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The Relationship Between Linear Measurements & Subjective Placings in Elite Angus Cattle

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THE RELATIONSHIP BETWEEN LINEAR MEASUREMENTS AND SUBJECTIVE PLACINGS IN ELITE ANGUS CATTLE

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THE RELATIONSHIP BETWEEN LINEAR MEASUREMENTS

AND SUBJECTIVE PLACINGS IN ELITE ANGUS CATTLE

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AND SUBJECTIVE PLACINGS IN ELITE ANGUS CATTLE

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The cattle shown from 1981 to 1984 at the American Angus Breeders' Futurity were studied to determine the relationship between linear measurements and the judge's subjective placings. Linear measurements taken prior to the showing included wither height, hip height, and body length for both bulls and heifers. In addition body weight and scrotal circumference were recorded for bulls. A total of 624 cattle were studied--407 heifers and 217 bulls.

The cattle were divided into five groups by age and sex to analyze the annual difference in means and standard deviations for all recorded measurements. Among all five groups of cattle, hip height increased at the fastest rate from 1981 to 1984. All measurements had a positive increase except body weight and scrotal circumference. The older bulls decreased by 61.67 lbs. in weight from 1981 to 1984 and decreased by 1.78 in. in scrotal circumference between 1983 and 1984.

Coefficients of correlation were obtained using the recorded measurements along with age for all five groups. Wither height showed the closest association to other measurements. Among all five groups body length had the most inconsistent association to other measurements, primarily due to difficulty involved in obtaining an accurate body length measurement.

Spearman's coefficient of rank correlation was conducted to determine which measurements the judges were giving most emphasis in the showring. It seems apparent that judges are continuing to select for larger framed

cattle, placing greater emphasis on wither and hip height measurements and lesser emphasis on body weight and scrotal circumference. The findings in this study support the fact that judges are selecting for larger framed, later maturing cattle with little if any selection being placed upon present weight or indicators of future reproductive performance.

CHAPTER I

INTRODUCTION

During the past fifteen years, very few topics related to beef production have generated as much discussion and controversy as cattle size. Several questions have troubled cattlemen and researchers in recent years as emphasis has continued to be placed on frame size in purebred breeding programs. There has been dramatic increase in the selection for larger framed, later maturing cattle. Cattlemen have been encouraged to select for larger framed cattle because of the showring. Many researchers are concerned that frame size may be negatively associated with reproductive efficiency. Further concern is that larger framed cattle have greater body maintenance requirements, and feedlot cattle may need to be finished to weights greater than those desired by most packers in order to yield acceptable quality carcasses.

Measurements of certain body size parameters including shoulder height, hip height, and body length have been of vital importance in recent years in cattle breeding. In the past two decades, these linear measurements have been used extensively as a selection tool to improve particular body size parameters. Since the heritabilities of most linear measures of frame size in cattle are high, marked increases in frame size have been noted among elite purebred cattle of most breeds. Furthermore, most researchers agree that the elite purebred cattle of the 1950's and 60's were much too early maturing and that selection for larger framed cattle resulted in later maturing cattle with less predisposition to fatness at younger ages and lighter weights. Of recent concern is the possibility that selection for increased frame size may have exceeded a practical level in many elite purebred herds.

The major purpose of this study was to determine whether cattle judges have been placing highest priority on linear measurements. Data collected from 624 elite Angus cattle shown during the past four years at the American Angus Breeders' Futurity were analyzed to determine the criteria that judges have used in showring placings. A further purpose was to determine whether judges were consistent in emphasizing larger framed cattle or whether there was a tendency to ignore frame size and place more emphasis on body composition and structural soundness.

CHAPTER II

LITERATURE REVIEW

Growth has been defined as a "phenomenon of change in size, weight, shape, composition, and structure" (Fuller, 1969); but it is normally thought of as an increase in size and weight. As more selection emphasis is being placed on size in purebred and crossbred cattle breeding programs, animal breeders and researchers are becoming more concerned. Berg and Butterfield (1976) suggest "there is no limit to how much we can change shape by selection if we so desire." An explanation of the rapid increase in size, primarily frame size, over the past two decades may be obtained by reviewing studies involving linear measurements and body weights in beef cattle.

