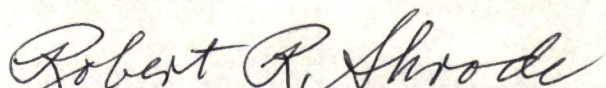
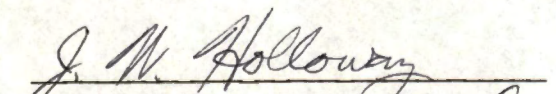
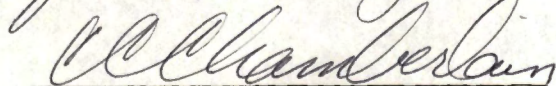


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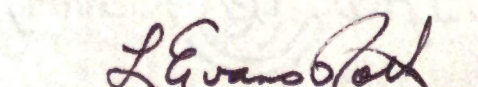
I am submitting herewith a thesis written by Gisela R. Dellmeier entitled "Utility of Various Variables Recorded from Weanling Beef Calves for Predicting Yearling Variables." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.


Robert R. Shrode, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:


Vice Chancellor
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Thesis

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UTILITY OF VARIOUS VARIABLES RECORDED FROM WEANLING BEEF
CALVES FOR PREDICTING YEARLING VARIABLES

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Gisela R. Dellmeier

March 1978

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ABSTRACT

Regression equations were constructed from data collected from Angus cattle raised at The University of Tennessee Plateau Experiment Station and Polled Hereford cattle raised at The University of Tennessee Tobacco Experiment Station.

These equations were developed in an effort to utilize certain linear body measurements and weight as recorded at weaning to obtain a more accurate prediction of weight and other variables of yearling calves than could be obtained using weaning weight alone.

Equations were developed using both single- and multiple-independent-variable models. The coefficients of determination by single-variable equations to predict yearling weight ranged from .75 with weaning weight as the independent variable to .35 with weaning hip width as the independent variable. The range for multiple-variable equations using two weaning variables as independent variables was from .77 with weaning height and weight to .38 with weaning length and hip width for the prediction of yearling weight.

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CHAPTER I

INTRODUCTION

One of the most important variables for evaluating beef cattle is live weight, which is important in all phases of beef production, from breeding to marketing. For the cow-calf producer, weight is important for evaluating animals at weaning time. Though the cow-calf producer generally does not see it, weight is important also at a year of age. This weight is important to the feedlot operator.

It is well documented that a strong relationship exists between weight at weaning age and weight at a year of age. It has been shown also that various body measurements and weight are associated in definite patterns.

The purpose of this study was to investigate the possibility of utilizing these relationships to predict accurately variables measured on yearling animals on the basis of weight and certain other variables recorded at weaning.

CHAPTER II

REVIEW OF LITERATURE

Numerous investigators have examined the usefulness of various body measurements, used both individually and in combinations and ratios, in the estimation or prediction of various important traits in cattle.

In a study of the changes in certain body measurements of beef calves during intensive fattening, Lush (1928) used a total of 17 different linear measurements taken on 185 steers at the beginning and at the end of a fattening period and found that fattening caused a greater increase in width than in length or depth of body and that height and head measurements showed the least increase. The chest girth measurement was found to be the most useful descriptive measure among those measurements found to increase rapidly with increasing fatness. Of the measurements taken which were found to have a rate of increase less rapid than weight, Lush found height, either at the withers or at the hip, most useful. Eight ratios of height or length measurements to width measurements also were studied in an attempt to find a reliable objective fatness indicator. Of these, the ratio of chest girth to wither height appeared to be most useful.

In a later study, Lush (1932) studied relationships between the conformations of 241 beef steers and their future performances in an attempt to identify body measurements which could be taken to describe conformation and determine its association with gain. A total of 23

measurements were studied, from which correlations with subsequent gains, dressing percentages, and values of dressed beef were calculated and found to be statistically significant, although small. A large heart girth with a shallow chest, wide loin, large initial weight and flank girth, and small paunch girth, width between eyes, and height over hips were found to be the most important measurements for high dressing percent and meat value. Large body length, wither height, and paunch girth with small flank girth and loin width measurements were found to be most associated with maximum gains.

