RELATIONSHIPS OF HIP HEIGHT MEASUREMENTS WITH GROWTH AND CARCASS TRAITS OF THREE-BREED CROSS, STRAIGHTBRED ANGUS, AND STRAIGHTBRED HEREFORD CALVES

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CHAPTER I

INTRODUCTION

Linear body measurements have been collected on beef cattle since the early 1900's, primarily to objectively describe breeds of cattle, to estimate live weight, to describe normal changes taking place during growth, and to determine slaughter grades and carcass compositional characteristics on cattle prior to slaughter. Due to the continuous changes in beef type brought about by the changing market demands, several studies have been conducted to compare performance and carcass traits on cattle of different breeds or types within breeds utilizing linear measurements. Relatively fewer reports have been concerned with the relationships between body measurements recorded early in life and subsequent growth, performance, and carcass traits. Height measurements are objective, highly repeatable, and relatively little affected by environment compared to other body measurements (Orme et al., 1959; Green and Carmon, 1976). Since visual appraisal is a widely used selection criteria, height may be used with other growth measurements as supplemental information to increase the accuracy of selecting breeding cattle.

Linear body measurements have been taken on cattle of different breeds or types at different ages and slaughtered on different bases. Some indiscriminate comparisons among estimates of relationships between size or frame of cattle with growth, performance, and carcass traits, tended to mask the real relationships existing for each different situation.

The primary objectives of this study were: (1) to determine the phenotypic correlations of hip height with growth, feedlot performance, and carcass traits of three-breed cross calves and straightbred Angus calves slaughtered at an estimated low choice carcass grade, and straightbred Hereford calves slaughtered at a constant final weight of 1150 pounds, and (2) to develop prediction equations for certain growth, performance, anc carcass traits using combinations of weight and height measurements.

CHAPTER II

REVIEW OF LITERATURE

This chapter will be divided into five parts: (1) growth characteristics of beef cattle; (2) genetic aspects of linear measurements; (3) feedlot performance and carcass traits comparison between different types and breeds of cattle; (4) relationships between linear measurements at slaughter and carcass traits; and (5) predictability of feedlot and carcass traits by linear measurements and conformation scores obtained at earlier ages.

Growth Characteristics of Beef Cattle

The knowledge of growth patterns of farm animals and the magnitude by which each measurable trait is influenced by heredity and environment is of primary importance in determining reliable parameters to use in describing or predicting economically important results.

The effect of environment on growth patterns of cattle has been investigated by many researchers. In an extensive study including 500 Hereford steers and heifers, Lush et al. (1930) discussed the patterns of normal growth from birth to maturity. Body measurements such as width dimensions that are highly affected by degree of fatness increased slowly from September to March (scanty feed supply and cold temperature), and more rapidly from March to September. Little effect of environment throughout the year is reported on measurements of the head and long bones such as height at withers or hips. These increased at a normal rate despite season or range conditions. Little environmental effect on several body measurements of Black Pied cattle has been reported by Schmidt and von Patow (1938). Related to the influence of nutrition on body composition, Stuedmann et al. (1969) conducted an investigation where different nutritional level rations were fed to Hereford calves from birth to eight months of age. A sample of calves from each nutritional level was slaughtered at eight months of age and significant differences were found in carcass composition between calves on different nutrition planes. When remaining calves were full fed and slaughtered at a constant weight of 950 pounds, the nutritional level imposed no longer had significant effects on final skeletal development. Calves on the restricted diet during early stages of life, however, required longer periods of time and were less efficient in attaining slaughter weight. Hendrickson (1961) demonstrated changes in conformation on steers kept on maintenance and submaintenance rations. While steers were actually losing weight and decreasing on width dimensions, height over withers continued to increase. Growth of longer bones continued at the expense of body tissues. Similar results were described by Levy et al. (1971) in a study of the effects of restricted rations on body composition of Israeli-Friesian cattle.

Black and Knapp (1937) stated that growth of a beef animal takes place in two ways: (1) through increase in skeletal structure, and (2) development of muscular and fat tissues. Skeletal development is the last of these growth parameters to be negatively influenced by adverse conditions. They concluded that skeletal development may be associated with increase in flesh, but it has been shown that flesh development can be independent of skeletal growth. This suggestion of independent genetic mechanisms for these two growth parameters is in agreement with Gregory (1933) who presented evidence indicating a certain degree of independence between the genetic factors regulating skeletal growth and soft tissue development.

Mature size for different body dimensions is attained at different stages. Guilbert and Gregory (1952), based on Hereford data collected during 25 years, showed that linear skeletal growth increases faster and matures earlier than thickness growth. Total agreement with this report was found by Brown et al. (1956) working with Aberdeen Angus cattle, who stated that mature size for several body dimensions was attained in the following decreasing order: height at hips, height at withers, width of shoulders, heart girth, depth of chest, length of body, and finally width at hips. Likewise, Davis et al. (1937) reported that dairy cattle attained approximately half of mature growth in height over withers before birth. At maturity, height was stated as being essentially a constant reflecting the genotype for size of skeleton.

Environment may influence growth patterns differently, depending on the genetic composition of the cattle studied. Butts et al. (1971) demonstrated that yearling heifers calved in Montana differed significantly in withers height when raised in Montana or in Florida. Heifers born and raised in Montana were .83 inches taller than those born in Montana and raised in Florida. Neville et al. (1978) stated significant differences on hip height on Angus heifers of similar genetic composition when raised in different locations.

Of the many measurable growth parameters exposed to adverse conditions, height at hips or withers is the least affected. This makes height measurements a more reliable parameter than other linear body measurements or weight, where growth is intended to be described per se and apart from the increase in body weight due to fleshing.

Genetic Aspects of Linear Measurements

A major factor influencing the response to selection for a particular trait is the heritability of that trait. Heritability estimates for skeletal size has been reported by many researchers. Heritability estimates based on several breeds and types of cattle are presented in Table I. The relatively high heritabilities for skeletal size are such that a response to selection can be expected (Cazemier, 1965).

There is a general agreement in the literature with respect to the relationship between height at the hips and height at the withers. Weber (1957) suggested that the same genetic basis regulates both parameters. Grabowski and Dyminicki (1974), based on the high genetic correlation between height at withers and height at sacrum (.94), concluded that both traits are influenced by the same genes. The phenotypic correlation calculated for these two traits was .74.

Selection for a single trait can result in changes in other traits as well because of the genetic correlations between traits. Selection for height on different types and breeds of cattle seems to bring about a general increase in body conformation (Cunningham, 1979; Okamoto, 1960; Reklewski, 1977; Touchberry, 1951; Udris, 1961). The high genetic correlation between several body measurements indicated in those studies that selection on any one parameter will result in an increase in all the others.

TABLE I

HERITABILITY ESTIMATES OF LINEAR HEIGHT MEASUREMENTS

Author and Year		Breed	No.	Class	Heritability	
					Wither Height	Hip Height
Arapovic,	1973	---	---	Yr. Bulls	.52	
Brown,	1956	Hereford	255	Calves	.29	.21
Brown,	1956	Angus	212	Calves	.38	.22
Buiatti,	1954	Chianina	---	Heifers	.60	
Buiatti,	1954	Chianina	---	Calves	.41	
Cunningham,	1969	Friesian }	558	Steers	.16	
Cunningham,	1969	Shorthorn }		Steers	.82	
Dawson,	1955	Milk. Shorth.	58	Steers	.65	
Gowen,	1933	Jersey	6300	Bulls & Cows	.60	
Grabowski,	1974	Black & White	1534	Cows	.33	.25
Kumazaki,	1963	Japanese	327	Newborns	.53	.54
Kumazaki,	1963	Japanese	327	Weaning	.81	.66
Kumazaki,	1963	Japanese	327	12 mos.	1.01	.93
Newman,	1973	Black Pied	4459	Yr. Bulls	.14 → .40	
Okamoto,	1966	Japanese	600	---	.42	.48
Pilla,	1973	Italian Br.	---	---	.46	.88
Romita,	1972	Italian	---	---	.46	.88
Schott,	1950	Shorthorn	101	Steers	1.00	
Touchberry,	1951	Holstein	187	Cows	.73	
Udris,	1961	Red Danish	3082	Heifers	.47	.45
Weber,	1957	---	175	Cows	.63	.50

Feedlot Performance and Carcass Traits Comparisons Between Different Types and Breeds of Cattle

Beef type is considered of primary importance in the beef cattle shows and markets. Since the early 1900's, there has been considerable change in the concept of beef type. The large, late maturing animal gave way to a smaller, earlier maturing type with smaller cuts of meat. Steers could be finished at an earlier age and lighter weight. Since then there has been much discussion and several experiments concerning the comparisons between the larger, later maturing types and smaller, earlier maturing types with respect to feedlot and carcass traits. The main interest of such studies was to determine which type of cattle, large or small, would produce a more desirable and profitable type of beef cattle. A study was conducted by Washburn et al. (1948) to investigate the nutrient utulization of feed by Shorthorn steers of the comprest and conventional types. The possibility of the comprest type being an endocrine anomaly was suggested, based on the difference encountered between types in metabolism and deposition of digested material. No differences were reported in food capacity or digestibility. The general opinion of several studies which compared both types was that the normal type at slaughter had eaten more, had larger total and daily gains, and weighed more than the comprest type. Differences in daily gain and final weight were generally significant while those in efficiency of gain and slaughter age were nonsignificant. Although nonsignificance is reported, the trend was for the conventional type to require longer periods of time on feed in order to attain similar conditions than the compact type. When slaughtered at the same slaughter grade, nonsignificant differences on carcass traits were reported (Woodward et al., 1942; Knox and Koger, 1946; Willey et al., 1951; Stonaker, Hazaleus and Wheeler, 1952; Blackwell and Cobb, 1956; Skinner, 1959). Dressing percentage was reported to be significantly larger for conventional type of animal by Stonaker, Hazaleus and Wheeler (1952), as well as by Knox and Koger (1946).

Knox and Koger (1946) also reported that differences in daily gain were no longer significant when corrected for initial weight. Type itself directly affected size and dressing percentage. Black and Knapp (1937) compared Milking Shorthorns as a large type of cattle versus Beef Shorthorns as a small type and concluded that differences in gain between types and sexes were due to differences in size. Similar conclusions were reported by Kidwell (1955) who computed the relationships between several body measurements, live grade, and slaughter grade on Hereford steers. Kidwell stated that steers of widely different forms may have equal carcass value and dressing percentages and vice versa.

Differences in body conformation, rate and efficiency of gain, and carcass traits were summarized by Schott et al. (1950). A total of 101 beef type Shorthorn steers and 62 milking type steers were slaughtered at a constant final weight of 900 pounds. Milking types were taller and longer than beef types and attained slaughter weight 23 days earlier. Slaughter and carcass grades were higher in the beef type. Nonsignificant differences were found for efficiency or daily gain as well as in dressing percentages. Feedlot and carcass traits were analyzed in 245 Hungarian Simmental and 201 Hereford bulls slaughtered at a constant degree of finish by Szuromi and Sardi (1979). No differences were stated between breeds in dressing percentage and carcass traits except for bone percentage which was 1.5 percent larger in the Simnental breed. Hereford cattle were 50 days younger at slaughter and Simmental were 234 pounds heavier at slaughter and gained .48 pounds more per day than Herefords.

Few investigators have made the same type of comparisons on grazing systems. Maino et al. (1981) studied the performance of crossbred steers representing three different frame sizes under different grazing conditions. On restricted gaining potential, the lack of any advantage in gain by the larger framed cattle, combined with a possible greater purchase price, suggested that smaller framed cattle would be more desirable. Weber (1957) examined the performance of 288 Hereford steers grazing in different nutritional levels sired by bulls of small, medium, and large sizes. Daily gains increased directly with size. Steers from smaller sized bulls tended to have higher slaughter and carcass weights when grazed under deferred systems and fattened on grass than steers from larger sized bulls. These differences were not evident under dry lot conditions. A similar study was conducted by Stonaker et al. (1952) during three years to compare daily gain and hay consumption of heifers classified in large, intermediate, and comprest types. Within a given group total hay consumption and gain increased with size. When results were reported in the amount of hay consumed per 1000 pounds of body weight maintained between different sizes of females, the differences were no longer significant.

Some reports (Knapp and Cook, 1933, Black et al., 1938; Kohli et al., 1952) indicate differences in carcass or slaughter grade depending on type. Compact steers had higher dressing percentages than rangier type steers. Such results usually occurred when differences in type were extreme and when there were differences in degree of finish as was the case for different types of cattle slaughtered at constant weights. When an attempt was made to slaughter at a similar degree of finish, differences in dressing percentage and other carcass traits tended to disappear.

In order to produce profitable and desirable beef cattle the literature seems to agree with Weber's (1957, p. 25) conclusion that within a breed "medium size cattle tend to combine the gaining ability of large cattle with the finishing ability of small cattle without sacrifice of efficiency of gain."

Relationships Between Linear Measurements at Slaughter and Carcass Traits

Selection for improvement of beef cattle carcasses is hampered by a lack of accurate indirect methods for estimating slaughter values on live animals. Prediction of carcass value by visual appraisal has been widely used in the past; however, its accuracy is relatively low. A more accurate method of evaluationg an individual's breeding value for carcass traits is a progeny test. This procedure has the inconvenience of being expensive and increases the generation interval, thus reducing the annual selection improvement.