Linear Measurements--Birth. The value of linear measurements at birth, as a predictor of the future performance and size of beef calves, is not yet clearly defined. However, due to rapid increases in weight and constant changes in size and shape mass selection is unlikely to be practiced among beef calves prior to weaning. Bernerd and Hidiroglou (1968) studied 254 calves and found that body measurements taken at birth, weaning, and one year of age showed significant differences between sexes. Male calves had consistently larger measurements than female calves in wither height and body depth. Males also exceeded females in heart girth and length of body at birth and weaning, but the difference decreased with age, becoming almost nil at one year. They also reported that calves from two- and three-year old cows had generally smaller measurements than those from older cows. In a similar previous study involving linear body measurements of beef calves, Flock et al. (1962) also reported differences in both weight and height between bulls and heifers. They concluded that birth weight was a better predictor of average daily gain during the preweaning period than any of the linear measurements taken at birth--indicating that calves heavier at birth gain, on the average, slightly better than lighter calves. In agreement, Nelsen and Kress (1979) reported that estimated genetic correlations--between birth weight and preweaning average daily gain, birth weight and weaning weight, and birth weight and postweaning average daily gain--were all in the moderate to high range (.37 to .74). Thus, birth weights may be a better predictor of future performance than linear body measurements. Furthermore, linear body measurements taken at birth may not be recommended as selection criteria to improve prediction of weaning performance.

Linear Measurements--Weaning. Beef producers have used linear measurements and body weights, taken at weaning, extensively as a means of selection for heavier, larger framed animals. However, their use as a measure of performance in beef cattle has not been established. Using 318 Hereford and 516 Angus cows and their progeny, McCurley and McLaren (1981) studied the relationship of linear body measurements, weight, age, and fatness to size and performance in beef cattle. By using a stepwise multiple regression analysis they indicated that calf fat thickness and cow weight had the most important effects on calf 205-day weaning weight. They reported that calf weaning weight increased by 7.35 kg. with each additional millimeter of fat thickness. McCurley and McLaren (1981) also reported that calf fat thickness and cow wither height had the greatest effects on calf wither height.

Brown et al. (1973) studied the relationship between nine skeletal measurements and body weight recorded on 550 Hereford and Angus bulls at 4, 8, and 12 months of age. They reported that Angus bulls with heavier weaning weights tended to be significantly larger framed; those bulls which were short in stature and body tended to be lighter in weight but wider through the shoulder, hip, and loin. They also noted that weight increased at a faster rate, than the nine body measurements, between four- and eight-month-old Angus bulls. Weight was followed by circumference at heart girth, body length, height at withers, height at hips, depth of body at foregirth, depth of body at rear flank, width at pelvic bones, width at the point of shoulders, and width at loin increasing at the slowest rate. However, Brown et al. (1973) also showed that bulls, selected at a particular age, could be quite different in shape at later ages. Thus selection on the basis of weight at young ages may yield bulls which differ in shape at older ages.

Linear measurements--Yearling. Several factors suggest that linear measurements taken around one year of age may be more advantageous than those taken at birth and weaning. During the post-weaning period animal growth may be influenced by several environmental factors including level of nutrition, general health, and weather conditions. These environmental factors can be minimized by grouping animals of similar age and sex into contemporary groups which can be managed uniformly. However, these environmental conditions will have a greater affect on weight than on linear measurements, suggesting that animals may be more accurately ranked on the basis of linear measurements than on body weight at one year of age (Brody, 1945).

In a study involving measures of size, condition, and growth in bulls, Long et al. (1979) noted that weight to height ratios increased with age indicating increasing maturity. Beginning at birth, cattle have attained a higher proportion of mature height than of mature weight, until both measures have reached mature values; therefore, weight has a slower maturing character than height (Brody, 1945). Black et al. (1938) showed that wither height was a more reliable source of information regarding true genetic growth rate than was weight, when he concluded that the ratio of weight to wither height gave the highest correlation with performance. These observations suggest that linear measurements, taken around one year of age, along with performance data may assist animal breeders in selecting potential seedstock.

