RELATIONSHIPS AMONG TRAITS MEASURED IN A BEEF PERFORMANCE TESTING PROGRAM AND THEIR EFFECT ON SALES PRICE

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Bachelor of Science in Agriculture

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Stillwater, Oklahoma

1986

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December, 1988

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ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to the Oklahoma State University Animal Science Department for providing the opportunity and financial support for this study.

My sincere thanks and appreciation are extended to Dr. J.R. Kropp, my major advisor for his understanding, patience and encouragement during the course of this study and the preparation of this manuscript. I would also like to express my gratitude to the members of my advisory committee, Drs. D.S. Buchanan and C.A. McPeake. Special thanks goes to Mr. J.E. Callahan for his advice and friendship as well as Amy Bruce and Katie Shell for their assistance.

My appreciation is also extended to Jeana DeMuth and Wendy Clouse for their assistance in typesetting and Leslie Stidham for patience and aid in data entry. In addition, the friendship and assistance of my fellow graduate students is deserving of many thanks.

I would especially like to thank my parents, Mr. and Mrs. Bernard Johnson along with my two sisters, Lisa and Brenda for their love, encouragement and financial support, which have allowed me to continue my education.

Finally, this work is dedicated to the life of my great friend Larry Don Ice. May his memory live forever in the hearts of the many who knew and loved him.

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CHAPTER I

INTRODUCTION

The descendants of the Spanish Longhorn cattle populated the United States western rangelands in the 1800's. Trail drives started after the civil war. Americans began to acquire a taste for beef. In the late 1800's several of the American British beef breed associations were organized (American Hereford Association, 1881; American Shorthorn Association, 1882; American Angus Association, 1883; American Polled Hereford Association, 1890). Simmental cattle were introduced in 1896, but had little impact on the industry at that time.

The early British cattle were used mainly for draft and milk. They were large framed, late maturing and were not finished until three to four years of age. During the first three decades of the 20th century a gradual trend developed toward cattle with reduced frame size, earlier maturity and the ability to fatten at younger ages. From the mid 1930's to the late 1950's intense selection pressure occurred for the smaller, more "compressed", earlier fattening cattle. The term "baby beef" came into use. Surplus feed and an increased demand for grain fed beef led to the start of the commercial feedlot era following World War II. "Snorter dwarfism" was reported in 1951 which is generally believed to have been the result of the intense selection for extremely small framed cattle.

In the mid 1960's, the beef cattle industry began selection for cattle that could be carried to desired slaughter weights without becoming overly fat. The carcass yield grading system was adopted in 1965. Charolais cattle had been imported to the United States from Mexico in 1936, but the feedlot performance of the Charolais crossbred steer in the 1960's created an awareness in the American cattlemen for the lean growth potential of some of the Continental European breeds. In the late 1960's the cattlemen of all breeds began selecting within their herds for larger framed, growthier and leaner cattle. Simmental cattle were reintroduced in 1966 and other breeds including Limousin were being imported to the North American Continent (Hawkins and Ritchie, 1988).

The concept of beef cattle genetic improvement programs began with research in the 1930's. Central to the concept was the transfer of genetic change in the purebred industry to the commercial industry. Research continued through the 1940's and the first central bull test stations were established in the early 1950's. Central test stations provide commercial cattleman as well as purebred producers a method of comparison for bulls tested under the same environmental conditions. One problem with central bull test stations was, and is today, that only a small number of bulls can be tested each year. State beef cattle improvement associations were organized in the mid 1950's which provided an educational and computerized record system. In the 1960's on-farm and ranch performance testing programs were nurtured and began to flourish providing sound objective within herd information which breeders could use in making selection decisions. In 1968 the Beef Improvement Federation was formed and began to provide the framework for standardized and systematic procedures for collecting beef cattle performance data. In the 1970's European breeds became very popular as selection for growth and frame intensified. In 1971-72 (Benyshek, 1988) the first National Sire Summary was published and all breeds began to establish their own data base. Today this has evolved to the extent that nearly all major breeds print annual sire summaries. Artificial insemination was utilized widely in purebred and commercial herds in the 1970's and along this time embryo transfer became popular (Wallace, 1988).

Over the past two decades, with more tools and knowledge to aid in selection than ever before, intense selection for large framed, later maturing cattle has led to a current population, much in contrast to that of the early 1960's. As a result, there is presently concern among many segments of the beef industry particularly about size and growth as it relates to other economically important traits such as muscle and leanness as well as reproductive efficiency, structural soundness and other measures of functionality.

There were two principal objectives to this study. The first was to evaluate the relationships existing among measurements of growth and other traits such as ribeye area, fat thickness and scrotal circumference, as well as, to evaluate the changes and trends occurring over a number of years in a performance testing program. The second major objective was to determine the influence of performance measurements on the selling price of performance tested bulls.

CHAPTER II

REVIEW OF LITERATURE

Linear Measurements

Through this century cattlemen have been very interested in use of linear measurements as an indication of skeletal size. Consequently, in several instances the use of these measures has been taken to extremes. This section of the literature review is primarily concerned with height measurements and their correlated traits.

Linear measurements are very objective. They serve as a means of describing animals, and are useful supplemental information in performance testing, since they can be used with other growth information to predict the overall genetic merit for growth. The use or misuse a breeder makes of linear measurements depends on the goals and objectives of his breeding program.

A major influence on the degree of success of a breeding program is the heritability of the trait(s) utilized in the selection program. Heritability estimates for skeletal size have been researched extensively and Table I presents an overview based on several breeds and types of cattle studied.

There is a general agreement in the literature with respect to the relationship between hip and wither height.

TABLE I

HERITABILITY ESTIMATES OF LINEAR HIP AND WITHER MEASUREMENTS

Author	Year	Breed	Class	Wither	Hip
Nelson	1986	Hereford	403 day bulls	---	.24
Nelson	1986	Hereford	490 day bulls	---	.49
Massey	1979	---	Yearlings	.60	.48
Neville	1978[b]	---	Cow herd	---	.54
Neville	1978[b]	---	Cow herd	---	.79
Grabowski	1975	---	Cows	.33	.25
Arapavic	1973	---	Yearling Bulls	.52	---
Romita	1972	Italian	---	.46	.88
Brum	1969	Holstein	Yearling Heifers	.52	---
Okamoto	1966	Japanese	---	.42	.48
Brown & Franks	1964	---	---	---	.69
Kumazaki	1963	Japanese	Newborns	.53	.54
Kumazaki	1963	Japanese	Weaning	.81	.66
Kumazaki	1963	Japanese	Yearlings	1.01	.93
Blackmore	1958	Holstein	Yearling Heifers	.44	---
Blackmore	1958	Holstein	2 yr. Heifers	.86	---
Brown	1956	Hereford	Calves	.29	.21
Brown	1956	Angus	Calves	.38	.22
Dawson	1955	Milking Shorthorn	Steers	.65	---
Buiatti	1954	Chianina	Heifers	.69	---
Schott	1950	---	Steers	1.00	---
Gowen	1933	Jersey	Cows & Bulls	.60	---

Lush (1928) reported that hip height was practically a duplication of wither height with hip height being larger by a fairly constant amount with a correlation coefficient of .90 between the two. Kidwell (1955) reported a correlation of .927 between hip and wither height. Weber (1957) suggested that the same genetic basis regulates both characteristics, the same conclusion reached by Grabowski and Dyminick (1975) based on the high genetic correlation (.94) between height at withers and height at the sacrum.

During normal growth, wither height increases faster than hip height, but the two measurements tend to reach equality as maturity is approached. Kidwell (1955) reported a difference of 1.5 inches (3.807 cm) between hip height and wither height in 10 to 16 month old Hereford steers with hip height being larger. Calculations from data reported by Guilbert and Gregory (1952) showed an average difference of 1.83 inches (4.67 cm) in wither and hip height of Hereford bulls from 124 to 725 days of age. Likewise, calculations from data collected by Brown (1958) showed the difference between wither and hip height to be approximately 2 inches (5.07 cm) for Angus and Hereford heifers, bulls and steers at 240 days of age. Massey (1979) reported a difference of 1.65 and 1.75 inches between wither and hip height in many breeds of beef cattle at 205 days of age with hip height being the largest.

Rate of Skeletal Growth

Guilbert and Gregory (1952) reported that hip height was very linear up to 12 months of age then slowed at a constant rate until maturity. They reported Hereford bulls hip height increased .0338 inches/day from 124 to 369 days of age and only .0167 inches/day from 369 to 487 days of age. Most all reports on this subject agreed with their findings regarding rate and pattern of growth. In 1973, Brown et al. reported hip height growth rates of .043 and .039 inches/day for Hereford and Angus bulls, respectively. In addition, Dori et al. (1974) reported higher height growth rates in 180 to 270 day old Israeli-Friesian bulls than from 270 to 505 day old, .043 inches/day and .026 inches/day, respectively.

