial hip height, in.	51.9	50.8	54.2
Initial fat cover, in.	0.08	0.05	0.10
Initial ribeye area, sq. in.	9.3	7.4	11.6
Starting weight, lb.	891	753	1090
Final weight, lb.	1251	1054	1359
Carcass weight	765.6	650.1	853.4
Carcass fat cover, in.	.25	0.16	0.47
Carcass ribeye area, sq. in.	14.0	12.0	16.1
Taller steers with more fat cover (22 head)			
Initial hip height, in.	52.3	49.8	54.2
Initial fat cover, in.	.19	.11	.37
Initial ribeye area, sq. in.	9.6	8.5	11.2
Starting weight, lb.	958	863	1043
Final weight, lb.	1311	1201	1416
Carcass weight	800.7	686.6	863.1
Carcass fat cover, in.	.44	.28	.67
Carcass ribeye area, sq. in.	13.3	11.5	15.4

All steers were sold as one group at a commercial beef-packing plant. Weights of hot carcasses were taken after slaughter, and measurements on the carcasses were obtained after 24 hours in the cooler. Ribeye area and fat thickness of each carcass was traced on sheets of acetate paper and measured later.

Measurements from individual animals and carcasses were used as the experimental unit in the statistical analysis. Exponential growth equations seemed to provide the best fit of the accretion of fat cover. Linear equations provided the best fit of the growth in area of the ribeye muscle.

Results and Discussion

The means and ranges of values for relevant measurements taken in this study are given in Table 1. Steers with more initial fat cover were heavier at the beginning of the study and tended to have larger ribeyes. Taller steers were initially heavier and tended to have larger ribeyes but fat thickness similar to the shorter steers. Steers with less initial fat cover had less fat at the end of the experiment as measured by ultrasound or on the carcasses.

The accuracy of the ultrasound measurements as compared with the carcass measurements is shown in Figure 1. Ultrasound measurements tended to over-estimate fat cover of steers with minimal fat cover and to underestimate fat cover of those with more fat. Similar trends were evident with ultrasound measurements of ribeye area. The correlation coefficients between ultrasound and carcass measurements were 0.83 and 0.80 for fat cover and ribeye area, respectively. Variation between ultrasound and the carcass measurements for any one animal could be due to error in either measurement as well as trimming on the carcasses.

Accumulation of subcutaneous fat over the 12th and 13th ribs fit the following exponential growth curve: fat thickness, in. = ae^{kt}; where a = first measure of fat thickness, e = base of natural logarithms (2.7183), k = rate constant, and t = time in days from first measurement. Growth of ribeye area fit the following equation: REA, sq. in. = a + kt; where a = REA at first measurement, k = rate constant, and t = time in days from first measurement.

None of the main effects studied in this experiment had any effect on growth of ribeye area (Table 2). Steers that had less fat cover at the beginning of the experiment gained fat faster after about 80 days; however, they still had less fat cover after 100 days. Taller steers started the experiment with larger ribeyes, but had the same rate of growth of ribeye area during the experiment. There were no differences in beginning fat thickness due to hip height, but taller steers gained fat cover at about 70% of the rate of shorter steers. Concentration of dietary energy had no effect on growth of the ribeye or accretion of fat cover. Steers fed the lower-energy diet consumed enough additional feed to reach a similar level of calories per day. Over this range of energy density in the diet, growth equations to predict accretion of fat or growth of ribeye area would not have to be adjusted for concentrations of dietary energy. High-gaining steers gained subcutaneous fat faster than slower-gaining steers (Table 2).

Dividing the steers into four groups based on hip height and initial fat thickness resulted in different growth curves for accretion of subcutaneous fat but no significant differences in growth of the ribeye (Figure 2 and Table 3). Short or tall steers with less initial fat thickness had faster rates of fat accretion. The greater rates of fat accumulation, however, were not evident until after about 80 days in the short steers and after 120 days in the tall steers (Figure 2).