Linear Measurements--Maturity. Mature size has been defined by Taylor and Fitzhugh (1971) as the final size eventually reached for traits which seldom show negative growth. They studied the relationship between mature weight and time taken to reach maturity. They also noted that the genetic correlations between time taken to mature and mature weight was 0.34, 0.41, 0.39, and 0.39 at birth, six, twelve, and eighteen months of age. For the average time taken to mature the genetic correlation was 0.48, an indication that animals genetically heavier at maturity tended to take a longer time to mature in body weight. In agreement, Brown et al. (1972), in a study of maturity patterns of Hereford and Angus cattle, indicated that selection for early maturity would lead to smaller mature weights. Furthermore, the genes contributing to an increased rate of maturity were conclusively associated with lighter weights at all ages.

Brown and Shrode (1971) indicated that as an animal grows toward maturity, the hip height gradually decreases relative to the wither height but the hip height usually remains slightly greater at maturity. Therefore linear measurements may be used as a means of predicting maturity.

In his study evaluating body size parameters in elite Angus cattle, Stone (1978) noted that the coefficients of correlation between wither height and weight were higher than correlations among other body measurements. In heifers, the coefficient of correlation between wither height and weight was 0.75. The bulls showed a slightly higher correlation between wither height and weight with a coefficient of 0.88 for twelve- to twenty-month old bulls and a coefficient of 0.80 for twenty- to thirty-month old bulls, respectively. Brody (1945) concluded that weight and age alone cannot be used to effectively represent the genetic potential of an individual for growth, and that of all linear measurements possible, wither height was the best measure of true genetic size.

Researchers and animal breeders are still not sure of the ideal size or type of cattle to fit all production situations. However, Berg and Butterfield (1976) suggested that until we are more aware of the problems, as well as the alleged advantages which go along with any change in size or shape, we would do well to use animal performance as an indicator of functionally efficient size and shape.

CHAPTER III

MATERIALS AND METHODS

The data used for the present study were collected at the prestigious American Angus Breeders' Futurity in Louisville, Kentucky. The Angus Futurity was established in 1948 as an event that would feature the judging and selection of America's best Angus cattle. The animals used in this study represent the top individuals from several herds, therefore making an excellent group of elite individuals to evaluate.

The data were collected from 1981 through 1984. Of the 624 individuals studied, 407 were heifers and 217 were bulls. The Futurity is held the first week of August each year at the Kentucky Fair and Exposition Center in Louisville, Kentucky. All linear measurements were taken on the Saturday prior to the show on the following Monday and Tuesday. All females were measured for height at the withers and hip and for body length, from the withers to the tail. Bulls were measured for wither height, hip height, body length, and circumference of scrotum. Scrotal circumference measurements have been taken for only the past two years, 1983 and 1984. Body weights were also measured on all bulls just prior to entering the showring on the day of the show.

All linear measurements were taken by the same individuals in each of the four years. The wither and hip height measurements were taken in a measuring chute designed by Pete Sweeney at Michigan State University. The same chute was used for all four years. It consisted of a horizontal crossbar which is lowered and raised by pulleys. The horizontal crossbar is lowered along a vertical, calibrated measuring rule, which is used to measure the height to the nearest one fourth of an inch. This device is portable so that it can move from the front to the rear of the animal where both wither and hip measurements can be obtained. The horizontal crossbar is lowered directly over the vertebra, the highest point of the shoulder, until the crossbar is level. The measurement is then recorded to the nearest one fourth of an inch. Hip height measurements were recorded by placing the horizontal crossbar over the highest point between the hooks. The crossbar was lowered until level, then the measurement was taken. The body length measurement was taken with a flexible steel tape calibrated in one quarter inch intervals. This measurement was taken from the midpoint of the top of the shoulder to a line connecting the prominences of the pins.

