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Breed Performance Trends and Price-Performance Relationship in 13 Years of Missouri Tested Bull Sales

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Chapter 1

INTRODUCTION

For centuries, cattle breeders relied upon visual appraisal as a means of selecting breeding stock. Selection trends were determined largely by showring placings. Showring placings are highly subjective and selection based entirely upon visual appraisal of conformation has been shown to be ineffective or even undesirable (Gregory *et al.*, 1964).

Patterson *et al.* (1949) and Chapman *et al.* (1972) found insignificant and negative correlations between type and average daily gain. Chapman *et al.* (1969) found that selection for type resulted in lower post weaning average daily gains ($P < .05$).

Within the last fifty years, beef cattle producers have begun to adopt performance testing as an alternative means of selection. Performance testing is considered a way to measure traits of real economic value to the producer, giving him guides in selecting animals that are actually faster gaining, and more efficient.

The idea of performance testing was discussed and finally implemented in the early 1930s. The first research was initiated by the United States Department of Agriculture at the U.S. Range Livestock Research Station, Miles City, Montana. From 1935 to 1945, U.S.D.A. continued their research and expanded it into programs in New Mexico and California.

U.S.D.A. Feeder Cattle Grade Standards were developed and the first central bull testing station was established at Balmorhea, Texas, in 1941. Between 1945 and 1955 the first extension Beef Cattle Improvement Associations were established in California, New Mexico, and Montana. These programs were soon adopted in several other states.

In 1954, the Red Angus Association was formed, requiring performance data on all pedigrees. In 1955, the Performance Registry International was established to promote performance testing and record keeping within all breeds.

The Angus Herd Improvement Record program was established in 1959 and the American Hereford Association's Total Performance Record program in 1964. Charolais breeders and many of the new exotic breed associations have placed a special emphasis on performance data. This has given the producers of the established breeds an extra incentive to promote and strengthen their own testing programs.

Organized performance testing programs began to develop in Missouri in the late 1950s. In 1962, a group of livestock producers and faculty of the University of Missouri Animal Husbandry Department met to develop guidelines for a Missouri Performance Tested Bull Sale.

The objectives of the committee were:

(1) to provide a supply of performance tested breeding stock to meet the current demand within the state, and

(2) to utilize these sales as an educational tool to promote performance testing throughout the state.

The committee was successful in organizing a sale and in November, 1963, the first performance tested bull sale in Missouri was held at the University Livestock Pavillion. Bulls entered in the sale had been tested at the University of Missouri Bull Testing Station or in the Missouri On-Farm Testing Program administered by the Extension Service. Since then, over 20 performance tested bull sales have been held at the University Pavillion and Livestock Center and at present five other district sales are held throughout the state.

The number of testing stations has increased. The University maintains stations at Columbia and Spickard and several private testing stations have been established.

In December, 1967, an organizational meeting of the Missouri Beef Cattle Improvement Association (MBCIA) was held. By-laws of the association were adopted in November of 1968 and the association was officially chartered as a non-profit corporation in July, 1969.

The association currently maintains two programs. The Plan A program records performance data from birth to weaning and the Plan B program records postweaning and yearling performance data. At present, the association is composed of approximately 1,400 members and maintains records on approximately 17,000 beef cows and their progeny at the state level and equally as many at the county level.

Purpose of Study

This study was undertaken to:

(1) investigate the relationship between performance traits and sale price,

(2) investigate the relationship between sale day condition and mode of presentation of the animal to sale price,

(3) establish the relative impact of performance testing through an analysis of trends in the individual performance traits, and

(4) measure the relative trends in breed numbers as evidenced by a frequency count of animals sold through the Missouri Performance Tested Bull Sales.

Methods of Investigation

The methods of investigation employed in the study included:

(1) analysis of data from past performance sale records through use of the Statistical Analysis System (SAS) package,

(2) computation of correlation coefficients between performance data, sale day data, and sale price,

(3) computation of mean values within year, within breed and within pooled data and calculation of trend lines utilizing the mean values and regression coefficients, and

(4) computation of a price ratio for each individual within each sale with the mean price paid equal to 100, in order to correct for changing market conditions and inflation and their effect upon price in comparisons between years.

Chapter 2

REVIEW OF THE LITERATURE

Performance Testing: Objectives, Development, and Possible Errors in Measurement

Performance testing programs were first established in the early 1930s (Baker, 1976). Early performance testing programs emphasized measurement of weight and rate of gain. Selection based on these traits was encouraged by initial research at the U.S. Range Livestock Experiment Station, Miles City, Montana, which indicated that approximately 72 percent of the variation in feedlot gains was of a hereditary nature (Pahnish, 1951).

Patterson *et al.* (1955) identified rate of gain, efficiency of gain, and reproductive efficiency as the most important factors in economical beef production. They concluded that selection based on performance could increase the volume of meat produced and lower the costs of production.

The need for objective measurements was stated by Orme *et al.* (1959). In a study of the relationship of live animal measurements to carcass measurements they concluded that carcass traits could be more accurately predicted from live animal measurements than from subjective visual appraisal.

Lush (1928), in a detailed study of the changes in body measurements of steers during fattening, found that human error and changes in the animal's position during measurement were serious limits to their validity. They found the usual standard deviation in single weights ranged from 2.73 to 5.45 kilograms. They suggested that cattle should be kept comfortable and calm and weighed to the nearest pound for optimal efficiency and accuracy. They found that 42 percent of the errors in single weights could be eliminated by taking an average of three weights taken on consecutive days.

Baker *et al.* (1947) found that three-day average weights were not significantly different from single weights when weaning weights of cattle were obtained under uniform conditions.

Whiteman *et al.* (1954) emphasized the importance of shrink as a source of error in weight measurements. They recorded overnight weight changes ranging from 17.5 to 57.0 kilograms from a base shrunk weight. They concluded by recommending that cattle undergo a shrink period of at least 10 to 15 hours prior to weighing. Another source of measurement error they noted was carryover effects from the pretreatment environment. In a study of the effects of various levels of preweaning nutrition on subsequent growth and development, Stuedemann *et al.* (1968) found that weaning weight, carcass grade, and skeletal scale were significantly affected ($P < .05$). Relative retardation of growth was greatest in fat tissue, followed by muscle and bone, respectively.

The importance of trait ratios as a means of comparing the performance of individuals tested in different stations was emphasized in a study by Wilton and

Batra (1972). They found significant genetic x environmental interactions within breeds at a particular station and within a particular breed at different stations.

Effects of Sale Methods and Performance Data on Sale Price

In a study by Marlowe (1969), factors that significantly influenced sire selection were identified by their relationship with sale price. They were, in order of importance: (1) Conformation, (2) Sale Year, (3) Life Average Daily Gain, (4) Age at Sale Date, and (5) Sale Order, in Angus Bulls. Among Hereford bulls the order was (1) Conformation, (2) Yearling Weight, (3) Sale Year, (4) Breeder, and (5) Life Average Daily Gain.

Warren (1957) found that lifetime ADG, conformation, and weight per day of age were not significantly correlated with sale price. However, when the three traits were combined in an index the "r" value was 0.74 which was highly significant ($P < .01$). Warren also found that ADG, weight per day of age and conformation accounted for 70 percent of the variation in sale price.

Terrill (1953) found sale order, adjusted body weight, type, condition and index to be significantly correlated ($P < .01$) with the sale price of Columbia, Targhee and Rambouillet rams. Body weight was most highly correlated with sale price in this study.

Rutherford *et al.* (1966) conducted a survey of operators of small (3-20 cows), medium (21-50 cows), and large (51-400 cows) herds. Operators were asked to select three factors from a list of 11 and to specify a price normally paid for a herd sire. Conformation and size were the main criteria utilized. However, health, breed type, and breeder reputation were also important factors. Operators of the larger commercial herds paid approximately 25 percent more for their herd bulls.

In a study involving purebred Hereford calves, Marlowe (1964) found that sale year, dwarf status, conformation grade, location of sale, average daily gain, weight, and age (in decreasing order of importance) had a significant influence on sale price. Williamson *et al.* (1961) studied the effects of sale size, lot size, weight, grade, and breed on average price received. There were positive correlations between lot size and price and between conformation grade and price. A preference for purebred calves, and Angus and Hereford calves in particular, was indicated by sale price.

Conformation

Conformation or type scores appear to be lowly to moderately heritable. Brown and Gacula (1964) obtained a heritability estimate of 0.15; Chapman *et al.* (1972) found heritability of 0.23, and Lasley (1972) averaged many reported heritability estimates for weaning score and obtained an estimate of 0.33.

Conformation is a difficult trait to measure because of the changing trends of the industry and because visual appraisal is a subjective type of measurement and more prone to error.

Lewis *et al.* (1969) found the standard deviation in live animal evaluation of U.S.D.A. quality grade to be from 1.4 to 2.2 grades. Correlations of live estimates with actual carcass grades in this study ranged from 0.40 to 0.71 and were significant ($P < .01$).

Wilson *et al.* (1964) estimated cutability percentage and quality grade and obtained correlations of 0.44 and 0.25, respectively. These correlations were significant ($P < .01$) and the investigators suggested that the prediction of carcass yield on a percent basis could be done more accurately than estimation of quality grade.

This suggestion was reinforced by an experiment of Gregory *et al.* (1964) in which correlations of live estimates with carcass cutability ranged from 0.54 to 0.71 and "r" values for slaughter grade ranged from 0.45 to 0.61. Gregory attributed the decreased accuracy in estimation of carcass grade to the influence of marbling, which could not be effectively estimated.

Chapman *et al.* (1972) found a positive correlation between weaning weight and type score ($r = .25$). However, they also computed a negative correlation coefficient for the relationship of type to postweaning average daily gain ($r = -0.42$). Patterson *et al.* (1949) obtained slightly negative correlations between initial weight and initial grade and between type score and average daily gain. However, Patterson did report a highly positive correlation ($r = 0.724$) between initial and final grades.

In a single trait selection experiment by Chapman *et al.* (1969), selection for type resulted in lower post-weaning average daily gains, in lighter carcass weights ($P < .05$) than the unselected control line, and substantially lighter carcass weights than lines selected for increased rate of gain and heavier weaning weights ($P < .05$).

Weight Measurements

Weaning Weight

Weaning weight in beef cattle seems to be moderately heritable. Gaskins *et al.* (1975) calculated a heritability estimate of 0.22, Chapman *et al.* (1972) obtained a value of 0.34, High (1970) computed an estimate of 0.50, Knapp and Nordskog (1946) stated that weaning weight was not heritable and Lasley (1972) averaged the estimates from 11 studies and obtained a mean heritability of 0.25.

The moderate heritability of weaning weight indicates that the trait is affected by environment as well as genetics. Harwin *et al.* (1966) found significant ($P < .05$) genetic x environmental interactions between year and age of dam and between year and age of calf. Harwin concluded that in poor years calves from two-year-old dams and younger calves suffer considerably more than older calves and calves of mature dams.

Gifford (1953) investigated the relationship between accumulated milk production of the dam and 6 month weight of the offspring and obtained a correlation of 0.65, which was significant ($P < .01$). Rutledge *et al.* (1971) attributed 60 percent of the variance in 205-day weights to differences in milk production of the dam. They obtained peak milk yield at 8.4 years of age and concluded that milk quantity affected calf gains more than milk quality.

Koch and Clark (1955) observed significant age of dam effects on weaning weight. Milk production peaked at six years of age in their study. Koch and Clark also observed a sex influence on weaning weight. Male calves averaged 11.9 kilograms heavier. Benyshek and Marlowe (1973) found a slight relationship between cow weight and 205-day weight of her calves; linear regression coefficients ranged from 0.07 ± 0.02 to 0.11 ± 0.02 kilogram per kilogram of cow weight.

In selection for weaning weight, correlations between weaning weight and other economic traits are important. Koger and Knox (1951) found that weaning weight was not significantly correlated with yearling pasture gain ($r = 0.04$, 0.09) and only slightly correlated with average daily gain ($r = 0.28$).

Lindholm and Stonaker (1957) found a low correlation between weaning weight and average daily gain ($r = 0.07$) and a highly significant negative correlation between weaning weight and total feedlot gain ($r = -0.45$, ($P < .01$). Costs of production and relative economic value of each trait were used to calculate net income. Weaning weight was significantly correlated with net income) $r = 0.80$, ($P < .01$). Koch *et al.* (1974) found weaning weight to be significantly correlated with yearling weight ($r = 0.733$) and slightly correlated with postweaning average daily gain ($r = 0.203$).

Koch and others found that sire selection represented 79 percent of the mid parent selection differential for weaning weight. However, they concluded that yearling weight contributed the most to selection applied.

Chapman *et al.* (1969) found that selection for weaning weight resulted in significantly heavier carcasses ($P < .05$).

Brown and Frahm (1975), in a selection experiment with mice, were able to improve 21-day weights (weaning weights) 26.4 percent in 10 generations of selection and 31.4 percent in 14 generations of selection ($P < .01$). Simultaneously, average daily gain was improved 14.1 and 16.8 percent, respectively. A genetic correlation between preweaning and postweaning growth rate (0.47) was observed.

Flower *et al.* (1964), utilizing an average selection differential of 2.0 to 4.23 kilograms, realized an average genetic improvement per year of 2.07 kilograms.

Postweaning Average Daily Gain

One of the primary traits initially considered in performance testing was average daily gain. The U.S. Range Livestock Experiment Station at Miles City, Montana, found that approximately 72 percent of the variations in feedlot gains were of a hereditary origin. They concluded that conformation was not indicative of ability to make rapid and efficient gains and on this hypothesis the foundations of performance testing were laid.

The heritability of average daily gain has been widely researched (Table 1) and the majority of the heritability estimates obtained indicate that the trait is highly heritable and, therefore, should be improved through selection.

Table 1

Heritability Estimates for Average Daily Gain

Author	Estimate
Knapp and Nordskog (1946)	0.46
Schott et al. (1950)	0.59
Patterson et al. (1955)	0.53
Brown and Gacula (1964)	0.93
Chapman et al. (1972)	0.51
Koch et al. (1973)	0.29 (bulls) 0.65 (heifers)
Gaskins et al. (1975)	0.28
Average Heritability	0.53
Lasley (1972) - avg. of 10 studies	0.57

Because of the high heritability estimates of average daily gain, environment would be expected to have only minor affects on this trait. In a study by Stuedemann *et al.* (1968), preweaning plane of nutrition appeared to have no carryover effects on postweaning daily gains. However, genetic x environmental interactions appear to have an influence on average daily gains. Wilton and Batra (1972) found significant breed x station and station x station interactions within breed.

Further sources of variation in postweaning gains identified by Chapman *et al.* (1972) were *herd of origin* and *age of animal* when placed on test. These papers reinforce the necessity of testing animals at about the same age and in the same environment. They also suggest avoidance of comparing actual weights of animals tested at different times or at different locations. A trait ratio can remove some of the error in this type of comparison, especially if the mean value for the group is known.

Genetic factors which appear to be related to average daily gain are birth weight, preweaning average daily gain, type, weaning weight, yearling weight, and efficiency of gain (Table 2).

Table 2

Genetic Correlations Involving Postweaning Average Daily Gain

Trait	Author	Correlation
Birth weight	Koch *et al.* (1973)	0.42
Birth weight	Chapman *et al.* (1972)	0.53
Preweaning ADG	Koch *et al.* (1973)	0.14
Preweaning ADG	Frahm and Brown (1975)	0.47 (mice)
Type	Chapman *et al.* (1972)	-0.42
Weaning weight	Chapman *et al.* (1972)	-0.28
Weaning weight	Hohenboken *et al.* (1973)	0.44
Feed efficiency	Lasley (1972)	0.51
Long yearling wt.	Koch *et al.* (1973)	0.87

Correlations in Table 2 indicate that selection for increased postweaning average daily gains would increase birth weight, preweaning growth rate, feed efficiency and yearling weight. The effect on weaning weight appears to be questionable, but it seems logical to assume that if preweaning growth rate was improved, weaning weight would be improved simultaneously.

Special attention might be given to the high correlation between yearling weight and average daily gain. Because feed efficiency is improved as rate of gain is improved, one might increase the amount of marketable product and increase its rate and efficiency of production by selecting primarily for yearling weight. However, structural soundness and muscling should also be considered to avoid selection toward overfat or unsound lines.

The importance of rate of gain was emphasized by Patterson *et al.* (1955) in an article on performance testing. Patterson and others stated that rate of gain, efficiency of gain, and reproductive capacity were the most important economical traits to the commercial beef producer. Patterson proposed that selection based on performance could increase the volume of meat produced and simultaneously reduce the costs of production.

Chapman *et al.* (1969) observed that selection for type resulted in lower postweaning average daily gain ($P < .05$) and that selection for rate of gain resulted in heavier carcass weights ($P < .005$).

Stolz *et al.* (1975) found that selection for both maximum and minimum average daily gains in mice was effective and also functioned to increase or decrease the weight of epididymal fat pads.

Brown and Frahm (1975) found that selection for average daily gain was effective ($P < .001$) and that ADG was improved 53.1 and 52.3 percent after 10 and 14 generations of selection in mice. Along with increases in ADG, both feed consumption and feed efficiency increased approximately 20 percent ($P < .001$). And, finally, Koch, Gregory and Cundiff (1974a) obtained a 0.37 standard deviation response per generation in selection for ADG.

Yearling Weight

Yearling weight is an important economic trait to the beef producer. In order for an animal to have an above average yearling weight, its weaning weight and postweaning average daily gain must be above average, or one of the traits must be outstanding if the other is substandard. Yearling weight is an important measure of growth rate because it is at the yearling stage, approximately, that many producers begin to sort out animals that will grade and market them.

Yearling weight appears to be highly heritable. Shelby *et al.* (1954) computed a heritability estimate of 0.84 for final weight on test. Kanpp and Nordskog (1946) estimated that the heritability of final test weight was 0.69. Knapp and Clark (1950) computed a heritability estimate of 0.86 for 15-month weight. Koch *et al.* (1973) obtained a 0.52 estimate for the heritability of 550-day weight of heifers and Gaskins *et al.* (1975) calculated a value of 0.23 for long yearling weights after a growing period on grass.

Yearling weight appears to be highly correlated with average daily gain. Roger and Knox (1951) obtained an "r" value of 0.25 between yearling weight and average daily gain. Brown *et al.* (1973) found that 365-day weight was strongly related to postweaning average daily gain ($r = 0.61$) in Herefords and ($r = 0.64$) in Angus. This study also attempted to establish the relationship between 365-day weight and feed consumption. Surprisingly, the experimenters obtained negative correlations between weight and feed consumption (= -0.06 in Herefords and $r = -0.26$ in Angus), observing that heaviers animals ate less.

Koch *et al.* (1974) found that yearling weight was significantly correlated with weaning weight and postweaning average daily gain, "r" values were 0.73 and 0.81, respectively.

If we conclude that yearling weight is related to average daily gain, then, based upon the relationship of average daily gain to feed efficiency, we would assume that feed efficiency was simultaneously improved. This hypothesis was tested by Kress (1975) and a phenotypic correlation of 0.51 was obtained.

In the same analysis, Kress examined the effect of inbreeding on final weight, computing a linear partial regression coefficient of -0.35 kilogram. This small effect of inbreeding indicates additive gene action and high heritability. Significant environmental variation in yearling weight was attributed to age of dam by Koch and Clark (1955). They recommended yearling weight adjustment factors ranging from zero to 10.9 kilograms.

In an experiment with selection for yearling weight and muscling combined, Koch *et al.* (1974) found that 88 and 84 percent, respectively, of the mid-parent selection differential was determined through sire selection. Koch concluded that yearling weight was the largest contributor to selection pressure applied.

Stanforth and Frahm (1975) observed that sire selection accounted for 83 percent of the primary selection differential for yearling weight. In 2.12 generations of selection, they increased yearling weights 5.9 percent and simultaneously increased average daily gains 9.2 percent.

An extended experiment with mice by Berger and Harvey (1975) produced no significant differences in 51-day weight through the first seven generations. However, in generations 8 to 10, selection for lower 51-day weights was effective.

