CHARACTERIZATION OF BOXED BEEF VALUE IN ANGUS FIELD DATA

By

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DEDICATION

This thesis is dedicated to my parents Bill and Linda Schutte, my brother Shane Schutte, my grandparents Gus and Ruth Schreiner, and the late George and "Toots" Schutte, and also to my uncle Jack Schutte. Their faith, love, encouragement, advice, and financial aid have made it possible for me to explore my dreams and accomplish my goals. Words cannot express the gratitude and love I feel for my family.

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NOMENCLATURE

NCBA	National Cattlemen's Beef Association
NBQA	National Beef Quality Audit
IMPS	Institutional Meat Purchase Specifications
hd	head
kg	kilogram (s)
BBC	Boxed Beef Calculator
hvy	heavy
cm	centimeter (s)
cm^2	centimeter (s) squared
Ch/Se	Choice/Select
EPDs	Expected Progeny Differences
USDA	United States Department of Agriculture
QG	USDA quality grade
YG	USDA yield grade

CHAPTER I

INTRODUCTION

The twenty-first century is just around the corner, which brings new opportunities and challenges for the beef industry to improve its market share and reward all segments of production. It is time to wipe the slate clean and eliminate problems that have haunted the success of the industry for decades. The most recent audit of the cattle industry, the 1995 National Beef Quality Audit, addresses many inefficiencies with the current beef production. The first concern of purveyors, retailers, and restaurateurs is low overall uniformity and consistency. The variation in carcass cutability and quality is too large leading to problems with excess fat, undesirable carcass weights, lack of red meat yield and unacceptable marbling. Unfortunately, this is not only poses as a problem to the retail and food service industries, it should also be a major concern for producers as carcasses that fail to conform result in a considerable opportunity cost to the producer. If the industry were to solve this problem, many of the remaining concerns that follow including inadequate tenderness, low overall palatability, and insufficient flavor possibly would also vanish. Although research dollars continue to be spent focusing on tenderness and its prediction, quality in the form of maturity and marbling continues to be used as a measurement of palatability. Carcasses with inadequate marbling contribute to consumer eating satisfaction in a negative way, which contributes to the decline in beef market share. As a result of the beef industries shortcomings, strategies were developed at the NBQA strategic workshop and include:

- Assist producers with use of selection and management techniques to produce cattle that fit customer expectations for marbling, red meat yield, and weight.
- Establish close-trim beef (.64 cm or less) as an industry standard.
- Encourage development of cattle-pricing systems that accurately identify and reward production of cattle with zero defects.
- Identify breeding systems that optimize production, palatability and profitability.

In order for the beef industry to improve in these areas, problems have to be solved before they begin. Each segment of the beef industry is responsible for understanding and targeting consumer demands of a highly palatable, consistent product. Cattle producers have to "fine-tune" their practices and through proper genetics and management produce cattle that excel not only in production performance and efficiency, but also in carcass quality and red meat yield. Historically, carcass traits have been reported as being moderately to highly heritable, which indicates that genetic progress can be made through carcass trait selection. To be successful as commercial and seedstock producers, multiple-trait selection is a must because single-trait selection may have detrimental effects on other economically important traits. Therefore, a basic understanding of relationships between reproductive, growth, and carcass traits is necessary to identify and use genetic lines to produce cattle with high red meat yields and the ability to marble without compromising performance.

The responsibility to improve genetic lines lies with the seedstock producer. Also, feedlot operators also have to make sure that cattle are sorted to meet slaughter endpoints in order to avoid over finished or underfinished animals resulting in "mis-fit" carcasses. Further down the chain are the packers who are responsible for eliminating excess "waste" fat being passed on to retailers by fabricating close-trim boxed beef and to negotiate fair prices with producers based on the current supply and demand of beef.

The traditional way of marketing cattle on a live cash basis by lot actually penalizes superior cattle and ultimately rewards inferior cattle. This type of price discovery does not provide the monetary incentive for producers to change their production practices. Within each lot the good high cutability, high quality cattle compensate for the poor low cutability, low quality cattle. The solution to this is the concept of value-based marketing where superior carcass traits for red meat yield and quality are rewarded, and those carcasses that don't fit boxed beef fabrication specifications are discounted. Many adversaries feel that value-based marketing does not provide enough profit incentives to make this type of marketing worth it and that the lack of price information creates too much confusion. In an attempt to realize a value based price reflecting individual carcass merit, the Oklahoma State University Boxed Beef Calculator (BBC; Gardner et al., 1997) was created. Quality grade, yield grade, carcass weight and dressing percent, as well as prices of 17 wholesale cuts, two lean trim levels, and drop credit for current market conditions are needed to establish the value of an individual carcass. It is imperative with this method of price discovery that producers know the type of cattle they are marketing. "Mis-fit" cattle that produce carcasses not conforming to boxed beef fabrication specifications will receive discounts that may in fact out weigh premiums. If producers have a population with unknowns, large discounts may be incurred.

Dr. Larry Corah (Certified Angus Beef™) and Dr. Gary Smith (Colorado State University) both agree. The greatest road block to improving quality in the beef industry is the lack of a marketing system that rewards superior carcass merit and penalized inferior cattle (Drovers Journal). Profits should follow a trickle-down effect to the seedstock and cow-calf operators who produce cattle of desirable and superior quality. Ward et al. (1997) interviewed employees of cattle feeders, beef packers, and related industry firms and organizations. In the authors opinion and in conclusion of the interviews with packers and feeders, there is a need to move and grow into value based pricing as marketing cattle on an average does not consider consumer demand in cattle production and marketing. The interviews indicated a need for change in genetics and production practices and for producers to be aware of the type of cattle they produce in order to target their desired markets and get paid for the value of their cattle when they are sold.

If the information is traced back to parent seedstock, value may be reflected as either yield or quality based because of seasonal high and lows.

Therefore, the benefit of using carcass value of individual sires to select seedstock becomes evident as both quality grade and red meat yield are reflected in that value. Considering the Choice/Select price seasonality, the question is if cattle tend to be higher quality than cutability or higher cutability than quality, when should they be marketed to achieve ultimate profitability.

The purpose of this study was to examine the impact of average, low and high Choice/Select quality grade price spreads on sire progeny mean boxed beef values as well as examine year, contemporary group, and sire effects on boxed beef value. A second objective was to characterize sire progeny groups relative to quality grade by yield grade frequencies and non-conformers. Another purpose was to determine sire close trim boxed beef value rankings based on progeny data and evaluate whether or not sire rankings differ significantly due to seasonal Choice/Select quality grade price spreads. The fourth objective was to quantify the progeny values for non-conformers and each quality by yield grade combination. Finally, this project was also completed to compare current American Angus Association retail product percentage yield predictions with closely-trimmed boxed beef total and subprimal percentage yield estimates.

CHAPTER II

REVIEW OF LITERATURE

Beef Pricing Systems.

Price discovery can be defined as the process of arriving at a transaction price for the specific quantity and quality of fed cattle at a specific time and place. Ward (1987) separates price discovery into two steps. Packers are responsible for stage one, which is finding and assessing the general overall price for fed cattle with respect to supply and demand. This is done by evaluating accurate and up to date carcass and boxed beef prices for a given type of cattle (Choice, yield grade 3, 600-850 lbs.), as well as any combination of carcass traits. Next, a field-level buyer is sent to feedlots, terminal markets and auction markets to purchase cattle. Estimating fed cattle price bids start initially with a base wholesale carcass price. An adjusted price is computed to account for gender, estimated yield grade, estimated quality grade and estimated carcass weight followed by a conversion to live price. The addition of by-product credits (drop credit) and the subtraction of both harvest costs and target profits result in an estimated live weight bid price (Ward, 1987).

Several ways to market or buy cattle exist: live weight, dressed weight, dressed weight and grade, and value-based marketing. Generally, cattle are from different genetic backgrounds and ages and are fed together in one lot with the idea that the lot will provide a profit. The live weight basis is historically the most dominant, however, this method is becoming less popular. This is in part because the risk of estimation errors such as yield grade, quality grade, dressing percentage, meat damage from grubs, bruises and or condemnation that are assumed by each bidder. With this method of marketing, those cattle that are genetically inferior and under or over finished receive higher monetary value in comparison with those that are genetically superior and finished within an acceptable fatness.

One way to eliminate some of the risk is to market cattle on a dressed weight basis. This pricing method pays on actual dressing percentage; therefore, risk associated with estimating dressing percent on the packer side is avoided. Dressed weight and grade is another marketing method. With this method, more information is provided eliminating the need to estimate dressing percent, and the distribution of carcass weight, quality grade and yield grade within each pen.

Fausti and Fuez (1995) studied two marketing methods based on the informational conditions and the risk associated with marketing cattle. The two marketing methods used were live weight which was considered as an incomplete marketing alternative along with dressed weight and grade as the full information marketing alternative. Results indicated that price differences existed between marketing alternatives. Packers monetarily consider the informational risk associated with the live weight basis when there is uncertainty in the total product. Therefore, the dressed weight and grade marketing method improved pricing efficiency by reducing the risk incurred by packers. Furthermore, the literature indicates that pricing accuracy improves as marketing methods move from live price to dressed weight and further to dressed weight and grade (Purcell, 1970; Riethmayer and Dietrich, 1972; Schneidau and Armstrong, 1970; and Stout and Thomas, 1970).

Within the past decade, producers have become frustrated about the lack of monetary difference among a variety of carcass traits using these marketing methods. However, according to Schroeder et al. (1997), previous research indicates that packers pay higher prices for pens of cattle that typically result in higher percentages of Choice or Prime quality grades as well as higher percentages of yield grades 1, 2, and 3. However, Schroeder's concern was that price differences do not represent value differences at the wholesale market. Because wholesale prices are virtually ignored with these methods of marketing, price signals are not clear between packers and producers.

A study completed by Feuz et al. (1993) examined four different marketing methods and their ability to efficiently price live cattle. The four methods included live weight basis; dressed weight basis; dressed weight and grade basis (all of which were described previously); as well as a value-based approach that rewards ribeye area as a percentage of carcass weight, and discounts excess fat from the base price of varying quality grades. Empirical results indicate that the profit level of the live weight basis is lower in relation to the other methods ($16.88 vs. $34.76, $32.92, and $34.17/hd, respectively). One explanation is that the live weight method provides security to the buyer/packer in case the bidder inaccurately estimates carcass traits. Marketing cattle on the dressed weight basis provided the greatest profit ($34.76/hd), and the value-based marketing approach provided a similar (P>.10) profit at $34.17/hd. The value-based approach produced a higher profit (P<.10) per head than the dressed weight and grade basis ($32.91/hd). Although profits did not increase drastically between the three marketing methods (excluding live weight), the value-based approach was the most efficient for reflecting the true or perceived value of the carcass.

Feuz et al. (1993) also indicated that if producers utilize the live or dressed weight methods for marketing their cattle, those producers would be rewarded for feedlot production factors and not carcass characteristics. This is unfortunate as carcass characteristics reflect consumer preferences more accurately and these signals are not being relayed back to the producers. Faminow et al. (1996) supported previous findings in that pricing on a live weight basis does not relay consumer demand toward retail product, and subsequently does not provide adequate price signals for the producer to strive toward producing a more consistent end product.

A study comparing three grid pricing formulas was completed from 1993 to 1996 and included 1,427,007 head of cattle (Doherty et al., 1998). The grid formulas consisted of a composite grid, a yield based grid, and a quality based grid. Results indicated that when the Choice/Select spread is $2.00/45.4 kg, higher yielding cattle perform better and when the Choice/Select spread increases to $11.00/45.4 kg, higher quality cattle perform better. The authors found that when analyzed on a 45.4 kg basis, grid pricing does a good job of rewarding cattle that conform to boxed beef fabrication specifications and discounting those that do not. Unfortunately, the benefits of using grid pricing vanished when gross price per carcass was determined. This research demonstrates the importance of carcass weight in that heavy cattle are sorted to the top and light cattle to the bottom which defeats the purpose of rewarding desirable cattle and discounting undesirable cattle.

Owen et al. (1991) explored the relationship between fabricated cut prices, carcass value, and fed cattle prices and determined that the greatest correlation of price was to its own past price. Moreover, Owen et al. (1971) determined that forecasting relationships among fabricated beef cut prices and fed cattle price would be helpful in predicting daily prices for cattle.

Barkema and Drabenstott (1990) indicated that consumer preferences included a leaner and more consistent product at a competitive price. Prior to this, the National Consumer Retail Beef Study was completed and revealed that close trimmed retail cuts to 0.64 cm of fat would improve the image and sales of beef (Savell, 1989 and Cross, 1986).

As a result, Safeway™ waged a "war on fat" in order to relieve concerns about beef's perceived price/value relationship in comparison to the competition, as well as the fat-related human health concern (Lusk, 1991). This included setting a goal to improve production efficiency by reducing excess trimmable fat by 20% and increasing lean production by 6% without causing a detrimental effect on palatability.

Furthermore, the Value Based Marketing Task Force of the National Cattlemen's Association decided in 1990 that an average of 39.92 kg of excess fat existed on each slaughter steer/heifer. This equated to a value of excess fat that was $97.00/hd in 1990. The problem at this point and time as indicated by Lusk (1991) and Savell (1991) was that retailers had responded to the consumer preference to reduce trimmable fat, however, the rest of the beef industry seemed to be lagging. The reason for the lag appeared to be the lack of clear economic signals being sent from retailers' back through the beef chain to producers.

The number one concern of retailers, purveyors, and restaurateurs in the 1991 National Beef Quality Audit (NBQA; NCBA, 1991) was excess external fat with excess seam fat, low overall cutability and insufficient marbling ranking in the top ten concerns. Moreover, too many overfat carcasses with relation to yield grade 4's and 5's was among the top ten concerns of beef packers.

The results of the 1991 NBQA helped communicate major problems to all sectors of the beef industry. Goals were set to "improve the consistency and competitiveness of fed-beef." Those goals included:

1) Encourage 0.64 cm fat trim as the new "commodity" fat-trim specification for beef primals/subprimals.
2) Change live-to-carcass price logic from dressing percentage to red meat yield.
3) Keep the "heat" on communicating cutability to retailers and packers by improving the understanding of the value of closer-trimmed beef.

4) Go after and correct management practices that create non-conformity.
5) Eliminate biological types of cattle that fail to conform.
6) Institute quality-based marketing.
7) Identify outlier-values for specific carcass traits.
8) Design and conduct the strategic alliance field-studies.
9) Use the NBQA data collection program to identify superior seedstock
10) Repeat the NBQA at periodic intervals to assess progress and identify new opportunities for improvements in consistency and competitiveness of fed-beef.

As a realization of the last goal, NCBA and cooperating universities completed a follow up audit in 1995. From 1992 to 1995 all sectors of the beef industry became better educated relative to close trim fat specifications and carcass price logic as it relates to value; also poor management practices and genetic decisions leading to non-conformities were addressed. Although it seemed that some improvements had been made, low overall uniformity and consistency, excess external fat, inappropriate USDA quality grade mix and low overall cutability were still among the top ten concerns for retailers, purveyors, and restaurateurs. Lack of uniformity and predictability of live cattle, excess external fat, inadequate marbling, and the price of beef relative to the value received were among the top ten concerns of beef packers in 1995 (NCBA, 1995).

Value-based marketing is an attempt to improve the beef industries short commings, and realize market signals and changes in consumer preferences from the retailer to the producer. Furthermore, value-based marketing allows incentive for producers to produce a consistent, palatable product, for seedstock operators to purchase better breeding stock, for feeders to sort animals more consistently to an acceptable harvest end point, for packers to realize the need to fabricate close trim products and for retailers to meet consumers demands.

Many meat packing companies provide their own grid matrix of acceptable standards including premiums and discounts that best suit their situation. The USDA Market News provides a weekly report (Table 1) establishing value adjustments and expected ranges that may be useful for determining current value on a carcass basis.

Gardner (1996) evaluated the OSU Boxed Beef Calculator for estimating boxed beef value based on carcass grade and yield parameters as well as harvest and fabrication costs. This method of determining carcass and live value reflects value based on boxed beef product considering both commodity (2.5 cm) and close-trim (0.64 cm) fat levels for fabrication costs and overall value. Gardner (1996) found the absolute price difference between commodity trim and close trim for a U.S. Choice, yield grade 2.0 to be $41.30/hd.

Feeders and packers were interviewed by Schroeder et al. (1997) and all agreed that the industry needs to move toward pricing cattle according to value, reflecting premiums and discounts for both quality and cutability. As a result, this bold move would link prices and quality by rewarding above average cattle and penalizing inferior cattle.

Meyer and Lang (1981) expressed hesitation from packers and cattle feeders to move toward pricing cattle according to value mainly because of the lack of trust between the two divisions. Schroeder (1997) also reported this conflict and considered it to be one of the biggest hindrances to the progress of value-based marketing in the beef industry.

Genetic Selection.

Beef cattle selection tools are comprised of many live and carcass traits all of which have to compliment each other to optimize production and maximize profitability. As the beef industry realizes the need for value-based marketing, and because most breeding programs implement multiple-trait selection practices, producers will need to comprehend how carcass traits are related to each other and to live traits, as well as understand production influences on quality and cutability.

Heritability. Heritability estimates for carcass traits are essential to improve and execute selection programs and realize carcass merit as a beef production endpoint. Heritability is defined as the additive genetic proportion of phenotypic variance for individuals of known pedigrees. Historically, carcass traits have been reported as being moderately (.20 - .40) to highly (> .40) heritable which indicates that genetic progress can be made through carcass trait selection. Cundiff et al. (1971) reported comparisons of carcass trait heritabilities involving Angus, Hereford, and Shorthorn sires adjusted for either age at slaughter, carcass weight, or the combined adjustment of age and carcass weight. The heritability estimate of carcass weight when adjusted for age was .56, for intramuscular marbling .31, for fat thickness .50, for longissimus dorsi area .41 and for percent cutability .28. Adjusting for weight, heritability estimates were .33 for marbling, .53 for fat thickness, .32 for longissimus dorsi area and .35 for estimated percent cutability. The discrepancy between adjustments for longissimus dorsi area was thought to be caused by the difference in genetic correlation between carcass weight and longissimus dorsi area (+.66) compared with the environmental correlation (+.39). Furthermore, the difference in heritability of percent cutability for adjusted age and adjusted weight (28% vs. 35%) was perceived to be caused by a higher environmental correlation for carcass weight and estimated cutability when compared with the genetic correlation.

Considering the same time period, work completed by Brackelsberg et al. (1971) indicated that heritability estimates of Hereford and Angus sires for carcass grade, ribeye area, and fat thickness (.74, .40 and .74, respectively) were highly heritable and within the range of heritabilities reported in previous studies. Furthermore, marbling heritability was reported to be .73, which is considerably higher than that reported by Cundiff et al. (1971).

Among studies considering Hereford sires or progeny, Dinkel and Busch (1973) determined carcass heritabilities after accounting for weight variation. They estimated heritability for ribeye area (.25) to be lower than the range in most previous studies (.40 - .76). However, fat thickness was recorded to be 57% heritable and marbling score 31% heritable which agrees with Cundiff et al. (1971).

Koch (1978) reported heritabilities similar to previous studies (Cundiff et al., 1971 and Brackelsberg et al., 1971) when comparing fat thickness and marbling score (.68 and .34, respectively). However, ribeye area for this study was lowly heritable at 28% and agrees with Dinkel and Bush's (1973) estimation of 25%. Koch et al. (1982) derived heritabilities for crossbred steers representing various sire breeds and found a drastic increase in heritability of ribeye (.56) from his earlier report of .28, as well as a decrease in fat thickness from .68 to .41. Other carcass traits (marbling, .40 and carcass weight, .63) remained similar with his previous work (marbling, .34 and carcass weight, .68). The changes in heritabilities between studies may have been due to the fact that different breeds of sires were involved in the latter study versus three line sires of Herefords in the previous study.

Heritabilities adjusted for weight were recorded for Hereford sires as reported in the American Hereford Association's National Sire Evaluation Program. Those included carcass weight , .19; quality grade .30; .44 for both fat thickness and ribeye area, and .38 for marbling (Benyshek et al., 1988). All traits are well within the average of the literature reviewed except for carcass weight, which is low in comparison to other carcass weight heritabilities.

Hereford sired progeny were studied by Lamb et al. (1990). Heritability estimates for ribeye area agreed with Dinkel and Busch (1973) and Koch (1978);

however, estimates appeared lower than reported in Cundiff et al. (1971) and Koch et al. (1982). Estimated heritability for fat thickness is the lowest (.24) among literature reviewed and lower for carcass weight when compared with work completed by Cundiff et al. (1971). The marbling heritability (33%) was average in comparison to studies reviewed (.26-.52). Reynolds et al. (1991) selected Hereford bulls to determine heritability estimates for carcass traits using son-sire (parent-offspring) regression. They found heritability for carcass weight to be 33% which is lower than reported heritabilities for Koch et al. (1982 ; .43), Benyshek et al. (1981; .54), and Cundiff et al. (1971; .56). The estimated heritability for longissimus dorsi area is very low at 1%. As a result Reynolds et al. (1991) indicated that the longissimus dorsi of 2-yr-old bulls were not good indicators of the estimated longissimus dorsi of their progeny.

Arnold et al. (1991) reported heritabilities from Hereford steers as a reference sire program for the American Hereford Association. Carcass trait heritabilities were all moderately heritable and ranged from .24 to .49. The estimated heritability for fat thickness (.49) and ribeye area (.46) were among the highest heritabilities reviewed. MacNeil et al. (1991) used several populations of bull semen to inseminate Hereford heifers and determined estimated fat thickness heritability adjusted to 365d. MacNeil et al. (1991) found fat thickness to be highly heritable at .52 and similar to previous studies (Arnold et al., 1991, .49; Benyshek et al., 1988, .44; Koch et al., 1982, .41).

Woodward et al. (1992) used data from the Simmental producers to determine single-trait heritabilities for live traits and marbling. The heritability estimate produced for marbling (.09) was much lower than estimates from other researchers considering English purebreds and English crosses.

VanVleck et al. (1992) found estimated heritabilities for longissimus dorsi area and marbling to be .62 and .43, which are among the highest heritabilities reported for those traits.

Veseth (1993) estimated genetic parameters by randomly selecting bulls from a Hereford herd. Heritability estimates for ribeye area (.51) and marbling (.31) proved to be similar to previous studies that used artificially selected herds (Brackelsberg et al., 1971; Cundiff et al., 1971; and Koch et al., 1982). The carcass weight heritability estimate was .38 which was lower than found for Koch et al. (1978, .68), Koch et al. (1982, .43 for cold side weight) and MacNeil et al. (1984, .44); however, Lamb et al. (1990) found the estimated heritability of carcass weight to be similar at 38%.

Wilson and Rouse (1987) evaluated carcass traits of steers from Angus sires adjusted by weight to determine carcass heritabilities. They found that adjusting for carcasses weighing less than 685 lbs., heritabilities for fat thickness, marbling score and ribeye area were .31, .32 and .29, respectively, while adjusting for carcasses that weighed more than 685 lbs., fat thickness and marbling score heritabilities decreased (.27 and .26) and ribeye area heritability increased to 40%. All heritabilities were considered moderately heritable.

Angus field data consisting of both steer and heifer data were evaluated by Wilson et al. (1993) to determine heritabilities for use in estimating breeding values. The data were adjusted to an age-constant endpoint and produced heritabilities for carcass weight (.31), marbling (.26), longissimus dorsi area (.32) and fat thickness (.26). Carcass weight, marbling and fat thickness heritabilities were somewhat lower than reported in previous studies which may in part be due to the inclusion of heifer data (Brackelsberg et al., 1971; Cundiff et al., 1971; Dinkel and Bush, 1973; Koch et al., 1978,1982; and Benyshek et al., 1981); however, these heritabilities agree with Wilson (1987) in which bull and heifer progeny were deleted.

Gregory et al. (1994) examined the possible effect of heterosis on meat traits and found estimated heritabilities of fat thickness (.30) and marbling (.52) to be comparable to other studies. Gregory et al. (1995) determined heritabilities for all breed groups, purebreds, and composites. They found heritabilities for marbling to be high for all three categories .48, .45, and .55, respectively in comparison with other studies; while carcass weight was average in comparison (.23, .20 and .34) and with in the range of .19-.63. However, heritabilities for fat thickness were .25, .20 and .39 for all breed groups, purebreds and composites and were on the low end of the range determined from the literature (.24-.52). Furthermore, longissimus dorsi area heritabilities of .22, .17, and .35 were estimated to be low in comparison. It is important to understand that while some estimated carcass heritabilities may vary between studies, they are for the most part moderately to highly heritable, and with appropriate selection practices improvement of carcass characteristics is possible for beef production.

Correlation. Genetic correlation, although somewhat less reliable than heritability estimates, is of significant importance as it provides an indirect prediction of the relationship between factors of production and carcass traits. If sire selection is based on information from sib and progeny tests, direct measurements of carcass traits are slow. Consequently, many studies have looked at selecting for production traits and their correlated responses to carcass traits. Results have indicated that selection emphasis when placed on growth traits was more effective than when placed on carcass traits in that selection for weight traits may result in more weight of retail cuts with less external fat while maintaining carcass quality (Cundiff et al., 1971; Dinkel and Busch, 1973; Koch et al., 1978,82 and Woodward et al., 1992). However, the time has come for packers to seek and reward producers for carcasses that combine acceptable quality and cutability and in turn supply a consistent beef product to the retail and food service industry. Therefore, it is necessary to review the effect of selection for leaner, higher quality carcasses.

Consideration has been given to the idea that if sires are selected for a single carcass trait, there may be an antagonism toward the selection of another carcass trait. Cundiff et al. (1971) reported a high negative correlation between marbling and estimated cutability of –1.22 and a high positive correlation when considering marbling and fat trim of primal cuts (.93) from Angus and Hereford sires. It is important to note that genetic correlations range from –1 to +1. In some reports, parameter estimates fall outside the bounds. Thus, results indicate that selection for these traits would be antagonistic and fruitless unless the economic importance was greater for one trait than the other.

Genetic correlations between steers from Hereford and Angus sires (Brackelsberg et al., 1971) showed that an increase in longissimus dorsi area would not affect selection for decreased fat nor an increase in marbling as the genetic correlations were close to zero (-.09 and –.12, respectively). Furthermore, Brackelsberg also noted that an increase in longissimus dorsi area would have a positive effect on carcass value (0.51). However, if selection was based primarily on decreasing fat thickness, then marbling score and overall carcass value would also decrease as the genetic correlations for average fat thickness and marbling was .62 and average fat thickness was negatively correlated with carcass value (-.85).

Dinkel and Busch (1973) studied genetic correlations between carcass traits of steers from Hereford sires and found results similar to Cundiff et al. (1971). Adjusting for carcass weight, the genetic correlations predicted that an increase in ribeye area was associated with a decrease in fat thickness (-.59) and an increase in cutability (.72); however, as one would expect, this selection would also cause a decrease in marbling (r_g=.61).

Age adjusted and weight adjusted data were considered by Koch (1978, 1982) to determine expected correlated responses to one standard deviation of selection. In Koch (1978), selection of Hereford sires for weaning weight or yearling weight proved to be favorable for increasing carcass weight. When adjusting the data for age, carcass weight increased and percentage retail product decreased while fat trim increased. On the other hand, adjusting for weight resulted in an increase of percentage retail product and a decrease in fat.

This selection toward an increase in carcass weight also led to a decline in marbling regardless of adjustment.

Koch et al. (1982) considered crossbred steers and revealed that an estimated selection response for increasing retail product would decrease fat thickness, increase ribeye area, and decrease marbling regardless of being adjusted to a constant age or weight. Koch et al. (1982) also found genetic correlations of fat thickness and retail product percent to be highly negative (-.74), and ribeye area correlated with retail product percent was highly positive (.53). Marbling correlations with retail product, lbs., fat thickness and ribeye area were fairly ineffective (-.02, .16 and –.14, respectively) which was opposite findings from Koch (1978) and the genetic correlations of marbling with retail product, fat thickness and ribeye area (-1.10, .73 and –1.34, respectively).

Among the research considering Hereford sires (Dinkel and Busch, 1973, Koch, 1978; Lamb et al., 1990; Arnold et al., 1991; Reynolds et al., 1991; and Veseth et al., 1992), Benyshek (1988), found that most of the genetic correlations of carcass traits were less than 0.1. However, the correlation of fat thickness and ribeye area has a negative association (-.52) which agrees with Dinkel and Busch (9173; -.59) and Arnold et al. (1991; -.37), but does not concur with Koch et al. (1982; .03) Lamb et al. (1991; -.04). The correlation between carcass weight and marbling was .35 and agrees with most of the literature considering Hereford sires (Lamb et al., 1991, .64; Arnold et al., 1991, .33; and Veseth et al., 1992, .38).

Lamb et al. (1990) reported that a decrease in fat may lead to undesirable changes in marbling as the genetic correlation is highly positive (.73), which is supported by data from Cundiff et al. (1971) and Brackelsberg et al. (1971). Arnold et al. (1991) however reported a lower genetic correlation between fat and marbling (.19) which is advocated by Dinkel and Busch (1973), Koch (1978, 1982) and Gregory et al. (1994, 1995). Other studies indicate that selecting for a decrease in fat would not cause a detrimental effect on marbling. Wilson (1987) reported a correlation between marbling and external fat of 0.08 for data adjusted to 283.50 kg, and –0.30 for data adjusted to 740.2 kg. Beneyshek et al. (1988) and Wilson (1997) also found the correlation between fat thickness and ribeye to have a small association (.08 and –.05, respectively), and Wilson et al. (1993) reported a correlation of –.13. Shimada and Willham (1992) found a highly negative genetic correlation between fat thickness and marbling (-.41), similar to Wilson (1987) data adjusted to 750 lbs.

Most of the research supports that marbling and ribeye area have a small association and selection for increased ribeye area should not drastically affect marbling (Brackelsberg et al., 1971, -.12; Dinkel and Busch, 1978 –.17; Koch et al., 1982, -.14; Wilson, 1987, -.03 and –.02; Benyshek et al., 1988, .04; Arnold et al., 1991, -.01; Shimada and Willham, 1992, -.04; Wilson et al., -.04; Gregory et al., 1995, -.02 and Wilson, 1997, -.09). However, Veseth et al. (1993) found the genetic correlation between marbling and ribeye area to be .51, which compared to Lamb et al. (1990, .57). Conversely, Koch (1978) reported a negative correlation of –1.34 and VanVleck et al. (1992) estimated the correlation between marbling and ribeye area to be –.40.

Dinkel and Busch (1993) estimated the correlation between cutability and marbling to be –.36, whereas Lamb et al. (1990) found a positive relationship (.26). However, actual percentage retail product correlations with marbling appear quite variable.

The estimated cutability of a carcass involves fat thickness, ribeye size, carcass weight, and percentage kidney, pelvic and heart fat. Each of these are a factor when considering retail product. An increase in ribeye size is beneficial for increasing cutability and retail product, while an increase in fat is detrimental. Many studies show the correlation between ribeye size and external fat to be negative. Brackelsberg et al. (1971) reported a genetic correlation of –.53 for ribeye area and fat trim. Subsequent research supported this correlation; as ribeye size increased, external fat decreased (Dinkel and Busch, 1973, -059; Wilson et al., 1993, -.40 and –.44; Benyshek et al., 1988,-.52; Arnold et al., 1991,-.37; and Shimada and Willham, 1992, -.45). Other research indicated that ribeye area and fat thickness had a genetic correlation near zero. This means that an increase in ribeye area will not have an effect on increasing or decreasing fat thickness (Koch, 1978, .03; Koch et al., 1982, -.15; Lamb et al., -.04; Wilson et al., 1993, -.06; Gregory et al., 1995, -.06; and Wilson 1997,-.05).

As carcass weight increases on a growth curve up to a point of finish, muscle increases then levels off and fat continues to increase until harvest. Many studies show the relationship between ribeye area and carcass weight to be moderately to highly positive. Cundiff et al. (1971) estimated the genetic correlation between ribeye area and carcass weight to be highly positive at .66 which compares well with Lamb et al. (1990, .68), Shimada and Willham, (1992, .61), and Gregory et al. (1995, .66). Other studies reported this correlation to be moderately positive (Koch et al., 1982, .44; Wilson et al., 1993, .47 and Wilson, 1997 .49). However, Koch (1978) noted a correlation of .02 for ribeye area and carcass weight suggesting that there is a minimal effect of change in ribeye to change in carcass weight as seen also by Benyshek et al. (1988, -.07) and Arnold et al. (1991, .09).

The relationship between fat and carcass weight is similar to the relationship between ribeye area and carcass weight. Cundiff et al. (1971) showed a genetic correlation of .34 between fat thickness and carcass weight which is similar in comparison with other research suggesting that as fat increased, carcass weight simultaneously increased (Koch, 1978, .90; Lamb, 1990, .36; Shimada and Willham, 1992, .23; Wilson et al., 1993, .38 and Wilson, 1997, .23.). Other research indicated that the relationship between fat and carcass weight was close to zero and was unaffected by any increase or decrease as was seen by Koch (1982, .08), Benyshek (1988, .04), Lamb (1990, .14) and Gregory (1995, .13)

Several National Cattle Evaluation Programs including Angus, Brangus, Limousin, Red Angus, Salers, and Simmental calculate Expected Progeny Differences (EPDs) for carcass traits (Dolezal, 1997). However, the number of sires with carcass trait EPDs are small for some breed programs and the accuracy of those EPDs suffer as a result.

The American Angus Association has a substantial number of records (n=38,000) from approximately 1,900 sires. Adjusted for age (480 d), heritabilities for carcass weight, marbling score, ribeye area, fat thickness and percent retail product are all moderately heritable (.30, .37, .27, .25 and .24, respectively). Genetic correlations between marbling score and ribeye area (–.09), marbling score and fat thickness (0.00) and marbling score and percent retail product (-.03) are all virtually zero showing little genetic association. This zero correlation indicates that traits can be selected for independently.

Carcass EPDs for the Angus sires include carcass weight (2.78 $\pm$ 5.10); marbling score (.07 $\pm$ 0.18); ribeye area (.774 $\pm$ 1.29) fat thickness (-.008 $\pm$ .05) and percent retail product (.07 $\pm$ 0.36). Gwartney et al. (1996) investigated the potential effect of marbling EPDs on fat thickness when fed to a constant marbling endpoint. Sires were selected based on high (>.40) or low (<-.16) EPDs for marbling. Results indicated that sires with high marbling EPDs were able to attain the Choice grade with less fat thickness while sires with low marbling EPDs required more time on feed and produced carcasses that were heavier and fatter than carcasses from high marbling EPD sires. Therefore, the use of marbling EPDs in sire selection is advantageous for maintaining marbling score while reducing external fat, which agrees with previous research as to the relationship between marbling and fat.

Table 1. National Carcass Premiums and Discounts for Slaughter Steers and Heifers[a]

Quality	Price Range ($/45.36kg)	Simple Average ($/45.36kg)	Change from last week ($/45.36kg)
Prime	3.00 – 10.00	5.67	0.00
Choice	0.00 – 0.00	0.00	0.00
Select	-8.75 – -11.00	-10.27	-0.06
Standard	-11.00 – -22.00	-18.81	-0.06
Certified programs			
Avg Choice/Higher	0.00 – 2.50	1.25	0.00
Bullock/Stag	-20.00 – -35.00	-25.20	0.00
Hardbone	-16.00 – -30.00	-21.83	0.00
Dark Cutter	-20.00 – -35.00	-27.33	0.00
Yield Grade, Fat (cm.)			
1.0-2.0, <.25 cm	0.00 – 3.00	1.67	0.00
2.0-2.5, <.51 cm	0.00 – 2.00	0.83	0.00
2.5-3.0, <1.0 cm	0.00 – 2.00	0.83	0.00
3.0-3.5, <1.5 cm	0.00 – -0.50	-0.08	0.00
3.5-4.0, <2.0 cm	0.00 – -1.00	-0.25	0.00
4.0-5.0, <3.0 cm	-12.00 – -23.00	-16.17	0.00
5.0/up, >3.0 cm	-17.00 – -27.00	-21.00	0.00
Weight			
180-230 kg	-14.00 – -30.00	-20.67	0.00
230-250 kg	-12.00 – -25.00	-17.33	0.00
250-400 kg	0.00 – 0.00	0.00	0.00
400-430 kg	0.00 – 0.00	0.00	0.00
430-450 kg	-10.00 – -23.00	-16.83	0.00
Over 450 kg	-10.00 – -30.00	-22.67	0.00

[a] For the week of November 3, 1998.

Source: NW LS195, USDA, AMS

CHAPTER III

CHARACTERIZATION OF BOXED BEEF VALUES IN ANGUS FIELD DATA

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ABSTRACT

A challenge for commercial and seedstock beef cattle producers is to identify sire genetics whose progeny excel in both quality grade and red meat yield. The Oklahoma State University Boxed Beef Calculator was identified as a tool to determine mean carcass values ($/45.4 kg) of sires (n=1,287) whose progeny (n=33,350) are represented in the 1998 Fall American Angus Association Carcass Field Records. Progeny value was determined using individual quality grade, yield grade, and carcass weight, as well as average close trim boxed beef subprimal prices and average drop credit values for 1995, 1996, and 1997. The seasonal pattern of boxed beef prices indicated that the average Choice/Select spread was significant (P<.05) for each year and each quarter. A linear trend revealed the lowest Choice/Select spread ($4.32/45.4 kg) in the first quarter and the highest spread ($13.44/45.4 kg) in the fourth quarter. As a result, low, average, and high quality grade spreads were used to evaluate sire progeny

mean closely-trimmed boxed beef values. Sire progeny records were run through the Boxed Beef Calculator using the low, average, and high quality grade spreads. Close trim carcass value, percentage boxed beef yield, percentage boxed beef yield with out lean trim, and percentage boxed beef major cuts yield were determined. Harvest date, gender, and sire were all significant ($P<.0001$) sources of variation for carcass price ($/45.4 kg) within the low, average, and high quality grade spreads. Residual correlations for all progeny data indicated that the three boxed beef yields, as well as percentage retail product had strong relationships especially with yield grade. Furthermore, Spearman rank correlations showed that relationships between the average and low quality grade spread and the average and high quality grade spread were both strong (.98; $P<.001$). Therefore, the average Choice/Select spread could be used in evaluating sire value based on boxed beef prices without significant rank order change. Sires ranked in the top 10% for boxed beef value had significantly ($P<.001$) higher quality carcasses with more desirable yield grade traits when compared with the bottom 10%. As a result, sires in the top 10% showed a carcass price ($/45.4 kg) and carcass value ($/hd) advantage for all three pricing periods. Prediction analysis indicated that the 'best' equation for predicting boxed beef price ($/45.4 kg) included marbling score, yield grade, and percentage boxed beef yield without lean trim as independent variables (R^2=.7033). Path coefficient analysis revealed that quality grade (direct r = -.75; indirect r = -.66) and yield grade explained a majority (R^2 = .88; $P<.001$) of the variation in carcass price ($/45.4 kg).

INTRODUCTION

The beef industry has incurred a drastic decline in market share to competing proteins in the last two decades. As a result, quality audits, surveys, scientific and economic research, and popular press have made an attempt to determine what the industry needs to change to regain market share and profitability. The most frequent response is that cattle producers need to make a better attempt to understand the consumer and their wants and needs. The 1995 NBQA recommended strategies to try to regain a competitive advantage. Many of the strategies included finding genetic lines to reduce the variation in carcass cutability and quality, and produce a consistent, palatable product while achieving feasible production performance and efficiency.

However, until there is a marketing system that sends price signals from packers down the chain to the seedstock and commercial segments, cattle producers will not likely change their programs. The historical method of marketing cattle on a live cash basis actually penalizes superior cattle and ultimately rewards inferior cattle. Therefore, price discovery needs to be directed toward individual carcass merit which rewards carcasses that are high in quality and red meat yield and discounts those that do not meet boxed beef fabrication specifications. In an attempt to realize a value-based price for individual carcass traits, Oklahoma State University developed the Boxed Beef Calculator (BBC; Gardner et al., 1997). The BBC is used to estimate live and carcass values for close trim and commodity trim fabrication generated from boxed beef subprimals.

This method of marketing requires producers to know their type of cattle, as those that do not conform to boxed beef fabrication specifications may receive large discounts that outweigh premiums.

The American Angus Association has made a tremendous effort to offer a comprehensive sire evaluation program as a tool to help producers make breeding decisions. The 1998 Fall Sire Evaluation Report produced by the American Angus Association shows the genetic correlation between marbling score and percentage retail product to be unassociated (-.03). This means that selection for an increase in marbling should not provide a decrease in percentage retail product and selection for an increase in percentage retail product should not have a detrimental affect on marbling score. The problem is that single-trait selection results in an undesirable affect on quality grade or red meat yield. What if a multiple-trait approach were available that weights quality grade, red meat yield, and carcass weight at the same time. The potential exists for a genetic correlation to be generated that combines red meat yield and quality grade into a single-trait selection tool.