Several reports in the last decade (Massey, 1979; Maino, et al., 1981; Healy, 1979; Baker, 1981) have led to the general conclusion that hip height growth rate is relatively similar among beef breeds. Up to a year of age height increases by approximately 1 inch per month.

Relationship of Height to Rate of Growth and Various Weights

Frame size at a given age is highly correlated with mature size and consequently if managed under normal environments larger framed cattle should be faster growing at a younger age (Cundiff, 1987). Most research has supported Cundiff's statement showing a positive relationship between height measurements and weight. However, variation in the results does exist depending on type and breed of cattle. In some of the first research concerning linear measurements and gain, Hultz and Wheeler (1927) reported that small framed steers made slightly more rapid gains during a 156 day feeding period than did intermediate or larger framed steers. Baker et al. (1981) reported that while correlations between off-test hip height and off-test weight were moderate to high (average .56) for Angus, Brangus, Charolais, Hereford and Polled Hereford, correlations between on-test or off-test hip height and average daily gain were low to moderate, averaging .14 to .33 respectively.

In contrast, Mangus et al. (1980) reported high genetic and phenotypic correlations of .81 and .72 respectively, for final weight and hip height, as well as moderate to high genetic (.64) and phenotypic (.45) correlations of daily gain to hip height on performance tested bulls representing 9 breeds in 1980. Johnson et al. (1980) reported correlations of .54, .45 and .78 between yearling hip height and average daily gain over a 140 day test on 3 groups of Angus bulls tested in Arkansas in 1974 and 1978. Slightly lower correlations (.32, .35, .41) on 3 groups of Hereford bulls were also reported. In the same study, Johnson reported correlations between hip height and off-test weight of .47, .41, .64 and .69, .62 and .87 for Hereford and Angus bulls, respectively. Correlations reported for wither height to final weight and average daily gain were similar to those for hip height in Johnson's study. A phenotypic correlation of .63 between hip height and daily gain was reported (Manda, et al., 1980) from data collected on Japanese cattle. Flock et al. (1962) reported that among several linear measurements taken at birth, wither height was the best predictor of preweaning growth rate in Angus calves, with a correlation of

.33 between preweaning daily gain and height. However, this was of little use in estimating preweaning growth in Shorthorns (.04) with an intermediate relationship in Herefords (.25). Nelson et al. (1986) reported that hip height not only had positive correlations with weight at 403 and 490 days of age in Hereford bulls, but also phenotypic correlations of .54 and .47, with preweaning average daily gain at 403 and 490 days, respectively. Brown et al. (1973) reported genetic correlations between hip height at 8 months and preweaning daily gain of 1.15 and .83 for Hereford and Angus bulls, respectively.

In an early study on the relationship of height to weight, Lush (1932) reported correlations of .72 and .73 between initial on-test weight and wither or hip height respectively. In the same experiment off-test weight to wither or hip height correlations were reported to be .71 and .69 respectively. Kholi et al. (1951) reported a low correlation of .26 between wither height and a constant final weight of 900 pounds. Correlations of .38 (Gregory, 1933) and .62 (Kidwell, 1955) were reported between wither height and body weight from data collected from Hereford steers.

Brungardt reported (1972) that wither height of Angus, Charolais, and Hereford steers increased as on-test and off-test weights increased with correlations of .70 and .83 respectively. Brungardt stated that although cattle with more height at the withers gained faster and were heavier at time of slaughter, the relationship was not strong enough to merit selection for height instead of weight adjusted for age.

Based upon research reported in this section of the review, it is logical to presume a general increase in weight and daily gain as height is increased, with the magnitude of the increase depending on many factors such as breed, nutrition, environment as well as shape and type of cattle. Any of the measurements (height, weight or daily gain) alone tell very little about condition or type of cattle, suggesting that height and weight measurements in tandem would be a more accurate means of describing cattle.

Relationship of Muscle and Fatness to Height and Other Growth Measures

One of the prime economic objectives in beef cattle breeding is efficiency of lean growth. Therefore, realistic evaluation of selection criteria for improving efficiency of beef production should include the effects of selection on carcass composition (Dickerson et al., 1974). This section of the review will focus on the relationship of muscling and degree of fatness to frame size and other measurements of growth.

Relationship of Frame to Muscle and Fat

In 1928, Lush concluded that fat thickness had no influence on either wither or hip height during fattening of Hereford and Brahman cross-bred calves. Other early reports (Knapp and Cook, 1933; Black et al., 1938; Kohli et al., 1951; Yao et al., 1953) indicated a difference in carcass composition depending on frame size. In general, the results of these early reports suggested that with weight held constant, those steers of smaller frame size had more fat, higher dressing percentages, higher slaughter and carcass grades, as well as more total and edible product than larger framed steers. However, when attempts were made to compare the animals at similar degrees of finish the differences tended to become negligible. In 1968, Klosterman et al., reported correlations of .89 and .51 between weight-height ratio and condition score or ultrasonic measurements of fat, respectively. They concluded that a weight-height ratio was a reliable measure of body condition for mature Charolais cross and straight Hereford cows. Busch et al. (1969) reported intra subclass correlations between wither height and closely trimmed edible portions of .60, .57, and .54 for three groups of Hereford steers. DeBaca and Mclnerney (1979) reported correlations of .23 and .38 between wither height and hot carcass weight or percent retail yield respectively.

Other reports indicate a positive relationship between muscling and height. In 1981, Maino et al. reported non-significant tendencies of larger framed crossbred steers to have larger ribeye areas, less fat thickness, less percentage of total fat, higher percentage of carcass lean and lower yield grades, as well as heavier carcass weights. In 1982, Long reported a highly significant correlation of .32 between hip height and ribeye area from data collected on 88 steers at time of slaughter. It is important to note that Long (1982) also reported a correlation of .67 between slaughter weight and hip height. While no correlation was reported between slaughter weight and ribeye in Long's study his findings would seem to indicate a positive relationship between final weight and ribeye area. In further agreement, Orne et al. (1959) reported that while correlations of .11 and -.04 between wither height to ribeye area or percentage of primal cuts respectively, were non-significant, there was a significant multiple correlation of .48 between height and ribeye area with live weight.

In 1980, USDA Standard for Feeder Cattle Grades, stated that hip height measurements have been taken on cattle of different breed type and different ages and slaughtered on a different basis and consequently, it is believed that height relative to age, or frame score, does have an influence on growth rate and composition at a given end point. Variation in frame size among young cattle primarily affect the composition of their gain. The gain in weight of large framed cattle normally consist of more muscle and less fat than smaller framed cattle. The composition of larger framed animals will consist of a lesser degree of fatness and a higher proportion of muscle than smaller framed animals at a given weight.

Relationship of Growth Rate to Muscle and Fat

There have been several studies investigating the correlation between growth rate and carcass merit. Cundiff et al. (1971) reported genetic correlations of .66 and .34 between carcass weight at a constant age and ribeye area or fat thickness, respectively. Dinkel and Busch (1973) reported genetic correlations between feedlot daily gain and muscling score, ribeye area or fat thickness to be .26, .49 and -.25 respectively. They also reported correlations of .24, .54 and -.56 between final weight and muscling score, ribeye area and fat thickness, respectively, from data collected on Hereford steers from three private herds in South Dakota. From a study in Nebraska, Koch et al. (1974) reported phenotypic correlations of muscling score to preweaning daily gain, weaning weight, postweaning daily gain and yearling weight of .19, .20, .36 and .38 respectively, in unselected lines of bulls. In 1982, Koch et al. reported correlations from an extensive, comprehensive, germ plasm evaluation program involving data collected from 2,453 crossbred steers representing 16 different sire breeds. Correlations reported between feedlot daily gain and ribeye area or fat thickness were .34 and .05 respectively. They reported that genetic aspects of higher growth rate led to increased growth of lean relative to fat. In contrast, environmental increases in growth rate led to relatively more fat deposition. Their results suggest that selection for growth rate results in later maturing lean types of animal.

In a selection study conducted in Nebraska using Hereford cattle, Buchanan et al. (1982) used lines selected for increased weaning weight, increased yearling weight and larger values of an index that included both yearling weight and muscle score. Results indicated that direct response to selection for yearling weight may be enhanced by inclusion of muscling score.

These studies are all in general agreement that a favorable positive relationship does exist between rate of growth and muscularity while there is less evidence of any quantifiable association between growth rate and fat measures.

