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The repeatability of live-animal and photographic measurements of beef cattle

William Mark Whitaker

To the Graduate Council:

I am submitting herewith a thesis written by William Mark Whitaker entitled "The repeatability of live-animal and photographic measurements of beef cattle." 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 Husbandry.

Charles S. Hobbs, Major Professor

We have read this thesis and recommend its acceptance:

E Winters, Harold J. Smith

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

August 1, 1950.

To the Committee on Graduate Study:

I am submitting to you a thesis written by William Mark Whitaker entitled, "The Repeatability of Live-Animal and Photographic Measurements of Beef Cattle." I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Charles S. Hobbs
Major Professor

We have read this thesis
and recommend its acceptance:

E. Winters

Harold J. Smith

Accepted for the Committee

C. V. Watkins
Dean of the Graduate School

THE REPEATABILITY OF LIVE-ANIMAL AND PHOTOGRAPHIC MEASUREMENTS OF BEEF CATTLE

A THESIS

Submitted to
The Committee on Graduate Study
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by
William Mark Whitaker

August 1950

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W.M.W.

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INTRODUCTION

The Southern Regional Beef Cattle Breeding Project "Improvement of Beef Cattle for Southern Regions through Breeding" was initiated in 1948, with 10 Southeastern land grant colleges actively cooperating with the Bureau of Animal Industry, for the purpose of studying methods of improving the beef breeds of cattle in the Southern states.

It was necessary to keep a uniform set of records to evaluate the animals included in this study. With the leaders of this project located at the various colleges it was apparent that they would not all be able to evaluate every animal included in the study. It was, therefore, necessary to keep records that were descriptive enough to evaluate the breeding worth of the cattle. Linear measurements have been used to a considerable extent in describing animals and studying changes in size and shape during growth and development. Statistical studies by Lush and Copeland (1930) have shown this technique of measuring animals to be almost completely objective and the results to have a higher accuracy than was at first expected. Some measurements, however, were dependent upon the position of the animal measured, and different men apparently used different techniques in obtaining their measurements which led to considerable variation. Observations indicated that there were considerable variations in the general appearance of animals, although there were only slight differences in actual linear measurement. It was further found that it was

difficult to visualize an animal from linear measurements. Also, linear measurements require considerable time and expense to get representative figures. The animals must be halter broken and trained to stand. Many animals are nervous and never completely become accustomed to handling. The measurements from such animals are apparently not highly repeatable.

The use of photographs as an objective, permanent, visual record was believed worthy of study. The present study was undertaken to ascertain the value of photographs in obtaining body measurements as compared to live-animal measurements. Statistical analysis was used to evaluate the relative accuracy and repeatability of body measurements obtained by the two methods. It was recognized from the beginning that a single photograph could not be used to obtain width and round plus side view measurements. All photographs were of the side view.

This study of the repeatability of photographic and live-animal measurements shows that the measurements obtained by the two methods of measurements are almost equally repeatable, with the photographic measurements in general having a slightly higher repeatability.

REVIEW OF LITERATURE

Lush and Copeland (1930) found that single linear measurements were accurate enough to obtain significant differences between dairy cattle but averages of two or more measurements were more accurate. Phillips and Dawson (1936) in comparing three different types of linear measurements found that measurements taken directly from the animal were more accurate than those obtained from photographs or by a scaling instrument. Phillips and Stoche (1945) working with sheared sheep found that measurements obtained from live-animals were more accurate than those obtained from photographs using their techniques. Touchberry and Lush (1950) reported that certain body measurements of dairy cattle were highly repeatable and that a single measurement was sufficient.

MATERIAL AND METHODS

A. Equipment

A "Bovine Photographic chute"[1] was used in the photographing of each animal. This photographic chute was mounted on two removable wheels and had a trailer hitch so that it was completely portable. The chute was of steel construction and consisted of a grid side, a solid movable side and sliding doors at each end. One of the doors was equipped with a head gate. The side grid was constructed of 5/8 inch steel bars welded together to form a 6 by 12 inch mesh screen. The lower 48 inches of this screen was reduced to a 3 x 6 inch mesh by vertical and horizontal 3/8 inch steel bars welded into the above grid. The overall size of the grid was 72 inches by 96 inches.