In an attempt to prove sire value, this project was completed to examine the impact of low, average, and high Choice/Select quality grade price spreads on sire progeny mean boxed beef values, as well as to examine year, contemporary group, and sire effects on boxed beef value. Additionally, sire progeny groups were summarized relative to quality grade by yield grade frequencies and non-conformers. The second objective was to examine sire progeny mean close trim boxed beef value rankings based on progeny data and to evaluate whether sire rankings differ significantly across seasonal Choice/Select quality grade price spreads. The third objective was to quantify progeny values for non-conformers and each quality by yield grade combination. Finally, this study addressed the comparison between current American Angus Association retail product percentage yield predictions and closely trimmed boxed beef total, subprimal without lean trim, and major subprimal percentage yield estimates.

MATERIALS AND METHODS

Data. Progeny data (n=37,848), adjusted for age at harvest (480 d), were received from the American Angus Association, St. Joseph, MO, and in cooperation with Iowa State University, Ames, IA. Data included herd code, harvest date, sire registration number, steer or heifer tag number, gender, fat thickness (cm, $12^{th}/13^{th}$ rib interface), ribeye area (cm^2), carcass weight (kg), percentage kidney, pelvic and heart fat, percentage retail product and marbling score for progeny harvested between spring 1975 and fall 1997.

Progeny marbling scores were converted to be compatible with U.S. quality grade (USDA, 1997) and numerical codes required for the BBC (Table 1). Progeny with marbling scores greater than 10.99 and less than 2.0 were eliminated from the data set. U.S. yield grade was calculated to the nearest 0.01 (USDA, 1997). U.S. yield grades were fixed with a "floor" function to eliminate rounding. All final yield grades ranging from 0.1 to 0.99 were converted to 1.0, while all final yield grades 6.0 and above were changed to 5.99 to meet the range required in the BBC. In order to eliminate progeny with unreasonably low carcass values, progeny with adjusted carcass weight less than 204 kg, adjusted percentage kidney, pelvic and heart fat less than 0.3%, and adjusted ribeye area less than 48.4 cm^2 were deleted. The number of progeny in some cases had insufficient data for more than one trait; however, the total number of progeny eliminated (n=300) resulted from the aforementioned yield grade traits and marbling scores. Also, duplicate data were found for 61 progeny and were deleted from the database.

Oklahoma State University Boxed Beef Calculator. The 1998 version of the OSU BBC was used to calculate carcass value specifically for close trim fabrication of 17 boxed beef subprimals and two levels of lean trim (Table 2). This spreadsheet was divided into four worksheets. The first worksheet required the input of drop credit value, freight costs, and the sum of harvest and fabrication costs. Boxed beef pricing comprised the second worksheet which allowed the entry of prices for boxed beef subprimals based on quality grade, commodity- and close-trim fat levels, as well as weight description for certain cuts. The third worksheet defined expected boxed beef yields for each subprimal and lean trim. Boxed beef yields were estimated by regression equations as a percentage of cumulative side weights and provided product weight, given an individual carcass weight and yield grade (Gardner, 1996). The final worksheet consisted of a carcass calculator. The calculator allowed for the input of individual carcass data including carcass weight, quality grade, yield grade, and dressing percentage. This worksheet contained a computer macro that calculated commodity and close trim carcass prices/45.4 kg, as well as commodity and close trim percentage box yield based on the three previous worksheets and individual carcass data. Three levels of close trim box yield were calculated to compare to adjusted percent retail product. The first box yield included all 17 wholesale cuts and two levels of lean trim as in Table 2. The second box yield (box yield w/o lean trim) included all wholesale cuts, but excluded lean trim, while the third box yield (box major cuts yield) included only nine major wholesale cuts (middle and end cuts; Table 2).

Boxed beef prices. Boxed beef prices for 1995, 1996, and 1997 were obtained from a major retail company in the U.S. that receives weekly subprimal prices from the top three U.S. packers. Prices for 1997 included upper two-thirds Choice, U.S. Choice and U.S. Select, while 1995 and 1996 prices included U.S. Choice and U.S. Select. Due to inconsistent recording of product type in 1995, 1996, and 1997, prices for close trim 120 brisket and 185C tri-tip were generated for the three years, and close trim 170 gooseneck prices were generated for 1997. Close trim prices for 120 brisket and 185C tri-tip were determined by a percentage increase from commodity prices, while in 1997, 170 gooseneck prices were established by using a ratio average of 1995 and 1996 (170 gooseneck:112A ribeye roll hvy). Cattle Fax, Englewood, CO provided average drop credit values for each month. Harvest and fabrication costs ($/hd) for U.S. yield grades 1 through 5 were set as

Yield grade 1	$100.00
Yield grade 2	$103.00
Yield grade 3	$106.00
Yield grade 4	$124.00
Yield grade 5	$124.00

Close trim boxed beef prices were of major interest and were entered into an Excel™ worksheet monthly for each year. Yearly averages were calculated and overall three-year averages were determined for each boxed beef item (Table 3). Upper two-thirds Choice values were not recorded for 1995 and 1996. Consequently, U.S. Choice and U.S. Select boxed beef prices were used with yield grade (1.00 to 5.99) in calculating close trim carcass value. U.S. Choice and U.S. Select quality grades, yearly and quarterly differences were determined by calculating close trim carcass value with a basic carcass consist (each year X each quarter X each quality grade X yield grades 1.5, 2.0, 2.5, 3.0 and 3.5, and by carcass weights 294.8, 317.5, 340.2, 362.9 and 385.6). Carcass price/45.4 kg was determined by entering the three year average close trim boxed beef prices into the boxed beef pricing worksheet and the three year average drop credit value in the harvest cost worksheet.

Premiums and discounts were later applied to the carcass price for U.S. Prime, upper two-thirds Choice, and U.S. Standard or no roll, as well as for U.S. yield grades 4 and 5 for all three years. Premiums for U.S. Prime and upper two-thirds Choice were $5.00 and $2.00/45.4 kg, respectively, while U.S. Standard progeny received a discount of $15.58/45.4 kg (two times the average

Choice/Select spread). Yield grade discounts were $15.00/45.4 kg for U.S. yield grade 4's and $20.00/45.4 kg for U.S. yield grade 5's. Furthermore, a discount of $25.00/45.4 kg was applied for light weight (< 249.5 kg) and very heavy weight (>453.6 kg) progeny, while progeny greater than 430.9 kg and less than 453.6 kg received a $10.00/45.4 kg discount. Carcass values within U.S. Standard were set to a constant price within the low, average, and high Choice/Select spreads, therefore, the carcass value did not reflect a yield grade premium (Table 3) as was the case for U.S. Prime to U.S. Select. Moreover, progeny within U.S. yield grade 4 and 5 were set to a constant value within quality grade for the low, average and high Choice/Select spreads (Table 4). The constant value was calculated by the BBC for U.S. Choice and Select carcasses with a yield grade 3.5 weighing 340 kg, and dressing 63.00 percent for the low, average, and high pricing periods. Yield premiums for carcasses within yield grade 1, 2, and 3 were determined by the BBC. This method of determining carcass value allows quick and easy changes for premium and discount values associated with quality grade.

After establishing the progeny database for quality grade and yield grade, progeny records were processed through the BBC using the low, average, and high quality grade spreads, as well as the low, average, and high drop credit values ($9.03/45.4 kg, $8.87/45.4 kg, and $8.88/45.4 kg, respectivly). A constant dressing percentage of 63.00 was used for all progeny. Close trim carcass values/45.4 kg and percent box yields were determined and premiums and discounts were applied as mentioned earlier. Finally, sires with less than 10 progeny were deleted from the database resulting in 33,350 progeny from 1,087 sires. Steers comprised 85.5% of the progeny records (n=31,181), while 6.5% of the records were from heifers (n=2,169). Of the 33,350 records, 28,210 progeny were considered to conform with boxed beef fabrication specifications (U.S. Prime through U.S. Select, U.S. yield grades 1, 2, or 3 and carcass weights within the range of 250 to 430 kg). Moreover, the data included 328 herds and 218 harvest dates (Month/Year).

Next, a price benchmark using a base U.S. Choice carcass value was determined by the BBC for a yield grade 3.99 carcass weighing 340 kg with a 63.00 dressing percentage for the low, average, and high Choice/Select spreads. Finally, an overall carcass value was determined by multiplying low, average, and high carcass prices ($/45.4 kg) times 340 kg. Benchmark prices and carcass values were then compared with mean sire values.

Statistical Analysis. A 3 X 4 matrix of year (1995, 1996, and 1997) and quarter (first, second, third, and fourth) was used to test quality grade (U.S. Choice versus U.S. Select) spread using the GLM procedure of SAS (SAS, 1995). Mean differences for quarterly carcass close trim boxed beef prices ($/45.4 kg) were separated by Tukey's HSD procedure. Quarterly quality grade differences indicated a difference ($P<.05$) for all four quarters, thus, yearly high (fourth quarter) and low (first quarter) spreads were determined and the overall three-year average was calculated.

Main effects of harvest date, gender, and sire were tested for significance ($P<.05$) using the residual error term (32,045) for the low, average, and high Choice/Select price spreads (SAS, 1995).

Pearson and Spearman rank correlations were performed to determine the relationship between carcass traits. These traits included quality grade, marbling score, fat thickness, ribeye area, carcass weight, kidney pelvic and heart fat percentage, yield grade, percentage retail product, percentage boxed beef yield, percentage boxed beef yield without lean trim, percentage boxed beef of major subprimals, as well as low, average, and high carcass values ($/45.4 kg). Adjusted carcass characteristics, percentage retail product, percentage boxed beef yield, percentage boxed beef yield without lean trim, and percentage boxed beef yield of major subprimals were used to determine which single- or multiple-trait model best predicted carcass price ($/45.4 kg) and carcass value ($/hd) using the STEPWISE procedure of SAS (SAS, 1995). Furthermore, appropriate residual correlations adjusted for harvest date, gender, and sire were determined for all carcass traits, along with the average pricing period. Path coefficients (standardized partial regression coefficients) were calculated and diagrams were constructed to determine the direct and indirect effects among selected carcass traits with carcass price and value (Wright, 1934).

Frequency distributions were determined for carcass traits of interest and for sires above and below the low, average, and high price spread benchmarks for carcass price ($/45.4 kg; $102.39, $102.67, and $105.18/45.4 kg, respectively) and carcass value ($/hd; $767.93, $770.03, and $788.85, respectively) using the PROC FREQ procedure of SAS (SAS, 1995).

RESULTS AND DISCUSSION

Boxed beef prices. Mean quality grade price spreads (U.S. Choice vs U.S. Select) in 1995, 1996, and 1997, for the first, second, third, and fourth quarters, as well as quarterly and yearly averages are presented in Table 5. Despite some overlapping values for quarter within year, the average quality grade price spread for each year and each quarter were significant (P<.05). Due to seasonality of the quality grade spread within each year, the linear trend for the first, second, third, and fourth quarter average spreads was of specific interest. The lowest spread occurred in the first quarter ($4.32/45.4 kg), while the highest spread was found in the fourth quarter ($13.44/45.4 kg).

The seasonality pattern observed is not an unusual phenomenon as Choice/Select spreads are typically lower in the first quarter and higher in the fourth quarter. This may be due to the seasonality of demand for higher quality middle meats in the fourth quarter around the holiday season. Another cause of the disparity of Choice versus Select may be due to the supply of Choice grading cattle. Smaller spreads are prevalent when the market is saturated with cattle grading Choice, and higher spreads occur when cattle grading Choice are lower in supply with relation to demand.

The percentage contribution to carcass value from middle, end cut, and thin meats along with lean trim and drop credit are represented in Figures 1, 2, 3, 4, and 5 for the low, average, and high Choice/Select spreads. Choice middle meats contributed a higher percentage to carcass price than Select middle meats for all three pricing periods (Figure 1). However, end cut meats, thin meats, and lean trim, along with drop credit within Choice contributed a lower percentage to carcass price than Select for all three quality grade spreads (Figures 2, 3, 4, and 5).

Marketing strategies have indicated that when the quality grade price spread is narrow (low Choice/Select spread), higher yielding cattle will be more valuable than when the spread is wide (high Choice/Select spread). This became apparent as the percentage contribution of middle meats to carcass value for Choice increased in comparison with Select across the average and high Choice/Select spreads, while the difference between the percentage contribution to carcass value from end cut meats, thin meats, lean trim, and drop credit within Choice and Select was less variable. Therefore, as the Choice/Select spread increased from low to high, yield grade premiums became less influential. Doherty et al. (1998) support this theory as their grid Choice/Select spread based on 60% Choice increased from $2.00/45.4 kg to $5.00, $8.00, and $11.00/45.4 kg, the population average discount increased ($.18, $-.38, $-.59, and $-.79/45.4 kg, respectively). In comparison, the present study agrees with previous findings that higher quality cattle are worth more during a period with a high Choice/Select spread.

Progeny data. Harvest date (month/year), gender, and sire were all significant (P<.0001) sources of variation for carcass price ($/45.4 kg) within the low, average, and high Choice/Select spreads (Table 6). Frequency distributions indicated that 84.6% of sire progeny conformed to boxed beef fabrication specifications while 15.4 % did not (Table 7). Notable difference was apparent between conforming and non-conforming progeny for percentage Choice or better (80.5 versus 68.7%) and for percentage Standard (0 versus 17.6%). Furthermore, non-conforming progeny carcasses were fatter and lighter muscled resulting in a lower expected percentage of boneless, closely trimmed retail cuts with 64.3% yield grade 4's and 4.7% yield grade 5's. Percentage cut-out variables (boxed beef yield, %; boxed beef yield w/o lean trim, %; boxed beef major cuts yield, %; and retail product, %) followed the yield grade trend in that estimated percentage cut-out was higher for conforming than non-conforming progeny. Another difference resulting in a sizeable discount was the distribution of carcass weight (kg) between conforming and non-conforming progeny. Non-conforming progeny carcass weights revealed 14.6% with less than 250 kg and 4.1% attained 430 kg or more.

Conforming progeny were worth more than non-conforming progeny as the discounts applied to non-conforming progeny had a direct effect on carcass price ($/45.4 kg) and carcass value ($/hd). The carcass price ($/45.4 kg) difference between conforming and non-conforming progeny averaged

$18.63/45.4 kg resulting in an average difference of $138.15/hd across all three quality grade spreads.

Percentage Choice or better for all progeny (78.7%) was 8.7% higher than the 1995 NCBA target of 70%; however, 2.7% of all progeny were Standard which is unacceptable from a palatability standpoint. The percentage of all progeny with yield grade 3.9 or better was lower in comparison with the 1995 NBQA and Doherty et al. (1998). Moreover, the percentage of progeny with yield grade 2.9 or better were substantially short (-30.8%) of reaching the NCBA target of 70%.

Carcass price ($/45.4 kg) by quality grade, illustrated in Figure 6, reveals the actual boxed beef prices for Choice and Select, as well as the discounted value of Standard progeny, and the increase in value of progeny grading premium Choice and Prime for all three pricing periods. Carcass price stratified by yield grade (Figure 7) indicated a significant decrease in progeny carcass price ($/45.4 kg) for yield grades 4 and 5, as well as a mild tendency for carcass price to increase as yield grade improved from 3.99 to 1.00. As mentioned earlier, yield grade has a greater influence on carcass price when the quality grade spread is narrow. Therefore, yield grade 1 carcasses had higher carcass prices in the low Choice/Select spread than those in the average. As yield grade became less desirable, any yield grade price advantage was offset by quality grade.

Subcutaneous fat thickness (cm) at the $12/13^{th}$ rib interface was broken down to assess the distribution and effect of fat thickness on carcass price

($/45.4 kg). Figure 8 reveals that 83% of all progeny data had less than 1.8 cm of subcutaneous fat which is slightly less than the 88.7% reported in the 1995 NBQA. Boxed beef value for progeny with less than 1.8 cm stayed relatively constant for all three Choice/Select spreads (Figure 9); whereas, progeny with 1.8 cm of fat or more showed a drastic decrease in boxed beef value ($/45.4 kg). This decrease likely occurred because the additive effect of closely trimmed product would not compensate for additional trimming of external fat. May et al. (1992) found similar results when examining the effect of external fat on live and carcass value. The authors determined that carcass fatness had the greatest effect on value, and as carcass fatness increased, the economic advantage of close trim product decreased.

Figure 10 indicates that as progeny were deleted for characteristics not conforming to boxed beef fabrication specifications, carcass price followed a linear decline in $/45.4 kg as fat thickness (cm) increased. Comparison of Figures 9 and 10 reveals that boxed beef values for all progeny associated with fat thickness was masked by non-conforming carcass weight and quality grade discounts.

The difference between the low, average, and high Choice/Select spreads indicated that as fat thickness increased, carcass value became less dependent on red meat yield and more dependent on quality, illustrated in both Figures 9 and 10. Carcass value in the low Choice/Select spread for progeny with less than .51 cm of fat was higher than in the average or high Choice/Select spreads;

whereas, with increasing fat thickness, progeny in the high Choice/Select spread were more valuable than the average or low spreads.

A ribeye area by carcass weight schedule is used by USDA in the short-cut method for determining yield grade and predicting red meat yield. This ratio requires an increase in ribeye area (7.7 cm^2) for every 45.4 kg increase in carcass weight. The frequency distribution (Figure 11) indicates that 58.8% of all progeny had adequate ribeye sizes (within 6.45 cm^2) with respect to carcass weight requirements, while 19.0% were between 6.45 cm^2 and 13.00 cm^2, and 6.9% fell short of carcass weight requirements by more than 13.00 cm^2. Figure 12 shows that carcass price improved as muscling increased from thin to very heavy for all three Choice/Select spreads. Figure 13 reveals that carcass price increased approximately $10.00/45.4 kg due to the elimination of yield grade 4's and 5's and light and heavy weight carcasses; however, the linear trend was still evident for improved carcass price as muscling increased from thin to very heavy.

Williams et al. (1989) compared carcasses differing in live muscle thickness at two external fat trim levels. This study found that heavy muscled steers produced carcasses that had larger ribeye areas and more desirable yield grades ($P<.05$) than light muscled steers, while adjusted fat thickness, marbling score and percentage kidney, pelvic, and heart fat did not differ ($P>.05$). Furthermore, carcasses from thick muscled steers contributed a higher percentage of their live weight to boxed beef yield than light muscled steers. May et al. (1992) examined the effect of muscle score on carcass value and determined that thick muscled carcasses had higher live weight values than average muscled carcasses when trimmed to an external fat thickness of .64 cm; whereas, the live weight value remained constant between average and thin muscled carcasses.

Of the progeny within an acceptable carcass weight range (250 to 430 kg), 97% had a relatively constant carcass price ($/45.4 kg) for all three Choice/Select spreads (Figures 14 and 15). Progeny weighing less than 250 kg were drastically lower in price ($/45.4 kg), while carcasses within the range of 430 to 480 kg also revealed a decline in value due to carcass weight discounts.

Estimated percentage retail product (Dikeman et al., 1998) included roast and steak meat trimmed to 0 cm trimmable fat as well as lean trim with 20% fat expressed as a percentage of untrimmed side weight. In comparison, all boxed beef yield variables included subprimals with .64 cm or less residual fat, and lean trim pools with 50% and 20% fat. These differences accounted for a portion of the disparity in mean values and relationships with carcass traits and carcass prices, as well as retail product predictions.

Residual correlations for all progeny data, after accounting for harvest date, gender, and sire (Table 8), indicated that percentage boxed beef yield, boxed beef yield without lean trim, boxed major cuts yield, and percentage retail product had a strong relationship with yield grade (r_p=-.94, -.99, -.99, and -.99, respectively). Phenotypic correlations between retail product and carcass weight (-.26), marbling score (-.18), ribeye area (.54) and fat thickness (-.80) were similar to those reported by Wilson et al. (1997) (-.27, -.16, .53, and -.80, respectively). Boxed beef cut-out variables followed the same phenotypic relationship with percentage retail product for all carcass characteristics and carcass values. Boxed beef subprimal yields computed without lean trim were most closely associated with retail product yield estimates. The elimination of progeny not conforming to boxed beef fabrication specifications slightly improved the correlation between percentage boxed beef yield and yield grade (-.96; Table 9).

Considering all progeny data, Figure 16 illustrates the percentage of progeny above and below the benchmark price for a low Choice, yield grade 3.99 weighing 340 kg (low Choice/Select=$102.39/45.4 kg, average Choice/Select=$102.67/45.4 kg, and high Choice/Select=$105.18/45.4 kg). This benchmark was determined for a 3.99 because the BBC allows for further segmentation of whole numerical yield grades (i.e., 3.99 vs 3). The low Choice/Select spread resulted in the highest percentage of progeny (78.8%) to exceed the carcass price benchmark. The percentage above the benchmark declined to 72.1 and 68.6% during the average and high Choice/Select spreads because as mentioned earlier, yield grade premiums were less important while quality grade requirements had a major impact on carcass price as the quality grade spread increased. The percentage of progeny above the carcass pricing benchmark increased dramatically during the low, average, and high Choice/Select spreads (93.0%, 85.2%, and 81.0%, respectfully) as records were removed due to non-conforming boxed beef fabrication specifications (Figure 17).

Carcass value benchmarks of $767.93, $770.03, and $788.85/hd were used for the low, average, and high pricing periods to determine the percentage of progeny that exceeded or fell short in carcass value ($/hd). Because carcass value ($/hd) was influenced by carcass weight (340 kg base), the percentages above and below the low, average, and high Choice/Select benchmarks were lower than percentages for carcass price ($/45.4 kg). Nevertheless, Figure 18 indicates over half of all progeny were above all three carcass value benchmarks. Those percentages improved as data not conforming to boxed beef fabrication specifications were removed (Figure 19).

Sire means. Sire progeny means and standard deviations for carcass traits and carcass values are presented in Table 10. Sire mean carcass price ($/45.4 kg) and carcass value ($/hd) were greater for the low Choice/Select spread compared with the average spread as was also the case in Table 7 for progeny means. Figures 20 and 21 help explain this occurrence as 82.9% of a yield grade 3.5 carcass weighing 340 kg was comprised of end cut meats, thin meats, and lean trim, while only 17.1% consisted of middle meats. Figure 21 shows that the average Choice/Select spread contributed a greater amount ($/hd) to middle meats than the low Choice/Select spread. However, the low Choice/Select spread contributed a higher dollar value to end cut and thin meats, as well as lean trim in comparison to the average Choice/Select spread. Therefore, the disparity in carcass price ($/45.4 kg) and carcass value ($/hd) was due to the price advantage in the low Choice/Select spread for 82.9% of carcass weight.

There is concern that when sires are ranked on carcass price using the average Choice/Select spread, rankings may change during the low and high quality grade spread seasons of the year. However, Spearman Rank correlations adjusted for harvest date, gender, and sire showed that the relationships between the average and low Choice/Select spreads, as well as the average and the high Choice/Select spreads were both strong (.98; P<.0001).

This indicates that when sires are ranked by the average Choice/Select spread, significant rank order change is not expected if progeny are harvested during the low or high quality grade seasonal spreads. The correlation between the low Choice/Select spread and the high spread drops to .93 (P<.0001), which suggests that some re-ranking of sires can be expected. Therefore, the average Choice/Select spread should be used to evaluate sire value based on boxed beef prices.

The absolute carcass price difference between the low and average Choice/Select spreads was $0.64/45.4 kg; 96% of the sires absolute carcass price difference between the average and low Choice/Select spreads were within $2.00/45.4 kg. The absolute carcass price difference between the average and high Choice/Select spreads was $1.61/45.4 kg and 99.5% of the sires absolute carcass price difference between average and high quality grade spreads was within $3.00/45.4 kg.

Of the 1,087 sires, the top and bottom 10% based on carcass value ($/45.4 kg) were evaluated and are presented for the low, average, and high quality grade spreads in Tables 11, 12, and 13. The top 10% showed an improvement of $14.74, $16.04, and $17.20/45.4 kg in carcass price in comparison with the bottom 10% during the low, average, and high Choice/Select spreads, respectively. This improvement in carcass price ($/45.4 kg) resulted in a carcass value advantage for all three pricing periods of greater than $200.00/hd. Progeny from the top 10% sires had significantly ($P<.001$) higher quality carcasses with less fat, larger ribeye areas, heavier carcass weights, and more desirable yield grades when compared to the bottom 10%. The improved value of the top 10% over the bottom 10% was also a direct effect of the minimal occurrence of percentage progeny not conforming to boxed beef fabrication specifications for one or more of the qualifying characteristics.

Percentage boxed beef yield showed an interesting trend as the percentage yield decreased for the top 10% and increased for the bottom 10% across the three pricing periods. This was because the bottom 10% had progeny with greater fat thickness measurements (cm) and as a result, contributed a greater amount (kg) of fat particularly for the 50% fat lean trim level. Consequently, lean trim levels were removed from the red meat yield estimate and showed a significant ($P<.001$) advantage in percentage boxed beef yield without lean trim for the top 10%. Percentage boxed beef major cuts yield and percentage retail product follow the same pattern as boxed beef yield without lean trim for all three pricing periods.

Considering the carcass price benchmarks mentioned earlier, 70.7% of sire progeny means were above the low Choice/Select quality grade benchmark ($102.39/45.4 kg), while 64.5 and 55.8% were above the average and high Choice/Select quality grade benchmarks ($102.39 and $105.18/45.4 kg, respectfully; Figure 22). Furthermore, the carcass value ($/hd) distribution of sires above Choice/Select spread benchmarks was 56.3% for low ($767.93/hd), 54.7% for average ($770.03/hd) and 51.7% for the high ($788.85/hd) pricing period as depicted in Figure 23.

Carcass value predictions. Stepwise regression presented in Table 14 reflects a three variable model with marbling score, yield grade and percentage boxed beef yield without lean trim as independent variables that accounted for 70.3% of the variation in boxed beef price ($/45.4 kg) for all progeny in the average quality grade spread with a residual standard deviation of 4.52. Including the independent variables of percentage boxed beef major cuts yield, percentage boxed beef yield, carcass weight, fat thickness, and ribeye area only accounted for an additional 1% variation in carcass price and did not dramatically improve the residual standard deviation (RSD=4.45). Removing progeny data that did not conform to boxed beef fabrication specifications (Table 15) changed the order of importance of independent variables in the prediction of carcass price. A three variable model including marbling score, yield grade, and percentage boxed beef yield without lean trim explained 70.3% of the variation in carcass price and improved the residual standard deviation to 2.41.

The 'best' equation for predicting boxed beef value ($/hd) for all progeny ($R^2$ of .915; RSD=33.4) included carcass weight, yield grade, marbling, and boxed beef yield without lean trim (Table 16). With the elimination of progeny not conforming to boxed beef fabrication specifications, carcass weight alone accounted for 86.9% (Table 17) of the variation in carcass value ($/hd; RSD=34.8). Including percentage boxed beef major cuts yield and marbling score improved the R^2 by .097 and decreased the residual standard deviation by 17.01. This three variable model accounted for 96.8% of the variation in carcass value ($/hd) with a residual standard deviation of 17.74.

Fuez et al. (1993) determined that the most important variables in explaining the profit of their value based marketing approach was quality grade and average daily gain The addition of dressing percent, ribeye area, and days on feed accounted for additional variation in profit with an R^2 of .94. Since live performance records and dressing percent were not evaluated in the present study, carcass characteristics were the strongest variables for providing the best prediction of carcass price ($/45.4 kg) and carcass value ($/hd).

Figures 24, 25, and 26 show path coefficients (standardized partial regression coefficients) using progeny that conformed to boxed beef fabrication specifications and the average quality grade spread for carcass price ($/45.4 kg) and carcass value ($/hd) determined by the relationships between various carcass traits. The variation in carcass price or carcass value as explained by the effect of carcass trait predictor variables can be calculated by squaring path coefficients (values in parenthesis). Therefore, the direct effect of carcass weight explained 82.8% ($.91^2 = .828$) of the variation in carcass value ($/hd) in Figure 24. However, residual correlations between all variables, provide an indirect effect for predictor variables explaining variation in the response variable. For example, the indirect effect of carcass weight through yield grade on carcass value ($/hd) is .91 x .26 = .24. Consequently, prediction of variation cannot be fully explained by indirect effects alone. Path coefficients between all predictor variables and the response variable were calculated using residual correlations adjusted for harvest date, gender, and sire. The sum of all path coefficients, direct and indirect, provided an explanation of the variation in the response variable.

Figure 24 indicates that carcass weight, quality grade, and yield grade explained 98% of the variation in carcass value ($/hd). Because carcass weight is a function of carcass value, carcass weight accounted for the greatest direct effect on carcass value ($/hd). When routed through carcass weight, the indirect effects of quality grade (-.08) and yield grade (.24) had the greatest impact on carcass value ($/hd). Quality grade and yield grade had similar impacts on carcass price ($/45.4 kg) in Figure 25. The direct effects of quality grade and yield grade accounted for 56 and 49% of the variation in carcass price ($/45.4 kg), respectively.

Figure 26 includes path coefficients of quality grade and the four characteristics that comprise yield grade. These selected traits accounted for 88% of the variation in carcass price ($/45.4 kg). Quality grade had the most dominant direct effect on carcass price ($/45.4 kg) followed by ribeye area and fat thickness. Magnitudinal order of the indirect paths were ribeye area (2^{nd}), fat thickness (3^{rd}), carcass weight (4^{th}), and percentage kidney, pelvic, and heart fat (5^{th}).

Conclusion. Quarterly differences were significant ($P<.05$) indicating that boxed beef prices reflect a significant Choice/Select spread seasonal pattern. The current study indicated that sire rankings based on carcass price ($/45.4 kg) are not expected to change between the low and average pricing periods or the average and high pricing periods. Sires in the top 10% had a higher carcass value ($/45.4 kg) because progeny from those sires had more desirable quality by yield grade combinations than the bottom 10%. Moreover, sires in the top 10% had higher carcass values expressed in $/hd for all three quality grade spreads because of heavier carcass weights and higher carcass prices ($/45.4 kg). The percentage of sires meeting carcass price($/45.4 kg) and carcass value ($/hd) benchmarks were acceptable; however, percentages could be improved with the elimination of progeny that do not conform to boxed beef fabrication specifications (U.S. Standard, yield grade 4's and 5's, and carcass weights less than 250 kg or greater than 430 kg). Prediction equations accounted for at least 70% of the variation in carcass closely-trimmed boxed beef price ($/45.4 kg) and 95% of the variation in carcass value ($/hd). Path coefficient analysis revealed that carcass weight had the greatest direct and indirect impact on carcass value expressed as $/hd, while quality grade and yield grade had a relatively similar direct and indirect impact on carcass price ($/45.4 kg).

IMPLICATIONS

The present study indicates that the boxed beef calculator may be used to determine sire progeny values. The potential exists to calculate genetic values (EPDs) as a future sire-selection tool. Applying an actual value to sires and their progeny that reflects both quality and red meat yield simultaneously, may help commercial and seedstock producers make genetic and management decisions to improve the supply of beef and meet the demands of today's consumers. It is inevitable, value based marketing will have to become a reality for the beef industry to compete with other protein sources. However, price information needs to be more readily available to eliminate confusion and promote fairness. It is imperative that price signals represent consumer demands and that producers be rewarded for meeting those demands.

Table 1. Conversion of marbling score to quality grade.

Quality grade [a]	Marbling [a]	Marbling score [a]	Calculator code
Prime +	Abundant	10.0-10.99	1
Prime o	Moderately Abundant	9.0-9.99	1
Prime -	Slightly Abundant	8.0-8.99	1
Choice +	Moderate	7.0-7.99	2
Choice o	Modest	6.0-6.99	2
Choice -	Small	5.0-5.99	3
Select	Slight	4.0-4.99	4
Standard +	Traces	3.0-3.99	5
Standard -	Practically Devoid	2.0-2.99	5
Utility	Devoid	1.0-1.99	--

[a] Source: American Angus Association Fall Sire Evaluation Report, Fall 1998.

Table 2. Boneless boxed beef subprimals and the Institutional Meat Purchase Specification (IMPS) numbers.

Boxed beef subprimal	IMPS	Category
Ribeye roll, lip on	112A	Middle
Shoulder clod	114	End cut
Chuck roll	116A	End cut
Brisket, boneless, deckle off	120	Thin
Knuckle	167	End cut
Inside round	168	End cut
Bottom (gooseneck) round	170	End cut
Strip loin, short cut, boneless	180	Middle
Top sirloin butt	184	Middle
Bottom sirloin flap	185A	Thin
Bottom sirloin ball tip	185B	Thin
Bottom sirloin tritip	185C	Thin
Full tenderloin	189A	Middle
Flank steak	193	Thin
Inside skirt	--	Thin
Cap & wedge meat	--	Thin
Back ribs	--	Thin
80% lean trim	--	Lean trim
50% lean trim	--	Lean trim

Table 3. Low, average, and high quality grade spread pricing for U.S. Standard.

	U.S. Standard ($/43.4 kg)		
Yield grade	Low Ch/Se spread [a]	Average Ch/Se spread [b]	High Ch/Se spread [c]
1.0 to 3.99	89.24	89.52	92.09

[a] Standard=104.82 – 15.58.
[b] Standard=105.10 – 15.58.
[c] Standard=107.67 – 15.58.

Table 4. Three year average pricing for yield grade 4's and 5's.

Quality grade	Yield grade 4[f] ($/45.4 kg)	Yield grade 5[g] ($/45.4 kg)
Prime[a]	95.10	90.10
Premium Choice[b]	92.10	87.10
Choice[c]	90.10	85.10
Select[d]	82.31	77.31
Standard[e]	74.52	69.52

[a] Prime=105.10 + 5.00.
[b] Premium Choice=105.10 + 2.00.
[c] Choice=105.10.
[d] Select=97.31.
[e] Standard=105.10 – 15.58.
[f] Yield grade 4 = 15.00 discount.
[g] Yield grade 5 = 20.00 discount.

Table 5. Mean boxed beef value ($/45.4 kg) differences between U. S. Choice and U. S. Select for three years stratified by quarter.

	Quarter				
Trait	**First**	**Second**	**Third**	**Fourth**	**Average**^{i}
1995	3.88^{h}	8.28^{d}	10.38^{c}	15.84^{a}	9.60
1996	3.92^{gh}	6.10^{ef}	6.15^{ef}	13.78^{b}	7.49
1997	5.15^{fg}	6.64^{e}	11.00^{c}	10.71^{c}	8.38
Average^{j}	4.32	7.01	9.18	13.44	

^{abcdefgh} Means without a common superscript differ (P<.05).

^{ij} All means differ (P<.05).

Table 6. Mean squares for fixed variables by low, average, and high Choice/Select spreads.

Source	df	Mean Square	P-value
Low Ch/Se Spread			
Month/year	217	354.91	.0001
Gender	1	3113.27	.0001
Sire	1086	211.59	.0001
Residual	32045	--	--
Average Ch/Se spread			
Month/year	217	433.47	.0001
Gender	1	2448.94	.0001
Sire	1086	242.16	.0001
Residual	32045	--	--
High Ch/Se spread			
Month/year	217	554.93	.0001
Gender	1	1749.49	.0001
Sire	1086	283.39	.0001
Residual	32045	--	--

Table 7. Carcass trait means for complete progeny data, progeny data conforming to boxed beef fabrication specifications, and progeny data not conforming to boxed beef fabrication specifications.

Traits	Complete	SD	Conforming	SD	Non-Conforming	SD
Number of progeny	33,350		28,210		5,140	
Marbling score[a]	5.77	1.02	5.81	.96	5.56	1.28
Quality grade [b]	2.85	.85	2.81	.78	3.10	1.14
Prime, %	3.1	-	3.0	-	3.4	
Prem Choice, %	32.8	-	33.0	-	32.2	-
Choice, %	42.8	-	44.5	-	33.1	-
Select, %	18.6	-	19.5	-	13.8	-
Standard, %	2.7	-	-	-	17.6	-
Fat thickness, cm	1.37	.41	1.30	.36	1.73	.58
Ribeye area, cm^2	79.79	8.84	80.82	8.39	74.18	8.90
Carcass weight, kg	337.93	40.10	338.08	35.60	337.06	58.99
< 250 kg	2.3	-	-	-	14.6	-
250 to 430 kg	97.1	-	100.0	-	81.2	-
430 to 450 kg	.6	-	-	-	3.7	-
450 kg >	.1	-	-	-	.4	-
KPH, %[c]	2.33	.62	2.28	.59	2.62	.69
Yield grade	3.18	.67	3.06	.54	3.87	.87
1.0 to 1.99	3.4	-	3.4	-	3.3	-
2.0 to 2.99	35.8	-	39.3	-	16.9	-
3.0 to 3.99	50.1	-	57.3	-	10.8	-
4.0 to 4.99	9.9	-	-	-	64.3	-
5.0 to 5.99	.7	-	-	-	4.7	-
Box yield, %	67.22	2.19	67.43	1.78	66.08	3.50
Box yield w/o lean trim, %	52.09	1.98	52.38	1.62	50.47	2.84
Box major cuts yield, %	40.29	1.64	40.53	1.32	38.95	2.40
Retail product, %	62.66	2.67	63.18	2.15	59.82	3.37
Low spread, $/45.4 kg	104.83	7.80	107.73	3.71	88.91	4.41
Average spread, $/45.4 kg	104.59	8.30	107.49	4.75	88.73	5.10
High spread, $/45.4 kg	106.23	9.06	109.05	6.20	90.75	6.19
Low spread, $hd	781.84	112.07	803.34	92.59	663.73	133.95
Average spread, $/hd	780.24	114.72	801.68	96.07	662.60	135.72
High spread, $/hd	792.56	119.72	813.49	102.46	677.72	140.68

[a] 5.00 to 5.99 = Small; 4.00 to 4.99 = Slight.
[b] 2.0 to 2.99 = premium Choice; 3.00 to 3.99 = Choice.
[c] Kidney, pelvic, and heart fat.

Table 8. Residual correlations[a] among carcass traits for all progeny data (n=33,350).

Traits	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Quality grade		-.88	-.26	-.39	-.47	-.07	.02	-.17	-.13	-.17	.19	.19	.19	.17
2. Marbling score[b]			.20	.30	.36	.07	-.02	.17	.13	.18	-.19	-.19	-.19	-.18
3. Low $/45.5 kg				.98	.91	-.16	.46	-.52	-.03	-.66	.51	.60	.60	.66
4. Average $/45.5kg					.98	-.14	.44	-.47	-.01	-.60	.46	.54	.54	.60
5. High $/45.5 kg						-.12	.40	-.41	.01	-.52	.40	.47	.47	.52
6. KPH, %[c]							-.01	.15	.04	.26	-.26	-.26	-.26	-.35
7. Ribeye area, cm^2								-.09	.40	-.55	.47	.50	.49	.54
8. Fat thickness, cm									.25	.80	-.74	-.79	-.79	-.80
9. Carcass weight, kg										.30	-.37	-.36	-.38	-.26
10. Yield grade											-.94	-.99	-.99	-.99
11. Box yield, %												.98	.98	.94
12. Box yield w/o lean trim, %													1.0	.98
13. Box major cuts yield, %														.98
14. Retail product, %														

[a] All correlations (P<.001).

[b] 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.

[c] Kidney, pelvic and heart fat..

Table 9. Residual correlations[a] among carcass traits for progeny (n=28,210) conforming to boxed beef fabrication specifications.

Traits	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Quality grade		-.87	-.48	-.66	-.69	-.07	.00	-.16	-.12	-.16	.17	.17	.17	.16
2. Marbling score[b]			.39	.52	.53	.06	-.00	.16	.12	.17	-.18	-.18	-.18	-.17
3. Low $/45.5 kg				.95	.85	-.16	.59	-.50	.09	-.73	.71	.72	.71	.74
4. Average $/45.5kg					.97	-.10	.45	-.34	.10	-.52	.50	.51	.51	.53
5. High $/45.5 kg						-.06	.35	-.23	.10	-.37	.35	.36	.35	.37
6. KPH, %[c]							.01	.10	.01	.22	-.22	-.22	-.22	-.33
7. Ribeye area, cm^2								-.01	.45	-.54	.48	.49	.49	.54
8. Fat thickness, cm									.21	.73	-.71	-.73	-.73	-.73
9. Carcass weight, kg										.24	-.30	-.31	-.32	-.20
10. Yield grade											-.96	-.99	-.99	-.99
11. Box yield, %												.99	.99	.96
12. Box yield w/o lean trim, %													1.0	.98
13. Box major cuts yield, %														.98
14. Retail product, %														

[a] All correlations (P<.001).

[b] 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.

[c] Kidney, pelvic and heart fat.

Table 10. Sire (n=1,087) progeny means for carcass traits.

Traits	Mean	SD	Minimum	Maximum
Quality grade[a]	2.94	0.50	1.73	5.00
Marbling score[b]	5.67	0.59	3.37	7.47
KPH, %[c]	2.41	0.45	1.09	3.67
Ribeye area, cm^2	79.08	5.10	63.98	100.30
Fat thickness, cm	1.32	.22	.64	1.98
Carcass weight, kg	331.95	31.47	237.25	426.21
Yield grade	3.18	0.36	2.04	4.43
Retail product, %	62.62	1.43	57.67	67.02
Box yield, %	67.35	1.35	63.86	73.34
Box yield w/o lean trim, %	52.15	1.13	48.60	56.59
Box major cuts yield, %	40.35	.94	37.29	44.07
Low spread, $/45.4 kg	104.09	4.43	83.59	114.65
Average spread, $/45.4 kg	103.76	4.77	83.87	115.30
High spread, $/45.4 kg	105.31	5.16	85.74	117.88
Low spread, $/hd	762.84	87.32	445.25	988.18
Average spread, $/hd	760.57	88.95	444.43	993.71
High spread, $/hd	772.05	91.87	449.66	1016.07

[a] 1.00 to 1.99 = Prime; 2.00 to 2.99 = premium Choice; 5.00 to 5.99 = Standard .