Several studies have attempted to develop objective indicators for evaluating carcass merit prior to slaughter. Studies in which several body measurements on different types and breeds of cattle taken shortly prior to slaughter at a constant weight of 900 pounds are reported by Knapp and Cook (1933), Black et al. (1938), Kohli et al. (1951), and Cook et al. (1951). The objective of these studies was to determine whether any relationship existed between body measurements and various production factors and meat characters. In general, the results suggested that with weight held constant, those steers with less height over withers, short legs, and less depth of body had higher efficiency of food utilization, more fat, more edible meat, and less bone than taller steers. Slaughter and carcass grades were also described as being larger on smaller types of cattle, the same as dressing percentage. Black et al. (1938) concluded that a slaughter grade was found to be a better measure of beef type than any ratios of measurement. Measurements should not replace but should supplement reliable slaughter grades.

When cattle were slaughtered according to a similar degree of finish, some of the relationships described above tended to change. Kidwell (1955), in an attempt to better describe conformation on fat calves, took several body measurements on 64 Hereford steers. The high correlation attained between height at withers and height at hips (.93) suggested that either one could be used with the same result in research investigations. A positive significant correlation coefficient was reported between height and dressing percentage, at variance with results presented by Black et al. (1938), Cook et al. (1951), and Kohli et al. (1951). Although not significant, slaughter and carcass grades tended to be positively related to height. In a similar investigation, Manda et al. (1980) collected data on 98 Japanese Black Cattle steers from 1973 to 1978. Several body measurements were correlated to carcass quality and quantitative traits of meat production. The low phenotypic and genetic correlations reported, indicated that carcass quality was little affected by body measurements. On the other hand, the high positive phenotypic and genetic correlation coefficients found between meat production traits and body measurements suggested that those production traits were much affected by linear measurements in the live cattle. Phenotypic correlations between height at withers and final weight, dressing percentage, and daily gain were .63 ($P < .01$); -.023; .488 ($P < .01$), respectively. Orme et al. (1959) analyzed 8 Angus and 23 Hereford steers and their results yielded highly repeatable estimates for height measurements. A correlation of .31 was reported between height and percentage of primal cuts.

A possible explanation for the discrepancy between some of these papers, with respect to carcass quality and body conformation when cattle are slaughtered at a constant weight of 900 pounds, is that taller cattle reach slaughter weight with a smaller amount of finish than cattle of smaller size. This fact may adversely affect slaughter and carcass grade as well as dressing percentage. Knox and Koger (1946) indicated that steers which gained more rapidly and efficiently reached a given constant weight (900 pounds) at an earlier age and smaller skeletal size than those that gained more slowly. Batra et al. (1973) presented phenotypic correlation coefficients between preslaughter body measurements and carcass traits. A close relationship was indicated between width measurements and carcass traits. This result agrees with Wanderstock (1946) who, in order to determine weight where scales were not available, measured 100 Angus and 45 Hereford steers. Body measurements were taken shortly before slaughter. Positive correlations were found between most body measurements and body weight. The single linear measurement more closely related to body weight was heart girth with correlations of .89 and .91 for Angus and Hereford, respectively.

Reklewski et al. (1977) directed a study of 20 Black and White bulls prior to slaughter to evaluate linear body measurements as indicators of slaughter value. The best linear body measurements in describing slaughter value were depth of forechest, height at withers, height at sacrum, and circumference of thigh. The changes that occurred in body conformation of 183 steers during fattening were objectively analyzed by Lush (1928). The results presented indicated that steers increased much more in width during fattening than they did in length or depth of body. Height and head measurements exhibited the smallest increase during the finishing preiod, while chest girth was the linear measurement which increased the most during that period. It was concluded that body measurements should be regarded as being of minor importance compared to weight changes in describing fattening changes. Pasek (1977) used 53 bullocks of the Bohemian Spotted breed and reported that in all stages of development the increase of liveweight produced the greatest effect on growth of girth, circumference of loin, and finally on height at hips. Heidler (1967) published 208 correlation coefficients between body measurements and carcass traits of 338 Black Pied Lowland bulls measured at a constant weight of 880 pounds. The correlation coefficients ranged from -.248 to .311. Only 37.5 percent were reported to be of statistical significance.

According to the literature, linear body measurements of live cattle describing width were significantly correlated to slaughter values and carcass traits. When used alone, however, their usefulness in describing important details of conformation and some carcass traits seemed to be of minor importance. In most cases weight changes and subjective grades were better estimators of slaughter values. Nevertheless, due to their high degree of objectivity and repeatability, linear body measurements should be regarded as supplementary tools to other means of description.

Predictability of Feedlot and Carcass Traits by Linear Measurements Obtained at Earlier Ages

The relationships studied up to this point were between body measurements and previous performance or to describe carcass traits in live cattle measured shortly before slaughter. Fewer investigations Have been concerned with the predictability of feedlot performance or carcass traits by linear body measurements taken in early life. If early measurements could accurately predict an animal's later performance, this would be a valuable aid in selecting animals to better accomplish a desired function or purpose. It could also bring about an improvement in the estimation of subsequent performance of feeder animals and allow more uniform outcome groups for feeding.

In answering the question of how early could cattle be measured and effectively predict subsequent performance, Flock et al. (1962) conducted an experiment involving 1425 calves of the three British beef breeds. The objective was to study the usefulness of data collected at birth for predicting weaning performance. The multiple regression analysis of weaning type and average daily gain on seven birth measurements indicated no utility of the latter as predictors of the former. The maximum coefficient of determination (R^2) attained was .138 for average daily gain on Angus cattle. Under the grazing conditions in southern Australia, Robinson and Cameron (1960) demonstrated that the predictive value of measurements made shortly after birth for similar measurements at 84 weeks of age may be quite high. However, the only measurement of value for the practical commercial point of view was live weight. At weaning time, Brown and Shrode (1971) selected certain body measurements on 158 Angus calves to estimate body shape and to predict subsequent growth rate and fatness. Prediction equations were developed in which weight and age were forced into each equation before incorporation of other variables. Various combinations of body measurements and body composition traits explained significantly more variation in the traits studied than was explained by using weight and size alone. Effectiveness of selection at weaning time is suggested to be appreciably increased if consideration is given to other traits in addition to weight and age. Ludwig (1980) collected field data on 243 Hereford steers and heifers. Body measurements were taken at the beginning of the finishing period and cattle were slaughtered at a constant weight of 1150 pounds. The correlation coefficients between hip height and days on feed, slaughter age, average daily gain, weight per day of age, fat thickness, retail yield and marbling score were reported to be -.52, -.52, .32, .43, -.28, .33, and -.16, respectively. The following formula was developed by Knapp (1939) from a curvilinear relationship between height at withers weight and slaughter grade from 167 steers of three British beef breeds taken at slaughter time:

$$\text{GRADE} = -223.2839 - 3.5853\ (H) + 157.9825\ (\log \omega)$$

where H is height at withers in inches, and ω is live weight in pounds.

An extensive study involving 241 feeder steers was reported by Lush (1932) who obtained 23 measurements at the start of the finishing period. A multiple correlation analysis was conducted to evaluate body measurements as predictors of feedlot and carcass traits. Fairly high correlations were reported between body measurements and daily gain and dressing percentage. When included in the multiple correlation analysis, the slight increase in R^2 attained by each independent variable suggested that much of that primary correlation was due to the effect of general size rather than a relation with that specific measurement. Maximum gain was associated with a long body, tall at the withers, with a large paunch girth but small flank girth and narrow at the loins. It was concluded that no standard based on conformation could ever be so accurate that the future performance of individual steers could be predicted without considerable error. Brown et al. (1973) measured 550 Hereford and Angus bulls at 4 and 8 months of age. Principal component analysis of ten body measurements for each breed was conducted in describing size and shape. The correlation coefficients showed that an increase in any body dimensions affected positively rate of gain, weight, and feed consumed in both breeds. Feed conversion was differently affected in both breeds; while the net result was favorable in Herefords, Angus bulls experienced a decrease in efficiency. Tall and narrow bulls of both breed groups at 4 and 8 months of age ate more, had larger daily gains, and were heavier at slaughter than short and wide bulls. Butts et al. (1980) reported a study in which 349 commercial calves of Angus, Hereford, Charolais cross, and Angus X Hereford breeding types were fed to a constant subcutaneous fat level. Initial fat thickness (ultrasonically measured), weight, wither height and body depth explained 54 percent of the variation in carcass weight and 34 percent of that in days on feed. In general, tall or rangy types of cattle produced heavier carcasses than did compact cattle. When animals were slaughtered at constant weights or ages, carcass compositional characteristics were associated with measures of type. When cattle were slaughtered at a constant finish, no association was reported. When subjective and more applicable methods were used, as frame and fat scores, a decrease of 10 and 6 percent in the variation explained in carcass weight and days on feed, respectively, was found. Frame effects were similar to those of measured wither height and body depth. However, subjective fat determination was less related than ultrasonically measured fat to response variables. Different conclusions were reached by Kidwell et al. (1959) in a study where the relationship between selected production traits and conformation scores and body measurements were analyzed on 98 yearling steers. Most of the correlations reported were nonsignificant and none were large enough to be of any practical value. Only 16 to 20 percent of the total variation in daily or economy of gain was accounted for by the feeder measurements. This indicated that none of the feeder measurements or combinations of them are useful indicators of a steer's ability to gain rapidly or efficiently. The prediction of edible portions in beef cattle carcasses by linear measurements and weight changes has been attempted as well. In all cases reported, final weight was found to be the best indicator of valuable cuts. Eighty percent of the variation in edible portion was explained by slaughter weight alone. When body measurements were included in the regression analysis, the coefficient of determination (R^2) was increased by only 2 to 4 percent. Correlation coefficients of .93 and .81 were calculated for final weight of roast and steak meat, respectively (White and Green, 1952; Cundiff et al., 1967; Busch et al., 1969).

Type of beef cattle as well as condition at the beginning of finishing period are important parameters influencing future gain and carcass traits. Future dressing percentage and carcass value, however, are more closely related to conformation than gain is. Initial fat has a definite effect on subsequent performance since it provides an estimate on degree of maturity and on subsequent maturity rate.

Prediction of future gains based on conformation of feeder cattle alone does not appear very accurate as Lush (1932, p. 29) concluded: "Steers of many shapes will gain well and steers which gain the same may be of different shapes."

CHAPTER III

MATERIALS AND METHODS

Data used in this study came from two different institutions and three different breeding groups: (1) Data Set One, Oklahoma State University (O.S.U.) crossbred cattle, (2) Data Set Two, O.S.U. Angus cattle, and (3) Data Set Three, American Hereford Association (A.H.A.) cattle. Each data set will be described separately.

Data Set One, O.S.U. Crossbred Cattle

Description of Experimental Animals

A total of 286 three-breed calves born during the spring of 1980 were included in the analyses. These cattle were part of an extensive experiment (Project 1502) in progress at the Oklahoma Agricultural Experiment Station to evaluate lifetime productivity of various two-breed cross cows. The foundation herd of two-breed cross cows was produced by mating Angus and Hereford cows to Angus (A), Hereford (H), Simmental (S), Brown Swiss (B), and Jersey (J) bulls in 1972, 1973, and 1974. Eight crossbred dam groups were thus developed (HA, AH, SA, SH, BA, BH, JA, JH). All heifer calves produced by these matings were introduced into the herd for subsequent evaluation as cows. Based on a preliminary analysis (Belcher and Frahm, 1979), for purposes of this particular study the data were combined and analyzed as four crossbred dam groups: HA reciprocal crosses, S crosses, B crosses, and J crosses. A detailed description of the cow herd has been reported by Belcher and Frahm (1979). In 1979, all crossbred dam groups were randomly mated to Charolais and Limousin bulls to produce 131 bull calves and 155 heifer calves in the spring of 1980. At calving the cow herd consisted of five-, six-, and seven-year-old cows.

Management and Data Collection

Cows were maintained on native and bermuda grass pasture at the Lake Carl Blackwell Research Range west of Stillwater, Oklahoma. All calves were weighed within 24 hours of birth. Calves remained with their dams on native range until weaning in September at an average age of 205 days. No creep feeding was supplied. At weaning all calves were weighed and a conformation and condition score was given by a panel of at least three persons. On the day of weaning all calves were trucked to the Southwestern Livestock and Forage Research Station at El Reno. The following day steers were placed in one feeding barn consisting of 14 pens and heifers were placed in another feeding barn consisting of 14 pens. Calves of the same three-breed cross and sex were randomly alloted to a pen in the respective feeding barns.

Height at the hips was measured twice to the nearest tenth of an inch and averaged for all calves at weaning, yearling, and slaughter time.

Cattle were fed *ad lib* the finishing ration shown in Table II. Cattle were individually removed from the feedlot and slaughtered when an estimated low choice carcass grade was attained.

Analysis of Traits

The following traits were involved in the analysis:

1. Preweaning average daily gain.

TABLE II

FINISHING RATION

Ingredient	Percent in Ration
Corn	78
Alfalfa	8
Cottonseed Hulls	4
Molasses	5
Supplemental Pellets[1]	5
Total	100

[1]Supplemental pellets consisted of 67.6% soybean oil meal (44%), 12% urea, 10% calcium carbonate, 8% salt plus Aurofac, vitamin A, and trace minerals.

2. Weaning weight (see explanation in item 3).

3. Yearling Weight. Calves were weighed at an average age of 205 and 365 days, respectively. Weights were adjusted to a standard age as follows:

205-day weaning weight = 205 (preweaning ADG) + birth weight

365-day yearling weight = 160 (weaning to yearling ADG) + 205-day weaning weight

No age of dam adjustment was necessary because all cows involved were mature.