In the years 1983 and 1984, scrotal circumference was taken on all bulls. The measurements were taken by using a flexible steel scrotal circumference tape calibrated in centimeters. The tape was placed around the scrotum, at the greatest diameter, then measured to the nearest one hundredth of a centimeter.

For all primary statistical analysis, the animals in the study were divided in five groups. Group I consisted of all bulls up to 12 months of age. Despite the wide range of variation in this group, it was still needed to study the changes over the past four years. Group II consisted of all bulls from 12 months to 20 months of age and represented the largest number, totaling 115 head. Group III was composed of all bulls from 20 months to 30 months of age. The heifers were divided into only two age groups. Group IV consisted of all heifers up to 12 months of age, and Group V consisted of all heifers from 12 months to 20 months of age.

Statistical analyses included obtaining coefficients of correlation and conducting analysis of variance as outlined by Steel and Torrie (1980). Coefficients of correlation were obtained using the recorded measurements along with age for all five groups. An analysis of variance was conducted to determine differences between years, age groups, sexes, and their interactions.

Using Spearman's coefficient of rank correlation, as described by Steel and Torrie (1980), a final analysis was conducted to determine which traits the judges were emphasizing most in the showring. This procedure applies to data in the form of ranks. The linear measurements and weights obtained were ranked within each judging class. This value was then paired with the judge's showring placing. The Spearman's coefficient of rank correlation was calculated by the formula $r_s = 1 - \frac{6 \sum di^2}{(n-1)\ n\ (n+1)}$, where di equals the difference between measurement or weight rank and judge's placings and n equals the number of animals in the judging class.

This coefficient of rank correlation value was then weighted for each judging class to remove variation due to class size differences. The derived formula, weighted correlation = $\frac{\sum (r_s \times n)}{\text{Total Number Animals}}$, where r_s equals the Spearman's coefficient of rank correlation and n equals the number of animals in the judging class, was used. The formula provides a correlation value which explains the degree of association between the judges' placing and the rank for recorded measurements.

CHAPTER IV

RESULTS AND DISCUSSION

General Analysis. The means and standard deviations for all measurements are presented in Tables 1, 2, 3, 4 and 5. The groups included a wide range of variation in age; therefore the means did not adequately describe animals of a particular age. However, animals were grouped by age to describe the degree of annual change among means and standard deviations over the past four years.

A comparison of measurements taken over the past four years indicated that the cattle are continuing to increase in frame size. Brown and Shrode (1971) showed that as an animal grows toward maturity, the difference between the wither height and hip height became relatively small with hip height being slightly greater at maturity. The comparison of wither height and hip height in Tables 1, 2, 3, 4, and 5 showed an increasing difference between wither height and hip height between 1981 and 1984. Therefore, based upon the conclusion of Brown and Shrode (1971), the cattle in this study appeared to become later maturing from 1981 to 1984. The Group III bulls in 1981 (Table 3) showed only .30 in. difference between wither height and hip height indicating that these bulls had reached maturity. However, the bulls in 1984 were 2.01 in. taller at the hip than at the withers indicating that these bulls were still growing and had not reached maturity.

When comparing means between sexes, it is significant that bulls are larger framed. In 1984 Group II bulls (Table 2) were 2.24 in. taller

Table 1. Annual means and standard deviations for all measurements in Group I (bulls up to 12 months of age).

	1981		1982		1983		1984	
Measurement	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
No.	20		16		15		17	
WH[a]	45.78	4.70	46.02	3.03	47.03	2.51	47.91	2.99
HH[b]	47.21	4.56	48.23	3.20	49.65	2.96	50.57	3.43
BL[c]	45.29	6.02	46.78	4.14	44.20	4.23	45.94	5.10
BW[d]	795	263	756	190	839	156	831	204

[a]WH, wither height, inches

[b]HH, hip height, inches

[c]BL, body length, inches

[d]BW, body weight, pounds

Table 2. Annual means and standard deviations for all measurements in Group II (bulls from 12 to 20 months of age).