Davis, Morgan, Brody, and Ragsdale (1937) took monthly measurements of dairy cows and found a definite relationship between weight and chest girth. They concluded that "quite an accurate estimate" of weight could be obtained by measuring chest girth and further stated that the accuracy could be measured by the height at withers measurement, which, it was pointed out, remains relatively constant despite changes in live weight and is approximately halfway completed before birth.

The interrelationships of heart girth, height at withers, round, body length, and weight measurements of 145 Aberdeen-Angus cows and heifers were studied by Wanderstock and Salisbury (1946), who found heart girth to be the most useful single measure in the estimation of live weight, which gave only slightly less accurate estimates than those obtained by the use of the Minnesota formula.

The Minnesota formula, proposed by Johnson (1940), is a ratio involving heart girth, body length, and a constant:

$$[(\text{heart girth})^2(\text{body length})] \div 300 = \text{weight in pounds.}$$

Flock, Carter, and Priode (1962) concluded that linear body measurements at birth could not be recommended as selection criteria to improve the prediction of performance to weaning. This study involved seven linear body measurements taken within 24 hours of birth, viz., height at withers, chest depth, body length, hip length, heart girth, round measure, circumference of cannon, and birth type. Four ratios also were calculated and analyzed for their predictive values: (1) $(\text{height at withers} - \text{depth of chest}) / (\text{height at withers})$; (2) $(\text{birth weight}) / (\text{length of body} \times \text{height at withers})$; (3) $(\text{heart girth}) / (\text{length of body} \times \text{height at withers})$; and (4) $(\text{round measure}) / (\text{length of body} \times \text{height at withers})$.

A study by Lush and Copeland (1930) of the accuracy of obtaining body measurements found an error of less than 2 percent for most of the measurements taken, which is about the same as the magnitude of error in taking body weights. This study involved 25 body measurements taken on 9 Jersey cows for 11 repetitions.

The accuracy and efficiency of procedures for obtaining cattle weights were studied by Fox, Fitzhugh, and Cartwright (1968), and they concluded that, although some increase in precision would be gained through averaging multiple weighings, this increase was seldom justifiable in terms of the cost of the additional time and labor involved in obtaining multiple weights. It was suggested that experimental precision would be better improved by an increase in the number of experimental animals in a treatment group rather than by the taking of multiple weights.

Brown and Shrode (1971) studied various body measurements, body composition traits, and performance traits in 158 Angus calves with respect to their value for predicting postweaning and lifetime ADG, fat thickness, and final condition score, and concluded that traits observed at an average age of 220 to 225 days yielded larger coefficients of multiple determination from equations for predicting the dependent variables than preweaning or interim (measured between birth and weaning) traits. They found also that weaning body composition traits in various combinations explained significantly more variation in the dependent variables than weight and age alone.

The use of linear body measurements along with age and weights at birth and slaughter in the estimation of an animal's carcass merit was investigated by Dement (1969), and prediction equations were constructed by a stepwise regression procedure. The results were found to warrant further studies.

Weights, body measurements, and fatness measurements were assessed for their values in the prediction of performance to yearling age in beef cattle by Hammack (1973), and it was concluded that predictive value was increased by the inclusion of skeletal size and a measure of body fatness along with age and body weight.

Shannon (1975) studied body measurements which included heart girth, body length, shoulder width, hip height, hip width, and chest depth, both individually and in combination, to determine their value in estimating live weight and found chest depth to be the most highly correlated with weight (0.95), followed closely by heart girth (0.93), and hip height to be the least correlated with weight (0.86).

Body volume was defined by Turner (1976) and included among variables studied in a comparison of progress expected from differing methods of selection and a comparison of different estimates of repeatability of cow productivity. High positive phenotypic correlations of the volume variables with the various gain variables were obtained, and the yearling volume variable was considered important because it provides an expression of an animal's size which excludes the errors inherent in body weights.

This review shows that some researchers have found linear body measurements useful in estimating future performance while others have found their use to be of little benefit. Of the linear measurements mentioned those in the chest area, particularly heart girth and chest depth, seem to be the most highly associated with future performance.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. SOURCE AND DESCRIPTION OF DATA

The data used in this study were collected from 1,635 calves; 615 Polled Herefords at the Tobacco Experiment Station (TES) of The University of Tennessee, Greenville, Tennessee, and 1,325 Angus at The University of Tennessee Plateau Experiment Station (PES), Crossville, Tennessee. Numbers by station and year are presented in Table 1. These calves were born in January, February, and March, from 1968 through 1974.