4. Weaning to yearling average daily gain.

5. Weaning height (see explanation in item 7).

6. Yearling height (see explanation in item 7).

7. Slaughter height. Hip height was measured as the vertical distance from the floor to the highest point in the region of the hooks. Regression coefficients of hip height on age at weaning and yearling were conducted for each sex separately. Regression coefficients of hip height on age were very similar among crossbred dam groups and were thus averaged to provide a linear adjustment for hip height to 205 days and 365 days, respectively. The average regression coefficients were: .0426 and .0462 inches per day at weaning age and .0257 and .0210 inches per day at yearling age for steers and heifers, respectively. Thus, hip height was adjusted to a standard age as follows:

205-day adj. height (steers) = .0426 (205--weaning age) + weaning height

205-day adj. height (heifers) = .0462 (205--weaning age) + actual weaning height

365-day adj. height (steers) = .0257 (365--yearling age) + actual yearling height

365-day adj. height (heifers) = .0210 (365--yearling age) + actual yearling height

These daily growth rates are consistent with those reported in the literature (Lush, 1928; Guilbert and Gregory, 1952; Brown et al., 1973; Dori et al., 1974; Massey, 1979; Maino et al., 1981; Baker, 1981). Corrections performed in this manner assume linear growth over the range of ages of the cattle at a given date of height measurement. The consensus in the literature supports this assumption.

8. Weaning to yearling growth. Daily growth was calculated by dividing the difference between weaning height and yearling height by the days between weaning and yearling time.

9. Weaning to slaughter growth. Daily growth was calculated by dividing the difference between weaning and slaughter by the days between weaning and slaughter time.

At an estimated low choice carcass grade, cattle were removed from the feedlot and the following traits were recorded:

10. Final weight.

11. Feedlot average daily gain.

12. Days on feed.

13. Slaughter age.

After slaughter, the following carcass traits were recorded:

14. Hot carcass weight.

15. Carcass weight per day of age.

16. Dressing percentage. Dressing percentage was calculated by dividing the hot carcass weight by the final weight.

17. Carcass grade.

18. Carcass conformation.

19. Marbling score.

20. Ribeye area. The ribeye area was calculated based on the tracing of the ribeye between the twelfth and thirteenth ribs.

21. Single fat thickness.

22. Average fat thickness. Average fat thickness was calculated as the average fat thickness at three equally spaced points over the ribeye.

23. Cutability. Murphey's equation was used to calculate cutability:

$$\begin{aligned}\text{Cutability Percent} = {} & 51.34 - 5.784 \text{ (single fat thickness, in.)} \\ & - .462 \text{ (kidney heart pelvic fat, percent)} \\ & + .74 \text{ (ribeye area, sq in.)} \\ & + .0093 \text{ (hot carcass weight, lb).}\end{aligned}$$

Statistical Analysis

Phenotypic correlations of height measurements with growth and carcass traits adjusted for sex, breed of sire, and crossbreed dam group were calculated by procedures available in the SAS program (Helwig and Council, 1979) using the following model:

$$Y_{ijkl} = \mu + Si + Cj + Xk + SC_{ij} + SX_{ik} + CX_{jk} + SCX_{ijk} + e_{ijkl}$$

where

Y_{ijkl} = observed value for a trait from the lth calf of kth sex out of the jth crossbred dam group and sired by the lth sire breed;

μ = effect common to all calves--it is the population mean if all other effects were zero;

S_i = effect of the ith breed of sire, i = 1, 2;

C_j = effect of the jth crossbred dam group, j = 1, 2, 3, 4;

X_k = effect of the kth sex, k = 1, 2;

SC_{ij} = effect of the interaction between the ith breed of sire and the jth crossbred dam group;

SX_{ik} = effect of the interaction between the ith breed of sire and the kth sex of calf;

CX_{jk} = effect of the interaction between the jth crossbred dam group and the kth sex of calf;

SCX_{ijk} = effect of the interaction between the ith breed of sire, the jth crossbred dam group, and the kth calf sex; and

e_{ijkl} = random effect associated with the lth calf of kth sex, out of the jth crossbred group and belonging to the ith breed of sire.

In addition to the above analysis, the data were subjected to several multiple regression analyses by procedures available in the SAS program (Helwig and Council, 1979) to predict feedlot average daily gain, final weight, days on feed, hot carcass weight, carcass weight per day of age, ribeye area, and single fat thickness, using 205-day weaning weight, pre-weaning daily gain, 205-day adjusted weaning height, 365-day yearling weight, and 365-day adjusted yearling height as independent variables. In these analyses the effects of breed of sire, crossbred cow group, and sex of calf were removed. The effect of every independent variable on the coefficient of determination (R^2) of each dependent variable described was studied by comparing all possible combinations among the independent variables.

Data Set Two, O.S.U. Angus Cattle

Description of Experimental Animals

The data analyzed in this section consisted of 199 straightbred Angus calves that were part of the beef cattle selection study at the Oklahoma Agricultural Experiment Station (Project 1256) initiated at the Southwestern Livestock and Forage Research Station at El Reno, Oklahoma, in the early 1960's. The purpose of the study involving Hereford and Angus was to compare the response to selection for increased weaning or yearling weight. The Angus cattle involved four lines: one line was selected for increased weaning weight, one line for increased yearling weight, one line for control, and one line for increased weaning weight based on progeny test information. A detailed description of the cow herd and selection criteria was presented by Chenette (1981). At the termination of the Angus selection lines, four bulls per line were selected based on the respective selection criteria from the 1978 calf crop and were randomly mated to all Angus cows to produce 98 heifer calves and 101 bull calves in the spring of 1980.

Management and Data Collection

The cow herd was maintained at the Southwestern Livestock and Forage Research Station at El Reno, Oklahoma, on native and bermuda grass pastures. Calves were born in the spring, from early February through April, and birth weights were recorded within 24 hours after birth. Calves were allowed to run with their dams on pasture without creep feed until weaning, at an average age of 205 days. All calves were weighed and conformation and condition scores determined by a committee of at least three persons. On the same day of weaning, calves were placed in the feedlot and fed _ad lib_ a corn-based ration (Table II). Calves were weighed and measured at the hips at an average age of 365 days. The hip measurement was taken twice on each calf to the nearest tenth of an inch and averaged. Height measurements were not taken at weaning or slaughter time. Calves were individually removed from the feedlot and slaughtered when an anticipated low choice carcass grade was estimated.

Analysis of Traits

Height measurement was recorded at yearling time in the O.S.U. Angus data set. All other growth and carcass traits were recorded following the same procedure described in the O.S.U. Crossbred Data Set. Preweaning daily gain was found to be a duplicate of 205-day adjusted weaning weight and was excluded from further analysis.

Since the Angus cows consisted of a wide mixture of ages, weaning weights were adjusted for age of dam, multiplying the 205-day weaning weight by 1.15, 1.10, 1.05, and 1.00 for two-, three-, four-, five-year-old and older cows, respectively.

Regression analysis of hip height on age at yearling was conducted for each sex separately. The regression coefficients at yearling were .028 and .026 inches per day for steers and heifers, respectively. Thus, hip height was adjusted to 365 days of age as follows:

365-day adj. height (steers) = .028 (365--yearling age) + actual yearling height

365-day adj. height (heifers) = .026 (365--yearling age) + actual yearling height.

The influence of age of dam on height of the calf has been reported less frequently than that of weight. Although there are some age of dam adjustment factors reported for height at weaning time (Massey, 1979; BIF, 1980), none has been developed to adjust height for age of dam at yearling time. To correct for possible difference in height at yearling due to age of dam influences, age of dam was included in all models as a fixed effect, as will be described in the section on Statistical Analysis.

Statistical Analysis

Phenotypic correlations for height at yearling time with growth and carcass traits, adjusted for sex and age of dam (Snecedor and Cochran, 1967), were calculated by SAS (Helwig and Council, 1979) using the following model:

$$Y_{ijk} = \mu + X_i + A_j + XA_{ij} + e_{ijk}$$

where

Y_{ijk} = observed value for a trait from the kth calf of ith sex and jth age of the dam group;

μ = effect common to all calves--the population mean if all other effects were zero;

X_i = effect of the ith sex, i = 1, 2;

A_j = effect of the jth age of the dam group;

XA_{ij} = effect of the interaction between ith sex of calf and jth age of dam group; and

e_{ijk} = random effect associated with kth calf belonging to the jth age of dam and of ith sex.

In addition to the above analysis, the data were subjected to several multiple regression analyses by procedures available in the SAS program (Helwig and Council, 1979) to predict feedlot average daily gain, final weight, days on feed, hot carcass weight, carcass weight per day of age, ribeye area, and single fat thickness, using 205-day adjusted weaning weight, 365-day adjusted yearling weight, and 365-day adjusted yearling height as independent variables. In these analyses the effects of sex of calf and age of dam were removed. The effect of every independent variable on the R^2 of each dependent variable described was studied by comparing all possible combinations among the independent variables.

Based on the slight differences in performance of progeny from the bulls from the four Angus lines reported by Aaron et al. (1982), no adjustment for line of sire effect was attempted.

Data Set Three, A.H.A. Hereford Cattle

Description of Experimental Animals

A total of 566 straightbred Hereford calves were analyzed in this section. The data were part of the Total Performance Record-Keeping Program (T.P.R.) developed and directed by the American Hereford Association since 1964. The cattle consisted of 412 steer calves and 154 heifer calves out of 47 sire groups from ten different herds. Calves were born from January through May in 1979.

Management and Data Collection

The ten herds were considered to be a representative sample of straightbred Hereford cattle with respect to genetic composition and management practices of the cow herds. Seven of the ten herds recorded birth weight of calves. On the other three a standard birth weight of 75 pounds for bull calves and 70 pounds for heifer calves was used in calculating the adjusted 205-day weight. Calves were kept with their dams until weaning at an age that varied among the different herds from 159 to 283 days. In one of the ten herds studied, creep feed was supplied for six weeks or longer. Following a variable period of time (from 9 to 70 days) after weaning, calves were placed in the feedlot and fed a finishing ration. Calves were removed from the feedlot and slaughtered when a constant final weight of 1150 pounds was attained. This in in contrast to the O.S.U. Crossbred and Angus data sets where cattle were slaughtered at an estimated low choice carcass grade.

Analysis of Traits

The following records were utilized in this study:

1. Weaning weight (see explanation in item 2).

2. Yearling weight. Calves were weighed at an average of 243 and 387 days, respectively. Weaning weights were adjusted to a standard age of 205 days by a correction factor developed by the A.H.A. (Table XXI, Appendix). Yearling weight was adjusted to 365-day yearling weight = 160 (weaning to yearling ADG) + 205-day weaning weight.

3. On test height. At the beginning of the feeding test, at an average age of 280 days, all calves were measured at the hips to the nearest tenth of an inch. On test height was the only measurement recorded in the Hereford data. The regression coefficients for both steers and heifers of height on age were calculated to provide a linear adjustment for hip height to 280 days. The coefficients obtained were .0343 and .0344 inches per day for steers and heifers, respectively. Hip height

was adjusted to a standard 280 days as follows:

280-day adj. height (steers) = .0343 (280--on test height) + actual on test height

280-day adj. height (heifers) = .0344 (280--on test height) + actual on test height.

When the required slaughter weight of 1150 pounds was attained, cattle were removed from the feedlot and the following traits were recorded:

4. Final weight.
5. Weight per day of age.
6. Slaughter age.
7. Days on feed.
8. Feedlot average daily gain.

After slaughter the following carcass traits were recorded:

9. Fat thickness.
10. Percentage of cutability.
11. Marbling score.

Statistical Analysis

Phenotypic correlations of height on test with growth and carcass traits, adjusted for sex and location (Snedecor and Cochran, 1978), were calculated by SAS (Helwig and Council, 1979) using the following model:

$$Y_{ijkm} = \mu + X_i + A_j + L_k + XA_{ij} + e_{ijkm}$$

where

Y_{ijkm} = observed value for a trait from the mth calf of sex ith belonging to the jth age of dam group and kth location;

μ = common effect to all calves--the population mean if all others were zero;

X_i = effect of the ith sex, i = 1, 2;

A_j = effect of the jth age of dam group, j = 1, 2, 3, 4;

L_k = effect of the kth location, k = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

XA_{ij} = effect of the interaction between the ith sex and the jth age of dam group; and

e_{ijkm} = random effect associated with the mth calf raised at the kth location, belonging to the jth age of dam group, and of the ith sex.

In addition, the data were subjected to several multiple regression analyses by procedures available in SAS program (Helwig and Council, 1979) to predict feedlot average daily gain, days on feed, final weight, weight per day of age, fat thickness, and cutability, using 205-day adjusted weaning weight, 280-day adjusted hip height, and 365-day adjusted yearling weight as independent variables. Age of dam, sex of calf, and location effects were removed in the analyses. The effect of every independent variable on the R^2 of each dependent variable described was studied by comparing all possible combinations of the independent variables.

CHAPTER IV

RESULTS AND DISCUSSION

The results for Data Set One, O.S.U. Crossbred Cattle; Data Set Two, O.S.U. Angus Cattle; and Data Set Three, A.H.A. Hereford Cattle will be presented separately. A general discussion will follow the presentation of the three data sets. For purposes of further describing the data sets, the means and standard deviations of various traits in each data set are presented in Table III.