Koch *et al.* (1974a) obtained an increase of 0.48 standard deviation per generation in selection for yearling weight and concluded that selection for yearling weight might increase weaning weights more than direct selection for weaning weight.

Body Measurements

Early studies involving body measurements attempted to develop a weight prediction formula from one or a combination of measurements. Later, as the relationship of individual body measurements to performance was studied, researchers found that certain body measurements were excellent indicators of performance.

In one of the early studies by Lush (1928) the relationship of body measurements to weight and to one another was discussed. Lush found height at withers to be a reliable and consistent measurement with a coefficient of error of 0.77 percent. Lush also found that height measurements were only slightly affected by the condition of the animal.

Black, Knapp and Cook (1938) found height at withers to be one of the best measures of performance because of its consistency and accuracy of measurement. Length of body was observed to have a higher relationship with rate and efficiency of gain and a ratio of weight to height gave the highest correlation with performance.

Height at withers appears to be highly heritable and body length appears to be lowly heritable (Table 3). Because height at withers and body length appear to be of approximately equal value in predicting performance and height at withers

Table 3

Heritability Estimates of Height at Withers and Body Length

Author	Height	Length
Brody (1930)	0.50	0.45
Schutte (1935)	0.76	0.48
Schott (1950)	1.00	0.00
Dawson (1952)	0.63	0.00
Buiatti (1954)	0.60	----
Miller (1970)	0.69	----
Avg. Heritability	0.70	0.23

has a much higher heritability estimate, the latter is currently used as a measure of body size and scale potential.

Gifford (1953) measured the relationship between accumulated milk production of the dam and the height and body length of her calves. He obtained correlation coefficients for height and body weight of 0.49 and 0.66 at 6 months and 0.58 and 0.64 at 12 months which were significant ($P < .01$).

Hohenboken *et al.* (1973) found that weaning weight was significantly ($P < .05$) related to height at withers ($r = 0.58$). This agrees with the observation of Gifford since weaning weight is an indirect measure of milk production of the dam.

Lush (1932) found that both height and length were related to average daily gain. He calculated correlation coefficients of 0.35 and 0.33. Presently, selection for height is practiced mainly as a means of improving the muscling and dressing percentage of market animals. Increased rate of gain appears to be a bonus in selection for improved meatiness.

Ultrasonic Measurements

Loin Eye Area

The concept of even distribution of muscle growth assumes that an analysis of a cross-section of an individual muscle is indicative of the development of the muscle mass as a whole. Lasley (1972) averaged estimates reported in three studies and arrived at an average estimate of 0.70 for the heritability of loin eye area. This is in accordance with the generally high heritability of the various carcass traits and indicates that substantial genetic improvement could be realized by selection for increased loin eye area.

Lewis, Suess and Kauffman (1969) observed that trained evaluators could significantly estimate the loin eye area of live animals ($r = 0.33$ to 0.65, $P < .05$ and $P < .01$, respectively). Standard deviations of the estimates ranged from 5.1 to 5.8 cm^2.

Henderson *et al.* (1966) tested four methods of direct measurement of the bovine longissimus dorsi area. He concluded that counting grids and planimeter measurements gave highly correlated results and that cutting errors contributed most to the inconsistency of measurements.

The real value of longissimus dorsi area estimates is in their relationship to muscling or to the weight of saleable cuts. Birkett, Good and Mackintosh (1965) obtained an "r" value of 0.49 ($P < .01$) for the relationship between longissimus dorsi area and weight of closely trimmed cuts. However, loin eye area was not correlated with percent closely trimmed cuts.

Hedrick *et al.* (1962) found correlation coefficients ranging from 0.58 to 0.89 ($P < .01$).

David, Temple and McCormick (1966) computed "r" values of 0.84 and 0.92 ($P < .01$) for the correlation between ultrasonic estimates and actual rib eye area. David also concluded that sex of the animal and different operators of the equipment accounted for most of the variance.

Stouffer *et al.* (1961), in a study with cattle and swine, obtained correlations of 0.22 to 0.85 ($P < .01$) between live ultrasonic measurements and actual carcass measurements. The repeatabilities of the estimates were significant, 0.67 to 0.95 ($P < .01$), and standard errors ranged from 0.84 to 4.45 cm^2.

Brungardt (1972) found that ultrasonic loin eye area estimates were highly correlated ($r = 0.63$) with pounds of muscle, but only slightly correlated with percent muscle ($r = 0.07$). And, in contrast to the findings of Lewis *et al.* (1969), Brungardt found that visual estimates were not significantly related to actual carcass muscling percentage ($r = 0.12$).

The preceding heritability estimates and correlations indicate that loin eye area is highly heritable and significantly correlated with muscling. However, it seems logical to place more emphasis on ^{40}K fat free body estimates which measure mass rather than ultrasonic evaluation of an individual muscle.

Backfat Thickness

In beef cattle, unlike swine, little importance has been placed upon backfat thickness in selection to date. A minimum amount of backfat is desired for optimal keeping qualities of carcass beef and some backfat will be present before adequate marbling occurs. Fluctuations in backfat measurements of breeding stock are more an indication of their current plane of nutrition than an estimate of their genetic potential. Lasley (1972) reports that the heritability estimate of backfat is 0.38. This value was somewhat lower than the estimates of the other carcass traits and implied that environment has a substantial effect upon backfat thickness.

The reliability and repeatability of ultrasonic backfat estimates appears to be acceptable. Stouffer *et al.* (1961) obtained correlations of 0.35 to 0.92 ($P < .01$) between ultrasonic estimates and actual measurements of carcass backfat. Repeatability of the estimates ranged from 0.67 to 0.95 ($P < .01$) and standard errors ranged from 0.08 to 0.20 centimeters.

Hedrick *et al.* (1962) obtained "r" values of 0.11 and 0.63 ($P < .01$) for the relationship between live ultrasonic estimates and carcass backfat.

Davis, Temple and McCormick (1966) obtained significant correlations of 0.57 to 0.75 ($P < .01$) between ultrasonic estimates and carcass measurements.

McReynolds and Arthaud (1970) compared two methods of ultrasonic measurement of fat thickness. The type "A" scan utilizing a Polaroid™ picture of the oscilloscope reading was correlated with carcass measurements ($r = 0.37$). However, the type "B" scan using a 510 Animal Scanner was correlated ($r = 0.63$) with carcass backfat measurements to a greater degree. The position of the measurements was important with greatest accuracy from readings taken between the 12th and 13th ribs, 13 centimeters from the midline. McReynolds and Arthaud also emphasized that estimates on very fat or very thin animals are subject to substantial error.

Brungardt (1972) observed that ultrasonic estimates were highly correlated with pounds of fat and percent fat ($r = 0.55$ and $r = 0.72$, respectively). Lewis *et al.* (1969), using trained evaluators, obtained correlations of 0.36 to 0.85 ($P < .01$) between live estimates and actual carcass measurements with a standard deviation of 0.51 to 0.56 centimeters.

In a selection experiment for high and low backfat in swine, Hetzer and Miller (1970) were able to utilize the moderate to high heritability of backfat thickness and increase the backfat 3.0 cm. over unselected controls in the high line and to lower backfat thickness 1.5 cm. in the low line. No effect on reproductive performance in either line was observed.

From the literature reviewed, it can be concluded that backfat thickness is a moderately heritable trait and one that can be measured with acceptable accuracy. Accuracy in measurement appears to be greatest with animals that are not extremely fat or thin and when measurements are taken directly from an animal scanner. Selection for fat thickness has been effective in swine.

^{40}K Evaluation

The use of ^{40}K evaluation as a predictor of lean muscle mass enables a producer to obtain an estimate of the actual muscling in a prospective herd sire without sacrificing the animal. The theoretical basis for the use of ^{40}K in determining lean body mass assumes a uniform displacement in the cellular content of potassium (Anderson, 1959). This assumption of uniform displacement has been questioned.

A study by Gillett and associates revealed significant differences in potassium concentration of steer muscle on a wet basis, fat-free basis, moisture-free and protein basis ($P < .05$). Variations ranged as high as 12.91 percent in comparisons of mean values. When values were adjusted for muscle, breed, and muscle-breed interaction effects, mean squares were significant on a fat-free, moisture-free, and protein basis ($P < .05$). It should be recognized that mean square values on a wet basis were not significant.

Ward *et al.* (1967) computed coefficients of variation of 9.0 and 14.7 percent on a fat-free and a fat-free dry matter basis, respectively.

Ward and his associates observed that with increases in fat content, the potassium concentration of fat-free tissue declined (correlation between potassium content and fat percentage $r = -0.94$) and explained this by the fact that adipose tissue is lower in potassium than muscle. K content ranged from 1.84 to 3.74 gm. K/kg.

Lohman and Norton (1968), in a study of the distribution of potassium by ^{40}K measurements, arrived at the distribution shown in Table 4.

Table 4

Distribution of Potassium in Steers

Tissue	Percent K
Standard trimmed lean	53.4
G.I. tract and contents	16.4
Bone	12.4
Head and organs	7.7
Carcass and adipose tissue	4.0
Hide	3.4
Blood, mesenteric fat	2.5
TOTAL	99.9

Lohman and Norton (1968) also found that Angus had significantly more carcass potassium per unit of fat-free, boneless mass than any other breed-type, while the biological variation within breed-types was found to be less than 3 percent.

Radioactivity of the diet, amount of gastrointestinal fill, and the "shrink" status of the animal also are potential sources of error in ^{40}K prediction of lean muscle mass, according to Johnson, Walters and Whiteman, 1973. These investigators stressed that fat-free body equations, developed with animals under standard environmental conditions, used on animals with varying amounts of shrink, fill, and radioactivity, are an important source of error in 40K predictions.

The reliability of ^{40}K counts was investigated by Lohman *et al.* (1966). They found that after steers were washed and background readings taken for two minutes each with two consecutive two-minute counts, the variation in counts averaged 3 percent and the standard error of the estimate was approximately 3.5 percent.

Frahm *et al.* (1971) evaluated the relationship between ^{40}K prediction and actual fat-free body of yearling beef bulls. They obtained a significant ($P < .01$) correlation coefficient of 0.87 and found that the standard error was 3.8 kilograms. Repeatability of the counts ranged from 0.89 to 0.96 and was significant ($P < .01$).

Johnson *et al.* (1973) obtained significant ($P < .01$) regression coefficients of ^{40}K count on body weight. Walker (1973) found significant correlations between three basic body measurements and fat-free body as determined by the whole body counter. Correlation coefficients were 0.85 to 0.93, 0.85 to 0.89, and 0.98 to 0.99 for height to FFB, length to FFB and weight to FFB, respectively.

Brungardt (1972) found that ^{40}K counts were highly correlated with pounds of muscle ($r = 0.79$) and to percent muscle ($r = 0.55$). Because of the very high correlation between weight and fat-free body, Brungardt found that livestock scales could account for 77 percent of the variation in total pounds of muscle as opposed to 63 percent due to K-40 counts. Brungardt observed that visual estimates of carcass muscling generally had little significance ($r = -.25$, 0.34 and 0.28) and that too often visual selection for muscling resulted in the selection of individuals heterozygous for "double muscling."

Studies to date support ^{40}K evaluation as an accurate and repeatable method of estimating lean meat in beef animals. The theoretical assumption of ^{40}K evaluation is that potassium is uniformly displaced throughout the cell contents. This assumption has been questioned and variance of potassium concentration has exceeded 12 percent. ^{40}K estimates of fat-free body are positively and significantly correlated with height, weight, length of body, and pounds of actual carcass lean.

Selection Indices

Before developing a selection index or a breeding program, one must consider the long-run outlook of the beef cattle industry. Cartwright (1970) developed proposed selection criteria for "beef cattle of the future." One might not agree entirely with the disposition of the traits as they are enumerated, but the importance of traits listed cannot be denied. Cartwright proposed that maternal lines be selected for:

1. Female fertility (perhaps twinning).

2. General soundness and longevity.
3. Desired milking qualities.
4. Freedom from calving difficulties.
5. Relatively small size.
6. Early maturity.

He proposed that sire lines be selected for:

1. High rate of gain.
2. Efficient feed conversion.
3. High cut-out percentage.
4. Tender, palatable beef.

Hazel and Lush (1942) identified three basic methods of selection and ranked them in increasing order of efficiency.

The tandem method involves concentration of selection on one trait at a time until it is improved to an acceptable level. This system is effective, but it is time consuming and very inefficient in its utilization of available breeding animals.

The independent culling system requires performance above specified minimum levels in several traits. This system is inefficient because quite often individuals which are outstanding in certain traits fail to meet the minimum standards in other traits.

Selection for a total score is most efficient because an individual with outstanding performance in one trait can balance out poor performance in another.

Lush stated that total score selection based on n characteristics, which are equally important and uncorrelated, is $\sqrt{n}$ times as efficient as tandem selection. However, progress made in any one trait by total score is only $1/\sqrt{n}$ times as much as if selection were directed at that trait alone.

Lush concluded by stating that the facts needed to determine the importance of a trait in a selection index were: (1) relative economic value, (2) heritability, and (3) genetic and phenotypic correlations.

Lindholm and Stonaker (1957) stated that the purpose of constructing a selection index was to attain maximum genetic progress toward increasing net income. In an attempt to maximize net income in a feeder calf operation, they utilized covariances in simultaneous equations to calculate partial regression coefficients to determine the weighting of each trait within the index. An analysis of several indices showed that selection for weaning weight alone was most effective in maximizing net income in that particular feeder calf operation.

In order for a selection index to be effective and for rapid progress to be made, the selection differential must be large and the generation interval as short as possible. Miller, in a 1969 paper on genetic trends, stated that increasing the replacement rate results in a faster genetic trend in two ways: (1) by capitalizing on superior progeny, and (2) by decreasing the ratio of involuntary to voluntary culls which allows for a high selection differential.

Vesely and Robison (1971), in a study on birth and weaning traits, observed that selection for weaning weight alone is less expensive and almost as effective as selection based on birth weight and weaning grade.

Wilson *et al.* (1963) found that weaning weight was negatively correlated with final grade and that final grade was least important in determining theoretical genetic progress from selection. Wilson concluded that daily gain must be included in an index if genetic improvement for average daily gain is to be realized.

The genetic basis of selection indices was demonstrated by Brown and Gacula (1964) who computed a heritability estimate of 0.79 for a production index. Some selection indices that have been developed are:

Marlowe *et al.* (1958) - I = (40 x ADG - 18) + (Type Score x 5)

Lindholm and Stonaker (1957) - I = Weaning Weight

I = Weaning Wt. + 72(ADG)

I = .58 (weaning wt.) + 18.64(ADG) - 0.73(days to grade choice) - 5.87(feed per lb. gain)

Selection indices are an important tool in long-run genetic planning. The selection index is an adaptation of total score selection weighted in relation to the importance of the individual traits. An index should consider real economic value, heritability, and correlations between traits. In order for selection to have a rapid and progressive effect the selection differential must be large and the generation interval must be kept as short as possible. Weaning weight, yearling weight and postweaning average daily gain appear to be some of the most important traits in selection.

Chapter 3

METHODS

Basic Requirements of Performance Testing Program

To qualify for entry into one of the central testing stations, bulls must be eligible for registry in a beef breed association.

Calves must have been born between February 15 and May 15 to be eligible for the fall test, or between August 15 and November 15 for the spring test.

Animals on test in the spring that meet minimum performance requirements are eligible for the fall sale and vice versa.

To be accepted at the test stations, a calf must have an adjusted weaning weight ratio of 90 percent or better within its management group or herd of origin. All bulls must have health certificates meeting state veterinary requirements and they are subject to expulsion due to illness at any time.

To be eligible for the State Performance Tested Bull Sale, bulls must have a 365-day weight of 1000 pounds or better, a weaning weight ratio of 100 or above, a yearling grade of B- or above and a shoulder height in excess of 44 ".

Measurement and Adjustment of Traits

Conformation

Animals on the testing programs are given conformation scores at weaning, at the end of the 140-day test and on sale day. Scores at weaning are based on the USDA Feeder Grade Standards (a 17 point scale). At the close of the 140-day test, bulls are given letter grades, based on the same scale, by extension area livestock specialists. Sale day grades are given by a committee of three specialists from the state extension staff. They base these grades on a numerical score which is further categorized into the following letter grades:

Score	*Grade*
97.0 - 100	A+
94.5 - 96.9	A
90.0 - 94.4	A−
87.0 - 89.9	B+
84.5 - 86.9	B
80.0 - 84.4	B−
77.0 - 79.9	C+
74.5 - 76.9	C
70.0 - 74.4	C−

Weaning Weight

Weaning weights were obtained between 160 and 250 days of age. Weights were adjusted for age of dam. Steer weights were adjusted upward 5% to determine average herd weaning weight for male calves, and all weights were adjusted for age to a 205-day, mature age of dam basis (Table 5).

Table 5

Weaning Weight Adjustments

Age of Dam Adjustment

Age of Dam at Calving	Adjustment
1 year 9 months to 2 years 9 months	Add 15%
2 years 9 months to 3 years 9 months	Add 10%
3 years 9 months to 4 years 9 months	Add 5%
4 years 9 months to 10 years 9 months	None
10 years 9 months and over	Add 5%

Sex Adjustment

Steer calves adjusted to a bull basis by adding 5%.

Age Adjustment

$$\frac{\text{(Weaning weight between 160-250 days - birth weight)}}{\text{Days of Age}} = \text{Preweaning A.D.G.}$$

Adjusted 205-day weight = Preweaning ADG x 205 + 70 lbs + Age of dam adj.

Postweaning Average Daily Gain

Bulls sold through the Missouri Performance Tested Bull Sale were on feed for at least 140 days either at one of the central test stations or in the extension on-farm testing program. A "warm-up" period of 21 to 28 days is required. Formulas for recommended rations for both the "warm-up" and test periods were supplied by the Extension Service (see Appendix, Table A1). Animals were weighed the day before and the day after starting on test with the average of these two weights taken as the beginning weight. The same procedure was used to obtain the final weight.

Yearling Weights

Yearling weights were obtained between 350 and 440 days of age; however, the management group was required to have an average age of 365 days. The adjusted 365-day weight incorporates the age of dam adjustment factor by adding the adjusted 205-day weight to the 160-day postweaning average daily gain. Formulas for the calculation of adjusted 365-day weight, life daily gain to 365 days, and 365-day adjusted yearling weight ratio are found in Table 6.

Table 6

365-Day Weight Adjustments

Adjusted 365-Day Weight

$$\text{Postweaning ADG} = \frac{\text{weight between 350 to 440 days - actual weaning wt.}}{\text{actual no. of days from weaning to final weight}}$$

Adjusted 365-day weight (postweaning ADG x 160) + adj. 205-day weight

Life Daily Gain to 365-Days

$$\text{365-day Life Average Daily Gain} = \frac{\text{adjusted 365-day wt. - 70 lbs.}}{365}$$

365-Day Adjusted Weight Ratio

$$\text{365-day wt. ratio} = \frac{\text{individual adj. 205-day wt. + individual 160-day postweaning gain}}{\text{herd avg. adj. 205-day wt. + group avg. 160-day postweaning gain}}$$

Adjusted 365-Day Height

Height measurements were obtained with the bulls standing on level ground and in as normal a position as possible. A caliper was used to obtain height at shoulders measurements. Height measurements were adjusted for age by multiplying 0.033 inches times the number of days less than 365 and adding this to the actual measurement, or multiplying 0.025 inches times the number of days greater than 365 and subtracting this value from the measurements. Height measurements were taken between 160 and 440 days. Sale day height measurements were taken sale day and adjusted to 540 days.

Frame Scores

Frame scores were descriptive classifications used to express relative size and growthiness. Frame scores were based solely on shoulder height. At 365 days they are as follows:

Frame Score	*Shoulder Height*
1	39" - 41"
2	41" - 43"
3	43" - 45"
4	45" - 47"
5	47" - 49"
6	49" - 51"
7	51" +

Ultrasonic Measurements

Longissimus dorsi area measurements were taken in accordance with the procedure outlined in the University of Missouri Extension Guide titled, "Use of Ultrasonics in Beef Cattle Improvement." Backfat measurements were taken in accordance with the procedure outlined in the University of Missouri Extension Guide, "Scanogram - Live Animal Evaluation Technique." Backfat measurements were taken the day preceding the sale.