Table 1. Number of Calves by Year and Station

Year	TES	PES	Combined
1968	54	169	223
1969	38	137	175
1970	60	148	208
1971	76	159	235
1972	85	158	243
1973	94	173	267
1974	<u>107</u>	<u>185</u>	<u>292</u>
Totals	514	1,129	1,643

Calves were kept with their dams until weaning, without creep feed. Cows were segregated according to the sex of their calves on approximately July 1 of each year. The calves were fed in dry lot after

weaning. The heifer calves' ration consisted daily of 2 pounds each of hay and grain, 1/2 pound of protein supplement per calf, and corn silage ad libitum. Bull calves were fed daily a pound of a 14 percent protein grain mixture per cwt. of live weight, 2 pounds of hay, and corn silage ad libitum. The calves were maintained on these rations until they were approximately a year of age.

Weight, fat thickness, and six linear body measurements were recorded:

✓1. heart girth (HG)--the body circumference immediately posterior to the front legs.

2. chest depth (DEPTH)--the vertical distance between the top and floor of the chest, immediately posterior to the front legs.

3. shoulder width (SWIDTH)--the horizontal distance between the points of the shoulders.

✓4. body length (LENGTH)--the horizontal distance along the back, from the center of the top of the shoulder to the posterior prominence of the pin bones.

✓5. hip width (HIP)--the horizontal distance between the hip bone prominences.

✓6. height (HT)--the vertical distance between the center of the peak of the hips and the ground.

Variable names preceded by a P refer to postweaning (yearling) variables.

These data were collected at approximately 240 days of age and 390 days of age. Birthweight was also recorded.

Weights were measured in pounds with conventional scales and were then converted to kilograms. Fat measurements were determined ultrasonically between the 12th and 13th ribs. An incremented steel caliper was used to measure depth and shoulder width. Height was measured with a metal height standard, and heart girth, body length, and hip width measurements were taken with a flexible metal tape.

These measurements were either recorded in centimeters or mathematically converted from inches to centimeters prior to analysis.

In addition to these measurements, the following ratios and volumes also were calculated:

$$\text{VOL} = [(\text{HG}^2 / (4 \times 3.14))] \text{LENGTH}$$

$$\text{VOL2} = \text{LENGTH} \times \text{HIP} \times \text{DEPTH} \times 3.14$$

$$\text{C RATIO} = \text{WEIGHT} / \text{HG}$$

$$\text{CYL RATIO} = \text{WEIGHT} / (\text{HG} \times \text{LENGTH})$$

$$\text{H RATIO} = \text{WEIGHT} / \text{HT}$$

$$\text{M RATIO} = \text{WEIGHT} / \text{VOL}$$

$$\text{L RATIO} = \text{WEIGHT} / \text{LENGTH}$$

$$\text{S RATIO} = \text{VOL} / \text{HT}$$

II. METHOD OF ANALYSIS

The analysis included the calculation of means of the variables studied, the calculation of correlation coefficients of the variables studied, simple regressions of yearling variables on weaning variables, simple regressions of yearling weight on certain weaning ratios and other calculated weaning variables, multiple regressions using two or more

weaning variables to predict yearling weight, stepwise regression both with and without weaning weight as one of the weaning variables, and Spearman rank order correlations.

CHAPTER IV

RESULTS AND DISCUSSION

The means of the variables included in this study are presented in Table 2.

Prior to more complicated analyses, Spearman rank order correlations were calculated, the results of which indicate the degree and direction of association that exist between members of pairs of the variables. Most of these rank correlations were significant at the .01 level. However, a few were significant neither at the .01 nor the .05 level. This type of analysis was performed at the outset rather than a product-moment correlation analysis because the interest in this study was to properly rank the animals with respect to yearling variables on the basis of weaning variables.

The results of the Spearman rank order correlation analysis are presented in Tables 3, 4, and 5. Table 5 shows the strength of relationship between weaning variables and yearling variables. This table is important because it reflects the accuracy which may be attained when using these weaning variables in simple regression equations to estimate yearling variables. The table of Spearman rank order correlations indicates also what the utility of regression equations that were not constructed might be, for the square of these correlations is a close approximation of R^2 , the coefficient of determination, which is the fraction of the variation in the dependent variable which can be explained on the basis of regression on the independent variables.