Data Set One, O.S.U. Crossbred Cattle

The primary interest of this study was to analyze the phenotypic correlations of hip height measurements with growth performance and carcass traits. Mean squares from analysis of variance are presented in the Appendix (Table XXII) only to show sources of variation.

Phenotypic correlation coefficients adjusted for breed of sire, sex of calf, and crossbred dam group are presented in Table IV. Correlations of height measured at weaning with weaning weight, preweaning daily gain, yearling weight, final weight, carcass weight, and carcass weight per day of age were .70, .62, .50, .45, .37, and .36, respectively ($P < .01$). A low significant correlation was found between weaning height and feedlot daily gain ($r = .14$). Taller cattle at weaning tended to gain more weight from weaning to yearling and to have larger rib eye areas at slaughter ($r = .11$ and $.10$, respectively, ns). Lower nonsignificant relationships

TABLE III

LEAST SQUARE MEANS AND STANDARD DEVIATIONS FOR VARIOUS TRAITS IN THE THREE DATA SETS

	Data Set					
	O.S.U. Crossbreds		O.S.U. Angus		A.H.A. Herefords	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Steers No.	131	---	101	---	412	---
Heifers No.	155	---	98	---	154	---
205-Day Adj. Wean. Wt. (lbs)	498	48	396	45	456	46
365-Day Adj. Yearl. Wt. (lbs)	945	81	803	79	793	75
205-Day Adj. Wean. Ht. (in.)	43.5	1.3	---	---	---	---
365-Day Adj. Yearl. Ht. (in.)	49.1	1.5	44.0	1.5	---	---
Slaughter Ht. (in.)	50.1	1.7	---	---	---	---
280-Day On-Test Height (in.)	---	---	---	---	43.1	1.4
Final Wt. (lbs)	1156	98	951	69	1098	55
Feedlot Daily Gain (lbs/day)	2.60	0.40	2.47	0.34	2.52	0.31
Days on Feed (days)	255	29	228	21	229	29
Slaughter Age (days)	463	35	440	22	507	30
Carcass Grade[a]	9.5	1.1	10.1	0.9	---	---
Cutability (%)	49.8	1.7	48.1	1.7	49.5	1.4
Rib Eye Area (sq in.)	12.8	1.5	10.5	1.1	---	---
Marbling Score[b]	4.7	1.0	5.1	0.7	5.4	0.7
Single Fat Thickness	0.49	0.17	0.69	0.20	0.53	0.16

[a]Carcass grade equivalents: 9 = High Good, 10 = Low Choice, and 11 = Average Choice.

[b]Marbling score equivalents: 4 = Slight, 5 = Small, and 6 = Modest.

TABLE IV

PHENOTYPIC CORRELATIONS OF HIP HEIGHT WITH GROWTH AND CARCASS TRAITS ADJUSTED FOR BREED OF SIRE, CROSSBRED DAM GROUP, AND SEX OF CALF

Traits	205-Day Weight	Prewean. ADG	365-Day Weight	Weaning to Yearling ADG	Final Weight	Feedlot ADG	Days on Feed	Slaughter Age	Hot Carcass Weight
205-day Height	.70	.62	.50	.11	.45	.14	-.05	-.05	.37
365-day Height	.53	.45	.57	.35	.53	.29	-.05	-.04	.43
Slaughter Height	.36	.31	.32	.14	.59	.02	.35	.40	.51
Weaning to Yearling Growth	-.20	-.23	.17	.39	.04	.28	.01	-.22	.01
Weaning to Slaughter Growth	-.23	-.27	.09	.31	.05	.32	.00	-.27	.04

TABLE IV (Continued)

Traits	Carcass Weight Per Day of Age	Carcass Grade	Dressing Percent	Cutability	Rib Eye Area	Marbling Score	Single Fat Thickness	Average Fat Thickness	Carcass Conformation
205-day Height	.36	-.06	-.04	-.05	.10	-.08	-.02	-.01	.01
365-day Height	.40	-.05	-.05	-.10	.14	-.10	.04	.01	.03
Slaughter Height	.17	.05	.01	-.03	.26	.04	.01	-.03	.02
Weaning to Yearling Growth	.15	-.08	-.07	-.05	.01	-.11	.08	.01	-.05
Weaning to Slaughter Growth	.18	-.06	-.03	-.03	.07	-.04	.10	.02	.03

$|r| > .12$, $P < .05$; $|r| > .16$, $P < .01$.

were observed with slaughter age, days on feed, carcass grade, dressing percentage, cutability, marbling score, fat thickness, and carcass conformation.

The same trends and similar magnitudes were observed for the correlations at yearling time. A stronger association was observed with feedlot daily gain, weaning to yearling gain, and rib eye area at yearling than at weaning time (r = .29, .35, .14 vs. .14, .11, and .10, respectively). Taller cattle at yearling age tended to have lower cutabilities and marbling scores ($P < .10$). As cattle moved from weaning to yearling, the magnitude of the correlation coefficients increased for those traits measured later in life and decreased for those measured at weaning.

Negative correlations ($P < .01$) were obtained for weaning to yearling growth with weaning weight, preweaning daily gain, and slaughter age (r = -.20, -.23, and -.22, respectively). Yearling weight, weaning to yearling gain, feedlot gain, and carcass weight per day of age increased significantly in faster growing calves during that period of time.

The phenotypic correlations of slaughter height with weight and carcass traits, in general, followed the pattern described at weaning and yearling time. Correlation coefficients with growth traits ranged from .14 to .36 ($P < .05$). Feedlot daily gain was not significantly related to slaughter height (r = .02). The correlation coefficients with days on feed and slaughter age were .35 and .40, respectively ($P < .01$). Rangier, later maturing cattle required a longer feeding period and were older at slaughter than smaller, earlier maturing cattle. Among carcass traits only carcass weight per day of age and rib eye area were significantly related to slaughter height (r = .17 and .26, respectively).

Phenotypic correlations of weaning to slaughter growth with weight and daily gain traits were similar in magnitude and direction to those reported for weaning to yearling growth. The negative relationship with weaning weight and preweaning daily gain (r = -.23 and -.27, respectively) suggested a compensatory gain due to preweaning environmental effects. There was a favorable association with feedlot daily gain, weaning to yearling daily gain, and carcass weight per day of age (r = .32, .31, and .18, respectively). The negative favorable relationship with slaughter age (r = -.27) indicated that cattle increasing faster in height during the finishing period tended to reach a low choice carcass at an earlier age.

In general, taller cattle were heavier at weaning, yearling, and slaughter time. Brungdart (1972) reported that faster growing cattle reached compositional maturity at a younger chronological age. The highly significant correlations reported for yearling height with weaning to yearling daily gain and feedlot daily gain indicated that taller yearling cattle would be faster growing cattle as well. Although nonsignificant, taller yearling cattle tended to reach slaughter condition earlier in life and in shorter periods of time, with lower marbling and consequently lower carcass grades, as indicated by the negative correlations with slaughter age, days on feed, marbling score, and carcass grade (r = -.04, -.05, -.10, and -.05, respectively). On the other hand, taller cattle at slaughter were positive and highly significant related to slaughter age and days on feed (r = .40 and .35, respectively), and tended to have more marbling and higher carcass grades (r = .05 and .04, respectively). Single fat thickness was not affected in the same way by compositional maturity at slaughter. This discussion can be better visualized by comparing the trends for yearling and slaughter height with the traits described (Table IV). As cattle moved from weaning to slaughter time, the correlation between height at hips and rib eye area increased (r = .10, .14, and .26 for rib eye area with weaning, yearling, and slaughter hip height, respectively).

These results are consistent with those reported in the literature in which cattle were slaughtered at the same degree of finish (Woodward et al., 1943; Knox and Koger, 1946; Willey et al., 1951; Stonaker, Hazaleus, and Wheeler, 1952; Kidwell, 1955; Blackwell and Cobb, 1956; and Skinner, 1959).

Some reports (Knapp and Cook, 1933; Black et al., 1938; Kohli et al., 1952) indicated differences in carcass or slaughter grades for different types of cattle. Such results usually occur when comparing different types of cattle slaughtered at a constant final weight.

Several multiple regression analyses were conducted to predict feedlot daily gain, final weight, days on feed, hot carcass weight, carcass weight per day of age, and single fat thickness, at weaning and yearling time, using models including 205-day adjusted weaning weight (A 205 WT), 205-day adjusted weaning height (A 205 HT), preweaning average daily gain (PRWDG), 365-day adjusted yearling weight (A 365 WT), and 365-day adjusted yearling height (A 365 HT) as independent variables. Breed of sire, crossbred dam group, and self of calf were included in all models as fixed effects. Since all possible two-way interactions among fixed effects were generally nonsignificant in the full model, they were excluded from the prediction models.

Table V presents prediction equations for feedlot gain. At weaning using the complete model, R^2 = .39. This indicated that most of the variation in feedlot daily gain (.61) remained unexplained. Excluding PRWDG

TABLE V

PREDICTION EQUATIONS FOR FEEDLOT DAILY GAIN

	Models								
	Weaning				Yearling				
	1	2	3	4	5	6	7	8	9
A205WT	0.0102**	0.0008	0.0100**	0.0012*	-.0031*	-.0053**		0.0009	-.0051**
A205HT	-.0069	0.0221			0.0947*	0.0405	-.0841**	-.0878**	
PRWDG	-.2003**		-.1974**		-.0408				
A365WT					0.0052**	0.0053**	0.0037**		0.0047**
A365HT					0.0892*	-.0259	0.0246	0.1284**	
R^2 [b]	.39	.34	.39	.34	.74	.73	.64	.40	.73

P < .10, *P < .05, **P < .01.

[a] To individually predict feedlot average daily gain on steers or heifers, see respective additive adjustments in Table XXIII (Appendix).

[b] R^2 = coefficient of determination.

(model 2) R^2 decreased by 13 percent when A205HT was removed and PRWDG re-included into the model (model 3) R^2 returned to .39. This indicated that variation in feedlot daily gain was little affected by differences in height at weaning. The best model at this time is considered to be No. 3, in which A205WT and PRWDG made highly significant contributions to explain the variation in feedlot daily gain. From a practical standpoint, the large proportion of unexplained variation limits its usefulness. The same model was most effective in prediction of carcass weight per day of age. Weaning height was the only variable not contributing significantly in the explanation of variation in carcass weight per day of age. The final model including A205WT and PRWDG accounted for 56 percent of the variation in carcass weight per day of age. Differences in height at weaning had very little effect on the variation in this carcass trait. The single most important variable in the model was A205WT. R^2 increased by 6 percent when PRWDG was included in combination with weaning weight.

Inclusing of yearling traits in the prediction models resulted in large increases in the R^2 values. This increase was mostly due to A365WT and its relationship with A205WT (model 9). When A205WT was removed (model 8) there was a decrease of 12 percent in R^2. This indicates that feedlot daily gain is little affected by height measurements, although their contribution was significant (models 5 and 8). Individually considered, A365WT was the principal variable, followed by A365HT. However, the best two-variable model was attained including A365WT and A205WT (model 9). These results are in agreement with those reported by Robinson and Cameron (1960), who stated that live weight was the only measurement whose correlation was high enough to be of practical value.

Table VI presents prediction equations for final weight. At weaning, in model one, all three variables made highly significant contributions in explaining the variation in final weight. However, by successively removing PRWDG and A205HT (models 2 and 3) R^2 decreased by only 1.4 percent. When A205WT was the only independent variable (model 4), R^2 was equal to .68; only about 3 percent of the total variation explained by the previous model was lost. This indicates that at weaning A205WT alone can explain almost as much variation in final weight as can be explained by taking birth weights and hip height measurements. A similar conclusion was reached when predicting hot carcass weight. By using a model with A205WT alone, 60 percent of the total variation in hot carcass weight was accounted for.

At yearling time the inclusion in the prediction models of yearling information increased R^2 for final weight by 14 percent. A365WT and A365HT were both statistically significant ($P < .01$ and $P < .05$, respectively). Models five and six showed that weaning data were of little utility at yearling time. In model eight, where A365HT was excluded, the variation explained by the model was reduced by only 1.25 percent. Little accuracy seems to be achieved in explaining final weight by including height measurements in a model where weight can be utilized. Similar conclusions were suggested for carcass weight per day of age and hot carcass weight, where R^2 in the models without A365HT were .52 and .55 percent lower compared to a model with A365WT alone.

Table VII presents prediction equations for days on feed. At weaning time the two models utilized explained relatively little of the total variation in days on feed; R^2 was equal to .26. Model two, without PRWDG, showed A205WT to be highly significant and A205HT significant at the .05

TABLE VI

PREDICTION EQUATIONS FOR FINAL WEIGHT

	Models							
	Weaning				Yearling			
	1	2	3	4	5	6	7	8
A205WT	2.07**	0.73**	2.47**	1.02**	-.14		-.05	
A205HT	10.31**	14.43**			5.69	2.47		
PRWDG	-28.32**		-32.56**					
A365WT					0.76**	0.72**	0.74**	0.85**
A365HT					9.61*	10.91*	12.98**	
R^2 [b]	.70	.69	.69	.68	.80	.80	.80	.79

P < .10, *P < .05, **P < .01.

[a] To individually predict final weight on steers and heifers, see respective additive adjustments in Table XXIV (Appendix).

[b] R^2 = coefficient of determination.