Other Influences on Growth Characteristics

Growth patterns of cattle and the magnitude by which they may be influenced by environment and nutritional levels are important to understand if accurate predictions of the response to selection are to be made. In some of the early research concerning this topic, Lush et al. (1930) utilized data from 500 Hereford steers and heifers and discussed patterns of normal growth from birth to maturity. Lush et al. (1930) reported that during colder conditions and less feed, September through March, body measurements such as width which are strongly influenced by degree of fatness, increased slowly. However, from March to September width measures increased more rapidly. Little environmental effect was observed throughout the year on measurements of hip or wither height, elbow length or head measures. These increased normally despite season or range conditions. Also, in a 1937 study involving dairy breeds Davis et al. reported that unlike body weight, skeletal development occurs relatively independent of environmental influence and mature skeletal size is primarily dependent on genotype. In 1938, Schmidt and

VonPatow reported little effect of environment on various body measurements of Black Pied cattle.

Environment may influence growth patterns differently, depending on the genotype of cattle studied. Butts et al. (1971) demonstrated that yearling heifers calved in Montana differed significantly in wither height when raised in Montana vs. Florida. Heifers born and raised in Montana were .83 inches taller than those born in Montana and raised in Florida. Neville et al. (1978a) reported significant difference on hip height measures taken on Angus heifers of similar genotype when raised in different locations.

In 1937, Black and Knapp reported that growth of a beef animal takes place in two ways, through the increase of skeletal structure and the development of muscle and fat tissue. They concluded that skeletal growth is the least likely of the two growth components to be influenced by adverse conditions and suggested that the two growth components were controlled by independent genetic mechanisms. In further agreement, Gregory (1933) presented evidence indicating a certain degree of independence between genetic factors regulating skeletal growth and soft tissue development.

In 1961, Hendrickson studied the effect of maintenance versus submaintenance level of feeding on growing steers. He reported that even while steers were losing weight and decreasing in width measures that wither height continued to increase. Growth of the long bones continued at the expense of other body tissues. Thus, the relationship between age and height cannot be changed as easily as that of weight and height or weight and age which are more easily manipulated by management, particularly nutritional levels. Similar findings were reported by Levy et al. (1971). When restricted diets were fed to Israeli-Friesian cattle more adverse effects were observed on soft tissue development than on skeletal growth. In 1968, Stuedman et al. reported on the effects of different nutritional levels imposed on Hereford calves from birth to eight months of age. Calves slaughtered at this time had significantly different carcass compositions depending on plane of nutrition. Bone development was affected the least followed by muscling and fat. When remaining calves were slaughtered after full feeding to a constant weight of 950 pounds the previous nutritional levels had no significant effect on final skeletal development. However, calves fed the restricted diets up to eight months were less efficient and took longer to reach slaughter weight. VandeMark et al. (1964) reported on the effects of feeding 60 versus 100 percent of the recommended digestible nutrient levels to Holstein bulls from eight weeks to nearly four years of age. Underfeeding greatly reduced body growth and growth of endocrine glands and the reproductive tract, although less drastically with increased age. Wither height in the underfed bulls was 15 percent, 12 percent, 7 percent and 4 percent less than that of the control group of bulls at 1,2,3 and 4.8 years old, respectively. While literature reports are somewhat varied, several studies indicate that energy intake is the primary factor influencing proportions of muscle and fat in composition of the carcass. Prior et al. (1977) compared Angus-Hereford crossbred steers at a constant carcass weight and reported significantly higher percentages of fat in carcasses of steers fed 3.2 versus 2.9 Mcal metabolizable energy per kilogram. Furthermore, steers fed the high energy ration had a higher average daily gain. In agreement, Fortin et al. (1981) reported that Angus steers fed ad libitum versus 70 percent ad libitum had a higher percentage of carcass fat and lower percent muscle at a constant carcass weight. In 1978, Ferrel et al. indicated similar results using Angus and Hereford steers.

Maturity for different body measurements is attained at different stages of life. When cattle of the same genotype and sex are compared their age and genetic potential for growth of various tissues is important in explaining the variation of the influence of nutrition on growth and composition. Guilbert and Gregory (1952), analyzed data from Hereford cattle collected over a period of 25 years, and reported that linear skeletal growth increases faster and matures earlier than thickness growth. Brown et al. (1956b) working with Angus cattle reported similar results. They reported that mature size for several body dimensions was attained in the following order: hip height, wither height, shoulder width, heart girth, depth of chest, length of body and finally, width at hips. Also reported in Brown's study, Hereford and Angus bulls reached 46 and 56%, respectively, of mature weight as well as 71-86% and 80-89%, respectively, of mature skeletal size by 12 months of age. The consensus of several older studies is at birth the cannon bone is approximately 85% of its mature length and wither height is approximately one-half of mature height. Furthermore, the early studies said that skeletal growth had practically ceased at 30 to 40 months of age (Eckles, 1915; Brody et al., 1937; Guilbert and Gregory, 1952; and Brown et al., 1956a and b). It is important to note, these estimates were from studies using smaller framed cattle, therefore, the estimates may vary with todays larger framed, later maturing beef animals. However, the high percentages of height at birth and as yearlings suggest that the majority of later size comes from the increase in development of muscle and fat tissue. In 1983, Trenkle reported that fat is a later maturing tissue than muscle. This was in agreement with Geay and Robelin (1979) who stated that when cattle of the same sex and genotype were compared at two levels of maturity and the same rate of gain, the more immature cattle deposited less fat and more muscle.

Relationship of Scrotal Circumference to Other Traits

Reproductive efficiency of beef cattle populations has many variables. Knowledge of genetic parameters for the variables is essential to make effective management decisions for genetic improvement of reproductive efficiency. Thereby, it is important to assess relationships between growth measurements, scrotal circumference and semen traits. Knowledge of the relationships would permit prediction of the effects of selection for growth on scrotal circumference and on seminal quantity and quality.

Several studies have reported that female reproductive traits have low heritabilities in beef cattle. (Lindley et al., 1958; Davenport et al., 1965; Dearborn et al., 1973; Bourdon and Brinks, 1982). In contrast to female reproductive traits, testicular measurements tend to be highly heritable and either favorably correlated or uncorrelated to production traits (Coulter et al. 1976; Coulter 1980; Latimer et al. 1982; Neely et al. 1982). Also Neely et al. (1982) reported that sperm quantity and testicular measurements are favorably correlated.

Brinks et al. (1978) reported a favorable genetic correlation (-.71) between scrotal circumference and age at puberty in heifers. Toelle and Robison (1985) found that most measures of testicular development, most notably diameter, were favorably correlated to pregnancy rates, age at first breeding and age at first calving. Toelle and Robison (1985) concluded that selection for increased testicular size should lead to improvement in female reproduction.

Bourdon and Brinks (1986) reported that scrotal circumference was affected by postweaning feed level, age, weight and height. Weight had the greatest effect and any factor which caused an increase in weight tended to increase scrotal circumference. Heritability of weight adjusted scrotal circumference was .46 and heritability of age adjusted scrotal circumference was .49. They found correlations among scrotal circumference and growth traits were moderate to high, with the highest genetic correlation of .44 being between scrotal circumference and yearling weight.

Knights et al. (1984), reported heritability estimates of .46, .49 and .36 for weaning weight, yearling weight and scrotal circumference. Estimates of phenotypic and genetic correlations between scrotal circumference and yearling weight were .26 and .68 respectively. Yearling weight was more strongly related to scrotal circumference than was birth or weaning weight. Johnson et al. (1974) reported correlations of .48 and .21 between testes weight and weaning weight or on-test gain, respectively, with the correlation between testes weight and post-yearling gain to slaughter being intermediate. Nelson et al. (1986) reported that scrotal circumference had correlations of .44 and .61 with weights taken on Hereford bulls at 403 and 490 days of age, respectively. Also reported were correlations of .35 and .61 between scrotal circumference and height at 403 and 490 days of age. In general, traits that positively effected weight positively effected scrotal circumference in Nelson's study.

Lunstra et al. (1978) reported a correlation of .80 between body weight and scrotal circumference in young beef bulls. In addition, Willet and Ohms (1957) reported that when bulls were placed on a 140 day performance test there was a correlation between body weight and scrotal circumference of .60 compared to .56 between the two traits off of test. In 1978 Coulter reported a similar decrease of off-test correlations compared to on-test correlations between scrotal circumference and body weight.

Genetic correlations of weights and gain with scrotal circumference at 365 days were moderate to high in the favorable direction. These results suggest that increasing testes size should not adversely affect growth performance traits except through the reduction of selection intensity (Neely, 1982).

