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Estimation of weight of cattle by means of skeletal measurements

David Shannon

To the Graduate Council:

I am submitting herewith a thesis written by David Shannon entitled "Estimation of weight of cattle by means of skeletal measurements." I have examined the final electronic copy of this thesis for form and content and 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:

James B. McLaren, John D. Smalling

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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John L. Smalling

Accepted for the Council:

Hilton A. Smith

Vice Chancellor
Graduate Studies and Research

A

ESTIMATION OF WEIGHT OF CATTLE BY MEANS OF SKELETAL MEASUREMENTS

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee

David Shannon

December 1975

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ABSTRACT

Body measurements, including heart girth, body length, shoulder width, hip width, hip height, and chest depth were recorded on both Angus and Polled Hereford calves. These measurements were studied individually and in combination to assess their value in estimation of live weight. The Angus calves used in this study were raised at the University of Tennessee Plateau Experiment Station, Crossville, Tennessee, while the Polled Hereford calves were raised at the University of Tennessee Tobacco Experiment Station, Greeneville, Tennessee. The calves were born in the years 1968 through 1974.

More than 5,000 sets of records were taken from more than 1,600 different calves. A total of 63 simple and multiple regression equations were constructed. In addition, a number of stepwise regression analyses were conducted. When all of the variables were available to the program for possible inclusion as independent variables to estimate weight, the final equation would include all of the variables except hip height; and the coefficient of determination would be about 0.96. When all of the variables except heart girth were available for inclusion, the final equation would include all of them; and the coefficient of determination would be about 0.95.

Chest depth was most highly correlated with weight (0.95), and heart girth was second (0.93). Hip height was found to be the variable least correlated with weight (0.86). The mean weight of calves studied was 211 kg with the range being 39 to 433 kg.

It was concluded that in Angus and Polled Hereford calves weighing

from 39 to 433 kg, an accurate estimation of weight could be made by using either chest depth or heart girth alone, but the coefficient of determination could be increased by adding additional measurements. However, the small increase in predictive value would not be justified in practice.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
II.	REVIEW OF LITERATURE	2
III.	EXPERIMENTAL PROCEDURES	4
	Source and Description of Data	4
	Method of Analysis	7
IV.	RESULTS AND DISCUSSION	9
V.	SUMMARY	23
LITERATURE CITED		25
VITA		27

LIST OF TABLES

TABLE		PAGE
I.	Number of Calves by Year, Breed and Sex	5
II.	Averages of the Variables Included in the Study	10
III.	Correlations Between and Repeatabilities of Variables . . .	11
IV.	Simple and Multiple Regression Equations for Prediction of Weight from Linear Measurements	13
V.	Curvilinear Equations for Estimation of Weight from Linear Measurements	15
VI.	Simple Regression Equations with No Intercept for Estimation of Weight from Linear Measurements	17
VII.	Regression Equations for Bulls	19
VIII.	Regression Equations for Heifers	19

CHAPTER I

INTRODUCTION

Weight is an important trait in almost every aspect of raising beef cattle. It is important in determining the amount of nutrients to be fed, the dosage of drugs to be administered, the price to be paid at slaughter, and in other areas of beef production as well. Direct determination of weight may be made through the use of scales; but scale weight is known to be subject to appreciable "fill" error, and scale equipment is expensive. To the person with limited funds, an alternative method of determining weight is desirable. For many years, this alternative has been to use a heart girth tape.

Linear measurements other than heart girth may be used to estimate weight. The purpose of the present study was to ascertain the value of using linear measurements individually and in combination in estimation of live weight of calves. It is quite conceivable that true metabolic mass could be estimated much more accurately from linear body measurements than by scale weight.

CHAPTER II

REVIEW OF LITERATURE

It was observed by Wanderstock and Salisbury (1946) that only a limited number of investigations had been made of the use of body measurements for the estimation of weight of beef cattle. That situation still prevails. A review of the literature revealed no published research in this area since the 1950's.

A thorough review was prepared by Ivar Johansson and S. E. Hildeman (1954). Their review included heart girth, withers height, and body length in addition to other indices. However, they found the most common measurement used to estimate weight was heart girth. They drew several conclusions. First, it was concluded that estimating weight by using two or more measurements was no more accurate than by using heart girth alone. Second, it was observed that regression of body weight on heart girth was shown to have the closest affinity to live weight of all the variables investigated. Third, it was found that, though weight and the linear measurements increase in a curvilinear fashion, there was little added accuracy when the curvilinear equations were compared to the linear ones. Fourth, it was determined that when age and heart girth were held constant, live weight increased with increased condition.