TABLE VII

PREDICTION EQUATIONS FOR DAYS ON FEED

	Models				
	Weaning		Yearling		
	1	2	3	4	5
A205WT	-.346*	-.211**	0.007		
A205HT	4.143*	3.728*	0.300		
PRWDG	2.860				
A365WT			-.187**	-.185**	-.139**
A365HT			4.160*	4.418**	
R^2 [b]	.26	.26	.35	.35	.32

P < .10, *P < .05, **P < .01.

[a] To individually predict days on feed on steers and heifers, see respective additive adjustments in Table XXV (Appendix).

[b] R^2 = coefficient of determination.

level. At yearling time, R^2 was increased by 38 percent. However, 65 percent of the variation in days on feed remained unexplained. A365WT and A365HT significantly influenced days on feed variation. The single most important variable was A365WT. When A365HT was excluded (model 5), R^2 decreased by 9 percent. Similar regression coefficients were reported by Butts et al. (1980) for days on feed on initial weight. Both indicated that increased initial height was associated with longer feeding periods. This is in contrast to the negative correlation presented in Table VI for yearling height and days on feed, suggesting that when weight was held constant, height per se was associated with longer feeding periods.

The prediction equations for rib eye area are presented in Table VIII. At weaning time the best model accounted for only 22 percent of total variation. The best model was achieved combining PRWDG and A205WT. Differences in height at weaning time did not influence differences in rib eye area at slaughter. When PRWDG was removed (model 3), R^2 decreased by 18 percent. At yearling time, R^2 was increased by only 9 percent using all available variables. Live weight and PRWDG were the principal traits affecting variation in days on feed. Since 76 percent of the differences in rib eye area remained unexplained, little can be foretold about rib eye area at yearling time.

Prediction equations for single fat thickness at weaning and yearling times are presented in Table IX. At weaning time, a relatively small R^2 was attained (.14). None of the independent variables had a significant effect. This indicated that very little of the variation in slaughter fat thickness can be explained by the models described at weaning time. At yearling time, R^2 increased by 43 percent. However, 80 percent of the total variation remained to be explained in the best model (model 5).

TABLE VIII

PREDICTION EQUATIONS FOR RIB EYE AREA

	Models				
	Weaning			Yearling	
	1	2	3	4	5
A205WT	0.037**	0.031**	0.007**	0.028**	0.002
A205HT	-.148			-.152	-.070
PRWDG	-.613**	-.553**		-.502**	
A365WT				0.004*	0.005**
A365HT				0.021	0.009
R^2 [b]	.22	.22	.18	.24	.21

P < .10, *P < .05, **P < .01.

[a] To individually predict rib eye area on steers and heifers, see respective additive adjustments in Table XXVI (Appendix).

[b] R^2 = coefficient of determination.

TABLE IX

PREDICTION EQUATIONS FOR SINGLE FAT THICKNESS

	Models					
	Weaning			Yearling		
	1	2	3	4	5	6
A205WT	0.0001	-.0001	-.0001	-.0010**	-.0010**	
A205HT	-.0021	-.0013		0.0026		
PRWDG	-.0051					
A365WT				0.0008**	0.0008**	0.0004**
A365HT				-.0053		
R^2 [b]	.14	.14	.14	.20	.20	.16

P < .10, *P < .05, **P < .01.

[a] To individually predict single fat thickness on steers and heifers, see respective additive adjustments in Table XXVII (Appendix).

[b] R^2 = coefficient of determination.

A205WT and A365WT had significant influences in single fat variation. In model six, when A205WT was excluded from the model, R^2 decreased by 20 percent. This indicated that both of the combined variables better explained differences in fat thickness at slaughter.

In general, the fraction of total variation in the dependent variables described was greatly increased by including yearling traits in the model. Differences in live weight at weaning and yearling times generally accounted for most of the differences in the traits analyzed. The small increases in R^2, generally achieved by including hip height measurements recorded at weaning and yearling times, indicated that height differences among calves had generally little effect in the variation of the traits studied. Coefficients of determination were relatively low for carcass traits for the models based on weaning and yearling traits. These results were consistent with those reported by Knox and Koger (1946) and Stonaker et al. (1952) where for cattle slaughtered at constant degree of finish, no association was found between carcass traits and measures of type.

Data Set Two, O.S.U. Angus Cattle

In order to show sources of variation for the traits analyzed, mean squares are presented in the Appendix (Table XXVII). The means and standard errors for various traits analyzed are presented in Table III.

Table X presents phenotypic correlations of yearling height with growth and carcass traits adjusted for sex of calf and age of dam. A strong positive correlation was found for yearling hip height and weaning weight, yearling weight, slaughter weight, and carcass weight (r = .51, .68, .59, and .59, respectively) which indicated that taller yearling

TABLE X

PHENOTYPIC CORRELATIONS OF YEARLING HIP HEIGHT WITH GROWTH AND CARCASS TRAITS ADJUSTED FOR SEX OF CALF AND AGE OF DAM

Traits	205-Day Adjusted Weaning Weight	365-Day Adjusted Yearling Weight	Weaning to Yearling ADG	Feedlot ADG	Final Weight	Slaughter Age	Days on Feed	Hot Carcass Weight
365-Day Adjusted Yearling Height	.51	.68	.53	.46	.59	-.32	-.33	.59

	Carcass Weight Per Day of Age	Carcass Grade	Dressing Percent-age	Cutability	Rib Eye Area	Marbling Score	Single Fat Thickness	Average Fat Thickness	Carcass Confor-mation
365-Day Adjusted Yearling Height	.62	-.07	.23	-.15	.23	-.03	.08	.05	.01

$|r| > .14$, $P < .05$.

$|r| > .19$, $P < .01$.

cattle were heavier at all stages. The phenotypic correlation coefficients with daily gain from weaning to yearling time, feedlot daily gain, and carcass weight per day of age were .53, .46, and .62, respectively. The relatively high phenotypic correlations suggested that faster growing cattle were taller cattle at the hips at yearling time. Similar relationships were described for the crossbred data set, where hip height at yearling time presented stronger relationship with daily gains than at slaughter time.

The correlation coefficients between feedlot daily gain and yearling height was positive and highly significant. Faster growing cattle would attain a stage of compositional maturity at a younger chronological age (Brungdart, 1972). This statement would explain the negative and highly significant correlation for yearling hip height with slaughter age and days on feed (r = -.32 and -.33, respectively). The correlation values obtained with dressing percentage, cutability, and single fat thickness were .23, -.15, and .08, respectively. These values suggested, as could be expected, that faster growing cattle would begin to deposit back fat at an earlier age; this was reflected by the positive trend with fat thickness which results in a higher dressing percentage and a lower cutability percentage, a trait much influenced by the amount of fat present in the carcass. Kidwell (1955) reported positive correlation coefficients between height at slaughter and dressing percentage. Negative nonsignificant values were obtained for marbling score and carcass grade (r = -.03 and -.07, respectively). Carcass grade is a trait very much dependent on marbling score. The negative association with these two carcass traits could be explained by the compositional stage at which faster growing cattle were slaughtered. At that relatively young age, although a fair amount of pelvic, kidney, heart, and back fat would be present, relatively little intramuscular fat would have developed. Marbling score directly depends upon the intramuscular fat deposition, which is the latest developing of all fat deposits. Carcass conformation showed nonsignificant relationship with yearling height.

The phenotypic correlations discussed were similar in direction, although generally larger in magnitude, than those presented for yearling hip height in Data Set One, Crossbred Cattle (Table IV).

Several multiple regression analyses were performed to predict feedlot daily gain, final weight, days on feed, hot carcass weight, rib eye area, and single fat thickness at yearling time by models which included all possible combinations of 205-day adjusted weaning weight (A205WT), 365-day adjusted yearling weight (A365WT), and 365-day adjusted yearling height (A365HT). Sex of calf and age of dam were forced into all models as fixed effects.

Table XI presents prediction equations for feedlot daily gain. R^2 was equal to .58 in the full model. Live weight at weaning and yearling times had significant effects on the variation in feedlot daily gain, while yearling height apparently had relatively little influence. In model two, when A205WT was removed, R^2 decreased by 10 percent. This suggested that both traits explained variation in feedlot daily gain in different ways. Yearling height was still a nonsignificant factor. When A365HT was removed (model 3) and the only independent variable was yearling weight, no change in R^2 occurred. Hip height at yearling time appears to be of little utility in predicting daily feedlot gains and maximum attention should be paid to differences in live weight. These results are consistent with those presented in Table V for the crossbred cattle.

TABLE XI

PREDICTION EQUATIONS FOR FEEDLOT DAILY GAIN

	Models		
	1	2	3
Intercept	-.4725	-.4945	0.2998
Sex of Calf			
Steers	0.0000	0.0000	0.0000
Heifers	-.0220	-.0479	-.0562
Age of Dam (yrs)			
2	0.0612	0.0569	0.0392
3	-.0932	-.0807	-.0915
4	-.0040	0.0305	0.0224
Mature	0.0000	0.0000	0.0000
A205WT	-.0027**		
A365WT	0.0035**	0.0024**	0.0027**
A365HT	0.0275	0.0233	
R^2 [b]	.58	.52	.52

P < .10, *P < .05, **P < .01.

[a] R^2 = coefficient of determination.

The prediction equations for final weight are presented in Table XII. Model one indicated that about 75 percent of the differences in final weight can be explained by the full model including all three independent variables. All traits significantly influenced final weight. A decrease of about 4 percent in R^2 occurred when A205WT was excluded (model 2). The unexplained variation was further increased by 3 percent when yearling height was removed, leaving A365WT alone as an independent variable. Yearling weight proved to be the single most important trait influencing final weight. As was suggested in Data Set One, O.S.U. Crossbred Cattle, little accuracy seems to be gained in predicting final weight by including height measurements in the prediction equations. Similar results were attained for carcass weight and carcass weight per day of age. R^2 in the three models was .52, .51, .50, and .75, .74, 72 for both traits, respectively.

Table XIII presents prediction equations for days on feed. A relatively small proportion of the differences in days on feed was influenced by the variables included in the models. About 54 percent of the total variation remained unexplained. A205WT was the only nonsignificant trait in model one. In model two, when A205WT was excluded, R^2 remained unchanged. When A365HT was excluded (model 3), a decrease of about 2 percent resulted in R^2, suggesting that differences in hip height measurements at yearling time--although statistically significant--are probably of little utility in predicting the length of feeding period needed to attain an estimated low choice carcass grade. Heavier yearling cattle, when yearling height and weaning weight were held constant, tended to require fewer days on feed. This is in agreement with the previous discussion where faster growing cattle remained fewer days on feed. However, when yearling weight and weaning weight were held constant (model 1), the

TABLE XII

PREDICTION EQUATIONS FOR FINAL WEIGHT

	Models		
	1	2	3
Intercept	104.609	108.661	507.671
Sex of Calf	**	**	**
Steers	0.000	0.000	0.000
Heifers	-50.883	-46.103	-50.264
Age of Dam (yrs)	**	**	**
2	-35.838	-35.047	-43.911
3	-38.789	-41.080	-46.485
4	-21.962	-28.321	-32.396
Mature	0.000	0.000	0.000
A205WT	0.503**		
A365WT	0.258**	0.456**	0.606**
A365HT	10.896**	11.685**	
R^2 [a]	.75	.72	.70

$P < .10$, *$P < .05$, **$P < .01$.

[a] R^2 = coefficient of determination.

TABLE XIII

PREDICTION EQUATIONS FOR DAYS ON FEED

	Models		
	1	2	3
Intercept	295.689	295.850	375.266
Sex of Calf	**	**	**
Steers	0.000	0.000	0.000
Heifers	-19.913	-19.723	-20.551
Age of Dam (yrs)	**	**	**
2	9.724	9.755	7.991
3	10.904	10.813	9.737
4	1.426	1.174	0.363
Mature	0.000	0.000	0.000
A204WT	0.020		
A365WT	-.211**	-.203**	-.173**
A365HT	2.294*	2.326*	
R^2 [a]	.46	.46	.45

P < .10, *P < .05, **P < .01.

[a] R^2 = coefficient of determination.

partial regression obtained for yearling height indicated that taller cattle tended to have longer feeding periods. This trend is in contrast to the correlation coefficient of -.33 ($P < .01$) presented in Table X for yearling height and days on feed. This conflict suggested that the majority of the relationships between hip height and days on feed was probably due to yearling weight. These results were similar to those reported for the crossbred cattle in Data Set One.

Table XIV presents prediction equations for rib eye area. The total variation explained by the full model (model 1) was only 22 percent,which suggested that predicting rib eye area using such a model would have limited value. Most of the differences in rib eye area must be due to other independent variables not considered in the model. Weaning weight was the single most important and significant variable in the full model. When A205WT was removed (models 2 and 3), R^2 decreased by 32 percent. This reduction indicated that weaning weight was more closely related to rib eye area than were either yearling weight or yearling height. The unexplained fraction, however, is too large to be useful from a practical standpoint.

Single fat thickness was the least predictable of the dependent variables studied (Table XV). The full model (model 1) explained only about 8 percent of the total variation in single fat thickness. Yearling weight was the most important trait affecting back fat, followed by weaning weight. When weaning and yearling weights were held constant, yearling height per se tended to be associated with leaner fat measurements. This trend is in contrast to the positive nonsignificant correlation presented in Table X for yearling height and single fat.

