Using Real-Time Ultrasound During the Feeding Period to Predict Cattle Composition.

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Summary

A feedlot trial to monitor ribeye area growth, 12th rib backfat, and intramuscular fat accretion was conducted. Data were collected using 112 yearling beef steers. The steers were fed at three intake levels (*ad libitum*, 95% of *ad libitum*, or 90% of *ad libitum*), which when combined with three feeding times (once daily in the morning, once daily in the afternoon, or twice daily), produced nine dietary treatments. Feedlot performance and carcass composition of beef steers was also determined. After analysis of ultrasound measures and animal performance data, equations were developed that described the ribeye area development (R^2 = .97), 12th rib fat accretion (R^2 = .81), and changes in intramuscular fat percentage (R^2 = .79).

Introduction

In this report a method of carcass parameter prediction by using real-time ultrasound will be described. The purpose of the study was to monitor changes in body composition of beef steers throughout the feedlot period. Butts et al. (1980) found that physical descriptors of British and European crossbred feeder calves, such as ultrasound subcutaneous fat depth, body depth, and wither height, explained 54% of the variation in carcass weight of the calves at slaughter, within dietary treatment. Our objective was to use similar parameters and combine them with performance data to develop prediction equations that explained more of the variation seen in the carcass composition of cattle.

Materials and Methods

Experimental Design

The study began September 26, 1995, at the Western Iowa Research and Demonstration Farm at Castana, Iowa. The calves used in the study were born August, September, and October 1994 at either the McNay or Rhodes Research Farms and were consuming warm season grass pasture prior to being placed in this study. One hundred twelve British crossbred yearling steers with an average weight of 750 pounds were implanted with Compudose™, injected with Ivomec™, and placed into 16 pens of seven animals each.

Steers were housed in pens with concrete floors and a shelter at the north end. Steers were fed in fence-line concrete bunks and had access to automatic waterers. Each pen of steers was assigned at random to a feeding frequency and intake level. There were three feeding frequencies: 1) feeding once per day at 8 am, 2) feeding once per day at 4 pm or 3) feeding twice per day at 8 am and 4 pm. There were also three feeding levels (*ad libitum*, 95% of *ad libitum*, or 90% of *ad libitum*), which when combined with the feeding frequencies, provided a total of nine treatments.

All steers were fed a diet of whole corn grain and chopped mid-bloom alfalfa hay. The 85% concentrate ration was supplemented with a urea-based 40% crude protein, vitamin and mineral premix. Molasses was added to control dust and increase palatability. Feed allotments were determined daily prior to the morning feeding. Feed samples were collected twice per week for dry matter determination. Alfalfa hay samples were collected weekly for determination of neutral detergent fiber (NDF) and acid detergent fiber (ADF) content (Goering and Van Soest, 1970; Van Soest et al., 1991).

Steers were individually weighed and scanned every 28 days, and also within 21 hours of slaughter. An ALOKA 500V real-time ultrasound machine with an attached 17 cm linear array transducer was used to collect images. Ultrasound measurements of rib eye area, 12th rib fat thickness, and intramuscular fat percentage were taken. In addition hip height and estimates of visual muscle score and visual fat thickness were recorded for each animal. The average daytime temperatures were recorded throughout the trial to help assess the effect of environment on the steers as well as on the ultrasound equipment.

Average daily gain and feed conversion were determined by adjusting each steer's final live weight to a constant dressing percentage of 61.5%. When pens of cattle reached 1,205 lb average live weight, they were processed at IBP in Denison, IA, a processing plant located 32 miles from the research farm. After a 24-hour chill, ribeye area (REA) and 12th rib fat thickness (backfat) were measured on the left half of each carcass. Carcass grades were provided by the USDA Meat Grading Service. After grading the carcasses, a thin tissue slice was removed from the face of the left ribeye and analyzed for lipid content to validate ultrasound measured intramuscular fat (USIMF).

Results and Discussion

Performance and carcass data.