Table 2. Averages of the Variables Included in the Study

Variable	Number of Observations	Mean	Range	
			Min.	Max.
HG	1635	136.0±0.21 cm	97.8 cm	157.5 cm
DEPTH	422	48.2±0.16 cm	37.0 cm	58.5 cm
SWIDTH	422	35.5±0.19 cm	23.0 cm	45.0 cm
LENGTH	1635	94.3±0.14 cm	71.1 cm	114.3 cm
HIP	1635	35.2±0.07 cm	25.4 cm	43.2 cm
HT	795	101.3±0.16 cm	82.0 cm	112.0 cm
WEIGHT	1634	207.5±0.90 kg	88.5 kg	317.5 kg
PHG	1612	155.2±0.24 cm	116.8 cm	180.3 cm
PDEPTH	484	53.9±0.15 cm	43.0 cm	63.0 cm
PSWIDTH	484	39.3±0.21 cm	25.0 cm	52.0 cm
PLENGTH	1612	104.6±0.15 cm	54.6 cm	121.9 cm
PHIP	1612	41.4±0.08 cm	30.5 cm	59.4 cm
PHEIGHT	772	109.7±0.15 cm	92.5 cm	120.0 cm
PWEIGHT	1617	291.3±1.30 kg	133.8 kg	433.2 kg
VOL	1635	140041.3±586.99 cm ³	58016.9 cm ³	225687.4 cm ³
VOL2	422	536847.4±4728.11 cm ³	209979.6 cm ³	853700.8 cm ³
S RATIO	795	1398.2±7.76	679.7	2051.7
M RATIO	1634	0.001±0.00	0.0	0.0
L RATIO	1634	2.2±0.01	1.1	3.0
H RATIO	794	2.0±0.01	1.0	3.0
C RATIO	1634	1.5±0.00	0.8	2.1
CYLRATIO	1634	0.016±0.00	0.0	0.0

Table 3. Rank Correlations Among Yearling Variables

	PHG	PDEPTH	PSWIDTH	PLENGTH	PHIP	PHT	PWEIGHT
PHG	1.00						
PDEPTH	0.88	1.00					
PSWIDTH	0.82	0.77	1.00				
PLENGTH	0.62	0.62	0.58	1.00			
PHIP	0.65	0.68	0.68	0.61	1.00		
PHT	0.69	0.68	0.58	0.65	0.59	1.00	
PWEIGHT	0.91	0.86	0.88	0.71	0.64	0.72	1.00

Table 4. Rank Correlations Among Weaning Variables

	HG	DEPTH	SWIDTH	LENGTH	HIP	HT	WEIGHT	VOL	VOL2	S RATIO	M RATIO	L RATIO	H RATIO	C RATIO	CYLRATIO
HG	1.00														
DEPTH	0.80	1.00													
SWIDTH	0.78	0.67	1.00												
LENGTH	0.69	0.67	0.54	1.00											
HIP	0.67	0.71	0.59	0.71	1.00										
HT	0.70	0.55	0.40	0.69	0.61	1.00									
WEIGHT	0.92	0.86	0.81	0.74	0.67	0.72	1.00								
VOL	0.96	0.81	0.76	0.85	0.74	0.75	0.92	1.00							
VOL2	0.82	0.89	0.67	0.86	0.91	0.59	0.88	0.89	1.00						
S RATIO	0.96	0.78	0.77	0.83	0.76	0.51	0.91	0.98	0.87	1.00					
M RATIO	-0.01	0.26	0.23	-0.19	-0.09	0.03	0.27	-0.08	0.11	-0.06	1.00				
L RATIO	0.88	0.82	0.81	0.52	0.54	0.64	0.95	0.81	0.77	0.83	0.43	1.00			
H RATIO	0.89	0.84	0.82	0.73	0.78	0.58	0.98	0.90	0.85	0.91	0.31	0.96	1.00		
C RATIO	0.82	0.84	0.77	0.72	0.63	0.68	0.98	0.85	0.86	0.84	0.40	0.94	0.97	1.00	
CYLRATIO	0.67	0.74	0.72	0.34	0.40	0.53	0.84	0.60	0.64	0.65	0.69	0.94	0.89	0.88	1.00