[b] 7.0 to 7.99=Moderate; 5.0 to 5.99=Small; 3.0 to 3.99=Traces.

[c] Kidney, pelvic and heart fat.

Table 11. Progeny carcass trait means for sires in the top and bottom 10% for the low Choice/Select spread.

	Low Choice/Select spread				
	Top Percent		Bottom Percent		
Traits	Mean	SD	Mean	SD	Diff**
Carcass Value, ($/45.4 kg)	109.87	.96	95.13	2.75	14.74**
Carcass Value, ($/hd)	824.67	92.15	620.95	131.71	203.72**
Number of sires	109	--	110	--	
Number of progeny	2776	--	1853	--	
Marbling score[a]	6.15	1.06	5.17	1.11	.98**
Quality grade[b]	2.54	.77	3.42	.99	-.88**
Prime, %	6.5	--	1.1	--	
Prem. Choice, %	43.4	--	17.8	--	
Choice, %	40.1	--	35.0	--	
Select, %	9.7	--	30.2	--	
Standard, %	.3	--	15.8	--	
Fat thickness, cm	1.19	.33	1.42	.53	-.23**
Ribeye area, cm^2	83.66	8.64	72.89	8.26	10.77**
Carcass weight, kg	340.32	34.44	294.82	49.24	45.50**
< 250 kg, %	0.3	--	19.8	--	
250 to 430 kg, %	99.4	--	79.8	--	
430 to 450 kg, %	.3	--	.5	--	
450 kg >, %	0	--	0	--	
KPH, % [c]	2.18	.56	2.95	.59	-.77**
Yield grade	2.80	.55	3.34	.81	-.54**
1.0 to 1.99, %	6.7	--	3.5	--	
2.0 to 2.99, %	57.4	--	32.3	--	
3.0 to 3.99, %	34.8	--	41.6	--	
4.0 to 4.99, %	1.1	--	20.0	--	
5.0 to 5.99, %	0.0	--	2.7	--	
Box yield, %	68.19	1.86	68.09	3.27	.10
Box yield w/o lean trim, %	53.11	1.67	52.23	2.60	.88**
Box major cuts yield, %	41.13	1.36	40.44	2.19	.69**
Retail product, %	64.25	2.18	61.59	3.16	2.66**

[a] 6.0 to 6.99=Modest; 5.0 to 5.99=Small.
[b] 2.00 to 2.99 = premium Choice; 3.00 to 3.99 = Choice.
[c] Kidney, pelvic and heart fat.
** (P<.05).

Table 12. Progeny carcass trait means for sires in the top and bottom 10% for the average Choice/Select spread.

	Average Choice/Select spread				
	Top Percent		Bottom Percent		
Traits	Mean	SD	Mean	SD	Diff**
Carcass value, ($/45.4 kg)	110.19	1.04	94.15	2.72	16.04**
Carcass value, ($/hd)	822.27	90.94	616.36	130.97	205.91**
Number of sires	109	--	110	--	
Number of progeny	2728	--	1751	--	
Marbling score[a]	6.29	1.06	5.05	1.04	1.24**
Quality grade[b]	2.44	.73	3.53	.96	-1.09**
Prime, %	7.7	--	.7	--	
Prem. Choice, %	47.4	--	14.7	--	
Choice, %	38.5	--	32.7	--	
Select, %	6.1	--	35.0	--	
Standard, %	.2	--	16.9	--	
Fat thickness, cm	1.22	.33	1.40	.53	-.18**
Ribeye area, cm^2	83.33	8.58	72.95	8.19	10.38**
Carcass weight, kg	339.55	34.29	292.89	48.44	46.66**
< 250 kg, %	.3	--	20.2	--	
250 to 430 kg, %	99.4	--	79.4	--	
430 to 450 kg, %	.3	--	.5	--	
450 kg >, %	.0	--	0	--	
KPH, %[c]	2.22	.57	2.96	.57	-.74**
Yield grade	2.84	.57	3.29	.79	-.45**
1.0 to 1.99, %	6.2	--	3.9	--	
2.0 to 2.99, %	53.8	--	34.3	--	
3.0 to 3.99, %	38.5	--	41.3	--	
4.0 to 4.99, %	1.4	--	18.2	--	
5.0 to 5.99, %	0.0	--	2.3	--	
Box yield, %	68.03	1.86	68.26	3.26	-.23**
Box yield w/o lean trim, %	52.97	1.69	52.38	2.58	.59**
Box major cuts yield, %	41.01	1.37	40.58	2.17	.43**
Retail product, %	64.03	2.23	61.78	3.11	2.25**

[a] 6.0 to 6.99=Modest; 5.0 to 5.99=Small.
[b] 2.00 to 2.99 = premium Choice; 3.00 to 3.99 = Choice.
[c] Kidney, pelvic and heart fat.
** (P<.01).

Table 13. Progeny carcass trait means for sires in the top and bottom 10% for the high Choice/Select spread.

	High Choice/Select spread				
	Top Percent		Bottom Percent		
Traits	Mean	SD	Mean	SD	Diff**
Carcass value, ($/45.4 kg)	112.35	1.12	95.15	2.72	17.20**
Carcass value, ($/hd)	821.71	89.99	616.46	129.03	205.25**
Number of sires	110	--	110	--	
Number of progeny	2791	--	1740	--	
Marbling score[a]	6.32	1.05	4.99	1.00	1.33**
Quality grade[b]	2.4	.71	3.59	.93	-1.19**
Prime, %	8.2	--	.5	--	
Prem. Choice, %	48.0	--	13.0	--	
Choice, %	39.2	--	30.7	--	
Select, %	4.5	--	39.1	--	
Standard, %	.1	--	16.7	--	
Fat thickness, cm	1.24	.33	1.37	.53	-.13**
Ribeye area, cm^2	83.21	8.64	73.08	8.13	10.13**
Carcass weight, kg	339.71	33.95	292.23	47.08	47.48**
< 250 kg, %	.3	--	19.8	--	
250 to 430 kg, %	99.4	--	79.8	--	
430 to 450 kg, %	.3	--	.4	--	
450 kg >, %	0	--	0	--	
KPH, %[c]	2.23	.56	2.94	.58	-.71**
Yield grade	2.88	.56	3.26	.78	-.38**
1.0 to 1.99, %	5.7	--	4.1	--	
2.0 to 2.99, %	51.8	--	34.3	--	
3.0 to 3.99, %	40.7	--	43.4	--	
4.0 to 4.99, %	1.7	--	16.0	--	
5.0 to 5.99, %	0	--	2.2	--	
Box yield, %	67.92	1.87	68.31	3.19	-.39**
Box yield w/o lean trim, %	52.87	1.69	52.45	2.51	.42**
Box major cuts yield, %	40.93	1.38	40.63	2.11	.30**
Retail product, %	63.89	2.23	61.89	3.06	2.00**

[a] 6.0 to 6.99=Modest; 4.0 to 4.99=Slight.
[b] 2.00 to 2.99 = premium Choice; 3.00 to 3.99 = Choice.
[c] Kidney, pelvic and heart fat.
** (P<.01).

Table 14. Boxed beef value ($/45.4 kg) predictions during the average Choice/Select spread for all progeny data.

	Carcass Traits											
Intercept	**RET**[a]	**MARB**[b]	**YG**[c]	**BBY/LT**[d]	**BBYM**[e]	**BBY**[f]	**CWT**[g]	**FAT**[h]	**REA**[i]	**R^2**	**RSD**	**Cp**
-3.47	1.72									.3083	6.91	46870.59
-45.54	2.01	4.16								.5596	5.51	17724.19
-179.93	3.80	4.09	7.24							.5660	5.21	
670.17		3.64	-34.43	-9.16						.7033	4.52	1066.46
707.15		3.65	-35.32	-15.03	6.74					.7049	4.51	880.02
1479.55		3.64	-76.57	-33.14		8.82	-.06			.7098	4.47	321.30
2142.32		3.64	-113.10	-40.38	-16.58	16.55	-.12			.7122	4.46	41.26
2134.81	.29	3.64	-112.69	-40.59	-16.88	16.73	-.12			.7123	4.45	30.08
2163.58		3.64	-115.12	-40.77	-16.82	16.78	-.11	1.17	-.05	.7124	4.45	17.27
2220.72	-.78	3.64	-119.73	-40.73	-16.59	16.70	-.09	3.00	-.15	.7125	4.45	10.00

[a] Retail product, %.
[b] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[c] Yield grade= 1.00 to 5.99 (USDA, 1997).
[d] Boxed beef yield without lean trim, %.
[e] Boxed beef major cuts yield, %.
[f] Boxed beef yield, %.
[g] Carcass Weight, kg.
[h] Fat thickness, cm.
[i] Ribeye area cm^2.

Table 15. Boxed beef value ($/45.4 kg) predictions during the average Choice/Select spread for data conforming to boxed beef fabrication specifications.

	Carcass Traits											
Intercept	MARB[a]	RET[b]	CWT[c]	BBYM[d]	REA[e]	BBY/LT[f]	BBY[g]	YG[h]	FAT[i]	R^2	RSD	Cp
91.06	2.83									.3249	3.90	45940.13
1.62	3.30	1.37								.7029	2.59	4423.01
-8.79	3.22	1.43	.02							.7299	2.47	1461.64
-27.17	3.24		.04	2.51						.7427	2.41	60.08
-26.29	3.24	.09	.04	2.36						.7427	2.41	56.39
-24.92	3.23	.11	.04	2.28	.01					.7428	2.41	52.74
-22.67	3.23	.13	.04	3.41	.01	-.93				.7428	2.41	52.43
224.96	3.23		.02		-.01	-5.37	2.65	-13.65	.35	.7432	2.41	10.02
277.89	3.23		.02	-1.98	-.01	-5.46	3.29	-16.63	.36	.7432	2.41	8.75
291.48	3.23	-.17	.02	-2.03	-.03	-5.41	3.29	-17.72	.77	.7432	2.41	10.00

[a] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[b] Retail product, %.
[c] Carcass Weight, kg.
[d] Boxed beef major cuts yield, %.
[e] Ribeye area cm^2.
[f] Boxed beef yield w/o lean trim, %.
[g] Boxed beef yield, %.
[h] Yield grade= 1.00 to 5.99 (USDA, 1997).
[i] Fat thickness, cm.

Table 16. Boxed beef value ($/hd) predictions during the average Choice/Select spread for all progeny data.

	Carcass Traits											
Intercept	CWT[a]	YG[b]	MARB[c]	BBY/LT[d]	BBY[e]	BBYM[f]	RET[g]	FAT[h]	REA[i]	R^2	RSD	Cp
-41.38	2.43									.7225	60.43	87147.22
43.64	2.76	-61.45								.8370	46.31	37416.90
-65.42	2.66	-67.92	28.19							.8963	36.95	11701.14
-387.11	2.64	-50.16	28.19				4.35			.8964	36.93	
3628.78	2.27	-230.10	26.64	-58.31						.9151	33.43	3533.52
16072.31	1.45	-883.95	26.54	-434.32	141.33					.9230	31.83	88.70
17627.55	1.31	-969.66	26.54	-451.30	159.46	-38.92				.9231	31.82	60.23
17580.17	1.29	-967.09	26.54	-452.66	160.60	-40.79	1.84			.9231	31.81	51.95
17787.17	1.35	-984.88	26.52	-454.31	161.16	-40.56		8.88	-.38	.9232	31.80	32.58
18451.52	1.58	-1038.46	26.52	-453.93	160.22	-37.96	-9.11	30.14	-1.51	.9232	31.79	10.00

[a] Carcass Weight, kg.
[b] Yield grade= 1.00 to 5.99 (USDA, 1997).
[c] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[d] Boxed beef yield without lean trim, %.
[e] Boxed beef yield, %.
[f] Boxed beef major cuts yield, %.
[g] Retail product, %.
[h] Fat thickness, cm.
[i] Ribeye area cm^2.

Table 17. Boxed beef value ($/hd) predictions during the average Choice/Select spread for data conforming to boxed beef fabrication specifications.

	Carcass Traits											
Intercept	CWT[a]	BBYM[b]	MARB[c]	BBY/LT[d]	BBY[e]	YG[f]	RET[g]	FAT[h]	REA[i]	R^2	RSD	Cp
-48.82	2.52									.8688	34.80	82072.94
-657.22	2.60						9.16			.9099	28.85	
-776.98	2.73	16.15								.9115	28.59	46191.45
-1004.46	2.69	18.71	23.78							.9657	17.79	621.78
-879.10	2.74	90.49	23.79	-58.23						.9659	17.74	443.94
4767.43	2.27		23.78	-157.54	64.00	-305.54				.9664	17.61	23.10
5583.01	2.19	-30.58	23.78	-158.92	73.85	-351.41				.9664	17.60	10.33
5578.29	2.18	-31.33	23.79	-159.56	74.34	-351.17	.59			.9664	17.60	9.59
5612.68	2.20	-31.14	23.78	-159.29	74.19	-354.71		2.32	-.09	.9664	17.60	8.53
5696.14	2.22	-31.49	23.78	-158.98	74.19	-361.35	-1.05	4.82	-.22	.9664	17.60	10.00

[a] Carcass Weight, kg.
[b] Boxed beef major cuts yield, %.
[c] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[d] Boxed beef yield w/o lean trim, %.
[e] Boxed beef yield, %.
[f] Yield grade= 1.00 to 5.99 (USDA, 1997).
[g] Retail product, %.
[h] Fat thickness, cm.
[i] Ribeye area cm^2.

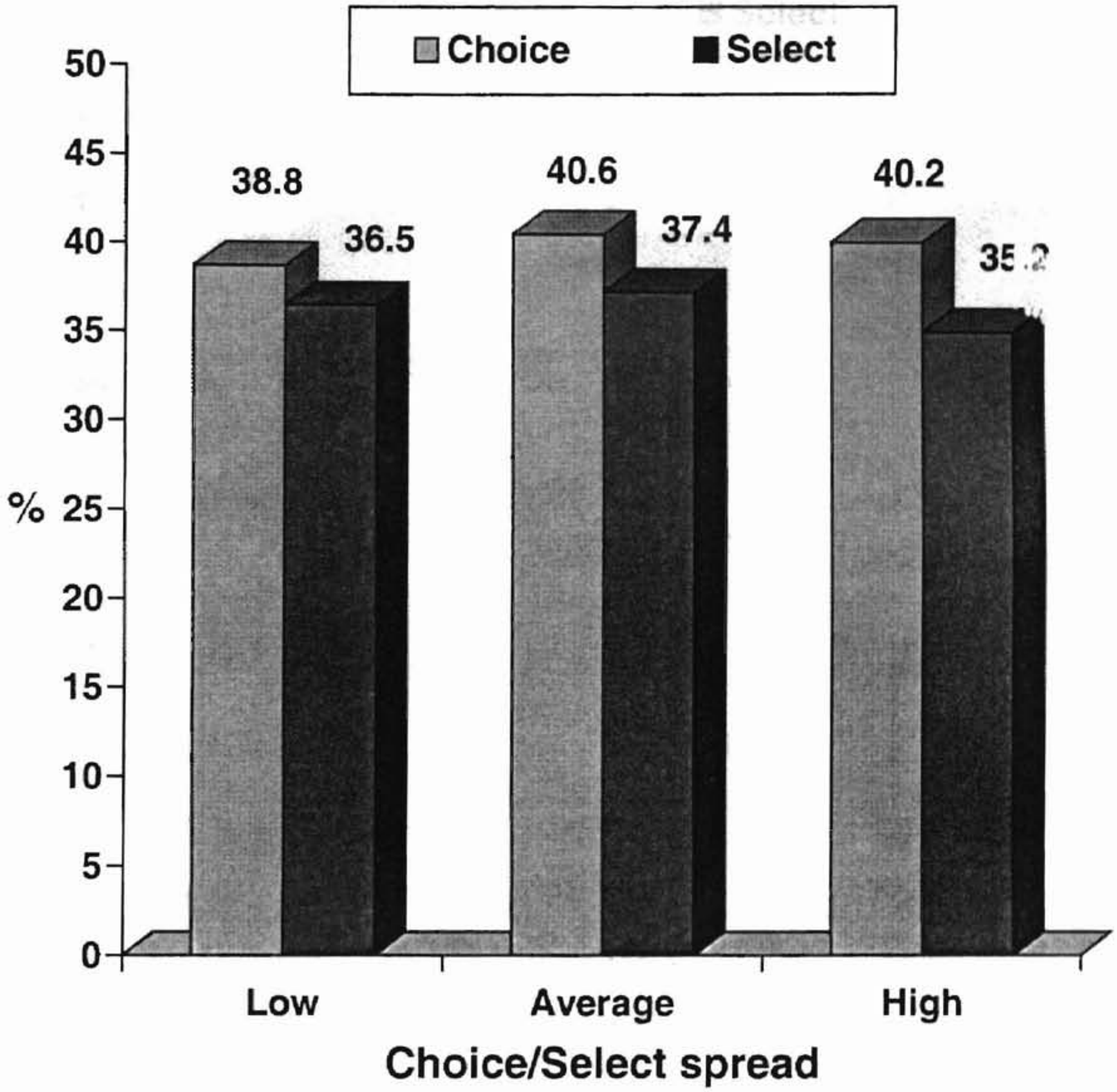


Figure 1. Percent contribution of middle meats ($/carcass) to carcass value for Choice and Select during the low, average, and high quality grade spreads.

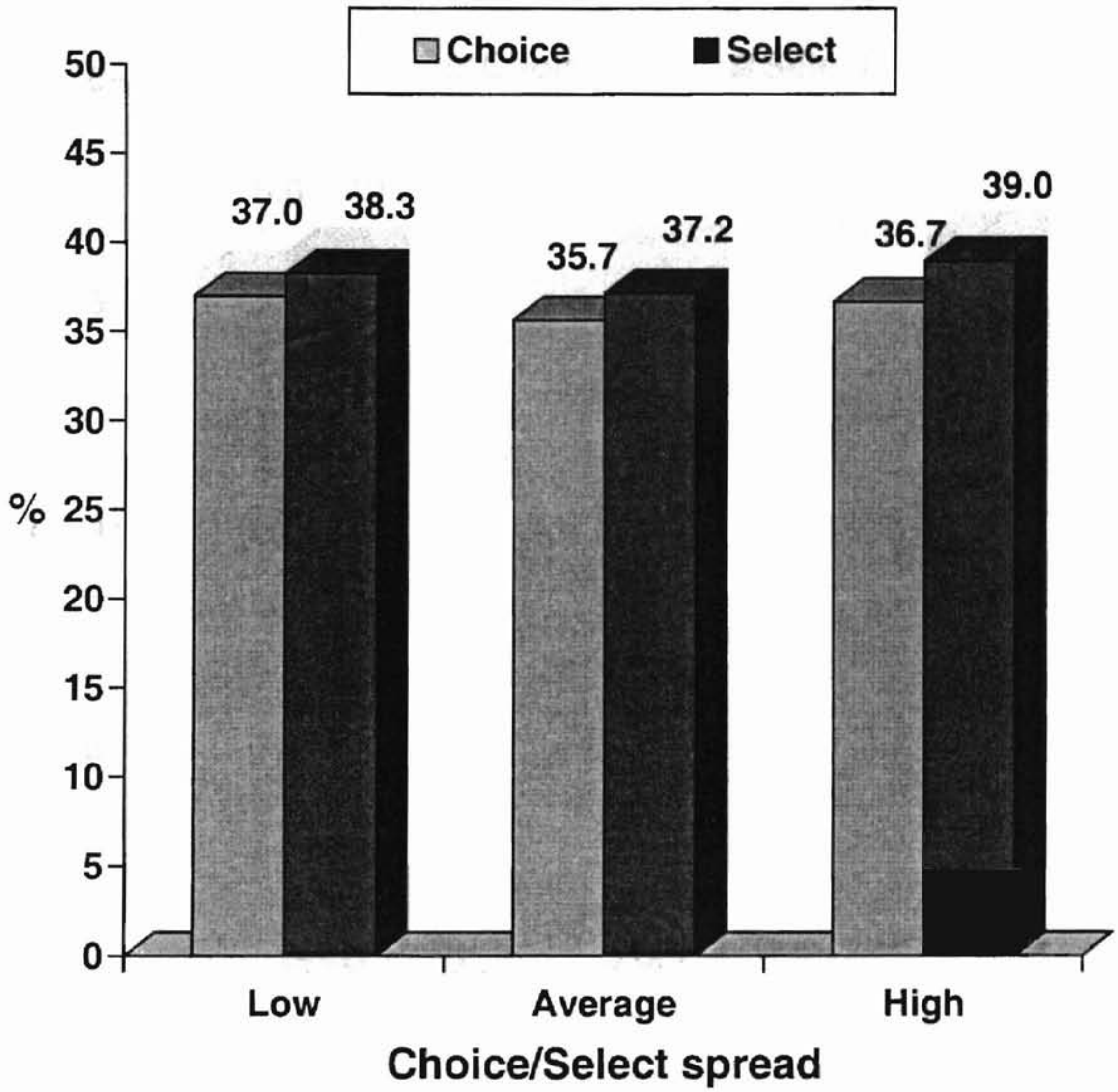


Figure 2. Percent contribution of end cut meats ($/carcass) to carcass value for Choice and Select during the low, average, and high quality grade spreads.

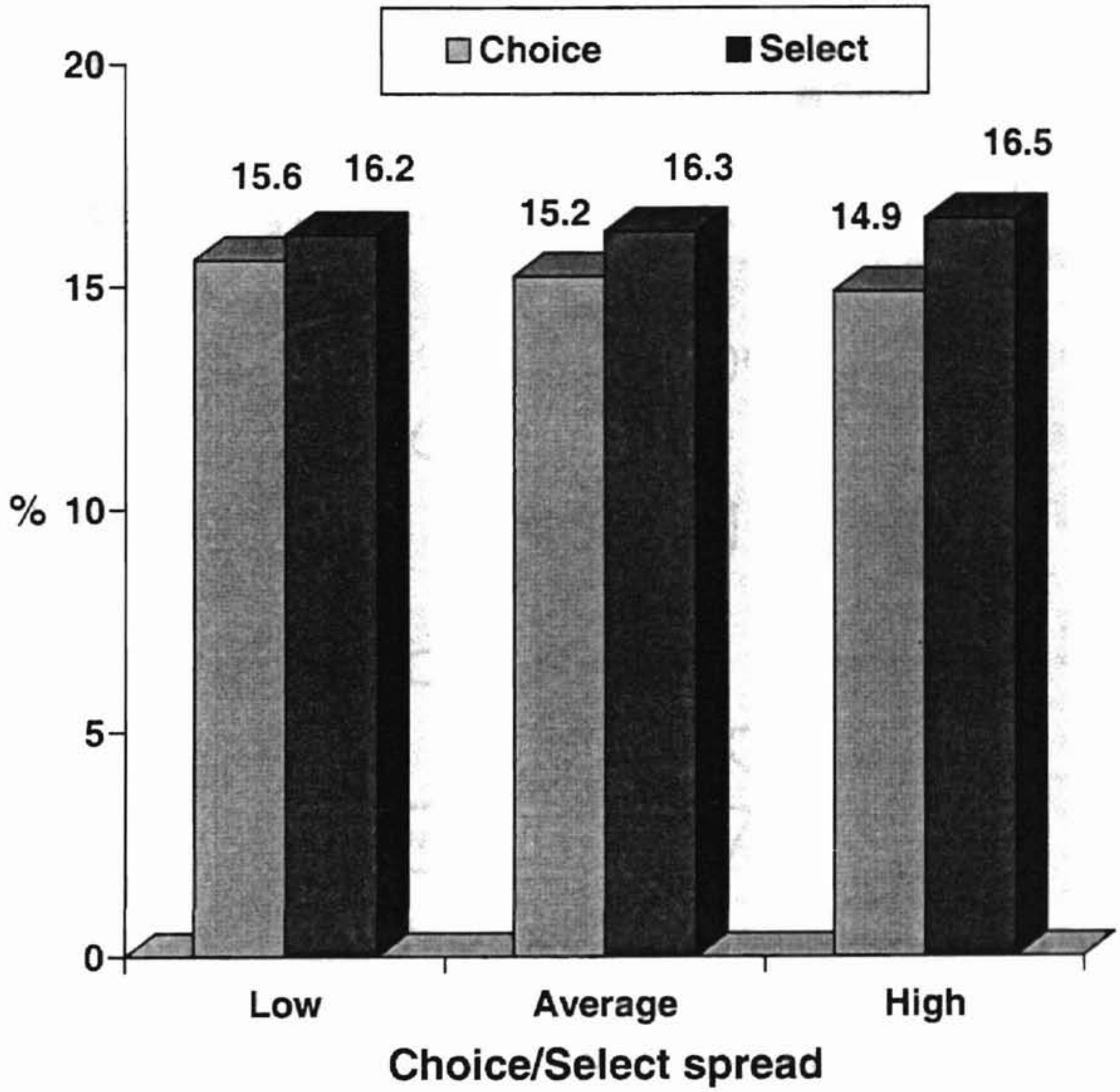


Figure 3. Percent contribution of thin meats ($/carcass) to carcass value for Choice and Select during the low, average, and high quality grade spreads.

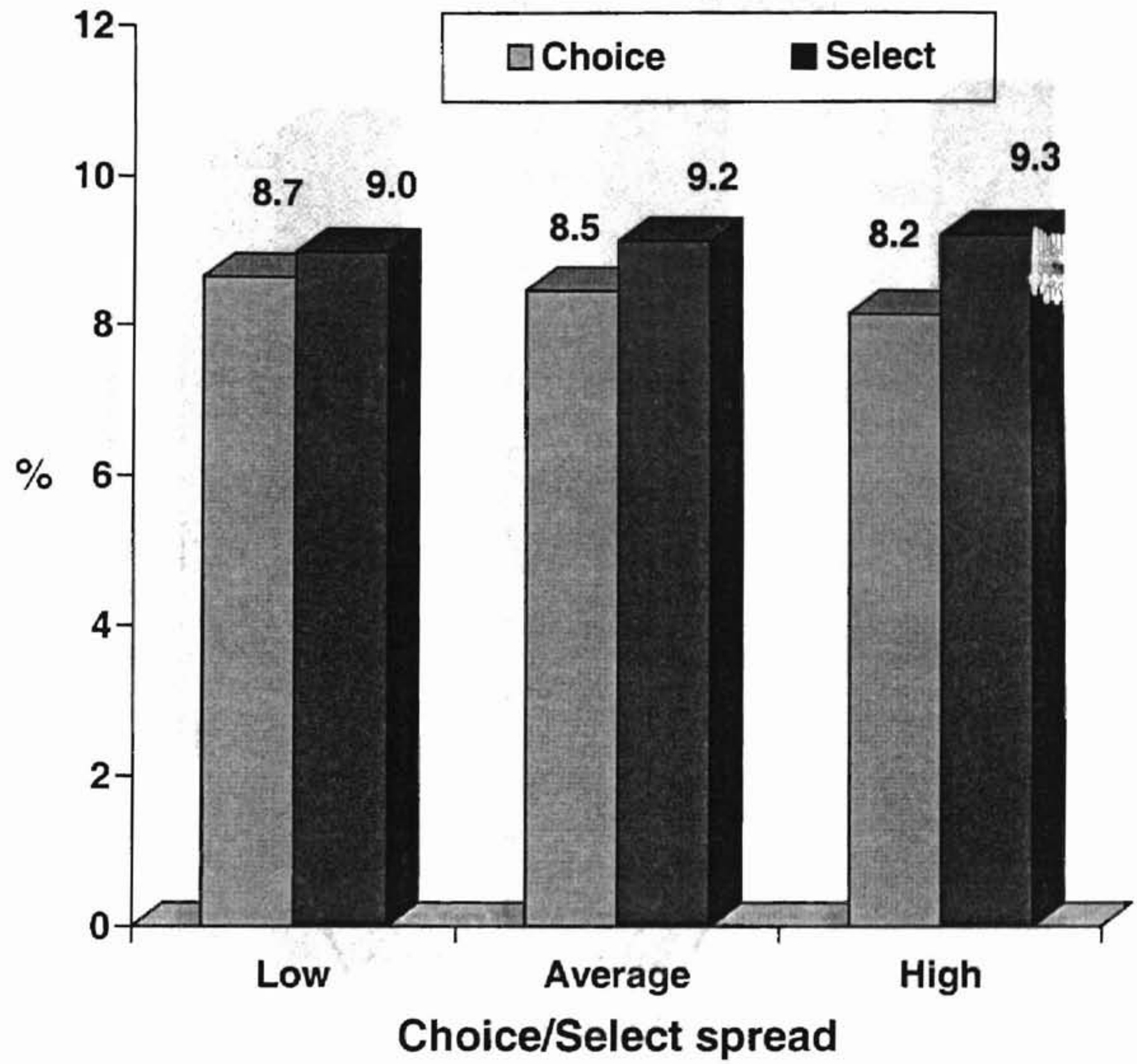


Figure 4. Percent contribution of lean trim ($/carcass) to carcass value for Choice and Select during the low, average, and high quality grade spreads.

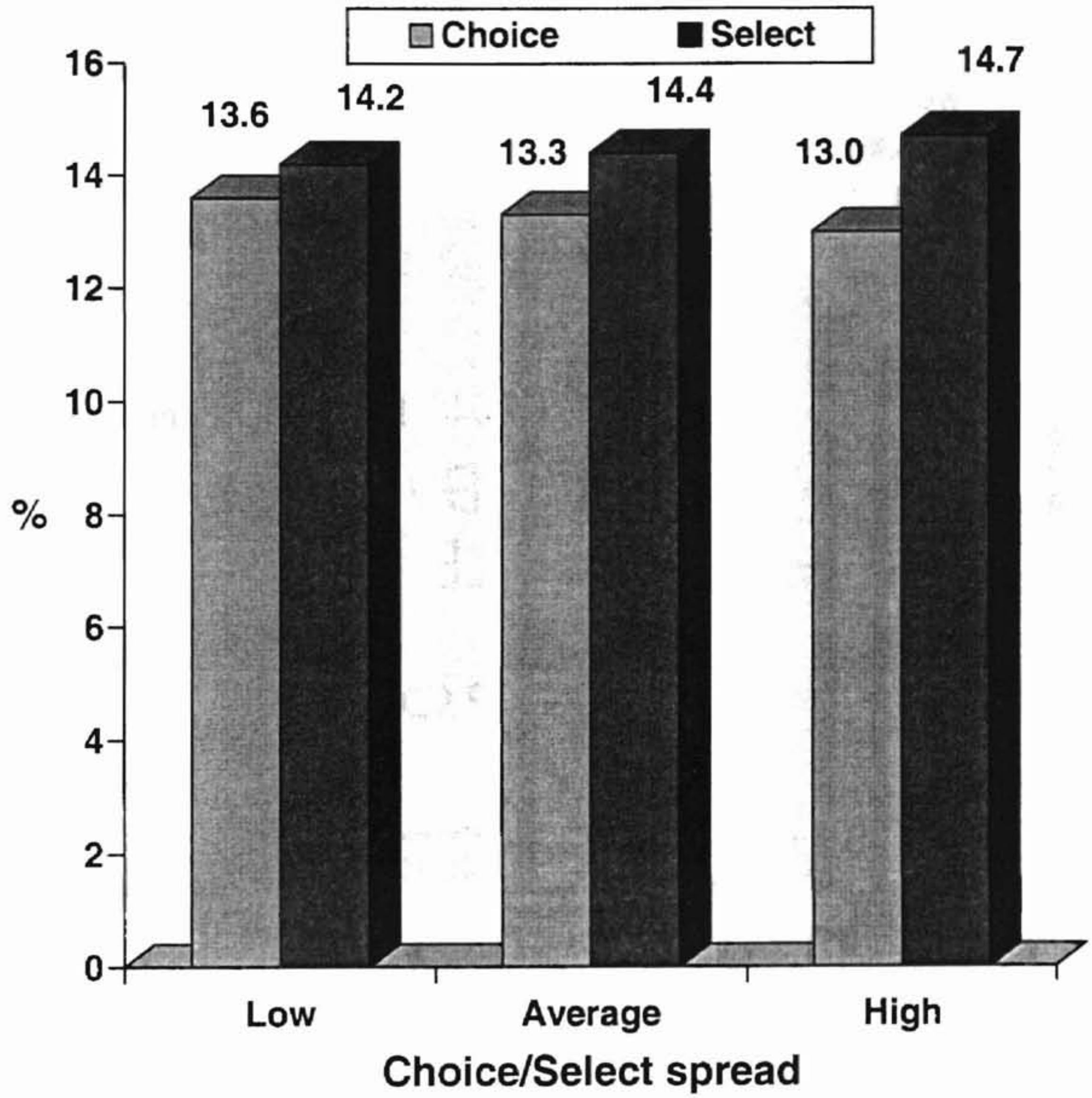


Figure 5. Percent contribution of drop credit ($/hd) to carcass value for Choice and Select during the low, average, and high quality grade spreads.

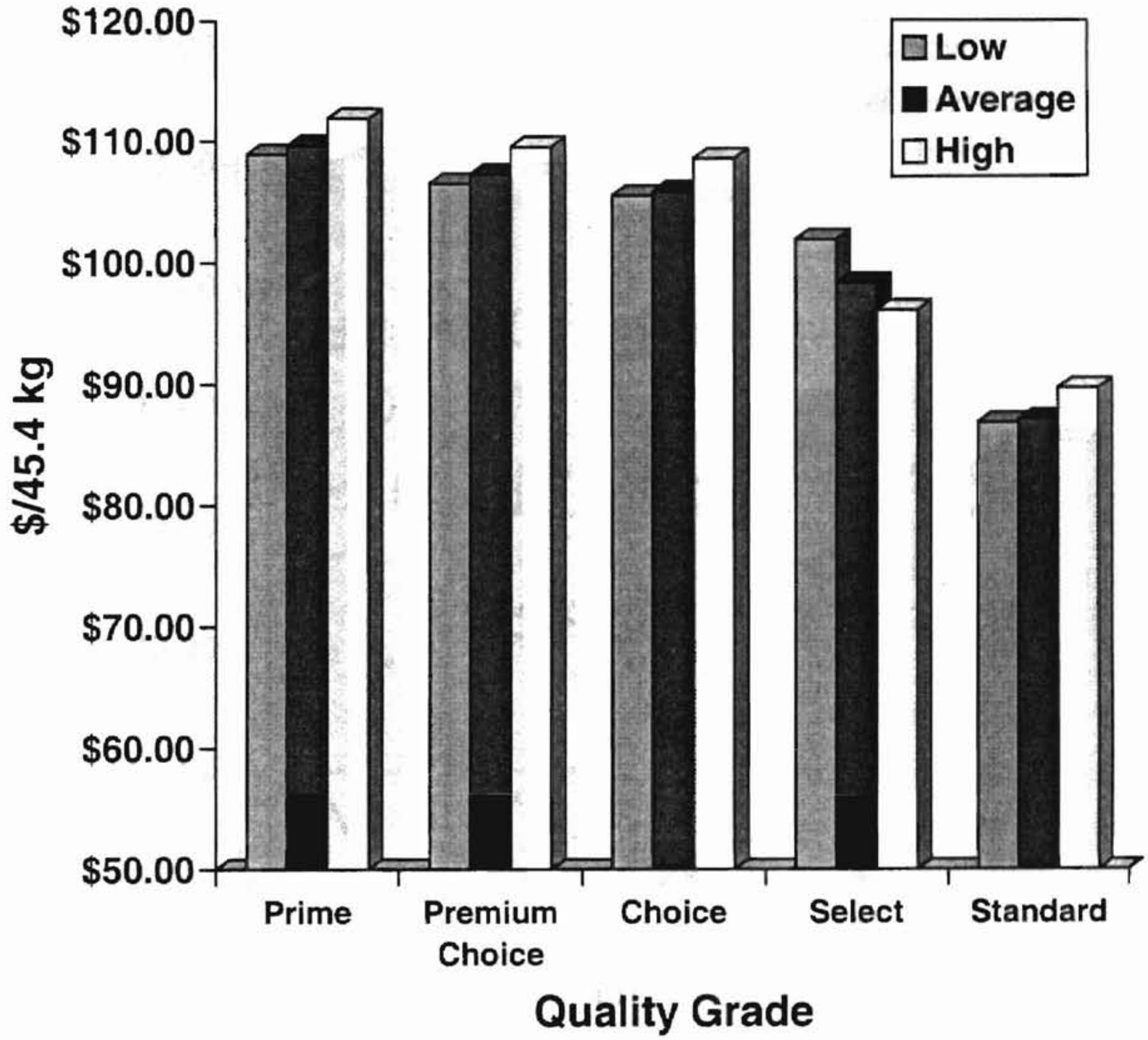


Figure 6. Boxed beef value ($/45.4 kg) means by quality grade for all progeny data (n=33,350) stratified by low, average, and high quality grade spreads.

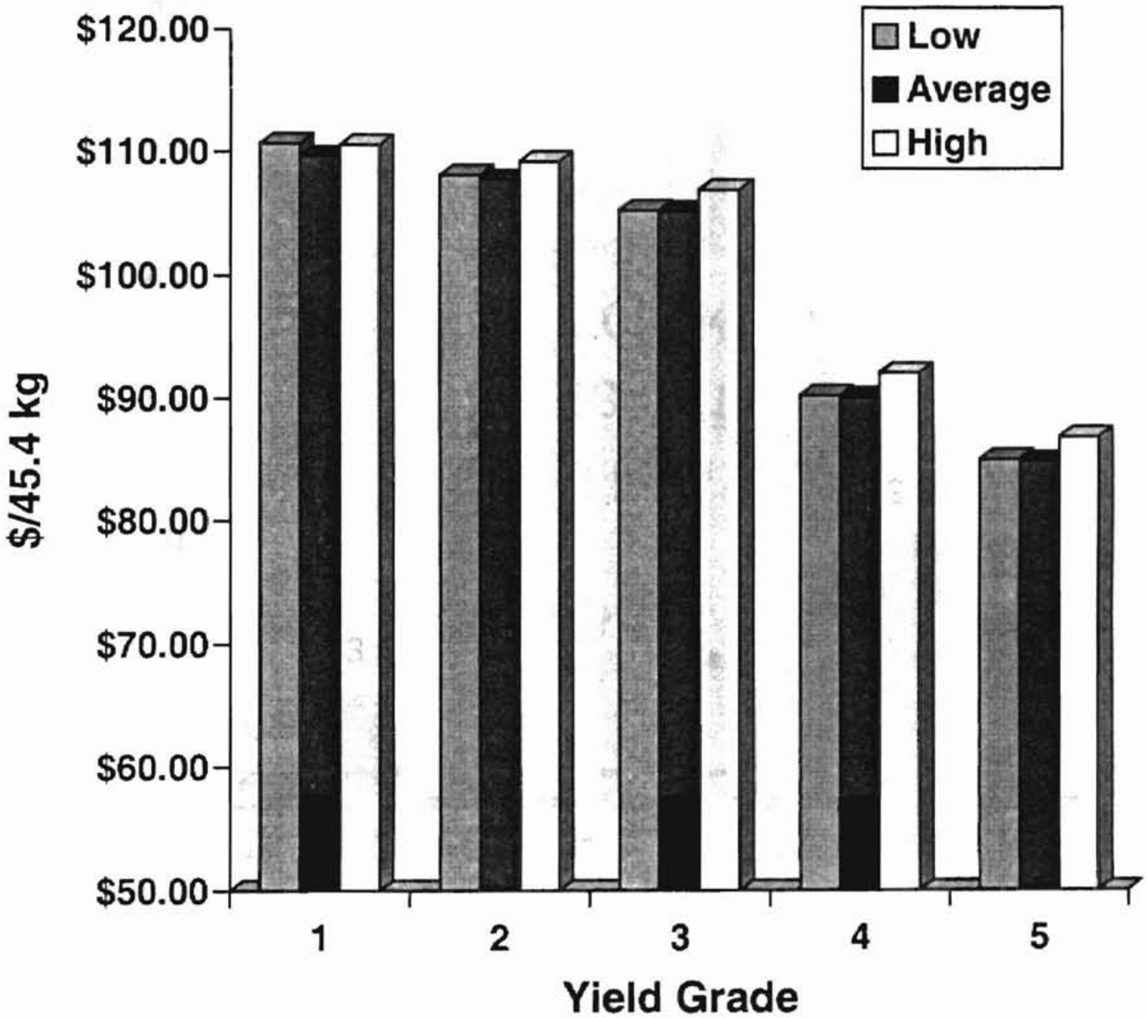


Figure 7. Boxed beef value ($/45.4 kg) means by yield grade for all progeny data (n=33,350) stratified by low, average, and high quality grade spread.