Effects of Nutrition on Scrotal Measurements

Level of nutrition obviously affects body weight and average daily gain, thus, one might expect nutrition to contribute to some of the differences found in scrotal circumference especially in a performance testing scenario where bulls are fed high energy diets ad libitum. In 1978 Coulter reported a significant difference in the scrotal circumference of Angus and Hereford bulls fed high versus low energy diets, concluding that the difference could be due to scrotal lipids. In studies concerning beef bulls (Bourdon and Brinks 1986) and dairy bulls (Bratton et al. 1959; VandeMark et al. 1964) levels of nutrition have been shown to alter testicular weight and scrotal circumference. Furthermore, Cates (1975) reported that the scrotal circumference of yearling beef bulls varied pending ration fed. Cates reported that high conditioned bulls may have 2-3 centimeter larger scrotal circumference than thin conditioned bulls. Noting that highly fitted, heavy conditioned bulls had a decrease of 1.5 to 5 centimeters after a "let down" period. Therefore, it is important to know the previous nutrition levels and degree of condition when evaluating scrotal circumference in various ages of bulls.

CHAPTER III

RELATIONSHIPS AMONG TRAITS MEASURED IN A BEEF PERFORMANCE TESTING PROGRAM AND THEIR EFFECT ON SALES PRICE

Abstract

Data were collected from 2303 bulls representing three breeds (A=1183 Angus, H=519 Hereford and P=601 Polled Hereford) from 1981 to 1987. These bulls were approximately 7 to 8 months old when placed on the 140 day test at Oklahoma Beef, Incorporated (OBI). OBI performance data was collected for the following traits; on-test weight (OW), on-test height (OH), off-test weight (FW), off-test height (FH), average daily gain (ADG), hip height daily growth (HDG), scrotal circumference (SC), ribeye area (REA), and ribfat (RF). H bulls were higher ($P<.05$) for OW, OH and FH than A and P bulls which were similar for these traits ($P>.05$). A bulls had the highest ADG ($P<.05$) while H and P bulls were similar ($P>.05$). A and H bulls were similar and had heavier ($P<.05$) FW and larger REA than P bulls. There were no significant differences among breeds for HDG ($P>.05$). A bulls had the largest ($P<.05$) SC while H and P bulls were similar ($P>.05$). H bulls had less RF than A bulls ($P<.05$) while P bulls were

similar to both breeds (P>.05). Comparison of traits by year (1=1981, 2=1982, 3=1983, 4=1984, 5=1985, 6=1986, 7=1987) revealed that HDG was lower in 3 than years thereafter and highest in 7 (P<.05). OH was lowest in 1 and highest in 6 (P<.05) although 6 did not differ from 7. OW was lowest in 1 and highest in 5, 6 and 7 (P<.05) although 7 was similar to 4 (P>.05). FH increased (P<.05) each year from 1 to 6 while 7 was similar to 5 and 6 (P>.05). FW increased (P<.05) each year from 1 to 5 while 5, 6 and 7 were similar (P>.05). ADG was lowest in 1 and highest in 6 and 7 (P<.05). SC was lowest in 1 and increased significantly each year from 1 to 4 while bulls in 4, 5, 6 and 7 were similar (P>.05). Bulls in 6 had the largest REA and bulls in 1 had the smallest REA (P<.05). No REA's were reported in 1987. Bulls tested in 4, 5, and 6 had the greatest RF estimates and bulls in 7 had less RF than all years except 1983 (P<.05).

Phenotypic correlations were calculated between all traits. All RF correlations were very low to negligible with all traits. SC correlations were moderately low but favorable to measures of growth and REA. REA had moderate to high correlations with measures of growth, being most strongly related to FW (.71). ADG had low to moderate correlations to other measures of growth, except OW. HDG had a low correlation of .22 to FH and low to moderate negative associations with FW, OH and OW. All measures of OW, OH, FW and FH were moderate to high in correlations with each other.

Performance records were combined with sales price from 448 bulls (208 Angus, 94 Hereford, 146 Polled Hereford) sold in eight OBI, All-Breed Performance Tested Bull Sales from 1983 to 1987 to evaluate the effect that performance had on selling price. Measures of performance that were included were FW, FH, ADG, REA, RF and SC. None of the traits was highly correlated with selling price, the highest correlation was between FW and price (.49). Average changes in price per unit change in each trait indicated that less than .40 of the variation in selling price was accounted for by variation in performance traits. In each breed FH and FW were the most important traits affecting selling price.

Introduction

It is of interest to purebred and commercial cattle breeders to make sound genetic improvements in their herds and to emphasize economically important traits. Eighty percent of the genetic improvement is achieved through sire selection (Kress, 1983). Thus, sire selection to meet the needs of a given breeding program is of utmost importance.

One method of evaluation and comparison of bulls is the central bull test station. Centralized bull test were first established in the early 1950's. Central test stations provide commercial cattlemen as well as purebred producers a means of comparison of bulls which have been tested under common management and environmental conditions but come from various breeders. One problem with centralized bull test stations is the relative small number of bulls can be tested each year.

Through the years, beef breeding programs and selection trends have changed a great deal. These changes are a result of many factors, such as, advanced technology, economics and consumer demands which necessitate changes in cattle type to meet the industry's needs. The latest such selection trend occurring over the past two decades has been toward larger framed, growthier, later maturing cattle (Hawkins and Ritchie, 1988).

In light of the current selection trend in the cattle industry it would be helpful for potential buyers to be able to quantify relationships among performance measurements of growth and other economically important traits as they evaluate bulls to meet the needs of a particular breeding program, especially, if sound genetic progress is to be made. In addition, it would be useful to potential buyers if they knew to what extent various performance traits contributed to selling price.

There were two primary objectives to this study. The first was to evaluate the relationships existing among measurements of growth and other traits such as ribeye area, fat thickness and scrotal circumference, as well as, to evaluate the change and trends occurring over a number of years in a performance testing program. The second major objective was to determine the influence of performance measurements on the selling price of performance tested beef bulls.

Materials and Methods

This study utilized performance data collected from Angus, Hereford and Polled Hereford bulls on test at Oklahoma Beef, Incorporated during the period from 1981 to 1987. A total of 2303 bulls (1183 Angus, 519 Hereford and 601 Polled Hereford) completed the 140 day test during this time.

These bulls were approximately 7 to 8 months of age when placed on test. Prior to beginning the official test, the Angus bulls were allowed a 2 week warm-up period while Hereford and Polled Hereford bulls were allowed a 3 week warm up period in order to acclimate to the new feed and environment. Table 2 shows the ration fed to the Angus bulls and Table 3 shows the ration fed to the Hereford and Polled Hereford bulls. Because two different rations were used, breed was confounded with ration in the entire study.
When bulls were placed on test, measurements of hip height, weight and scrotal circumference were obtained with exception in 1981 when on-test height measurements were not taken on 23 Angus bulls. Scrotal circumference was obtained by drawing the testicles down into the scrotum and placing a self releasing metal tape around the widest diameter. Two

TABLE II

RATION FED TO ANGUS BULLS

Ingredient	Percent of Ration
Cottonseed hulls	10.00
Corn	58.95
Oats	15.00
Soybean oil meal	6.50
Cottonseed meal	6.50
Salt	.30
Calcium carbonate	1.00
Dicalcium phosphate	.25
Vitamin A	+
Tylan 40G	+
Fat	2.00

TABLE III

RATION FED TO HEREFORD AND POLLED HEREFORD BULLS

Ingredient	Percent of Ration
Corn	33.87
Oats	15.00
Cottonseed hulls	10.00
Alfalfa pellets	15.00
*Supplement pellet	24.38
Fat	1.75
*Supplement Pellet	
Soybean oil meal	46.72
Rice mill feed	47.90
Calcium carbonate	1.07
Salt	2.05
Dicalcium phosphate	2.13
Bovatec 68 gram	.09
Vitamin premix	.05

measures of hip height and scrotal circumference were taken by different people. If a large difference between the measurements was recorded, both people repeated the measurement. Repeating the measurements was done to acquire the most accurate measurements for each trait.

Bulls were weighed every 28 days throughout the test for Oklahoma Beef, Incorporated performance information. The bulls were approximately 12 to 13 months of age when they completed the test. Upon completion of each test body measurements of hip height, scrotal circumference, weight, ribfat thickness and ribeye area were obtained. No scrotal circumference measurements were taken on Angus or Polled Hereford bulls in 1981, thus only 1837 off-test scrotal measurements were used in this analysis. In addition, due to misfunction of scanogram only 2050 measurements of off-test ribeye area and 2157 measurements of off-test ribfat were obtained for use in analyses. Ribeye area and ribfat thickness were estimated with a scanogram manufactured by the Ithaca Company, Ithaca, New York. Growth data such as hip height growth rate and average daily gain were calculated. Table 4 describes how calculations of these were made.

Data analyses were conducted using the least squares analysis of variance. The model included main effects of breed, year and breed by year interaction. Phenotypic correlations between traits were obtained using pooled within breed by year correlations.