Table 5. Rank Correlations Between Yearling and Weaning Variables

	PHG	PDEPTH	PSWIDTH	PLENGTH	PHIP	PHT	PWEIGHT
HG	0.75	0.75	0.18	0.57	0.63	0.64	0.73
DEPTH	0.71	0.81	0.22	0.47	0.58	0.52	0.69
SWIDTH	0.62	0.63	0.21	0.54	0.59	0.42	0.67
LENGTH	0.58	0.61	0.12	0.62	0.64	0.62	0.60
HIP	0.45	0.58	0.12	0.45	0.62	0.52	0.45
HT	0.69	0.62	0.24	0.62	0.62	0.76	0.69
WEIGHT	0.79	0.80	0.20	0.64	0.68	0.66	0.83
VOL	0.74	0.75	0.60	0.63	0.68	0.68	0.74
VOL2	0.66	0.73	0.56	0.56	0.63	0.57	0.67
S RATIO	0.75	0.70	0.55	0.62	0.65	0.59	0.75
M RATIO	0.20	0.23	0.39	0.09	0.06	0.05	0.31
L RATIO	0.76	0.76	0.71	0.55	0.59	0.60	0.80
H RATIO	0.78	0.75	0.69	0.62	0.70	0.58	0.82
C RATIO	0.77	0.78	0.73	0.64	0.66	0.64	0.83
CYLRATIO	0.66	0.68	0.70	0.46	0.48	0.51	0.73

The simple regression equations for predicting yearling weights and linear measurements from weaning weights and linear measurements are presented in Table 6. Included also in this table are the coefficients of determination. Within each group of equations predicting a single dependent variable, the equations are presented in decreasing order of magnitude of their coefficients of determination. Therefore, within each group, these equations are in order from the most to the least accurate.

In predicting yearling weight, weaning weight is the single most useful independent variable. The equation using weaning weight as the independent variable explains 95 percent of the variation in yearling weight. The second most accurate equation in this group is the one containing heart girth as the independent variable. This equation explains 58 percent of the variation in yearling weight. The other linear measurements in this group of equations fall in the decreasing order of depth (54 percent), shoulder width (50 percent), length (45 percent), height (43 percent), and, finally, hip width (35 percent). The least useful independent variable in this group, hip width, yields a coefficient of determination less than half that obtained when weaning weight is used to predict yearling weight.

Of the other dependent variables, the group of equations predicting chest depth at a year of age contains the second highest coefficient of determination among all equations in the table. This equation uses chest depth at weaning as the independent variable and explains 69 percent of the variation in chest depth at a year of age.

Additional detailed information may be found in Tables 7, 8 and 9.

Table 6. Simple Regression Equations for Predicting Yearling Variables from Weaning Variables

Dependent Variable	N	Intercept	Coefficients of Regression on:					R ²
			WEIGHT	HG	DEPTH	SWIDTH	LENGTH	
PWEIGHT	483	28.18	1.26					.75
	484	-373.05		4.91				.58
	413	-298.59			12.34			.54
	413	-69.48				10.32		.50
	484	-306.69					6.33	.45
	484	-563.56						.43
	484	-117.19						.35
								11.32
PDEPTH	413	12.69			.85			.69
	483	38.41	.07					.67
	484	13.00		.30				.59
	413	32.16				.61		.46
	484	17.35					.38	.45
	484	26.88						.41
	484	3.15						.40
								.74
PHG	483	308.39	.22					.68
	484	29.64		.93				.61
	413	43.22			2.34			.56
	484	-5.63					1.15	.44
	484	45.68						.44
	413	91.88						.44
	484	81.59				1.81		.33
							2.03	

Table 6 (continued)

Dependent Variables	N	Intercept	Coefficients of Regression on:						R ²
			WEIGHT	HG	DEPTH	WIDTH	LENGTH	HT	
PHT	484	37.58						.71	.58
	483	94.31	.07						.47
	484	67.00					.44		.43
	484	68.86		.30					.42
	413	75.52			.71				.36
	484	84.46						.69	.25
	413	91.97				.51			.23
PHIP	483	30.15	.06						.57
	484	9.66		.25					.48
	484	10.51					.34		.43
	484	3.61						.46	.41
	413	14.79			.59				.38
	413	25.02				.51			.38
	484	20.23						.63	.35
PSWIDTH	483	19.87	.09						.54
	413	9.71				.82			.44
	413	5.78			.93				.42
	484	6.58		.33					.38
	484	1.01					.42		.28
	484	19.22						.58	.28
	484	10.30						.79	.24

Table 6 (continued)

In decreasing order of accuracy, the other independent variables in the group of equations predicting yearling chest depth are weaning weight (67 percent), heart girth (59 percent), shoulder width (41 percent), and height (40 percent).