The side opposite the grid consisted of a solid sheet of 3/16 inch steel plate mounted in a 1 7/16 inch angle iron frame. This side was mounted on four screws, one at each corner, and was fitted with a cog-chain drive. A 1/4 horse power reverse cycle single phase motor was mounted on the frame of the chute to operate the screws, thereby increasing or decreasing the distance between the sides as desired, from a minimum of 4 inches to a maximum of 36 inches. A

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[1]This chute was designed by Dr. C. S. Hobbs of the Animal Husbandry Department, University of Tennessee, in cooperation with J. A. Ewing and M. L. Chandler of the Middle Tennessee Experiment Station, University of Tennessee, and was constructed by M. L. Chandler.

crank could also be used in emergencies or if desired. This movable side made it possible to minimize photographic distortion by holding the animal as close to the stationary grid as possible.

All photographs were taken with the same Speed Grapic "45" camera (4 x 5 inch). A "Kodak Super - XX high speed panchromatic" film pack was used. All photographs were taken inside a barn with artificial lights after preliminary work indicated the necessity of avoiding shadows and variable weather. The artificial lights consisted of two stands containing 3 bulbs each. These lights were controlled by the use of a transformer which could increase the power of the par 38 projector flood bulbs from a low of 150 watts to a high of 750 watts each. The artificial lights had a trade name of "Colortran" and were manufactured by the Colortran Convertor Company, Los Angeles, California. The lights were focussed in such a manner as to minimize shadows.

Length, depth and height live-animal measurements were taken by the use of wooden linear calipers graduated in centimeters divided into tenths from zero to two hundred. Round measurements were read from a steel tape graduated in inches, divided into sixteenths of an inch, from zero to seventy two inches. All measurements were taken while the animal was standing on a level wooden platform.

B. Animals

Ten cows, twenty-three yearlings and ten calves, making a total of forty three animals were used. The cows consisted of purebreds, five

of which were Angus, three Shorthorn, and two Hereford. The yearlings and calves were purebred Angus and Hereford for the most part but some Shorthorn-Angus and Shorthorn-Hereford crosses were also used. Ten of the yearling and the ten calves represented two calf crops of the ten cows. These animals from the University of Tennessee college herd had been, with the exception of the calves, handled for class instruction and were gentle and easily managed.

C. Methods of Obtaining Photographs and Measurements

The camera was mounted on a tripod and set up thirteen feet from the front of the grid and two feet behind and between the artificial lights. The lens was focussed on a point made by the crossing of the horizontal 36 inch bar and the vertical 48 inch bar. The "f" stop was set between 5.6 and 7.3 and the shutter speed was set at a twenty-fifth of a second. Two photographs were taken of each animal while standing in the photographic chute. The movable side wall was adjusted so as to hold the animal snugly but not tight against the grid. Reference points were marked on each animal with a thick paste of whitewash to indicate the point of the shoulder and the point of hooks as an aid in obtaining photographic measurements. Attention was given to obtaining a normal standing position, with the feet placed squarely under the body and the head up, before taking each photograph. The position was changed for each photograph. Immediately after the second photograph was taken the animal was haltered and led on to the wooden platform where the live-animal measurements were taken. Each

live animal measurement was taken by each of two men. There was no particular order observed in obtaining each measurement or in the order taken by each man. This procedure of taking photographs and measurements was followed both in the morning and in the afternoon of the same day for each animal for each series. There was approximately a two weeks period between the two series. There was no known tendency for either man to remember the measurement between the times of day or between series.

The photographs were developed under the direction of the Editor of the University of Tennessee Extension Service. An eight by ten enlargement was made of each 4 x 5 negative with an Omega enlarger equipped with a Wallensak lens after preliminary studies had shown that 4 x 5 prints were not large enough for detailed measurements. Each of the two men measured one morning photograph and one afternoon photograph of each series. An engineering rule graduated in inches, divided into thirty seconds, was used to measure the animal in each photograph (Figs. 1, 2 and 3). Photographic and enlargement distortion was taken into account and a measurement factor was calculated for each individual photograph in order to eliminate this distortion. This factor was calculated in the following manner: The actual distance between two points on the grid was determined in inches, the number of 32nd of an inch between these two points was measured on the photograph and was divided into the actual grid distance. This quotient was multiplied by 2.54 to convert inches to centimeters.