TABLE IV

CALCULATION OF ON-TEST AND OFF-TEST TRAITS

Trait	Calculation
on-test height	actual height
on-test weight	actual weight
off-test height	actual height
off-test weight	actual weight
average daily gain	off-test weight minus on-test weight / 140 days
hip height daily growth	off-test height minus on-test height / 140 days
scrotal circumference	actual scrotal circumference
ribeye area	actual ribeye area
ribfat	actual ribfat

Performance records were combined with sale prices of 448 bulls that sold from 1983 to 1987 to evaluate the effect that performance had on selling price. These analyses included off-test measurements of height, weight, ribeye area, ribfat, scrotal circumference and average daily gain on test along with sales price of (208 Angus, 94 Hereford, 146 Polled Hereford) bulls that sold in 8 Oklahoma Beef, Incorporated All Breed Performance Tested Bull Sales during the research period.

Sale catalogs were available to buyers prior to the sale. The catalogs included identification of each bull, the bull's sire and dam, birth date, owner and from the fall sale of 1985 to 1987 the expected progeny differences of the sire of each bull if available within the respective breed sire summary. Performance data included in catalog were: on-test weight, off-test weight, adjusted yearling height, adjusted yearling weight, scanogram measurements of ribeye area and ribfat, scrotal circumference, average daily gain and weight per day of age as well as, number in group tested and an index of on-test performance. The index was a composite score with basically three traits considered: average daily gain, weight per day of age, and adjusted yearling weight. Index for each breed was calculated in a slightly different way.

The relationship among selling price and the performance traits were evaluated by calculating the correlation between price and performance traits. Contributions of each trait to selling price for each breed was independently evaluated by using the Backwards Elimination Multiple Regression Procedure (Draper and Smith, 1966) to obtain partial regressions of price on each performance trait. These regressions were obtained simultaneously for all the traits after accounting for variation due to year. The trait that contributed the least in each breed was removed from consideration and the analyses were repeated until only those traits that made significant contributions to selling price remained. In this way traits could be ranked by order of effect.

Results and Discussion

Least squares analysis of variance revealed significant effects of year and breed by year interaction for all traits ($P<.05$). The effects of breed were significant for all traits except hip height daily growth and ribfat ($P<.05$).

Least Square Means by Breed

Table 5 list least squares means and standard errors of performance traits by breed while Table 6 provides the gives number of observations used for each calculation. Hereford bulls were taller at the hip on and off-test and had heavier on-test weights ($P<.05$) than Angus or Polled Hereford bulls who were similar with respect to these traits. Angus bulls had the highest average daily gain ($P<.05$) while Hereford and Polled Hereford were similar. Angus and

TABLE V

LEAST SQUARES MEANS BY BREED

	Angus	Hereford	Polled Hereford
on-test height (cm)	113.72[a] (.11)	114.90[b] (.26)	114.04[a] (.15)
on-test weight (kg)	290.05[a] (1.22)	306.6[b] (2.94)	288.8[a] (1.69)
off-test height (cm)	126.05[a] (.11)	126.98[b] (.26)	126.30[a] (.15)
off-test weight (kg)	535.22[a] (1.48)	538.27[a] (3.57)	524.93[b] (2.04)
average daily gain (kg)	1.75[a] (.006)	1.65[b] (.015)	1.68[b] (.008)
height daily growth (cm)	.088[a] (.0004)	.086[a] (.0009)	.087[a] (.0005)
scrotal circumference (cm)	37.77[a] (.13)	36.43[b] (.18)	35.90[b] (.17)
ribeye area (cm^2)	34.33[a] (.08)	34.12[a] (.11)	33.63[b] (.11)
ribfat (cm)	1.00[a] (.008)	0.94[b] (.026)	1.00[ab] (.013)

[ab] = means on the same line bearing a common subscript are not different ($P > .05$).

TABLE VI

NUMBER OF OBSERVATIONS IN CALCULATING LEAST SQUARES MEANS BY BREED

	Angus	Hereford	Polled Hereford
on-test height	1160	519	601
on-test weight	1183	519	601
off-test height	1183	519	601
off-test weight	1183	519	601
average daily gain	1183	519	601
height daily growth	1160	519	601
scrotal circumference	921	447	469
ribeye area	1047	479	524
ribfat	1103	505	549

Hereford bulls were similar and had heavier off-test weights ($P<.05$) than Polled Hereford bulls. There were no significant differences among breeds for hip height daily growth. Angus bulls had the largest scrotal circumference ($P<.05$) while there was no difference between Hereford and Polled Hereford bulls. Polled Hereford bulls had the smallest ribeye area ($P<.05$) while Angus and Hereford bulls were similar with respect to this trait. Hereford bulls had less ribfat than Angus bulls ($P<.05$) while Polled Hereford bulls were similar to both breeds for ribfat ($P>.05$). It should be noted that breed and ration are confounded since the Angus and Hereford bulls were fed different rations. This, based on the review of literature offers partial explanation for Angus having higher ADG, scrotal circumference and ribfat.

<u>Least Squares Means by Year</u>

Without exception, all measures of growth generally made an increase from 1981 to 1987. Least squares means and standard errors by year are provided in Table 7 while Table 8 lists the number of observations used in each calculation. Hip height daily growth was significantly lower in 1983 than in any year thereafter. In 1987 hip height daily growth was higher than any other year ($P<.05$), while 1981, 1982, 1984, 1985 and 1986 ranked as intermediates. Overall hip height daily growth ranged from .084 ($\pm$ .0007) in 1983 to .094 ($\pm$ .002) centimeters per day in 1987. These values are in 1

TABLE VII

LEAST SQUARES MEANS BY YEAR

	1981	1982	1983	1984	1985	1986	1987
on-test height (cm)	110.65 (.16) a	112.20 (.17) b	113.67 (.19) c	114.03 (.21) c	115.94 (.23) d	116.86 (.26) e	116.18 (.55) de
on-test weight (kg)	268.46 (1.81) a	282.48 (1.88) b	291.80 (2.18) c	295.65 (2.32) cd	309.29 (2.61) e	312.00 (2.91) e	306.37 (6.21) de
off-test height (cm)	122.52 (.157) a	124.17 (.163) b	125.41 (.188) c	126.33 (.201) d	128.34 (.226) e	129.02 (.252) f	129.33 (.536) ef
off-test weight (kg)	492.30 (2.20) a	512.65 (2.28) b	524.56 (2.64) c	534.19 (2.81) d	549.32 (3.16) e	558.02 (3.53) e	558.60 (7.53) e
average daily gain (kg)	1.60 (.009) a	1.64 (.009) b	1.66 (.011) b	1.70 (.012) c	1.71 (.013) c	1.76 (.015) d	1.80 (.032) d
height daily growth (cm)	.085 (.0006) ab	.086 (.0006) abd	.084 (.0007) b	.088 (.0008) cd	.089 (.0008) cd	.087 (.0009) acd	.094 (.002) e
scrotal circum-ference (cm)	35.77 (.26) a	36.07 (.12) b	36.45 (.13) c	36.94 (.14) d	36.85 (.16) cd	36.72 (.18) cd	37.39 (.37) d
ribeye area (cm^2)	32.29 (.11) a	32.96 (.11) b	34.75 (.14) c	34.12 (.14) d	34.58 (.16) c	35.45 (.18) e	g
ribfat (cm)	.98 (.011) a	.98 (.011) a	.96 (.013) ab	1.04 (.014) c	1.05 (.016) c	1.06 (.018) c	.84 (.060) b

abcdef = means on the same line bearing a common subscript are not different (P > .05).

g = no estimates made due to scanogram misfunction.

TABLE VIII

NUMBER OF OBSERVATIONS IN CALCULATING LEAST SQUARES MEANS BY YEAR

	1981	1982	1983	1984	1985	1986	1987
on-test height	459	461	415	339	255	213	138
on-test weight	482	461	415	339	255	213	138
off-test height	482	461	415	339	255	213	138
off-test weight	482	461	415	339	255	213	138
average daily gain	482	461	415	339	255	213	138
height daily growth	459	461	415	339	255	213	138
scrotal circum-ference	80	441	397	330	252	199	138
ribeye area	478	446	379	323	251	173	0[a]
ribfat	479	457	393	329	253	175	71

[a] = no estimates due to scanogram misfunction

general agreement with other literature (Dori et al., 1974; Massey, 1979; Maino et al., 1981; Healy, 1979; Baker, 1981) with respect to rate of hip height growth being approximately 2.54 centimeters (1 in.) per month. On-test height increased significantly from 1981 to 1982, from 1982 to 1983 and 1984, and from 1985 to its highest value in 1986. 1987 was intermediate to 1985 and 1986 and did not differ (P>.05) from either year. On-test weight increased significantly from 1981 to 1982 and from 1982 to 1983. 1983 and 1984 were similar, as were 1984 and 1987. 1985, 1986 and 1987 were similar while in 1985 and 1986 on-test weights were significantly higher than any year previous (P<.05). Off-test height increased significantly each year from 1981 to 1986 while 1987 was similar to 1985 and 1986 (P>.05). Off-test weight made significant increases from 1981 to 1985 while 1985, 1986 and 1987 were all similar. Bulls tested in 1981 had significantly lower average daily gains than any other year. 1982 and 1983 average daily gains were similar (P>.05) as were bulls in 1984 and 1985 but significantly higher than in any year previous. Bulls tested in 1986 and 1987 were similar (P>.05) and posted the highest (P<.05) ADG.