Adjusted Fat Free Body

Fat free body estimates were obtained via Potassium-40 evaluation at the University of Missouri Low Level Radiation Laboratory. Feed and water were withheld approximately 15 hours before evaluation. Animals were washed and weighed before being placed in the counting chamber. Background readings were taken to account for radiation within the counting chamber prior to the arrival of the animal. The animals were then counted and fat free body adjusted to 540 days using the equation: [(age in days) x -0.000826) + 1.4428] x fat free body (lbs.) = adj. 540-day fat free body. Percent fat free body was also calculated at this time by dividing the fat free body weight by the whole body weight.

Index

A sale index was computed in order to establish the sale order. The index was established by the state extension staff with the primary objective of increasing production of lean, red meat. The index is based on the following four weighted factors:

Adjusted 365-day weight	40%
Adjusted 540-day height	30%
Adjusted 540-day fat free body	20%
Fat free body percent	10%

Statistical Analysis

The Statistical Analysis System (S.A.S.) as outlined by Service (1972) was used in analysis of the data. Means, correlations, stepwise regression, and an analysis of variance were computed.

To correct for inflation and other outside factors affecting sale price, a price ratio was computed within each sale by dividing the individual sale prices by the average price paid in that sale.

Data were sorted by breed, year, and season and by breed within a particular year and season. This study was restricted primarily to Angus, Herefords, and Polled Herefords, because of the lack of sufficient numbers of other breeds. The data are incomplete in some areas because the trait or traits were not measured at that time or because records of those measurements were not available.

Chapter 4

RESULTS AND DISCUSSION

This study investigated the relationship between performance and sale day data and sale price. Trends in breed frequencies and trends in performance traits were also determined. An analysis of variance identified significant components of price variation and regression coefficients were calculated to estimate the relative effect of specific traits on price variation.

Sale Price

To remove the effects of inflation, market fluctuations and other outside effects, a price ratio was computed within each sale. Use of this ratio eliminated year and seasonal effects and made the pooling of data from various sales possible. Non-performance factors significantly affecting sale price were year, season, breed, and sale order.

Breed effects were significant ($P < .01$), and the remaining factors significantly affected sale price at the $P < .01$ level. In general, Polled Hereford bulls were the highest selling, followed by Angus and Herefords (see Figure 2 and Appendix Table A18). Sale price for all bulls increased significantly ($P < .01$) over the period studied (see Figure 1).

To determine if feeder calf prices were related to bull sale prices, the average price per hundredweight for feeder calves in Missouri was graphed on the same chart as the average bull sale price per year. The coefficient of correlation (r) between these two variables was 0.74 and was highly significant ($P < .01$). The coefficient of determination (or r^2) was .55, showing that feeder calf prices explained about 55 percent of the variation in yearly bull prices. Thus 45 percent of the variation in bull prices was left unexplained.

Probably a large part of the bull price increase over the years was due to a significant improvement in performance traits, and the increased awareness of the buyers of the value of superior performance tested sires. The effect of sale year on price observed in this study agrees with the findings of Marlowe (1968) who observed that sale year was the second most important factor affecting sale price.

Seasonal effects on sale price were highly significant ($P < .01$). Animals sold through the spring sales averaged approximately $150 per head higher than those sold in the fall sales. This effect may have been due to the decreased number of bulls available in relation to the number available in the fall sales, or it may have been due to an increased demand for bulls in the spring because of the proximity of the sale date to the beginning of the spring breeding season in Missouri (see Figure 3 and Appendix Table A4).

Sale order significantly affected sale price ($P < .01$). However, because sale order is based upon an index of performance traits the actual effect of sale order alone on sale price was impossible to determine. In this study sale order had a

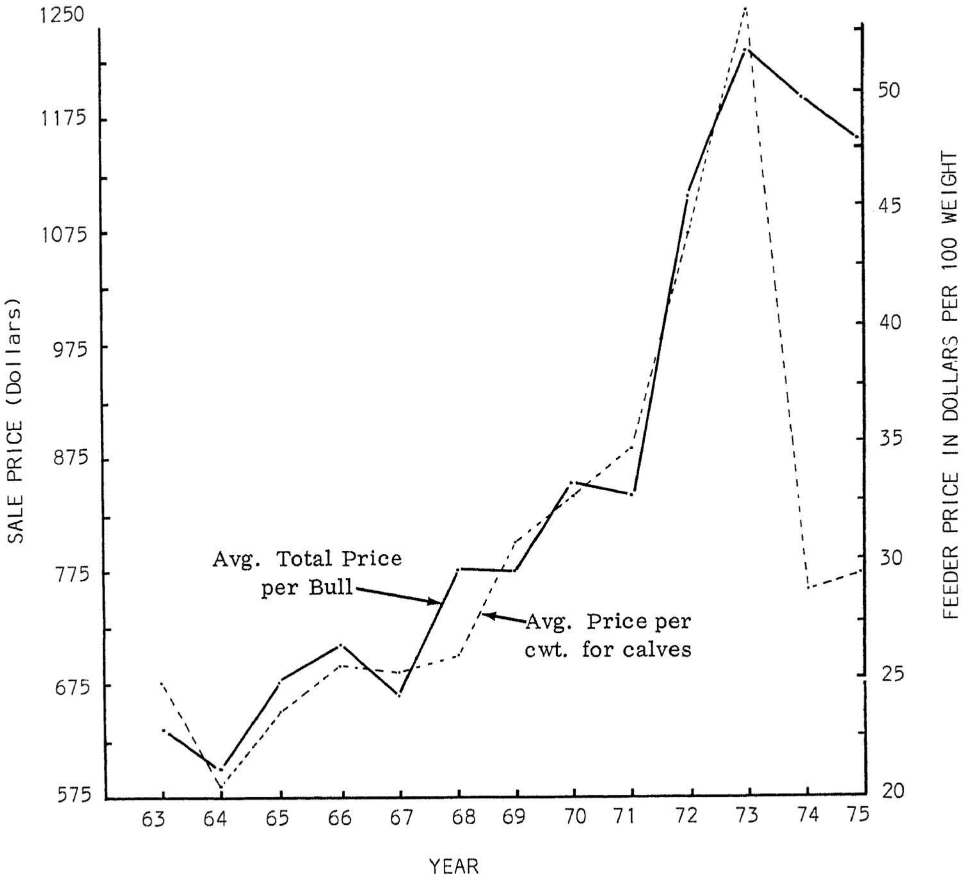

Fig. 1—A comparison of the average sale price of bulls in the tested bull sales with average feeder calf prices in Missouri. The solid line shows the average sale price per bull per year. The broken line shows the average price per hundred weight for feeder calves.

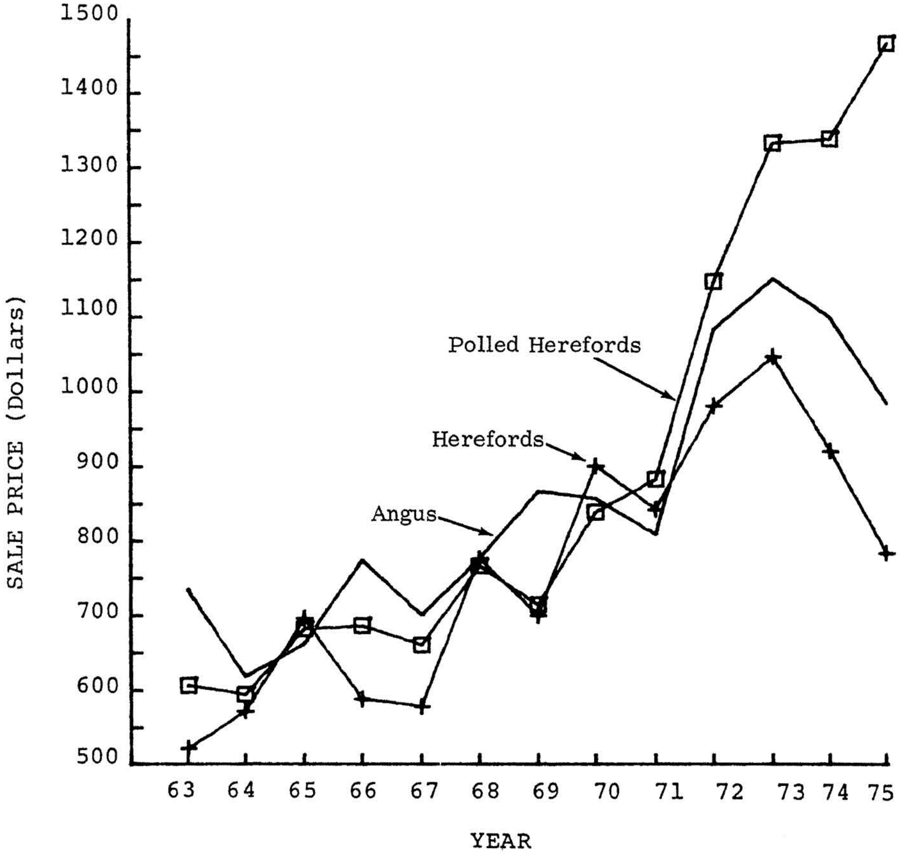

Fig. 2—Sale Price Trends By Breed. (Breed effects were significant.)

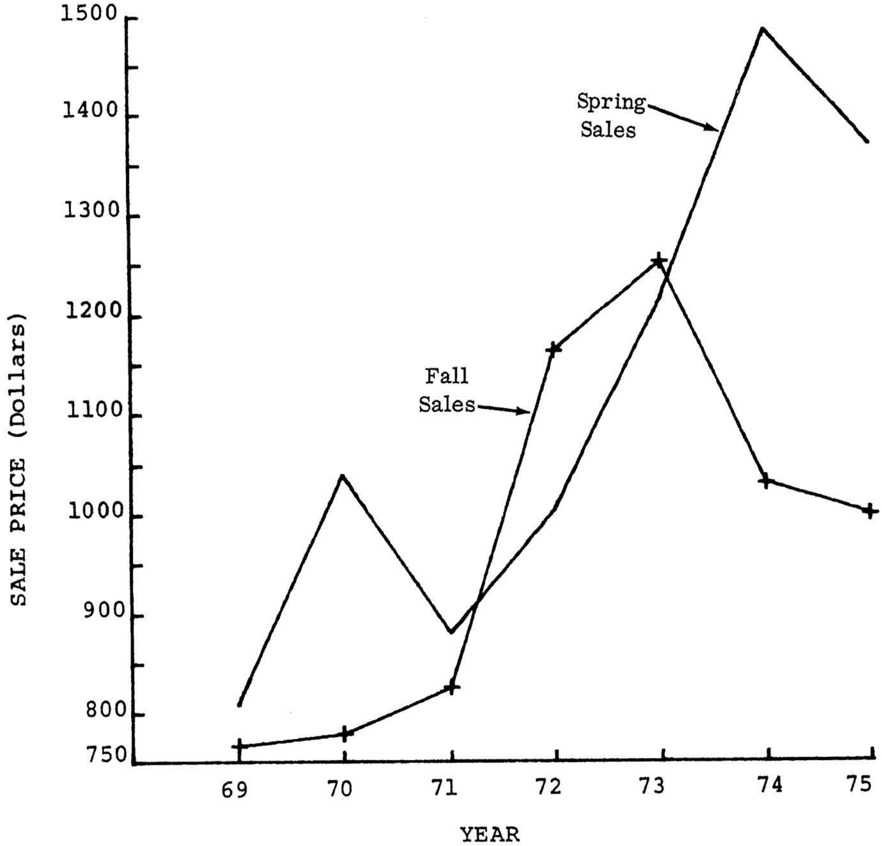

Fig. 3—Sale Price by Season. (Seasonal differences were significant.)

significant inverse relationship with sale price and accounted for 9 percent of the variance in sale price.

Performance traits significantly affecting the variation in sale price were sale day grade, sale day weight, 365 day weight and yearling conformation. Correlations of performance traits with sale price are given in Table 7 and interrelationships among all traits are given in Appendix Table A2.

Table 7

Correlations of Performance Traits with Sale Price

Trait	# Paired Observations	Correlation Coefficient
Adj. 205-day wt.	2554	0.19
Postweaning A.D.G.	2551	0.10
Adj. 365-day wt.	2554	0.26
365-day height	802	0.16
Longissimus dorsi area	742	0.08*
Adj. 540-day fat free body	735	0.09*
Frame	1140	0.19
Yearling conformation	2406	0.25
Index	587	0.29
Sale day grade	2274	0.44
Sale day backfat	1304	N.S.
Sale day height	1110	0.26
Sale day weight	2089	0.36
Sale day age	2554	0.07

N.S. - Not Significant.

*(P < .05).

All others - (P < .01).

Sale day grade was moderately correlated with sale price ($r = 0.44$, $P < .01$). Sale day grade accounted for 33 percent of the variation in sale price. When data from all sales were pooled, buyers paid $293.38 for each increment increase in sale day grade.

Buyers generally preferred heavier bulls. The correlation of sale day weight with sale price was significant ($r = 0.36$, $P < .01$). Sale day weight accounted for 7 percent of the variation in sale price and buyers paid $0.72 for each pound increase in sale day weight.

Adjusted 365-day weight was moderately related to sale price ($r = 0.26$, $P < .01$). Yearling weight accounted for 2 percent of the variation in sale price and buyers paid $1.95 for each pound increase in yearling weight. Yearling conformation was moderately correlated with sale price ($r = 0.25$, $P < .01$) and accounted for 1 percent of the sale price variation. Buyers paid $64.82 for each increment increase in yearling conformation grade.

Breed Frequency Trends

An examination of breed numbers per sale reveals that Angus and Polled Hereford bulls have steadily risen in numbers, while Hereford bulls have declined in number (see Figure 4 and Appendix Table A19). This trend in breed numbers coincides with similar trends in sale price and performance traits. Angus and Polled Hereford breeders seem to be steadily increasing the number of animals tested, while Hereford breeders are testing fewer animals.

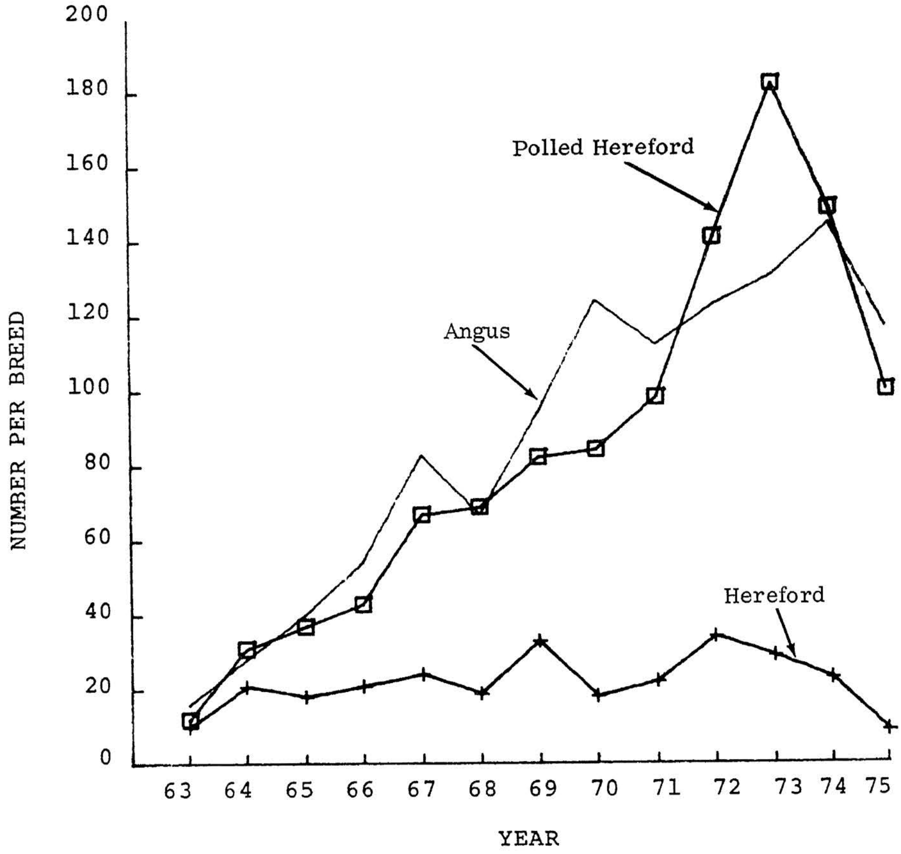

Fig. 4—Breed Frequency Trends By Year.

Weaning Weight

Weaning weight of sale bulls has improved significantly ($P < .01$) over the time period studied (Figure 5). Average adjusted 205-day weight has improved from 511.7 pounds in 1963 to 596.0 pounds in 1975. Weaning weight was lowly correlated with sale price ($r = 0.19$, $P < .01$). However, adjusted 205-day weight was not a factor in sale price variation. Due to the moderate heritability of weaning weight one would expect both heredity and environment to be important factors affecting this trait.

This hypothesis was supported in this study when significant ($P < .01$) breed, year, season, and breed x year interactions were found. Hereford bulls were

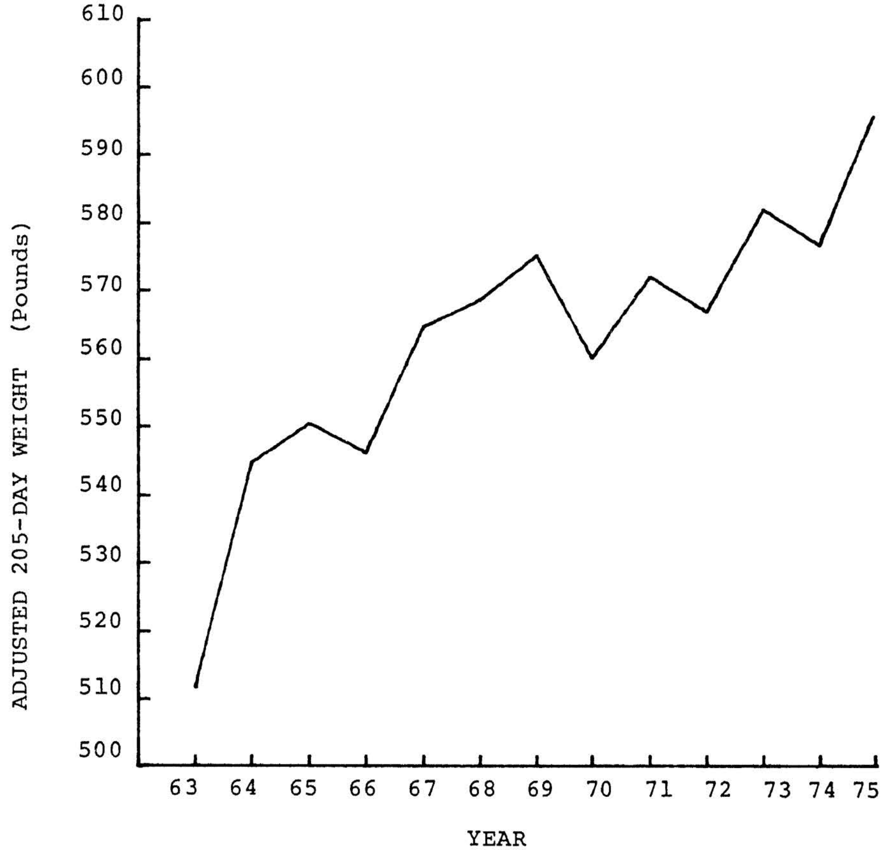

Fig. 5—Adjusted 205-day Weight By Year. (Regression of adjusted 205-day weight on year was significant.)

heaviest at 205 days, followed by Polled Hereford, and Angus. Mean adjusted 205-day weights were 583.6, 577.1, and 556.5 pounds, respectively.

Bulls sold through the spring sales, which primarily would have been weaned the previous spring, had a mean adjusted 205-day weight of 567.2 pounds compared to a mean weight of 580.8 pounds for those bulls sold in the fall sales. Appendix Tables A4, A5, A9, A13, A15 and A16 contain more detailed data in regard to adjusted 205-day weight.