Although the present study was concerned with beef cattle, the work of Touchberry and Lush (1950) with linear body measurements of dairy cattle should be mentioned, particularly with respect to their conclusions concerning accuracy of measurements, which included wither height, chest depth, body length, heart girth and paunch girth taken on animals in a Holstein herd at ages of six months, one year, two years, three years, four years, five years and seven years. Paunch girth was most accurate, followed by heart girth, wither height, chest depth and body length. It was concluded that single observations of each measurement at each measurement time are sufficiently accurate for practical purposes, but multiple measurements do increase accuracy and insure against gross reading errors.

CHAPTER III

EXPERIMENTAL PROCEDURES

I. SOURCE AND DESCRIPTION OF DATA

General

Two breeds of cattle, Angus and Polled Hereford, were used in this study. The Angus calves were produced at the University of Tennessee Plateau Experiment Station, Crossville, Tennessee, and the Polled Hereford calves at the University of Tennessee Tobacco Experiment Station, Greeneville, Tennessee. These calves were raised as part of the S-10 regional project. The data presented here were collected from calves born in 1968 through 1974. The numbers of calves in the study by year, breed, and sex are shown in Table I.

Management and Feeding

A limited breeding season was used at both stations, the calves being born in January, February, and March. Approximately July 1 of each year, the cows were segregated according to the sex of the calf they were nursing. The calves were kept with their dams, without creep feed, until they were weaned. After weaning, the calves were fed in dry lot. At this time the feeding regime of the heifer and bull calves changed. The heifer calves were fed daily a ration of corn silage *ad libitum*, two pounds of hay, two pounds of grain, and one-half pound of protein supplement each. This ration was designed to produce an average daily gain of about one pound per day which would consist of a limited amount of fat. The bull calves were fed a more liberal ration than the

TABLE I

NUMBER OF CALVES BY YEAR, BREED AND SEX

Year	Number of Calves						Grand Total
	Angus			Hereford			
	Bulls	Heifers	Total	Bulls	Heifers	Total	
1968	79	90	169	27	27	54	223
1969	70	69	139	20	18	38	175
1970	72	76	148	31	29	60	208
1971	88	71	159	44	32	76	235
1972	77	84	161	42	44	86	247
1973	94	78	172	50	45	95	267
1974	101	84	185	46	60	106	291
Totals	581	552	1133	260	255	515	1646

heifers. They were daily fed corn silage *ad libitum* with about two pounds of hay and about one pound of a 14 percent protein grain mixture per cwt of live weight. These rations were fed until the first of April. At that time the yearlings being added to the breeding herd were placed on pasture and no more supplemental feeding was provided until the next winter.

Data Collection

In the years since 1968 (1969-1974) three measurement periods were scheduled each year. The first collection was made when the calves were about 120 days old. It was performed in June or July of each year on the calves born in that year. The second collection was at weaning (weaning collection). It was performed in September or October on the calves born in that year. The third collection was the post-weaning collection. It occurred in February or March of the year following the calves' birth.

In 1968, three additional measurement collections were made. These measurements were collected in the periods between the three previously mentioned collections in such a way that one additional collection was made between the pre-weaning and the weaning collections and two additional collections were made between the weaning and the post-weaning collections.

Measurements taken included heart girth (HG), shoulder width (SWIDTH), hip width (HIP), chest depth (DEPTH), hip height (HT), and body length (LENGTH). The live weight (WEIGHT) and fat thickness (FAT) were recorded as well. The measurements were taken as described below:

HG–the circumfrence of the body just posterior to the front legs as measured with a metal tape measure.

SWIDTH–the horizonal distance between the points of the shoulders as measured with an incremented caliper.

HIP–the horizonal distance between the prominances of the hip bones as measured with a metal tape measure.

DEPTH–the vertical distance between the top and floor of the chest just posterior to the front legs as measured with an incremented caliper.

HT–the vertical distance between the ground and the top of the hips as measured with a metal standard.

LENGTH–the distance along the back as measured with a metal tape from the center of the top of the shoulder to the posterior end of the pin bones.

Each of these measurements was recorded either in centimeters or mathematically converted to centimeters from inches prior to analysis. Not all measurements were recorded each year. Weight was measured to the nearest five pounds but converted to kilograms prior to analysis. Fat thickness was measured between the twelfth and thirteenth ribs in centimeters using an ultrasonic device.