Scrotal circumference increased significantly each year from 1981 to 1984 with bulls in 1984, 1985, 1986 and 1987 being similar in scrotal circumference. Bulls in 1985 and 1986 were intermediate in value between 1983 and 1984. Ribeye area estimates were largest in 1986 and smallest in 1981 (P<.05). 1982 bulls had significantly larger ribeye areas than bulls tested in 1981 and smaller than any year thereafter. 1983, 1984 and 1985 ribeye area estimates were intermediate in value to years before and after. No ribeye area estimates were recorded in 1987. Bulls tested in 1984, 1985 and 1986 had the greatest ribfat estimates ($P<.05$). Bulls tested in 1987 had significantly less ribfat than bulls tested in any other year except 1983. Bulls tested in 1981 and 1982 were intermediate in value and similar to 1983 ($P>.05$).

Correlations Among Traits

Table 9 lists phenotypic correlation coefficients (left of diagonal) and number of observations used in calculating correlations (right of diagonal) associated with nine performance traits measured while on test.

Of all traits evaluated in this study, ribfat thickness had the weakest association with all other traits measured. All correlations between ribfat and other traits were low to negligible. Correlations of ribfat and on or off-test hip heights were .04 and .01, respectively, and nonsignificant. These figures tend to support Lush (1928) who concluded that hip height and fat thickness do not influence each other. Correlations between ribfat and on-test weight, off-test weight, average daily gain, hip height daily growth, scrotal circumference and ribeye area were .16, 22, .14, -.10, .10 and .05 respectively. These correlations agree with literature reviewed that rate of growth has no quantifiable relationship with fatness (Koch et al., 1982; Dinkel and

TABLE IX

CORRELATION COEFFICIENTS AMONG TRAITS (LEFT OF DIAGONAL) AND NUMBER OF OBSERVATIONS (RIGHT OF DIAGONAL)

Trait		1	2	3	4	5	6	7	8	9
on-test height	(1)	1.00	2280	2280	2280	2280	2280	1837	2027	2134
on-test weight	(2)	** .75	1.00	2303	2303	2303	2280	1837	2050	2157
off-test height	(3)	** .86	** .56	1.00	2303	2303	2280	1837	2050	2157
off-test weight	(4)	** .72	** .80	** .67	1.00	2303	2280	1837	2050	2157
average daily gain	(5)	** .17	-.04	** .35	** .57	1.00	2280	1837	2050	2157
height daily gain	(6)	** -.30	** -.37	** .22	** -.11	** .33	1.00	1837	2025	2025
scrotal circum-ference	(7)	** .22	** .26	** .20	** .33	** .20	-.04	1.00	1629	1735
ribeye area	(8)	** .56	** .53	** .57	** .71	** .45	-.01	** .30	1.00	2047
ribfat	(9)	.04	** .16	.01	** .22	** .14	** -.10	** .10	** .05	1.00

* Significance Level (P < .05)
** Significance Level (P < .01)

Busch, 1973; Cundiff et al., 1971). In addition, other factors such as age, environment and nutrition may have a strong effect on degree of fatness (Koch et al., 1982; Prior et al., 1977; Fortin et al., 1981; Ferrel et al., 1978, Trenkel, 1983).

Ribeye area had moderate to high correlations with all measures of growth except for a non-significant correlation with hip height daily growth. Ribeye area had moderate correlations to on-test height, on-test weight, off-test height and average daily gain of .56, .53, .57 and .45, respectively, as well as a high correlation of .71 to off-test weight. Ribeye area had a moderately low correlation of .30 to scrotal circumference. The correlations of ribeye area to height and weight growth measures are all in agreement, although higher than literature estimates.

Literature estimates of scrotal circumference correlations to growth measures are somewhat higher than those found in this study. Except for a non-significant association with hip height daily growth, correlations between growth measures and scrotal circumference are all in the favorable direction and in agreement with literature findings (Coulter et al., 1976; Coulter, 1980; Latimer et al., 1982; Neely et al., 1982; Bourdon and Brinks, 1986). Scrotal circumference correlations to on-test height, on-test weight, off-test height, off-test weight and average daily gain were .22, .26, .20, .33 and .20, respectively, and were moderately low in value.

Average daily gain had correlations of .17, .35, .33 and .57 to on-test height, off-test height, hip height daily growth and off-test weight, respectively. Average daily gain was not significantly correlated to on-test weight. These estimates are similar to those reported by Baker, (1981), although somewhat lower than those reported by Mangus et al., (1980) and Johnson et al., (1980).

Hip height daily growth had a low correlation of .22 to off-test height, as well as, low to moderate unfavorable correlations of -.11, -.30 and -.37 to off-test weight, on-test height and on-test weight. Based on the review of literature this is possibly explained by the age-height relationship (Henrickson, 1961). Bulls that are older begin the test taller and at heavier weights while slowing in their rate of hip height daily growth earlier than bulls beginning tests at a lesser state of maturity (Guilbert and Gregory, 1952; Brown et al., 1956a and b).

Off-test weight had high correlations with on-test height, on-test weight and off-test height of .72, .80, and .67, respectively. These values are in general agreement with the review of literature. Possible explanation of off-test weight being more strongly associated to on-test height than off-test height is the age-height relationship associated with on-test heights is less easily manipulated than the age-weight or height-weight relationships more closely associated with off-test measurements (Henrickson, 1961; Levy et al., 1971; Klosterman et al., 1968). Off-test height measurements had moderate and high correlations with on-test weight and on-test height, .56 and .86, respectively. On-test height was highly correlated to on-test weight at .75, these correlations are in general agreement with the review of literature.

Performance Traits Influence on Selling Price

Correlations between the various performance traits and selling price are shown in Table 10. Measures of off-test, weight and height had the strongest correlation to selling price although only moderate in value at .49 and .47, respectively. Moderate to low correlations between ribeye area and ADG to price were .37 and .32, respectively. Low correlations, near zero, were noted for ribfat and scrotal circumference to price.

The average change in price per unit of change in each trait is shown in Table 11. These are shown for each breed separately. Missing values indicate that traits did not make significant contributions to selling price. Thus ribeye area, ribfat and scrotal circumference did not account for any of the variation in selling price of any breed. The regression coefficients indicate the amount of change in selling price that can be explained by one unit of change of a given trait. Based on the review of literature the relative difficulty of changing final height by 1 centimeter versus changing average daily gain or final weight by 1 kilogram, the greatest impact on selling price

TABLE X

CORRELATION COEFFICIENTS BETWEEN SALES PRICE AND OFF-TEST TRAITS

	Price	Number
weight	** .49	448
height	** .47	448
ribeye area	** .37	394
ribfat	.05	394
scrotal circumference	* .10	394
average daily gain	** .32	448

* Significance Level: (P < .05)
** Significance Level: (P < .01)

TABLE XI

PARTIAL REGRESSIONS OF SALE PRICE ON OFF-TEST TRAITS

Number	Angus 208	Hereford 94	Polled Hereford 146
weight ($/kg)[a]	** 5.13 (7.59)[c]	** 5.69 (20.31)[c]	* 3.78 (7.71)[c]
height ($/cm)[a]	** 71.66 (7.88)[c]	** 69.12 (17.97)[c]	** 76.58 (11.48)[c]
ribeye area ($/cm^2)[a]			
ribfat ($/cm)[a]			
scrotal circum-ference ($/cm)[a]			
average daily gain ($/kg)[a]	* 706.96 (4.24)[c]		* 628.17 (5.03)[c]
R^{2b}	.3656	.3796	.3989

[a]=change in price per unit change indicated for each trait

[b]=proportion of variation in price accounted for by traits having coefficients for that breed.

[c]=change in price per standard deviation unit.

*significance level: (P<.05)
**significance level: (P<.01)

is that of 1 unit of change of final height in all breeds. Each centimeter of change in final height would change selling price by $71.66, $69.12 and $76.58 in Angus, Hereford and Polled Hereford, respectively. The row headed R^2 indicates the proportion of the variation in price that is explained by the performance traits indicated. In these analyses the greatest proportion of variation in price was .3989, accounted for by final height, final weight and average daily gain in Polled Hereford bulls. Final height, final weight and average daily gain accounted for .3656 of the variation in price of Angus bulls. Only final weight and height were significant sources of variation in Hereford bulls accounting for .3796 of variation in sales prices. All of the regression coefficients are in the favorable direction. Performance traits do not explain more than 40 percent of the selling price for any breed.