TABLE XIV

PREDICTION EQUATIONS FOR RIB EYE AREA

	Models		
	1	2	3
Intercept	5.7420	5.8316	7.4143
Sex of Calf			
Steers	0.0000	0.0000	0.0000
Heifers	-.1576	-.0743	-.0782
Age of Dam (yrs)			
2	-.1813	-.1686	-.1955
3	-.2024	0.2437	-.2564
4	-.0012	-.1138	-.1214
Mature	0.0000	0.0000	0.0000
A205WT	0.0088**		
A365WT	-.0002	0.0033*	0.0040**
A365HT	0.0347	0.0481	
R^2 [a]	.22	.15	.15

P < .10, *P < .05, **P < .01.

[a] R^2 = coefficient of determination.

TABLE XV

PREDICTION EQUATIONS FOR SINGLE FAT THICKNESS

	Models		
	1	2	3
Intercept	0.9016	0.8938	0.3889
Sex of Calf			
Steers	0.0000	0.0000	0.0000
Heifers	0.0289	0.0216	0.0258
Age of Dam (yrs)	*	+	+
2	-.0381	-.0392	-.0292
3	-.0844	-.0808	-.0752
4	-.0959	-.0861	-.0821
Mature	0.0000	0.0000	0.0000
A205WT	-.0008+		
A365WT	0.0009*	0.0006*	0.0004*
A365HT	-.0138	-.0150	
R^2 [a]	.08	.06	.06

P < .10, *P < .05, **P < .01.

[a] R^2 = coefficient of determination.

In general, similar results to those reported for the crossbred cattle were obtained. The total variation in most dependent variables studied was better explained by differences in weight at weaning and yearling times than by differences in yearling height. Attention apparently should be paid more closely to weight differences rather than height differences in cattle to attain desirable growth and carcass traits. The accuracy gained in the prediction equations by including hip height measurements, although sometimes statistically significant, appears to be of little practical value.

Data Set Three, A.H.A. Hereford Cattle

In order to show sources of variation for the traits analyzed, mean squares are presented in Table XXIX (Appendix). The means and standard deviations are presented in Table III. The Hereford cattle were slaughtered as near as possible to 1150 pounds, which is in contrast to the intended low choice carcass grade for determining slaughter time for the other two data sets.

Phenotypic correlation coefficients of on-test hip height with growth, performance, and carcass traits adjusted for sex of calf, age of dam, and location are presented in Table XVI. Positive, relatively high correlation coefficients were found for on-test hip height with weaning weight, yearling weight, and weight per day of age (r = .66, .56, and .55, respectively). These values indicated that taller on-test cattle were generally heavier. In spite of the intended slaughter weight of 1150 pounds, taller cattle on-test had larger slaughter weight (r = .25).

On-test hip height had a relatively low positive correlation coefficient with weaning to yearling daily gain and feedlot daily gain (r = .19

TABLE XVI

PHENOTYPIC CORRELATIONS OF ON-TEST HIP HEIGHT WITH GROWTH AND CARCASS TRAITS ADJUSTED FOR SEX OF CALF, AGE OF DAM, AND LOCATION

Trait	205-day Adjusted Weaning Weight	365-day Adjusted Yearling Weight	Weaning to Yearling Adg.	Final Weight	Age at Slaughter	Days on Feed	Feedlot Adg.	Weight Per Day of Age	Fat Thickness	Cutability	Marbling Score
280-day Adjusted On-Test Hip Height	.66	.56	.19	.25	-.52	-.51	.18	.55	-.19	.16	-.17

$|r| > .09$, $P < .05$; $|r| > .11$, $P < .01$.

and .18, respectively). These values suggested that taller cattle tended to reach 1150 pounds with more rapid daily gains than smaller cattle. When slaughter wegith was attained, taller on-test cattle were generally younger and remained fewer days on feed; the correlation values with slaughter age and days on feed were -.52 and -.51, respectively. These relationships may possibly be explained by the different stages on the growth curve that cattle of different sizes would be at the same final weight. Taller, larger framed cattle would generally be younger at constant weights and faster rates of gain would be expected than in smaller framed cattle. The correlations obtained for carcass traits tended to agree with those obtained in the previous two data sets. Taller on-test cattle would be expected to attain slaughter weight earlier in life with less back fat, as indicated by the negative relationship between on-test hip height and fat thickness (r = -.19). Cutability, a trait inversely proportional to fat thickness, presented a low significant correlation with on-test hip height (r = .16). Cattle slaughtered at younger ages would generally tend to have less intramuscular fat than cattle slaughtered at older ages. Marbling score directly depends on the amount of intramuscular fat in the carcass, thus explaining the -.17 correlation between on-test hip height and marbling score.

These results are in close agreement with those reported by Ludwig (1980) on a similar study directed by the American Hereford Association. The discrepancy between these results and some studies reported in the literature (Knapp and Cook, 1933; Black et al., 1938; Kohli et al., 1952), where a constant final weight was also required, may be possibly elucidated by the difference in final weight required. Previous reports were generally concerned with a final weight of 900 pounds, while 1150 pounds were required by the American Hereford Association in both studies. As final weight iş increased, the differences in growth characteristics between cattle of different sizes are stressed. Smaller type cattle would require comparatively longer feeding periods, would be older at slaughter with lower average daily gains and less efficient. More back fat would be expected, increasing dressing percentage and decreasing cutability. As slaughter age increases with increasing final weight, smaller cattle compared to larger cattle would be at an advanced stage of maturity at slaughter time and more intramuscular fat would be deposited, resulting in higher marbling scores and consequently higher carcass grades.

Several multiple regression analyses were performed to predict feedlot daily gain, weight per day of age, days on feed, and fat thickness at the beginning of the feeding period by models which included all possible combinations of 205-day adjusted weaning weight (A205WT), 365-day adjusted yearling weight (A365WT), and 280-day adjusted on-test hip height (A280HT). Sex of calf, age of dam, and location were included in all models as fixed effects.

Table XVII presents prediction equations for feedlot daily gain. About 76 percent of the variation in feedlot daily gain was not accounted for by the full model (model 1). A205WT and A365WT had a highly significant influence on daily gain and on-test hip height appeared to have a smaller effect. However, when A205WT was removed from the model (model 2), R^2 decreased only by 4 percent, suggesting that although statistically significant the proportion of variation explained by A205WT was relatively small. Model three, where A365WT was the only independent variable, indicated no change at all in R^2. As pointed earlier for data sets one and

TABLE XVII

PREDICTION EQUATIONS FOR FEEDLOT DAILY GAIN

	Models		
	1	2	3
Intercept	0.8536	1.3100	1.2841
Location	**	**	**
Sex of Calf			
Steers	0.0000	0.0000	0.0000
Heifers	-.0561	-.0576	-.0581
Age of Dam (yrs)			
2	-.0372	-.0569	-.0564
3	0.0202	0.0072	0.0072
4	0.0089	0.0052	0.0051
Mature	0.0000	0.0000	0.0000
A205WT	-.0012**		
A365WT	0.0017**	0.0014**	0.0014**
A280HT	0.0157	-.0007	
R^{2a}	.24	.23	.23

P < .10, *P < .05, **P < .01.

[a] R^2 = coefficient of determination.

two, hip height contributed very little to the prediction of feedlot daily gain, compared to yearling and weaning weights.

Table XVIII presents prediction equations for weight per day of age. The variation in weight per day of age was significantly affected by all three variables and 69 percent of the variation in this trait was accounted for by the full regression model. In model two, when A205WT was removed, R^2 decreased by only 1.4 percent, suggesting that the proportion of the variation attributed to A205WT was relatively small. When A280HT was excluded and A365WT remained as the only independent variable (model 3), R^2 decreased by 4.4 percent, indicating that yearling weight is the most important of the three independent variables in the prediction of weight per day of age. The proportion of variation accounted for by on-test hip height, when weaning and yearling weights were held constant, suggested that when cattle are slaughtered at a constant final weight of 1150 pounds the inclusion of on-test hip height in the prediction equation for weight per day of age resulted in only marginal improvement.

Table XIX presents prediction equations for days on feed. The full model (model 1) accounted for 73 percent of the total variation in days on feed and all three variables had statistically significant effects. Models two and three pointed out that the best model to predict days on feed included only A365WT. Adding A205WT or A280HT separately or in combination resulted in very little increases of R^2 values. The relative lack of influence of on-test hip height on the variation in days on feed is in apparent contradiction with the relatively high correlation coefficient reported for the two variables in Table XVI ($r = -.51$). This discrepancy suggested that when yearling weight was held constant, hip height per se accounted for a relatively small proportion of the total variance

TABLE XVIII

PREDICTION EQUATIONS FOR WEIGHT PER DAY OF AGE

	Models		
	1	2	3
Intercept	.1104	-.0827	0.9783
Location	**	**	**
Sex of Calf			
Steers	0.0000	0.0000	0.0000
Heifers	-.0235	-.0228	-.0035
Age of Dam (yrs)			
2	-.0615	-.0531	-.0729
3	-.0140	0.0085	-.0081
4	-.0007	0.0008	0.0061
Mature	0.0000	0.0000	0.0000
A205WT	0.0005**		
A365WT	0.0011**	0.0012**	0.0015**
A280HT	0.0237**	0.0307**	
R^{2}[a]	.69	.68	.65

P < .10; *P < .05; **P < .01.

[a] R^2 = coefficient of determination.

TABLE XIX

PREDICTION EQUATIONS FOR DAYS ON FEED

	Models		
	1	2	3
Intercept	557.442	586.932	478.456
Location	**	**	**
Sex of Calf	**	**	**
Steers	0.000	0.000	0.000
Heifers	-21.341	-21.423	-23.387
Age of Dam (yrs)			
2	6.128	4.852	6.876
3	4.433	3.584	3.544
4	1.942	1.707	1.169
Mature	0.000	0.000	0.000
A205WT	-.075**		
A365WT	-.214**	-.233**	-.266**
A280HT	-2.069*	-3.137**	
R^2 [a]	.73	.72	.71

P < .10; *P < .05; **P < .01.

[a] R^2 = coefficient of determination.

in days on feed, indicating that the majority of the relationships between on-test hip height and days on feed was probably due to weight.

Prediction equations for fat thickness are presented in Table XX. The relatively small R^2 value attained in the full model (model 1) indicated that most of the variation in fat thickness (about 88%) remained unexplained. Among the independent variables included in model one, on-test hip height was the only variable significantly affecting fat thickness. The R^2 value decreased by 33 percent when A280HT was excluded in the prediction model (model 3). This result is in contrast to those presented in data sets one and two in which cattle slaughtered at a constant degree of finish, weight--not height--was the single most important variable. The relatively large proportion of unexplained variation suggested that little can be foretold about fat thickness on the carcass at the beginning of the feeding period. A similar discussion applied for cutability, which is inversely proportional to fat thickness. Partial regression coefficients of similar magnitude but opposite in direction were observed. R^2 values for models one, two, and three were .13, .12, and .09, respectively.

General Discussion

In general, the three data sets analyzed tended to show similar relationships for hip height with growth traits. Taller cattle in the three data sets and at all stages for the crossbreeds were generally heavier at weaning, yearling, and slaughter times. This positive relationship with hip height was also observed for carcass weight, carcass weight per day of age, and weight per day of age. Crossbred and Angus cattle were slaughtered at an estimated low choice carcass grade; correlation coefficients

TABLE XX

PREDICTION EQUATIONS FOR FAT THICKNESS

	Models		
	1	2	3
Intercept	1.4895	1.6293	0.6675
Location	**	**	**
Sex of Calf	*	*	
Steers	0.0000	0.0000	0.0000
Heifers	0.0401	0.0397	0.0223
Age of Dam (yrs)			
2	-.0605	-.0665	-.0486
3	-.0142	-.0182	-.0185
4	0.0043	0.0031	-.0016
Mature	0.0000	0.0000	0.0000
A205WT	-.0004		
A365WT	0.0002+	0.0001	-.0002+
A280HT	-.0227**	-.0278**	
R^{2}[a]	.12	.12	.08

P .10; *P .05; **P .01.

[a] R^2 = coefficient of determination.

of hip height with feedlot performance tended to be high, while the association with carcass traits were generally lower. Hereford cattle which were slaughtered at a constant final weight of 1150 pounds generally had closer associations between hip height and carcass traits than those in data sets one and two. These results are consistent with those in the literature, where the closeness of association for height measurements with performance and carcass traits generally varied depending on the slaughter criteria. Since the correlations observed for slaughter hip height in the crossbred cattle estimate relationships with growth, performance, and carcass traits at physiological stages not analyzed in the Angus or Hereford data sets, this general discussion will be based on correlations for hip height measured at yearling time (365 days) in the crossbred and Angus cattle and correlations for hip height measured on-test (280 days) in the Hereford cattle. Correlation coefficients for hip height with performance traits were larger in magnitude in the crossbred and Angus cattle than in Hereford cattle. This suggests that hip height is more strongly related to growth up to a fixed physiological stage than when cattle are slaughtered at a fixed weight. The higher correlation coefficients reported in the Hereford data set for on-test hip height with carcass traits indicated that when a constant final weight of 1150 pounds is the slaughter criteria, taller cattle at the beginning of the feeding period would generally be younger at slaughter, remaining fewer days in the feedlot. Marbling scores and carcass grades would be expected to be lower in taller cattle, since intramuscular fat deposition increases with increasing age. These relationships were not so evident for cattle slaughtered at an estimated low choice carcass grade. However, the Angus cattle were intermediate and the crossbreeds had the lowest relationships between hip height at yearling time and carcass characteristics.