II. METHOD OF ANALYSIS

Data presented here were analyzed with the aid of an IBM 360/65 computer and the Statistical Analysis System (SAS) programs. Individual data records with one or more missing values were deleted.

Procedures and options within the SAS package that were incorporated into the anlysis included calculations of means, correlations, analyses of variance, simple regressions, multiple regressions, and stepwise regressions.

In calculating the stepwise regression, all of the default options of SAS were used, so that an intercept term was included, the significance level for entry of a variable into the equation was 0.50, and the significance level for a variable to remain in the equation at each step was 0.10.

Repeatabilities were calculated by pooling the variables by animal and using the ANOVA proceedure of SAS.

CHAPTER IV

RESULTS AND DISCUSSION

To give a general impression of the magnitudes and variation of the variables studied, the means and ranges are presented in Table II. The average of the weights is smaller than that in any of the studies reviewed by Johansson and Hildeman (1954).

Table III contains the correlations between variables and repeatabilities of the variables. As shown in this table, the variables most highly correlated with weight were DEPTH and HG. The manner in which these measurements were taken may explain in part the fact that HT was less highly correlated with WEIGHT than were the other variables. Because the calves were held in a head gate, they often fought this restraint by pulling away from the head gate. This resulted in a lower HT measurement on those calves that reacted in this manner. Since the weight would not be affected by this particular behavior; some error may have been introduced into the relationship between the two variables, and this error may well have been non-random.

Repeatabilities of the linear measurements and weight are presented in Table III as well. The range of these repeatabilities is from 0.9109 for DEPTH to 0.6760 for HIP.

Since the review by Johansson and Hildeman (1954) did not include shoulder width or chest depth, a thorough comparison with the present study is impossible. In their review, they concluded that heart girth alone was a sufficient estimator of weight. The present study confirms

TABLE II

AVERAGES OF THE VARIABLES INCLUDED IN THE STUDY

Variable	Number of Observations	Mean	Range Min.	Range Max.
SWIDTH	1224	35.83±0.12 cm	18.0 cm	52.0 cm
DEPTH	1224	48.69±0.12 cm	31.0 cm	63.0 cm
LENGTH	5553	93.01±0.14 cm	61.6 cm	121.9 cm
HIP	5552	35.04±0.08 cm	22.9 cm	50.8 cm
HT	2366	100.17±0.19 cm	71.0 cm	120.0 cm
HG	5553	136.16±0.23 cm	84.0 cm	180.3 cm
WEIGHT	5548	211.43±0.96 kg	39 kg	433 kg

TABLE III

CORRELATIONS[a] BETWEEN AND REPEATABILITIES[b] OF VARIABLES

	SWIDTH	DEPTH	LENGTH	HIP	HT	HG	WEIGHT
SWIDTH	0.8933						
DEPTH	0.8362	0.9101					
LENGTH	0.7648	0.9034	0.7904				
HIP	0.7856	0.9180	0.9057	0.6760			
HT	0.7029	0.8517	0.8720	0.8668	0.8182		
HG	0.8604	0.9561	0.9245	0.9139	0.8795	0.8538	
WEIGHT	0.8794	0.9504	0.8764	0.8814	0.8598	0.9338	0.8418

[a]Correlations off main diagonal.

[b]Repeatabilities on main diagonal.

that conclusion and indicates that chest depth is sometimes more useful in estimating weight than is heart girth. This is shown in Table IV. This table begins with equations having one independent variable and continues to an equation containing six independent variables. In the simple regression equations DEPTH yielded a slightly higher coefficient of determination (0.90) than HG (0.87). Thereafter, in the multiple regression equations, the equations with HG in them either show a higher coefficient than those containing DEPTH, or both variables are contained in the same equation.

The results of estimation of weight from linear measurements using squares of the measurements as well as the measurements in regression equations are shown in Table V. When this table is compared to Table IV, it becomes apparent that weight estimation using the quadratic term in addition to the linear term yields only a very small increase in the coefficient of determination.

In an effort to determine which variables would add information to a regression analysis of weight, the linear measurements were made available for possible inclusion in a stepwise regression equation. The equation which was created depended upon which variables were available. When all of the variables were available, the final equation included all variables except HT. The coefficient of determination for this equation was approximately 0.96. However, when all of the variables except HG were made available to the program, the resulting equation included HT and all of the other available variables, and the coefficients of determination were approximately 0.95.