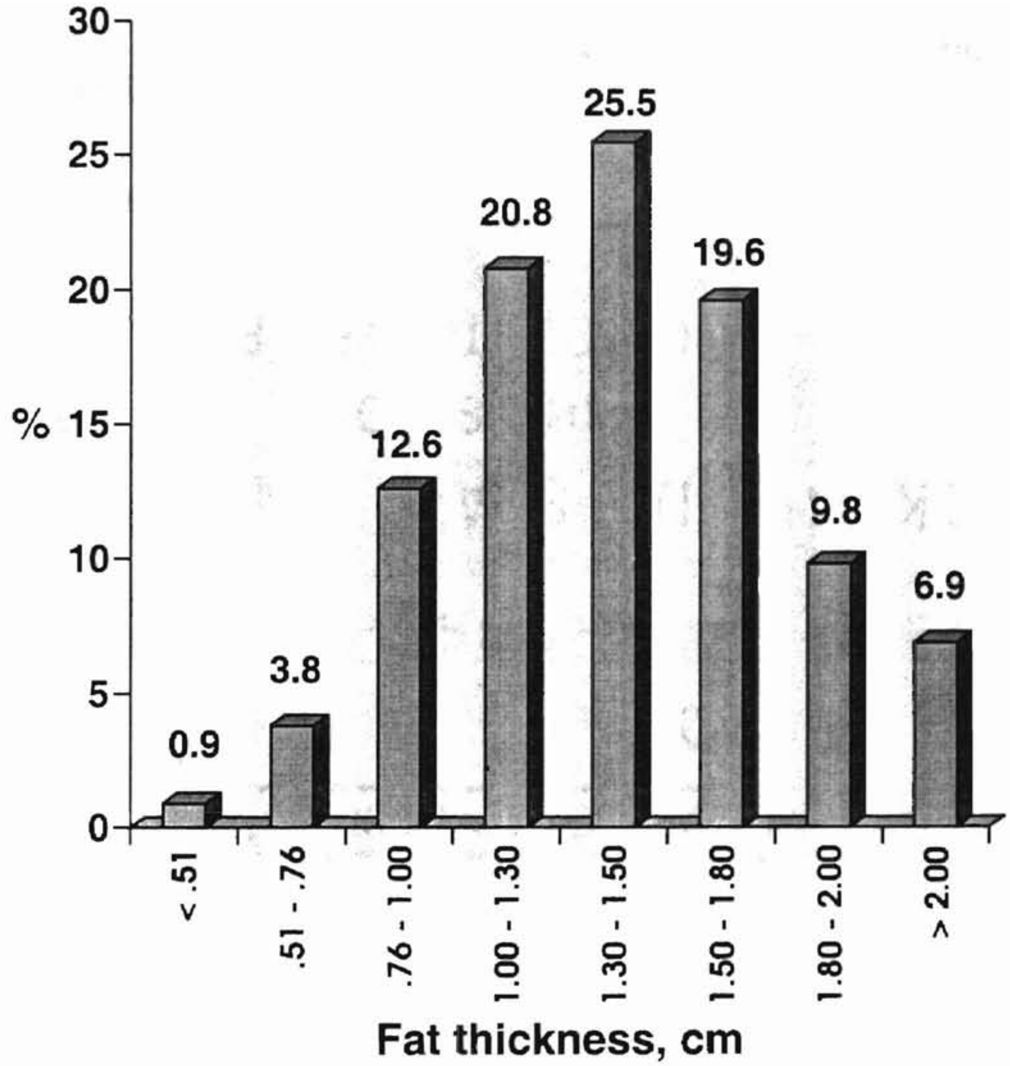


Figure 8. Distribution of fat thickness for all progeny (n=33,350).

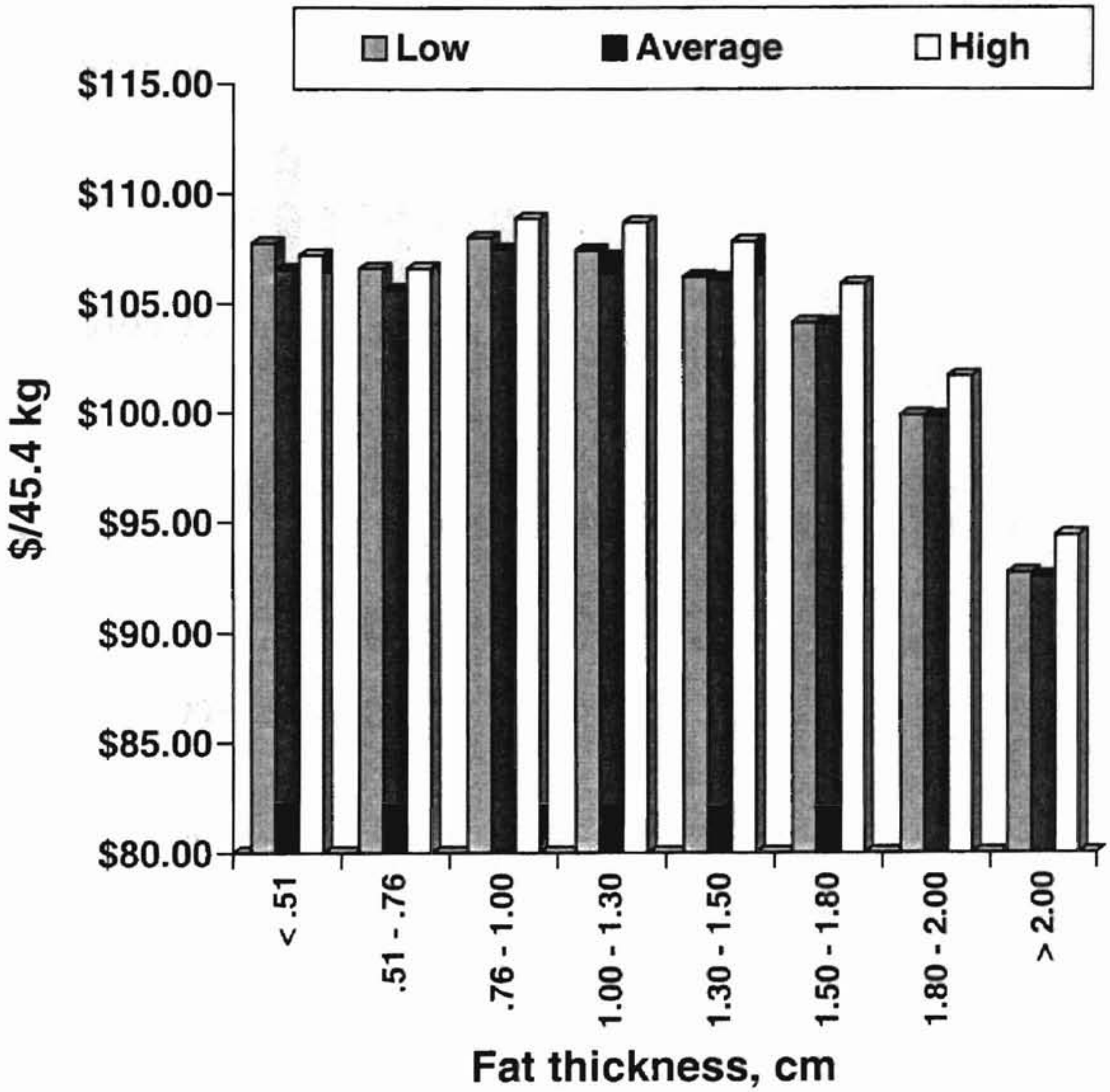


Figure 9. Boxed beef value ($/45.4 kg) by fat thickness for all progeny (n=33,350) stratified by low, average, and high quality grade spreads.

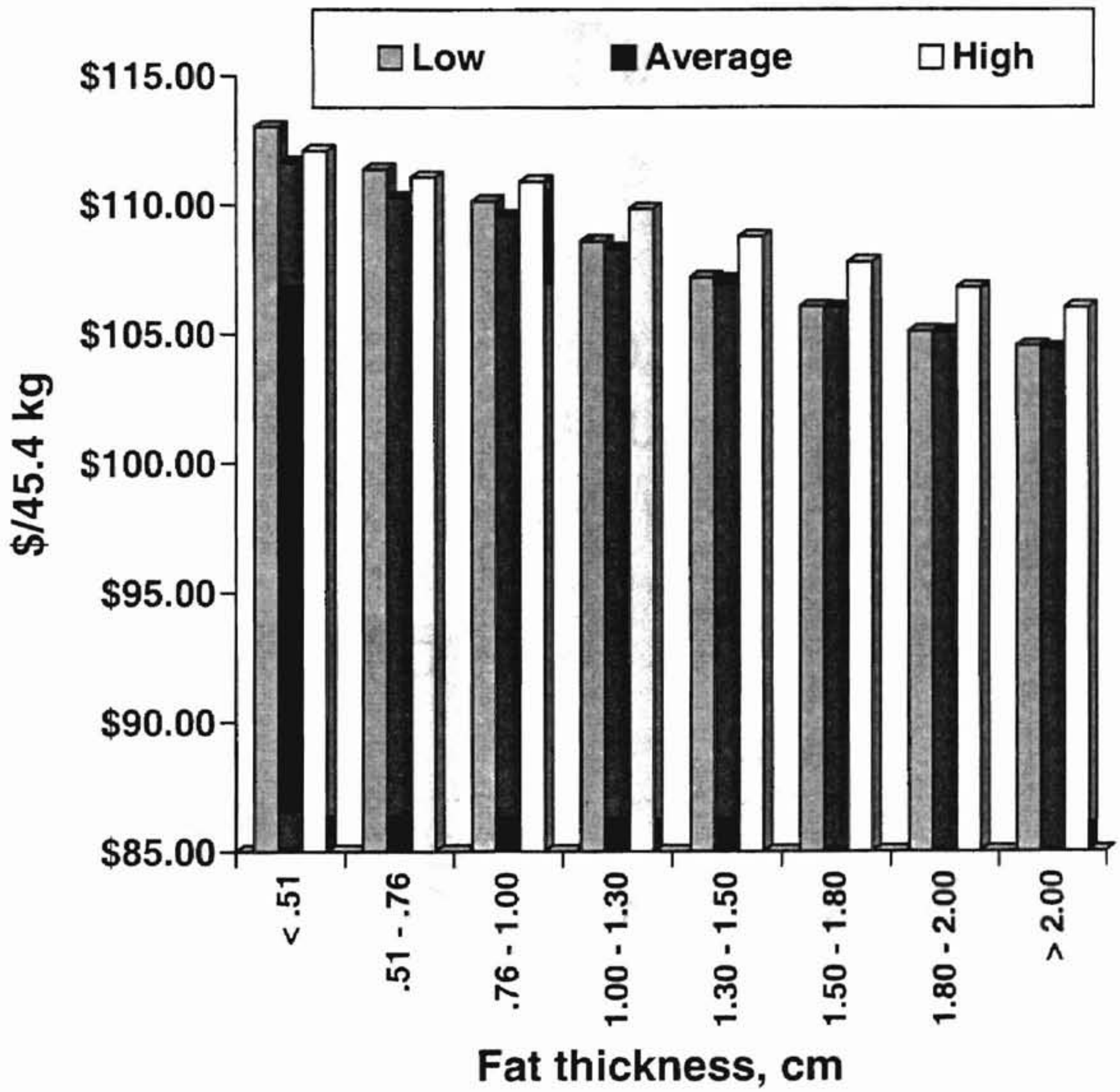
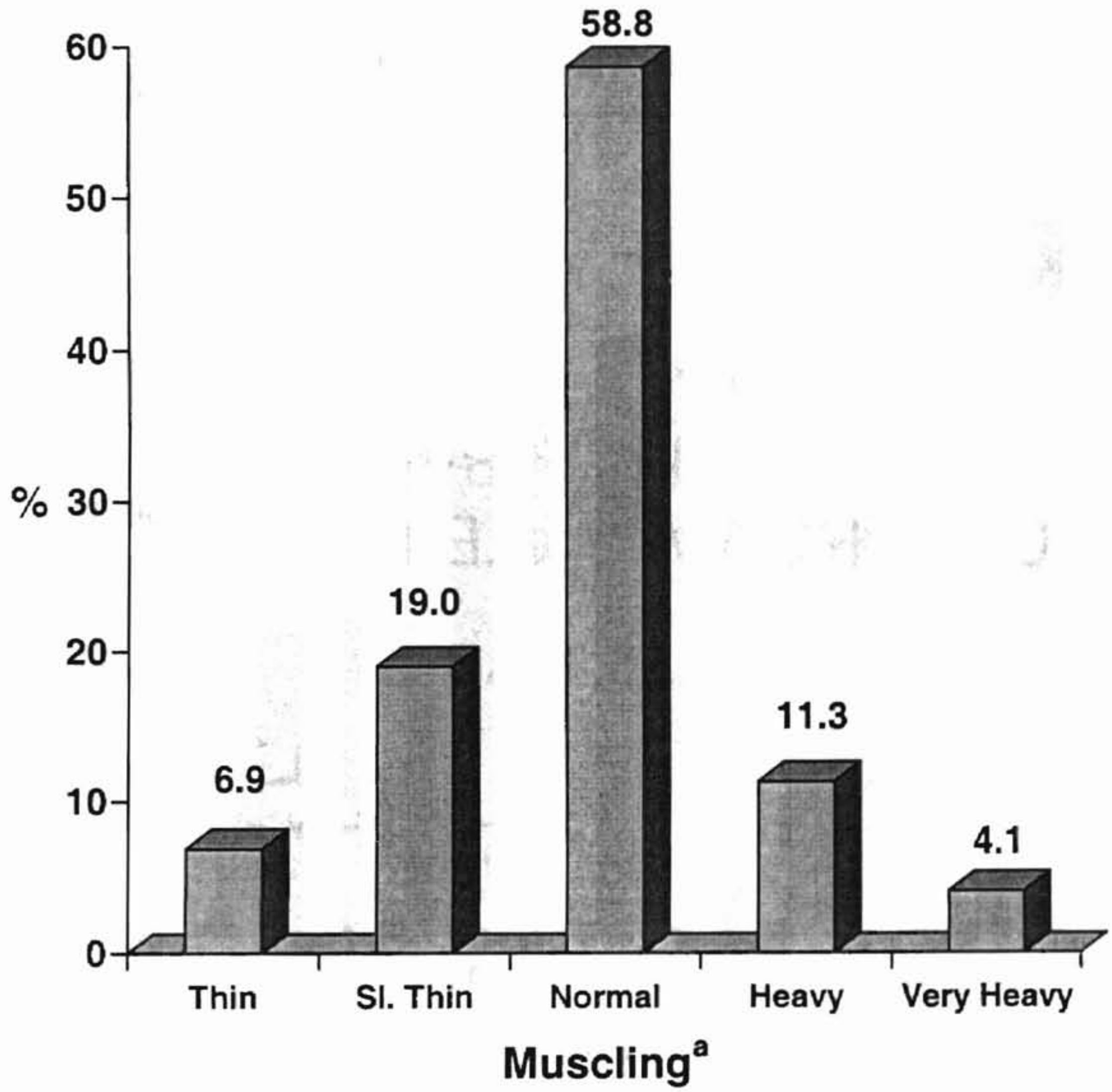
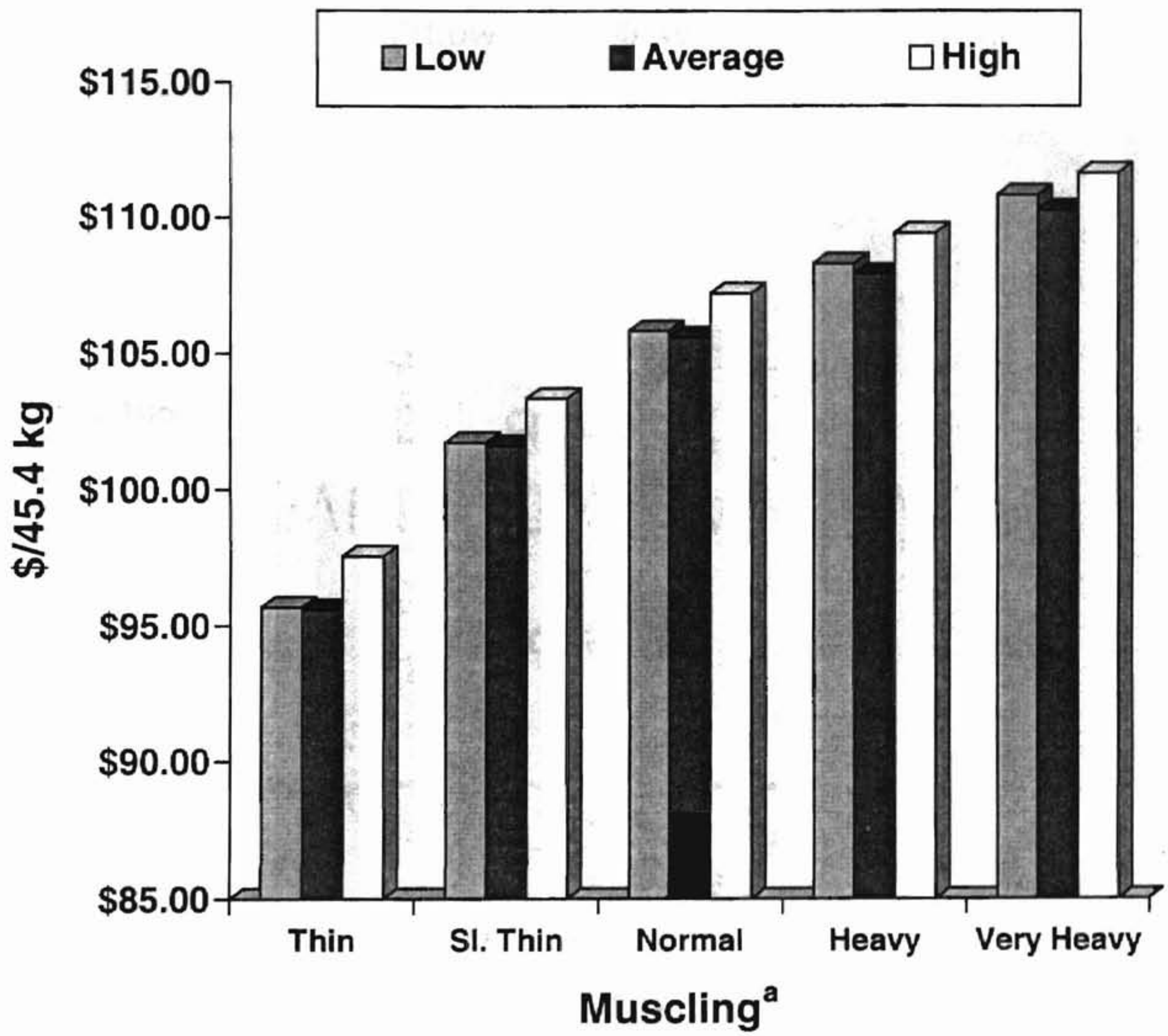


Figure 10. Boxed beef value ($/45.4 kg) by fat thickness for progeny (n=28,210) conforming to boxed beef fabrication specifications stratified by low, average, and high quality grade spreads.



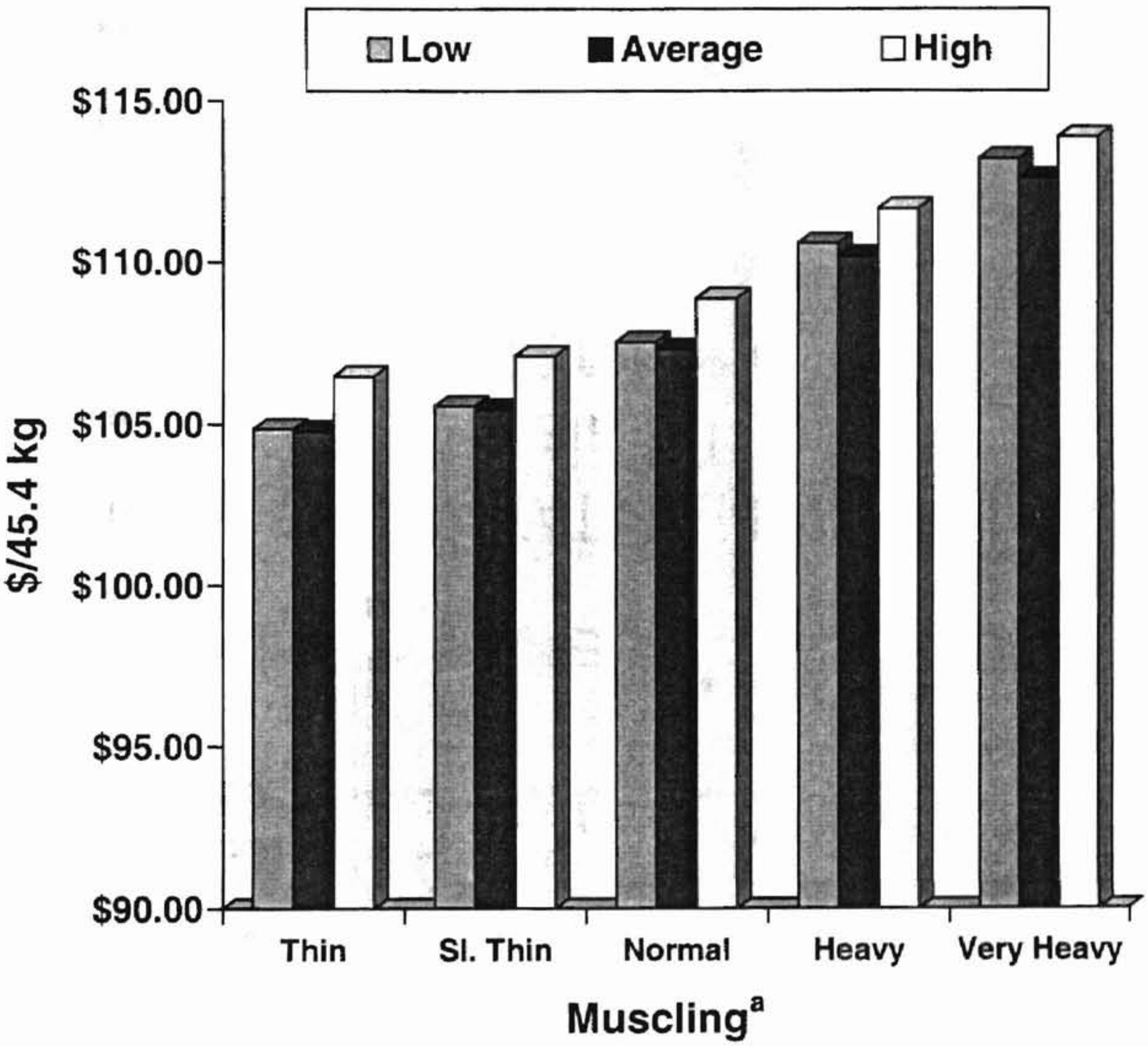
[a]Estimated by carcass weight to USDA ribeye schedule Thin= < (13.00) cm^2 ; Slightly Thin= (13.00) – (6.45) cm^2 ; Normal= (6.45) - 6.45 cm^2 ; Heavy= 6.45 – 13.00 cm^2 ; Very Heavy= > 13.00. cm^2

Figure 11. Distribution of muscling (ribeye area cm^2) for all progeny data (n=33,350).



[a]Estimated by carcass weight to USDA ribeye schedule Thin= < (13.00) cm^2 ; Slightly Thin= (13.00) – (6.45) cm^2 ; Normal= (6.45) - 6.45 cm^2 ; Heavy= 6.45 – 13.00 cm^2 ; Very Heavy= > 13.00. cm^2

Figure 12. Boxed beef value ($/45.4 kg) by muscling (ribeye area cm^2) for all progeny data (n=33,350) stratified by low, average, and high quality grade spreads.



[a]Estimated by carcass weight to USDA ribeye schedule Thin= < (13.00) cm^2 ; Slightly Thin= (13.00) – (6.45) cm^2 ; Normal= (6.45) - 6.45 cm^2 ; Heavy= 6.45 – 13.00 cm^2 ; Very Heavy= > 13.00. cm^2

Figure 13. Close trim boxed beef value ($/45.4 kg) by muscling (ribeye area cm^2) for progeny (n=28,210) conforming to boxed beef fabrication specifications stratified by the low, average, and high quality grade spreads.

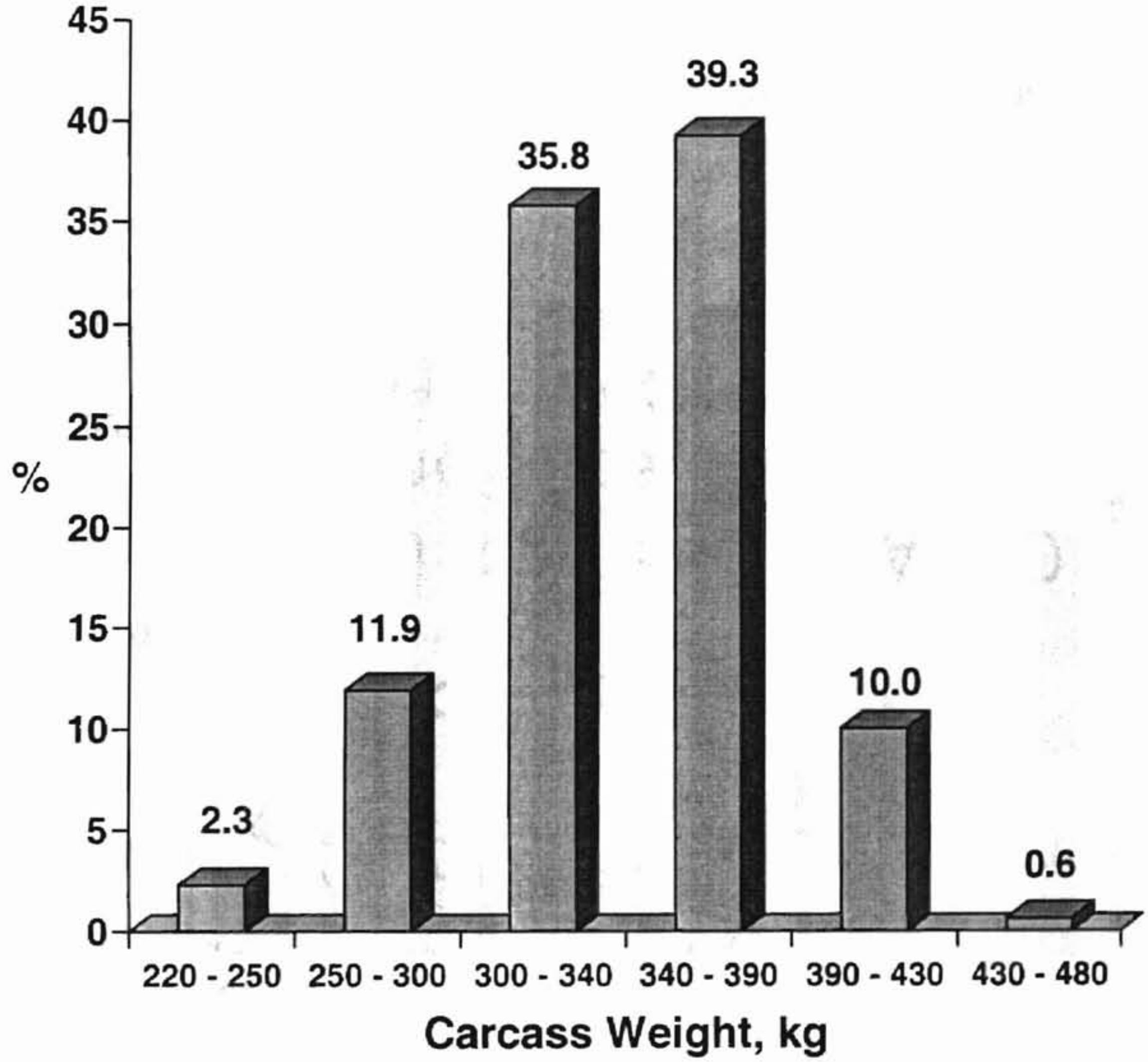


Figure 14. Distribution of carcass weight (kg) for all progeny data (n=33,350).

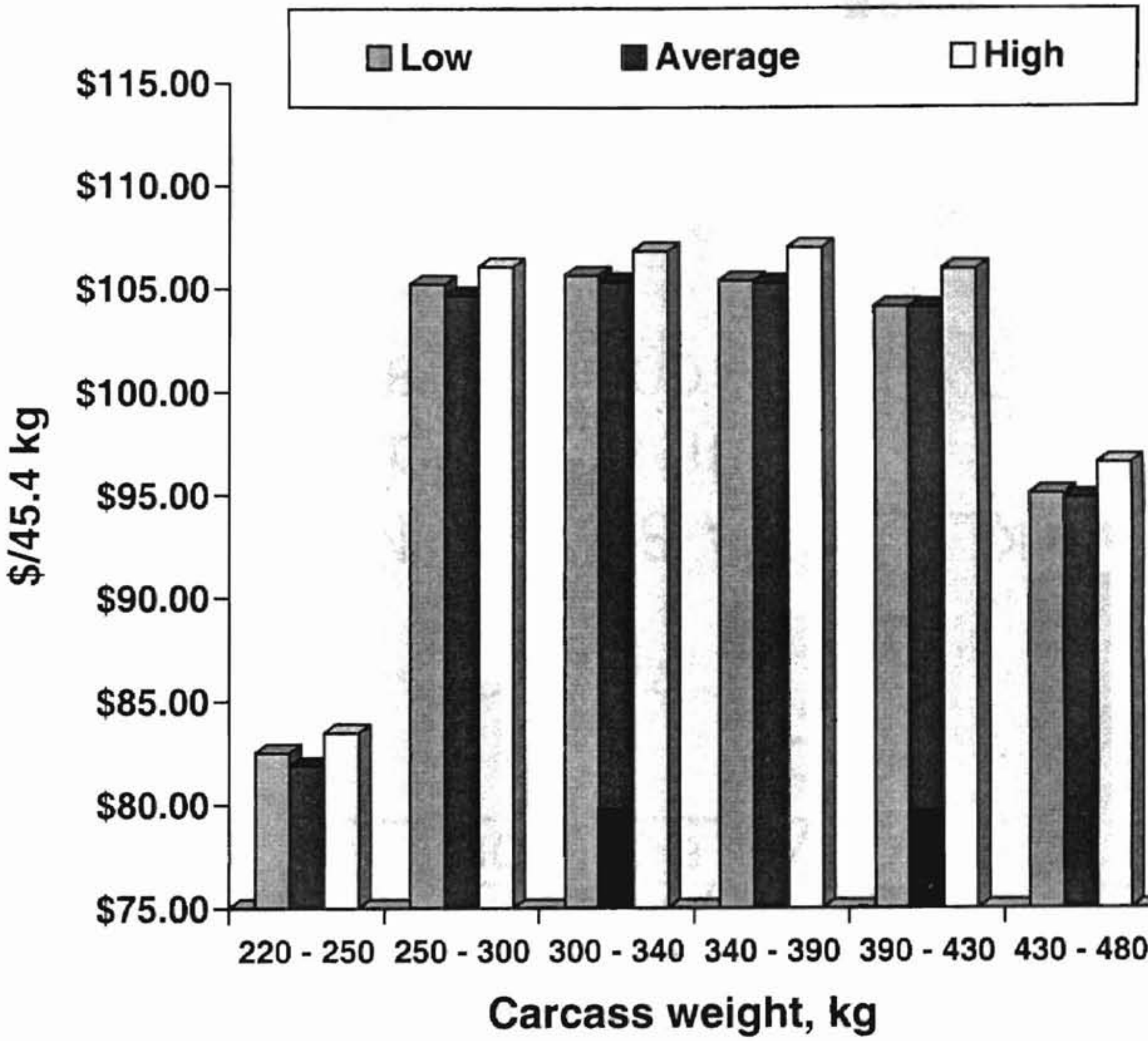
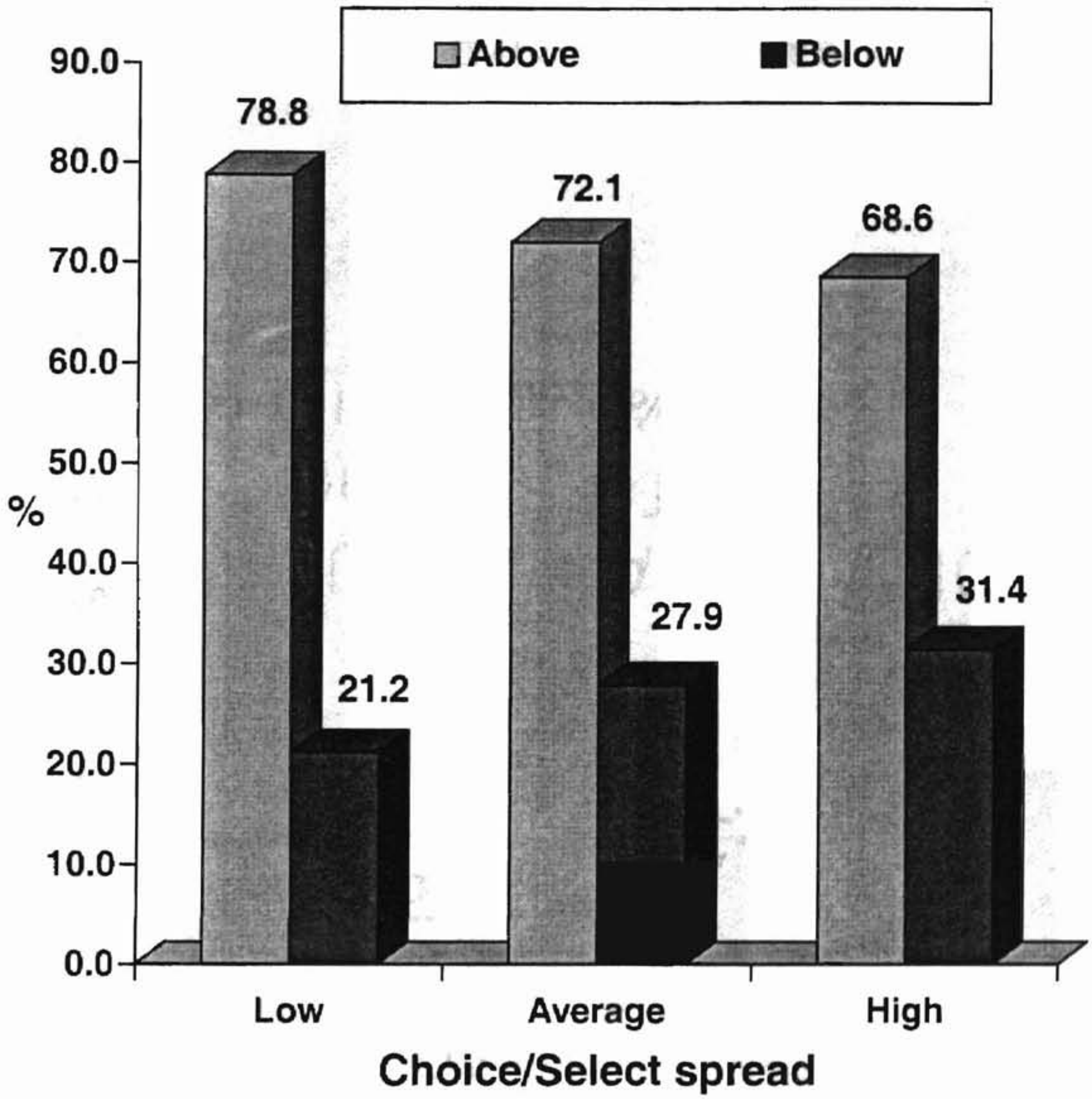
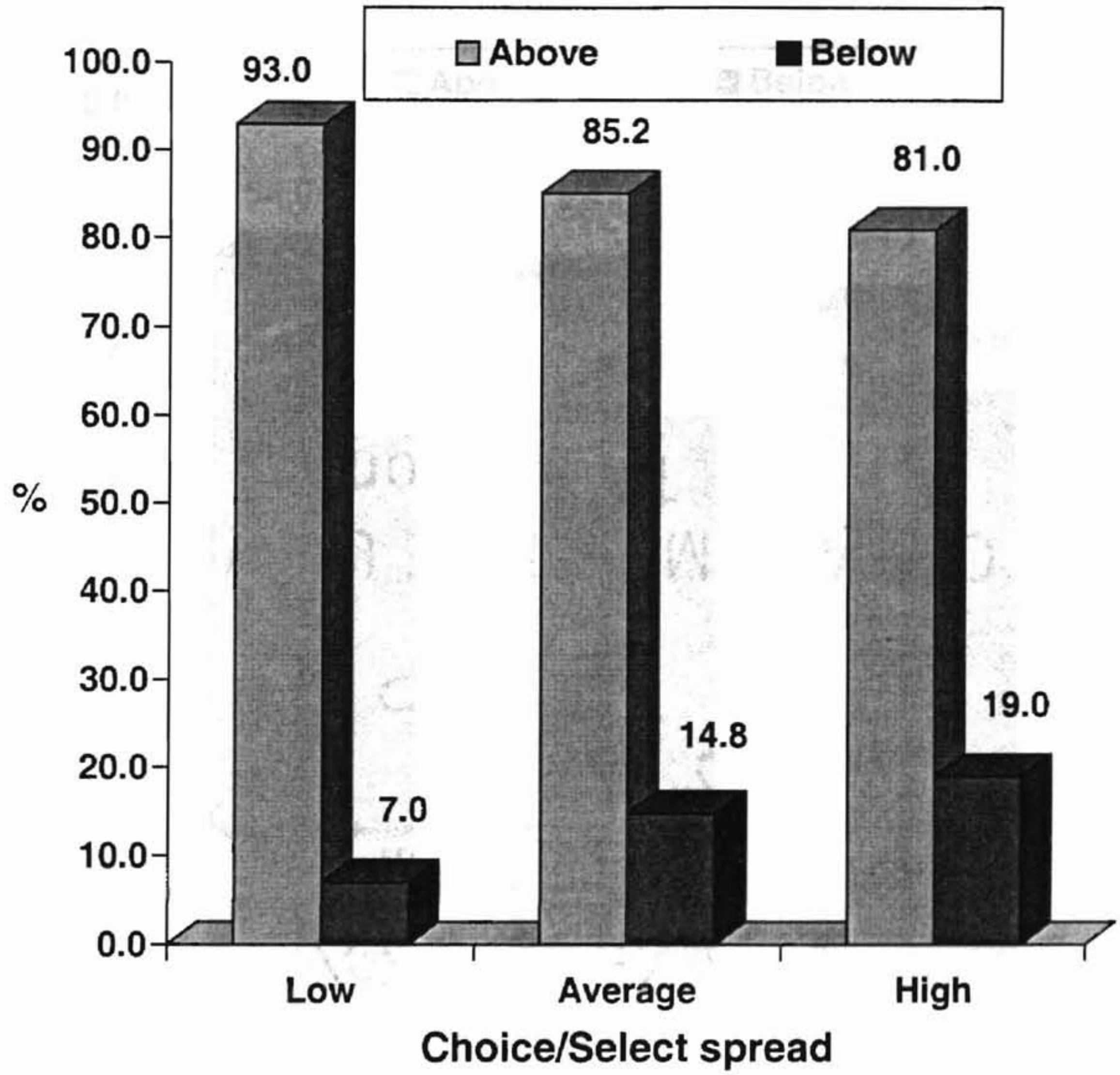


Figure 15. Boxed beef value ($/45.4 kg) by carcass weight (kg) for all progeny (n=33,350) stratified by low, average, and high quality grade spreads.