	1981		1982		1983		1984	
Measurement	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
No.	23		31		30		31	
WH[a]	53.22	1.39	53.48	1.06	53.09	1.59	54.06	1.75
HH[b]	54.65	1.34	55.49	1.15	55.60	1.80	56.80	1.85
BL[c]	54.04	2.20	56.35	2.18	52.85	2.28	54.64	3.12
BW[d]	1403	124	1404	133	1349	142	1380	148
SC[e]					39.18	2.31	37.98	2.29

[a]WH, wither height, inches

[b]HH, hip height, inches

[c]BL, body length, inches

[d]BW, body weight, pounds

[e]SC, scrotal circumference, centimeters

Table 3. Annual means and standard deviations for all measurements in Group III (bulls from 20 to 30 months of age).

Measurement	1981		1982		1983		1984	
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
No.	9		7		9		9	
WH[a]	58.28	1.03	58.61	1.56	57.86	2.17	58.22	1.74
HH[b]	58.58	0.99	59.57	1.80	59.75	1.91	60.53	1.11
BL[c]	61.31	1.83	62.93	2.09	60.31	2.53	61.58	2.28
BW[d]	2069	122	2031	95	1987	272	2008	193
SC[e]					42.17	2.05	40.39	1.71

[a]WH, wither height, inches

[b]HH, hip height, inches

[c]BL, body length, inches

[d]BW, body weight, pounds

[e]SC, scrotal circumference, centimeters

Table 4. Annual means and standard deviations for all measurements in Group IV (heifers up to 12 months of age).

Measurement	1981		1982		1983		1984	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
No.	36		37		36		27	
WH[a]	44.43	3.83	44.53	2.47	45.61	2.04	45.89	2.87
HH[b]	46.40	3.68	46.77	2.61	48.15	2.43	48.74	2.88
BL[c]	43.37	4.58	44.72	3.51	43.91	2.92	44.31	3.74

[a] WH, wither height, inches

[b] HH, hip height, inches

[c] BL, body length, inches

Table 5. Annual means and standard deviations for all measurements in Group V (heifers from 12 to 20 months of age).

	1981		1982		1983		1984	
Measurement	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
No.	77		73		67		54	
WH[a]	49.83	1.08	50.22	1.06	50.44	1.78	51.49	1.32
HH[b]	51.80	1.63	52.37	1.11	53.07	1.80	54.56	1.37
BL[c]	50.26	1.95	51.97	1.81	50.15	2.25	51.50	2.18

[a]WH, wither height, inches

[b]HH, hip height, inches

[c]BL, body length, inches

at the hip than heifers of comparable age (Table 5). This comparison agrees with that of Bernerd and Hidiroglou (1968) and Flock et al. (1962), who concluded that bulls had consistently larger measurements than heifers of similar ages.

The means for the growth parameters presented in Table 1 indicated that cattle have become larger, but the standard deviations also indicated that considerable variation was present in the population. The Group I bulls measured in 1981 showed the greatest amount of variation in wither height, hip height, body length, and body weight as compared to Group I bulls in more recent years. However, the amount of variation in 1981 for the Group II and Group III bulls, shown in Tables 2 and 3, was lower than 1984. This decrease indicates that the Group II and Group III bulls have as much or more genetic variation for wither height, hip height, body length, and body weight today as compared to previous years. However, the Group I bulls (Table 1) exhibited less variability in 1984, indicating that in the future variation in these measurements may be less. However, since this study involves show animals, a conclusive result that we are losing genetic variability cannot be supported since most breeders are bringing only the larger framed cattle to the show.

The change in annual means for all measurements over the past four years is expressed in Table 6. Hip height has increased at the fastest rate over the past four years among all five groups. Bulls in Group I have increased at the fastest rate in both hip and wither height, an indication that these bulls will continually become larger framed as they reach maturity. All cattle have increased in wither height, hip height, and body length with one exception--bulls in Group III have not shown an increase in wither height. Thus, wither height may remain

Table 6. Change in annual means for all measurements over the past four years.