Postweaning Average Daily Gain

Average daily gain was significantly ($P < .01$) affected by breed, year, season, and breed x year interactions. Angus bulls recorded the highest average daily gains, followed by Polled Herefords and Herefords. Mean average daily gains were 3.03, 2.94, and 2.71 pounds per day, respectively. Average daily gains have improved significantly ($P < .01$), from a mean of 2.64 pounds per day in 1963 to a mean of 3.16 pounds per day in 1975 (Figure 6 and Appendix Table A5).

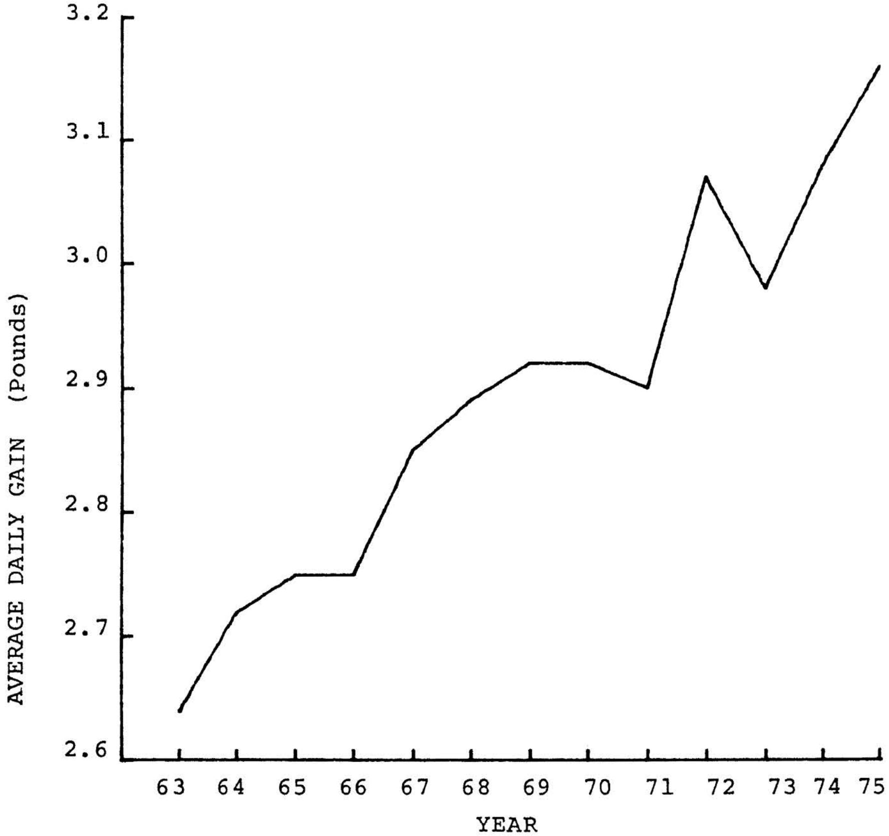

Fig. 6—Postweaning Average Daily Gain By Year. (Regression of average daily gain on year was significant.)

Seasonal effects were significant ($P < .01$). Bulls sold in the spring sale had a mean average daily gain of 3.07 pounds per day and bulls sold in the fall sale had a mean average daily gain of 2.98 pounds per day. A portion of this variation in average daily gain most probably was due to thermal stress. Bulls sold in the fall sales began their 140-day test in May and were tested through the summer, while bulls sold in the spring sales began their test period in November.

Appendix Tables A4, A5, A9, A13, A15, and A16 contain more detailed data concerning postweaning gain.

Yearling Weight

Adjusted 365-day weight was significantly ($P < .01$) affected by breed, year, and breed x year interactions. Polled Hereford bulls were the heaviest at 365 days, followed by Angus and Herefords. Mean adjusted 365-day weights were 1044.2, 1036.5, and 1009.4 pounds, respectively. Mean adjusted 365-day weights have improved significantly ($P < .01$) from 901.3 pounds in 1963 to 1099.7 pounds in 1975 (Figure 7). More detailed information concerning adjusted 365-day weight is contained in appendix Tables A4, A5, A9, A13, A15, and A16.

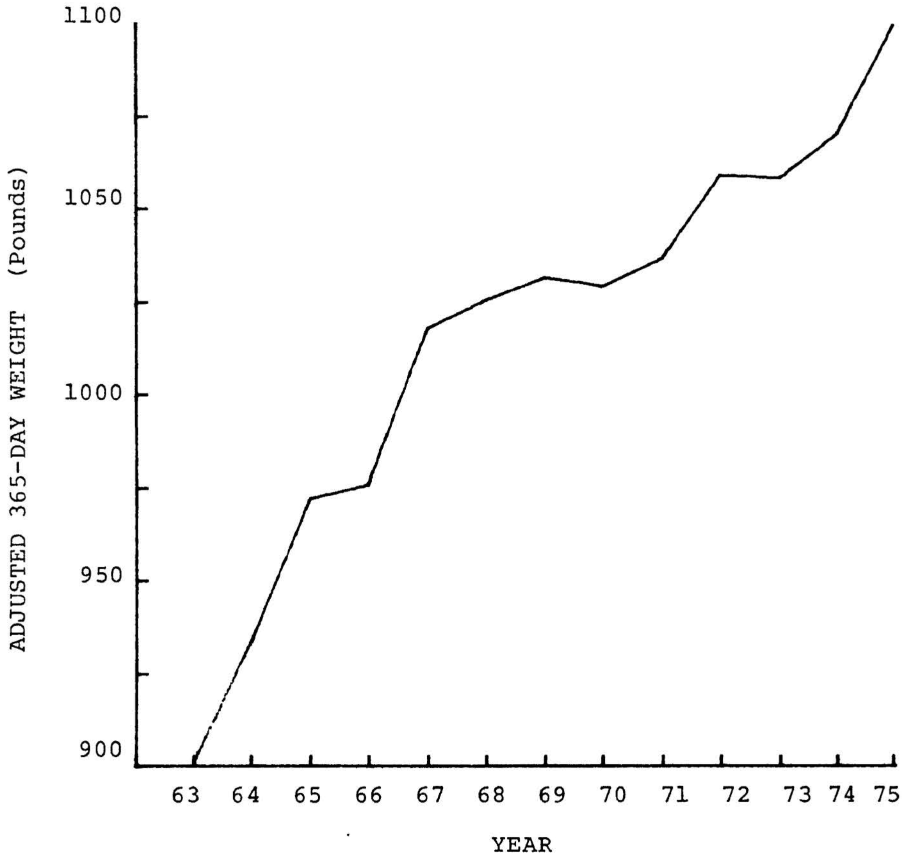

Fig. 7—Adjusted 365-day Weight By Year. (Regression of 365-day weight on year was significant.)

Frame Score Height Measurements

Adjusted 365-day height measurements have only been recorded the last three years. Most probably this is too short a time period for significant improvement in this trait. In any ase, 365-day height did not significantly affect sale price, nor was it significantly affected by breed (Angus, Herefords, and Polled Herefords considered), year, or season.

On the other hand, frame scores or classifications were significantly improved during the period 1972-1975. Mean frame scores rose from 3.47 to 3.96 (Figure 8). The three breeds studied appear to be relatively homogeneous in regard to height and all appear to be gradually increasing in average height. Further information pertaining to height may be found in appendix Tables A4, A5, A9, A13, A15, and A16.

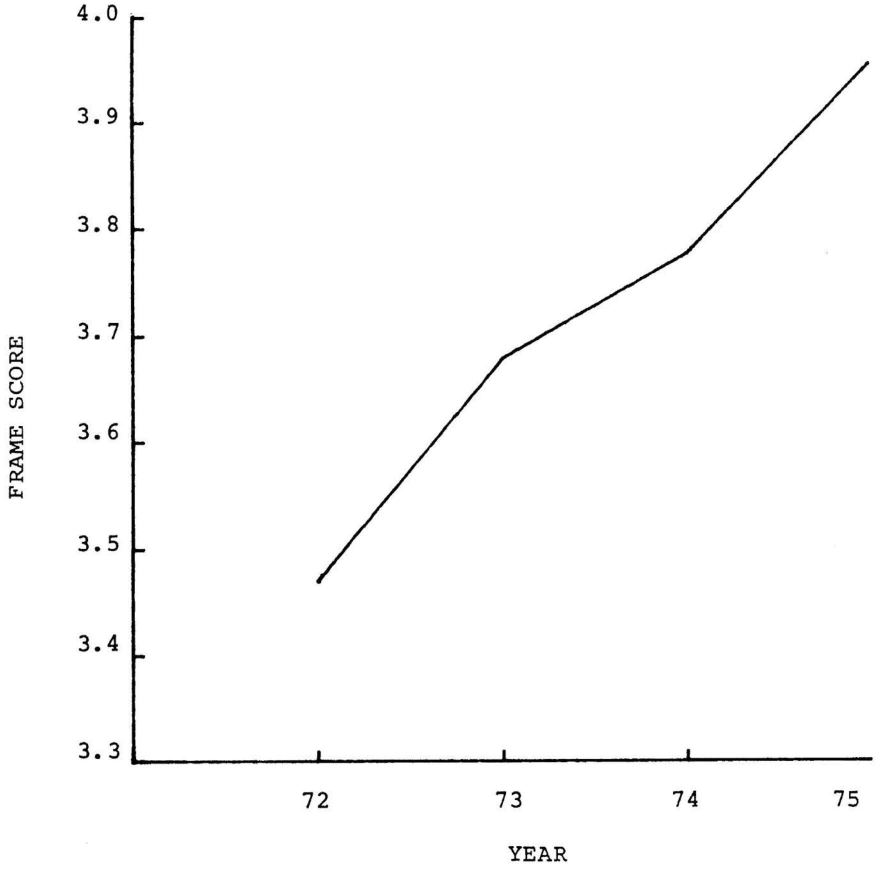

Fig. 8—Frame Scores By Year. (Regression of frame score on year was significant.)

Longissimus Dorsi Area

Longissimus dorsi area measurements differed significantly ($P < .05$) between breeds. Angus bulls had a mean longissimus dorsi area of 13.38 square inches, Herefords 13.36 and Polled Herefords 13.18 square inches per 1000 pounds body weight.

Longissimus dorsi area also varied significantly between years ($P < .01$) but no clear trend was established (Figure 9). This variation may have been due more to the variation in numbers of animals with ultrasonic measurements than actual variation within the trait.

Longissimus dorsi area did not significantly affect sale price. Further data related to longissimus dorsi area may be found in appendix Tables A4, A5, A9, A13, A15 and A16.

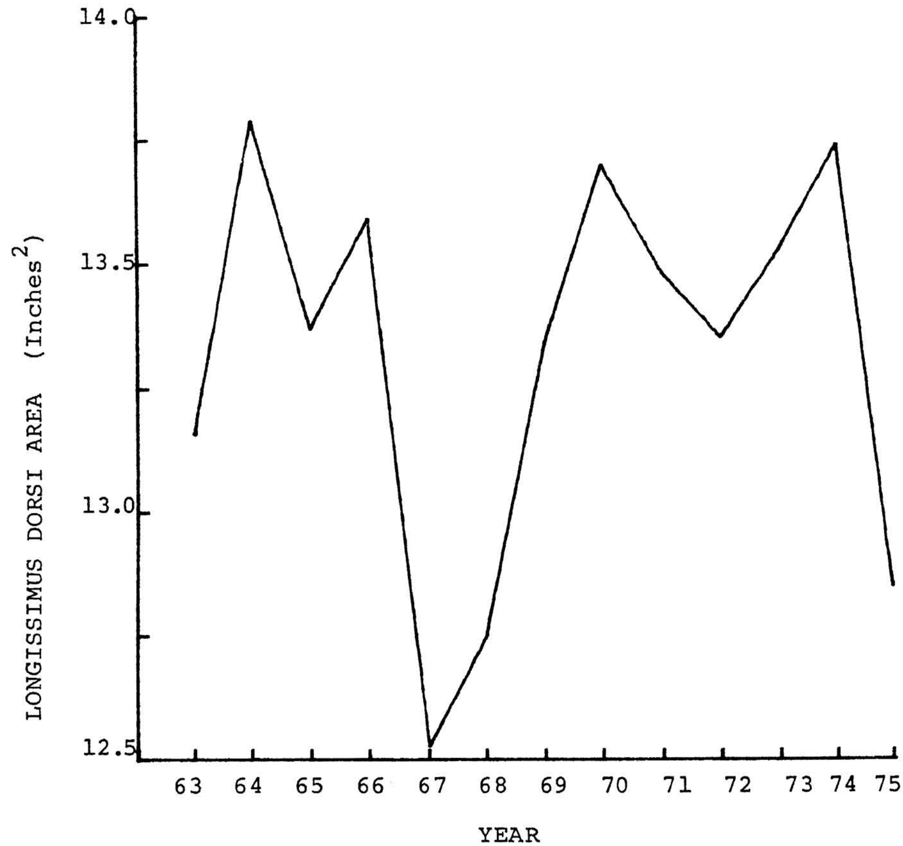

Fig. 9—Longissimus Dorsi Area By Year. (Regression of Longissimus Dorsi area on year was significant.)

Fat Free Body

Adjusted 540-day fat free body has increased significantly (P< .01) over the time period 1971-1975 (see Figures 10 and 11). A limited number of animals in 1971 (10) had an average fat free body weight of 879.5 pounds. From 1972-1975, FFB weights increased from 813.7 to 876.5 pounds.

There was not a significant difference between breeds in pounds of fat free body. However, percent fat free body did show a significant (P< .01) breed effect. Angus bulls were significantly meatier than Herefords or Polled Herefords according to the ^{40}K evaluations. Mean fat free body percentages were 70.5, 69.5, and 68.8, respectively.

Adjusted 540-day fat free body was lowly correlated with sale price (r = 0.09, P< .05) but did not cause significant variation in sale price. Further data related to adjusted fat free body measurements may be found in appendix Tables A4, A5, A9, A13, A15, and A16.

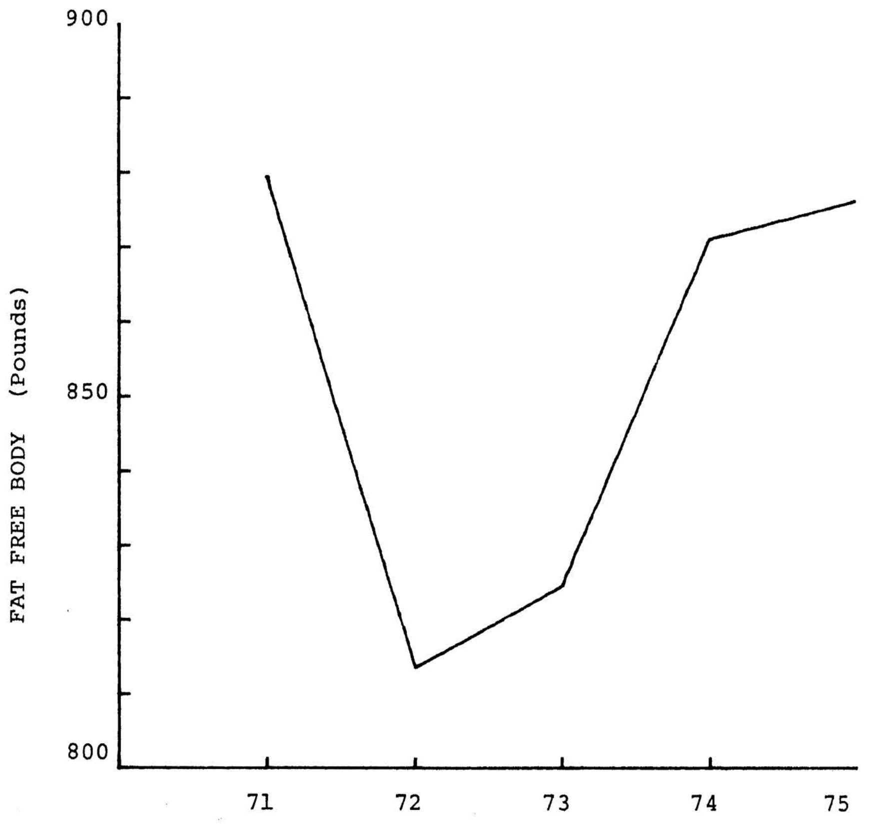

Fig. 10—Adjusted 540-day fat free body by year. (Regression of fat free body on year was significant.)

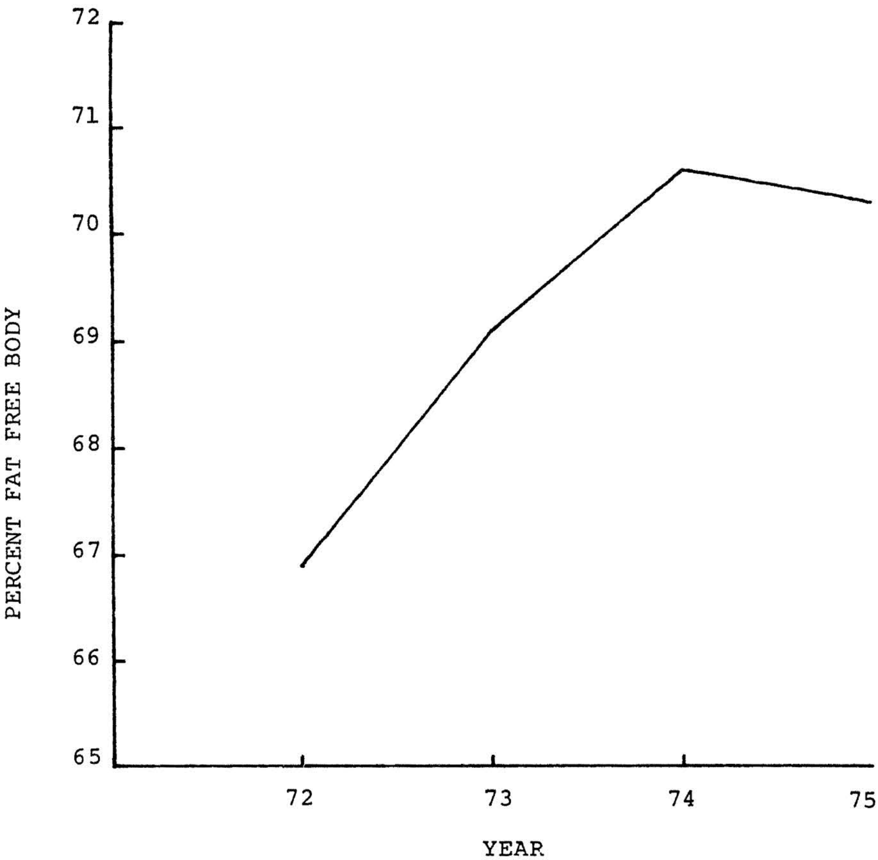

Fig. 11—Percent fat free body by year. (Regression of percent fat free body on year was significant.)

Conformation

Yearling conformation grades were significantly ($P < .01$) affected by breed, year, and season. Angus bulls averaged highest in grade, followed by Herefords and Polled Herefords. However, the mean values for all three breeds fell within the "B" classification. Mean yearling conformation scores have improved significantly ($P < .01$) from a mean score of "B-" in 1963 to a mean score of "B" in 1975 (Figure 12).

A significant ($P < .01$) seasonal effect on conformation grade was observed. Bulls sold through the fall sales had a mean conformation score of 13.2 (B), compared to a mean conformation score of 13.0 (B) for bulls in the spring sales.