The partial regression coefficients and R^2 values observed for the dependent variables analyzed were generally similar in magnitude in the three data sets. Yearling weight in all three groups generally was the most effective independent variable explaining variation in the traits analyzed. When weaning and yearling weights were held constant, the magnitude and direction of the regression coefficients obtained for hip height measurements were generally similar for growth traits in the three data sets. However, for some carcass traits the direction of the coefficients was different, depending on slaughter criteria. For example, a partial regression coefficient of -2.06 (model 1, Table XIX) was observed for days on feed and on-test hip height in the Hereford data set, while 4.42 (model 4, Table VII) and 2.29 (model 1, Table XIII) were the coefficients for crossbred and Angus cattle, respectively. Larger, negative, partial regression coefficients for single fat thickness on hip height measurements were observed in the Hereford data set; compared to crossbred and Angus cattle the values were: -.0227 (model 1, Table XX), -.0053 (model 4, Table IX), and -.0138 (model 1, Table XV), respectively. The coefficients for fat thickness on height had the same direction as the correlation coefficient (-.19, Table XVI) in the Hereford data set; however, for data sets one and two a different direction was observed between correlation coefficients and regression coefficients for single fat thickness on hip height: r = .04 and .08 for crossbred and Angus cattle, respectively. This indicated that when weight was held constant, height per se was associated with less back fat in all cases. Much of the relationship observed between single fat thickness and yearling hip height was probably due to weight in crossbred and Angus cattle. The relatively large proportion of unexplained variation in the dependent variable indicated that other independent variables would generally be needed to make the prediction equations useful from a practical standpoint. However, the practical applicability of any equation would be inversely proportional to the number of variables needed because of the time, effort, and cost required to obtain them. Results reported in the literature (Lush, 1932; Brown and Shrode, 1971) in which different models including various combinations of independent variables were used suggested that for the most important traits, weight generally explained the majority of variations accounted for by the models. Butts et al. (1980) noticed that when on-test fat thickness was accurately measured, it had an important influence on the R^2 value associated with carcass weight and days on feed. Differences in fat thickness at that stage probably indicated differences in stage of physiological maturity on cattle of different sizes when managed in a similar way.

CHAPTER V

SUMMARY

The objectives of this study were to estimate phenotypic correlation coefficients for hip height measurements with growth performance and carcass traits, and to determine the prediction equations of certain growth and carcass traits with models including height and weight measurements. The data analyzed came from two institutions and three breeding groups.

Data Set One, O.S.U. Crossbred Cattle

A total of 286 three-breed cross calves were produced in the spring of 1980, from the mating of eight crossbred dam groups (Hereford-Angus, Angus-Hereford, Simmental-Hereford, Simmental-Angus, Brown Swiss-Hereford, Brown Swiss-Angus, Jersey-Hereford, and Jersey-Angus) to Charolais and Limousin bulls. Calves remained with their dams on a native range until weaning at an average age of 205 days. Immediately after weaning, calves were placed in the feedlot. Height at the hips was measured twice and averaged for all calves at weaning, yearling, and slaughter times. Each animal was removed from the feedlot and sent to slaughter when an estimated low choice carcass grade was attained. Data on growth, feedlot performance, carcass weight, carcass weight per day, carcass grade, fat thickness, and carcass conformation were collected from each animal to calculate phenotypic correlations with hip height measurements independent of breed of sire, crossbred cow group, and sex of calf. Hip height at yearling time was relatively highly associated with preweaning daily gain, weaning weight, yearling weight, final weight, hot carcass weight, and carcass weight per day of age (r = .45, .53, .57, .53, .43, and .40, respectively).

Moderate, highly significant relationships were observed for yearling hip height with weaning to yearling average daily gain and feedlot average daily gain (r = .35 and .29, respectively). Among carcass traits the closest related to yearling hip height was rib eye area, r = .14 ($P < .05$). Similar trends though generally smaller values with carcass characteristics were observed for hip height measured at weaning time. Low, nonsignificant values were observed for weaning hip height with slaughter age and days on feed (favorable trend, r = -.05), and with carcass grade, dressing percentage, cutability, and marbling score (unfavorable trend, r = -.06, -.04, -.05, and -.08, respectively). Single fat, average fat, and carcass conformation were the least related to hip height measured at weaning time (r = -.02, -.01, and .01, respectively). A same direction but generally lower correlation coefficients than those reported at yearling time were observed for hip height measured at slaughter time with growth traits. However, a different direction and a stronger relationship was found for slaughter height with slaughter age and days on feed (r = .40 and .35 vs. -.04 and -.05 for slaughter and yearling time, respectively). The same pattern was observed for hip height correlation values at slaughter and yearling times with carcass grade, dressing percentage, and marbling score, although the magnitude of the correlations was smaller.

Prediction equations were developed for feedlot average daily gain, final weight, days on feed, hot carcass weight, carcass weight per day of age, rib eye area, and single fat thickness using weaning weight, preweaning daily gain, weaning height, yearling weight, and yearling height as independent variables. Compared to the R^2 values attained using weaning data, the inclusion of yearling traits in the prediction models resulted in large increases in the proportion of total variation in the dependent variables accounted for the models. The largest R^2 values attained at yearling time for each trait were: feedlot average daily gain, .73; slaughter weight, .80; days on feed, .35; hot carcass weight, .72; carcass weight per day of age, .77; rib eye area, .24; and single fat thickness, .20. Yearling weight was found to be the variable accounting for the majority of the variation in most variables analyzed.

Data Set Two, O.S.U. Angus Cattle

Data from 199 straightbred Angus calves, born in the spring of 1980, were analyzed. Management, data collection, and slaughter criteria were similar to those described for Data Set One, O.S.U. Crossbred Cattle; however, hip height was measured only at yearling time. Yearling hip height was strongly associated with weaning weight, yearling weight, weaning to yearling daily gain, feedlot daily gain, final weight, hot carcass weight, and carcass weight per day of age (r = .51, .68, .53, .46, .59, .59, and .62, respectively). Favorable moderate relationships were observed for yearling hip height with slaughter age and days on feed (r = -.32 and -.31, respectively). Lower but significant associations were obtained with dressing percentage, cutability, and rib eye area for which the r values were .23, -.15, and .23, respectively. A low unfavorable nonsignificant trend was observed with carcass grade, marbling score, single fat, and average fat thickness (r = -.07, -.03, .08, and .05, respectively).

Carcass conformation was the least related to yearling hip height ($r = .01$, $P < .92$).

Prediction equations for feedlot average daily gain, final weight, days on feed, hot carcass weight, carcass weight per day of age, rib eye area, and single fat thickness were developed combining weaning height, weaning weight, yearling height, and yearling weight as independent variables. The largest R^2 values obtained were: feedlot average daily gain, .58; final weight, .75; days on feed, .46; hot carcass weight, .52; carcass weight per day of age, .74; rib eye area, .23; and single fat thickness, .08. In general, models including yearling weight as the only independent variable explained almost as much variation as when weaning weight or yearling height were included separately or in combination. Generally when weaning and yearling weight were held constant, the relatively small proportion of total variation accounted for by yearling hip height suggested that most of the relationship observed between hip height and most of the dependent variables was probably due to weight.

Data Set Three, A.H.A. Hereford Cattle

Data from 566 straightbred Hereford calves were analyzed. The data were part of the Total Performance Record Program (TPR) directed by the American Hereford Association. The calves came from ten herds which were considered a representative sample of Hereford cattle with regard to genetic composition and management. From 9 to 70 days after weaning, calves were placed in the feedlot. Cattle were removed from the feedlot when a constant final weight of 1150 pounds was attained. Slaughter criterion was the most important difference in procedures between the Hereford data set (1150 pounds slaughter weight target) and the two O.S.U.

data sets (slaughtered at an estimated low choice carcass grade). Hip height was recorded for each calf at the beginning of the feeding period, at an average age of 280 days. Data on growth, feedlot performance, slaughter age, fat thickness, cutability, and marbling score were collected from each animal to calculate phenotypic correlations with on-test hip height independent of sex of calf, age of dam, and location. The strongest relationships for on-test hip height observed were .66, .56, -.52, -.51, and .55 with weaning weight, yearling weight, slaughter age, days on feed, and weight per day of age, respectively. Lower but significant coefficients were observed with weaning to yearling daily gain, feedlot daily gain, final weight, fat thickness, cutability, and marbling score (r = .19, .18, .25, -.19, .16, and -.17, respectively). At a constant final weight of 1150 pounds, taller on-test cattle generally had the more favorable growth, performance, and carcass associations.

Weaning weight, yearling weight, and on-test hip height were used as independent variables to predict feedlot daily gain, weight per day of age, days on feed, fat thickness, and cutability. The R^2 values obtained with the three independent variables in the model were: feedlot daily gain, .24; weight per day, .69; days on feed, .73; fat thickness, .12; and cutability, .13. The majority of the variations accounted for in feedlot daily gain, days on feed, and weight per day of age was explained by yearling weight. On-test hip height was the independent variable explaining the largest proportion of the R^2 values observed for fat thickness and cutability.

General Discussion

Overall, comparing the relationships for hip height measurements with growth, performance, and carcass traits observed for yearling hip height in O.S.U. Crossbred cattle with those reported for the O.S.U. Angus and A.H.A. Hereford cattle, the associations were similar with weight traits. Closer associations between hip height and daily gains were observed in the O.S.U. Crossbred and Angus cattle slaughtered at a constant carcass grade than in the A.H.A. Hereford cattle slaughtered at a constant 1150 pounds. The A.H.A. Hereford cattle had stronger relationships for hip height with slaughter age, days on feed, and carcass traits than O.S.U. Crossbred and Angus cattle. The magnitude of the values observed for Angus cattle generally tended to be intermediate between those observed for the A.H.A. Hereford and O.S.U. Crossbred cattle.

For some carcass traits, the directions of the regression coefficients were dependent on slaughter criteria. When weight was held constant the relationship between hip height and the variables studied was very much reduced, as indicated by the small proportion of variation accounted for by hip height measurements. The proportion of total variation accounted for in the dependent variables was increased by adding yearling traits to the model. Yearling weight in all three data sets explained most of the variations in the traits analyzed. The relatively small proportion of total variation in the dependent variables studied explained by hip height measurements suggested that little improvement will be attained by including hip height measurements in prediction models where weight measurements can be utilized.

In conclusion, a distinction for slaughter criteria, stage of physiological maturity when measurements are taken, and any other possible source of variation should be made when comparing correlation coefficients of hip height measurements with growth and carcass traits. When cattle are slaughtered at a constant final weight, the association between height measurements and traits analyzed will vary for cattle of different sizes depending on the magnitude of the final weight specified. For example, in cattle slaughtered at a relatively lighter weight, taller on-test cattle would generally have unfavorable associations with carcass traits, while similar associations would be expected with growth and performance characteristics. On the other hand, when a heavier final weight is specified, taller cattle would generally have favorable relationships with growth, performance on feedlot, and carcass traits, with the possible exception of marbling score and consequently carcass grade.

For cattle slaughtered at a constant degree of finish, the phenotypic correlations for hip height with weight and daily gain traits will generally be positive and relatively high. Generally negative and lower relations than those observed for weight and daily gain traits would be expected for height with slaughter age and length of feeding period. Among all traits studied, the association between height and carcass traits for cattle slaughtered at similar degree of finish should be expected to be the lowest. Among carcass traits, those related to weight (hot carcass weight, carcass weight per day of age) generally will be the most closely related to height measurements.

Taller cattle will generally be heavier at all stages. The relationships between hip height and weight traits were generally strong and positive. The associations of hip height with daily gain, length of feeding period, age at slaughter, and most carcass traits will depend on slaughter criteria. Cattle slaughtered at a similar degree of finish will have closer associations of hip height with daily gain, while cattle slaughtered at a constant weight will generally have stronger relationships with feeding period, slaughter age, and carcass traits.

Cattle with different frames may be equally profitable from the physiological standpoint if slaughtered at proper times. From the economical standpoint, profitability will depend on the general condition which may vary on different locations and which tend to change from time to time, such as market demands and packing industry. Not less important economically are the type, whether grain or forage, and cost of feed available to finish cattle; these two variables are much influenced by supply and by competition of other livestock species. Finally, consumer preference has to be considered, since the beef industry has to adjust production to the quality of retail cuts according to the actual demand.

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APPENDIX

TABLE XXI

CALCULATING ADJUSTED 205-DAY WEIGHTS (A.H.A.)

$$\text{205-day adj. wt} = \frac{\text{Weaning wt - BW*}}{\text{Age in days}} \times 205 + \text{Age of calf adj.**} + \text{Birth wt*} + \text{Age of dam factor***}$$

* Standard Birth Weights

If actual not reported:	Bull calves	= 75 lbs.
	Heifer calves	= 70 lbs.