It is interesting to note that when all of the coefficients of determination within a group are averaged, the equations predicting yearling chest depth have a higher average coefficient of determination (52) than those predicting yearling weight (51), although the highest coefficient of determination among all the equations in the table is the one predicting yearling weight from weaning weight.

The group of equations predicting yearling heart girth had both the third highest average coefficient of determination (50 percent) and contained the third highest coefficient of determination for a single equation among all equations in the table. The most accurate equation in this group uses weaning weight as its independent variable and explains 68 percent of the variation in yearling heart girth. Following in decreasing order are heart girth (61 percent), chest depth (56 percent), height (44 percent), length (44 percent), shoulder width (44 percent), and hip width (33 percent).

In decreasing order of their average coefficients of determination, the remaining groups of equations are those predicting yearling hip width (43 percent), yearling height (39 percent), yearling shoulder width (37 percent), and yearling length (32 percent). The equation predicting yearling height from weaning height is the most accurate single equation ($R^2 = .58$) among all the equations in these remaining groups.

Table 7. Multiple Regression Equations for Predicting Yearling Weight Using Two Weaning Variables

N	Intercept	Coefficients of Partial Regression on:						R ²
		WEIGHT	HG	DEPTH	WIDTH	LENGTH	HT	HIP
769	-82.720	1.140					1.325	
412	92.050	1.395		-1.959				
412	41.428	1.301			-0.667			
1607	109.898	1.402						-3.124
1607	146.473	1.486	-1.205					
1607	58.703	1.266				-0.325		
770	-523.112		3.511				3.295	
413	-502.525				7.625		5.218	
413	-393.407		3.063	5.609				
413	-275.706			7.956	5.318			
413	-316.870		3.538		3.631			
413	-550.666			9.255			3.959	
413	-289.105				6.981	3.519		
413	-383.281			8.982		2.569		
1608	-387.484		3.803			1.709		
770	-577.222					3.774	4.991	
770	-531.892						5.659	6.838
1608	-334.247		4.793					-0.757
413	-305.236			11.560				1.217
413	-149.348				8.340			4.111
1608	-239.298					5.029		1.598

Table 8. Simple Regression Equations for Predicting Yearling Weight from Calculated Variables

N	Intercept	C RATIO	H RATIO	S RATIO	VOL	CYLRATIO	VOL2	H RATIO	R ²
1607	-70.530	238.321							0.713
769	-4.794		143.659						0.712
770	7.108			0.201					0.583
1608	55.856				0.002				0.568
1607	-142.745					27015.426			0.556
413	74.054						0.0004		0.519
1607	54.607							159654.659	0.712

Table 9. Stepwise Regression Equations, With and Without Weaning Weight, for Predicting Yearling Variables

Dependent Variable	Intercept	Coefficients of Partial Regression on:							R ²
		WEIGHT	DEPTH	WIDTH	HIP	HT	LENGTH	HG	
PWEIGHT	136.911	1.695			-4.287	1.556		-1.494	0.776
PDEPTH	17.852	0.036	0.494		-0.121	0.087			0.734
PDEPTH	3.851		0.573	0.968		0.123		0.047	0.724
PHG	76.385	0.203	0.416		-0.786	0.441			0.712
PHG	-4.065		1.046	0.314	-0.567	0.608		0.420	0.672
PWEIGHT	-524.885		4.424	4.062	-2.720	2.911	1.118	1.175	0.669
PHT	43.154	0.019				0.526	0.096		0.657
PHT	35.910					0.538	0.126	0.054	0.650
PHIP	20.318	0.062	-0.242			0.156	0.055		0.624
PSWIDTH	46.490	0.144		0.247	-0.426			-0.232	0.612
PHIP	-3.464			0.147		0.194	0.998	0.088	0.573
PSWIDTH	-13.797		0.531	0.536	-0.300	0.188			0.528

Table 7 shows multiple regression equations using two independent variables to predict yearling weight. The most accurate of these uses weaning weight and height; of those not including weaning weight as an independent variable, the most accurate uses heart girth and height.