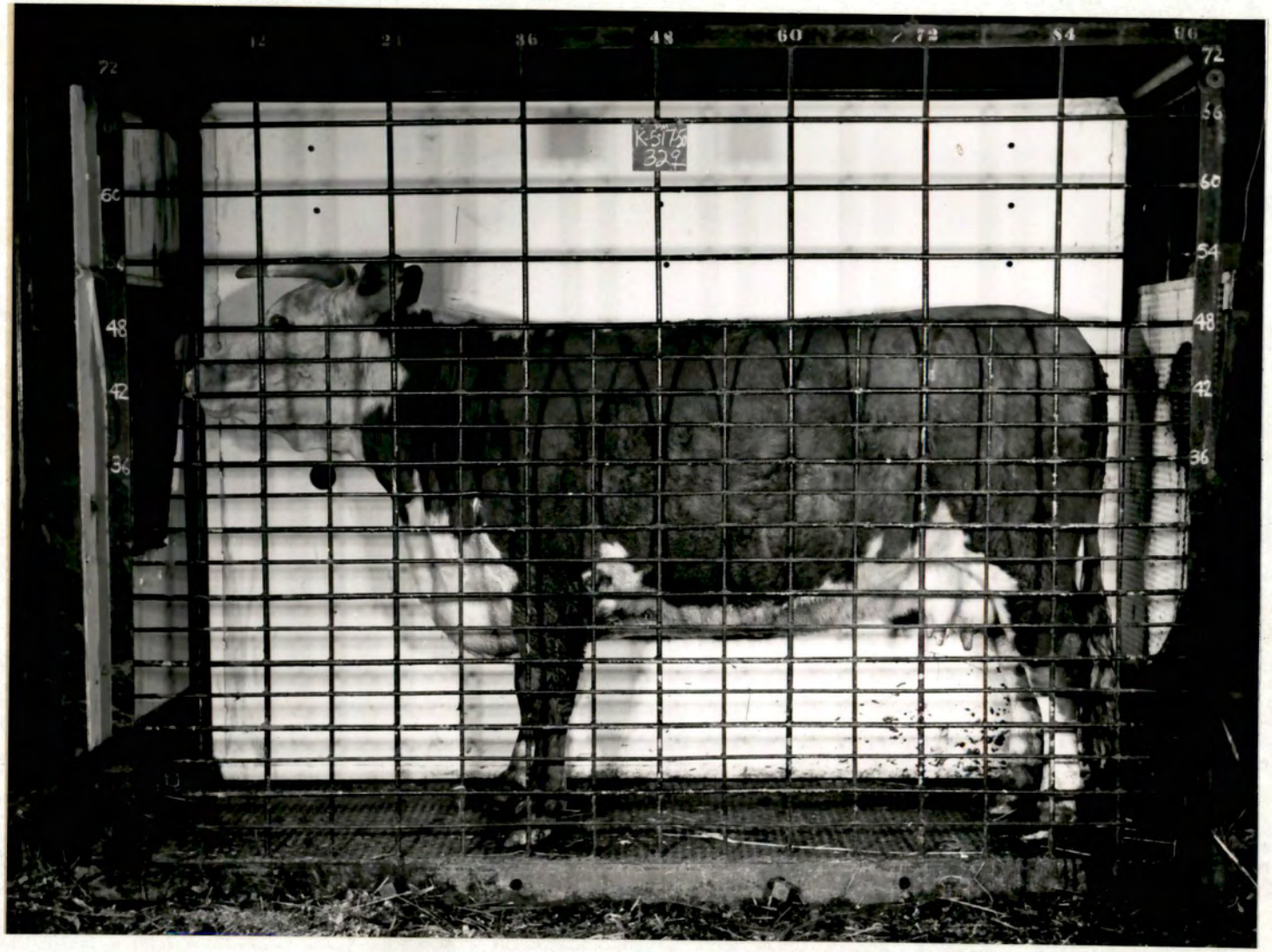

Figure 1. Cow in photographic chute

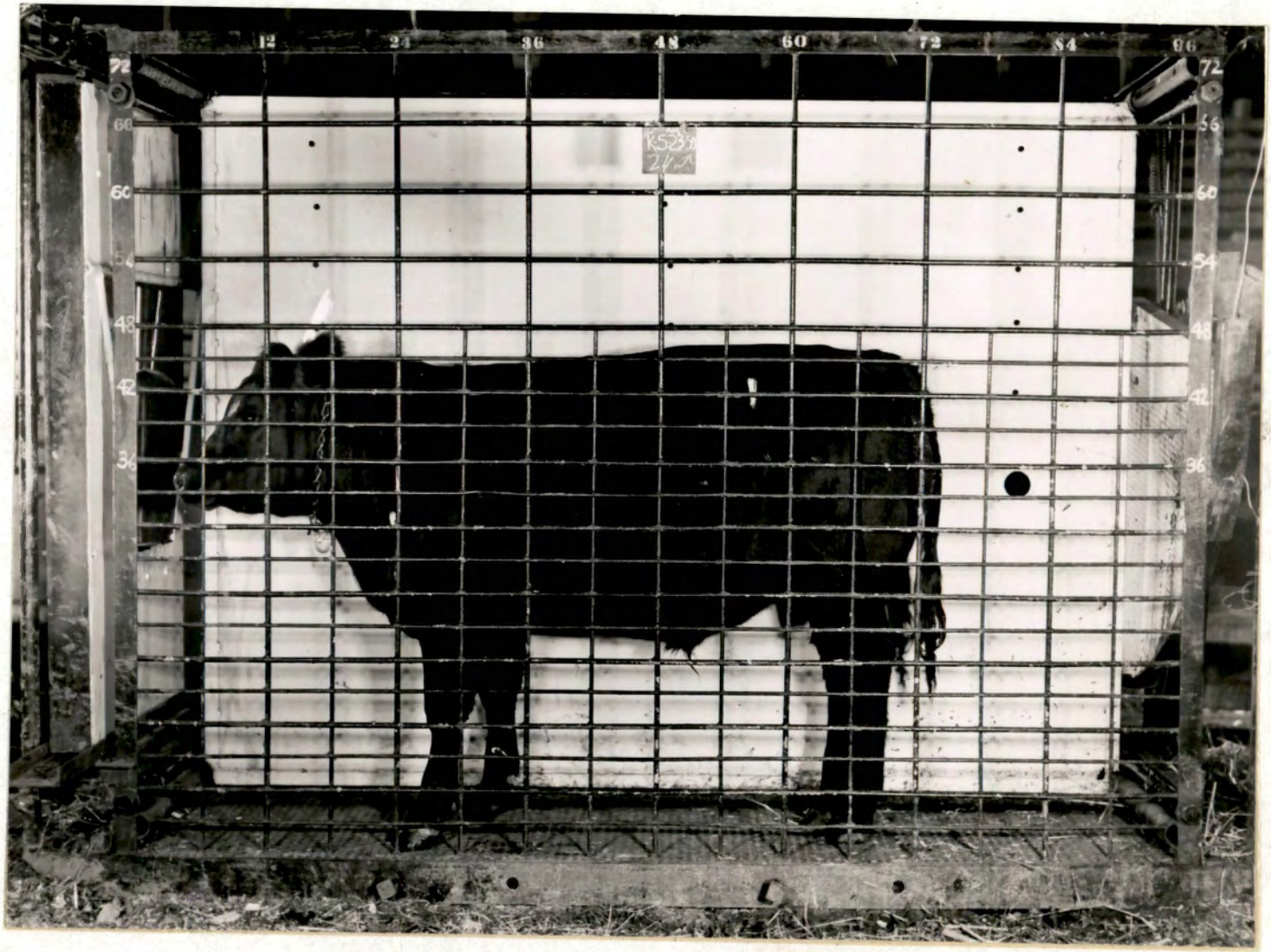

Figure 2. Yearling in photographic chute

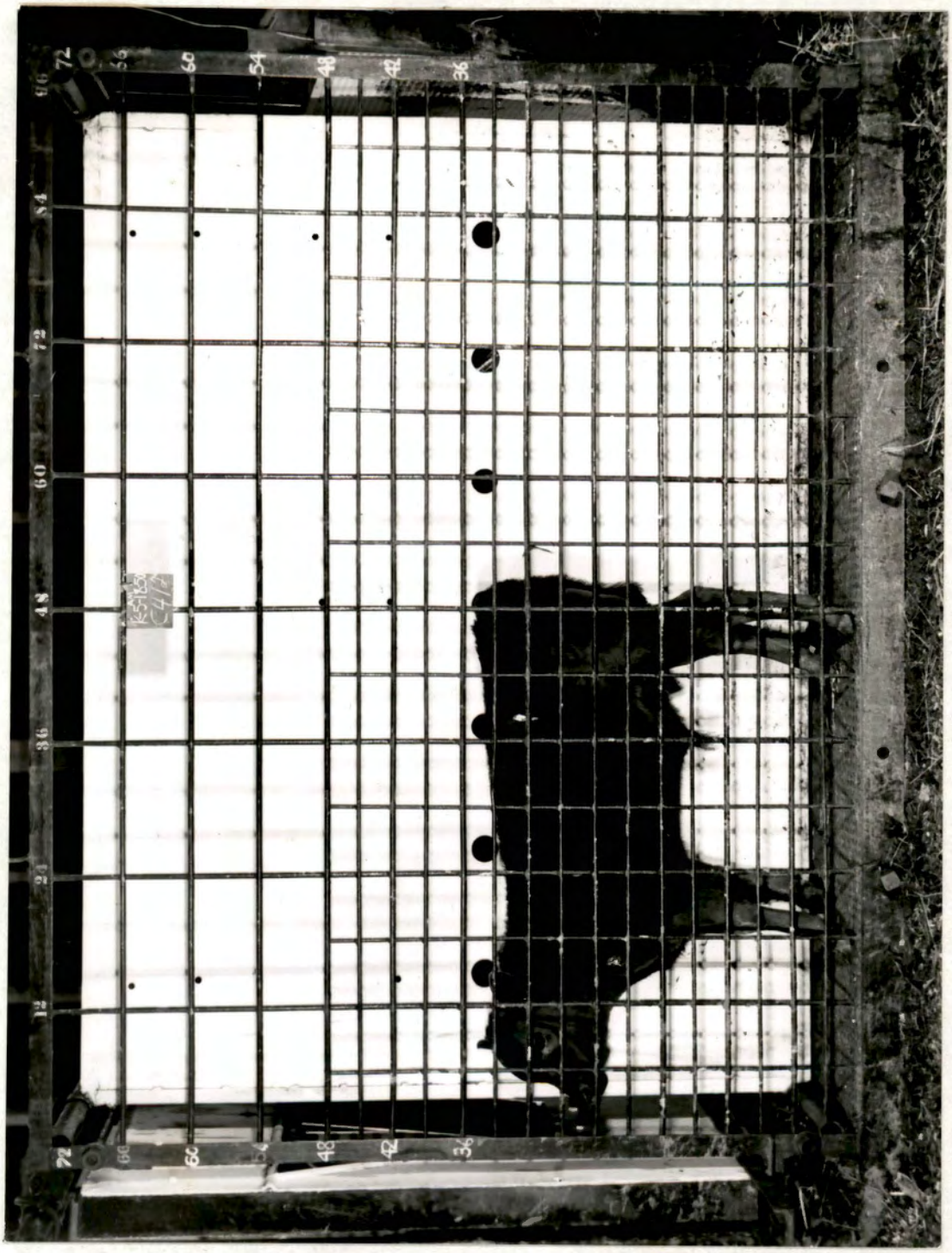

Figure 3. Calf in photographic chute

Thus $\frac{A}{B} \times 2.54 = C$, where C equals the measurement factor in centimeters, A equals grid distance between two points in inches, and B equals photographic distance between the same grid points in 32nd of an inch. When the photographic measurements in 32nd of an inch were multiplied by the measurement factor the actual measurement of the animal in centimeters was obtained. In all photographs the measurement factor was obtained from points that would enclose the subject to be measured. Two measurement factors were determined for each photograph, one for vertical measurements and one for the diagonal measurement.

Photographic measurements were obtained for height at the withers, depth at the heart girth, and length from the point of the shoulders to the point of the pin bones. Live-animal measurements were obtained for eleven measurements, but only four were used in this study. They included the three used in photographic measurements plus a round measurement from patella to patella. Live-animal and photographic measurements for height at the withers, depth at the heart girth and length of body from shoulder point to pin bones were analyzed statistically. The round measurement, from patella to patella, was analyzed statistically for live-animal measurements.

RESULTS AND DISCUSSION

In order for photographic measurements to be of value, they should be as repeatable as live-animal measurements. Further, both methods should measure the same thing. It was assumed that photographic and live-animal measurements were equally repeatable and were measures of the same thing. This hypothesis was not disproved, and in general the photographic measurements were slightly more repeatable. With but one possible exception, there was no reason to believe that the two methods of measurement were not measuring the same thing.

Differences between the means of live-animal and photographic measurements with the standard deviation of the means are shown in Table I. The differences are not, for the most part, significant.