Measurement	Group I Bulls	Group II Bulls	Group III Bulls	Group IV Heifers	Group V Heifers
WH[a]	+ 2.14	+ 0.84	- 0.06	+1.47	+1.66
HH[b]	+ 3.36	+ 2.15	+ 1.94	+2.34	+2.76
BL[c]	+ 0.65	+ 0.59	+ 0.28	+0.93	+1.24
BW[d]	+36.97	-23.80	-61.67	-----	-----
SC[e]	------	- 1.20	- 1.78	-----	-----

[a]WH, wither height, inches

[b]HH, hip height, inches

[c]BL, body length, inches

[d]BW, body weight, pounds

[e]SC, scrotal circumference, centimeters

relatively constant at that age. Furthermore, as bulls became older and larger framed there was a decrease in body weight of 23.80 and 61.67 lbs. for Groups II and III, respectively. The decline in body weight with an increase in frame size is in agreement with Brown et al. (1973), who suggested that as bulls become larger framed they do not necessarily become heavier. On the other hand, Group I bulls increased in weight by 36.97 lbs. from 1981 to 1984, also in agreement with Brown et al. (1973), who found that four- and eight-month old Angus bulls increased in weight at a faster rate than wither height, hip height, and body length. The values in Table 6 suggest that most selection over the past four years has been placed on increased hip height for both bulls and heifers.

The bulls in Groups II and III not only showed a decrease in body weight, but also a decrease in scrotal circumference. It is possible then that larger framed, later maturing bulls may have smaller testicles at a given age and, therefore, may be somewhat older before reaching sexual maturity.

Coefficients of Correlation. Coefficients of correlation for all measurements within each group are given in Tables 7, 8, 9, 10, and 11. The data in Tables 7, 8, and 9 show that as bulls increase in age the coefficients of correlation between body measurements become lower, suggesting a close association between body measurements at young ages. The data also suggest that wither height, hip height, body length, and weight increase at relatively proportional rates; however, scrotal circumference appears to increase independently of body measurements. Thus, if more selection pressure is placed on frame size and since the coefficient of correlation between scrotal circumference and other body measurements is lower, then the result may be later maturing bulls with smaller testicles.

Table 7. Coefficients of correlation among body measurements in Group I[a].

Measurement	(6)	(5)[b]	(4)	(3)	(2)	(1)
1. Age	.92	.24	.84	.84	.90	1.00
2. Wither Height	.96	.24	.88	.93	1.00	
3. Hip Height	.89	.21	.79	1.00		
4. Body Length	.88	.06	1.00			
5. Scrotal Circumference[b]	.36	1.00				
6. Weight	1.00					

[a] $r_{.01} = .311$, $r_{.05} = .239$ (n=68)

[b] $r_{.01} = .590$, $r_{.05} = .468$ (n=18)

Table 8. Coefficients of correlation among body measurements in Group II[a].

Measurement	(6)	(5)[b]	(4)	(3)	(2)	(1)
1. Age	.82	.34	.64	.54	.66	1.00
2. Wither Height	.78	.16	.72	.88	1.00	
3. Hip Height	.66	.19	.66	1.00		
4. Body Length	.72	.07	1.00			
5. Scrotal Circumference[b]	.22	1.00				
6. Weight	1.00					

[a] $r_{.01} = .240$, $r_{.05} = .184$ (n=115)

[b] $r_{.01} = .328$, $r_{.05} = .252$ (n=61)

Table 9. Coefficients of correlation among body measurements in Group III[a].

Measurement	(6)	(5)[b]	(4)	(3)	(2)	(1)
1. Age	.75	.30	.60	.39	.71	1.00
2. Wither Height	.80	.31	.67	.77	1.00	
3. Hip Height	.56	.31	.55	1.00		
4. Body Length	.69	.27	1.00			
5. Scrotal Circumference[b]	.42	1.00				
6. Weight	1.00					

[a] $r_{.01} = .437$, $r_{.05} = .339$ (n=34)

[b] $r_{.01} = .590$, $r_{.05} = .468$ (n=18)

Table 10. Coefficients of correlation among body measurements in Group IV[a].