Table 8 shows regression equations using calculated variables. Of these calculated variables, the C RATIO and the H RATIO have the highest R^2 values, .713 and .712, respectively.

A stepwise regression procedure was used to investigate the use of variables in combinations in an effort to predict yearling variables. With respect to yearling weight, the best equation ($R^2 = .776$), from a statistical point of view, is one containing weaning weight, weaning heart girth, weaning hip width, and weaning hip height. When weaning weight is omitted, the best equation for predicting yearling weight includes all six of the linear body measurements recorded at weaning. The coefficient of determination for this equation is 67 percent.

Table 9 presents the dependent variables in the stepwise regression in decreasing order of the R^2 values for the equations. It is apparent from this table that yearling weight is the variable which can be most accurately predicted when weaning weight is in the model. However, when yearling weight is predicted without the benefit of weaning weight in the model, the estimate is not nearly as accurate, and both yearling depth and yearling heart girth, including and excluding weaning weight in the model, are more accurately predicted than is yearling weight.

Table 9 shows that the range of R^2 values is from the high of .776 for the prediction of yearling weight with weaning weight included

in the model, to the low of .470 for predicting yearling length, excluding weaning weight from the model. The number of independent variables necessary to get these "best" equations from the stepwise procedure ranges from a low of three variables to a high of six variables.

It should be recognized that there are criteria for selecting "best" equations other than the solely statistical considerations used by the stepwise regression procedure to add and delete independent variables. These other considerations are such things as the economy of measurement and the accuracy of measurement. Under the economy of measurement are included the cost of labor involved, the cost of equipment, the ease of measurement, and the necessary skill. These are real factors that must be considered in attempting to establish alternate methods of evaluating calves or predicting the ranking of animals at a year of age.

The rank correlations indicate that there is a very high association between most of the yearling variables that do show a high rank order correlation with yearling weight and, thus, some of these variables may be useful in evaluating an animal's worth in terms of food value. This is due to the fact that some linear measurements are more accurate in terms of repeatability than is weight, since weight is subject to such errors as variation in fill. Fill itself is not an error of measurement of weight, but it does result in an overestimation of the animal's mass. The fill is not part of the animal, but it is part of the observed scale weight.

Linear body measurements are not subject to errors such as unbalanced scales, require less operator knowledge, and are less

influenced by fill. In addition, the taking of linear body measurements requires less expensive equipment than the taking of weight. This is an important consideration to small scale beef producers such as are commonly found in Tennessee.

A comparison of Tables 6 and 8, pages 17 and 22, respectively, shows that the simple regression of yearling weight on weaning weight is more pronounced than that of yearling weight on any of the ratios or volumes that were calculated. Some of the ratios are more accurate than the linear measurements; however, this difference, for the most part, is not large enough to warrant the additional expenditure of time and effort necessary for their calculation since all of the ratios and volumes require at least two variables in their calculation. Therefore, they should be compared to the multiple regression equations having two independent variables, which are shown in Table 7, page .

A comparison of Tables 7 and 8 shows that weight and any other single linear body measurement is more accurate than C RATIO, which, among the calculated variables, is the most accurate predictor of yearling weight. Further comparison of these two tables shows that more than half of the two-variable equations are more accurate than the ratio and volume equations, with the exception of the C RATIO and the H RATIO.

Therefore, it would appear that if the expense of collecting more than one variable at weaning was worthwhile, it would generally be better to use the variables in a multiple regression equation rather than performing any calculations and then using the resulting variable in a simple regression.

On the basis of a comparison of the combinations in Table 8, page 22, with each other, those variables including weaning weight with the linear body measurements are the most accurate. Of these, the equation containing weaning weight and height has the highest R^2 (.769). The most accurate equation among those equations excluding weaning weight from the model is the one using weaning heart girth and height; its coefficient of determination is .636. As a rule, the next most accurate equations are those containing either weaning chest depth or heart girth. The least accurate equations are those containing weaning hip width as the independent variable.