In the case of the length of body measurement for the cows there is a significant difference with the live-animal measurements being larger in both series. There is no indication in the data as to which method is the more accurate, although the photographic measurements (Table III) have a slightly higher repeatability. Correlation coefficients between averages of morning and afternoon live-animal and photographic measurements (Table IV) indicate that the two methods were not, necessarily, measuring the same thing.

The differences between live-animal and photographic measurements for the yearlings were not significant. It was observed that live-animal measurements for length of body tended to be larger than photographic measurements in the larger animals. The calves were not accustomed to handling and were difficult to manage during the process

TABLE I

MEANS OF LIVE-ANIMAL AND PHOTOGRAPHIC MEASUREMENTS OF THE VARIOUS AGE GROUPS FOR EACH OF THE TWO SERIES

Age groups and items measured	First series				Difference live-animal photographic measurements
	Live-animal measurements		Photographic measurements		
	Mean	Standard deviation[1]	Mean	Standard deviation[1]	
Cows:					
Length of body (cm)	149.0	2.54	143.9	2.52	5.1**
Height at withers (cm)	120.7	3.57	120.6	3.64	.1
Depth of chest (cm)	69.3	1.81	68.5	2.10	.8
Patella to patella (cm)	99.8	1.86			
Yearlings:					
Length of body (cm)	123.4	4.33	121.1	3.86	2.3
Height at withers (cm)	108.2	3.60	109.4	3.57	-1.2
Depth of chest (cm)	59.0	1.82	59.6	1.52	- .6
Patella to patella (cm)	91.0	4.85			
Calves:					
Length of body (cm)	80.0	4.69	81.7	4.22	-1.7
Height at withers (cm)	75.6	3.96	80.2	3.46	-4.6*
Depth of chest (cm)	35.6	2.24	39.8	1.76	-4.2**
Patella to patella (cm)	66.0	2.83			
	Second series				
Cows:					
Length of body (cm)	149.5	3.94	143.4	3.23	6.1**
Height at withers (cm)	121.1	3.70	121.0	2.96	.1
Depth of chest (cm)	69.6	1.90	68.5	1.78	1.1
Patella to patella (cm)	100.6	2.73			
Yearlings:					
Length of body (cm)	124.8	5.38	123.2	4.33	1.6
Height at withers (cm)	109.0	3.68	110.6	3.49	-1.0
Depth of chest (cm)	59.	2.59	60.5	1.84	-1.5
Patella to patella (cm)	91.5	4.03			
Calves:					
Length of body (cm)	83.3	4.92	84.2	3.56	- .9
Height at withers (cm)	79.4	3.64	83.4	3.08	-4.0*
Depth of chest (cm)	37.7	2.12	40.6	1.80	-2.9**
Patella to patella (cm)	67.6	2.93			

* Significant at the .05 level
** Significant at the .01 level
1 Standard deviation between animals

TABLE III

VARIANCE COMPONENTS AND REPEATABILITY ESTIMATES

Age groups and items measured	Variance components[1]					Repeatability	
	E	D	C	B	A	Both series[2]	Av. series[1] +series II[3]
Live-animal measurements							
Cows:							
Length of body	-.09	-.17	.08	7.87**	7.94	.504	.546
Height at withers	.01	.01	.34	11.09**	1.75	.840	.889
Depth of chest	.03	.01	.08	3.33**	.73	.797	.784
Patella to patella	.24	-.01	-.08	2.56*	5.40	.316	.463
Yearlings:							
Length of body	.45*	.17	.31*	22.39**	8.42	.705	.762
Height at withers	.18	.01	.03	12.01**	1.35	.884	.906
Depth of chest	-.01	-.01	-.01	6.86**	.75	.905	.914
Patella to patella	.04	-.03	.08	15.79**	7.65	.671	.769
Calves:							
Length of body	7.02**	-.11	.04	17.55**	4.39	.607	.898
Height at withers	6.98**	-.02	-.02	14.01**	1.79	.616	.888
Depth of chest	2.25**	-.01	-.01	4.65**	.57	.624	.890
Patella to patella	1.16**	-.04	1.16**	6.90**	1.67	.634	.708

* Significant at the .05 level

** Highly significant at the .01 level

1 See table II for meaning of variance components

2 Based on the combined data for the two series, 8 measurements per animal. Total variance includes differences between series. Where differences between series are partly due to growth, these figures would underestimate the true value for repeatability of the various measurements.