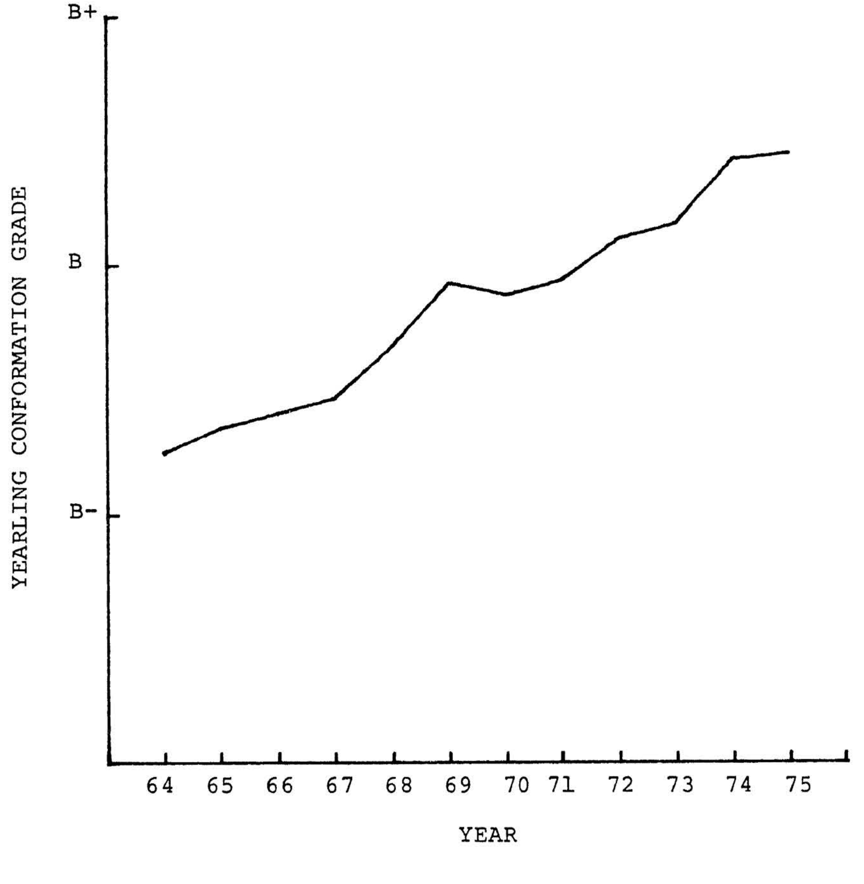

Fig. 12. Yearling Conformation Grades By Year. (Regression of yearling conformation grade on year was significant.)

Sale Day Index

The sale index was computed primarily as a means of establishing a sale order. Index values were significantly correlated with sale price ($r = 0.29$, $P < .01$). However, index scores did not account for a significant portion of the variance in sale price. Index scores were not affected by breed, year, or season.

Sale Day Grade

Sale day grade was significantly ($P < .01$) affected by year and season. Sale day grade has improved significantly from a mean grade of "B-" in 1965 to a mean grade of "B" in 1975 (Figure 13). Sale day grade was significantly affected by season. Bulls in the fall sales graded slightly higher than those in the spring sales. However, mean sale day grades for both groups were in the "B" classification. It should be emphasized that sale day grade was the most important factor in sale price variation, accounting for 33 percent of that variation.

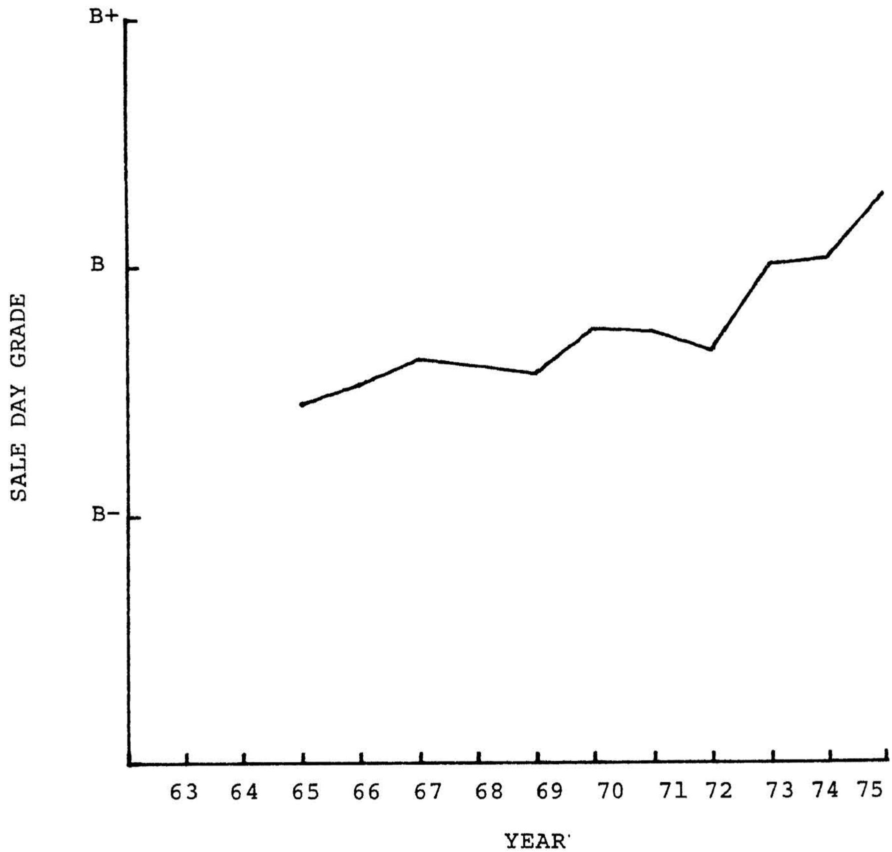

Fig. 13—Sale Day Grade By Year. (Regression of sale day grade on year was significant.)

Sale Day Backfat

Sale day backfat was significantly (P< .01) affected by breed, year, and season. Angus bulls carried the least backfat on sale day compared to Herefords and Polled Herefords. Mean sale day backfat measurements were 0.34, 0.40, and 0.42, respectively. Sale day backfat measurements have decreased from a mean backfat measurement of 0.48 inches in 1971 to a mean of 0.31 inches in 1975 (Figure 14).

Seasonal effects on sale day backfat measurements were significant (P< .01). Bulls in the spring sales carried 0.41 inches of backfat compared to 0.34 inches of backfat for bulls sold in the fall. Possibly some of the increased gain observed in the spring sale bulls was reflected in their increased backfat thickness. However, the fact that spring sale bulls had just finished a winter grain feeding period while many fall sale bulls had been recently taken off grass, seems to be a more plausible cause.

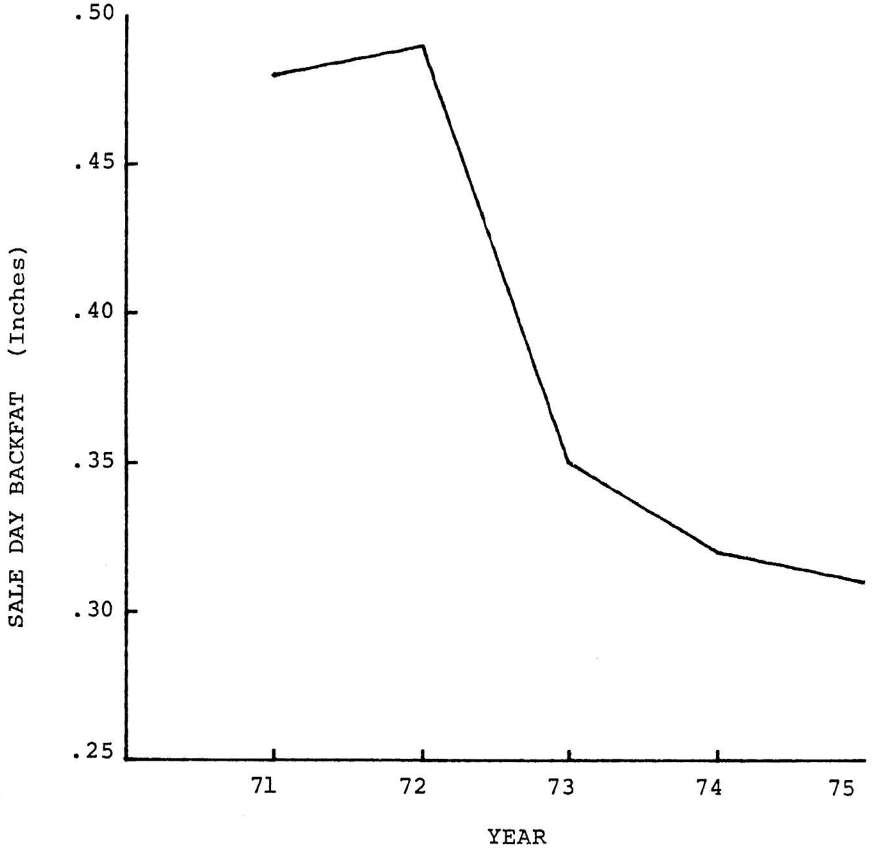

Fig. 14—Sale Day Backfat By Year. (Regression of sale day backfat on year was significant.)

Sale Day Height

Sale day height was significantly ($P < .01$) affected by breed and year. Breed differences were significant but slight. Polled Hereford bulls had higher average sale day heights than Hereford or Angus. Mean sale day heights were 48.0, 47.9, and 47.8 inches, respectively. Mean sale day heights have increased significantly from 47.0 inches in 1972 to 49.1 inches in 1975 (Figure 15). Further data relating to sale day height is contained in appendix Tables A4, A5, A9, A13, A15, and A16.

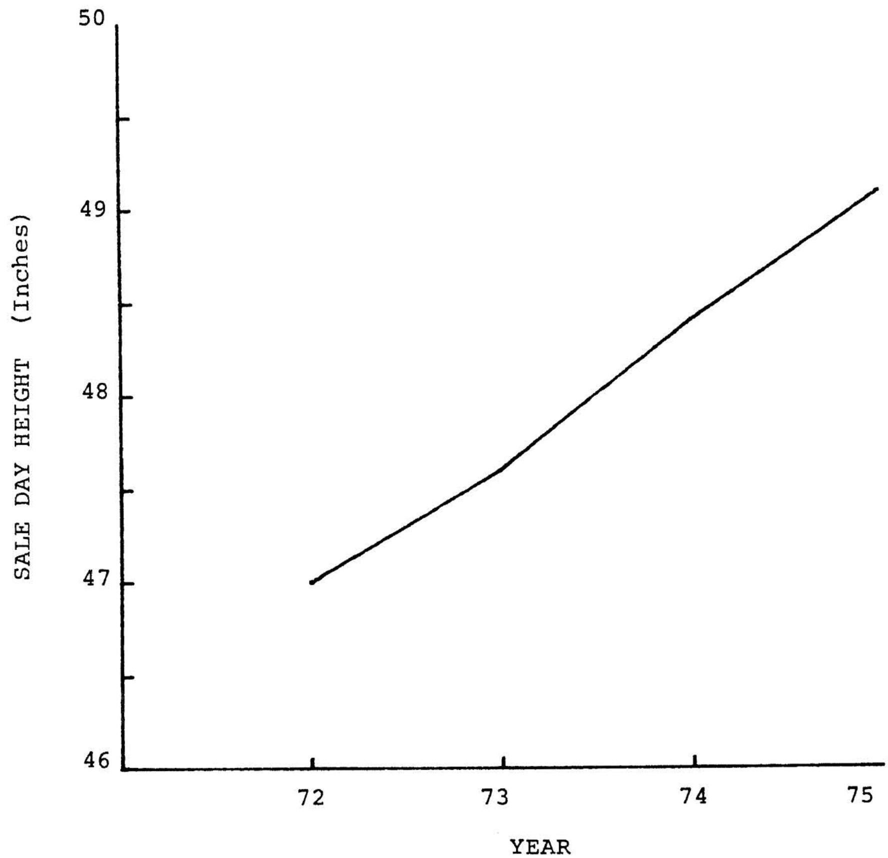

Fig. 15—Sale day height (Adjusted to 540 Days) by year. (Regression of sale day height on year was significant.)

Sale Day Weight

Sale day weight was a significant ($P < .01$) factor affecting variation in sale price, accounting for 9 percent of that variation. Sale day weight was significantly ($P < .01$) affected by breed and year. Mean sale day weights were heaviest for Hereford bulls followed by Polled Herefords and Angus. Mean sale day weights were 1313.1, 1302.0, and 1266.4 pounds, respectively.

Sale day weights have varied significantly ($P < .01$) between years, ranging from 1271.5 pounds to 1319.1 pounds. However, no apparent trend was observed (Figure 16).

More detailed data pertaining to sale day weight is contained in appendix Tables A4, A5, A9, A13, A15 and A16.

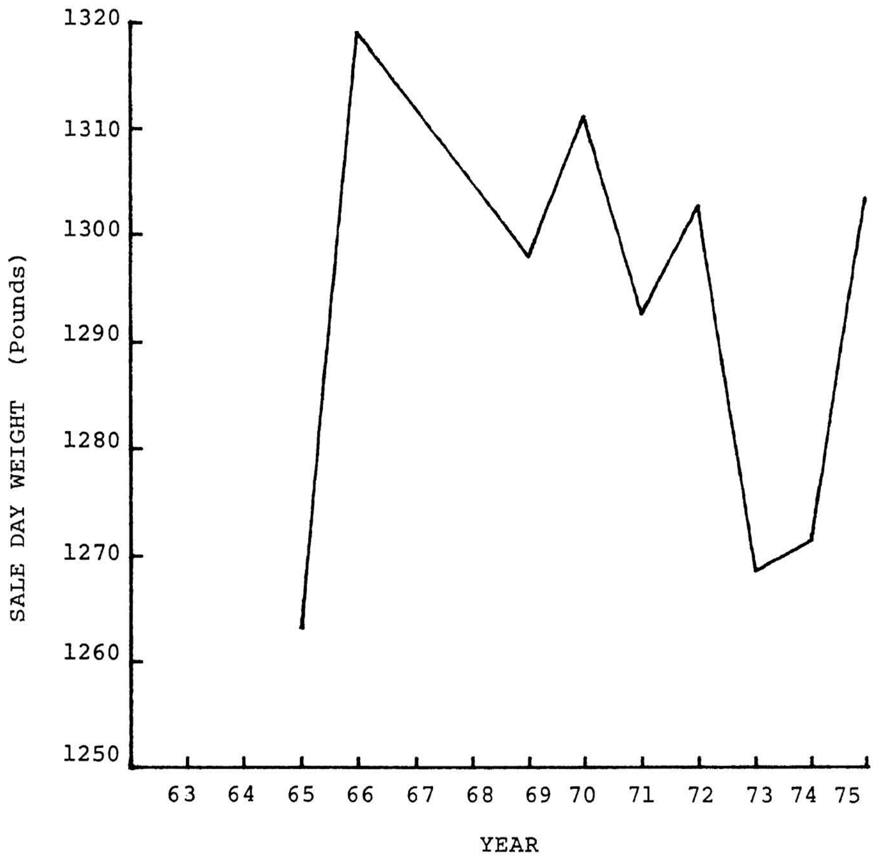

Fig. 16—Sale day weight by year. (Regression of sale day weight on year was significant.)

Sale Day Age

Sale day age was not a significant factor in sale price variation. Sale day age was significantly affected by breed and season. Mean sale day ages were highest for Hereford bulls (596.2 days) followed by Angus (587.4 days) and Polled Herefords (582.3 days). Regression of sale day age on year was not significant (Figure 17). Sale day age was significantly affected by season ($P < .01$). Bulls sold in the fall sales were significantly older than bulls in the spring sales.

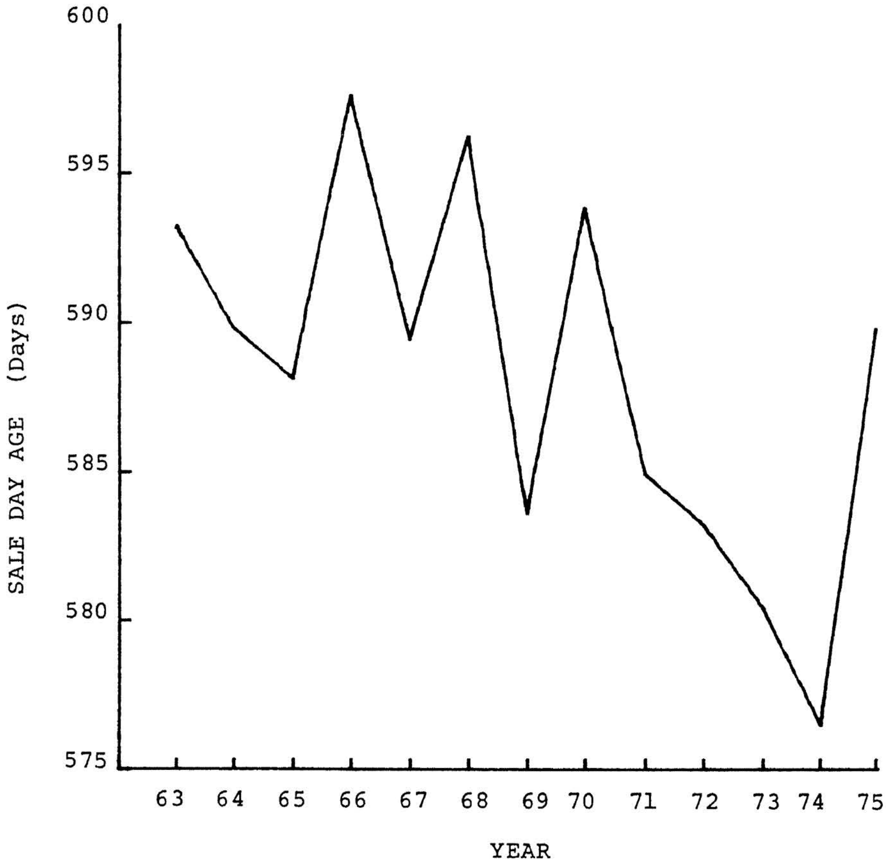

Fig. 17—Sale day age by year. (Regression of sale day age on year was not significant.)

Chapter 5

SUMMARY AND CONCLUSIONS

Sale Price Relationships

During the period 1963-1975 sale prices have increased significantly. Inflation has been a key factor in this price increase; however, an increasing awareness of the value of performance testing has caused demand for tested bulls to rise rapidly.

Through the sale prices they have paid, buyers have shown a significant preference for Polled Hereford bulls.

Sale price was significantly correlated with sale day grade, sale day weight, 365-day weight, and yearling conformation grade. Sale day grade was by far the most important factor in sale price variation ($r^2 = 0.33$). On the average, buyers paid $293.38 for each increment increase in sale day grade.

Season affected sale price significantly. Bulis sold in the spring sales averaged $150 more per head than those sold in fall sales.

Sale day weight accounted for 9 percent of the sale price variation. Three hundred sixty-five day weight was responsible for 2 percent of the sale price variation and yearling conformation grade accounted for the remaining 1 percent of sale price variance explained in this study.

Performance Trends

Adjusted 205-day weight, postweaning average daily gain, and adjusted 365-day weight have all increased significantly over the years.

Longissimus dorsi area measurements have not increased significantly, considering all breeds measured. However, Angus bulls have produced significantly ($P < .05$) larger longissimus dorsi area measurements.

Five hundred forty-day adjusted fat free body and percent fat free body have increased significantly ($P < .01$).

Yearly conformation grade and sale day grade have improved significantly, from a mean of "B-" to a mean grade of "B" in both traits.

Sale day backfat has decreased significantly ($P < .01$), and sale day weight has varied between years. However, no trend has developed.

A significant ($P < .01$) breed difference was observed in sale day weight.

Breed Frequency Trends

Angus and Polled Herefords have rapidly increased in the number of bulls tested and sold and in the number of breeders participating in the sale. Hereford numbers have fluctuated slightly, but have failed to keep pace with the Angus or Polled Herefords. Mean prices have increased in all breeds, although less for Herefords than for the Angus or Polled Herefords.

Conclusions

Sale price has increased significantly during the time period studied. The determination of the amount of this increase due to increased demand, as opposed to simple inflation of price, was beyond the scope of this study as was the effect of breeder reputation on sale price. Seasonal variation in sale price is significant and is most probably related to supply and demand interactions. Breed effects on sale price are minimal and basically related to the current popularity of the breed.

The performance:price relationship is significant. However, buyers still seem to be selecting herd sires on the basis of weight (sale day weight) and conformation (sale day grade) rather than productive performance measures such as adjusted 365-day weight or adjusted 540-day fat free body.