This is the third in a series of limit feeding trials. The performance and carcass data of the trials are summarized in Tables 1 and 2. Cattle fed once daily in the morning or once daily in the afternoon and limited to 95% and 90% of *ad libitum*, tended to gain less than cattle fed once daily and given *ad libitum* access to feed (Table 1). However, feed efficiencies (FE) favored limit fed cattle. Cattle fed twice daily seemed to have the best gains and FE when limited to an intake 95% of that of cattle given free access to feed. Overall, cattle on the limited intake diets had better FE than cattle fed *ad libitum*. Limit fed cattle tended to have higher quality grades (Table 2). Cattle fed twice daily tended to have smaller ribeye areas (REA), more backfat (BF), and better quality grades versus cattle fed once-daily in the morning or evening.

Ribeye area, backfat, and intramuscular fat development.

A plot of average ultrasound measured ribeye area (USREA), backfat (USBF), and intramuscular fat (USIMF) observations, obtained every 28 days throughout the feeding period, are displayed in Figures 1, 2, and 3. An average daily temperature is also indicated in each figure on the day of measurement. As can be observed on day 139 of the trial (23 ^{o}F) and to a lesser extent on day 84 (25 ^{o}F), the values recorded seem to have been affected thus resulting in inflated USREA and USBF measurements (Figures 1 and 2, respectively), and USIMF estimates (Figure 3) seem to have been depressed. Although determining temperature influences on ultrasonic analysis was not the intent of this trial, it does appear that cold temperatures have some impact on the measurement. Table 3 provides an estimate of the bias and standard error of prediction (SEP) for the days slaughter data were available. Fortunately, some of the cattle were sold on day 139, therefore producing some slaughter data to estimate bias and SEP on that day. The subsequent bias and SEP calculated on day 139 when compared with the bias and SEP obtained from days 153 and 174 provide some idea of the magnitude of the effect external elements may have on ultrasonic images.

The trend concerning ribeye area (REA) development as well as backfat (BF) and intramuscular fat (IMF) accretion seems to be linear. These linear trends, however, seem to project a lower final resulting REA and BF, whereas IMF estimates seem to be similar to actual IMF. The effect of external influences may provide some explanation for the differences between predicted and actual carcass measures, but these results do seem to match others. Brethour (1992) indicates carcass BF generally seems higher than USBF due to processes such as removing the hide. USREA likewise could be different than carcass REA due to hanging of the carcass or the cut used to split the carcass at the 12th - 13th rib. These discrepancies observed between actual and estimated values could occur more readily as REA or BF becomes more extreme in size because equipment calibration would be less likely to include a full set of outlying values. The REA and BF values (Table 4) in this trial, however, did not seem extreme in size or depth.

The observed trend of linear REA, BF, and IMF development was used as the basis by which a number of equations were produced to describe this process. Some discussion may stem from this stance because REA, BF, and IMF slopes of development over time could change and probably will as the animal matures or has a change in diet. The data, although representing a small segment of the potential developmental process of cattle, does illustrate a time frame that is of interest for commercial beef production, for it is through this stage in contemporary beef producing systems that cattle are placed in the feedlot, fed, and marketed. Thus, documenting and modeling the development of finishing cattle beyond the point considered to be mature slaughter weight/condition does not currently seem necessary.

The equations developed for REA, BF, and IMF have the form: $y = mx + b$. Using the initial ultrasound value (day 0 of trial) as the y intercept (b), the actual carcass measurement as the y value, and doing a regression analysis to determine the appropriate inputs and parameters for the slope (m), three equations capable of estimating REA (Equation 1), BF (Equation 2), and IMF (Equation 3) on a given day (x) during a feeding period resulted. The equations have been applied to other data sets for crossbred steers of unknown origin and age fed high concentrate diets, and seem to predict ribeye area and backfat well.

Value of ultrasonic measurements for sorting cattle: A preliminary observation.

Visually scoring muscle and fat initially showed no correlation to initial ultrasound measures (-.02), leading us to believe that ultrasound cannot be replaced by simple visual appraisal in sorting cattle into feeding groups based on carcass composition.