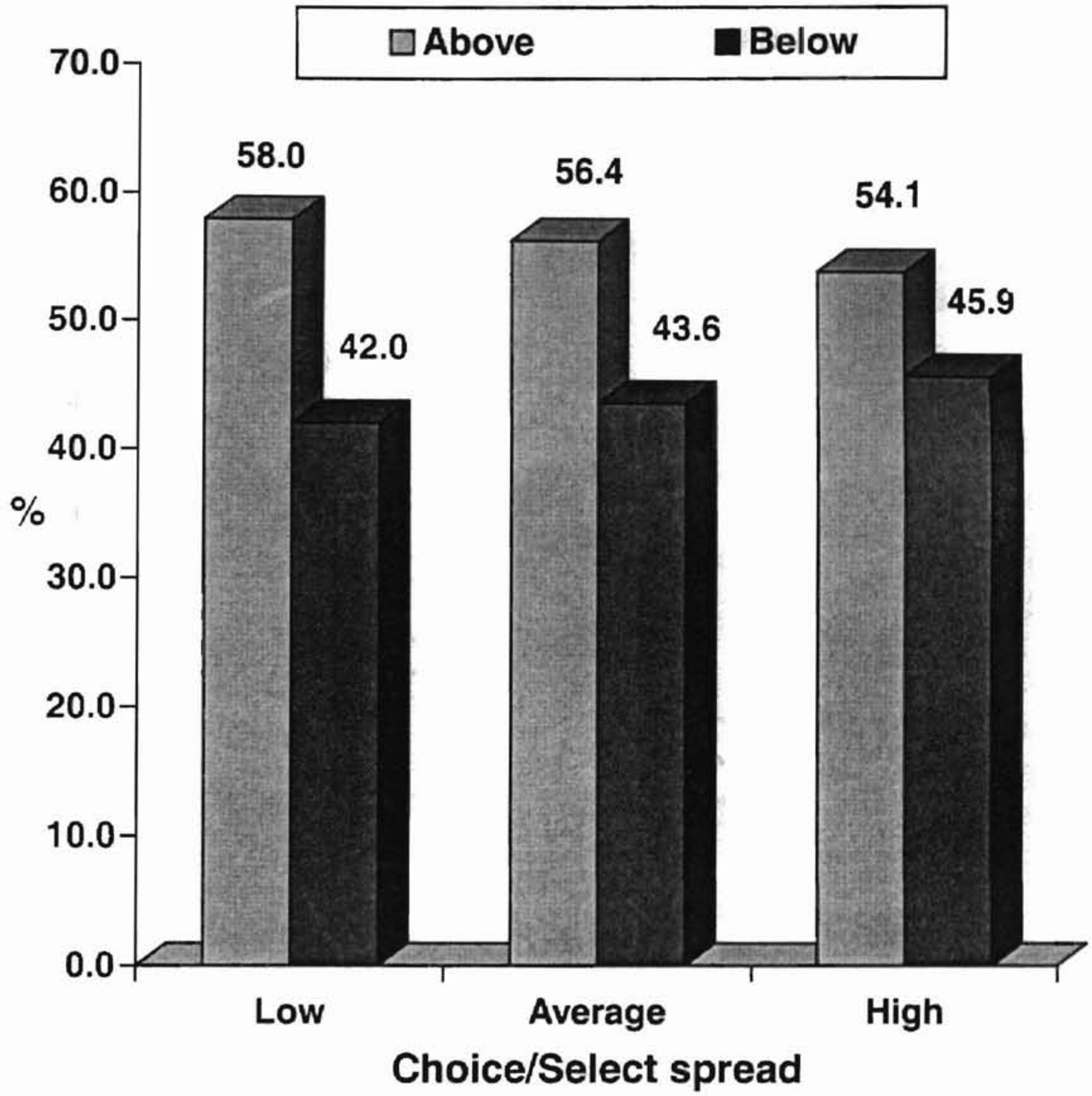
[a] Choice, yield grade 3.99, 340 kg carcass weight: Low spread=$102.39/45.4 kg; Average spread=$102.67/45.4 kg; High spread=$105.18/45.4 kg.

Figure 16. Percent of all progeny (n=33,350) above and below the average benchmark for the low, average, and high quality grade spreads[a].



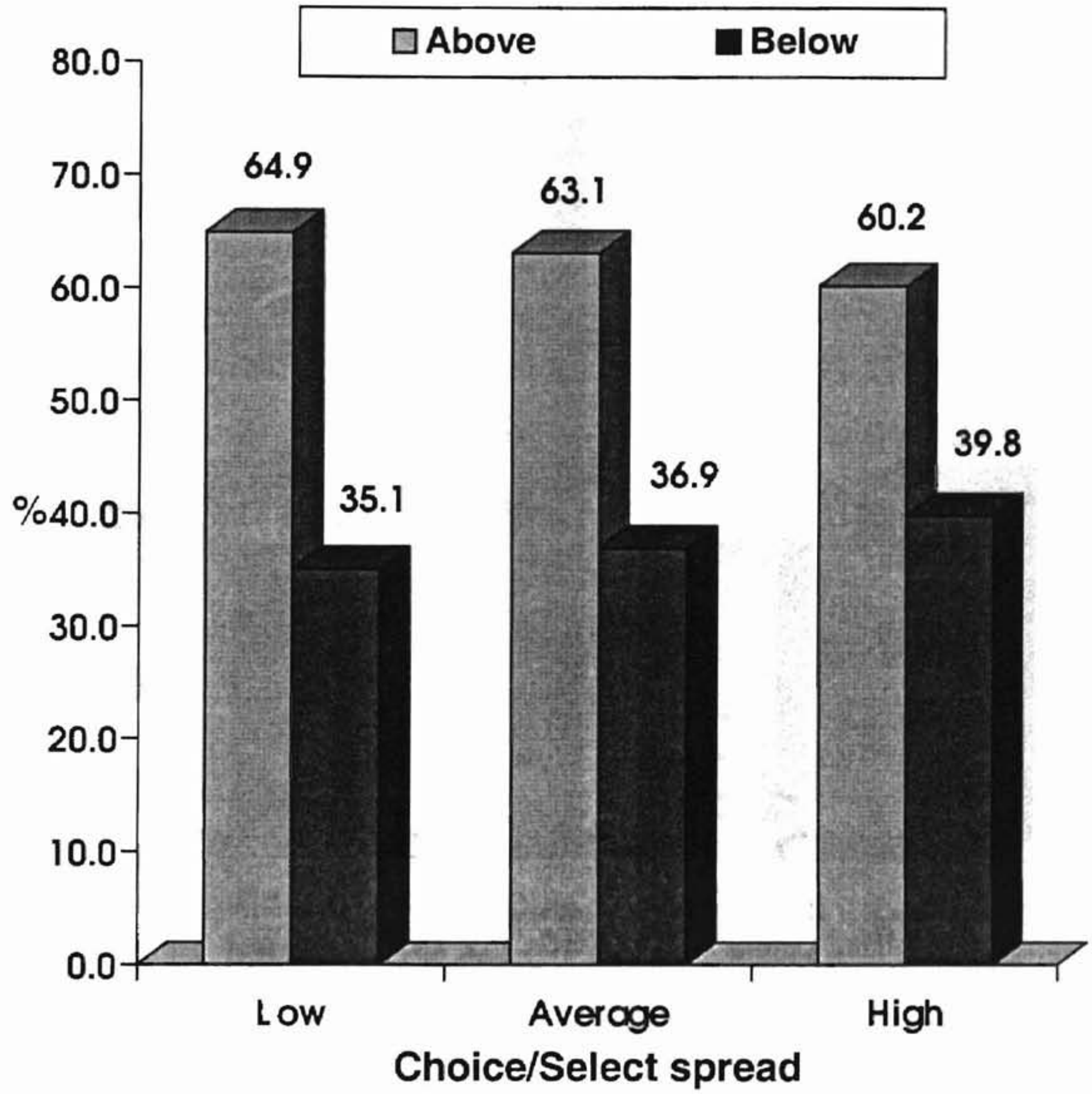
[a] Choice, yield grade 3.0, 340 kg carcass weight: Low spread=$102.39/45.4kg; Average spread=$102.67/45.4kg; High spread=$105.18/45.4kg.

Figure 17. Percent of progeny (n=28,210) conforming to boxed beef fabrication specifications above and below the average benchmark for low, average, and high quality grade spreads[a].



[a] Low, average and high quality grade spread benchmark prices X 340 kg carcass weight/45.4 kg: Low spread=$767.93/hd; Average spread =$770.03/hd; High spread=$788.85/hd.

Figure 18. Percent of all progeny (n=33,350) above and below the average carcass value benchmark for the low, average, and high quality grade spreads[a].



[a] Low, average and high quality grade spread benchmark prices X 340 kg carcass weight/45.4 kg: Low spread=$767.93/hd; Average spread=$770.03/hd; High spread=$788.85/hd.

Figure 19. Percent of progeny (n=28,210) conforming to boxed beef fabrication specifications above and below the average carcass value ($/hd) benchmark for the low, average, and high quality grade spreads[a].

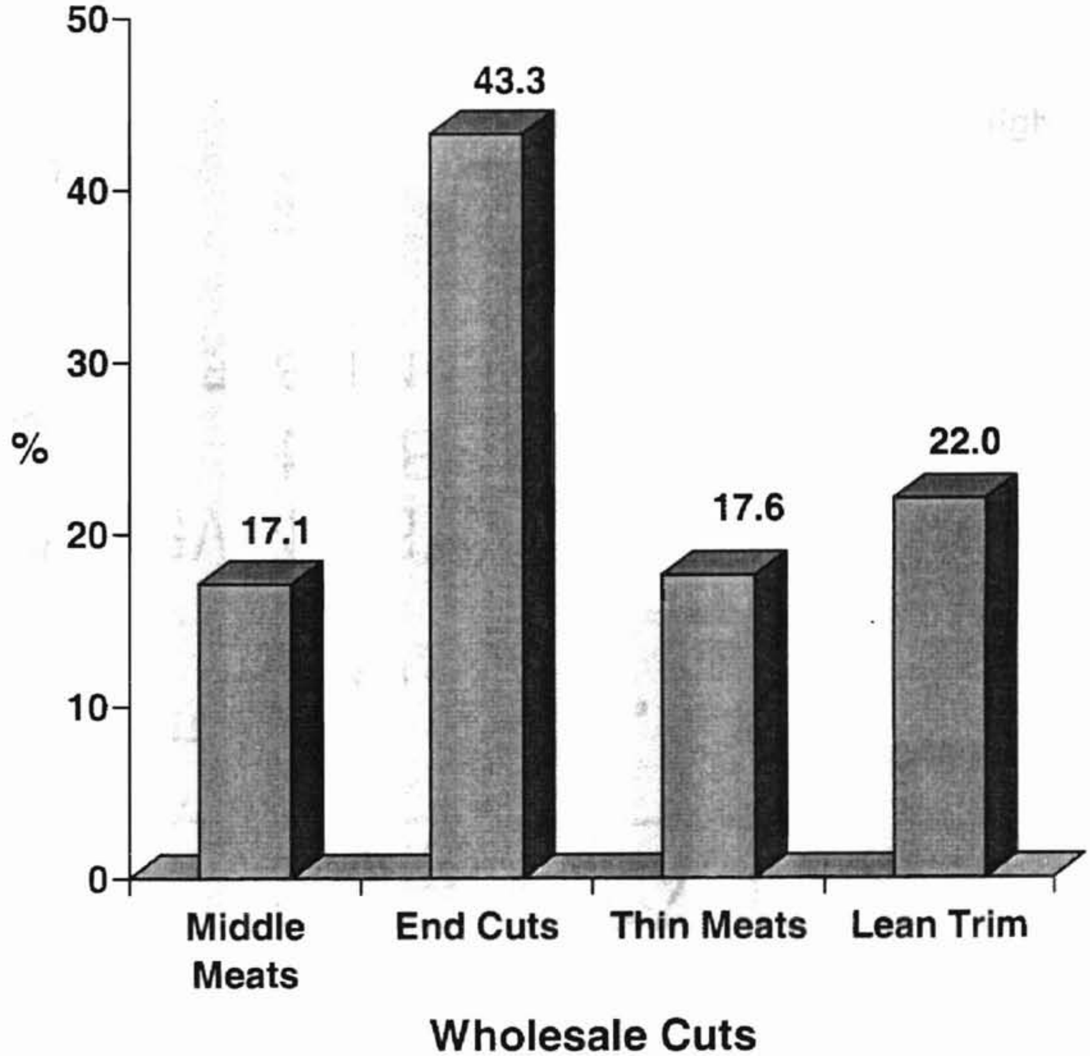


Figure 20. Percent contribution of wholesale cut weight to carcass weight for a YG 3.5 weighing 340 kg.

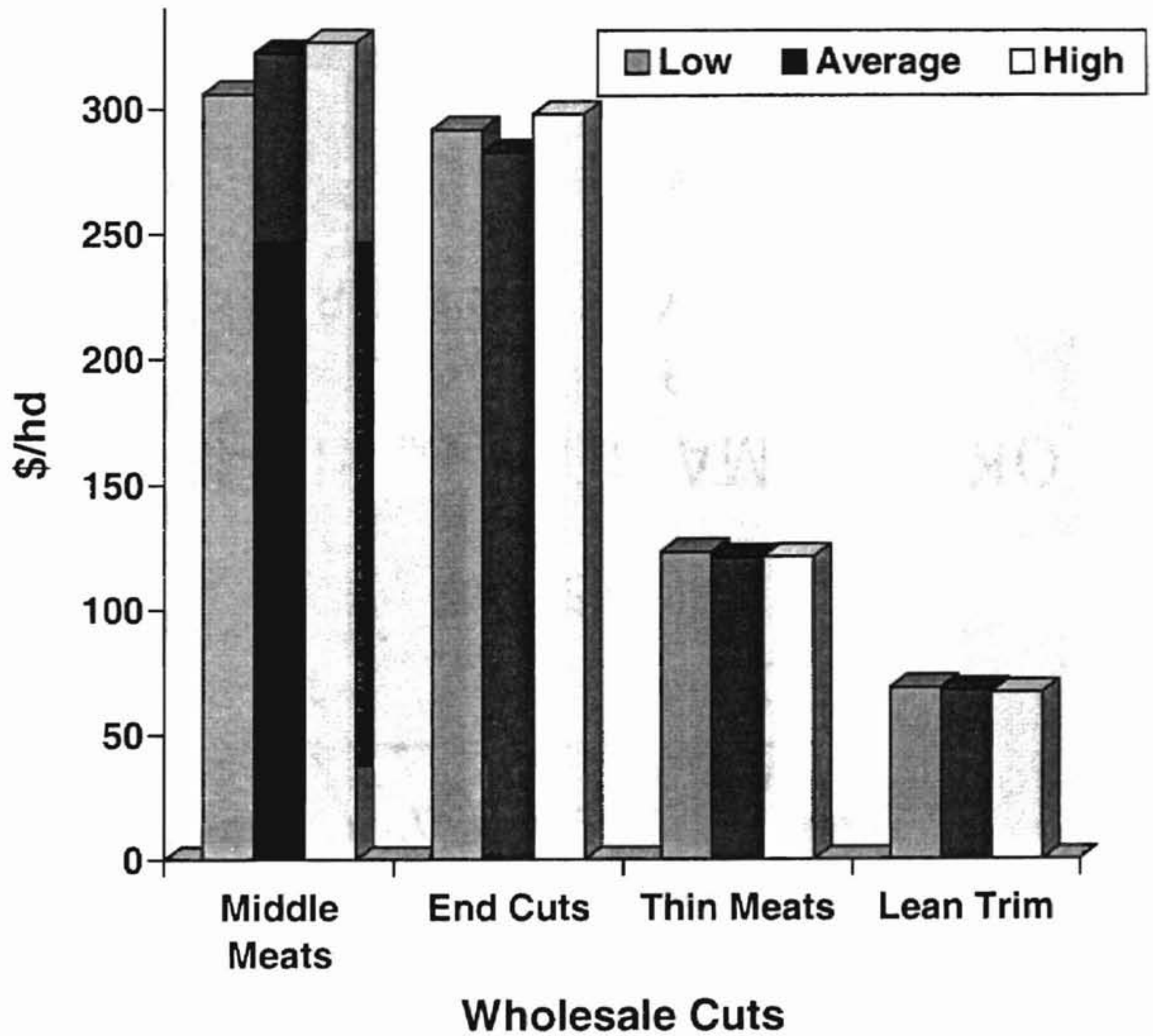
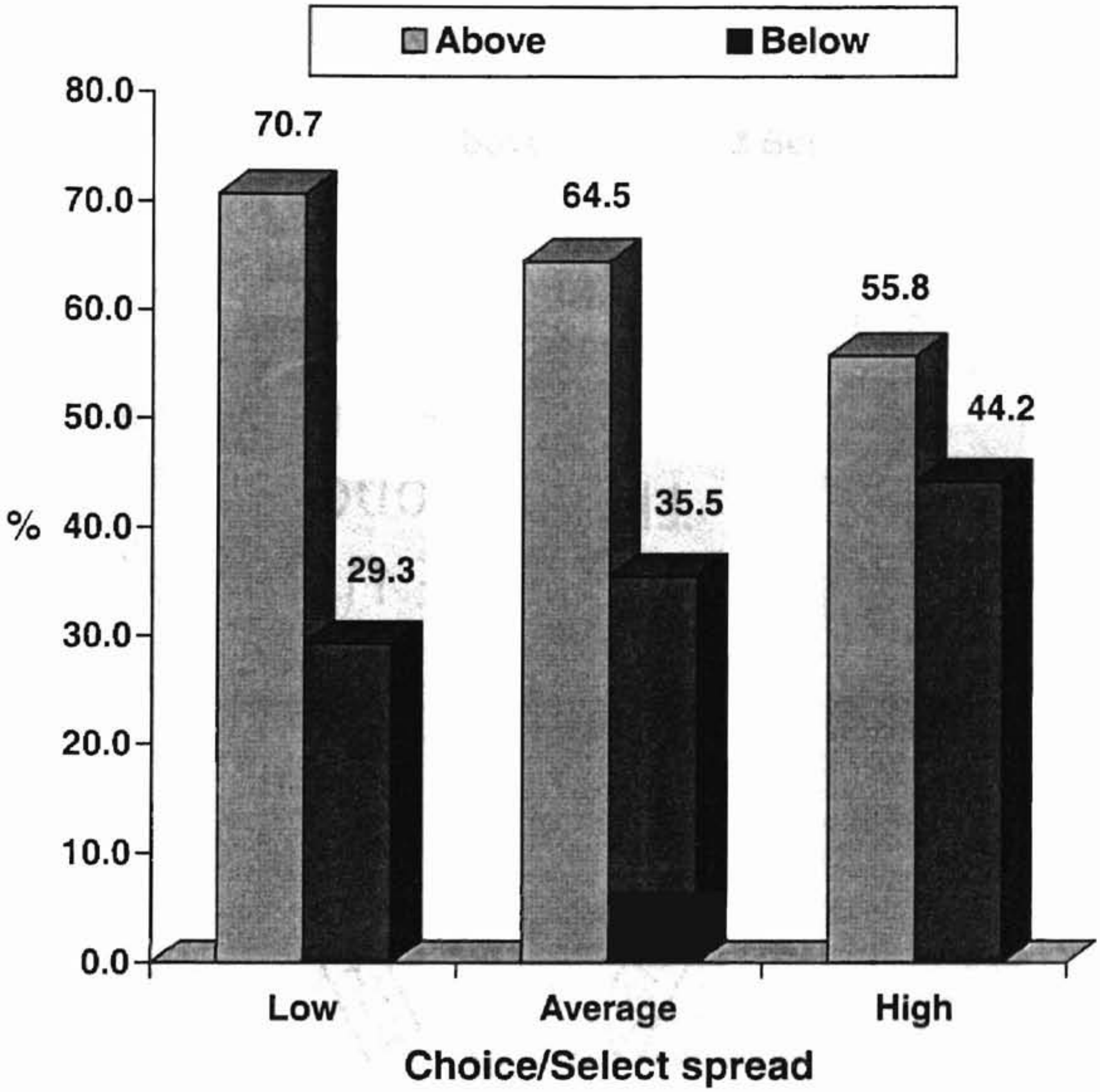
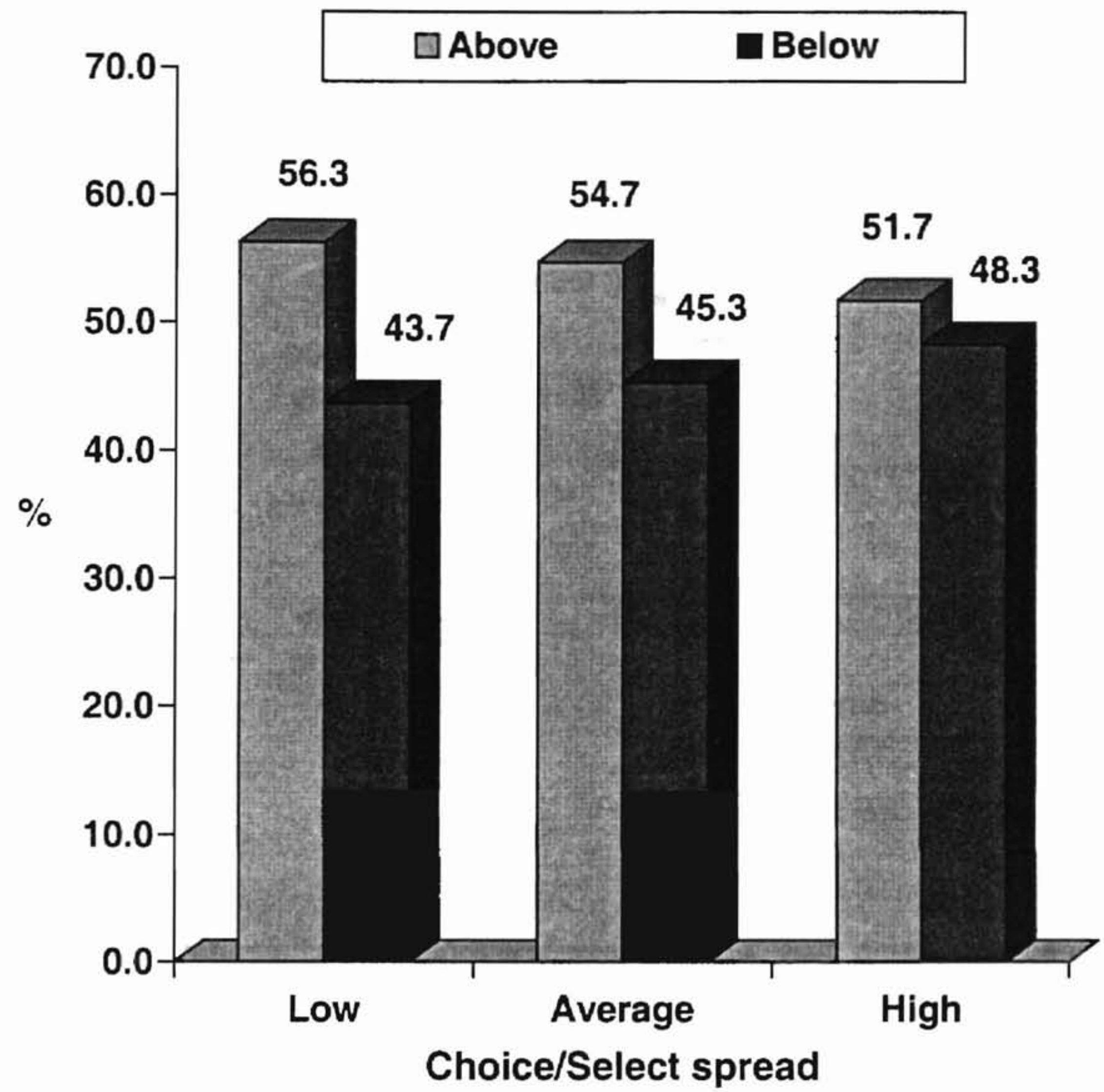


Figure 21. Wholesale cut contribution to boxed beef price for the low, average, and high pricing periods within Choice.



[a] Choice, yield grade 3.0, 340 kg carcass weight: Low spread=$102.39/45.4kg; Average spread=$102.67/45.4kg; High spread=$105.18/45.4kg.

Figure 22. Percent sire progeny means above and below the average benchmark for the low, average, and high quality grade spreads[a].



[a] Low, average and high quality grade spread benchmark prices X 340 kg carcass weight/45.4 kg: Low spread=$767.93/hd; Average spread=$770.03/hd; High spread=$788.85/hd.

Figure 23. Percent of sire progeny means (n=1,087) above and below the average carcass value ($/hd) benchmark for the low, average, and high quality grade spreads[a].

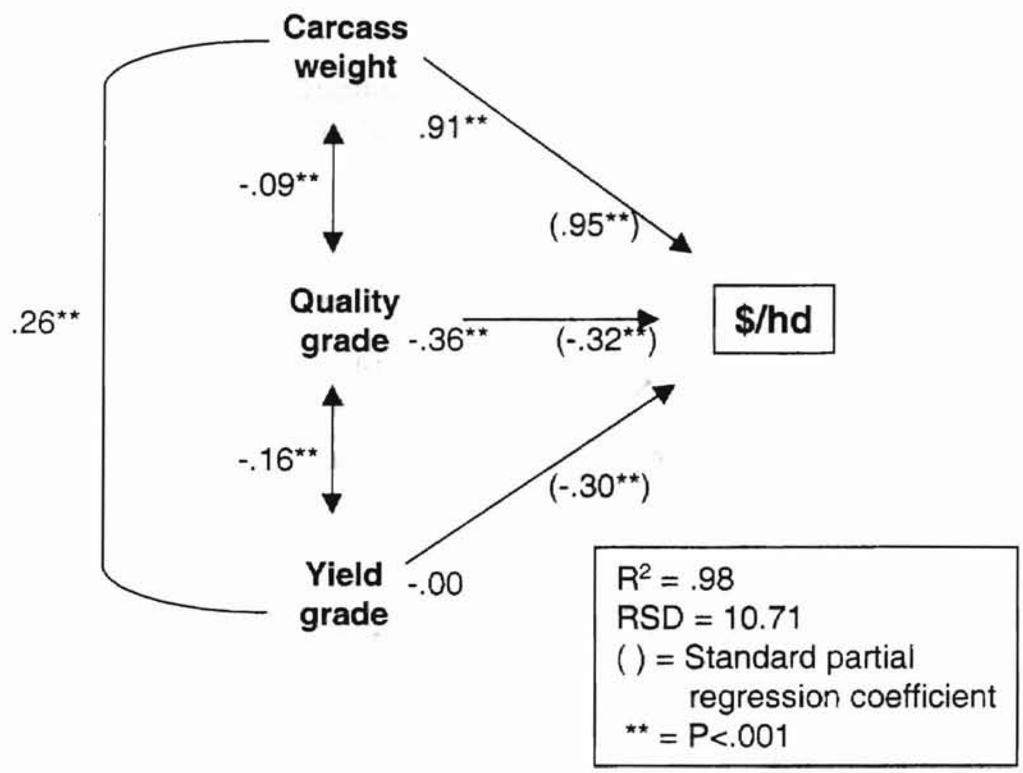


Figure 24. Path coefficient diagram of quality grade, yield grade, and carcass weight for carcass value ($/hd) during the average quality grade spread.

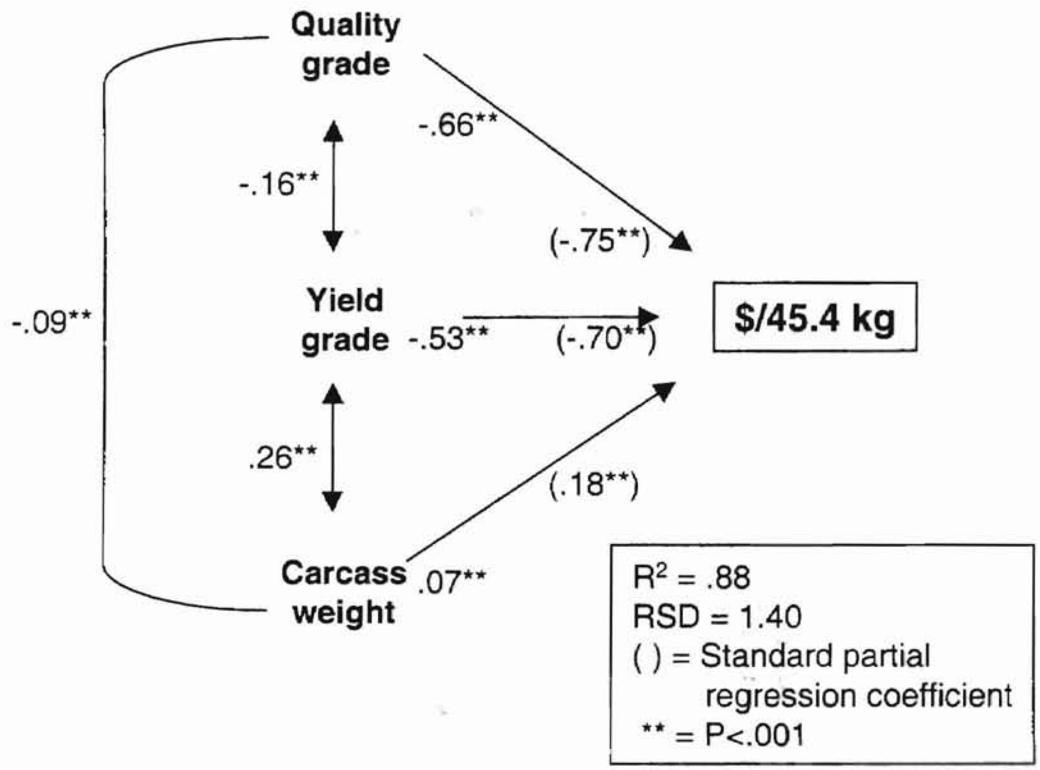


Figure 25. Path coefficient diagram of quality grade, yield grade, and carcass weight for carcass price ($/45.4 kg) during the average quality grade spread.

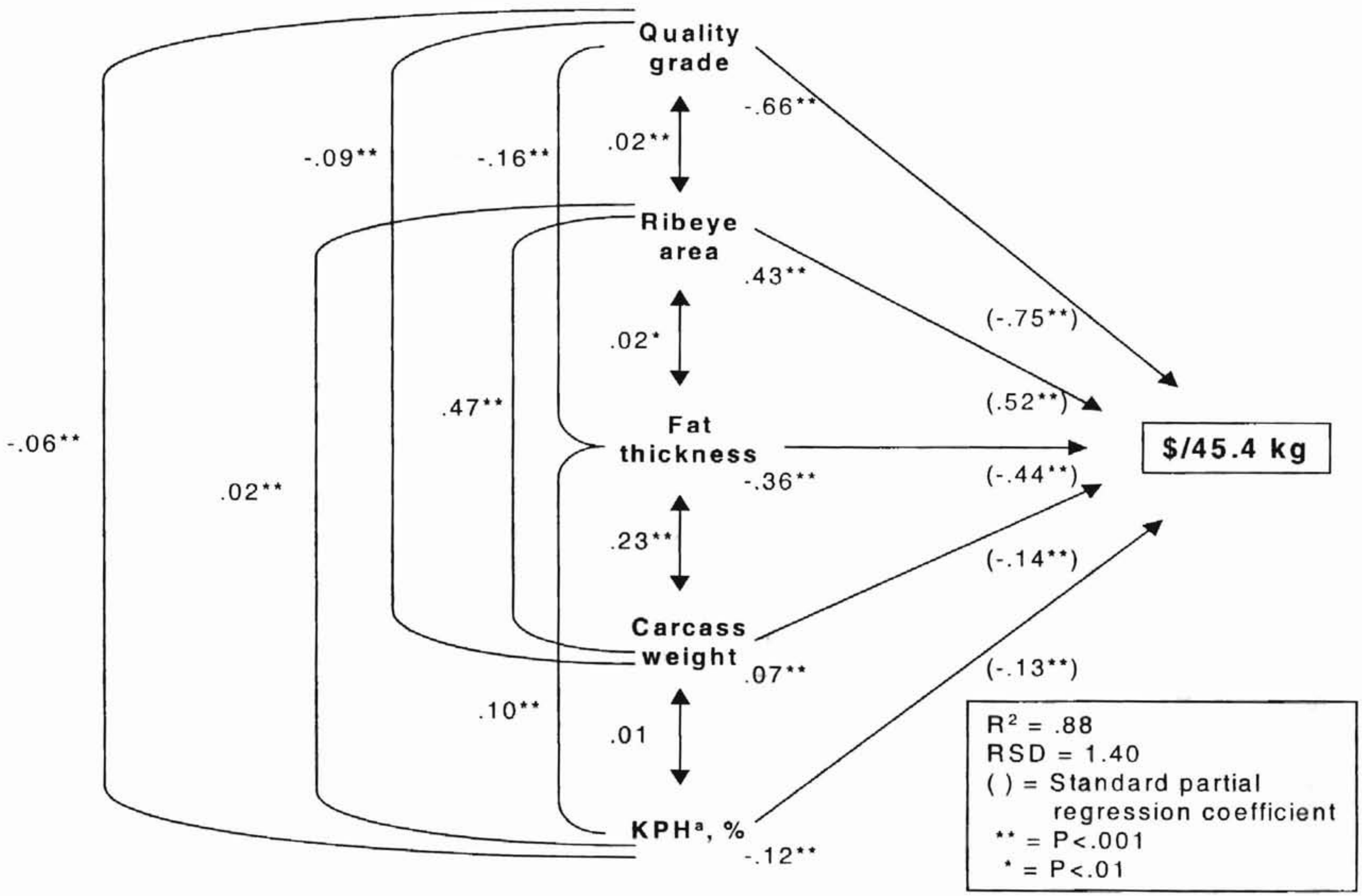


Figure 26. Path coefficient diagram of quality grade, ribeye area, fat thickness, carcass weight, and percentage kidney, pelvic, and heart fat for carcass price ($/45.4 kg) during the average quality grade spread.

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APPENDIX A

BOXED BEEF CALCULATOR HARVEST COST WORKSHEET

OKLAHOMA STATE UNIVERSITY BOXED BEEF YIELD VALUE CALCULATOR 1998

These data updated on 11/2/1998

	INPUTS	**TRIM LEVEL**	**COMMOD.**	**0.25 INCH**
CARCASS WEIGHT LBS	**756**	**CALC ULATED LIVE WT**	**1200**	**1200**
QUALITY GRADE (1-5)	**3**	**GROSS CARC VALUE**	**$857.92**	**$805.99**
YIELD GRADE (1.0 TO 4.9)	**3.29**	**EST DROP CREDIT**	**$106.57**	**$106.57**
DROP CREDIT $ / CWT	**$8.88**	**GROSS LIVE VALUE**	**$964.49**	**$912.55**
ESTIMATED DRESS %	**63.00**	**NET CARCASS $/CWT**	**$116.15**	**$108.90**
KILL-FAB COST EST. COMOD.	**$100.00**	**NET LIVE $/CWT**	**$73.18**	**$68.61**
KILL-FAB COST EST. .25 INCH	**$106.00**	**US CHOICE**		**CLOSE PREM.**
CATTLE FREIGHT $ / CWT	**$0.36**	**YIELD GRADE 3**		**($57.93)**
		RECOVERY AS A % OF HOT WT*	**97.95%**	**97.43%**
		PERCENT BOX BEEF YIELD	**69.88%**	**66.31%**
		PERCENT BOX BEEF NO TRIM		**51.55%**
		PERCENT MAJOR		**39.86%**

Kill and Fabrication Costs	Commodity	Close
Yield Grade 1	$94.00	$100.00
Yield Grade 2	$97.00	$103.00
Yield Grade 3	$100.00	$106.00
Yield Grade 4	$116.00	$124.00

* Recovery as a percent of hot carcass weight represents the error in our regression equations in the prediction of the sum of the box cuts. It does not represent cooler shrink or cutting losses. In some cases recovery can exceed 100 percent. This is the reason for restricting the use of these equations as cited below.

IMPORTANT NOTICE: THE DATA USED IN MAKING THESE ESTIMATES WERE OBTAINED FROM CUTTING TESTS IN A COMMERCIAL PACKING PLANT. 453 STEERS AND 120 HEIFERS WERE FABRICATED. THE CARCASSES WEIGHED 555 TO 1008 POUNDS. FAT THICKNESS RANGED FROM 0.08 TO 1.28 INCHES. RIBEYE AREA RANGED FROM 9.3 TO 18.9 sq.in. THE TEST CARCASSES GRADED 60.2% U.S. CHOICE AND 39.8% U.S. SELECT

SUGGESTED USE RANGE IS 650 TO 875 POUND CARCASSES AND YIELD GRADES BETWEEN 1.0 AND 4.5.

DEVELOPED AT OKLAHOMA STATE UNIVERSITY BY GLEN DOLEZAL, DONALD GILL AND TOM GARDNER

APPENDIX B

BOXED BEEF CALCULATOR – BOXBEEF PRICING WORKSHEET

These data updated on 11/2/1998

BOXED BEEF CUTS	PRICES FOR COMMODITY TRIM PRODUCTS					PRICES FOR CLOSELY TRIMED PRODUCTS				
(GRADE--->>)	PRIME	PREM CH	CHOICE	SELECT	NO ROLL	PRIME	PREM CH	CHOICE	SELECT	NO ROLL
112A RIBEYE <11 lbs						$469.21	$469.21	$469.21	$332.20	$332.20
112A RIBEYE 11> lbs						$431.04	$431.04	$431.04	$325.90	$325.90
114 SH CLOD						$121.22	$121.22	$121.22	$122.50	$122.50
116A CHUCK ROLL						$139.10	$139.10	$139.10	$129.40	$129.40
120 BRISKET						$112.98	$112.98	$112.98	$110.47	$110.47
167 KNUCKLE						$150.43	$150.43	$150.43	$141.49	$141.49
168 INSIDE RND						$160.82	$160.82	$160.82	$151.33	$151.33
170 GOOSENECK						$135.52	$135.52	$135.52	$122.79	$122.79
180 STRIP LOIN <12 lbs						$388.81	$388.81	$388.81	$272.92	$272.92
180 STRIP LOIN 12-13.9 #						$388.81	$388.81	$388.81	$272.92	$272.92
180 STRIP LOIN 14> lbs						$388.81	$388.81	$388.81	$272.92	$272.92
184 TOP BUTT <12 lbs						$186.21	$186.21	$186.21	$142.85	$142.85
184 TOP BUTT 12> lbs						$186.21	$186.21	$186.21	$142.85	$142.85
185A BOT SRLN FLAP						$186.24	$186.24	$186.24	$181.18	$181.18
185B BOT SRLN BALL TIP <2						$144.65	$144.65	$144.65	$135.34	$135.34
185B BOT SRLN BALL TIP 2>						$149.96	$149.96	$149.96	$139.26	$139.26
185C BOT SRLN TRITIP						$167.58	$167.58	$167.58	$153.04	$153.04
189A TENDERLOIN <5 lbs						$699.76	$699.76	$699.76	$647.76	$647.76
189A TENDERLOIN 5> lbs						$702.57	$702.57	$702.57	$617.01	$617.01
193 FLANK STEAK						$287.48	$287.48	$287.48	$283.12	$283.12
INSIDE SKIRT						$167.18	$167.18	$167.18	$167.18	$167.18
CAP & WEDGE MEAT						$147.69	$147.69	$147.69	$147.69	$147.69
BACK RIBS						$65.77	$65.77	$65.77	$65.77	$65.77
80% LEAN TRIM						$70.15	$70.15	$70.15	$70.15	$70.15
50% LEAN TRIM						$47.99	$47.99	$47.99	$47.99	$47.99

APPENDIX C

BOXED BEEF CALCULATOR – BOX BEEF YIELD WORKSHEET

	SIDE BASIS		CARCASS BASIS				CLOSE	COMMOD
	WEIGHT	WEIGHT	WEIGHT	WEIGHT	PRICE	PRICE	PRODUCT	PRODUCT
BOXED BEEF CUTS	CLOSE	COMMOD	CLOSE	COMMOD	CLOSE	COMMOD	VALUE	VALUE
112A RIBEYE <11 lbs	12.38	12.38	24.76	24.76	$469.21	$469.21	$106.73	$106.73
112A RIBEYE 11> lbs	12.38	12.38	24.76	24.76	$431.04	$431.04		
114 SH CLOD	19.51	21.35	39.01	42.69	$121.22	$121.22	$47.29	$51.75
116A CHUCK ROLL	28.82	31.32	57.65	62.65	$139.10	$139.10	$80.19	$87.14
120 BRISKET	9.71	11.74	19.42	23.48	$112.98	$112.98	$21.94	$26.53
167 KNUCKLE	10.10	10.71	20.19	21.42	$150.43	$150.43	$30.38	$32.22
168 INSIDE RND	20.35	22.24	40.70	44.48	$160.82	$160.82	$65.45	$71.52
170 GOOSENECK	26.50	27.93	53.01	55.85	$135.52	$135.52	$71.84	$75.69
180 STRIP LOIN <12 lbs	12.00	14.13	24.00	28.26	$388.81	$388.81	$93.33	$109.89
180 STRIP LOIN 12-13.9 #	12.00	14.13	24.00	28.26	$388.81	$388.81		
180 STRIP LOIN 14> lbs	12.00	14.13	24.00	28.26	$388.81	$388.81		
184 TOP BUTT <12 lbs	11.36	12.99	22.72	25.98	$186.21	$186.21	$42.30	$48.38
184 TOP BUTT 12> lbs	11.36	12.99	22.72	25.98	$186.21	$186.21		
185A BOT SRLN FLAP	3.55	3.55	7.10	7.10	$186.24	$186.24	$13.22	$13.22
185B BOT SRLN BALL TIP <2	2.35	2.35	4.69	4.69	$144.65	$144.65	$7.03	$7.03
185B BOT SRLN BALL TIP 2>	2.35	2.35	4.69	4.69	$149.96	$149.96		
185C BOT SRLN TRITIP	2.67	3.12	5.34	6.24	$167.58	$167.58	$8.95	$10.46
189A TENDERLOIN <5 lbs	5.78	5.78	11.56	11.56	$699.76	$699.76	$81.21	$81.21
189A TENDERLOIN 5> lbs	5.78	5.78	11.56	11.56	$702.57	$702.57		
193 FLANK STEAK	1.80	1.80	3.61	3.61	$287.48	$287.48	$10.37	$10.37
INSIDE SKIRT	4.27	4.27	8.54	8.54	$167.18	$167.18	$14.27	$14.27
CAP & WEDGE MEAT	12.16	12.16	24.31	24.31	$147.69	$147.69	$35.90	$35.90
BACK RIBS	6.55	6.55	13.10	13.10	$65.77	$65.77	$8.61	$8.61
80% LEAN TRIM	33.29	33.29	66.57	66.57	$70.15	$70.15	$46.70	$46.70
50% LEAN TRIM	21.11	21.11	42.22	42.22	$47.99	$47.99	$20.26	$20.26
EDIBLE TALLOW	72.67	60.12	145.34	120.24				
BONE	51.40	51.40	102.81	102.81				

APPENDIX D

BOXED BEEF CALCULATOR – CARCASS CALCULATOR WORKSHEET

START AT CARCASS NO--->	1
START CALCULATION AT NO-->	**1**
OBSERVATION COUNTER	1000

These data updated:
11/2/1998

1 756.06 3 3.29 63

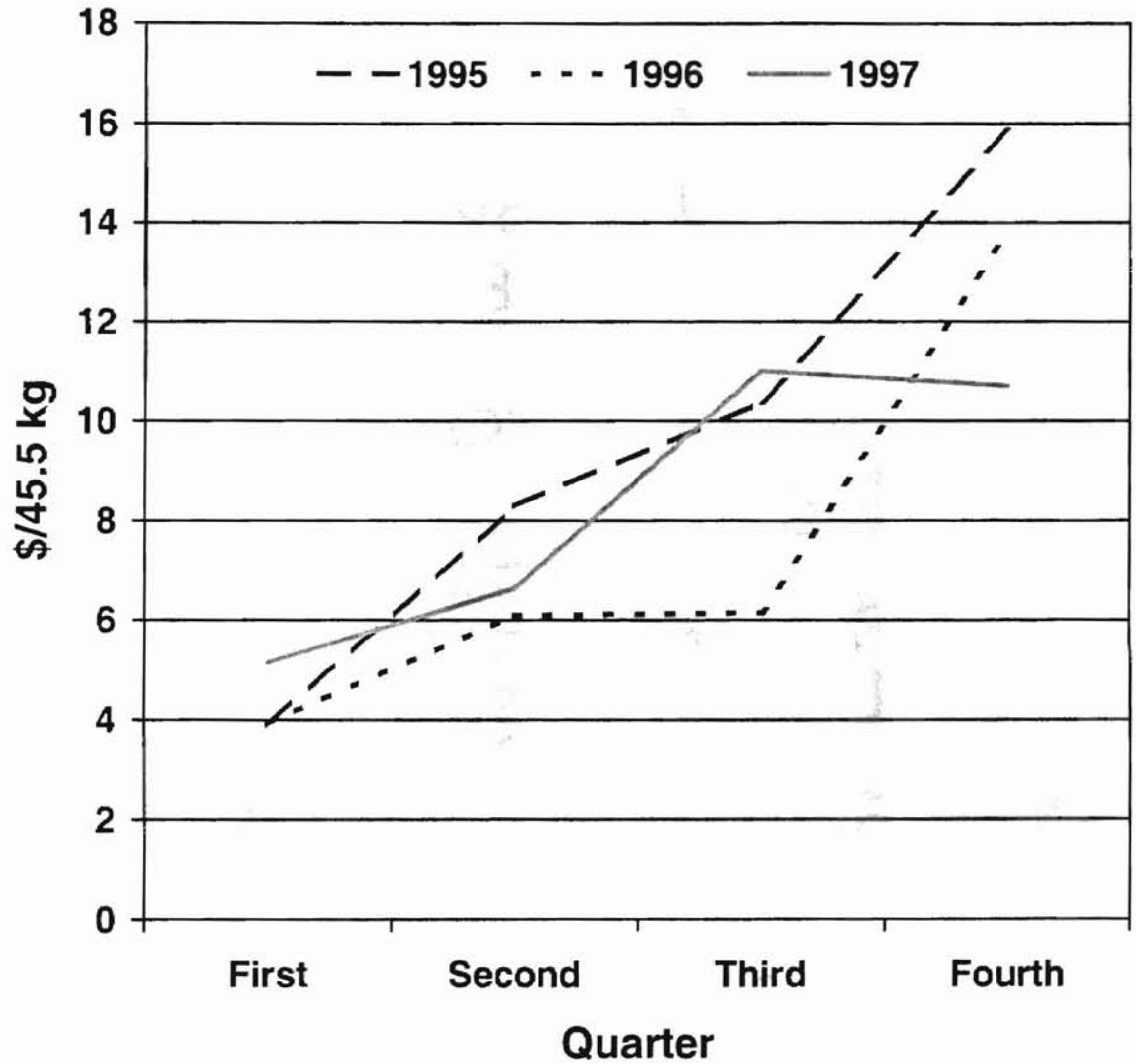
OKLAHOMA STATE UNIVERSITY BOX BEEF CALCULATOR NEWCUT 1998

'Prime=1, Prem Choice=2, Choice=3, Select=4, NoRoll=5.