Predictions of the final ultrasound measurements or the carcass measurements using the first ultrasound measurements with the equations in Table 3 are shown in Figure 3. There was considerable amount of scatter around the prediction lines for both fat cover and ribeye area. There seemed to be somewhat less scatter in predicting ribeye area than fat cover. There was not much difference whether predicting carcass measurements or the last ultrasound measurements even though the equations were derived from the ultrasound measurements. Of the total of 84 carcasses used in this comparison, 51 had less than 0.4 in. of fat cover (Table 4). The prediction equations indicated there would have been 58 carcasses with less than 0.4 in. of fat cover. The prediction equations found 46 of the 51 carcasses and 44 of the 53 steers with less than 0.4 in. of fat cover. If these equations had been used to sort the cattle at the beginning, 58 steers would have been grouped together. Within this group of 58, 46 carcasses would have had less than 0.4 in. of fat cover, and 12 greater than 0.4 in. of fat. Five steers that should have been included with the group would have

Table 2. Equations describing growth of fat cover and ribeye area of yearling steers as influenced by initial fat cover, hip height, and concentration of dietary energy.

Group	Equation	r
Low initial fat	Fat cover, in. = $.0821e^{.0136 \text{ days}}$	0.83
	REA, sq. in. = 8.88 + .044 days	0.85
High initial fat	Fat cover, in. = $.1720e^{.0093 \text{ days}}$	0.74
	REA, sq. in. = 9.42 + .039 days	0.86
Short hip height	Fat cover, in. = $.1153e^{.0138 \text{ days}}$	0.80
	REA, sq. in. = 8.95 + .041 days	0.83
Tall hip height	Fat cover, in. = $.1287e^{.0098 \text{ days}}$	0.65
	REA, sq. in. = 9.35 + .041 days	0.87
0.59 Mcal/lb.	Fat cover, in. = $.1200e^{.0120 \text{ days}}$	0.75
	REA, sq. in. = 9.11 + .043 days	0.87
0.64 Mcal/lb.	Fat cover, in. = $.1249e^{.0111 \text{ days}}$	0.68
	REA, sq. in. = 9.23 + .040 days	0.83
Slow-gaining steers	Fat cover, in. = $.1378e^{.0095 \text{ days}}$	0.63
	REA, sq. in. = 9.41 + .038 days	0.84
Fast-gaining steers	Fat cover, in. = $.1097e^{.0135 \text{ days}}$	0.79
	REA, sq. in. = 8.95 + .040 days	0.86

Table 3. Equations describing growth of fat cover and ribeye area of yearling steers as influenced by initial fat cover and hip height.

Group	Equation	r
Shorter steers		
Less initial fat	Fat cover, in. = $.0803e^{.0160 \text{ days}}$	0.89
	REA, sq. in. = 8.75 + .042 days	0.82
More initial fat	Fat cover, in. = $.1646e^{.0115 \text{ days}}$	0.86
	REA, sq. in. = 9.16 + .040 days	0.86
Taller steers		
Less initial fat	Fat cover, in. = $.0863e^{.0114 \text{ days}}$	0.80
	REA, sq. in. = 9.05 + .045 days	0.89
More initial fat	Fat cover, in. = $.1809e^{.0085 \text{ days}}$	0.76
	REA, sq. in. = 9.49 + .037 days	0.87

Table 4. Efficacy of prediction equations for finding carcasses with less than 0.4 in. fat cover.

	Number in group of 84
Number of carcasses with less than 0.4 in. fat cover	51
Number of steers with less than 0.4 in. fat cover at last US	53
Number of carcass predicted to have less than 0.4 in. fat cover	58
Number of carcasses with less than 0.4 in. fat cover found by prediction equations	46
Number of steers with less than 0.4 in. fat cover found by prediction equations	44

been missed. The equations to predict fat thickness shown in Table 3 are quite sensitive to the initial measurement of fat thickness. A change of 0.01 in. of fat cover would result in a difference of 0.05, 0.03, 0.03, and 0.02 in. of predicted fat cover 100 days later for the shorter steers with less and more initial fat and the taller steers with less and more initial fat, respectively. The initial measurement is taken at a time when cattle normally do not have much fat, and it is not easy to precisely measure fat thickness with ultrasound.

The results of this study confirm earlier experiments that growth of subcutaneous fat and area of ribeye muscle fit the exponential and linear equations--at least this seems to be the case for yearling cattle. The rate constants for fat accretion ranged from .009 to .014; the lower number being more appropriate for larger frame steers and slower gaining steers, while the large value is more appropriate for medium frame steers and faster gaining steers. The rate constant for increase in area of ribeye in this study with steers implanted with estradiol and trenbolone acetate ranged from .038 to .044, with no definite trend showing that the higher or lower value should be used with any group of steers. In other experiments we have established that hormone implants do affect the rate constant for ribeye area, but have less effect on fat thickness. Because fat thickness has the most influence in the yield grade equation, it seems most important to be able to predict fat thickness, especially for selling cattle on a pricing grid based on yield grade. More experiments should be conducted to evaluate additional factors that might influence these rate constants for use in sorting feeder cattle into potential outcome groups.