3 Average of within series estimates of repeatability based on 4 measurements per animal for each series. These figures are taken as representing the more accurate estimates of repeatability in this study.

TABLE III

VARIANCE COMPONENTS AND REPEATABILITY ESTIMATES (Contd.)

Age groups and items measured	Variance components[1]					Repeatability	
	E	D	C	B	A	Both series[2]	Av. series[1] +series II[3]
Photographic measurements							
Cows:							
Length of body	.02	-.03	.02	7.38**	3.06	.706	.726
Height at withers	.04	.02	.03	10.44**	1.27	.889	.918
Depth of chest	-.01	.04	.04	3.46**	.57	.844	.908
Yearlings:							
Length of body	2.28**	.29**	-.02	15.65**	3.19	.732	.844
Height at withers	.77**	-.02	-.01	11.83**	1.45	.844	.908
Depth of chest	.46**	-.01	.02	4.87**	1.11	.755	.841
Calves:							
Length of body	2.99**	.12	.07	15.78**	3.34	.708	.841
Height at withers	4.95**	-.00	-.03	10.40**	1.13	.632	.927
Depth of chest	.35**	-.03	.02	2.71**	1.07	.658	.807

* Significant at the .05 level

** Highly significant at the .01 level

1 See Table II for meaning of variance components

2 Based on the combined data for the two series, 8 measurements per animal. Total variance includes differences between series. Where differences between series are partly due to growth, these figures would underestimate the true value for repeatability of the various measurements.

3 Average of within series estimates of repeatability based on 4 measurements per animal for each series. These figures are taken as representing the more accurate estimates of repeatability in this study.

TABLE IV

SIMPLE CORRELATION COEFFICIENTS BETWEEN AVERAGES FOR VARIOUS ITEMS MEASURED BY DIFFERENT METHODS AND AT DIFFERENT TIMES OF DAY

Age groups and items correlated	First series				Second series			
	Body length	Ht. at withers	Depth of chest	Patella to patella	Body length	Ht. at withers	Depth of chest	Patella to patella
Cows:[1]								
Av. A.M. photos - Av. P.M.photos	+.64	+.97	+.96		+.88	+.91	+.95	
Av. A.M. photos - Av. A.M.mes.	+.52	+.90	+.74		+.71	+.80	+.86	
Av. A.M. photos - Av. P.M.mes.	+.61	+.86	+.93		+.95	+.92	+.87	
Av. P.M. photos - Av. A.M.mes.	+.58	+.89	+.77		+.61	+.73	+.75	
Av. P.M. photos - Av. P.M.mes.	+.59	+.86	+.89		+.51	+.85	+.71	
Av. A.M. mes. - Av. P.M.mes.	+.49	+.97	+.86	+.51	+.82	+.95	+.91	+.74
Yearlings[2]								
Av. A.M. photos - Av. P.M.photos	+.92	+.95	+.90		+.84	+.97	+.87	
Av. A.M. photos - Av. A.M.mes.	+.82	+.96	+.79		+.71	+.96	+.75	
Av. A.M. photos - Av. P.M.mes.	+.76	+.96	+.77		+.90	+.88	+.83	
Av. P.M. photos - Av. A.M.mes.	+.84	+.96	+.89		+.64	+.95	+.90	
Av. P.M. photos - Av. P.M.mes.	+.82	+.97	+.84		+.85	+.90	+.89	
Av. A.M. mes. - Av. P.M.mes.	+.74	+.96	+.95	+.78	+.73	+.91	+.92	+.86
Calves:[1]								
Av. A.M. photos - Av. P.M.photos	+.83	+.96	+.92		+.96	+.99	+.97	
Av. A.M. photos - Av. A.M.mes.	+.92	+.96	+.77		+.82	+.86	+.57	
Av. A.M. photos - Av. P.M. mes.	+.86	+.95	+.88		+.74	+.91	+.72	
Av. P.M. photos - Av. A.M. mes.	+.88	+.97	+.93		+.90	+.85	+.47	
Av. P.M. photos - Av. P.M. mes.	+.83	+.95	+.91		+.79	+.92	+.63	
Av. A.M. mes. - Av. P.M. mes.	+.85	+.95	+.97	+.97	+.74	+.84	+.92	+.77

1 Value of .632 necessary for significance at .05 level, .765 at .01 level
2 Value of .413 necessary for significance at .05 level, .526 at .01 level

of taking live-animal measurements. They tended to fight the halter and would fall back against it; this caused them to have their feet braced forward and not squarely under them. The calves also had a heavier coat of hair than any of the other groups. A combination of these two reasons probably accounts for a large portion of the differences in depth of body and height at the withers between live-animal and photographic measurements. The photographic measurements were slightly more repeatable for height of withers, and the live-animal measurements were more repeatable for depth of chest.