Seq No	Sire no.	Ear Tag	Carcass Weight	Qual Grade	Yield Grade	Dress %	Live $/cwt Comod. Trim	Live $/cwt Close Trim	Carcass $/cwt Comod Trim	Carcass $/cwt Close Trim	Percent Box Yield Comod Trim	Percent Box Yield Close Trim
1	11294119	034	756.06	3	3.29	63.00	$73.18	$68.61	$116.15	$108.90	69.88%	66.31%
2	11294119	040	877.48	2	3.30	63.00	$74.50	$69.98	$118.26	$111.08	70.44%	66.81%
3	11294119	042	812.61	3	2.68	63.00	$75.70	$71.81	$120.16	$113.98	71.40%	68.32%
4	11294119	049	858.51	2	2.64	63.00	$76.40	$72.60	$121.27	$115.25	71.83%	68.79%
5	11294119	054	791.92	2	3.65	63.00	$72.64	$67.67	$115.31	$107.42	69.25%	65.35%
6	11294119	094	809.61	3	2.84	63.00	$75.19	$71.12	$119.36	$112.89	70.99%	67.78%
7	11294119	0103	849.06	4	1.96	63.00	$69.65	$66.94	$110.55	$106.26	73.65%	71.21%
8	11294119	0110	816.16	3	3.81	63.00	$72.52	$67.36	$115.11	$106.93	69.05%	64.99%
9	11294119	0118	871.58	3	2.45	63.00	$77.18	$73.62	$122.51	$116.85	72.46%	69.59%
10	11652657	131	798.58	2	3.14	63.00	$73.99	$69.58	$117.44	$110.45	70.27%	66.79%
11	11652657	134	873.64	2	3.45	63.00	$74.05	$69.35	$117.54	$110.08	70.09%	66.32%
12	11652657	136	764.4	3	3.16	63.00	$73.59	$69.15	$116.80	$109.77	70.15%	66.68%
13	11652657	142	833.3	3	2.80	63.00	$75.59	$71.59	$119.99	$113.63	71.23%	68.05%
14	11652657	150	856.54	2	3.38	63.00	$74.02	$69.38	$117.50	$110.13	70.10%	66.39%
15	11652657	157	788.88	3	4.24	63.00	$70.08	$64.28	$111.24	$102.03	68.35%	63.95%
16	11652657	178	847.68	3	3.12	63.00	$74.62	$70.27	$118.44	$111.54	70.59%	67.12%
17	11652657	189	784.64	2	2.75	63.00	$75.18	$71.19	$119.34	$113.00	71.11%	67.97%
18	11652657	191	921.4	3	3.54	63.00	$74.43	$69.69	$118.15	$110.61	70.39%	66.54%
19	11652657	1103	686.54	3	2.70	63.00	$74.51	$70.56	$118.26	$112.00	71.41%	68.37%

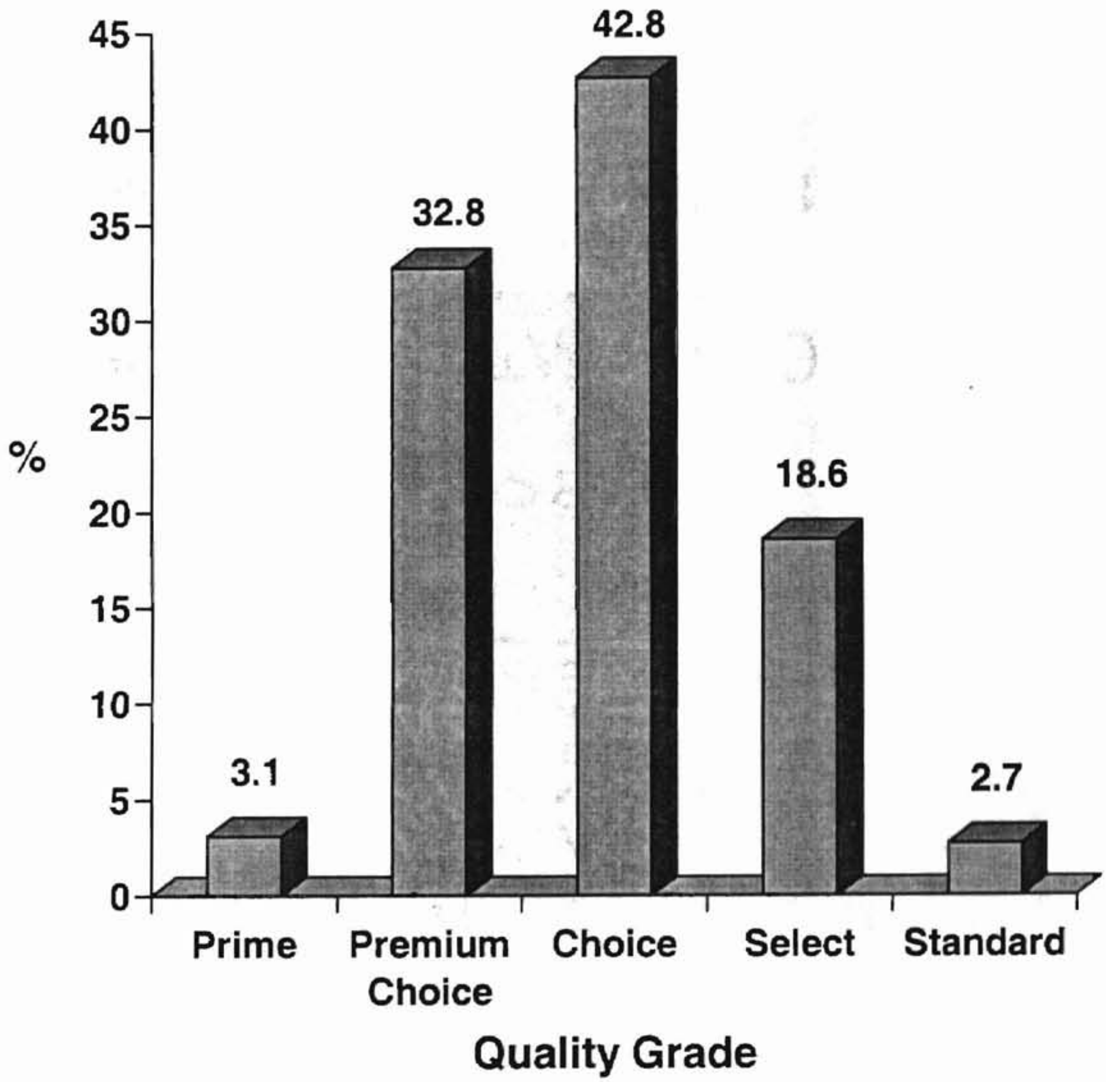
APPENDIX E

QUALITY GRADE SPREAD ($/45.4 kg) BY YEAR AND QUARTER



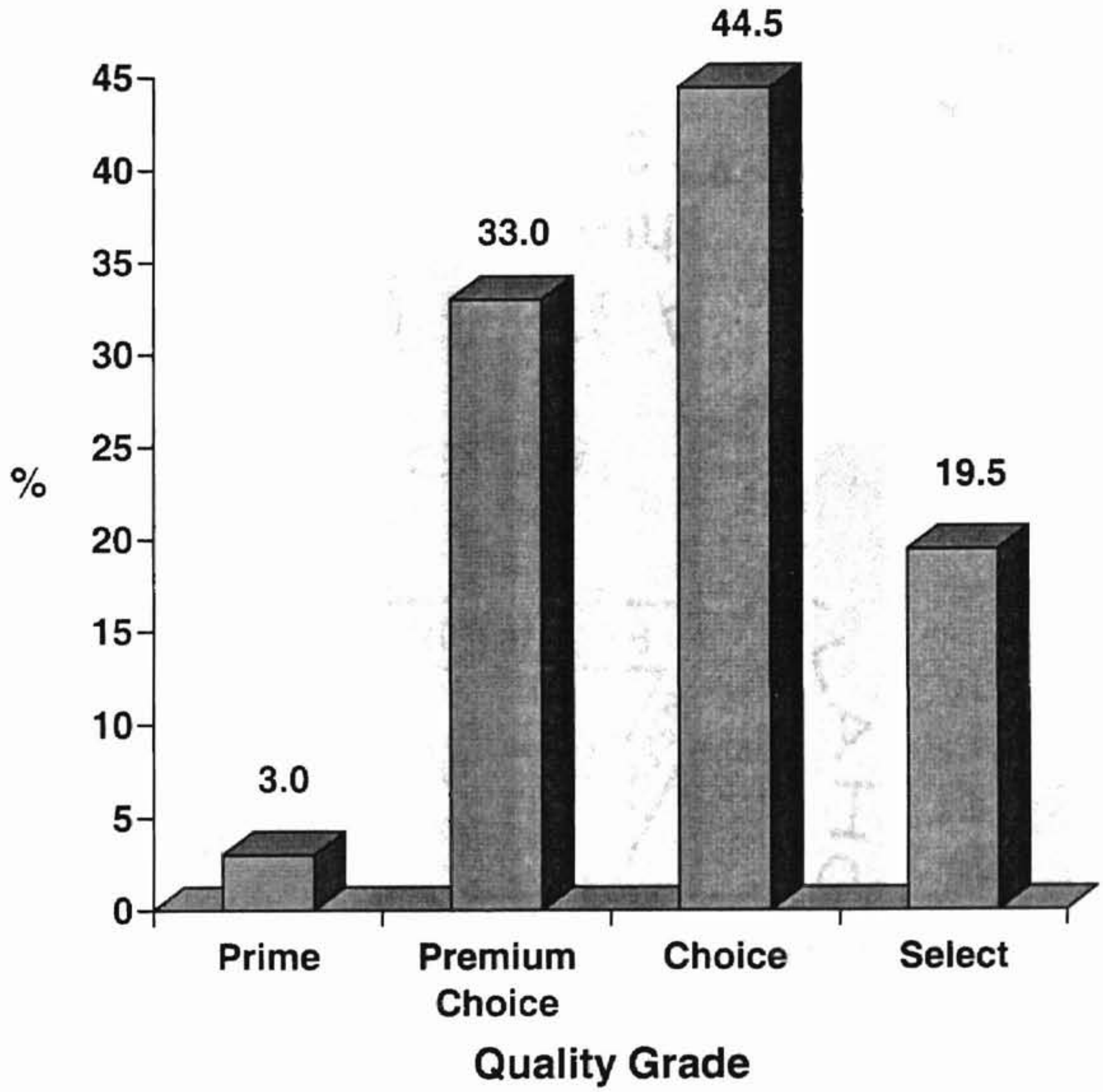
APPENDIX F

QUALITY GRADE DISTRIBUTION FOR ALL PROGENY DATA (n=33,350)



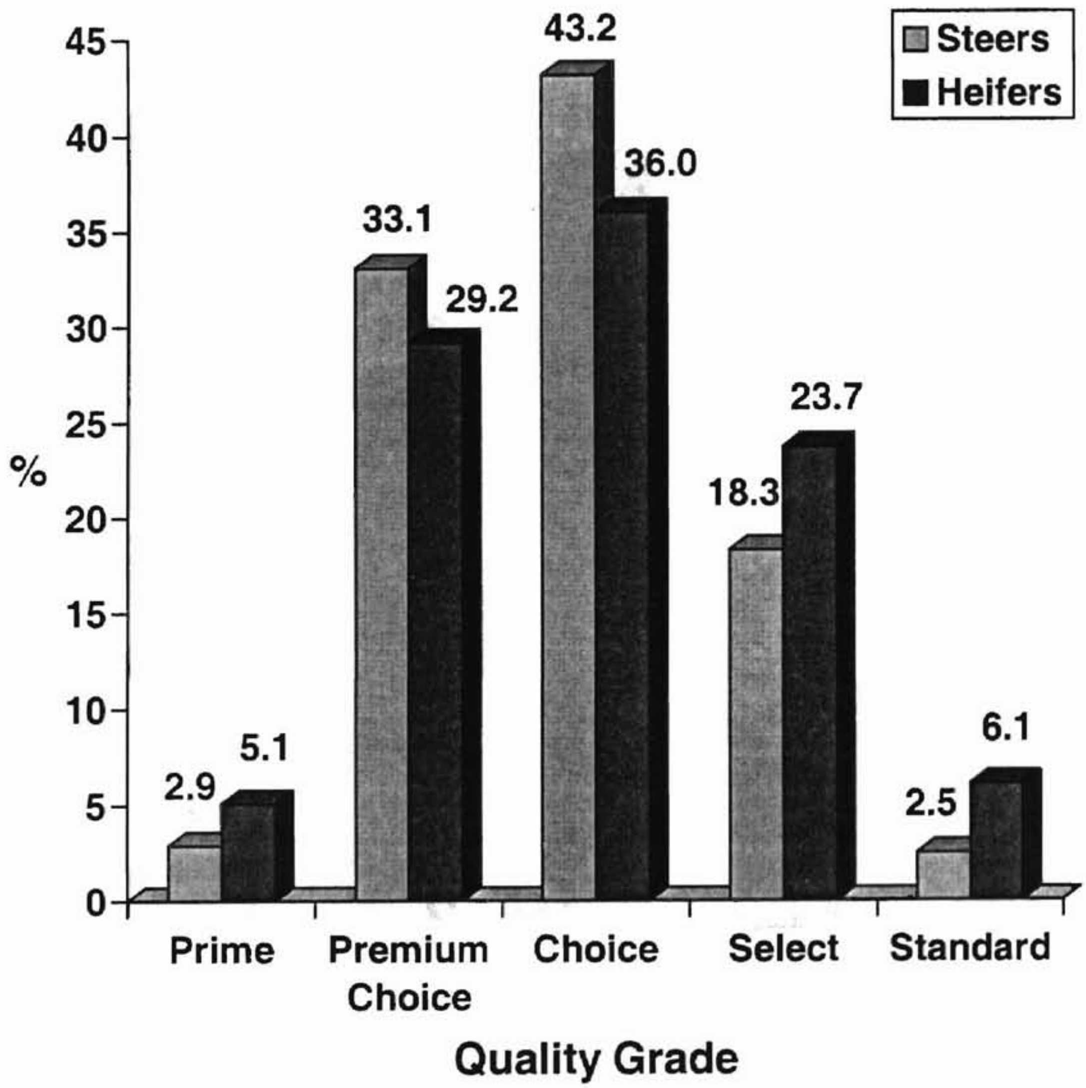
APPENDIX G

QUALITY GRADE DISTRIBUTION FOR PROGENY (n=28,210) CONFORMING TO BOXED BEEF FABRICAITON SPECIFICATIONS



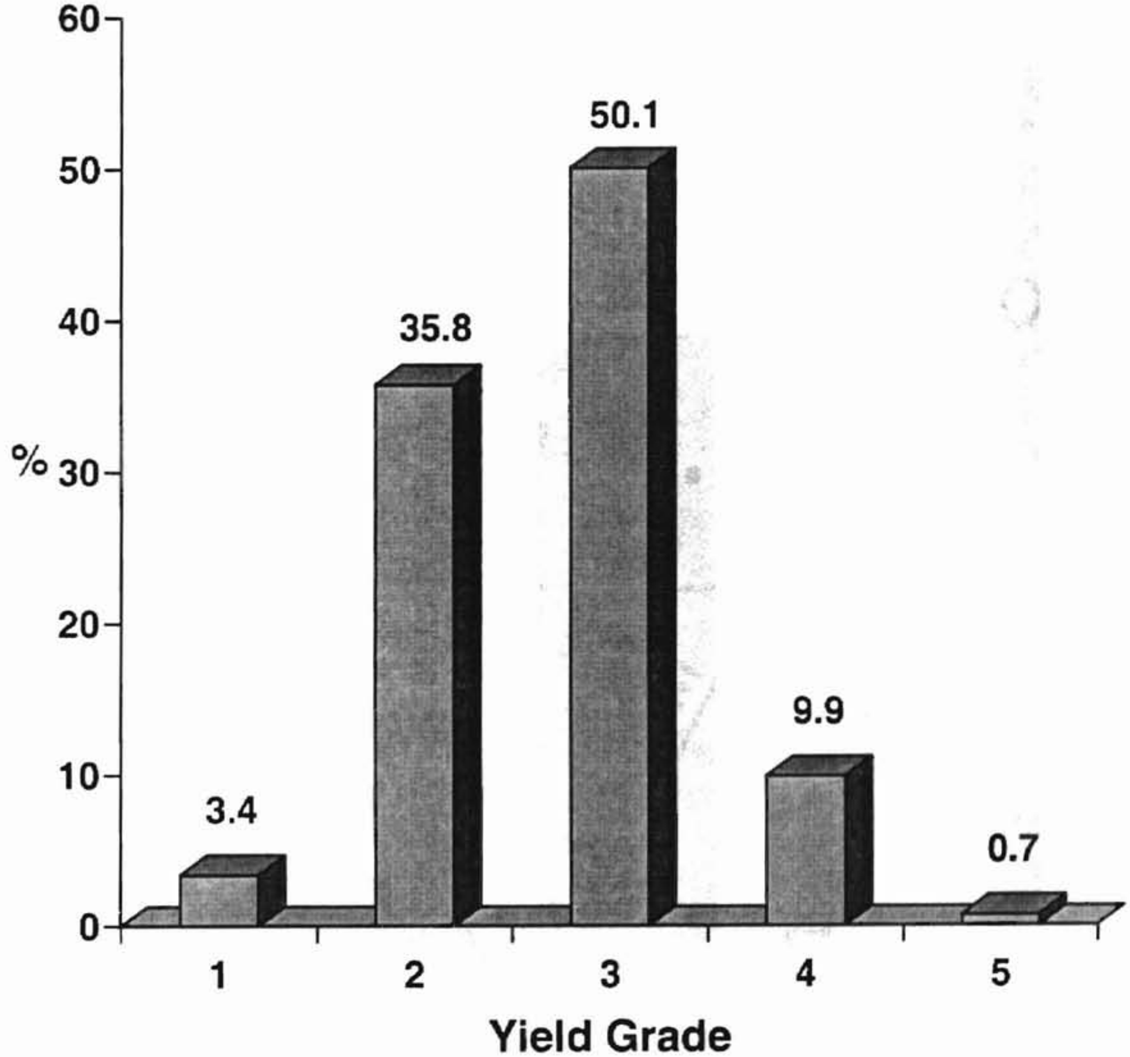
APPENDIX H

QUALITY GRADE DISTRIBUTION FOR STEER (n=31,181) AND HEIFER (n=2,169) PROGENY



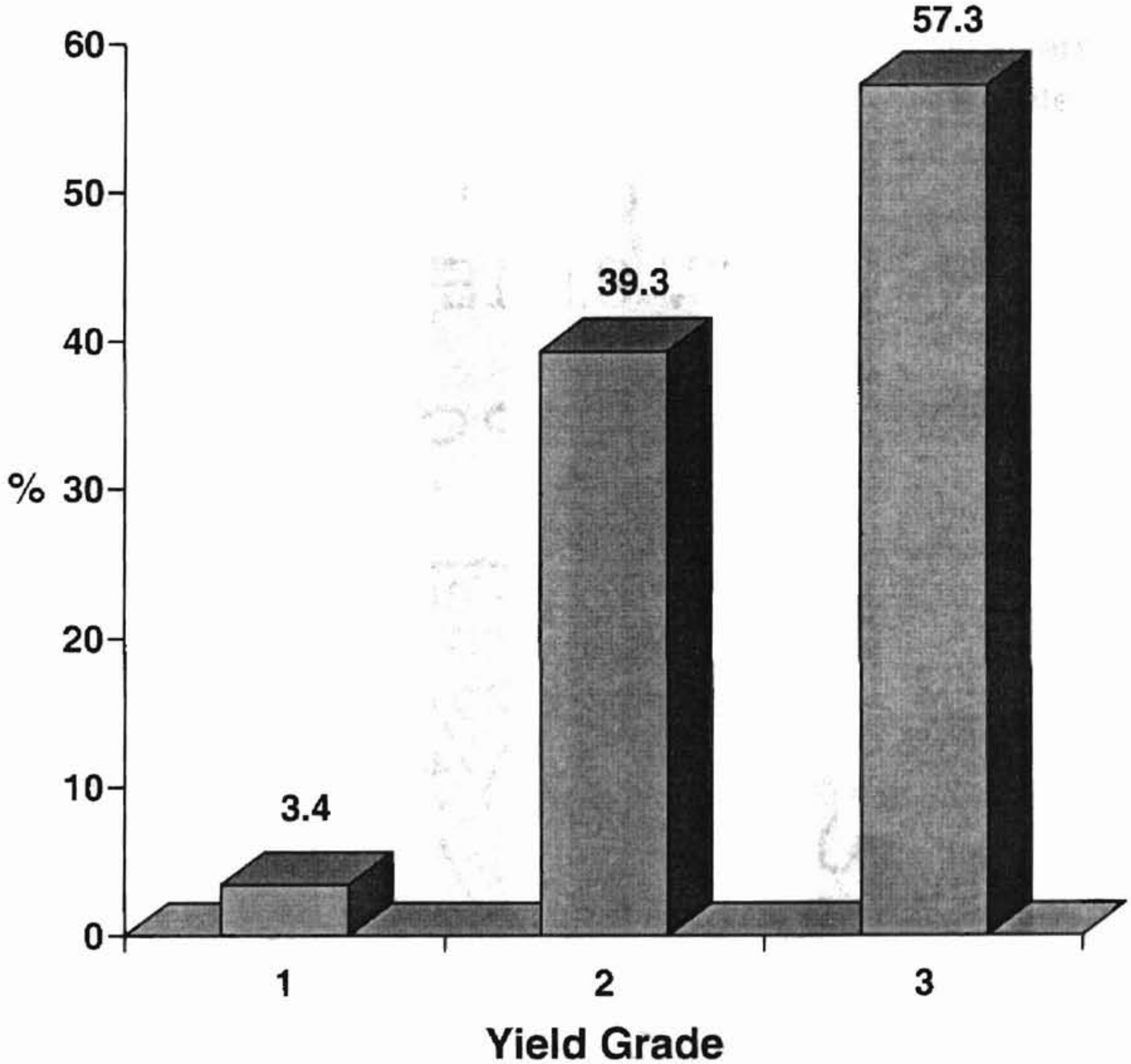
APPENDIX I

YIELD GRADE DISTRIBUTION FOR ALL PROGENY DATA (n=33,350)



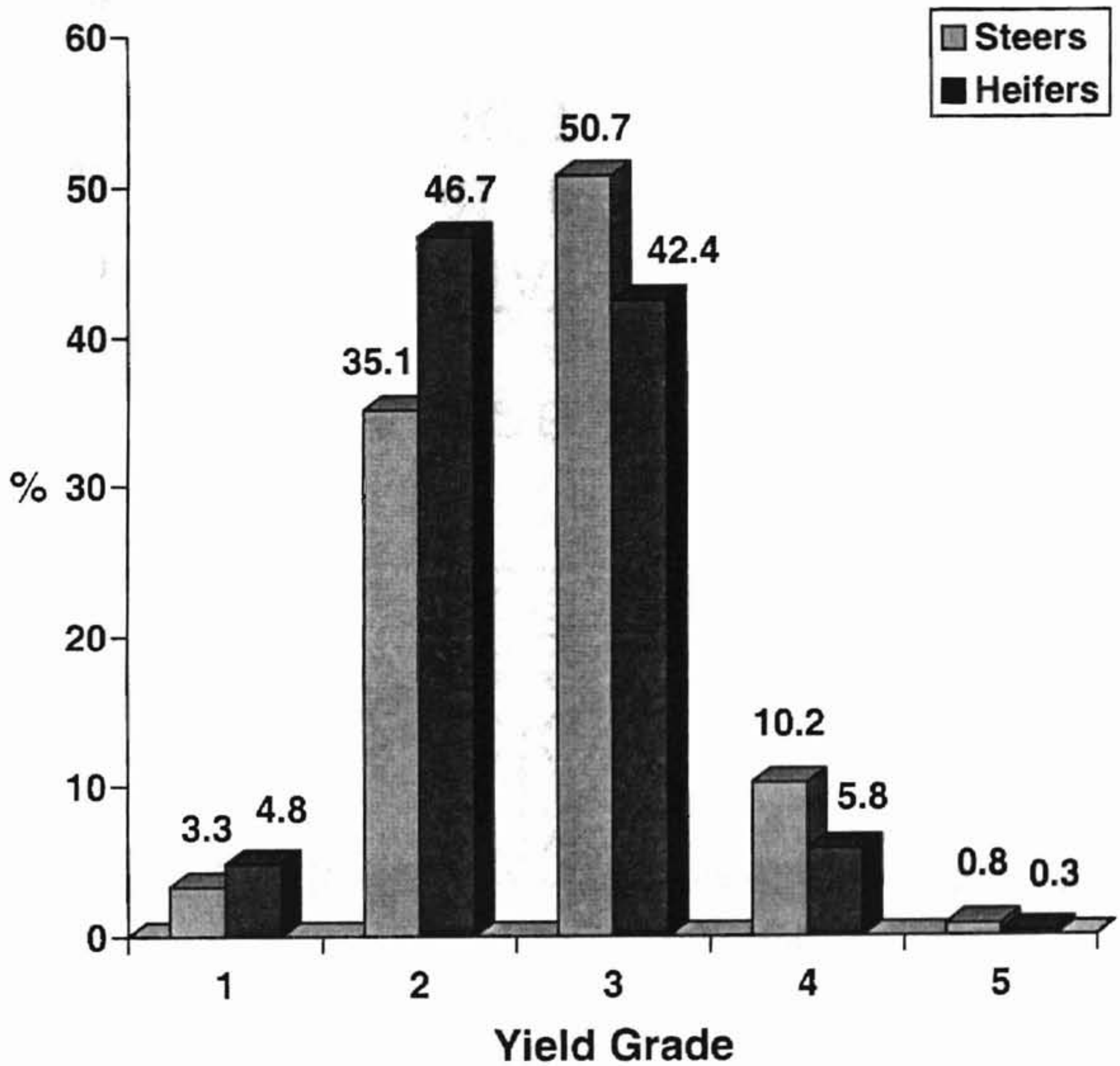
APPENDIX J

YIELD GRADE DISTRIBUTION FOR PROGENY (n=28,210) CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS



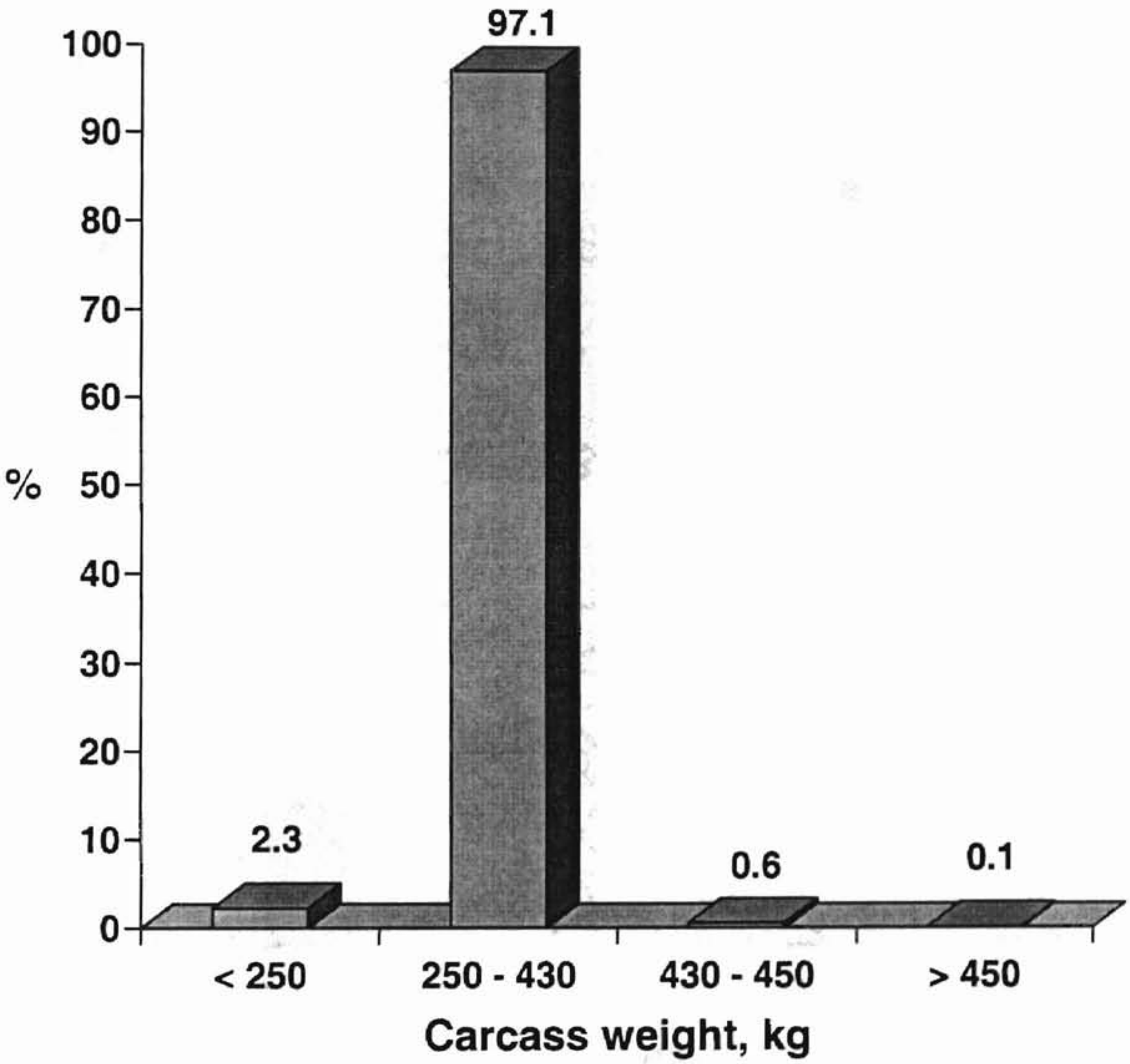
APPENDIX K

YIELD GRADE DISTRIBUTION FOR STEER (n=31,181) AND HEIFER (n=2,169) PROGENY



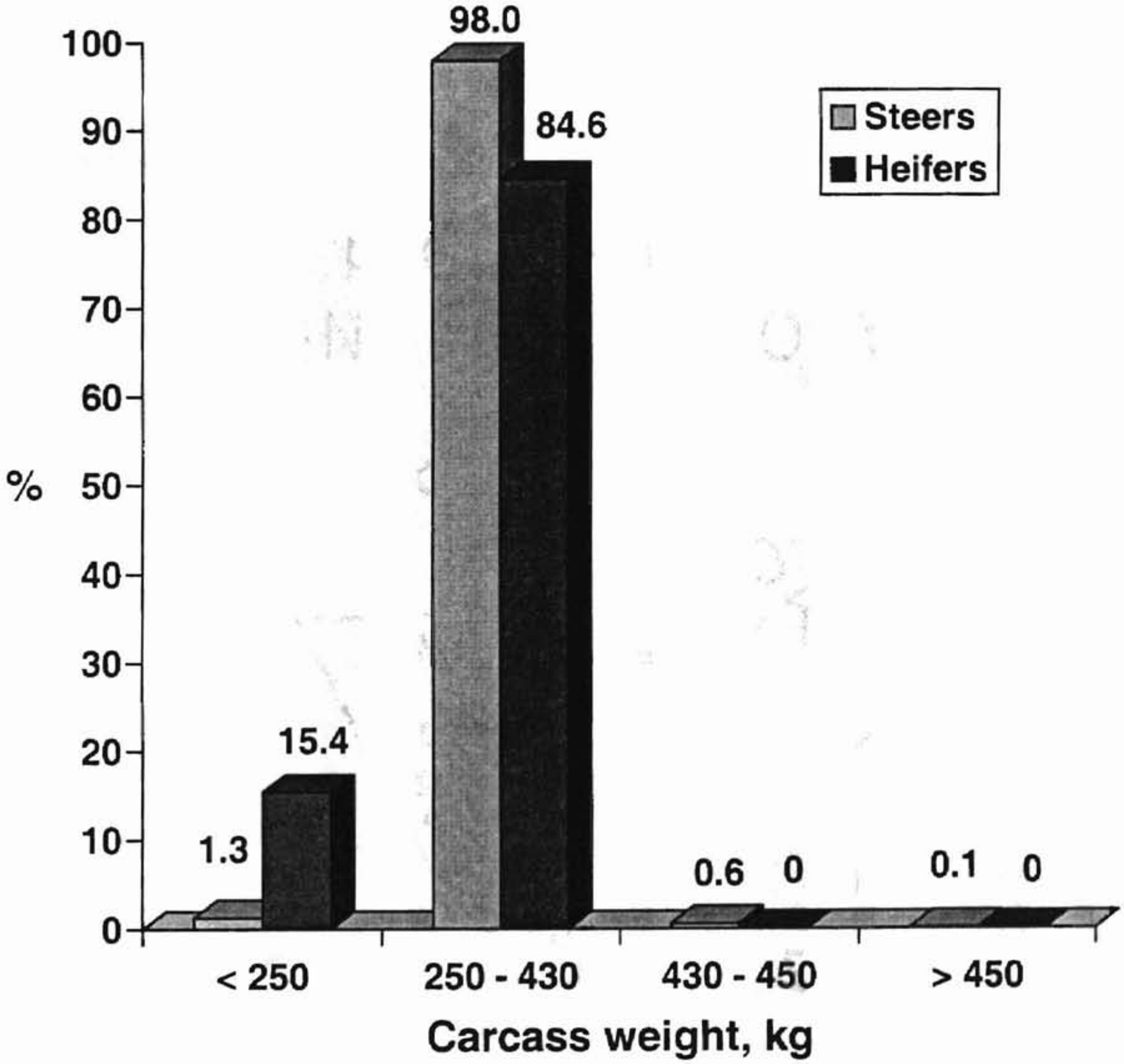
APPENDIX L

CARCASS WEIGHT DISTRIBUTION FOR ALL PROGENY DATA (n=33,350)