Implications

The results of this study indicate that growth of the ribeye muscle area and accretion of fat cover can be reasonably predicted from ultrasound measurements taken on yearling steers 103 days prior to slaughter. The equations to predict accumulation of fat cover should be adjusted for frame size and initial fat cover, but do not have to be adjusted for dietary energy over the range of 0.59. to 0.64 Mcal NEg/lb. dry matter. Frame size, dietary energy, nor initial fat thickness had no effect on growth of ribeye area.

Acknowledgments

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Figure 1. Relationship of carcass fat cover and ribeye area measured by ultrasound.

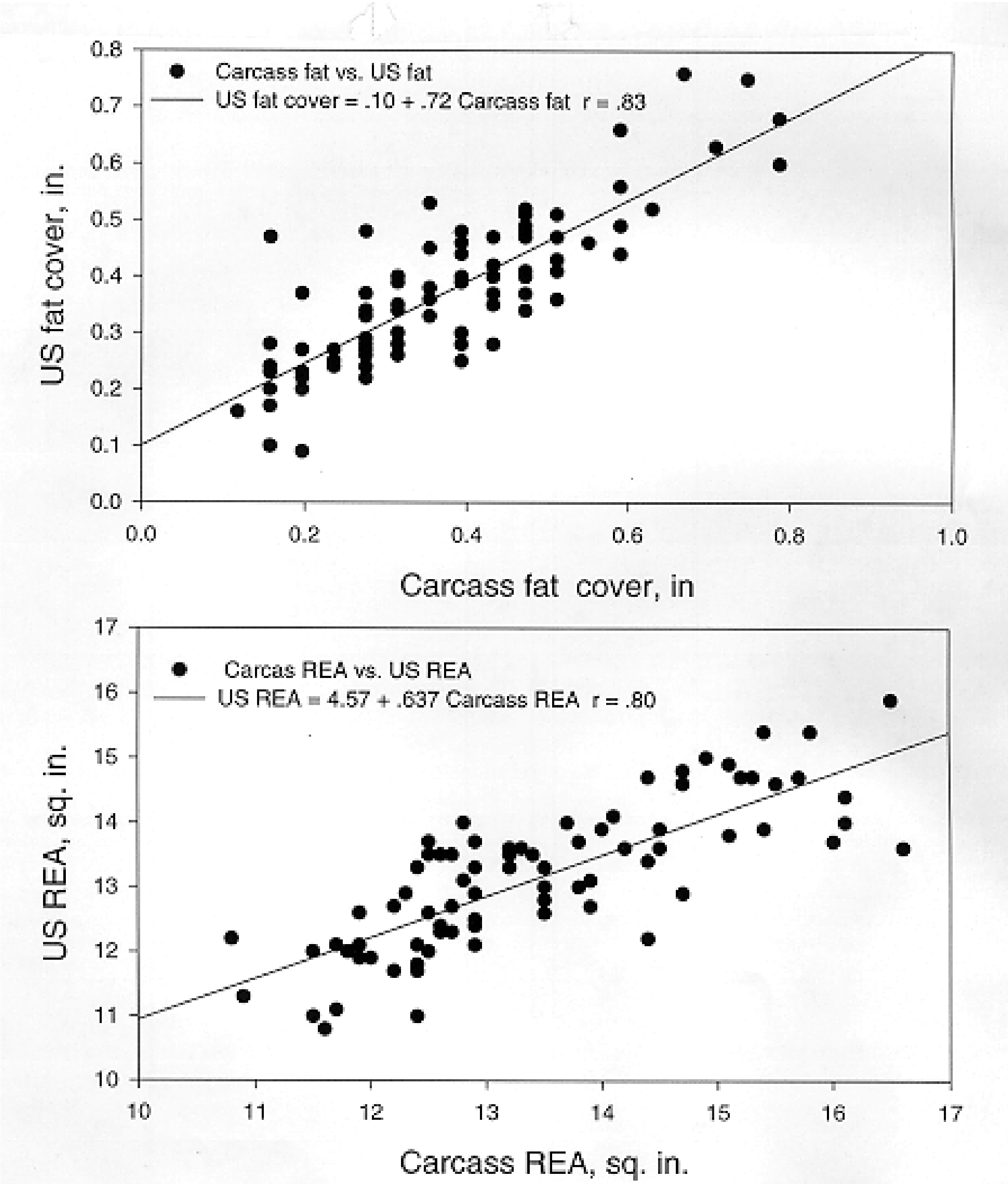

Figure 2. Effects of frame size and initial fat thickness on increase in fat thickness and ribeye area of yearling steers.