Measurement	(4)	(3)	(2)	(1)
1. Age	.88	.87	.88	1.00
2. Wither Height	.92	.97	1.00	
3. Hip Height	.90	1.00		
4. Body Length	1.00			

[a] $r_{.01} = .221$, $r_{.05} = .169$ (n=136)

Table 11. Coefficients of correlation among body measurements in Group V[a].

Measurement	(4)	(3)	(2)	(1)
1. Age	.05	.37	.17	1.00
2. Wither Height	.66	.81	1.00	
3. Hip Height	.53	1.00		
4. Body Length	1.00			

[a] $r_{.01} = .158$, $r_{.05} = .121$ (n=271)

For both bulls and heifers, there is a strong association between wither height, hip height, and body length. The coefficients of correlation between wither height and other measurements, excluding scrotal circumference, were consistently higher than other values, ranging from .66 to .96. These results agree with those of Stone (1978), who noted that coefficients of correlation involving wither height were the highest of those linear measurements studied. In Stone's (1978) study, the coefficients of correlation between wither height and hip height ranged from .87 to .95 for data from 1974 to 1978. Since wither height has the strongest association with other body measurements, it can be suggested that breeders place more reliance on wither height measurements. Brody (1945) also stated that of all linear measurements wither height was the best measure of true genetic size.

The coefficients of correlation between body length and other body measurements were inconsistent ranging from .06 to .88. Stone's (1978) findings, also revealed inconsistency in the coefficients of correlation, ranging from .23 to .80, between body length and other body measurements. Results from this study and the Stone (1978) study suggest that we cannot emphasize body length measurements due to the difficulty in obtaining accurate, consistent measurements.

Linear Measurements and Show Ring Placings. The weighted coefficients of correlation between the various linear measurements and the judges' placings for bulls and heifers using Spearman's coefficient of rank correlation are given in Tables 12 and 13. Spearman's coefficient of rank correlation applies to data in the form of ranks. The calculated values in this study represented the association of the animals' ranking for each linear measurement within each class with the judges' placing within

Table 12. Weighted Spearman's coefficient of rank correlations between linear measurements and judge's placings for bulls.[a]

Measurement	1981	1982	1983	1984
!. Wither Height	.85	.80	.58	.71
2. Hip Height	.76	.77	.74	.77
3. Body Length	.52	.65	.03	.79
4. Body Weight	.51	.47	.39	.44
5. Scrotal Circumference[b]	---	---	.48	.23

[a] $r_{.01}$ = .176, $r_{.05}$ = .134 (n=217)

[b] $r_{.01}$ = .261, $r_{.05}$ = .200 (n=97)

Table 13. Weighted Spearman's coefficient of rank correlations between linear measurements and judge's placings for heifers.[a]

Measurement	1981	1982	1983	1984
1. Wither Height	.59	.61	.71	.56
2. Hip Height	.66	.71	.76	.68
3. Body Length	.61	.45	.63	.38

[a] $r_{.01} = .127$, $r_{.05} = .098$ (n=407)

each class. These values showed how the relationship between the judges' subjective placings and linear measurements have changed over the past four years.

The values expressed in Table 12 and 13 show a strong association between height measurements and the judges' ranking of each class. Hip height measurements consistently had the greatest association for bulls and heifers with an overall mean of .73 for both sexes from 1981 to 1984 in influencing the judges rankings. Therefore, those cattle which have been tall at the withers and hips have been ranked toward the top of their respective classes regardless of their overall body conformation or structural correctness. The values also show that the coefficients of correlation between the bull's body weight and judge's rankings have decreased since 1981, an indication that the heavier bulls are not necessarily the largest framed bulls. It also suggests that judges have not used body weight as a major criterion in their selection toward larger framed cattle.