These results seem to indicate that weaning weight alone is a very accurate estimator of yearling weight. Except for the single equation containing weaning weight and height, none of the two-variable equations is as accurate as using weaning weight alone to predict yearling weight.

Therefore, it would seem that if weight can be economically and practically recorded at weaning, no other measurements need be recorded, with the possible exception of height. However, if weight at weaning cannot be recorded, then heart girth, height, shoulder width, and chest depth in the combinations shown in Table 7, page 21, are more accurate than the simple regressions on linear body measurements shown in Table 6, page 17.

Table 10 gives the relative predictive values of selected weaning variables used to predict yearling weight. The values in this table were calculated by dividing the product-moment correlation between each

Table 10. Relative Predictive Values of Selected Weaning Variables
in Estimating Yearling Weight

Variable	Relative Value
WEIGHT	1.0000
S RATIO	0.9159
VOL	0.9069
HG	0.8910
DEPTH	0.8546
VOL2	0.8498
SWIDTH	0.8298
LENGTH	0.7524
HIP	0.6065
HT	0.5716

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weaning variable and yearling weight by the correlation between weaning weight and yearling weight. Weaning weight is the standard of comparison, having been assigned the relative predictive value of 1.0, and each of the other variables is assigned its value relative to that of weaning weight. Of the ratios included in Table 10, none were calculated using weaning weight. This was deliberate, since an assessment of what might be accomplished by a small-scale cow-calf producer (without livestock scales) was of primary interest.

The S RATIO is the variable with the greatest value for predicting yearling weight relative to the predictive value of weaning weight. This might be expected since the S RATIO is calculated from heart girth, length, and height, and thereby gives a reasonable description of the body size of an animal. The S RATIO apparently incorporates the shape, proportion, and scale of the body into a single number which reflects well the animal's growth potential. This ratio would be useful to the small-scale cow-calf producer without scales who selects replacement breeding heifers at weaning time on the basis of their performance up to that time.

The VOL variable has the second largest relative predictive value, which might be expected since the S RATIO is calculated from VOL and HT. Heart girth and depth rank third and fourth, respectively. They have been discussed previously.

The remaining variables included in Table 10 fall into the decreasing order of relative accuracy of VOL2, shoulder width, length, hip width, and height.

The concept of objectively determined shape as a characteristic of beef cattle has received little attention in the past. Traditionally, weight has received considerable attention as well as the subjective evaluation commonly referred to as "type."

Measurements, ratios, and volumes presented here have been shown to be highly correlated with yearling weight. In addition, these variables are objective rather than subjective values. Shape may ultimately be a characteristic in which the beef industry is, or should be, very much interested. The heaviest animal is not necessarily the most desirable animal, either for beef or for breeding. Thus, it may be that equations such as those derived herein could be utilized to reflect the shape of an animal. Such shape calculations could be used with or without weight to evaluate animals for breeding or beef.

From a practical point of view, if a farmer were to predict yearling weight from weaning data, it would appear that the common practice of taking heart girth to estimate the current weight could be easily expanded to predict future weight. If this were done, height could be included to increase accuracy.

This study, as much as anything, points out the need for conducting additional research to determine the relationships that exist among the variables included in the study and traits of practical or economic importance, such as dressing percent, yield grade, carcass weight, and breeding value of an animal. Also, from a breeding standpoint, reliable estimates of heritabilities would be very desirable.

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CHAPTER V

SUMMARY

Regression equations were constructed in an effort to utilize certain linear body measurements and weight as recorded at weaning to obtain a more accurate prediction of weight and other yearling variables than could be obtained by using weaning weight alone. The data were collected from 615 Polled Hereford calves raised at The University of Tennessee Tobacco Experiment Station and 1,325 Angus calves raised at The University of Tennessee Plateau Experiment Station. These calves were born from 1968 through 1974.

Both single- and multiple-independent-variable equations were developed. The coefficients of determination by single-variable equations to predict yearling weight ranged from .75 with weaning weight as the independent variable to .35 with weaning hip width as the independent variable. The multiple-variable equations using two weaning variables as independent variables yielded coefficients of determination ranging from .77 with weaning height and weight in the model to .38 with weaning length and hip width in the model.

It was suggested that linear body measurements could be utilized for the prediction of future performance when scales are not available or used in combination with weaning weight to improve the accuracy of prediction and also to take into consideration the shape and proportion of an animal.



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