The ultrasonic images of REA, BF, and IMF from the cattle when compared to the final actual carcass values of REA, BF, and chemical IMF, in terms of rank, are displayed in Table 5. The cattle in this trial were not sorted into treatment groups based on these measures. Instead they were randomly allotted to treatment group by color and weight, measured, and observed to see how the rank of individual animals changed in each group. The use of the simple correlation between the ultrasonic image and the final image was used in the analysis provided on Table 5. The use of a rank correlation could have been used because ranking the animals from smallest to largest for purposes of feedlot and marketing management would be the ultimate goal here. However, the closeness of the measurements, especially at the beginning of the trial where the ranking of animals may be decided on 1/100 square inches of REA, or 1/1,000 of an inch of BF, does cause some concern. Small differences such as these could indeed be legitimate differences in animals, but could easily be due to the data measurement and processing as well. Due to this potential for errors, an apparent change in rank could take place even if an actual change did not.

As indicated in Table 5, initial measures of REA tended to correlate well with the final carcass REA measures; the cattle with larger REA at the start had the larger REA at the end. BF measures tended to improve as the cattle approached their finished weight, and IMF measures were fairly constant throughout. There also seemed to be an improvement in the correlation between measurements as the spread between the measured values in the pen was greater. An illustration of this point is shown in Figure 4, where the standard deviation of the day 0 ultrasonic REA value for each lot was plotted along with the corresponding correlation to the final REA.

Measurements of initial body weight and hip height likewise were observed because these two measures provide the basis of frame size scoring, the current standard for sorting besides cattle type. The results of an ultrasonic sort, although not perfect, do show promise when compared with what initial hip height and initial body weight might indicate when cattle are placed on feed.

Another point that may be significant, is that when the cattle were started on feed there did not seem to be any correlation between REA and BF (see Table 6). This may indicate that these cattle entered the lot at a similar stage of maturity and received similar treatment in terms of nutrition previously (as was the case). In a situation where cattle vary in age and/or are combined with other sources, a correlation between REA and BF may occur. A positive correlation between the REA and BF (larger REA - thicker BF) may indicate a previous treatment effect such as nutrition. Thus the strength of sort based on initial REA alone may be less; however, the use of BF in this situation may enhance the process.

Implications

Based on the findings of this study, it seems that ultrasound measures taken on cattle coming into the feedlot, and performance data collected during the finishing phase can be used to effectively predict ribeye area, backfat thickness, and percentage intramuscular fat at any point during the finishing phase. The use of real-time ultrasound may provide a means of sorting cattle, based on their initial body condition, into different feedlot groups, which is more accurate than simple visual appraisal.

References

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Table 1. Feedlot performance data for three trials.

Feeding frequency	Item	Feeding levels			
		Ad libitum	95%	90%	Avg
Once daily in am	Initial wt, lb	813.86	813.59	805.26	810.90
	Final wt[a], lb	1,239.72	1,212.89	1,227.46	1,226.69
	Daily DMI, lb	26.07	24.78	23.16	24.67
	ADG, lb	3.35	3.27	3.24	3.29
	FE, DM/lb	7.87	7.63	7.15	7.55
Once daily in pm	Initial wt, lb	814.50	814.96	806.26	811.91
	Final wt[a], lb	1,220.25	1,200.51	1,221.64	1,214.13
	Daily DMI, lb	25.99	24.70	23.21	24.63
	ADG, lb	3.16	2.98	3.09	3.08
	FE, DM/lb	8.30	8.29	7.65	8.08
Twice daily	Initial wt, lb	814.13	814.94	807.29	812.12
	Final wt[a], lb	1,222.44	1,217.78	1,221.65	1,220.62
	Daily DMI, lb	26.04	24.76	23.18	24.66
	ADG, lb	3.15	3.29	2.98	3.14
	FE, DM/lb	8.29	7.56	7.84	7.90
Avg	Initial wt, lb	814.16	814.50	806.27	
	Final wt[a], lb	1,227.47	1,210.39	1,223.58	
	Daily DMI, lb	26.03	24.75	23.18	
	ADG, lb	3.22	3.18	3.10	
	FE, DM/lb	8.15	7.83	7.55	