** Age of Calf Adjustment:	Add
Below 231 days =	0
231 through 240 days	1.5%
241 through 250 days	2.5%
251 through 270 days	4.0%
271 through 280 days	5.0%
Above 280 days	6.0%

*** Age of Dam Adjustment	lbs. added to wean. wt.
Up to 2 years, 3 months	52
2 years, 3 months to 3 years	35
3 years to 3 years, 11 months	23
3 years, 11 months to 4 years, 11 months	9
4 years, 11 months to 12 years	0
Over 12 years	12

TABLE XXII

MEAN SQUARES FOR GROWTH, HEIGHT, AND CARCASS TRAITS: DATA SET ONE, O.S.U. CROSSBRED CATTLE

Source	df	205-day Weaning wt (lb)	Pre-Weaning ADG (lb/day)	365-day Yearling wt (lb)	Weaning to Yearling ADG (lb/day)	Final Weight (lbs)	Feedlot ADG (lb/day)
Sirebreed of Calf (s)	1	33429.99**	40.15**	41716.59**	164.82	106139.04**	.53+
Crossbred Dam Group (c)	3	45016.98**	80.74**	128310.52**	12630.12**	382815.50**	.67**
Sex of Calf (sex)	1	100403.97**	158.36**	888492.51**	153100.76**	1858480.16**	16.28**
S x C	3	2168.49	6.05	4390.21	435.01	11514.40	.08
S x Sex	1	111.24	1.244	6116.30	3198.88	647.90	.18
C x Sex	3	75.82	.18	6726.50	6401.94	33029.63	.31
Error	249	2282.00	4.84	6634.62	1413.23	9546.63	.16

TABLE XXII (Continued)

Source	df	205-day Weaning Height (in)	365-day Yearling Height (in)	Slaughter Height (in)	Weaning To Yearling Daily Growth (in/day)	Weaning To Slaughter Daily Growth (in/day)
Sirebreed of Calf (s)	1	.56	4.76	2.17	.00042**	.00016**
Crossbred Dam Group (c)	3	51.48**	72.72**	75.80**	.00026**	.00005+
Sex of Calf (sex)	1	106.09**	185.22**	217.58**	.00055**	.00037**
S x C	3	1.58	2.32	0.91	.00003	.00003
S x Sex	1	1.28	0.00	0.79	.00008	.00013*
C x Sex	3	3.10	5.77*	6.33+	.00002	.00003
Error	249	1.78	2.14	2.83	.00004	.00002

TABLE XXII (Continued)

Source	df	Slaughter Age (days)	Days On Feed (days)	Hot Carcass Weight (lbs)	Carcass Weight Per Day Age (lbs/day)	Cutability (%)	Dressing (%)	Rib Eye Area (sq in)	Marbling Score[1]	Carcass Grade[2]	Single Fat Thickness (in)	Average Fat Thickness (in)	Carcass Conformation[3]
Sirebreed of Calf (s)	1	669.60	4538.00*	16990.90+	0.00	15.60*	.0049**	5.78	0.00	0.27	0.24**	0.20*	1.70
Crossbred Dam Group (c)	3	12407.51**	16345.12**	194036.86**	0.63**	3.94	.0016+	23.94**	0.06	0.31	0.21**	0.07+	5.86**
Sex of Calf (sex)	1	2.93	589.05	709165.62**	3.37**	128.52**	.0006	1.02	4.09**	10.76**	0.29**	0.38**	20.53**
S x C	3	1068.93	1262.42	5344.54	0.02	1.63	.0007	0.77	0.32	1.72	0.01	0.03	1.86
S x Sex	1	300.42	496.62	3747.45	0.04	8.38+	.0021+	0.19	0.95	0.27	0.06	0.06	0.01
C x Sex	3	1777.31	1848.16+	4307.54	0.04	3.41	.0002	2.67	0.22	0.13	0.03	0.04	1.82
Error	249	1252.78	869.41	5355.27	0.03	2.80	.0007	2.26	0.56	1.12	0.03	0.03	1.54

+ P < .10, *P < .05, **P < .01.

[1] Marbling Score Equivalents: 4 = Slight, 5 = Small, and 6 = Modest.

[2] Carcass Grade and Conformation Equivalents: 9 = High Good, 10 = Low Choice and 11 = Average Choice.

TABLE XXIII

ADDITIVE ADJUSTMENTS TO PREDICT FEEDLOT DAILY GAIN

	Models								
	Weaning				Yearling				
	1	2	3	4	5	6	7	8	9
Intercept	1.947	1.369	1.715	2.118	-.003	-.023	1.657	-.224	0.140
Breed of Sire[1]					+	+		+	+
CH	0.008	0.065	0.012	0.055	0.064	0.063	-.005	0.087	0.059
LIM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crossbred Dam Group[2]		+		+					
AH	0.019	0.132	0.024	0.122	0.002	0.031	0.063	0.126	0.024
SX	0.033	0.159	0.033	0.163	-.086	-.056	0.051	0.069	-.063
BX	0.022	0.100	0.020	0.109	-.055	-.025	-.040	0.032	-.026
JX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sex of Calf	**	**	**	**	*	*	**	**	*
Steers	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Heifers	-.437	-.464	-.434	-.475	-.078	-.081	-.140	-.380	-.087

+ P < .10, *P < .05, **P < .01.

[1] CH = Charolais; LIM = Limousin.

[2] AH = Hereford Angus reciprocal crosses; S = Simmental, G = Brown Swiss; J = Jersey; X = Hereford and Angus crosses combined.

TABLE XXIV

ADDITIVE ADJUSTMENTS TO PREDICT FINAL WEIGHT

	Models							
	Weaning				Yearling			
	1	2	3	4	5	6	7	8
Intercept	234.86	153.18	576.46	642.94	-241.58	-192.85	-179.19	329.26
Breed of Sire[1]		*			**	**	**	*
CH	15.63	23.63	10.16	17.29	25.75	23.99	25.09	18.70
LIM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crossbred[2] Dam Group	**	**	**	**	**	**	**	**
AH	65.59	81.55	58.58	74.69	66.37	67.21	65.31	57.77
SX	124.56	142.45	123.64	145.06	102.29	102.42	101.46	108.27
BX	47.14	58.26	49.25	63.87	33.27	32.87	33.17	42.43
JX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sex of Calf	**	**	**	**	**	**	**	**
Steers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heifers	-122.30	-126.14	-126.58	-133.35	-62.50	-64.04	-63.44	-70.02

+ P < .10, *P < .05, **P < .01.

[1] CH = Charolais, LIM = Limousin.

[2] AH = Hereford Angus reciprocal crosses; S = Simmental, B = Brown Swiss, J = Jersey; X = Hereford and Angus crosses combined.

TABLE XXV

ADDITIVE ADJUSTMENTS TO PREDICT DAYS ON FEED

	Models				
	Weaning		Yearling		
	1	2	3	4	5
Intercept	173.444	181.694	197.850	199.361	374.464
Breed of Sire[1]					
CH	-2.241	-3.049	-2.420	-2.271	-4.225
LIM	0.000	0.000	0.000	0.000	0.000
Crossbred Dam Group[2]	**	**	**	**	**
AH	23.846	22.233	25.653	25.407	22.476
SX	44.088	42.281	47.604	47.481	49.741
BX	25.171	24.048	26.726	26.767	30.075
JX	0.000	0.000	0.000	0.000	0.000
Sex of Calf	+		**	**	**
Steers	0.000	0.000	0.000	0.000	0.000
Heifers	-6.692	-6.304	-17.691	-17.608	-19.704

+ $P < .10$, *$P < .05$, **$P < .01$.

[1] CH = Charolais, LIM = Limousin.

[2] AH = Hereford Angus reciprocal crosses; S = Simmental, B = Brown Swiss, J = Jersey, X = Hereford and Angus crosses combined.

TABLE XXVI

ADDITIVE ADJUSTMENTS TO PREDICT RIB EYE AREA

	Models				
	Weaning			Yearling	
	1	2	3	4	5
Intercept	12.160	7.273	8.402	10.250	8.440
Breed of Sire[1]					
CH	-.024	0.054	0.175	0.014	0.154
LIM	0.000	0.000	0.000	0.000	0.000
Crossbred Dam Group[2]	**	**	**	*	**
AH	0.434	0.535	0.808	0.425	0.682
SX	0.925	0.938	1.302	0.820	1.083
BX	0.312	0.282	0.530	0.249	0.415
JX	0.000	0.000	0.000	0.000	0.000
Sex of Calf	*	*	+	**	**
Steers	0.000	0.000	0.000	0.000	0.000
Heifers	0.421	0.482	0.367	0.695	0.726

+ P < .10, *P < .05, **P < .01.

[1] CH = Charolais, LIM = Limousin.

[2] AH = Hereford Angus reciprocal crosses; S = Simmental, B = Brown Swiss; J = Jersey; X = Hereford and Angus crosses combined.

TABLE XXVII

ADDITIVE ADJUSTMENTS TO PREDICT SINGLE FAT THICKNESS

	Models					
	Weaning			Yearling		
	1	2	3	4	5	6
Intercept	0.6605	0.6459	0.6004	0.4194	0.3037	0.1821
Breed of Sire[1]	**	**	**	**	**	**
CH	-.0621	-.0606	-.0600	-.0611	-.0594	-.0725
LIM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Crossbred Dam Group[2]	**	**	**	**	**	**
AH	0.1070	0.1099	0.1105	0.0946	0.0959	0.1173
SX	-.0123	-.0091	-.0093	-.0409	-.0433	-.0399
BX	0.0303	0.0323	0.0317	0.0140	0.0114	0.0021
JX	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sex of Calf	**	**	**			
Steers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Heifers	-.0773	-.0780	-.0774	-.0207	-.0191	-.0274

+ $P < .10$, *$P < .05$, **$P < .01$.

[1] CH = Charolais, LIM = Limousin.

[2] AH = Hereford Angus reciprocal crosses; S = Simmental, B = Brown Swiss; J = Jersey; X = Hereford and Angus crosses combined.

TABLE XXVIII

MEAN SQUARES FOR YEARLING HEIGHT, GROWTH, AND CARCASS TRAITS: DATA SET TWO, O.S.U. ANGUS CATTLE

Source	df	205-day[a] Weaning Weight (lbs)	365-day[a] Yearling Weight (lbs)	365-day Yearling Height (in)	Weaning to Yearling ADG (lb/day)	Feedlot ADG (lb/day)	Final Weight (lbs)	Days on Feed (days)
Sex of Calf (s)	1	17053.14**	183462.50**	42.87**	3.47**	1.31**	248881.94**	2051.19*
Age of Dam (A)	3	529.33[a]	5610.94[a]	4.16	0.22	0.28+	24428.00**	1549.50*
SXA	3	8589.39**	9384.16	3.03	0.08	0.25+	14448.80*	619.01
Error	177	2045.22	6202.69	2.19	0.13	0.12	4788.62	443.94

TABLE XXVIII (Continued)

Source	df	Age at Slaughter (days)	Hot Carcass Weight (lbs)	Carcass Weight Per Day of Age (lb/day)	Carcass Grade[1]	Dressing Percent (%)	Cutability (%)	Rib Eye Area (sq in)	Marbling Score[2]	Single Fat Thickness (in)	Average Fat Thickness (in)	Carcass Conformation[3]
Sex of Calf (s)	1	2113.00**	114540.91**	0.40**	0.04	0.00	12.95*	1.92	0.05	0.07	0.01	0.93
Age of Dam (A)	3	1387.39*	12645.49**	0.93**	0.92	0.00	4.50	0.82	1.30*	0.07	0.05	1.27
SXA	3	1033.83	6697.28+	0.06*	0.53	0.00	3.82	0.85	0.48	0.09+	0.05	0.38
Error	177	502.34	2720.01	0.02	0.87	0.00	2.73	1.12	0.47	0.04	0.04	1.08

+ P < .10; *P < .05; **P < .01.

[1,3] Carcass grade and conformation equivalents: 9 = High Good, 10 = Low Choice, 11 = Average Choice.

[2] Marbling score equivalents: 4 = Slight, 5 = Small, 6 = Modest.

TABLE XXIX

MEAN SQUARES FOR ON-TEST HIP HEIGHT, GROWTH, AND CARCASS TRAITS: DATA SET THREE, A.H.A. HEREFORD CATTLE

Source	df	205-day[a] Weaning Weight (lbs)	365-day[a] Yearling Weight (lbs)	On Test Height (in)	Weaning to Yearling ADG (lb/day)	Feedlot ADG (lb/day)	Final Weight (lbs)	Days On Feed (days)
Sex of Calf(s)	1	20938.63**	300326.18**	1.90	6.35**	1.13**	16486.61**	40.27
Age of Dam(D.)	3	10709.77**	38950.43**	1.08	0.37*	0.01	3376.98	1293.34
Location	9	83195.77**	159190.76**	26.49**	4.45**	0.24**	27069.75**	26542.63**
SXD	3	1064.95	11638.78+	1.64	0.40*	0.42**	26824.70**	242.98
Error	506	2155.82	5594.03	1.92	0.12	0.01	3011.46	816.52

[a] Traits previously adjusted for age of dam.

+ P < .10; *P < .05; **P < .01.

TABLE XXIX (Continued)

Source	df	Age At Slaughter (days)	Weight Per Day of Age (lbs/day)	Fat Thickness (in)	Cutability (%)	Marbling Score
Sex of Calf(s)	1	8.30	0.65**	0.04	0.63	0.04
Age of Dam (D)	3	1305.21	0.01	0.01	0.85	0.37
Location	9	32070.38**	0.58**	0.12**	10.13**	3.53**
SXD	3	42.63	0.10*	0.03	1.20	0.10
Error	506	897.64	0.03	0.03	2.04	0.45

+ P < .10; *P < .05; **P < .01.

VITA

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Master of Science

Thesis: RELATIONSHIPS OF HIP HEIGHT MEASUREMENTS WITH GROWTH AND CARCASS TRAITS OF THREE-BREED CROSS, STRAIGHTBRED ANGUS, AND STRAIGHTBRED HEREFORD CALVES

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