A simple ranking of the traits obtained through these analyses is given in Table 12. The ranks indicate that measures of growth, most notably off-test height and weight generally had the most important effect on selling price. Off-test height, off-test weight and average daily gain ranked 1, 2, and 3, respectivly in each breed.

It is important to note, both sale order and the physical appearance of bulls may have had a profound effect on these results. Certain bulls have physical characteristics which may lead to an increase or decrease in price at sale time. The extent to which visual appraisal is used to determine a bull's price is unknown but probably quite large. In addition, certain breeders and lines of breeding, as well as performance measures of a bull's sire may have a profound impact on selling price of performance tested beef bulls.

TABLE XII

RANKING OF OFF-TEST TRAITS IN ORDER OF IMPORTANCE AS CONTRIBUTORS TO SALES PRICE

Number	Angus 208	Hereford 94	Polled Hereford 146
weight	2	2	2
height	1	1	1
ribeye area	6	4	4
ribfat	5	6	6
scrotal circum-ference	4	5	5
average daily gain	3	3	3

CHAPTER IV

SUMMARY AND CONCLUSIONS

It is of interest to purebred and commercial cattle producers to make sound genetic improvements in their herds and to emphasize economically important traits. Eighty percent of genetic improvement is achieved through sire selection (Kress, 1983), thereby sire selection to meet the needs of a particular breeding program is very important. Central bull test stations provide commercial cattleman and purebred producers with a means of comparing bulls which are tested under common management and environmental conditions but come from various breeders. With the current trend in beef cattle selection toward larger framed, growthier, leaner types of animals, this study was conducted to provide information to potential buyers of performance tested bulls. There were two objectives in this study; first, to quantify the relationships existing among all performance traits measured in a performance testing program and second, to determine which traits most strongly influence selling price of performance tested beef bulls.

This study utilized performance records collected on 2303 bulls (1183 Angus, 519 Hereford and 601 Polled Hereford) tested at Oklahoma Beef, Incorporated from 1981 to

1987. Bulls began the test at approximately 7-8 months of age after being allowed a two week warm-up period to acclimate to the new feed and surroundings. On-test measurements of hip height and weight were taken at that time. Bulls were weighed every 28 days during the test for performance data calculations. Bulls were approximately 12-13 months old when completing the 140 day test. Upon completion of the test measurements of hip height, weight and scrotal circumference were obtained. Also, estimates of ribeye area and ribfat thickness were made using a scanogram at that time. These data were then used to calculate average daily gain and hip height daily growth. The data were analyzed using the least squares analysis of variance The model included main effects of breed, year and breed by year interaction. Phenotypic correlation coefficients were calculated using pooled within breed by year correlations.

Performance records were combined with sale prices from 448 bulls selling from 1983 to 1987. There were 8 all-breed Oklahoma Beef, Incorporated sales during this time. Among the performance traits listed in the sales catalog, off-test measurements of height, weight, ribeye area, ribfat, scrotal circumference and average daily gain were evaluated to determine their effects on sale price. The relationships were evaluated by calculating the correlation between price and performance traits. Contributions of each trait to selling price for each breed was independently evaluated by using the Backwards Elimination Multiple Regression

Procedure (Draper and Smith, 1966) to evaluate the effects of one unit of change in each trait on selling price. This procedure allowed for a simple ranking of the traits effect on selling price.

Significant effects of year and breed by year interaction for all traits were noted. The effects of breed were significant for all traits except hip height daily gain and ribfat.

Comparison of least squares means by breed revealed that Hereford bulls had the highest on-test weight and hip height, the tallest off-test hip height and along with Angus bulls were significantly heavier off-test than Polled Herefords. Angus bulls had the largest scrotal circumference and the highest average daily gains. There were no differences between breeds for hip height daily growth and the level of this trait was in agreement with estimates in the literature. Polled Hereford bulls had the smallest ribeye area estimates while Hereford bulls had the least ribfat and Angus bulls the most.

Without exception, all measures of growth made increases from beginning to end of this study. This was expected based on the literature reviewed. The greatest increases were made in heights and weights both on and off-test.

Scrotal circumference and ribeye area estimates also made general increases over the course of this study, although not at the same magnitude or pattern of growth measures. Although bulls tested in 1987 had less ribfat than any other year except 1983, no real pattern could be established from year to year for this trait in relationship to measures of growth.

The results of the phenotypic correlations are generally in agreement with much of the literature reviewed. Of all traits evaluated ribfat had the weakest association to all other traits with all correlations being very low to negligible. Ribeye area had moderate to high correlations with all measures of growth except for a non-significant correlation with hip height daily growth. Ribeye area had a moderately low correlation to scrotal circumference. Although the correlations between scrotal circumference and growth traits were somewhat lower than those in the review, all were in the favorable direction. Average daily gain correlations were somewhat lower than some literature findings and were low to moderate in value to off-test height, off-test weight, on-test height and on-test weight. All correlations between heights and weights on and off-test were moderate to high in value.

Analyses of performance records and sale prices of 448 bulls sold from 1983 to 1987 indicated that none of the traits were highly correlated with selling price. Average changes in price per unit change in each trait revealed that only up to 40 percent of selling price was explained by variation in performance traits. In each breed off-test hip height and off-test weight were the first and second most important traits influencing price, while only moderate in correlation at .47 and .49, respectively.

In conclusion, growth measurements, ribeye area, ribfat and scrotal circumference do display variation pending breed type and year. As well, quantifiable relationships exist among most all of the traits. Growth rates appear to show the most difference with respect to year. Although central bull test stations serve as a means of evaluating bulls based on performance under common management and environment, slightly less than 40 percent of selling price can be accounted for by performance traits. Only measurements of growth, most notably off-test height and weight, have any profound effect on selling price. The physical appearance of bulls and the sale order might have quite an effect on selling price. Certain bulls have characteristics which may lead to a drastic increase or decrease in price at sale time. The extent that visual appraisal is used to determine selling price is unknown, but probably quite large. In addition to these, certain breeders and lines of breeding, as well as performance measures of a bull's sire may play a large role in determining selling price of performance tested beef bulls.

It would be interesting to see further research on influences of selling price taking more variables into account to possibly explain a larger proportion of the selling price.

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APPENDIX A

DATA ANALYSES BY 28 DAY PERIOD

TABLE XIII

ANGUS BULLS LEAST SQUARES MEANS BY YEAR

	1981	1982	1983	1984	1985	1986	1987
on-test height (cm)	110.79 (.24) a	111.42 (.22) a	112.15 (.22) b	113.34 (.24) c	114.76 (.29) d	116.65 (.30) e	116.92 (.39) e
on-test weight (kg)	272.72 (2.50) a	273.37 (2.45) a	283.19 (2.38) b	287.36 (2.64) bc	292.88 (3.14) c	305.40 (3.35) d	315.43 (4.26) d
off-test height (cm)	122.44 (.23) a	123.58 (.22) b	124.24 (.22) c	125.73 (.24) d	127.58 (.29) e	129.14 (.31) f	129.69 (.39) f
off-test weight (kg)	508.60 (3.28) a	515.81 (3.22) ab	517.63 (3.12) b	537.57 (3.47) c	533.20 (4.13) c	557.06 (4.41) d	576.71 (5.60) e
average daily gain (kg)	1.68 (.014) a	1.73 (.014) b	1.67 (.014) a	1.79 (.015) c	1.72 (.018) ab	1.80 (.019) c	1.87 (.025) d
height daily growth (cm)	.083 (.0009) a	.086 (.0008) bc	.086 (.0008) c	.088 (.0009) bcd	.092 (.001) e	.089 (.0011) be	.091 (.0014) de
scrotal circum-ference (cm)	g	37.26 (.17) a	37.29 (.16) a	38.1 (.18) b	37.44 (.21) a	37.70 (.23) ab	38.86 c
ribeye area (cm^2)	33.56 (.16) a	33.36 (.16) a	34.95 (.16) b	34.16 (.17) c	34.22 (.208) c	35.74 (.26) d	h
ribfat (cm)	1.07 (.016) bc	1.07 (.016) b	1.08 (.016) bc	1.12 (.017) c	1.04 (.020) b	1.04 (.026) b	.62 (.032) a

abcdef = means on the same line bearing a common subscript are not different ($P > .05$).

g = No scrotal measurements taken in that year on this breed.

h = No estimates due to scanogram misfunction.