Performance trends of bulls tested in this program illustrate the effectiveness of the testing in increasing red meat production. However, it appears that the discrimination of the bull buyers, in general, has not kept pace with the innovations of the performance testing program.

BIBLIOGRAPHY

Anderson, E.C. 1959. Applications of natural gamma activity measurements to meat. Journal of Food Research. 24:605.

Baker, A. L., R. W. Phillips and W. H. Black. 1947. The relative accuracy of one-day and three-day weaning weights of calves. Journal of Animal Science. 6:56.

Baker, F. H. 1967. History and development of beef and dairy performance programs in the United States. Journal of Animal Science. 26:1261.

Benyshek, L. L. and T. J. Marlowe. 1973. Relationship between Hereford cow weight and progeny performance. Journal of Animal Science. 37:406.

Berger, P. J. and W. R. Harvey. 1975. Realized genetic parameters from index selection in mice. Journal of Animal Science. 40(1):38.

Birkett, R. J., D. L. Good and D. L. Mackintosh. 1965. Relationship of various linear measurements and percent yield of trimmed cuts of beef carcasses. Journal of Animal Science. 24:16.

Black, W. H., B. J. Knapp and A. C. Cook. 1938. Correlation of body measurements of slaughter steers with rate and efficiency of gain and with certain carcass characteristics. Journal of Agricultural Research. 56:465.

Brody, Samuel, E. A. Trowbridge and J. E. Comfort. 1930. Growth and development. XV. Energy and nitrogen metabolism during the first year of postnatal life. Missouri Agricultural Experiment Station Research Bulletin 143.

Brown, C. J. and Maximo Gacula. 1964. Estimates of heritability of beef cattle performance traits by regression of offspring on sire. Journal of Animal Science. 23:321.

Brown, J. E., C. J. Brown and W. T. Butts. 1973. Evaluating relationships among immature measures of size, shape and performance of beef bulls. III. The relationships between postweaning test performance and size and shape at twelve months. Journal of Animal Science. 37:11.

Brown, M. A. and R. R. Frahm. 1975. Feed efficiency in mice selected for preweaning and postweaning growth. Journal of Animal Science. 41(4):1002.

Brungardt, V. H. 1972. A study of the usefulness of the livestock scale, scanogram, K-40 counter and visual methods to estimate carcass composition in live cattle. *Research Report R2401,* University of Wisconsin, Madison, Wisconsin.

Buiatti, P. G. 1954. The heritability of live weight and height at withers and correlation between them in Chiana heifers. Rov. Zootecnia 27:59-63 (Abs. 914. Animal Breeding Abstracts 22:207).

Cartwright, T. C. 1970. Selection criteria for beef cattle of the future. Journal of Animal Science. 30:706.

Chapman, H. D., T. M. Clyburn and W. C. McCormick. 1969. Selection of beef cattle for single traits. Journal of Animal Science. 29:225.

Chapman, H. D., T. M. Clyburn and W. C. McCormick. 1972. Comparison of criteria for selecting introduced beef sires. Journal of Animal Science. 35(2):321.

Davis, J. K., R. S. Temple and W. C. McCormick. 1966. A comparison of ultrasonic estimates of rib-eye area and fat thickness in cattle. Journal of Animal Science. 25:1087.

Dawson, W. M., T. S. Yao and A. C. Cook. 1952. Heritability of growth, beef characters and body measurements in Milking Shorthorn steers. (Abs.) Genetics. 37:575.

Flower, A. E., J. S. Brinks, J. J. Urick and F. S. Willson. 1964. Selection intensities and time trends for performance traits in range Hereford cattle under mass and recurrent selection. Journal of Animal Science. 23:189.

Frahm, R. R., L. E. Walters and C. R. McLellan. 1971. Evaluation of ^{40}K count as a predictor of muscle in yearling beef bulls. Journal of Animal Science. 32:463.

Frahm, R. R., and M. A. Brown. 1975. Selection for increased preweaning and postweaning weight gain in mice. Journal of Animal Science. 41(1):33.

Gaskins, C. T., W. R. Harvey and G. F. Ellis, Jr. 1975. Response to selection for weaning and yearling traits. Journal of Animal Science. 40(1):174.

Gifford, Warren. 1953. Records-of-performance tests for beef cattle in breeding herds. Arkansas Agricultural Experiment Station Bulletin 531.

Gillett, T. A., A. M. Pearson, D. M. Allen and R. A. Merkel. 1967. Variation in potassium and sodium content of bovine muscles. Journal of Animal Science. 26:46.

Gregory, K. E., L. A. Swiger, B. C. Breidenstein, V. H. Arthaud, R. B. Warren and R. M. Koch. 1964. Subjective live appraisal of beef carcass traits. Journal of Animal Science. 23:1176.

Harwin, G. O., J. S. Brinks and H. H. Stonaker. 1966. Genetic and environmental interactions affecting weaning weights of Hereford calves. Journal of Animal Science. 25:779.

Hazel, L. N. and J. L. Lush. 1942. The efficiency of three methods of selection. Journal of Heredity. 33:393.

Hedrick, H. B., W. E. Meyer, M. A. Alexander, S. E. Zobrisky and H. D. Naumann. 1962. Estimation of rib-eye area and fat thickness of beef cattle with ultrasonics. Journal of Animal Science. 21:362.

Henderson, D. W., D. E. Goll, M. H. Stromer, M. J. Walter, E. A. Kline and R. E. Rust. 1966. Effects of different measurement techniques and operators on bovine longissimus dorsi area. Journal of Animal Science. 25:334.

Hetzer, H. O. and R. H. Miller. 1970. Influence of selection for high and low fatness on reproductive performance of swine. Journal of Animal Science. 30:481.

High, J. W. 1970. Selection indexes for beef cattle. Tennessee Agricultural Experiment Station Bulletin 470.

Hohenboken, W. D., E. R. Hauser, A. B. Chapman and L. V. Cundiff. 1973. Phenotypic correlations between dam traits expressed during development lactation and traits of progeny in cattle. Journal of Animal Science. 37:1.

Johnson, R. K., L. E. Walters and J. V. Whiteman. 1973. Relationship between weight and ^{40}K count in steers. Journal of Animal Science. 36:37.

Knapp, B., Jr. and A. W. Nordskog. 1946. Heritability of growth and efficiency in beef cattle. Journal of Animal Science. 5:62.

Knapp, B., Jr. and R. T. Clark. 1950. Revised estimates of heritability of economic characteristics in beef cattle. Journal of Animal Science. 9:582.

Koch, R. M. and R. T. Clark. 1955. Influence of sex, season of birth and age of dam on economic traits in range beef cattle. Journal of Animal Science. 14:386.

Koch, R. M., L. V. Cundiff, K. E. Gregory and G. E. Dickerson. 1973. Genetic and phenotypic relations associated with preweaning and postweaning growth of Hereford bulls and heifers. Journal of Animal Science. 36:235.

Koch, R. M., K. E. Gregory and L. V. Cundiff. 1974. Selection in beef cattle. I. Selection applied and generation interval. Journal of Animal Science. 39:449.

Koch, R. M., K. E. Gregory and L. V. Cundiff. 1974a. Selection in beef cattle. II. Selection response. Journal of Animal Science. 39:459.

Koger, Marvin and J. H. Knox. 1951. The correlation between gains made at different periods by cattle. Journal of Animal Science. 10:760.

Kress, D. D. 1975. A genetic analysis of postweaning gain in Herefords. Journal of Animal Science. 41(1):251.

Lindholm, H. B. and H. H. Stonaker. 1957. Economic importance of traits and selection indexes for beef cattle. Journal of Animal Science. 16:998.

Lohman, T. G., B. C. Breidenstein, G. S. Smith and H. W. Norton. 1966. Symposium on atomic energy in animal science. II. Estimation of carcass lean muscle mass in steers by ^{40}K measurement. Journal of Animal Science. 25:1218.

Lohman, T. G. and H. W. Norton. 1968. Distribution of potassium in steers by ^{40}K measurements. Journal of Animal Science. 27:1262.

Lush, J. L. 1928. Changes in body measurements of steers during intensive fattening. Texas Agricultural Experimental Station Bulletin 385.

Lush, J. L. 1932. The relation of body shape of feeder steers to rate of gain, dressing percent and to value of dressed carcass. Texas Agricultural Experimental Station Bulletin 471.

Lush, J. L., F. W. Christensen, C. V. Wilson and W. H. Black. 1928. The accuracy of cattle weights. Journal of Agricultural Research. 36:551.
The accuracy of cattle weights. Journal of Agricultural Research. 36:551.
Marlowe, T. J. 1964. Influence of various factors on the sale price of purebred Hereford calves in southwest Virginia. Virginia Journal of Science. 15:168.

Marlowe, T. J. 1969. Bull selection criteria as indicated by sale price. Journal of Animal Science. 28:437.

Marlowe, T. J., C. M. Kincaid and G. W. Litton. 1958. Virginia beef cattle performance testing program. Virginia Agricultural Experiment Station Bulletin 489.

McReynolds, W. E. and V. H. Arthaud. 1970. Ultrasonic application for estimating fat thickness of beef cattle. Journal of Animal Science. 30:186.

Miller, Paul. 1969. Relating progeny superiority to genetic trend in cattle. Journal of Animal Science. 28:577.

Miller, Paul. 1970. *The Ankony Scoring System.* Published by Ankony Angus Corporation, Rhinebeck, New York.

Orme, L. E., A. M. Pearson, W. T. Magee and L. J. Bratzler. 1959. Relationship of live animal measurements to various carcass measurements in beef. Journal of Animal Science. 18:991.

Pahnish, O. F. 1951. Performance test selects faster gaining cattle. Progressive Agriculture in Arizona. 3:11.

Patterson, R. E., J. H. Jones, J. J. Bayles and R. V. Turnbough. 1949. Performance testing and progeny testing of beef breeding stock as an aid to selection. Journal of Animal Science. 8:608.

Patterson, R. E., T. C. Cartwright, J. H. Jones and J. J. Bayles. 1955. Performance testing of beef breeding stock. Journal of Animal Science. 14:1034.

Rutherford, John, L. L. Wilson, R. R. Garrigus and K. J. Drewry. 1966. Beef bull selection criteria used by southern Indiana commercial producers. Journal of Animal Science. 25:1279.

Rutledge, J. J., O. W. Robison, W. T. Ahlschwede and J. E. Legates. 1971. Milk yield and its influence on 205-day weight of beef calves. Journal of Animal Science. 33:563.

Schott, R. G., W. M. Dawson, A. C. Cook and M. L. Kohli. 1950. Inheritance of certain body measurements and measures of performance in steers. Genetics. 35:690.

Schutte, D. J. 1935. Factors affecting the growth of range cattle in semiarid regions. Anderstepoort Journal of Veterinary Science and Animal Industry. 5:535.

Service, Jolayne. 1972. *A User's Guide to the Statistical Analysis System.* Student Supply Stores, North Carolina State University, Raleigh, North Carolina.

Shelby, C. E., R. T. Clark, J. R. Quesenberry and R. R. Woodward. 1954. Heritability of some pre- and post-slaughter characteristics in beef cattle. Journal of Animal Science. 13:962.

Stanforth, T. A. and R. R. Frahm. 1975. Selection for weaning and yearling weight in Hereford cattle. Journal of Animal Science. 41(1):259.

Stolz, D., J. White and R. Martin. 1975. Influence of genetic selection for high and low post-weaning growth rate in mice. Journal of Animal Science. 41(1):435.

Stouffer, J. R., M. V. Wallentine, G. H. Wellington and A. Diekmann. 1961. Development and application of ultra-sonic methods for measuring fat thickness and rib-eye area in cattle and hogs. Journal of Animal Science. 20:759.

Studedmann, J. A., J. J. Guenther, S. A. Ewing, R. D. Morrison and G. V. Odell. 1968. Effect of nutritional level imposed from birth to eight months of age on subsequent growth and development patterns of full-fed beef calves. Journal of Animal Science. 27:234.

Terrill, Clair E. 1953. The relation between sale price and merit in Columbia, Targhee and Rambouillet Rams. Journal of Animal Science. 12:419.

Vesely, J. A. and O. W. Robison. 1971. Conventional selection indexes for birth and weaning traits in beef calves. Journal of Animal Science. 33:537.

Walker, P. M. 1973. Body measurements in combination with fat free body, as determined by the whole body counter, and their use in identifying and predicting bovine growth patterns. Unpublished Master's thesis. University of Missouri-Columbia.

Ward, G. M., J. E. Johnson and T. R. Tyler. 1967. Relationship of potassium measured as ^{40}K to the moisture and fat of ground beef. Journal of Animal Science. 26:298.

Warren, W. M. 1957. Relationship of performance test score to price received for beef bulls at public auction. Proceedings of the 54th Annual Meeting of the Association of Southern Agricultural Workers. Page 91.

Whiteman, J. V., Doyle Chambers, L. S. Pope and D. F. Stephens. 1954. Some sources of error in weighing steers off grass. Journal of Animal Science. 13:832.

Williamson, kK. C., R. C. Carter and J. A. Gaines. 1961. Effects of selected variables on prices of calves in Virginia feeder calf sales. Journal of Farm Economics. 43:697.

Wilson, L. L., C. A. Dinkel, D. E. Ray and J. A. Minyard. 1963. Beef cattle selection indexes involving conformation and weight. Journal of Animal Science. 22:1086.

Wilson, L. L., C. A. Dinkel, H. J. Tuma and J. A. Minyard. 1964. Live animal prediction of cutability and other beef carcass characteristics by several judges. Journal of Animal Science. 23:1102.

Wilton, J. W. and T. R. Batra. 1972. Variance of gain of beef bulls in central stations. Journal of Animal Science. 34:538.

APPENDIX

Table A1

Rations for Progeny Testing

RATION #1
(40% Roughage)

	Lbs.	C.P.	TDN	Ca	P
Shelled corn	745	66.3	596.0	0.15	2.31
Soybean meal	324	147.9	248.0	0.98	2.08
Molasses	110	3.3	59.3	0.90	0.09
Alfalfa meal (13%)	150	21.5	74.5	2.07	0.43
Cottonseed hulls	650	23.3	222.2	0.87	0.54
Limestone	6	--	--	2.00	--
Dicalcium phosphate	4	--	--	1.06	0.82
Trace mineral salt	10	--	--	--	--
Total	2,000	262.3	1,200.0	8.03	6.27
Percent		13.12	60.0	0.40	0.31

RATION #2
(20% Roughage)

	Lbs.	C.P.	TDN	Ca	P
Shelled corn	1,245	110.8	996.0	0.25	3.86
Soybean meal	270	112.9	206.0	0.81	1.73
Molasses	60	1.8	32.3	--	--
Alfalfa meal (13%)	100	14.3	49.7	1.38	0.29
Cottonseed hulls	300	11.6	111.0	0.43	0.27
Limestone	15	--	--	5.08	--
Trace mineral salt	10	--	--	--	--
Total	2,000	251.4	1,395.0	7.95	6.15
Percent		12.57	69.8	0.397	0.30

Vitamin A, 1,500 I.U./lb. feed.
Antiobiotics, 3.5 mg./lb. feed.

Table A2

Total Phenotypic Correlations Among Traits, All Breeds and Sales Pooled

	WW	ADG	YW	YH	LEA	FRAME	YCON	INDEX	SALEG	BF	SALEH	SALEW	SALE AGE	AFFB	PRICE
WW		-0.37	0.55	0.38	N.S.	0.28	0.12	0.42	0.13	-0.08	0.24	0.22	N.A.	0.15	0.19
ADG	2551		0.50	0.73*	N.S.	0.10	0.15	0.33	0.12	N.S.	0.09	0.10	N.A.	0.09	0.10
YW	2554	2551		0.43	N.S.	0.34	0.29	0.72	0.25	-0.08	0.31	0.31	N.A.	0.23	0.26
YH	802	802	802		-0.28	0.90	0.23	0.25	0.28	-0.16	0.66	0.36	N.A.	0.15	0.16
LEA	742	742	742	94		-0.24	0.10	N.S.	0.10	N.S.	N.S.	N.S.	N.A.	N.S.	0.08*
FRAME	1140	1140	1140	802	134		0.29	0.24	0.31	-0.16	0.58	0.28	N.A.	0.16	0.19
YCON	2406	2403	2406	693	722	1031		0.16	0.39	-0.11	0.23	0.14	N.A.	0.14*	0.25
INDEX	587	587	587	587	90	587	478		0.29	N.S.	0.23	0.45	N.S.	0.13	0.29
SALEG	2274	2274	2274	802	618	1140	2164	587		-0.09	0.54	0.36	0.06	0.21	0.44
BF	1304	1304	1304	802	166	1140	1194	587	1304		-0.20	0.17	N.S.	-0.11	N.S.
SALEH	1110	1110	1110	802	131	1110	1001	587	1110	1110		0.51	0.16	0.31	0.26
SALEW	2089	2089	2089	802	492	1140	1979	587	2089	1304	1110		0.43	0.21	0.36
SALE AGE	2554	2251	1554	802	742	1140	2406	587	2274	1304	1110	2089		N.A.	0.07
AFFB	735	735	735	596	112	723	633	543	735	725	723	735	735		0.09*
PRICE	2554	2551	2554	802	742	1140	2406	587	2274	1304	1110	2089	2554	735	

N.A. - Not applicable.
N.S. - Not significantly correlated.
* - (P < .05).
All others (P < .01).

Total phenotypic correlations are contained in the upper right matrix; lower left matrix contains the number of paired observations for each correlation.

Table A3

Total Phenotypic Correlations With Price by Breed*

Breed	WW	ADG	YW	YH	LEA	FRAME	YCON	INDEX	SALEG	BF	SALEH	SALEW	SALE AGE
Angus	0.24/1134	0.10/1134	0.26/1134	0.36/336	N.S.	0.37/48	0.24/1069	0.55/262	0.53/1023	N.S.	0.42/470	0.56/940	0.11/1134
Hereford	0.21/281	N.S.	0.35/281	0.51/54	N.S.	0.52/83	0.27/266	0.57/32	0.46/231	N.S.	0.43/79	0.54/196	N.S.
Polled Hereford	0.19/1095	0.11/1092	0.28/1095	0.22/368	N.S.	0.22/533	0.27/1034	0.28/249	0.42/976	N.S.	0.35/517	0.29/909	0.06/1095

A/B - Top Value = Correlation Coefficient, Bottom Value = Number of Paired Observations.

N.S. - Not statistically significant.

*($P < .05$).

All others ($P < .01$).

Table A4

Mean Performance for Several Traits by Season for Years 1969-75

Season	Number of Animals	Adj. 205-Day Weaning Weight (lbs.)	Postweaning A.D.G. (lbs.)	Adj. 365-day Weight (lbs.)	365-Day Height (in.)	Loin Eye Area (in.^{2})	Adj. 540-day Fat Free Body (lbs.)
Spring	686	567.2 (76.2)	3.07 (0.45)	1058.3 (68.5)$^{\text{N.S.}}$	[227] 45.2 (1.2)$^{\text{N.S.}}$	[111] 13.65 (0.99)	[263] 860.2 (68.1)
Fall	1208	580.8 (61.6)	2.98 (0.40)	1056.1 (66.5)$^{\text{N.S.}}$	[575] 45.4 (1.4)$^{\text{N.S.}}$	[263] 13.46 (0.75)	[504] 962.1 (66.4)

N.S. - Non-significant differences.

All others ($P < .01$).

Table A4 (Cont.)