Scrotal circumference showed a small but highly significant rank correlation (.44) with the judge's placings of bulls in 1983; however, in 1984 the rank correlation between scrotal circumference and the judge's placing was only .23. This decrease indicates that judges are placing the least emphasis on scrotal circumference, a reproductive trait which is one of the most economically important traits to livestock breeders today. With less influence being placed on scrotal circumference, several problems could arise including delayed sexual maturity and the possibility of infertile bulls.

The relationship between body length and the judge's placings was very variable from a low value of .03 for bulls in 1983 to a high value of .79 for bulls in 1984. In 1984, the rank correlation between body length and the judge's placing for heifers was only .38. This variation in the association between body length and the judge's placings further shows the difficulty in measuring body length from an objective and/or subjective standpoint. These findings further support the conclusion that body length should receive little or no emphasis in a selection program.

Analysis of Variance. An analysis of variance was conducted to determine differences between years, age groups, and sex using the hip height measurement to determine if Angus cattle studied had become significantly larger framed during the study period. The analysis of variance for year, age group, and sex effects on hip height is shown in Table 14. There were significant differences in hip heights ($P < .01$) among years, age groups, and sex. The means for each year revealed a significant increase in hip height ($P < .05$) from 1981 to 1984. The means also showed a significant increase in hip height ($P < .05$) among all three groups, with a 11.73 in. increase from group I to group II. Differences between sexes indicated that bulls were 3.15 in. taller at the hip than heifers, thus providing an explanation for the significant difference in hip height ($P < .05$) and the interaction of age group X sex.

Table 14. Analysis of variance for year, age group, and sex effects on hip height.

Source of Variation	df	Mean Square	F Value
Year	3	189.969	39.717**
Age Group	2	2897.258	605.738**
Sex	1	608.157	127.149**
Year X Age Group	6	2.880	.602
Year X Sex	3	1.387	.290
Age Group X Sex	2	30.801	6.440*
Year X Age Group X Sex	3	4.100	.857
Residual	603	4.783	

**Significant at ($P < .01$)

*Significant at ($P < .05$)

CHAPTER V

SUMMARY

The major purpose of this study was to determine the body measurements being given the highest priority by judges at the American Angus Breeders' Futurity over the past four years. By using Spearman's coefficient of rank correlation, as outlined by Steel and Torrie (1980), it was possible to analyze the data and arrive at conclusions concerning the relationship of linear measurements and subjective placings in Angus cattle. A further purpose of this study was to determine the relationships between various linear measurements in Angus cattle and to compare the relationships of measurements with maturity patterns.

The information obtained in this study indicated that linear measurements changed over the past four years with a marked increase in both wither and hip height; however, it also indicated that weight does not always proportionally increase with height. The study results showed a positive increase in the difference between wither height and hip height in all age groups over the past four years, an indication that as cattle increased in frame size, maturity was delayed.

The coefficients of correlation obtained showed that wither height was more closely associated with other measurements and, therefore, may be the best predicator of true genetic size. Although hip height has become the most widely used measure of frame size in the purebred beef cattle industry, results of this study showed wither height to be more closely associated with weight. The coefficients of correlation between hip height and wither height ranged from .77 to .97 for the five groups, respectively. Body length had low and inconsistent relationships with other measurements; therefore, body length should not be highly emphasized in making selection decisions.

Scrotal circumference measurements were not highly associated with other measurements. The range of the coefficients of correlation between scrotal circumference and other measurements was .06 to .42 for the three bull groups. Probably the most significant finding concerning scrotal circumference was a decrease for bulls in both Group II and Group III from 1983 to 1984. Such results may mean that scrotal circumference decreases as frame size increases.

It seems apparent that judges are continuing to select for larger framed cattle, with their highest priority of selection being placed on wither and hip height measurements. They are tending to place the least emphasis on scrotal circumference and body weight. Spearman's rank correlation between the judge's placings and the rank for wither height, hip height, and body length in bulls for 1984 were .71, .77, and .79; however, in heifers similar correlations were only .56, .68, and .38. Therefore, it seems obvious that the primary consideration for placing bulls in 1984 was frame size, but other factors must have been considered in arriving at placings for the heifers.

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