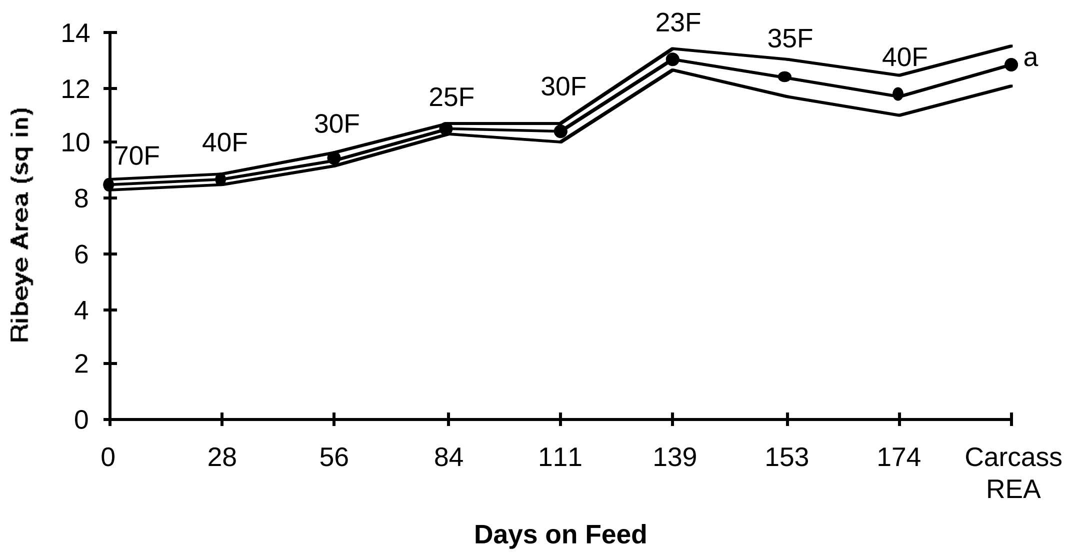
[a] Final weights are adjusted to a constant dressing percentage (61.5%).

Table 2. Carcass data for three trials.

Feeding frequency	Item	Feeding levels *Ad libitum*	95%	90%	Avg
Once daily in am	Final wt[a], lb	1,239.72	1,212.89	1,227.46	1,226.69
	Hot carcass wt, lb	766.21	737.76	752.49	752.15
	Dressing %	61.01	60.07	60.68	60.59
	Backfat, in	0.38	0.34	0.35	0.36
	REA, sq in	13.21	13.30	12.86	13.12
	Liver wt, lb	15.12	14.73	14.91	14.92
	Yield grade	2.16	2.02	2.15	2.11
	Quality grade[b]	6.56	6.88	6.63	6.69
Once daily in pm	Final wt[a], lb	1,220.25	1,200.51	1,221.64	1,214.13
	Hot carcass wt, lb	750.80	735.97	750.19	745.65
	Dressing %	59.18	59.85	61.11	60.05
	Backfat, in	0.35	0.42	0.40	0.39
	REA, sq in	12.86	12.72	12.44	12.67
	Liver wt, lb	15.10	14.97	14.33	14.80
	Yield grade	2.01	2.12	2.10	2.08
	Quality grade[b]	6.24	6.97	7.12	6.78
Twice daily	Final wt[a], lb	1,222.44	1,217.78	1,221.65	1,220.62
	Hot carcass wt, lb	740.62	751.04	752.02	747.89
	Dressing %	60.63	60.73	60.87	60.74
	Backfat, in	0.41	0.44	0.42	0.42
	REA, sq in	12.68	12.38	12.76	12.61
	Liver wt, lb	14.67	14.50	14.79	14.65
	Yield grade	2.16	2.25	2.12	2.18
	Quality grade[b]	6.53	6.87	6.99	6.80
Avg	Final wt[a], lb	1,227.47	1,210.39	1,223.58	
	Hot carcass wt, lb	752.54	741.59	751.57	
	Dressing %	60.27	60.22	60.89	
	Backfat, in	0.38	0.40	0.39	
	REA, sq in	12.92	12.80	12.69	
	Liver wt, lb	14.96	14.73	14.68	
	Yield grade	2.11	2.13	2.12	
	Quality grade[b]	6.44	6.91	6.91	