Season	Fat Free Body (%)	Frame	Conformation Grade	Sale Day Grade	Backfat (in.)	Sale Day Height (in.)	Sale Day Weight (lbs.)	Price ($)
Spring	[263] 70.36 (3.52)	3.68 (0.59)	B (0.72)**	B (0.82)	0.41 (0.20)	48.2 (1.5)$^{\text{N.S.}}$	1282.1 (115.9)	1152.73
Fall	[504] 69.62 (3.26)	3.76 (0.72)	B (0.70)**	B (0.78)	0.34 (0.18)	48.0 (1.6)$^{\text{N.S.}}$	1293.9 (103.3)	996.77

**Mean conformation grades were significantly different between seasons, within the grade classification.

Table A5

Weight Trends by Year*

Year	Number of Animals	Adj. 205-day Weight**	Postweaning A.D.G.	Adj. 365-day Weight	Sale Day Weight
1963	38	511.7 (61.0)	2.64 (0.30)	901.3 (67.6)	------
1964	80	544.7 (63.8)	2.72 (0.34)	933.9 (60.8)	------
1965	95	550.4 (71.1)	2.75 (0.42)	972.1 (78.7)	1263.3 (105.5)
1966	118	546.2 (55.6)	2.75 (0.29)	975.7 (62.1)	1319.1 (113.7)
1967	174	564.8 (60.2)	2.85 (0.33)	1017.6 (58.3)	------
1968	155	568.7 (66.5)	2.89 (0.40)	1025.4 (65.3)	------
1969	209	575.3 (69.5)	2.92 (0.47)	1031.5 (61.2)	1297.9 (116.2)
1970	227	560.1 (61.2)	2.92 (0.38)	1028.8 (54.3)	1311.2 (104.9)
1971	232	572.3 (67.9)	2.90 (0.39)	1036.7 (57.0)	1292.6 (109.5)
1972	298	567.0 (68.1)	3.07 (0.43)	1058.8 (65.9)	1302.9 (106.0)
1973	342	582.1 (63.5)	2.98 (0.44)	1058.1 (61.5)	1268.5 (98.8)
1974	331	577.0 (64.4)	3.08 (0.40)	1070.3 (65.1)	1271.5 (99.6)
1975	256	596.0 (77.8)	3.16 (0.41)	1099.7 (75.1)	1303.5 (118.5)

*Standard deviations in parentheses.

**All weights are expressed in pounds.

Table A6

Height Trends by Year*

Year	Number of Animals	Adj. 365-day Height (in.)	Frame	Sale Day Height (in.)
1963-1791	"Height Measurements Were Not Taken"			
1972	298	------	3.47 (0.55)	47.0 (1.4)
1973	342	45.2 (1.0)	3.68 (0.57)	47.6 (1.2)
1974	331	45.2 (1.3)	3.78 (0.68)	48.4 (1.4)
1975	256	45.8 (1.5)	3.96 (0.82)	49.1 (1.6)

*Standard deviation in parentheses.

Table A7

Longissimus Dorsi Area, Backfat and Fat Free Body Trends by Year*

Year	Number of Animals	Adj. 540-day Fat Free Body (lbs.)	Adj. 540-day Fat Free Body (%)	Loin Eye Area (inches^2)	Sale Day Backfat (in.)
1963	20	------	------	13.16 (0.87)	------
1964	41	------	------	13.79 (1.08)	------
1965	49	------	------	13.37 (0.88)	------
1966	76	------	------	13.59 (0.88)	------
1967	120	------	------	12.53 (0.91)	------
1968	62	------	------	12.75 (0.99)	------
1969	72	------	------	13.34 (0.67)	------
1970	102	------	------	13.70 (0.64)	------
1971	110	[10]** 879.5 (30.9)	------	[54] 13.48 (1.24)	0.48 (0.16)
1972	298	[93] 813.7 (70.4)	66.9 (2.8)	[39] 13.35 (0.67)	0.49 (0.21)
1973	342	[89] 824.7 (69.0)	69.1 (3.5)	[17] 13.53 (1.25)	0.35 (0.18)
1974	331	871.2 (50.0)	70.6 (3.2)	[59] 13.74 (1.19)	0.32 (0.16)
1975	256	876.5 (85.1)	70.3 (3.1)	[31] 12.85 (0.86)	0.31 (0.16)

*Standard deviations in parentheses.

**Numbers in brackets preceding a mean value represent the number of animals that have been measured for that trait.

Table A8

Age, Conformation and Price Trends by Year*

Year	Number of Animals	Yearling Conformation Grade **	Sale Day Grade	Sale Day Age (days)	Sale Price
1963	38	------	------	593.2 (43.0)	638.03 (245.31)
1964	80	B- (0.49)	------	589.8 (32.2)	597.38 (269.46)
1965	95	B- (0.54)	B- (0.80)	588.1 (34.0)	676.89 (219.86)
1966	118	B- (0.57)	B (0.78)	597.6 (40.6)	709.19 (326.09)
1967	174	B- (0.65)	B (0.79)	589.4 (36.6)	668.97 (369.62)
1968	155	B (0.72)	------	596.2 (38.9)	773.10 (428.81)
1969	209	B (0.77)	B (0.71)	583.6 (48.1)	779.09 (367.98)
1970	226	B (0.73)	B (0.79)	593.8 (44.9)	853.94 (387.88)
1971	232	B (0.78)	B (0.74)	584.9 (44.7)	843.73 (317.81)
1972	298	B (0.69)	B (0.81)	583.2 (44.2)	1100.92 (475.57)
1973	342	B (0.61)	B (0.80)	580.4 (44.4)	1238.89 (623.22)
1974	331	B (0.64)	B (0.69)	576.5 (44.1)	1192.07 (653.37)
1975	256	B (0.59)	B (0.72)	589.8 (47.5)	1157.11 (1798.64)

*Standard deviations in parentheses.

**Standard deviations of conformation grades are based on the difference between grades (e.g. B to B+) being equal to 1.0.

Table A9

Weight Trends by Year and Season*

Year	Season	Number of Animals	Adj. 205-day Weight**	Postweaning A.D.G.	Adj. 365-day Weight	Sale Day Weight
1963	F	38	511.7 (61.0)	2.642 (0.296)	901.3 (67.6)	------
1964	F	80	544.7 (63.8)	2.716 (0.336)	933.9 (60.8)	------
1965	F	95	550.4 (71.1)	2.745 (0.420)	972.1 (78.7)	1263.3 (105.5)
1966	F	118	546.2 (55.6)	2.754 (0.290)	975.7 (62.1)	1319.1 (113.7)
1967	F	174	564.8 (60.2)	2.854 (0.332)	1017.6 (58.3)	------
1968	F	155	568.7 (66.5)	2.889 (0.397)	1025.4 (65.3)	------
1969	S	74	571.0 (82.2)	2.950 (0.428)	1040.5 (78.4)	1292.0 (130.2)
1969	F	135	574.7 (52.4)	2.906 (0.491)	1026.8 (48.9)	1303.3 (105.3)
1970	S	65	552.0 (79.0)	2.984 (0.377)	1027.1 (56.7)	1334.9 (122.3)
1970	F	161	563.3 (52.5)	2.911 (0.314)	1029.6 (53.4)	1301.6 (95.7)
1971	S	76	580.6 (83.8)	2.870 (0.409)	1039.7 (60.9)	1268.2 (112.5)
1971	F	156	568.2 (58.5)	2.916 (0.378)	1035.2 (55.2)	1293.1 (111.7)
1972	S	117	555.4 (78.9)	3.095 (0.515)	1051.1 (55.5)	1296.2 (104.2)
1972	F	181	574.5 (59.0)	3.055 (0.365)	1063.8 (71.5)	1307.2 (107.3)
1973	S	127	565.5 (68.7)	3.135 (0.463)	1067.2 (63.4)	1273.1 (117.6)
1973	F	215	591.9 (58.3)	2.882 (0.392)	1052.7 (59.9)	1265.7 (86.0)
1974	S	118	562.2 (72.0)	3.089 (0.449)	1057.4 (64.7)	1247.7 (98.3)
1974	F	213	585.2 (58.3)	3.076 (0.374)	1077.4 (64.4)	1284.6 (98.1)
1975	S	109	584.7 (71.7)	3.223 (0.368)	1100.4 (74.8)	1286.2 (119.9)
1975	F	147	604.3 (81.3)	3.106 (0.431)	1099.2 (75.5)	1316.4 (116.2)

*Standard deviations in parentheses.

**All weights are expressed in pounds.

Table A10

Height Trends by Year and Season*

Year	Season	Number of Animals	Adj. 365-day Height (in.)	Frame	Sale Day Height (in.)
1963 - 1971	"Height Measurements Not Taken"				
1972	S	30	------	3.40 (0.498)	------
1972	F	181	------	3.49 (0.554)	46.95 (1.359)
1973	S	127	------	3.55 (0.515)	47.31 (1.448)
1973	F	215	45.16 (1.031)	3.76 (0.584)	47.73 (1.066)
1974	S	118	44.97 (1.103)	3.73 (0.549)	48.17 (1.193)
1974	F	213	45.31 (1.371)	3.81 (0.743)	48.46 (1.542)
1975	S	109	45.52 (1.194)	3.86 (0.673)	49.16 (1.342)
1975	F	147	46.02 (1.672)	4.03 (0.914)	49.11 (1.825)

*Standard deviations in parentheses.

Table A11

Loin Eye Area, Backfat and Fat Free Body Trends by Year and Season*

Year	Season	Number of Animals	Adj. 540-day Fat Free Body (lbs.)	Adj. 540-day Fat Free Body (%)	Loin Eye Area (inches^2)	Sale Day Backfat (in.)
1963	F	20	------	------	13.16 (0.87)	------
1964	F	41	------	------	13.79 (1.08)	------
1965	F	49	------	------	13.37 (0.88)	------
1966	F	76	------	------	13.59 (0.88)	------
1967	F	120	------	------	12.53 (0.91)	------
1968	F	62	------	------	12.75 (0.99)	------
1969	S	23	------	------	13.50 (0.67)	------
1969	F	49	------	------	13.29 (0.61)	------
1970	S	22	------	------	13.47 (0.90)	------
1970	F	80	------	------	13.77 (0.54)	------
1971	S	76	------	------	[19]** 13.81 (0.58)	0.48 (0.16)
1971	F	34	[10] 879.5 (30.9)	------	13.53 (0.56)	------
1972	S	117	[2] 946.1 (17.7)	------	[15] 13.16 (0.87)	0.52 (0.22)
1972	F	181	[91] 810.7 (68.3)	------	[24] 13.47 (0.50)	0.47 (0.20)
1973	S	127	[36] 809.8 (68.4)	------	[13] 13.30 (1.18)	0.40 (0.18)
1973	F	215	[53] 834.8 (68.2)	------	[4] 14.29 (1.35)	0.33 (0.17)
1974	S	118	840.9 (72.6)	------	[18] 14.54 (1.25)	0.37 (0.17)
1974	F	213	862.3 (66.4)	70.46 (2.930)	[41] 13.40 (1.00)	0.29 (0.15)
1975	S	109	871.6 (76.9)	70.35 (3.325)	------	0.29 (0.15)
1975	F	147	880.1 (90.8)	70.19 (3.015)	[31] 12.85 (0.86)	0.31 (0.17)

*Standard deviations in parentheses.

**Numbers in brackets preceding a mean value represent the number of animals that have been measured for that trait.

Table A12

Age, Conformation and Price Trends by Year and Season*

Year	Season	Number of Animals	Yearling Conformation Grade**	Sale Day Grade	Sale Day Age (days)	Sale Price
1963	F	38	------	------	593.2 (43.0)	638.03 (245.31)
1964	F	80	B- (0.49)	------	589.8 (32.2)	597.38 (269.46)
1965	F	95	B- (0.54)	B- (0.80)	588.1 (34.0)	676.89 (219.86)
1966	F	118	B- (0.57)	B (0.78)	597.6 (40.6)	709.19 (326.09)
1967	F	174	B- (0.65)	B (0.79)	589.4 (36.6)	668.97 (369.62)
1968	F	155	B (0.72)	------	596.2 (38.9)	773.10 (428.81)
1969	S	74	B (0.73)	B (0.66)	571.5 (60.3)	808.58 (298.18)
1969	F	135	B (0.77)	B (0.75)	590.4 (38.1)	766.81 (402.20)
1970	S	65	B (0.73)	B (0.88)	594.2 (63.8)	1038.38 (421.14)
1970	F	161	B (0.73)	B (0.74)	593.1 (34.3)	779.47 (348.17)
1971	S	76	B (0.80)	B (0.83)	569.8 (58.3)	880.13 (269.14)
1971	F	156	B (0.77)	B (0.74)	592.3 (34.2)	825.99 (338.40)
1972	S	117	B (0.67)	B- (0.76)	580.4 (51.6)	1004.91 (353.46)
1972	F	181	B (0.68)	B (0.82)	584.9 (38.7)	1162.98 (531.79)
1973	S	127	B (0.64)	B (0.82)	576.0 (53.8)	1215.55 (585.82)
1973	F	215	B (0.57)	B (0.79)	583.0 (37.6)	2352.67 (645.24)
1974	S	118	B (0.62)	B (0.70)	567.2 (53.2)	1485.04 (607.61)
1974	F	213	B (0.65)	B (0.69)	581.7 (37.2)	1030.75 (621.96)
1975	S	109	------	B (0.77)	583.1 (53.3)	1370.32 (2680.47)
1975	F	147	B (0.59)	B (0.67)	594.7 (42.2)	999.01 (525.73)

*Standard deviations in parentheses.

**Standard deviations of conformation grades are based on the difference between grades (e.g. B to B+) being equal to 1.0.

Table A13

Mean Performance for Several Traits of Angus Bulls by Year and Season[1]

Year	Season	Number of Animals	Adj. 205-day weight	Postweaning A.D.G.	Adj. 365-day weight	Sale Day Weight	Adj. 365-day Height (inches)	Frame	Sale Day Height (inches)
1963	F	16	502.2 (45.6)	2.66 (0.36)	905.5 (61.7)	------			
1964	F	28	530.4 (67.1)	2.66 (0.29)	912.3 (60.3)	------			
1965	F	40	545.7 (63.9)	2.59 (0.38)	939.1 (63.5)	1208.9 (97.2)			
1966	F	54	533.8 (52.2)	2.77 (0.30)	968.6 (60.4)	1287.4 (104.6)			
1967	F	83	554.3 (49.8)	2.91 (0.30)	1017.0 (51.9)	------			
1968	F	67	562.9 (64.8)	2.94 (0.41)	1026.7 (65.0)	------	No height measurements were taken.		
1969	S	34	548.2 (63.1)	3.07 (0.48)	1029.4 (71.2)	1274.0 (132.5)			
1969	F	60	570.9 (50.8)	2.96 (0.56)	1023.1 (48.9)	1292.6 (113.3)			
1970	S	34	537.9 (58.5)	2.99 (0.36)	1017.1 (51.4)	1334.9 (121.5)			
1970	F	90	548.7 (43.1)	2.96 (0.29)	1021.8 (48.1)	1279.6 (94.0)			
1971	S	32	552.7 (70.6)	2.92 (0.41)	1020.0 (43.7)	1233.4 (117.0)			
1971	F	80	548.9 (45.7)	3.04 (0.35)	1035.4 (53.4)	1248.0 (116.6)			
1972	S	46	532.0 (63.7)	3.27 (0.44)	1055.0 (59.0)	1265.7 (87.6)	------	3.30 (0.48)	------
1972	F	77	566.9 (52.7)	3.14 (0.32)	1070.1 (66.7)	1290.1 (98.8)	------	3.49 (0.55)	46.55 (1.34)
1973	S	57	548.7 (63.7)	3.28 (0.48)	1073.4 (62.6)	1233.1 (115.0)	------	3.65 (0.52)	46.74 (1.51)
1973	F	74	588.6 (55.3)	2.92 (0.46)	1056.1 (63.4)	1265.0 (91.6)	44.99 (0.77)	3.70 (0.46)	48.01 (1.00)
1974	S	55	556.1 (61.3)	3.21 (0.41)	1070.1 (64.5)	1246.3 (104.3)	45.25 (0.96)	3.85 (0.49)	48.15 (1.17)
1974	F	90	561.0 (54.3)	3.21 (0.35)	1075.2 (59.7)	1257.1 (82.9)	45.15 (0.87)	3.76 (0.50)	47.96 (1.02)
1975	S	49	569.6 (59.3)	3.26 (0.39)	1091.7 (73.2)	1242.2 (107.9)	45.34 (1.03)	3.80 (0.65)	48.87 (0.96)
1975	F	68	584.5 (65.5)	3.22 (0.42)	1096.0 (66.2)	1291.5 (100.2)	45.51 (0.95)	3.79 (0.59)	48.57 (0.94

[1]Standard deviations in parentheses, all measurements in pounds.

Table A13 (Cont.)

Year	Season	Number of Animals	Adj. 540-day Fat Free Body (lbs.)	Adj. 540-day Fat Free Body (%)	Longissimus Dorsi Area (inches^2)	Sale Day Backfat (inches)	Yearling Conformation Grade	Sale Day Grade	Sale Day Age (days)	Sale Price
1963	F	16	------	------	12.91 (0.99)	------	------	------	592.3 (45.9)	734.38 (276.17)
1964	F	28	------	------	13.87 (1.39)	------	B- (0.36)	------	591.2 (33.7)	618.39 (271.72)
1965	F	40	------	------	13.38 (0.95)	------	B- (0.47)	B- (0.90)	592.3 (33.0)	662.63 (220.38)
1966	F	54	------	------	13.70 (0.93)	------	B- (0.64)	B (0.79)	597.9 (37.7)	774.17 (372.29)
1967	F	83	------	------	12.59 (0.81)	------	B- (0.69)	B (0.83)	586.5 (31.1)	701.39 (458.43)
1968	F	67	------	------	13.28 (0.62)	------	B (0.71)	------	593.6 (35.0)	777.54 (414.79)
1969	S	34	------	------	13.45 (0.64)	------	B (0.80)	B (0.71)	565.9 (54.6)	881.62 (340.14)
1969	F	60	------	------	13.27 (0.41)	------	B (0.84)	B (0.77)	585.6 (40.2)	859.92 (545.10)
1970	S	34	------	------	13.70 (0.90)	------	B (0.73)	B- (0.82)	619.9 (55.9)	1128.24 (517.64)
1970	F	90	------	------	13.76 (0.51)	------	B (0.72)	B (0.77)	591.8 (32.7)	754.56 (343.21)
1971	S	32	------	------	[11] 13.71 (0.41)	0.43 (0.14)	B (0.88)	B- (0.88)	567.9 (66.0)	874.06 (243.20)
1971	F	80	------	------	13.54 (0.49)	------	B (0.78)	B (0.76)	588.9 (34.9)	783.00 (279.71)
1972	S	46	------	------	[5] 13.16 (0.85)	0.44 (0.19)	B (0.65)	B- (0.70)	589.7 (50.1)	1014.78 (371.16)
1972	F	77	------	66.97 (2.53)	[13] 13.61 (0.52)	[77] 0.41 (0.14)	B (0.66)	B (0.79)	589.8 (45.5)	1122.73 (598.73)
1973	S	57	------	69.56 (3.22)	[12] 13.32 (1.23)	[57] 0.37 (0.18)	B (0.68)	B (0.83)	578.6 (52.2)	1062.81 (426.91)
1973	F	74	------	69.99 (3.32)	[4] 14.29 (1.35)	[74] 0.29 (0.14)	B (0.55)	B (0.77)	587.9 (36.3)	1218.38 (544.60)
1974	S	55	------	71.99 (3.68)	[17] 14.43 (1.20)	0.33 (0.17)	B (0.63)	B (0.75)	568.8 (49.8)	1370.45 (459.42)
1974	F	90	854.8 (64.3)	71.38 (3.05)	[29] 13.23 (1.02)	0.27 (0.12)	B (0.67)	B (0.66)	581.8 (33.7)	932.28 (354.55)
1975	S	49	865.1 (70.8)	71.52 (3.59)	------	0.29 (0.15)	------	B (0.65)	574.1 (50.5)	1086.53 (575.77)
1975	F	68	862.5 (52.8)	71.02 (2.81)	[21] 13.06 (0.84)	0.30 (0.13)	B+ (0.61)	B (0.68)	601.6 (41.2)	912.13 (430.27)

[1]Standard deviations in parentheses, all measurements in pounds.