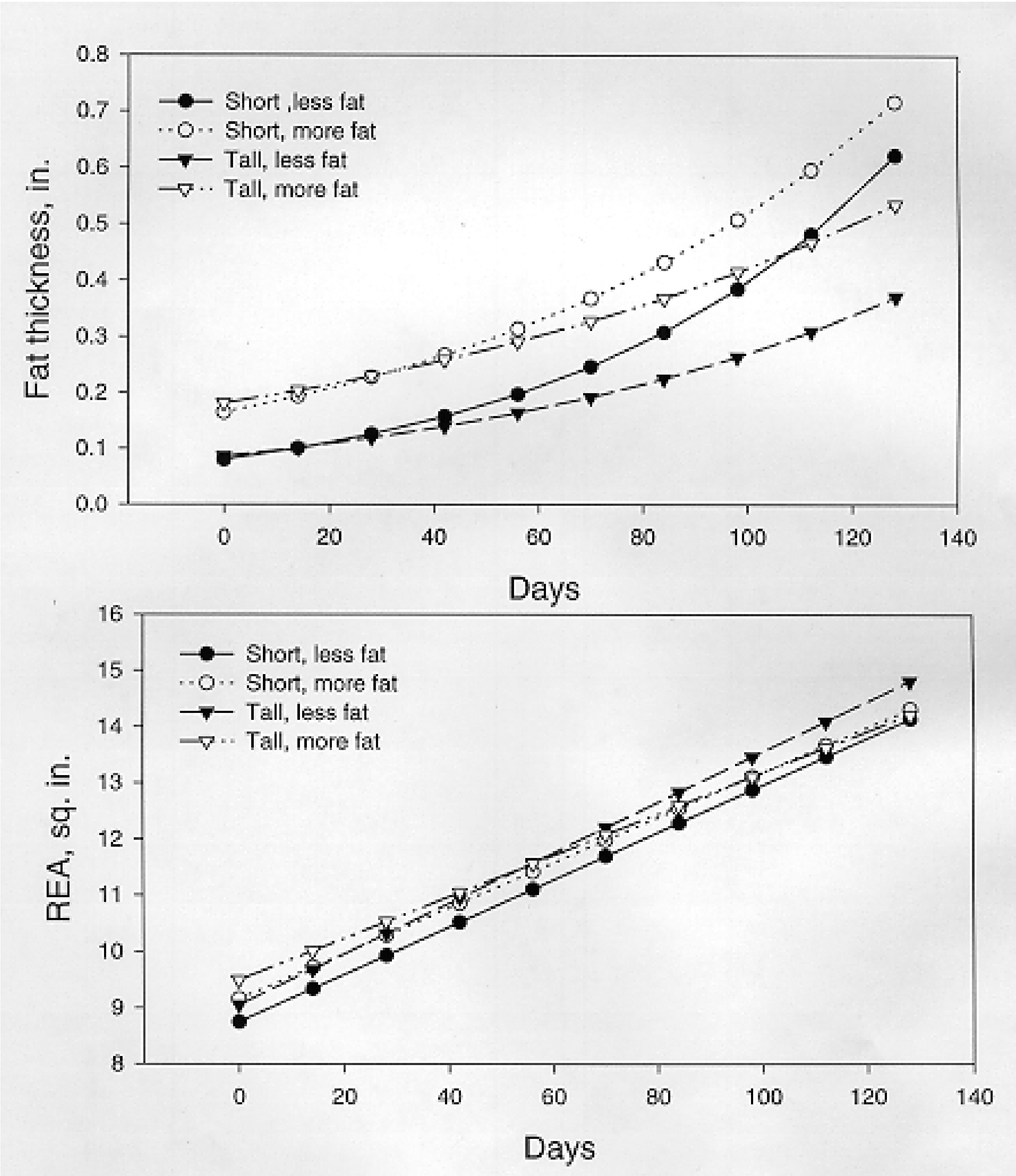

Figure 3. Relationship of final ribeye area and fat thickness with respective predicted values.