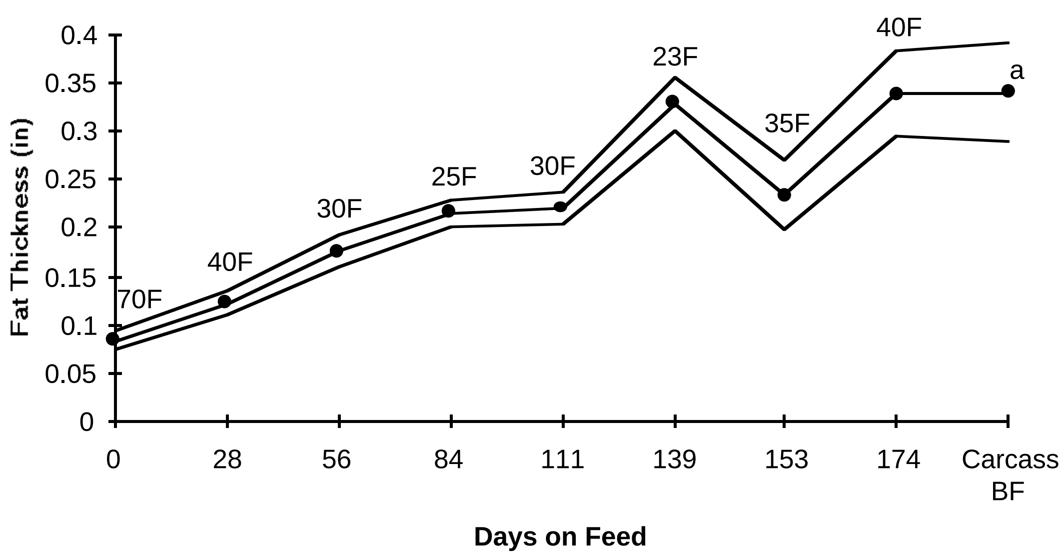
[a] Final weights are adjusted to a constant dressing percentage (61.5%).
[b] Select^{+} = 6, Choice^{-} = 7.

Figure 1. Ultrasound measured ribeye area by days on feed.



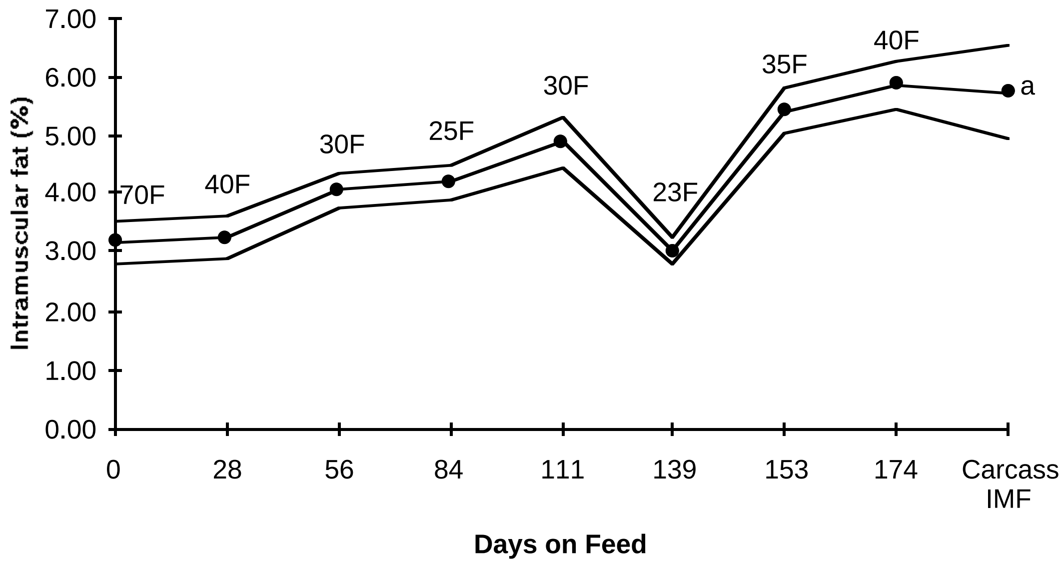
[a]Solid line represents means, and dashed lines are standard deviations for each mean (±).