TABLE IV

SIMPLE AND MULTIPLE REGRESSION EQUATIONS FOR PREDICTION OF WEIGHT FROM LINEAR MEASUREMENTS[a]

CONSTANT	DEPTH	SWIDTH	HT	LENGTH	HIP	HG	RECORDS	R^2
-378.86	12.46						1224	.9033
-288.22						3.67	5567	.8720
-179.18					11.16		5567	.7768
-242.52		13.13					1224	.7734
-271.62				5.20			5567	.7681
-462.61			6.72				2366	.7393
-371.10		2.56				3.63	1224	.9493
-383.22	3.45					3.17	1224	.9477
-353.88			0.39			3.85	2366	.9311
-379.19	9.38	4.21					1224	.9272
-348.34	8.09				4.85		1224	.9241
-293.58		5.82			8.33		1224	.9224
-407.33	9.34			1.87			1224	.9161
-431.13	10.83		1.29				1224	.9092
-398.27		6.68		4,02			1224	.9058
-482.68		8.33	4.03				1224	.8794
-280.42					2.15	3.06	5567	.8767
-293.31				0.54		3.35	5567	.8731
-309.48			1.78		9.44		2365	.8715
-427.86			2.18	4.46			2366	.8455
-244.27				2.58	6.17		5567	.8108
-355.39		2.74			2.96	2.67	1224	.9560
-393.21		2.69		1.23		2.90	1224	.9548
-382.72	3,13	2.37				2.67	1224	.9542
-369.42	2.75				2.10	2.75	1224	.9508
-397.69		2.73	0.64			3.31	1224	.9506
-395.35	2.78			0.82		2.92	1224	.9498
-389.18	3.39		0.15			3.12	1224	.9477
-351.16	5.58	3.91			4.45		1224	.9446
-406.13	6.51	4.09		1.77			1224	.9386
-328.08			0.04		2.74	3.19	2366	.9366
-358.03			-0.02	1.15		3.39	2366	.9354
-348.45		5.26		1.85	5.58		1224	.9342
-434.92	7.58	4.28	1.38				1224	.9339
-374.28		5.54	1.54		6.55		1224	.9310
-369.64	7.19			1.03	3.95		1224	.9272
-375.75	7.64		0.62		4.48		1224	.9254
-466.43		6.23	1.86	2.92			1224	.9185
-434.40	8.78		0.76	1.63			1224	.9179
-335.22			0.96	2.16	6.82		2366	.8862
-282.09				0.14	2.04	3.01	5567	.8768

TABLE IV (continued)

CONSTANT	DEPTH	SWIDTH	HT	LENGTH	HIP	HG	RECORDS	R^2
-366.60	2.28	2.57			2.45	2.14	1224	.9583
-373.94		2.79		0.83	2.26	2.41	1224	.9580
-396.96	2.31	2.53		0.96		2.35	1224	.9572
-370.75		2.82	0.35		2.81	2.55	1224	.9563
-404.46		2.77	0.30	1.16		2.79	1224	.9550
-399.47	2.93	2.50	0.42			2.52	1224	.9547
-380.19	2.44			0.55	1.70	2.66	1224	.9516
-368.01	2.76		-0.03		2.12	2.75	1224	.9508
-393.37	2.79		-0.05	0.83		2.94	1224	.9498
-385.45	4.97	3.98	0.77		3.98		1224	.9495
-372.20	4.70	3.90		1.01	3.56		1224	.9576
-437.79	5.81	4.15	0.89	1.49			1224	.9411
-336.46			-0.16	0.79	2.15	3.02	3465	.9383
-393.45		5.18	1.06	1.49	4.89		1224	.9379
-386.28	6.97		.42	.93	3.78		1224	.9278
-379.39	1.89	2.64		.66	1.98	2.02	1224	.9596
-376.35	2.20	2.63	.23		2.37	2.07	1224	.9585
-381.13		2.83	.18	.79	2.21	2.36	1224	.9581
-404.44	2.25	2.58	.20	.92		2.29	1224	.9573
-374.74	2.46		-.14	.58	1.73	2.69	1224	.9517
-395.35	4.36	3.96	.59	.88	3.32		1224	.9487
-383.84	1.86	2.67	.12	.63	1.95	2.00	1224	.9596

[a]To use this table for estimation of weight, choose the row which contains exactly the variables needed and no more or less. Then use recorded measurements (in centimeters), multiplying each measurement by the appropriate number in the table above. Then add the constant term. This results in the estimated weight in kilograms.