TABLE XIV

NUMBER OF OBSERVATIONS IN CALCULATING LEAST SQUARES MEANS FOR ANGUS BULLS

	1981	1982	1983	1984	1985	1986	1987
on-test height	189	221	235	190	134	118	73
on-test weight	212	221	235	190	134	118	73
off-test height	212	221	235	190	134	118	73
off-test weight	212	221	235	190	134	118	73
average daily gain	212	221	235	190	134	118	73
height daily growth	189	221	235	190	134	118	73
scrotal circumference	0[a]	202	222	183	133	108	73
ribeye area	212	219	217	182	134	83	0[b]
ribfat	212	219	220	183	134	83	52

[a]=no scrotal measurements taken in that year on this breed.
[b]=no estimates due to scanogram misfunction.

TABLE XV

HEREFORD BULLS LEAST SQUARES MEANS BY YEAR

	1981	1982	1983	1984	1985	1986	1987
on-test height (cm)	112.14 (.26) e	113.30 (.29) d	114.94 (.39) ab	114.81 (.38) a	116.66 (.42) c	116.08 (.45) bc	116.35 (1.42) abc
on-test weight (kg)	288.31 (3.24) a	294.60 (3.54) ab	300.77 (4.87) bc	309.30 (4.63) cd	322.07 (5.16) d	318.70 (5.61) d	312.26 (17.57) acd
off-test height (cm)	123.68 (.26) a	125.21 (.29) b	126.30 (.39) c	126.63 (.38) c	128.94 (.42) d	128.17 (.45) d	129.93 (1.42) d
off-test weight (kg)	496.87 (3.60) a	516.38 (3.94) b	533.42 (5.42) c	535.24 (5.15) c	566.85 (5.74) d	554.67 (6.24) d	564.46 (19.55) cd
average daily gain (kg)	1.49 (.016) a	1.58 (.017) b	1.66 (.023) cd	1.61 (.023) bc	1.75 (.025) e	1.69 (.027) de	1.80 (.086) de
height daily growth (cm)	.082 (.001) abc	.085 (.001) bd	.081 (.001) c	.084 (.001) abcd	.088 (.002) de	.086 (.002) abde	.097 (.006) e
scrotal circum-ference (cm)	35.77 (.24) a	35.99 (.20) ab	36.51 (.27) bc	36.41 (.26) abc	36.48 (.29) abc	36.58 (.32) bc	37.24 (.98) abc
ribeye area (cm^2)	31.88 (.18) a	33.38 (.21) b	35.39 (.31) c	34.25 (.27) d	34.60 (.29) cd	35.23 (.33) c	f
ribfat (cm)	.78 (.019) ab	.79 (.021) b	.72 (.030) a	1.00 (.028) c	1.13 (.031) d	1.10 (.035) d	1.13 (.17) cd

abcde=means on the same line bearing a common subscript are not different (P>.05).

f=no estimates due to scanogram misfunction

TABLE XVI

NUMBER OF OBSERVATIONS IN CALCULATING LEAST SQUARES MEANS FOR HEREFORD BULLS

	1981	1982	1983	1984	1985	1986	1987
on-test height	147	123	65	72	58	49	5
on-test weight	147	123	65	72	58	49	5
off-test height	147	123	65	72	58	49	5
off-test weight	147	123	65	72	58	49	5
average daily gain	147	123	65	72	58	49	5
height daily gain	147	123	65	72	58	49	5
scrotal circum-ference	80	123	64	71	58	46	5
ribeye area	145	113	52	68	56	45	0[a]
ribfat	146	121	62	70	58	46	2

[a]=no estimates due to scanogram misfunction.

TABLE XVII

POLLED HEREFORD BULLS LEAST SQUARES MEANS BY YEAR

	1981	1982	1983	1984	1985	1986	1987
on-test height (cm)	109.01 (.35) a	111.88 (.36) b	113.93 (.36) c	113.93 (.45) c	116.39 (.49) de	117.84 (.58) d	115.27 (.50) e
on-test weight (kg)	244.35 (3.85) a	279.46 (3.95) b	291.44 (3.98) c	290.29 (4.87) bc	312.90 (5.38) d	311.88 (6.29) d	291.44 (5.51) bc
off-test height (cm)	121.45 (.32) a	123.72 (.33) b	125.69 (.33) c	126.64 (.41) c	128.51 (.45) d	129.75 (.52) d	128.38 (.46) d
off-test weight (kg)	471.42 (4.35) a	505.77 (4.46) b	522.65 (4.50) c	529.76 (5.50) c	547.92 (6.08) de	562.34 (7.12) d	534.64 (6.23) ce
average daily gain (kg)	1.62 (.016) a	1.62 (.016) a	1.65 (.017) ab	1.71 (.021) c	1.68 (.023) bc	1.79 (.027) d	1.74 (.024) dc
height daily growth (cm)	.089 (.001) ad	.085 (.001) b	.084 (.001) b	.091 (.001) cd	.087 (.002) abd	.085 (.002) ab	.094 (.002) c
scrotal circumference (cm)	f	34.96 (.22) a	35.55 (.22) ab	36.33 (.27) c	36.62 (.30) c	35.87 (.35) bc	36.07 (.30) bc
ribeye area (cm^2)	31.42 (.21) a	32.16 (.21) b	33.91 (.22) c	33.97 (.27) c	34.93 (.29) d	35.40 (.34) d	g
ribfat (cm)	1.09 (.02) a	1.08 (.02) ac	1.08 (.02) ab	1.01 (.03) bcd	.98 (.03) d	1.03 (.03) acd	.77 (.06) e

abcde=means on the same line bearing a common subscript are not different (P>.05).
f=no scrotal measurements taken in that year on this breed.
g=no estimates due to scanogram misfunction.

TABLE XVIII

NUMBER OF OBSERVATIONS IN CALCULATING LEAST SQUARES MEANS FOR POLLED HEREFORD BULLS

	1981	1982	1983	1984	1985	1986	1987
on-test height	123	117	115	77	63	46	60
on-test weight	123	117	115	77	63	46	60
off-test height	123	117	115	77	63	46	60
off-test weight	123	117	115	77	63	46	60
average daily gain	123	117	115	77	63	46	60
height daily growth	123	117	115	77	63	46	60
scrotal circum-ference	0[a]	116	111	76	61	45	60
ribeye area	121	114	110	73	61	45	0[b]
ribfat	121	117	111	76	61	46	17

[a]=no scrotal measurements taken in that year on this breed.
[b]=no estimates due to scanogram misfunction.

TABLE XIX

LEAST SQUARES MEANS OF TEST WEIGHTS BY BREED

Number	Angus 1183	Hereford 519	Polled Hereford 601
28 day weight (kg)	337.33 (1.31) $_c$	355.11 (3.15) $_a$	342.40 (1.80) $_b$
56 day weight (kg)	390.42 (1.37) $_b$	405.43 (3.30) $_a$	391.20 (1.89) $_b$
84 day weight (kg)	443.03 (1.40) $_b$	452.08 (3.39) $_a$	438.67 (1.94) $_b$
112 day weight (kg)	489.55 (1.45) $_b$	497.58 (3.50) $_a$	484.24 (2.00) $_c$

abc = Means on the same line bearing a common subscript are not different (P >.05).

TABLE XX

LEAST SQUARES MEANS OF TEST WEIGHTS BY YEAR

Number	1981 482	1982 461	1983 415	1984 339	1985 255	1986 213	1987 138
28 day weight (kg)	316.63 (1.94) a	327.40 (2.01) b	342.29 (2.33) c	347.42 (2.48) c	361.45 (2.79) d	363.80 (3.12) d	355.61 (6.65) cd
56 day weight (kg)	363.30 (2.03) a	375.65 (2.11) b	390.48 (2.44) c	398.32 (2.60) d	415.48 (2.92) e	414.65 (3.27) e	411.90 (6.97) de
84 day weight (kg)	410.39 (2.09) a	423.06 (2.17) b	436.57 (2.51) c	448.01 (2.67) d	463.26 (3.00) e	466.59 (3.35) e	464.25 (7.15) e
112 day weight (kg)	453.34 (2.16) a	470.55 (2.24) b	481.16 (2.59) c	491.10 (2.76) d	509.55 (3.10) e	514.96 (3.46) e	512.54 (7.39) e

abcde=means on the same line bearing a common subscript are not different.

TABLE XXI

CORRELATION COEFFICIENTS BETWEEN SALES PRICE AND PERFORMANCE TRAITS

	selling price	number
on-test height	** .39	448
28 day weight	** .37	448
56 day weight	** .37	448
84 day weight	** .40	448
112 day weight	** .44	448
height daily growth	* .12	448

*=significance level: (P<.05).
**=significance level: (P<.01).

VITA

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Master of Science

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