Figure 2. Ultrasound measured 12th rib fat thickness by days on feed.



[a]Solid line represents means, and dashed lines are standard deviations for each mean (±).

Figure 3. Ultrasound measured intramuscular fat percentage by days on feed.



[a]Solid line represents means, and dashed lines are standard deviations for each mean (±).

Table 3. Average bias and standard error of prediction (SEP) of ultrasound measurement to final carcass measurement at slaughter.

Days on feed at slaughter	Ribeye area bias (in^2)	SEP	Backfat bias (in)	SEP	Marbling bias (%)	SEP
139	0.02	0.93	0.02	0.10	-2.09	2.08
153	-1.08	0.96	-0.10	0.11	-0.17	1.82
174	-1.49	1.09	-0.08	0.13	-0.38	1.40
Overall	-0.95	1.15	-0.062	0.12	-0.65	1.85

Table 4. Summary of derived equation effectiveness for describing source data.

	Ribeye Area		Backfat		Marbling	
	Estimated	Actual	Estimated	Actual	Estimated	Actual
Correlation	0.67		0.48		0.55	
Mean	12.96	12.96	0.34	0.34	5.86	5.74
Std. Deviation	0.77	1.10	0.06	0.15	1.06	1.90
Minimum	11.00	10.50	0.23	0.10	3.40	2.08
Maximum	14.49	15.50	0.55	1.00	8.29	13.20

Equation 1. Ribeye Area Development

REAc = REAi + (ADG x .01267 + DMF x .00607 - WTR x .04830) x DOF

where:
REAc = current ribeye area (in^2)
REAi = initial ribeye area (in^2)
ADG = cumulative average daily gain (lb) since initial ribeye measurement was taken
DMF = [current daily dry matter intake / current body weight (lb)] x 100
WTR = [current shrunk body weight - initial shrunk body weight] / estimated shrunk weight at 50% choice
DOF = days since initial ribeye area measurement was taken

Parameters of Slope Describing Ribeye Area Development

Input	Parameter	R^2	Partial R^2	Stand. Error	Prob. > F
ADG	0.01267	0.9607	0.9607	0.002	0.0001
DMF	0.00607	0.9655	0.0048	0.001	0.0001
WTR	-0.04830	0.9687	0.0033	0.014	0.0012

Equation 2. Backfat Development

BFc = BFi + (ADG x .00035 + MWT x .0935 + BWT x .0259) x DOF

where:
BFc = current backfat (in)
BFi = initial backfat (in)
ADG = cumulative average daily gain (lb) since initial backfat depth measurement was taken
MWT = initial percentage of intramuscular fat / body weight at time of measurement(lb)
BWT = [initial backfat (in) / body weight at time of measurement (lb)] x 100
DOF = days since initial backfat depth measurement was taken

Parameters of Slope Describing Backfat Development

Input	Parameter	R^2	Partial R^2	Stand. Error	Prob. > F
ADG	0.00035	0.7997	0.7997	0.0001	0.0001
MWT	0.09350	0.8073	0.0077	0.0568	0.0403
BWT	0.02590	0.8106	0.0032	0.0192	0.1806

Equation 3. Marbling Development

MAc = MAi + (WT x .00004 - DMF x .00923 + BFi x .07793) x DOF

where:
MAc = current percentage of intramuscular fat
MAi = initial percentage of intramuscular fat
WT = weight (lb) when initial marbling measure was taken
DMF = [current daily dry matter intake / current body weight (lb)] x 100
BFi = initial backfat measure (in)
DOF = days since initial intramuscular fat measurement was taken

Parameters of Slope Describing Marbling Development

Input	Parameter	R^2	Partial R^2	Stand. Error	Prob. > F
WT	0.00004	0.7731	0.7731	0.00001	0.0001
BFi	0.07793	0.7826	0.0532	0.03700	0.0372
DMF	-0.00923	0.7915	0.0564	0.00500	0.0048

Table 5. Correlation between day of ultrasound measurement and final carcass value.