TABLE V

CURVILINEAR EQUATIONS FOR ESTIMATION OF WEIGHT FROM LINEAR MEASUREMENTS[a]

CONSTANT	HIP	HIP^2	SWIDTH	$SWIDTH^2$	HT	HT^2	LENGTH	$LENGTH^2$	DEPTH	$DEPTH^2$	HG	HG^2	RECORDS	R^2
36.504											-1.6035	.0208	5567	.9422
116.497									-8.4898	.2181			1224	.9163
415.300					-11.9875	.983							2366	.8422
55.116							-2.7522	.0469					5567	.8403
0.040	.1269	.1643											5567	.8017
-246.579			13.3616	-.0031									1224	.7734

[a]To use this table, find the equation for the desired measurement. Multiply the measurement (in kilograms) by the first term showing the measurement. Multiply the square of the measurement by the second term. Adding those two products and the constant term gives an estimate of weight (in kilograms).

The present research points out several things. Estimation of weight based upon linear measurements may be done with varying levels of accuracy, but in each of the cases studied the coefficient of determination was higher than the corresponding coefficient of non-determination (the complement of the coefficient of determination). Although, as pointed out by Brody (1945), weight is a curvilinear phenomenon, the results of this research are in close agreement with the conclusion of Johansson and Hildeman (1954) that little additional variation is explained by the addition of the quadratic term to regression equations for estimation of weight. It was casually observed, however, that on the extremes of the range of the data set, the estimated weight using the quadratic equation was more "believable" than the estimate from purely linear equations. Since the calves in this study were measured only up to a year of age, the relationships of measurements to weights is a changing one because the animals are growing both in linear form and in mass as well. This may influence the results of this study.

An interesting result of running the PROC REGR proceedure of SAS in a simple regression with no intercept is the rank of the variables with respect to the coefficient of determination. Under the conditions of the program, the HIP measurement becomes the best predictor of weight with DEPTH and HG less effective. This is shown in Table VI. It may be observed also that the coefficients of determination are of greater magnitude in the non-intercept equations than in the comparable intercept equations of Table IV. Because the lower limit of the variables studied here is considerably greater than zero, this regression analysis is of no practical use and is only of academic interest.

TABLE VI

SIMPLE REGRESSION EQUATIONS WITH NO INTERCEPT FOR ESTIMATION OF WEIGHT FROM LINEAR MEASUREMENTS[a]

DEPTH	SWIDTH	HT	LENGTH	HIP	HG	RECORDS	R^2
				6.17		5568	.9577
	6.51					1225	.9549
					1.59	5568	.9544
4.8						1225	.9532
			2.32			5568	.9480
		2.14				2367	.9300

[a]To use this table to estimate weight, first find the appropriate coefficient, then multiply that by the recorded measurement. The product is the estimated weight in kilograms.

The bulls were fed a ration higher in energy content than that fed the females and therefore gained faster than the females and, on the average weighed more at the end of the data collection period than did the females. The estimation of weight from measurements is different in the two sexes, which is shown in Tables VII and VIII. In every case but one the equation for the male is a more accurate predictor of weight than the corresponding female equation. The one exception is the HT equation which, as was pointed out earlier, may be influenced a great deal by the animal's temperament. It is well recognized that bulls are, on the average, more agressive than heifers. This could explain the exception. It should be pointed out also that the ranking of the equations is not the same for the two sexes when the equations are ranked on the basis of their coefficients of determinations. This is a reflection of some of the biological differences that exist between bulls and heifers.

As a comparison of Tables VII and VIII shows, the regression coefficients calculated using the data from bulls are different from those calculated using the data from heifers. Although no tests of significance of this difference were performed, the tendency is for the B value for bulls to be larger than that for heifers with respect to each of the independent variables. Since the management of the bulls was different from that of the heifers during part of the period, no tests of significance of sex difference were performed because sex and management were confounded.

A nested regression of WEIGHT on HG with FAT held constant was performed on the records which had somascope readings of fat thickness

TABLE VII

REGRESSION EQUATIONS FOR BULLS[a]

CONSTANT	DEPTH	SWIDTH	HT	LENGTH	HIP	HG	RECORDS	R^2
-421.18	13.5						631	.9341
-297.10						3.79	2821	.8808
-274.13		13.94					631	.8308
-197.34					12.05		2821	.8212
-289.07				5.49			2821	.7892
-510.37			7.29				1200	.7477

[a]To estimate weight from a linear measurement find the corresponding line above. Multiply the measurement (in centimeters) by the appropriate term above and add the constant term to that product. The final product is the estimated weight (in kilograms).