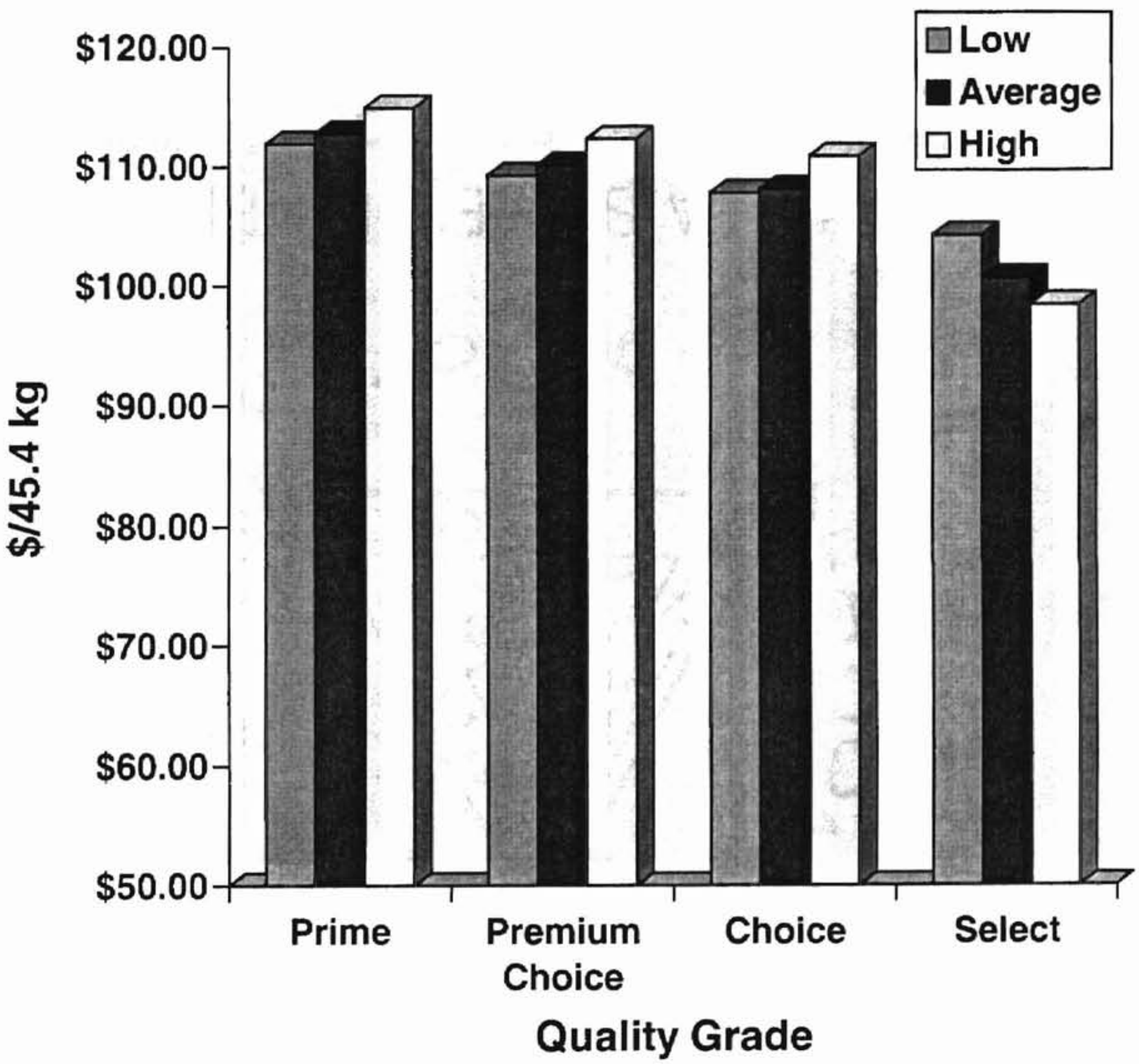
APPENDIX M

CARCASS WEIGHT DISTRIBUTION FOR STEER (n=31,181) AND HEIFER (n=2,169) PROGENY



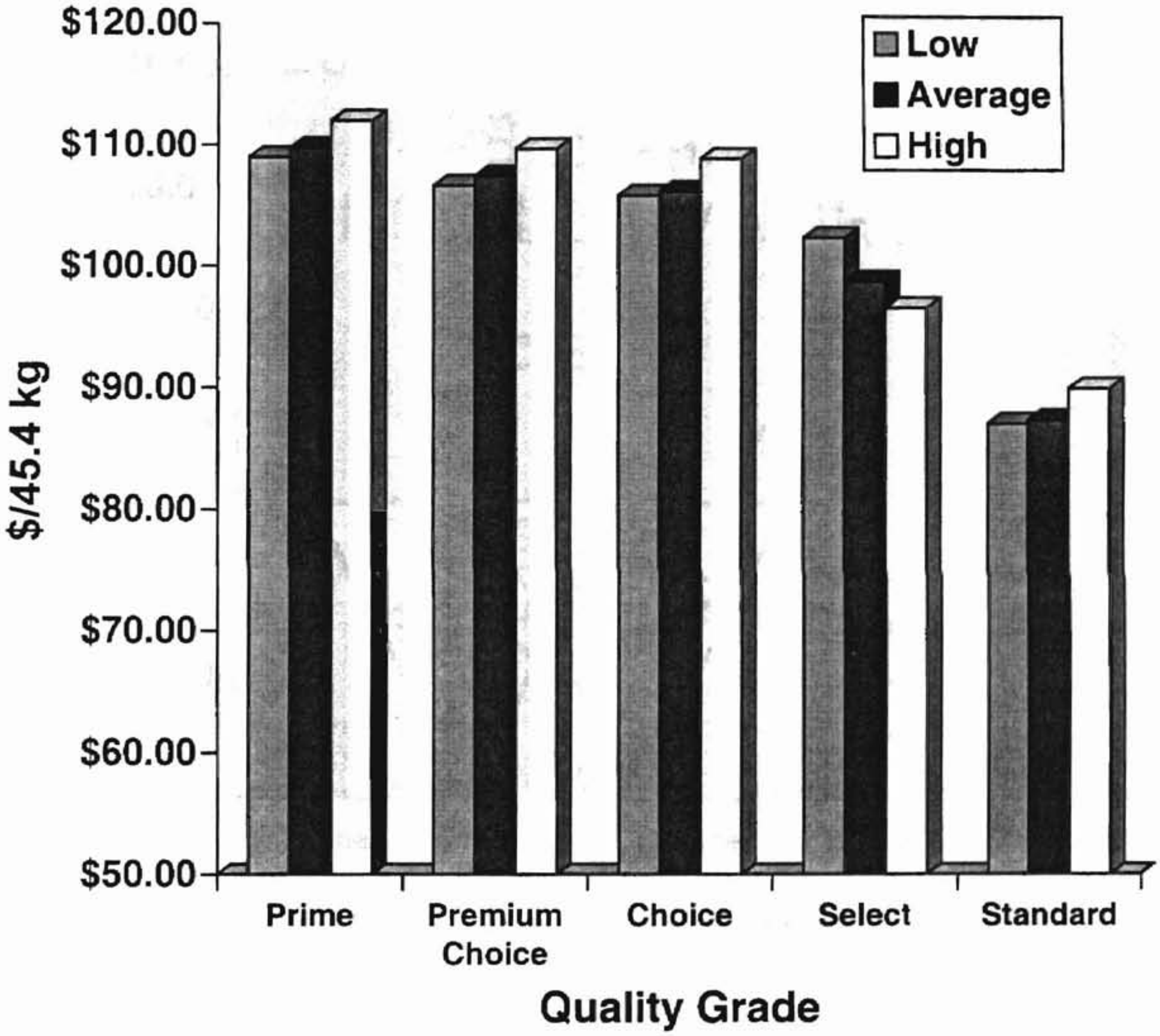
APPENDIX N

BOXED BEEF VALUE ($/45.4 kg) MEANS BY QUALITY GRADE FOR PROGENY (n=28,210) CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS STRATIFIED BY LOW, AVERAGE, AND HIGH QUALITY GRADE SPREADS



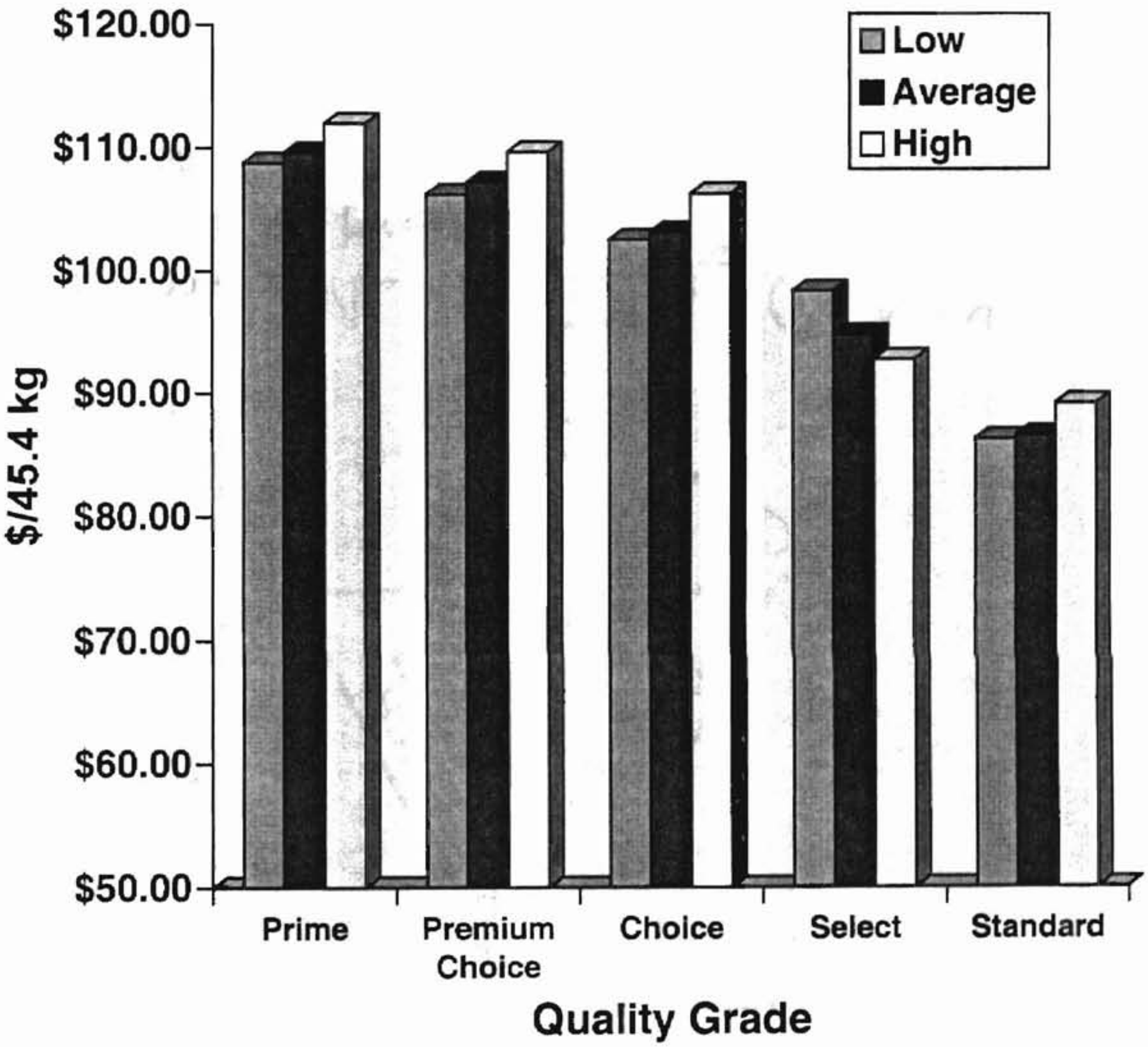
APPENDIX O

BOXED BEEF VALUE ($/45.4 kg) MEANS BY QUALITY GRADE FOR STEER PROGENY (n=31,181) STRATIFIED BY LOW, AVERAGE, AND HIGH QUALITY GRADE SPREADS



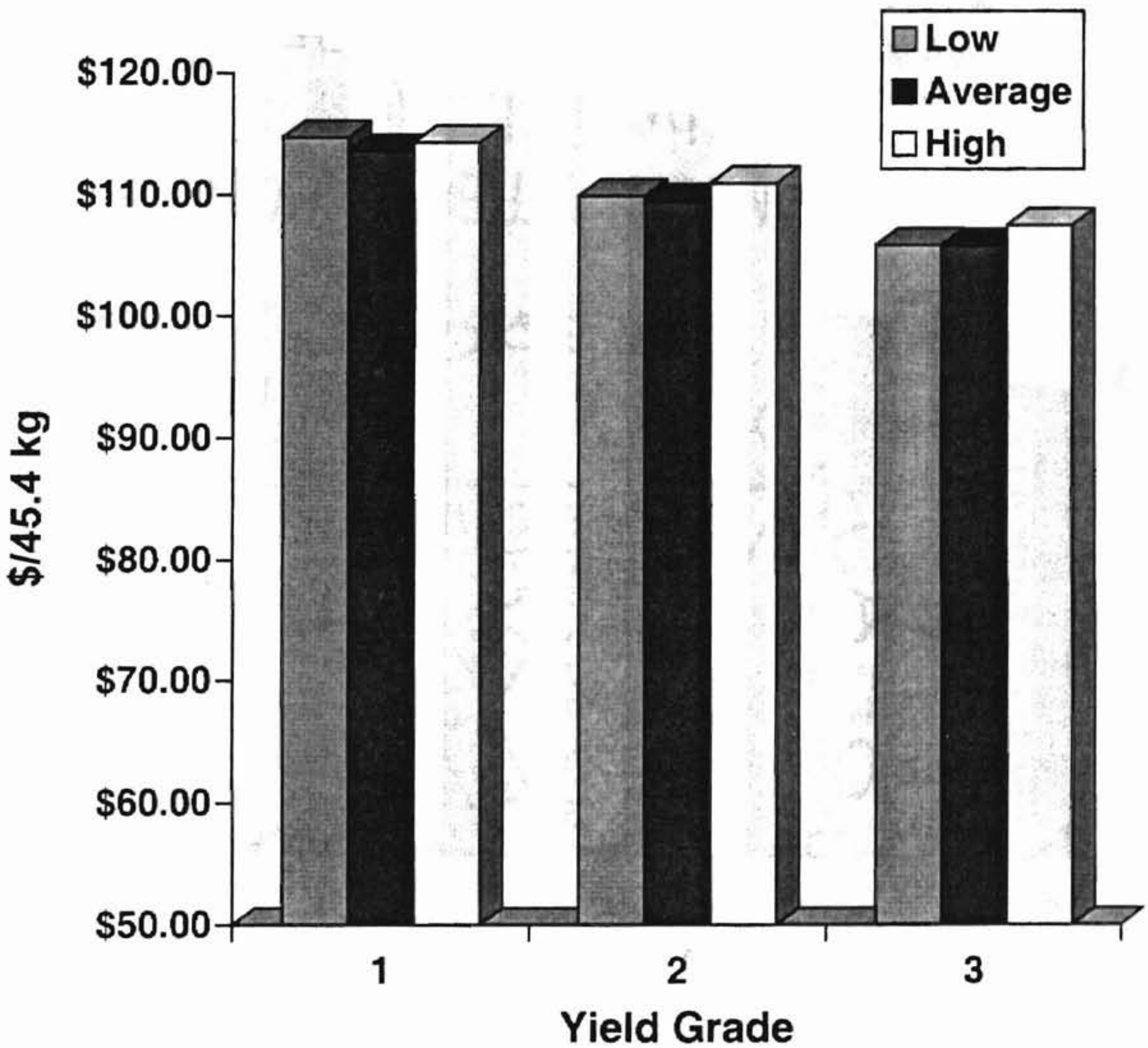
APPENDIX P

BOXED BEEF VALUE ($/45.4 kg) MEANS BY QUALITY GRADE FOR HEIFER PROGENY (n=2,169) STRATIFIED BY LOW, AVERAGE, AND HIGH QUALITY GRADE SPREADS



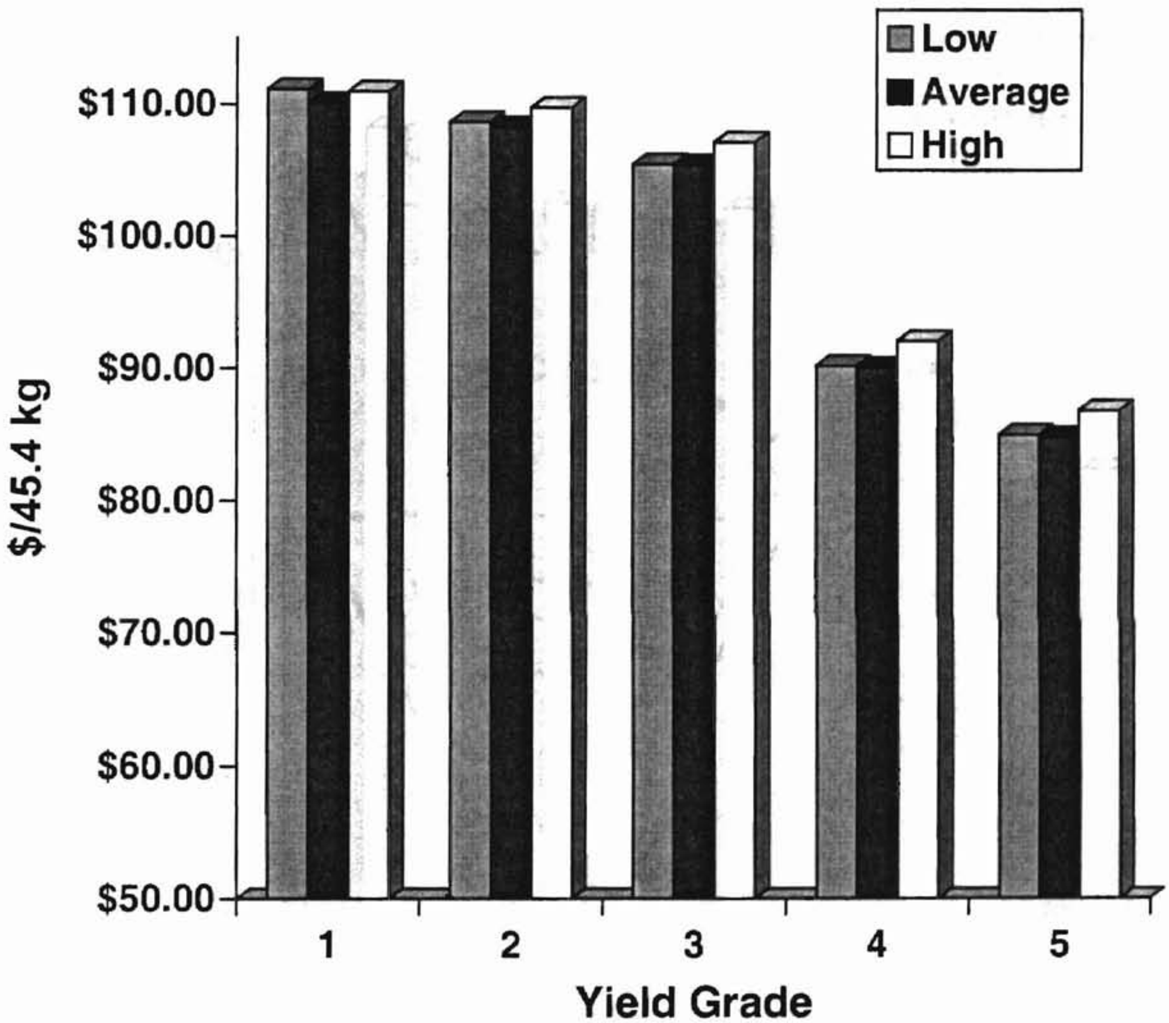
APPENDIX Q

BOXED BEEF VALUE ($/45.4 kg) MEANS BY YIELD GRADE FOR PROGENY (n=28,210) CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS STRATIFIED BY LOW, AVERAGE, AND HIGH QUALITY GRADE SPREADS



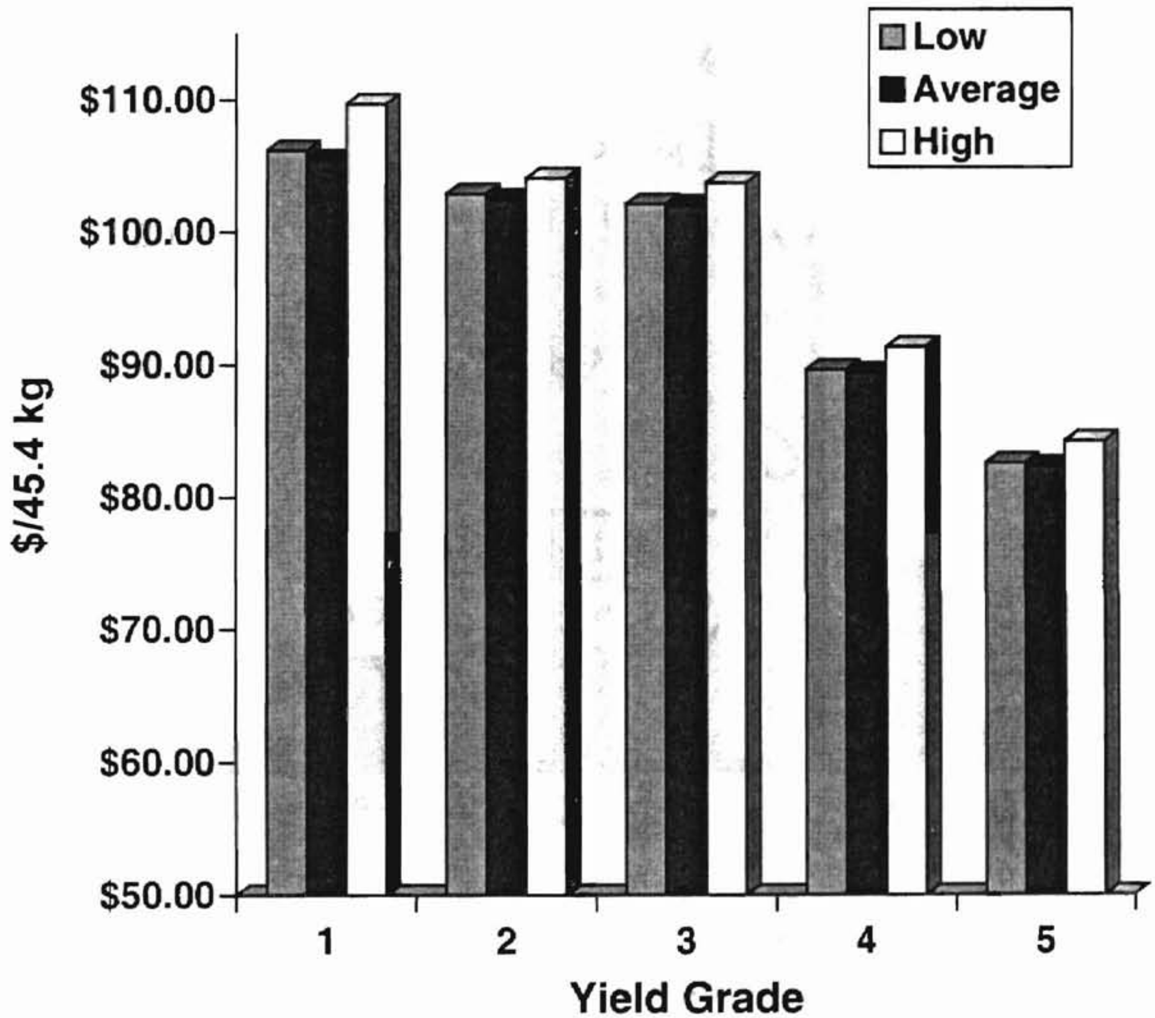
APPENDIX R

BOXED BEEF VALUE ($/45.4 kg) MEANS BY YIELD GRADE FOR STEER PROGENY (n=31,181) STRATIFIED BY LOW, AVERAGE, AND HIGH QUALITY GRADE SPREADS



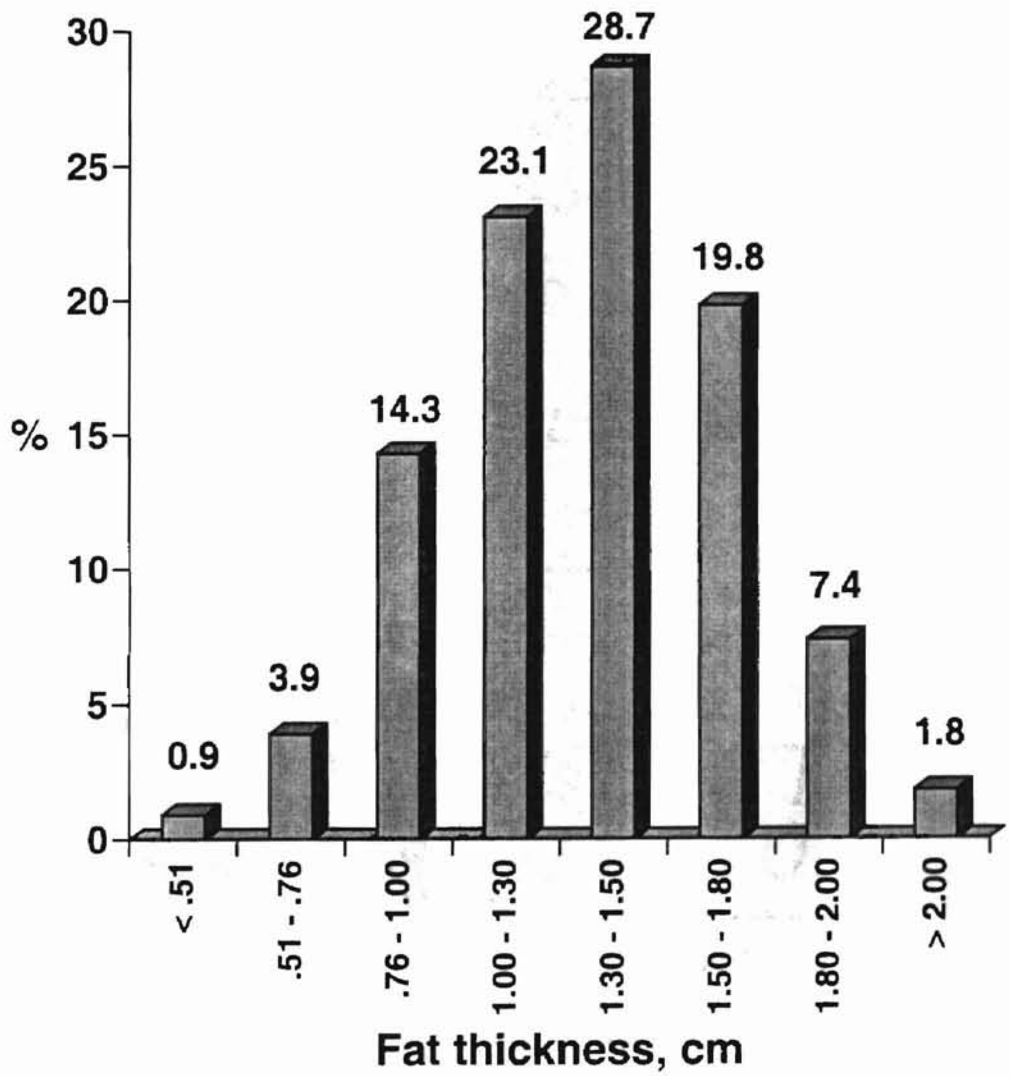
APPENDIX S

BOXED BEEF VALUE ($/45.4 kg) MEANS BY YIELD GRADE FOR HEIFER PROGENY (n=2,169) STRATIFIED BY LOW, AVERAGE, AND HIGH QUALITY GRADE SPREADS



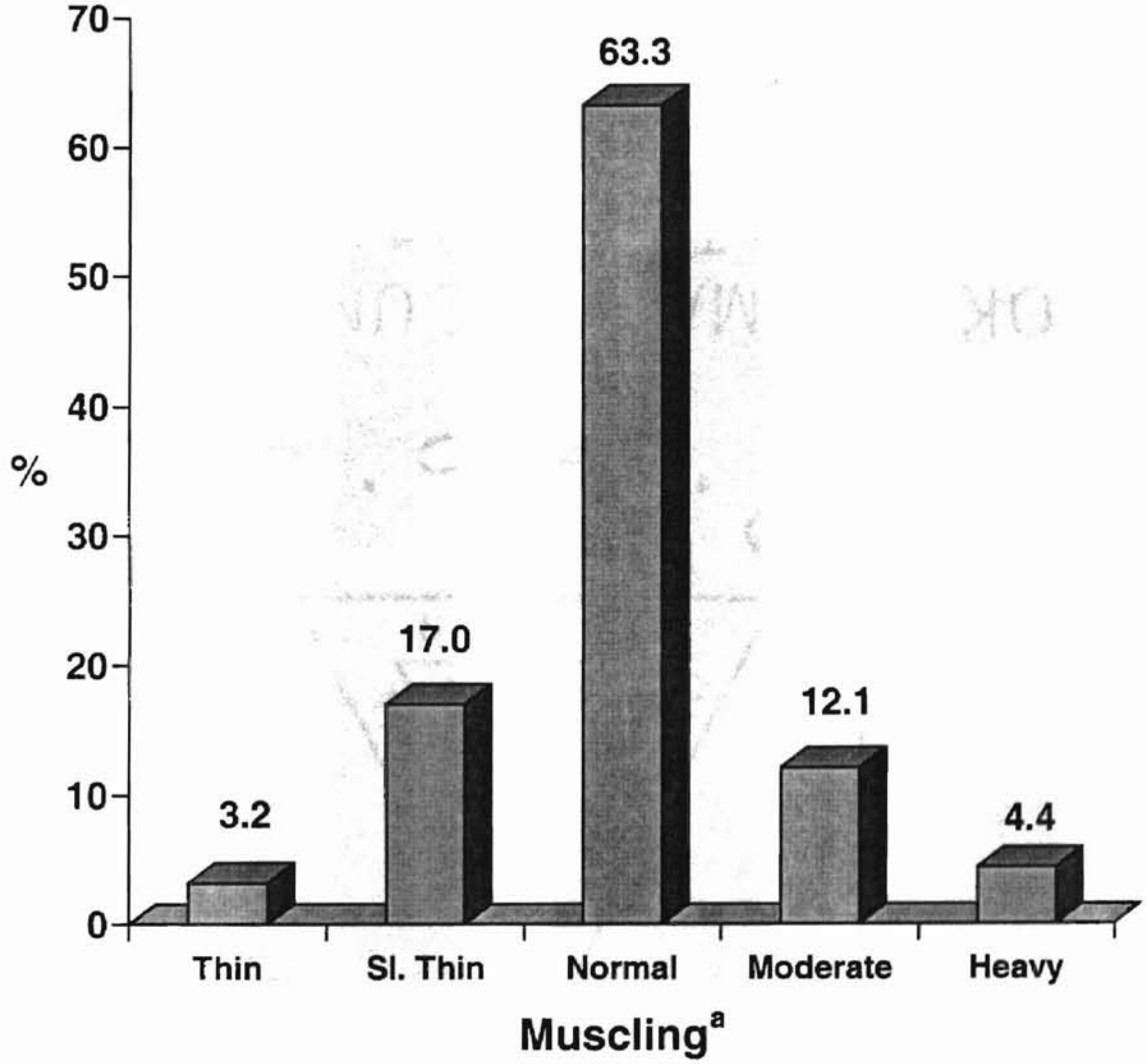
APPENDIX T

DISTRIBUTION OF FAT THICKNESS FOR PROGENY (n=28,210) CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS



APPENDIX U

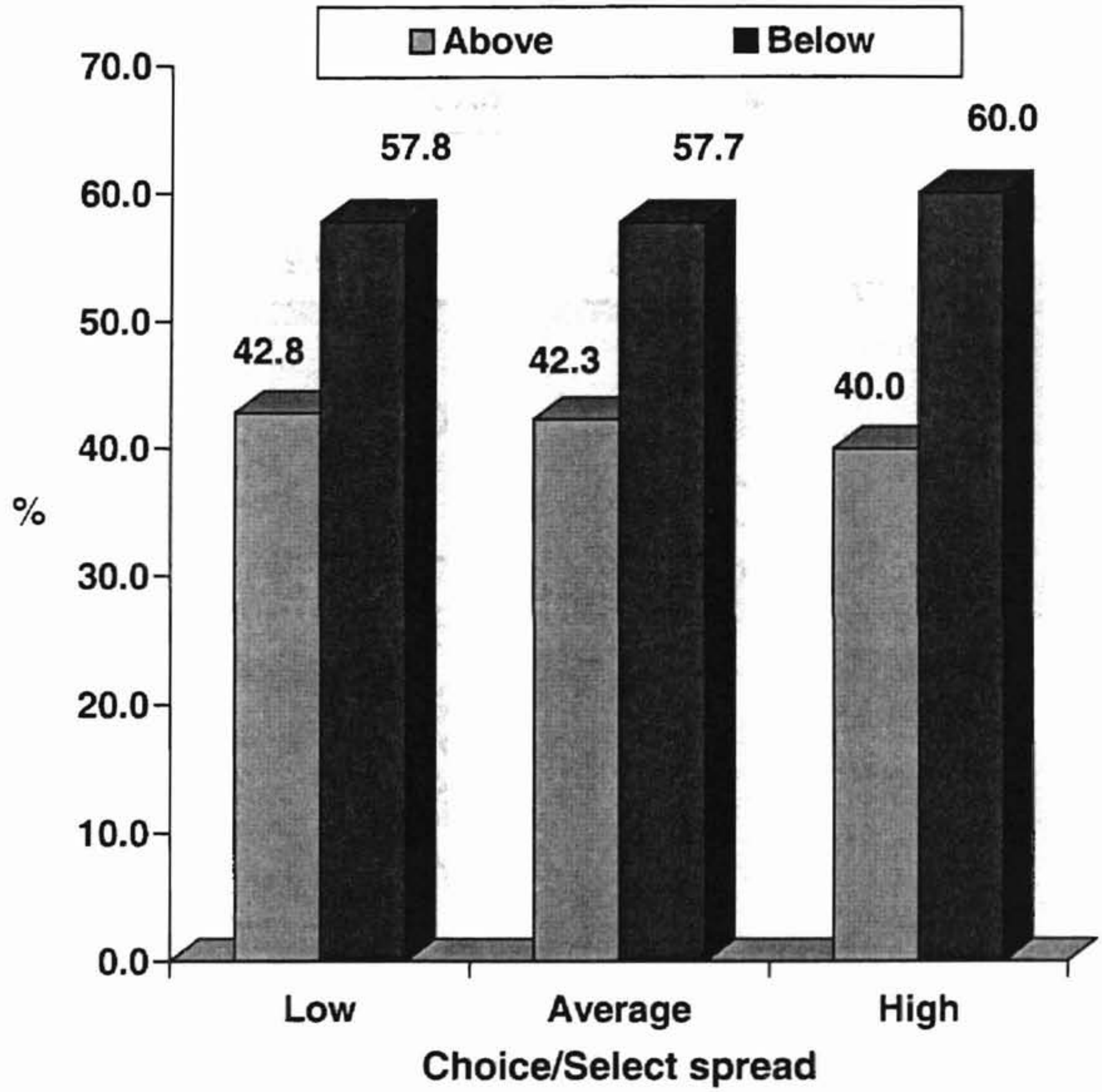
DISTRIBUTION OF MUSCLING (RIBEYE AREA CM^2) FOR PROGENY (n=28,210) CONFORMING TO BEEF FABRICATION SPECIFICATIONS[a]



[a] Estimated by carcass weight to USDA ribeye schedule Thin= < (13.00) cm^2 ; Slightly Thin= (13.00) – (6.45) cm^2 ; Normal= (6.45) - 6.45 cm^2 ; Moderate= 6.45 – 13.00 cm^2 ; Heavy= > 13.00. cm^2

APPENDIX V

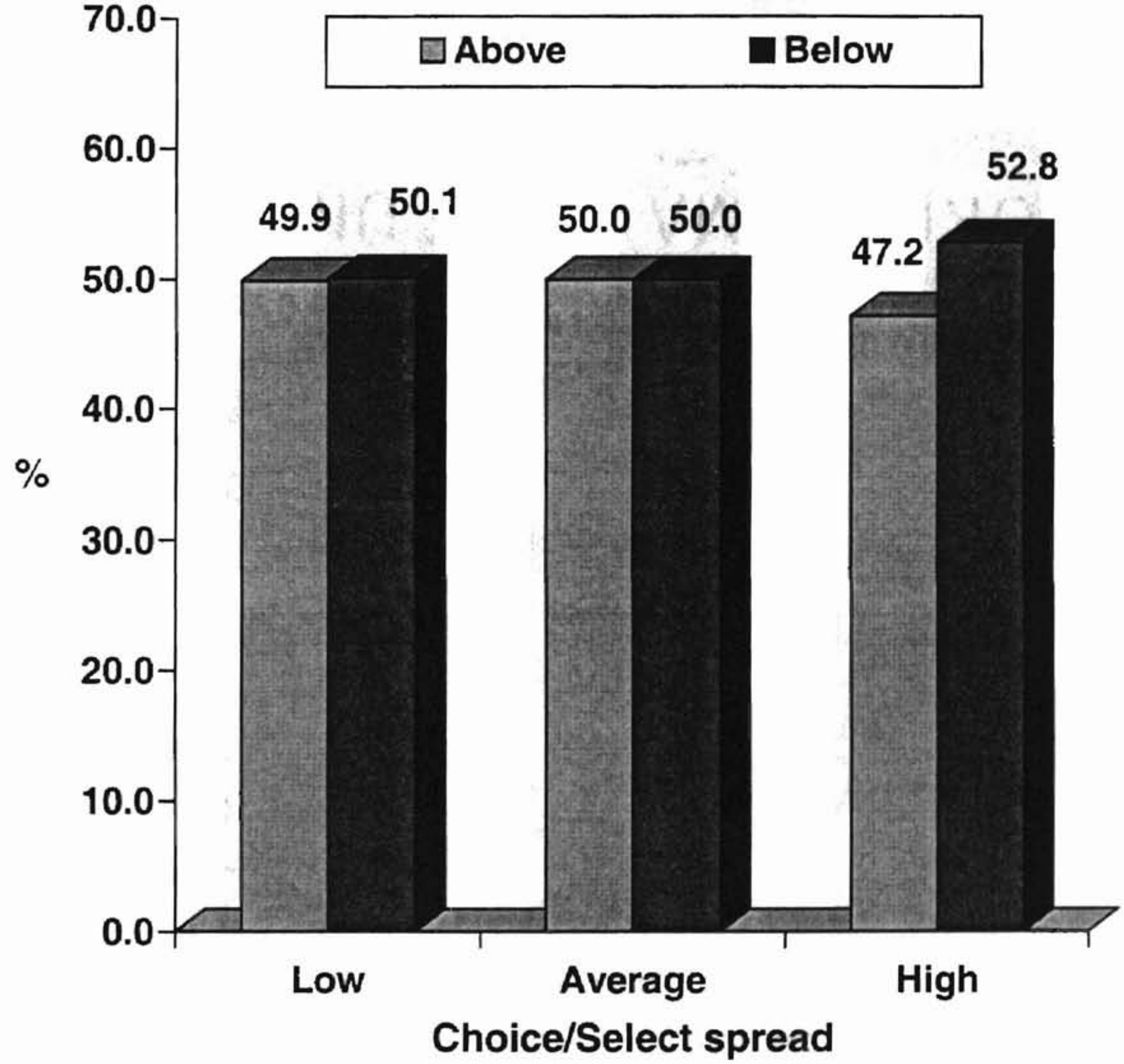
PERCENT OF ALL PROGENY (n=33,350) ABOVE AND BELOW THE AVERAGE BENCHMARK ($/45.4 kg) FOR THE LOW, AVERAGE, AND HIGH QUALITY GRADE SPREADS[a]



[a] Choice, yield grade 3.00, 350 kg carcass weight: Low spread=$107.56; Average spread=$107.85; High spread=$110.50.

APPENDIX W

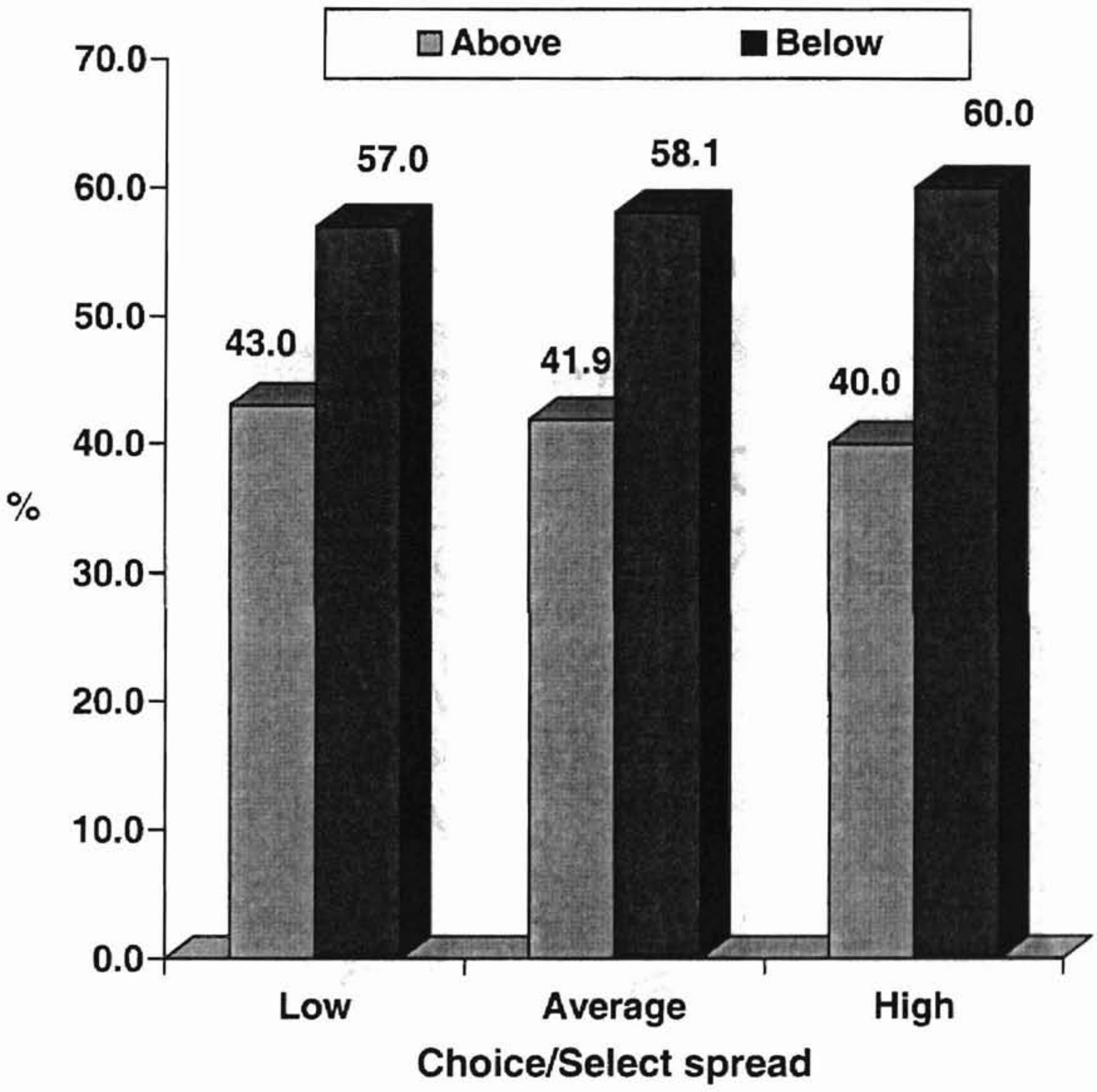
PERCENT OF ALL PROGENY (n=28,210) CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS ABOVE AND BELOW THE AVERAGE BENCHMARK ($/45.4 kg) FOR THE LOW, AVERAGE, AND HIGH QUALITY GRADE SPREADS[a]



[a] Choice, yield grade 3.00, 350 kg carcass weight: Low spread=$107.56; Average spread=$107.85; High spread=$110.50.