Table A14

Mean Performance for Several Traits of Charolais Bulls by Year and Season**

Year	Season	Number of Animals	Adj. 205-day Weight***	Postweaning A.D.G.	Adj. 365-day Weight	Sale Day Weight	Adj. 365-day Height (in.)	Frame	Sale Day Height (in.)	Adj. 540-day Fat Free Body (lbs.)
		1963 - 1971	"Measurements Were Not Taken"							
1974	F	7	672.7 (75.6)	2.946 (0.40)	1144.3 (74.1)	1460.71 (84.4)	48.47 (1.82)	5.43 (0.98)	51.59 (1.91)	1010.7 (61.0)
1975	S	2	843.5 (44.5)	2.995 (0.53)	1322.5 (129.4)	1535.0 (7.1)	49.30 (1.41)	5.50 (0.71)	53.15 (0.78)	1066.0 (65.1)
1975	F	10	709.9 (117.7)	2.954 (0.55)	1182.4 (101.8)	1520.0 (85.5)	48.06 (1.64)	4.90 (0.99)	52.26 (1.22)	1111.1 (63.0)

**Standard deviations in parentheses.

***All measurements in pounds.

Table A14 (Cont.)

Year	Season	Number of Animals	Adj. 540-day Fat Free Body (%)	Loin Eye Area (inches^2)	Sale Day Backfat (in.)	Yearling Conformation Grade	Sale Day Grade	Sale Day Age (Days)	Sale Price
		1963 - 1971							
1974	F	7	72.20 (3.29)	------	0.13 (0.05)	B (0.53)	B (0.79)	580.3 (37.08)	907.14 (303.35)
1975	S	2	70.70 (0.57)	------	0.20 (0.00)	------	B (0.0)	574.5 (65.76)	850.00 (212.13)
1975	F	10	74.31 (2.80)	------	0.12 (0.05)	B (0.70)	B (0.32)	568.5 (32.79)	791.50 (311.50)

**Standard deviations in parentheses.

***All measurements in pounds.

Table A15

Mean Performance for Several Traits of Hereford Bulls
by Year and Season**

Year	Season	Number of Animals	Adj. 205-day Weight	Postweaning A.D.G.	Adj. 365-day Weight	Sale Day Weight	Adj. 365-day Height (in.)	Frame	Sale Day Height (in.)	Adj. 540-day Fat Free Body (lbs.)
1963	F	10	506.3 (60.3)	2.56 (0.17)	863.2 (56.9)	------				------
1964	F	21	571.1 (49.2)	2.64 (0.41)	959.3 (53.8)	------				------
1965	F	18	595.8 (70.1)	2.81 (0.45)	1023.8 (72.9)	1292.8 (86.0)				------
1966	F	21	569.1 (65.5)	2.64 (0.31)	965.6 (66.9)	1275.0(134.3)				------
1967	F	24	557.5 (75.0)	2.69 (0.33)	992.1 (58.5)	------	1963 - 1971	"Height Measurements Not Taken"		------
1968	F	19	615.2 (74.1)	2.69 (0.48)	1035.2 (83.8)	------				------
1969	S	14	634.0(101.1)	2.74 (0.28)	1074.6 (99.4)	1327.8(150.0)				------
1969	F	19	577.5 (52.7)	2.82 (0.51)	1018.5 (54.6)	1339.2 (89.5)				------
1970	S	6	600.2(156.4)	2.88 (0.48)	1064.8 (97.5)	1426.7 (41.7)				------
1970	F	12	585.4 (81.5)	2.75 (0.17)	1024.7 (71.6)	1379.2 (95.7)				------
1971	S	9	575.7(102.1)	2.86 (0.44)	1032.6 (56.7)	1361.1 (85.1)				------
1971	F	13	601.6 (56.2)	2.61 (0.41)	1019.8 (52.7)	1366.5 (88.6)				------
1972	S	16	612.4(131.3)	2.72 (0.70)	1047.4 (50.8)	1357.2 (63.4)	------	3.75 (0.50)	------	------
1972	F	18	569.4 (51.0)	2.77 (0.39)	1012.9 (37.8)	1299.0(112.0)	------	3.56 (0.62)	47.08 (1.34)	------
1973	S	7	607.9 (85.7)	2.63 (0.51)	1029.0 (51.5)	1262.9(104.1)	------	3.57 (0.54)	47.36 (1.28)	------
1973	F	22	573.5 (72.8)	2.72 (0.41)	1009.1 (38.3)	1245.2 (88.5)	45.07 (1.22)	3.64 (0.58)	47.73 (1.10)	------
1974	S	11	588.9 (72.6)	2.46 (0.58)	993.1 (44.3)	1221.4 (73.4)	44.68 (0.87)	3.45 (0.52)	48.27 (0.96)	------
1974	F	12	601.4 (60.5)	2.74 (0.46)	1039.7 (61.1)	1325.4 (89.1)	45.58 (1.20)	3.83 (0.72)	48.53 (1.00)	839.5 (62.0)
1975	S	5	574.4 (71.1)	2.88 (0.27)	1034.8 (31.2)	1271.0 (49.9)	44.96 (0.53)	3.60 (0.55)	48.82 (0.64)	885.6 (28.9)
1975	F	4	555.5 (23.9)	2.90 (0.15)	1020.0 (20.2)	1290.0 (34.9)	45.45 (1.20)	3.75 (0.96)	48.78 (0.97)	858.3 (40.3)

**Standard deviations in parentheses.

Table A15 (Cont.)

Table A15 (Cont.)

Year	Season	Number of Animals	Adj. 540-day Fat Free Body (%)	Loin Eye Area (inches^2)	Sale Day Backfat (in.)	Yearling Conformation Grade	Sale Day Grade	Sale Day Age (Days)	Sale Price
1963	F	10	------	12.96 (0.95)	------	------	------	595.3 (46.9)	522.00 (198.99)
1964	F	21	------	14.18 (0.78)	------	B- (0.68)	------	599.5 (38.9)	572.14 (270.30)
1965	F	18	------	13.13 (0.81)	------	B (0.70)	B (0.65)	599.6 (41.3)	696.11 (270.49)
1966	F	21	------	13.90 (1.20)	------	B- (0.48)	B (0.93)	593.6 (50.5)	588.33 (220.38)
1967	F	24	------	12.31 (1.26)	------	B (0.76)	B- (0.88)	602.9 (43.2)	578.33 (204.13)
1968	F	19	------	13.40 (0.30)	------	B (0.66)	------	580.6 (36.5)	776.32 (377.44)
1969	S	14	------	12.76 (0.32)	------	B (0.77)	B (0.83)	595.4 (70.5)	713.93 (343.27)
1969	F	19	------	13.28 (0.46)	------	B (0.63)	B (0.76)	621.8 (24.3)	690.79 (249.36)
1970	S	6	------	13.67 (0.31)	------	B (0.52)	B- (0.55)	573.8 (10.8)	835.00 (83.67)
1970	F	12	------	14.52 (0.55)	------	B (0.67)	B (0.74)	612.8 (47.2)	935.42 (371.03)
1971	S	9	------	[4]*** 13.40 (0.51)	0.52 (0.14)	B (0.87)	B (0.71)	577.7 (31.1)	875.00 (240.77)
1971	F	13	------	------	------	B (0.86)	B (0.60)	615.3 (24.5)	822.31 (478.00)
1972	S	16	------	------	0.46 (0.19)	B (0.68)	B (0.89)	588.6 (37.6)	867.81 (134.39)
1972	F	18	------	[2] 13.73 (0.01)	0.51 (0.19)	B (0.75)	B (0.91)	596.0 (29.4)	1080.56 (485.79)
1973	S	7	------	------	0.56 (0.23)	B (0.49)	B (0.90)	578.0 (56.5)	1107.14 (453.39)
1973	F	22	------	------	0.30 (0.15)	B (0.66)	B (0.68)	583.8 (38.1)	1027.27 (287.01)
1974	S	11	------	------	0.31 (0.13)	B (0.79)	B (0.50)	581.8 (48.0)	796.36 (168.06)
1974	F	12	69.43 (2.48)	------	0.34 (0.12)	B (0.49)	B (0.65)	616.7 (53.7)	1035.42 (471.03)
1975	S	5	69.90 (2.83)	------	0.32 (0.15)	------	B (0.55)	557.4 (38.4)	875.00 (50.00)
1975	F	4	68.60 (1.90)	------	0.34 (0.08)	B+ (0)	B (0.50)	616.0 (70.5)	671.25 (192.28)

**Standard deviations in parentheses.

***Numbers in brackets, preceding a mean value, represent the number of animals that have been measured for that trait.

Table A16

Mean Performance for Several Traits of Polled Hereford Bulls by Year and Season**

Year	Season	Number of Animals	Adj. 205-day Weight	Postweaning A.D.G.	Adj. 365-day Weight	Sale Day Weight	Adj. 365-day Height (in.)	Frame	Sale Day Height (in.)
1963	F	12	529.0 (78.8)	2.70 (0.30)	927.4 (73.8)	------			
1964	F	31	539.8 (65.9)	2.83 (0.29)	936.2 (60.5)	------			
1965	F	37	533.5 (71.4)	2.88 (0.40)	982.5 (81.4)	1316.3 (93.9)			
1966	F	43	550.7 (51.6)	2.79 (0.27)	989.7 (60.7)	1369.2 (103.1)			
1967	F	67	580.5 (63.7)	2.84 (0.35)	1027.4 (63.6)	------	1963 - 1971	"Height Measurements Not Taken"	
1968	F	69	561.6 (61.6)	2.90 (0.35)	1021.5 (60.6)	------			
1969	S	26	566.8 (78.9)	2.91 (0.38)	1036.7 (72.8)	1296.2 (116.0)			
1969	F	56	577.8 (54.8)	2.88 (0.40)	1033.5 (47.0)	1302.6 (100.2)			
1970	S	25	559.5 (76.8)	3.00 (0.38)	1031.7 (49.3)	1313.0 (129.0)			
1970	F	59	581.0 (52.3)	2.88 (0.36)	1042.4 (55.6)	1319.3 (87.5)			
1971	S	35	607.4 (83.7)	2.83 (0.41)	1059.5 (70.0)	1276.1 (101.1)			
1971	F	63	585.8 (65.1)	2.83 (0.36)	1038.0 (58.3)	1335.3 (82.4)			
1972	S	55	558.3 (61.4)	3.06 (0.45)	1048.9 (54.5)	1304.0 (117.7)	------	3.38 (0.50)	------
1972	F	86	582.2 (65.3)	3.04 (0.37)	1068.9 (77.2)	1324.2 (112.1)	------	3.47 (0.55)	47.28 (1.30)
1973	S	63	576.1 (68.1)	3.06 (0.39)	1065.9 (64.5)	1310.6 (110.3)	------	3.46 (0.50)	47.82 (1.21)
1973	F	119	597.4 (56.8)	2.89 (0.33)	1058.6 (58.0)	1269.9 (82.0)	45.29 (1.13)	3.82 (0.65)	47.56 (1.08)
1974	S	52	563.1 (81.8)	3.09 (0.35)	1057.7 (61.1)	1254.7 (96.9)	44.74 (1.23)	3.65 (0.59)	48.18 (1.28)
1974	F	97	594.5 (48.1)	2.98 (0.29)	1070.6 (53.5)	1281.9 (87.9)	44.95 (1.07)	3.61 (0.59)	48.36 (1.09)
1975	S	48	590.7 (66.2)	3.19 (0.30)	1100.4 (55.3)	1310.7 (100.9)	45.39 (0.88)	3.79 (0.54)	49.06 (1.27)
1975	F	52	591.5 (64.9)	3.03 (0.37)	1076.5 (60.9)	1292.5 (107.5)	45.43 (0.96)	3.71 (0.57)	48.28 (1.01)

**Standard deviations in parentheses.

Table A16 (Cont.)

Year	Season	Number of Animals	Adj. 540-day Fat Free Body (lbs.)	Adj. 540-day Fat Free Body (%)	Loin Eye Area (inches^2)	Sale Day Backfat (in.)	Yearling Conformation Grade	Sale Day Grade	Sale Day Age (Days)	Sale Price
1963	F	12	------	------	13.70 (0.31)	------	------	------	592.7 (39.3)	606.25 (197.93)
1964	F	31	------	------	13.60 (1.08)	------	B- (0.43)	------	582.1 (24.1)	595.48 (274.20)
1965	F	37	------	------	13.51 (0.84)	------	B- (0.51)	B- (0.71)	577.9 (28.9)	682.97 (196.50)
1966	F	43	------	------	13.41 (0.72)	------	B- (0.53)	B- (0.70)	599.0 (39.8)	686.63 (291.42)
1967	F	67	------	------	12.52 (0.94)	------	B- (0.54)	B (0.70)	588.1 (39.8)	661.27 (279.46)
1968	F	69	------	------	12.41 (1.05)	------	B (0.72)	------	602.9 (42.1)	767.90 (460.08)
1969	S	26	------	------	13.82 (0.60)	------	B (0.62)	B (0.49)	566.1 (61.0)	764.04 (176.90)
1969	F	56	------	------	13.31 (0.76)	------	B (0.73)	B (0.74)	584.9 (34.8)	692.86 (194.95)
1970	S	25	------	------	13.19 (0.95)	------	B (0.73)	B (0.99)	564.1 (67.4)	965.00 (275.09)
1970	F	59	------	------	13.71 (0.57)	------	B (0.75)	B (0.70)	590.9 (33.1)	785.76 (348.59)
1971	S	35	------	------	[4]*** 14.49 (0.57)	0.52 (0.16)	B (0.68)	B (0.81)	569.4 (57.4)	887.00 (303.53)
1971	F	63	------	------	13.50 (0.68)	------	B (0.76)	B (0.72)	591.8 (33.6)	881.35 (369.96)
1972	S	55	------	------	[10] 13.16 (0.93)	0.61 (0.23)	B (0.69)	B (0.77)	570.3 (55.2)	1036.55 (376.69)
1972	F	86	------	------	[9] 13.21 (0.45)	[86] 0.53 (0.22)	B (0.70)	B (0.82)	578.3 (32.6)	1216.28 (474.73)
1973	S	63	------	------	[1] 13.09 (0)	[63] 0.40 (0.16)	B (0.60)	B (0.81)	573.3 (55.7)	1365.79 (683.53)
1973	F	119	------	------	------	[119] 0.35 (0.19)	B (0.53)	B (0.82)	579.7 (38.2)	1315.67 (736.68)
1974	S	52	------	------	[1] 16.40 (0)	0.42 (0.16)	B (0.56)	B (0.65)	562.4 (57.9)	1751.92 (654.88)
1974	F	97	854.1 (48.2)	69.47 (2.35)	[10] 13.69 (0.55)	0.34 (0.16)	B (0.66)	B (0.71)	578.5 (37.0)	1116.96 (826.07)
1975	S	48	858.3 (63.9)	68.91 (2.57)	------	0.32 (0.14)	------	B (0.87)	593.5 (57.1)	1758.85 (3983.25)
1975	F	52	842.1 (56.8)	68.14 (1.98)	[7] 12.57 (0.87)	0.42 (0.17)	B (0.53)	B (0.73)	589.0 (39.3)	1200.58 (658.37)

**Standard deviations in parentheses.

***Numbers in brackets, preceding a mean value, represent the number of animals that have been measured for that trait.

Table A17

Mean Performance of Simmental Bulls by Year and Season**

Year	Season	Number of Animals	Adj. 205-day Weight	Postweaning A.D.G.	Adj. 365-day Weight	Sale Day Weight	Adj. 365-day Height (in.)	Frame	Sale Day Height (in.)	Adj. 540-day Fat Free Body (lbs.)
1974	F	7	652.3 (45.4)	3.41 (0.62)	1197.9 (98.5)	1431.4 (129.0)	48.70 (1.84)	5.57 (0.98)	53.13 (1.86)	962.4 (78.6)
1975	S	5	581.8 (51.4)	3.63 (0.43)	1163.6 (99.1)	1397.0 (220.8)	47.48 (1.71)	4.80 (0.84)	51.76 (0.57)	970.6 (125.3)
1975	F	13	693.2 (80.1)	2.96 (0.54)	1166.8 (78.1)	1393.5 (79.4)	49.67 (1.31)	5.92 (0.76)	52.94 (1.06)	953.8 (95.8)

**Standard deviations in parentheses.

Table A17 (Cont.)

Year	Season	Number of Animals	Adj. 540-day Fat Free Body (%)	Loin Eye Area (inches^2)	Sale Day Backfat (in.)	Yearling Conformation Grade	Sale Day Grade	Sale Day Age (Days)	Sale Price
1974	F	7	72.63 (3.96)	[2]*** 14.25 (2.19)	0.14 (0.05)	B+ (0.53)	B (0.49)	567.3 (23.23)	1217.86 (249.46)
1975	S	5	72.96 (2.75)	------	0.09 (0.10)	------	B (1.14)	602.2 (40.70)	1125.00 (506.21)
1975	F	13	71.32 (2.12)	[3] 12.03 (0.40)	0.13 (0.04)	B+ (0.51)	B+ (0.52)	594.5 (49.5)	907.69 (324.42)

**Standard deviations in parentheses.

***Numbers in brackets, preceding a mean value, represent the number of animals that have been measured for that trait.

Table A18

Sale Price by Year and Breed

Year	No.	Angus	No.	Hereford	No.	Polled Hereford
1963	16	734.38	10	522.00	12	606.25
1964	28	628.39	21	572.14	31	595.48
1965	40	662.63	18	696.11	37	682.97
1966	54	774.17	21	588.33	43	686.63
1967	83	701.39	24	578.33	67	661.27
1968	67	777.54	19	776.32	69	767.90
1969	94	867.77	33	700.61	82	715.43
1970	124	857.02	18	901.94	84	839.11
1971	112	809.02	22	843.86	98	883.37
1972	123	1082.36	34	980.44	141	1146.17
1973	131	1150.69	29	1046.55	182	1333.02
1974	145	1098.48	23	921.09	149	1338.56
1975	117	985.17	9	784.44	100	1468.55
Total Animals	1134		281		1095	
Overall Mean Price		921.12		785.05		1044.80

Table A19

Breed Frequency Trends by Year

Year	Angus	Hereford	Polled Hereford
1963	16	10	12
1964	28	21	31
1965	40	18	37
1966	54	21	43
1967	83	24	67
1968	67	19	69
1969	94	33	82
1970	124	18	84
1971	112	22	98
1972	123	34	141
1973	131	29	182
1974	145	23	149
1975	117	9	100

Table A20

Analysis of Variance for Sale Price of Angus, Herefords and Polled Herefords for Years 1963-75

Source	DF	Mean Square	F Value
Breed	2	1,854,734.698	4.115**
Year	12	3,908,752.469	7.516**
Season	1	7,793,581.399	14.985**
Breed x Year	24	745,998.326	1.620*
Error	2464	520,076.915	

*P < .05

**P < .01

Table A21

Stepwise Regression Adjusted for Year and Season
(Forward Selection Procedure for
Dependent Variable Price)

Number in Model	R-Square	Variables in Model*
1	0.33490885	SALEG
2	0.39640543	SALEG SALEDW
3	0.42947512	AGE SALEG SALEDW
4	0.44851194	AGE SALEG SALED SALEDW
5	0.46305892	ADJ3 AGE SALEG SALED SALEDW
6	0.46764690	ADJ3 AGE FRAME SALEG SALED SALEDW
7	0.47160557	ADJ3 AGE AFFB FRAME SALEG SALED SALEDW
8	0.47349186	POST ADJ3 AGE AFFB FRAME SALEG SALED SALEDW
9	0.47523950	POST ADJ3 AGE AFFB FRAME SALEG BF SALED SALEDW

No other variables met the required 0.5000 significance level
for entry into the model.

*See Table A22 for Glossary of Abbreviations.

Table A22

Glossary of Abbreviations

AGD - postweaning average daily gain

ADJ - 205-day weight, adjusted for age, sex and age of dam

ADJ3 (YW) - 365-day weight, incorporates 160-day postweaning ADG and 205-day weight

AFFB - fat free body adjusted to 540 days of age

AGE (SALE AGE) - age in days on sale day

BF - backfat thickness on sale day

FRAME - yearling frame scores based on shoulder height

INDEX - sale day index

LEA - loin-eye area or longissimus dorsi area

PRICE - sale price paid at auction

SALEH (SALED) - sale day shoulder height

SALEG - sale day grade

YCON - conformation grade given at approximately 365 days

YH - yearling shoulder height