TABLE VIII

REGRESSION EQUATIONS FOR HEIFERS[a]

CONSTANT	DEPTH	SWIDTH	HT	LENGTH	HIP	HG	RECORDS	R^2
-292.74	10.46						593	.9086
-254.25							2746	.8689
-142.89					9 72		2746	.7829
-377.68			5.76				1166	.7661
-226.48				4.59			2746	.7646
-191.25		11.68					593	.6092

[a]To estimate weight from a linear measurement find the corresponding line above. Multiply the measurement (in centimeters) by the appropriate term above and add the constant term to that product. The final product is the estimated weight (in kilograms).

to determine whether the conclusion reached by Johansson and Hildeman (1954) was true for these data. The equation derived from this analysis showed, as Johansson and Hildeman had stated, that with a given heart girth, the fatter the animal, the greater the weight. This increase in weight amounted to about one-half kilogram for each centimeter increase in heart girth. The variation explained by this equation was significant ($P < 0.0001$).

The following conclusions are warranted.

1. Using two or more measurements to estimate weight is no more accurate than using heart girth or chest depth alone.

2. Regression of body weight on each of the measurements was greater in bulls than in females. However, no tests for significance of this sex difference in regression were performed.

3. Depth was shown to have the closest affinity (highest correlation) to weight. Heart girth was second, but there was little difference between these two.

4. A linear regression equation estimates weight quite adequately. However, an equation having both the variable and the square of the variable seemed to estimate weight more accurately at the extremes of the data range.

5. It was determined that when heart girth was held constant, live weight increased with increased condition. This increase amounted to approximately one-half kilogram for each centimeter increase in heart girth.

The preceding conclusions agree closely with those of Johansson and Hildeman (1954). In addition, the following conclusions were reached.

1. Chest depth had the highest repeatability of the measurements studied. Heart girth was third, falling behind both shoulder depth and shoulder width.

2. The bull calves' coefficient of determination was higher than that from heifers for each of the linear measurements. The one exception was the hip height measurement.

These results indicate that, as has been known for a long time, heart girth is a very good estimator of weight. They indicate also that shoulder depth is sometimes better than heart girth in estimating weight. These facts bring up a point of practical importance, which is: Just how much trouble are some of these measurements to collect relative to each other and to their reliability as estimators of weight? For one person to take a heart girth reading, he must of necessity bend over the animal in order to pass the tape around the animal's body. During this time the person is vulnerable to injury from quick movements of the animal. The design of many squeeze chutes is such that injury to the back is possible in this situation due to being pinned against the frame. On the other hand, to take a reading of the chest depth of an animal, a person stands completely to the side of the animal, thus reducing the chance of injury. The other measurements require varying degrees of contact with the animal between those required for heart girth and chest depth or the same as these measurements. On this basis, chest depth would appear to be the preferred measurement to take on calves. However, another consideration must be the equipment necessary to determine the measurements. The caliper and standard necessary to measure shoulder width, chest depth and hip height are expensive when compared to the cost of the metal tape necessary for the other measurements, although all of these are inexpensive when compared to the cost of weight scales. In view of all this, the heart girth measurement may be the preferred one.

CHAPTER V

SUMMARY

Body measurements, including heart girth, body length, shoulder width, hip width, hip height, and chest depth were recorded on both Angus and Polled Hereford calves. These measurements were studied individually and in combination to assess their value in estimation of live weight. The Angus calves used in this study were raised at the University of Tennessee Plateau Experiment Station, Crossville, Tennessee, while the Polled Hereford calves were raised at the University of Tennessee Tobacco Experiment Station, Greeneville, Tennessee. The calves were born in the years 1968 through 1974.

More than 5,000 sets of records were taken from more than 1,600 different calves. A total of 63 simple and multiple regression equations were constructed. In addition, a number of stepwise regression analyses were conducted. When all of the variables were available to the program for possible inclusion as independent variables to estimate weight, the final equation would include all of the variables except hip height; and the coefficient of determination would be about 0.96. When all of the variables except heart girth were available for inclusion, the final equation would include all of them; and the coefficient of determination would be about 0.95.

Chest depth was most highly correlated with weight (0.95), and heart girth was second (0.93). Hip height was found to be the variable least correlated with weight (0.86). The mean weight of calves studied was 211 kg with the range being 39 to 433 kg.

It was concluded that in Angus and Polled Hereford calves weighing from 39 to 433 kg, an accurate estimation of weight could be made by using either chest depth or heart girth alone, but the coefficient of determination could be increased by adding additional measurements. However, the small increase in predictive value would not be justified in practice.

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VITA

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