APPENDIX X

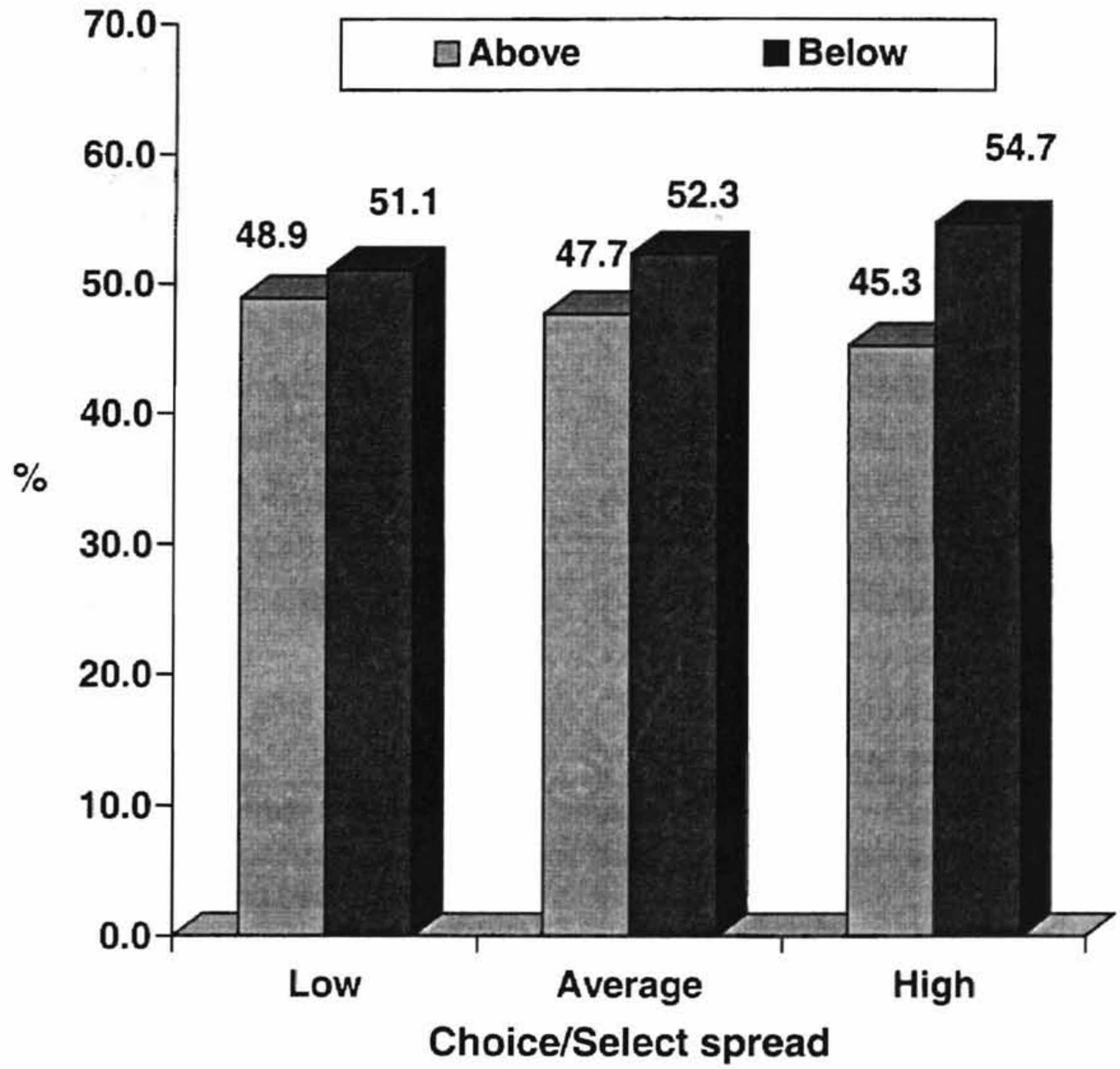
PERCENT OF ALL PROGENY (n=33,350) ABOVE AND BELOW THE AVERAGE CARCASS VALUE ($/hd) BENCHMARK FOR THE LOW, AVERAGE, AND HIGH QUALITY GRADE SPREADS[a]



[a] Low, average and high quality grade spread benchmark prices (Choice, yield grade 3.0, 340 kg carcass weight) X 340 kg carcass weight/45.4 kg: Low spread=$806.70/hd; Average spread=$808.88/hd; High spread=$828.75/hd.

APPENDIX Y

PERCENT OF PROGENY (n=28,210) CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS ABOVE AND BELOW THE AVERAGE CARCASS VALUE ($/hd) BENCHMARK FOR THE LOW, AVERAGE, AND HIGH QUALITY GRADE SPREADS[a]



[a] Low, average and high quality grade spread benchmark prices (Choice, yield grade 3.0, carcass weight 340 kg) X 340 kg carcass weight/45.4 kg: Low spread=$806.70/hd; Average spread=$808.88/hd; High spread=$828.75/hd.

APPENDIX Z

MEAN CARCASS TRAITS FOR ALL PROGENY DATA (n=33,350)

Traits	Mean	SD	Minimum	Maximum
Quality grade[a]	2.85	0.85	1.00	5.00
Marbling score[b]	5.77	1.02	2.06	10.[illegible]
KPH, %[c]	2.33	0.62	0.30	5.90
Ribeye area, cm^2	79.79	8.84	46.05	134.03
Fat thickness, cm	1.37	.41	.05	4.04
Carcass weight, kg	337.93	40.10	204.26	473.10
Yield grade	3.18	0.67	1.00	5.99
Retail product, %	62.66	2.67	48.60	75.58
Box yield, %	67.22	2.19	61.24	79.36
Box yield w/o lean trim, %	52.09	1.98	45.08	60.58
Box major cuts yield, %	40.29	1.64	33.80	47.42
Low quarter, $/45.4 kg	104.83	7.80	69.24	127.32
Average quarter, $/45.4 kg	104.60	8.30	69.52	128.45
High quarter, $/45.4 kg	106.23	9.06	69.22	130.97
Low quarter, $/hd	781.84	112.07	360.99	1128.00
Average quarter, $/hd	780.24	114.72	345.42	1137.00
High quarter, $/hd	792.56	119.72	338.25	1160.00

[a] 1.00 to 1.99 = Prime; 2.00 to 2.99 = premium Choice; 5.00 = Standard.

[b] 10.0 to 10.99=Abundant; 5.0 to 5.99=Small; 2.0 to 2.99=Traces.

[c] Kidney, pelvic and heart fat.

APPENDIX AA

MEAN CARCASS TRAITS FOR PROGENY (n=28,210) CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS

Traits	Mean	SD	Minimum	Maximum
Quality grade[a]	2.81	0.78	1.00	4.00
Marbling score[b]	5.81	0.96	4.00	10.98
KPH, %[c]	2.28	0.59	0.30	5.00
Ribeye area, cm^2	80.82	8.39	52.89	134.03
Fat thickness, cm	1.30	.36	.05	2.90
Carcass weight, kg	338.08	35.60	249.55	430.74
Yield grade	3.06	0.54	1.00	3.99
Retail product, %	63.18	2.15	58.45	75.37
Box yield, %	67.43	1.78	64.51	76.81
Box yield w/o lean trim, %	52.38	1.62	49.61	59.82
Box yield – major, %	40.53	1.32	38.23	46.65
Low quarter, $/45.4 kg	107.73	3.71	97.73	127.32
Average quarter, $/45.4 kg	107.49	4.75	94.42	128.45
High quarter, $/45.4 kg	109.05	6.20	92.26	130.97
Low quarter, $/hd	803.36	92.59	546.22	1128.00
Average quarter, $/hd	801.68	96.07	528.02	1137.00
High quarter, $/hd	813.49	102.46	519.56	1160.00

[a] 1.00 to 1.99 = Prime; 2.00 to 2.99 = premium Choice; 5.00 = Standard.

[b] 10.0 to 10.99=Abundant; 5.0 to 5.99=Small; 4.0 to 4.99=Slight.

[c] Kidney, pelvic and heart fat.

APPENDIX BB

PEARSON (ABOVE DIAGONAL) AND SPEARMAN CORRELATIONS (BELOW DIAGONAL) AMONG CARCASS TRAITS AND CARCASS VALUES FOR ALL PROGENY DATA (n=33,350)

Traits	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Quality grade		-.91	-.35	-.47	-.55	.01**	-.04	-.20	-.21	-.19	.24	.22	.24	.18
2. Marbling score[a]	-.94		.29	.39	.45	.01**	.03	.20	.18	.19	-.24	-.22	-.22	-.18
3. Low $/45.5 kg	-.41	.36		.98	.93	-.27	.49	-.46	.12	-.59	.35	.49	.48	.61
4. Average $/45.5kg	-.52	.47	.97		.98	-.25	.46	-.41	.14	-.53	.31	.43	.43	.55
5. High $/45.5 kg	-.52	.47	.95	.99		-.23	.42	-.35	.14	-.47	.26	.37	.37	.49
6. KPH, %[b]	-.01**	.02	-.26	-.23	-.21		-.12	.13	-.19	.25	-.37	-.20	-.20	-.14
7. Ribeye area, cm^2	-.04	.04	.55	.48	.45	-.11		-.04	.51	-.44	.27	.35	.33	.46
8. Fat thickness, cm	-.20	.21	-.49	-.41	-.39	.11	-.03		.30	.82	-.76	-.81	-.81	-.81
9. Carcass weight, kg	-.18	.18	.08	.08	.07	-.17	.50	.30		.32	-.50	-.44	-.45	-.24
10. Yield grade	-.19	.20	-.67	-.56	-.55	.23	-.42	.80	.31		-.92	-.98	-.98	-.99
11. Box yield, %	.22	-.23	.57	.48	.47	-.35	.30	-.77	-.43	-.95		.98	.98	.89
12. Box yield w/o lean trim, %	.21	-.22	.61	.51	.50	-.18	.34	.80	-.41	-.99	.99		1.0	.96
13. Box major cuts yield, %	.21	-.22	.60	.51	.49	-.18	.32	.80	-.42	-.98	.99	1.0		.96
14. Retail product, %	.18	-.19	.69	.58	.56	-.15	.44	-.79	-.24	-.99	.93	.96	.96	

[a] 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.

[b] Kidney, pelvic and heart fat.

** (P>.05); all other correlations (P<.001).

APPENDIX CC

PEARSON (ABOVE DIAGONAL) AND SPEARMAN CORRELATIONS[a] (BELOW DIAGONAL) AMONG CARCASS TRAITS AND CARCASS VALUES FOR PROGENY (n=28,210) CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS

Traits	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Quality grade		-.90	-.50	-.69	-.73	-.02	-.03	-.17	-.13	-.16	.18	.17	.18	.15
2. Marbling score[a]	-.93		.43	.57	.59	.03	.02	.17	.12	.16	-.18	-.17	-.17	-.15
3. Low $/45.5 kg	-.40	.44		.95	.86	-.21	.56	-.48	.13	-.71	.65	.68	.67	.73
4. Average $/45.5kg	-.65	.59	.96		.98	-.16	.45	-.32	.14	-.51	.45	.47	.47	.52
5. High $/45.5 kg	-.64	.58	.92	.99		-.12	.35	-.22	.13	-.36	.31	.33	.33	.37
6. KPH, %[c]	-.03	.03	-.19	-.15	-.13		-.06	.07	-.19	.20	-.35	-.17	-.16	-.14
7. Ribeye area, cm^2	-.04	.04	.54	.44	.40	-.05		.05	.54	-.46	.34	.38	.37	.47
8. Fat thickness, cm	-.17	.18	-.47	-.34	-.33	.06	.05		.23	.74	-.71	-.73	-.73	-.72
9. Carcass weight, kg	-.13	.14	.13	.13	.11	-.17	.54	.23		.24	-.38	-.35	-.36	-.16
10. Yield grade	-.15	.16	-.70	-.53	-.51	.19	-.42	.74	.24		-.95	.99	.99	-.99
11. Box yield, %	.17	-.18	.64	.49	.48	-.34	.32	-.71	-.35	-.96		.99	.99	.93
12. Box yield w/o lean trim, %	.17	-.18	.66	.50	.49	-.16	.34	-.73	-.34	-.99	.99		1.0	.96
13. Box major cuts yield, %	.17	-.18	.66	.50	.48	-.15	.33	-.73	-.35	-.99	.99	1.0		.96
14. Retail product, %	.14	-.15	.71	.55	.52	-.13	.44	-.72	-.16	-.99	.93	.96	.96	

[a] All correlations (P<.001).

[b] 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.

[c] Kidney, pelvic and heart fat.

APPENDIX DD

BOXED BEEF VALUE ($/45.4 kg) PREDICTIONS DURING THE LOW PRICING CHOICE/SELECT SPREAD FOR ALL PROGENY DATA

	Carcass Traits											
Intercept	RET[a]	YG[b]	BBY/LT[c]	MARB[d]	BBYM[e]	BBY[f]	CWT[g]	FAT[h]	REA[i]	R^2	RSD	Cp
-7.46	1.79									.3771	6.16	40879.86
-208.73	4.46	10.78								.3934	6.08	
762.79		-37.14	-10.36							.5954	4.96	14868.35
679.05		-34.58	-9.21	2.69						.7113	4.19	1065.03
709.84		-35.32	-14.10	2.70	5.61					.7125	4.18	914.93
1391.11		-71.60	-30.24	2.69		7.72	-.05			.7170	4.15	383.16
2063.08		-108.64	-37.58	2.69	-16.81	15.55	-.11			.7198	4.13	47.67
2054.68	.33	-108.18	-37.82	2.69	-17.15	15.75	-.12			.7200	4.13	30.46
2085.53		-110.77	-37.99	2.69	-17.06	15.79	-.11	1.23	-.05	.7201	4.13	26.75
2133.41	-.66	-114.64	-37.96	2.69	-16.88	15.72	-.09	2.76	-.14	.7201	4.13	15.57

[a] Retail product, %.
[b] Yield grade= 1.00 to 5.99 (USDA, 1997).
[c] Boxed beef yield without lean trim, %.
[d] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[e] Boxed beef major cuts yield, %.
[f] Boxed beef yield, %.
[g] Carcass Weight, kg.
[h] Fat thickness, cm.
[i] Ribeye area cm^2.

APPENDIX EE

BOXED BEEF VALUE ($/45.4 kg) PREDICTIONS DURING THE HIGH CHOICE/SELECT SPREAD FOR ALL PROGENY DATA

	Carcass Traits											
Intercept	**RET**[a]	**MARB**[b]	**YG**[c]	**BBY/LT**[d]	**BBYM**[e]	**BBY**[f]	**CWT**[g]	**FAT**[h]	**REA**[i]	R^2	**RSD**	**Cp**
2.88	1.65									.2368	7.92	41489.73
-47.37	1.99	4.97								.5377	6.16	11983.88
-176.79	3.71	4.90	6.97							.5427	6.13	
651.31		4.47	-33.62	-8.90						.6514	5.35	838.82
689.63		4.47	-34.54	-14.99	6.99					.6529	5.34	697.15
1526.13		4.46	-79.30	-34.98		9.66	-.06			.6576	5.30	234.39
2198.10		4.46	-116.33	-42.32	-16.81	17.49	-.12			.6597	5.29	30.60
2191.29	.26	4.46	-115.96	-42.51	-17.08	17.66	-.13			.6598	5.29	24.91
2218.39		4.46	-118.26	-42.69	-17.03	17.71	-.12	1.12	-.05	.6599	5.29	16.48
2283.26	-.89	4.46	-123.50	-42.65	-16.78	17.62	-.09	3.19	-.16	.6600	5.29	10.00

[a] Retail product, %.
[b] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[c] Yield grade= 1.00 to 5.99 (USDA, 1997).
[d] Boxed beef yield without lean trim, %.
[e] Boxed beef major cuts yield, %.
[f] Boxed beef yield, %.
[g] Carcass Weight, kg.
[h] Fat thickness, cm.
[i] Ribeye area cm^2.

APPENDIX FF

BOXED BEEF VALUE ($/hd) PREDICTIONS DURING THE LOW CHOICE/SELECT SPREAD FOR ALL PROGENY DATA

	Carcass Traits											
Intercept	CWT[a]	YG[b]	MARB[c]	BBY/LT[d]	BBY[e]	BBYM[f]	RET[g]	FAT[h]	REA[i]	R^2	RSD	Cp
-31.79	2.41									.7424	56.89	93249.92
55.45	2.74	-63.06								.8688	40.59	31133.27
-26.73	2.67	-67.94	21.24							.9040	34.72	13814.63
-368.43	2.64	-49.07	21.24				4.63			.9042	34.69	
3724.57	2.27	-232.62	19.67	-59.21						.9244	30.82	3821.83
15574.94	1.49	-855.30	19.58	-417.29	134.59					.9319	29.24	119.06
17416.45	1.32	-956.79	19.57	-437.41	156.06	-46.08				.9320	29.22	70.40
17363.73	1.31	-953.93	19.57	-438.92	157.33	-48.17	2.04			.9321	29.21	57.30
17584.86	1.37	-972.85	19.54	-440.63	157.85	-47.75		9.46	-.39	.9321	29.20	31.77
18184.80	1.58	-1021.24	19.55	-440.29	157.00	-45.39	-8.22	28.65	-1.42	.9322	29.19	10.00

[a] Carcass Weight, kg.
[b] Yield grade= 1.00 to 5.99 (USDA, 1997).
[c] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[d] Boxed beef yield without lean trim, %.
[e] Boxed beef yield, %.
[f] Boxed beef major cuts yield, %.
[g] Retail product, %.
[h] Fat thickness, cm.
[i] Ribeye area cm^2.

APPENDIX GG

BOXED BEEF VALUE ($/hd) PREDICTIONS DURING THE HIGH CHOICE/SELECT SPREAD FOR ALL PROGENY DATA

	Carcass Traits											
Intercept	CWT[a]	YG[b]	MARB[c]	BBY/LT[d]	BBY[e]	BBYM[f]	RET[g]	FAT[h]	REA[i]	R^2	RSD	Cp
-50.13	2.49									.6978	65.81	66702.22
32.16	2.81	-59.48								.7963	54.03	34082.08
-99.73	2.69	-67.31	34.09							.8759	42.18	7747.50
-395.78	2.67	-50.96	34.09				4.01			.8760	42.16	
3405.95	2.32	-221.21	32.62	-55.33						.8914	39.45	2598.38
16169.19	1.48	-891.86	32.52	-441.00	144.96					.8991	38.03	61.46
17658.56	1.35	-973.94	32.51	-457.27	162.32	-37.27				.8992	38.02	43.89
17614.54	1.33	-971.55	32.52	-458.53	163.38	-39.01	1.71			.8992	38.01	39.68
17139.85	1.78	-970.76	32.51	-443.95	146.12		-10.50	32.58	-1.65	.8992	38.01	26.22
18527.03	1.64	-1046.24	32.50	-459.68	162.95	-36.15	-9.80	31.29	-1.59	.8993	38.00	10.00

[a] Carcass Weight, kg.
[b] Yield grade= 1.00 to 5.99 (USDA, 1997).
[c] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[d] Boxed beef yield without lean trim, %.
[e] Boxed beef yield, %.
[f] Boxed beef major cuts yield, %.
[g] Retail product, %.
[h] Fat thickness, cm.
[i] Ribeye area cm^2.

APPENDIX HH

BOXED BEEF VALUE ($/45.4 kg) PREDICTIONS DURING THE LOW CHOICE/SELECT SPREAD FOR DATA CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS

	Carcass Traits											
Intercept	RET[a]	MARB[b]	CWT[c]	BBY/LT[d]	BBY[e]	YG[f]	FAT[g]	BBYM[h]	REA[i]	R^2	RSD	Cp
28.21	1.26									.5324	2.54	93018.41
6.69	1.40	2.14								.8292	1.53	16076.56
-3.13	1.45	2.06	.02							.8685	1.35	
-26.36		2.08	.04	2.07						.8909	1.23	77.81
47.25		2.08	.03		.72	-3.82				.8911	1.23	26.43
99.12		2.08	.03	-1.51	1.27	-6.54				.8912	1.23	17.80
98.48		2.08	.03	-1.49	1.26	-6.55	.09			.8912	1.23	12.42
133.41		2.08	.03	-1.55	1.68		.08	-1.31		.8912	1.22	8.84
136.32		2.08	.03	-1.59	1.71	-8.75	.18	-1.37	-.01	.8912	1.22	8.30
140.66	-.05	2.08	.03	-1.57	1.71	-9.09	.31	-1.39	-.01	.8912	1.22	10.00

[a] Retail product, %.
[b] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[c] Carcass Weight, kg.
[d] Boxed beef yield without lean trim, %.
[e] Boxed beef yield, %.
[f] Yield grade= 1.00 to 5.99 (USDA, 1997).
[g] Fat thickness, cm.
[h] Boxed beef major cuts yield, %.
[i] Ribeye area cm^2.

APPENDIX II

BOXED BEEF VALUE ($/45.4 kg) PREDICTIONS DURING THE HIGH CHOICE/SELECT SPREAD FOR DATA CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS

	Carcass Traits											
Intercept	MARB[a]	RET[b]	CWT[c]	BBYM[d]	BBY/LT[e]	FAT[f]	BBY[g]	YG[h]	REA[i]	R^2	RSD	Cp
86.85	3.82									.3482	5.01	16697.94
-1.46	4.29	1.36								.5643	4.09	1808.77
-12.40	4.20	1.41	.02							.5819	4.01	
-30.72	4.22		.04	2.48						.5897	3.97	64.52
-24.12	4.22		.05	6.26	-3.06					.5898	3.97	56.73
-25.93	4.22		.05	6.25	-3.03	.19				.5899	3.97	55.29
-24.28	4.22	.10	.04	6.52	-3.38	.20				.5899	3.97	54.74
522.71	4.22			-4.36	-12.06	.56	6.50	-31.70	-.02	.5906	3.97	8.53
471.51	4.22		.01	-2.71	-10.91	.61	5.58	-27.33	-.02	.5906	3.97	9.06
498.16	4.22	-.33	.02	-2.82	-10.81	1.41	5.58	-29.45	-.07	.5907	3.97	10.00

[a] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[b] Retail product, %.
[c] Carcass Weight, kg.
[d] Boxed beef major cuts yield, %.
[e] Boxed beef yield w/o lean trim, %.
[f] Fat thickness, cm.
[g] Boxed beef yield, %.
[h] Yield grade= 1.00 to 5.99 (USDA, 1997).
[i] Ribeye area cm^2.

APPENDIX JJ

BOXED BEEF VALUE ($/hd) PREDICTIONS DURING THE LOW CHOICE/SELECT SPREAD FOR DATA CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS

	Carcass Traits											
Intercept	CWT[a]	BBYM[b]	MARB[c]	BBY/LT[d]	REA[e]	BBY[f]	YG[g]	FAT[h]	RET[i]	R^2	RSD	Cp
-36.56	2.48									.9122	27.43	230593.89
-691.16	2.58								9.86	.9634	17.70	
-820.18	2.72	17.38								.9655	17.20	73596.74
-966.95	2.69	19.03	15.34							.9898	9.36	1927.94
-865.22	2.73	77.29	15.35	-47.25						.9899	9.29	1482.52
-856.81	2.72	77.77	15.33	-47.81	.05					.9899	9.29	1466.02
-872.71	2.72	74.05	15.34	-45.68	.05	.83				.9899	9.29	1451.25
5258.77	2.21	-36.54	15.34	-143.10		69.76	-332.83			.9904	9.06	11.41
5244.06	2.21	-36.13	15.33	-142.97		69.58	-332.23	.50		.9904	9.06	8.83
5264.09	2.21	-36.58	15.34	-143.19	-.04	69.82	333.89	1.17		.9904	9.06	8.62
5310.41	2.23	-36.78	15.34	-143.02	-.11	69.82	-337.58	2.55	-.58	.9904	9.06	10.00

[a] Carcass Weight, kg.
[b] Boxed beef major cuts yield, %.
[c] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[d] Boxed beef yield w/o lean trim, %.
[e] Ribeye area cm^2.
[f] Boxed beef yield, %.
[g] Yield grade= 1.00 to 5.99 (USDA, 1997).
[h] Fat thickness, cm.
[i] Retail product, %.

APPENDIX KK

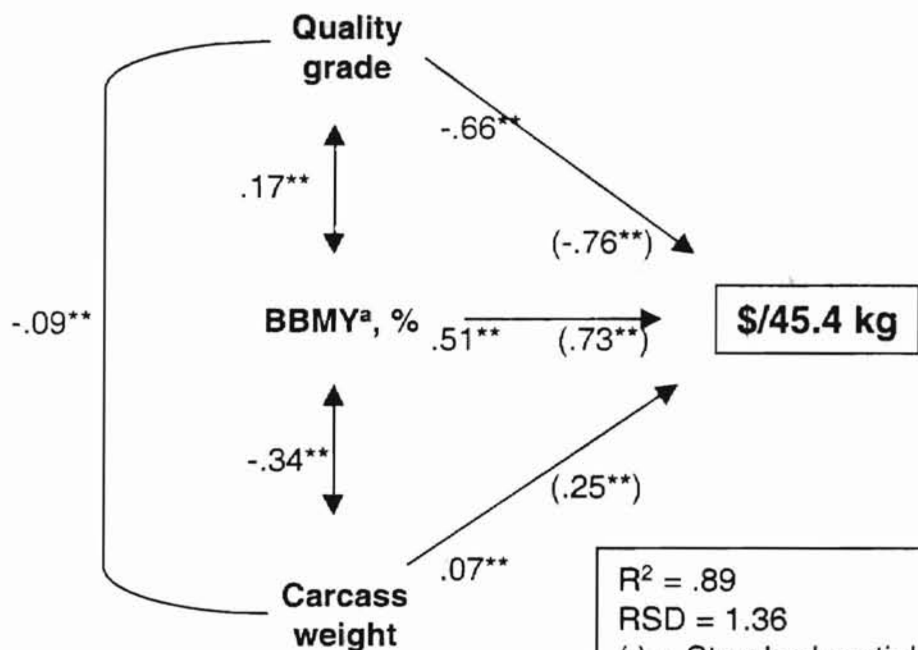
BOXED BEEF VALUE ($/hd) PREDICTIONS DURING THE HIGH CHOICE/SELECT SPREAD FOR DATA CONFORMING TO BOXED BEEF FABRICATION SPECIFICATIONS

	Carcass Traits											
Intercept	CWT[a]	MARB[b]	BBYM[c]	BBY/LT[d]	BBY[e]	YG[f]	RET[g]	FAT[h]	REA[i]	R^2	RSD	Cp
-59.76	2.58									.8053	45.21	40711.36
-189.84	2.49	27.57								.8707	36.85	17575.58
-902.41	2.58	30.75					10.50			.9173	29.47	
-1043.25	2.73	30.91	18.58							.9194	29.09	329.79
-876.78	2.79	30.93	113.91	-77.33						.9197	29.03	214.32
5617.35	2.25	30.93		-185.56	74.97	-352.95				.9203	28.93	12.28
6285.09	2.18	30.93	-25.03	-186.69	83.03	-390.51				.9203	28.92	10.61
6275.91	2.17	30.94	-26.51	-187.93	83.98	-390.03	1.14			.9203	28.92	8.77
6356.84	2.20	30.93	-26.53	-187.53	83.86	-397.43		3.97	-.17	.9203	28.92	8.57
6498.53	2.25	30.93	-27.13	-187.01	83.86	-408.72	-1.78	8.21	-.40	.9203	28.92	10.00

[a] Carcass Weight, kg.
[b] Marbling score= 10.00 to 10.99=Abundant; 9.00 to 9.99=Moderately abundant; 8.00 to 8.99=Slightly abundant; 7.00 to 7.99=Moderate; 6.00 to 6.99=Modest; 5.00 to 5.99=Small; 4.00 to 4.99=Slight; 3.00 to 3.99=Traces; 2.00 to 2.99=Practically devoid.
[c] Boxed beef major cuts yield, %.
[d] Boxed beef yield w/o lean trim, %.
[e] Boxed beef yield, %.
[f] Yield grade= 1.00 to 5.99 (USDA, 1997).
[g] Retail product, %.
[h] Fat thickness, cm.
[i] Ribeye area cm^2.

APPENDIX LL

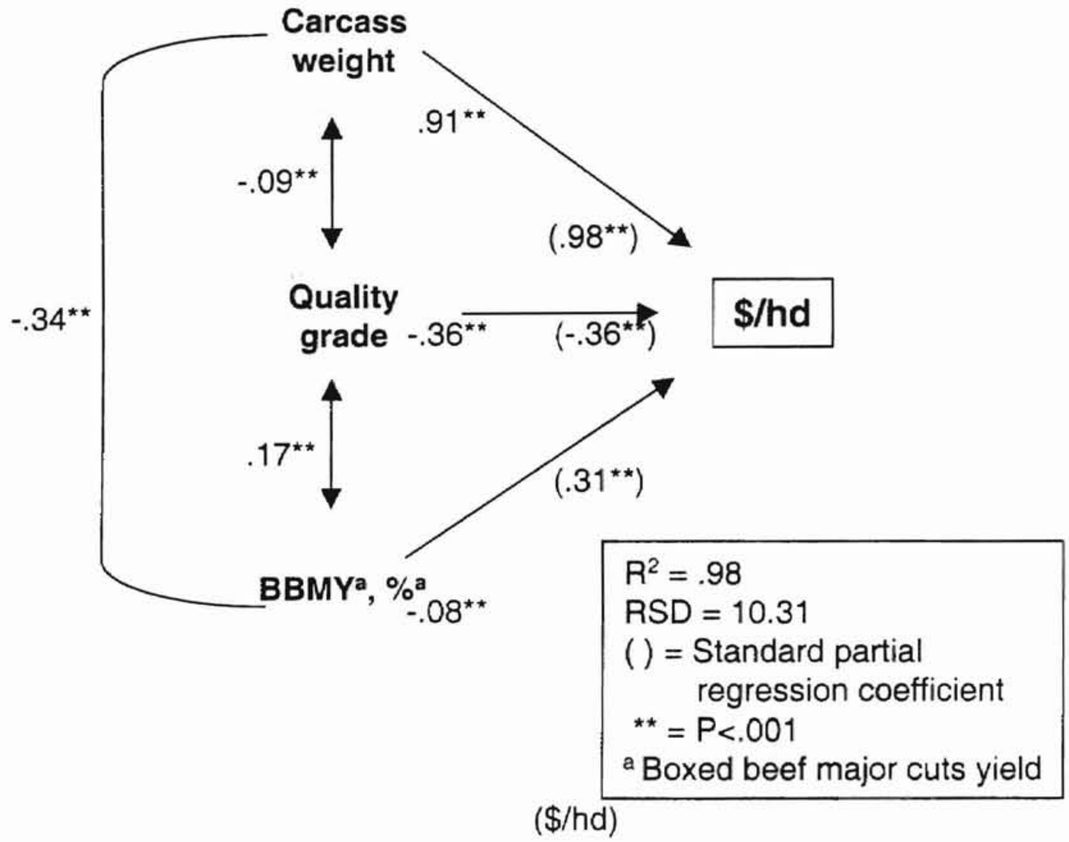
PATH COEFFICIENT DIAGRAM OF QUALITY GRADE PERCENTAGE BOXED BEEF MAJOR CUTS YIELD, AND CARCASS WEIGHT FOR CARCASS PRICE ($/45.4 kg)



$R^2 = .89$
RSD = 1.36
( ) = Standard partial regression coefficient
** = P<.001
[a] Boxed beef major cuts yield

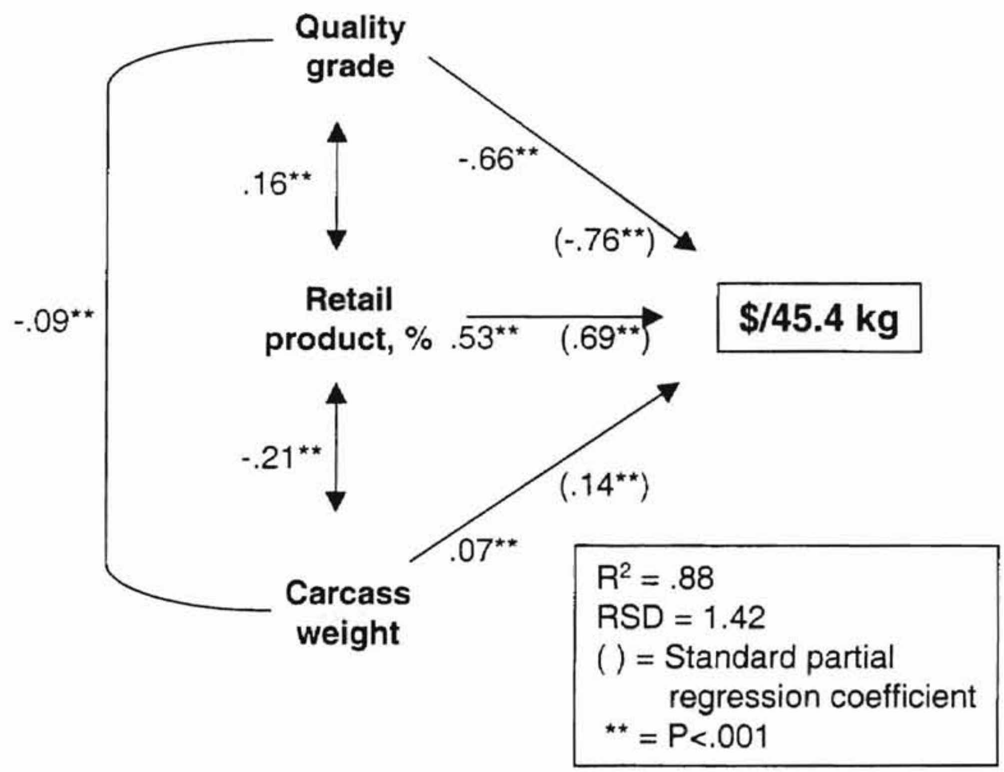
APPENDIX MM

PATH COEFFICIENT DIAGRAM OF QUALITY GRADE, PERCENTAGE BOXED BEEF MAJOR CUTS YIELD, AND CARCASS WEIGHT FOR CARCASS VALUE



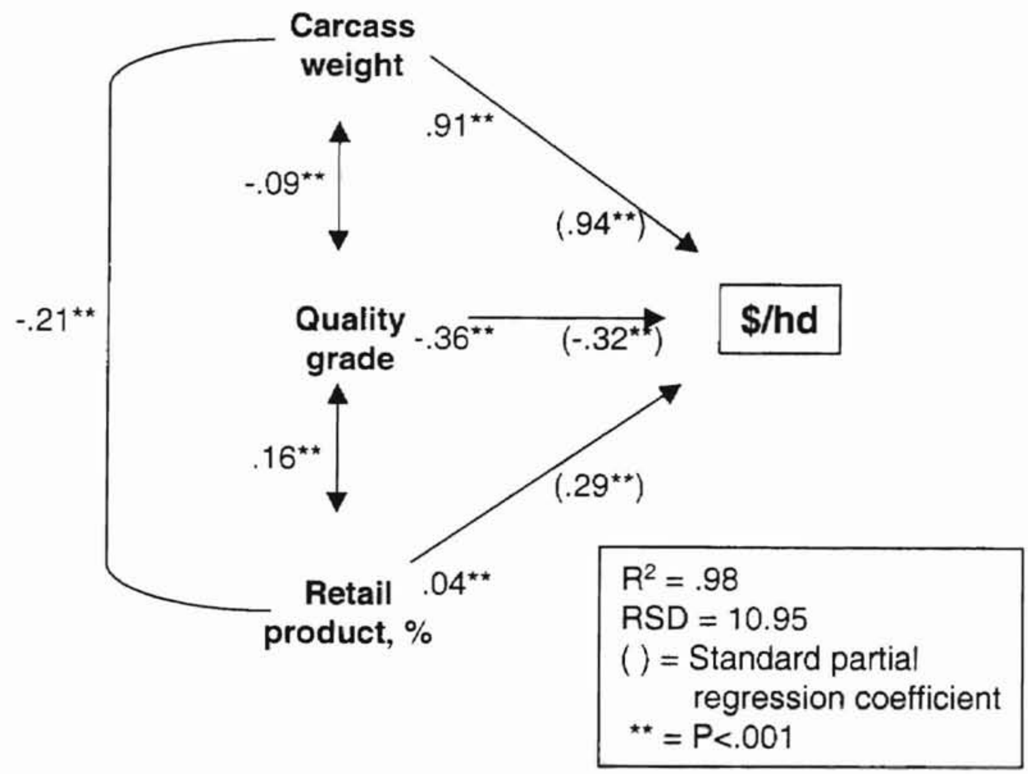
APPENDIX NN

PATH COEFFICIENT DIAGRAM OF QUALITY GRADE, PERCENTAGE RETAIL PRODUCT, AND CARCASS WEIGHT FOR CARCASS PRICE ($/45.4 kg)



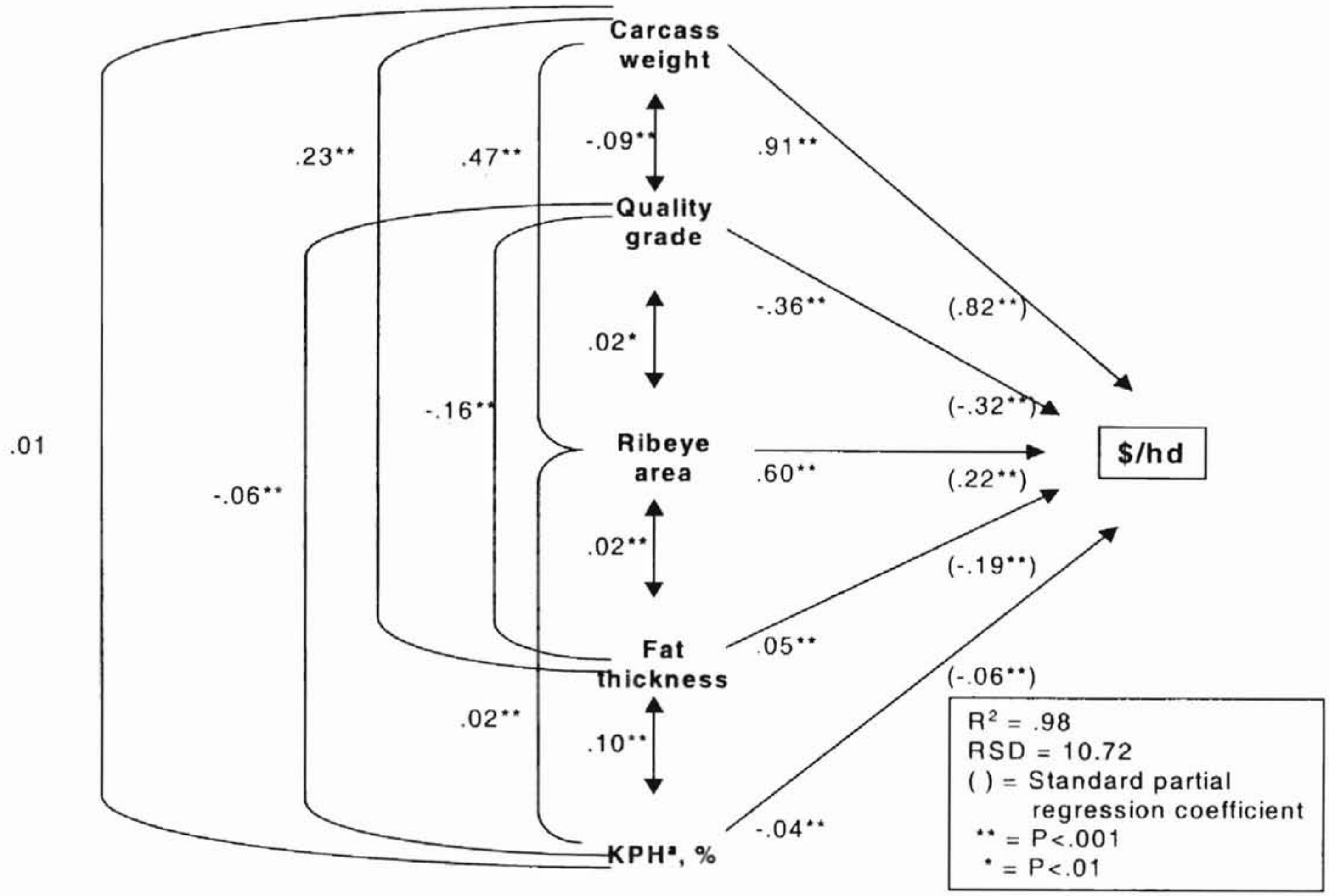
APPENDIX OO

PATH COEFFICIENT DIAGRAM OF QUALITY GRADE, PERCENTAGE RETAIL PRODUCT, AND CARCASS WEIGHT FOR CARCASS VALUE ($/hd)



APPENDIX PP

PATH COEFFICIENT DIAGRAM OF QUALITY GRADE, RIBEYE AREA, FAT THICKNESS, CARCASS WEIGHT, AND PERCENTAGE KIDNEY, PELVIC, AND HEART FAT FOR CARCASS VALUE ($/hd)



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