Days on Feed	Ribeye Area	Backfat	Marbling
0 (09/26/1995)	0.60	0.33	0.40
28	0.62	0.32	0.25
56	0.61	0.49	0.17
84	0.47	0.59	0.23
111	0.40	0.63	0.34
139	0.46	0.59	0.33
Final*	0.55	0.62	0.29

*Final is the comparison made across all slaughter groups. The slaughter groups were composed of steers sold at day 139, 154, and 174. All groups were measured with ultrasound 13 to 21 hours prior to slaughter.

Figure 4. Correlation between day zero and final carcass REA measurements as the standard deviation of REA within a lot increases.

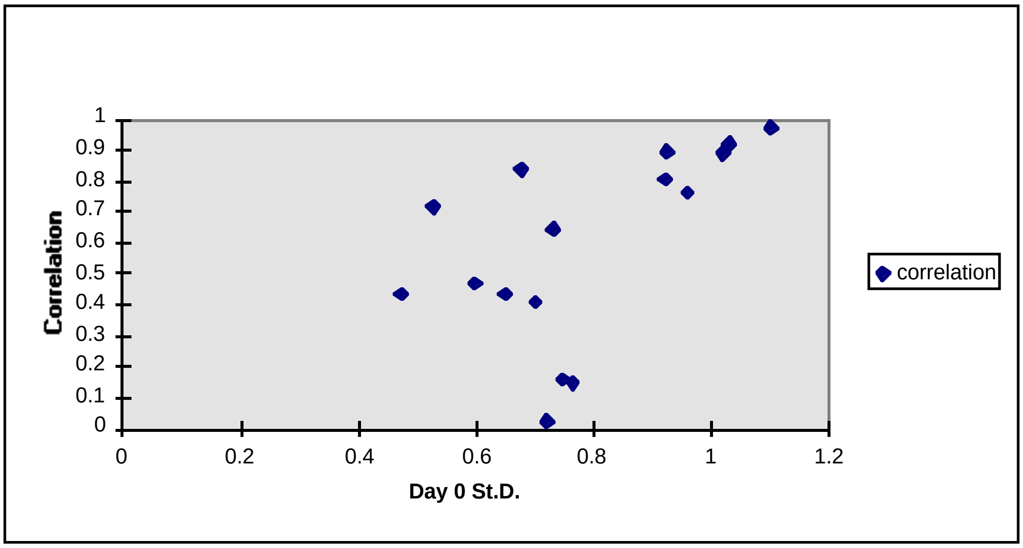


Table 6. Correlations between initial body measures and final carcass and performance measures.

Measure at day 0	Range	Correlation to final REA	BF	IMF	KPH	CarWT	YG	DOF	QG
Initial weight	630 - 840	0.36	-0.14	0.24	0.24	0.51	-0.04	-0.02	0.15
Hip height	45.8 - 50.0	0.18	-0.16	0.04	-0.04	0.32	-0.07	0.09	0.00
REA	6.61 - 10.10	0.60	0.03	-0.35	-0.07	0.19	-0.38	0.00	-0.13
BF	0.04 - 0.18		0.33	0.08	0.38	0.20	0.35	0.26	0.22
IMF	1.00 - 4.48			0.40	0.14	-0.08	0.19	0.00	0.37
		Final carcass value means							
Average		12.96	0.34	5.74	2.20	738.17	2.48	156.06	Low Choice
Std. Deviation		1.10	0.13	0.17	0.59	53.34	0.58	11.94	1/3 grade