The repeatability or correlation of single measurements on the same animal was calculated for each measurement to determine the relative accuracy and repeatability of the various measurements obtained by the two methods studied.

The general form of analysis used was the same as that used by Hetzer et. al. (1950) in their study of the relationship between body and carcass characteristics of swine. The analysis of variance for the various body measurements obtained by the two methods, involved the segregation of the specific sources of variance and the principles of intra-class correlation. The repeatability of measurements furnishes information as to which method of obtaining measurements was the most reliable, and provides a method of determining the number of observations necessary to arrive at a reasonably accurate estimate of repeatability for a particular body measurement. An example of the method used is shown in Table II. This table shows the analysis of variance for live-animal length of body measurements for twenty-three yearlings which

TABLE II

ANALYSIS OF VARIANCE IN BODY LENGTH FOR THE 23 YEARLINGS WHICH WERE EACH MEASURED TWICE BY EACH OF TWO MEN, ONCE EACH IN THE A.M. AND ONCE EACH IN THE P.M., FOR EACH OF TWO SERIES (LIVE-ANIMAL MEASUREMENTS)

Source of variation	Degrees of freedom	Mean squares	Composition of Mean Squares		
Total	183	30.42			
Series	1	50.00*	A + 92E	E =	.45
Time of day	1	24.00	A + 92D	D =	.17
Men	1	37.00*	A + 92C	C =	.31
Animals	22	187.50**	A + 8B	B =	22.39
Error	158	8.42	A	A =	8.42

A - variance due to interaction components
B - variance due to difference between animals
C - variance due to differences between measurements of the two men
D - variance due to differences in time of day measurements
E - variance due to differences between measurements of the two series

Repeatability[1] between single measurements on the same animal = $\frac{B}{A+B+C+D+E} = 0.705$

* Significant at the .05 level
** Highly significant at the .01 level
1 This estimate includes the variance due to differences between series and may underestimate the true value if part of the differences between series is due to growth.

were measured by each of two men in the morning and repeated again in the afternoon of the same day for each of two series separated by approximately two weeks.

The variance components with the estimates of repeatability for the various measurements studied are given in Table III. The estimates of repeatability for length of body was considerably more variable than either the depth of chest or the height at withers, with a range of .546 for the cows to .898 for the calves. The photographic measurements were more repeatable for cows and yearlings, but the live-animal measurements were slightly more repeatable for calves for length of body. For height at withers the range of variation of repeatability was from a low of .888 in the live-animal calf measurements to a high of .927 in the photographic calf measurements. The photographic measurements were more repeatable in all three age groups for the height at withers. The photographic measurements were more repeatable for depth of chest in the cows. However, live-animal measurements for the yearlings and calves for depth of chest were more repeatable. The range of variation for depth of chest was from .807 to .914, the low figure being for photographic measurements for calves and the high figure being for yearling for live-animal measurements.

Data for a round measurement from patella to patella obtained by the live-animal measurement method was analyzed. The estimate of repeatability for this measurement was lower than any of the other measurements analyzed in this study. The variation was considerable

and ranged from a low of .463 for the cows to a high of .769 for the yearlings.

A study of the variance components in Table III shows that the relative accuracy of the various measurements was primarily a function of the interaction components. The relatively large variation between series in calves and yearlings is probably due to growth and development during the interval between series. The variation between measurements taken at different times during the day were too small to be of significance in all but one case. In only two cases was the variance significant between measurements of the two men.

To determine whether the two methods of measurement were measuring the same thing, correlation coefficients between the averages for the various items measured by different methods and at different times of day were calculated. These correlation coefficients are shown in Table IV. Approximately 85 per cent of the correlation coefficients are above the .01 level of significance and only 7 percent are below the .05 level of significance. The majority of the correlation coefficient that are below the .05 level are for the length of body measurements for the cows which have been mentioned previously. In studying Table IV it seems reasonable to believe that the two methods are measuring the same thing for the majority of the measurements. The high percentage of highly significant correlation coefficients indicates in general that the two methods of measurements are highly repeatable although there is no proof as to absolute accuracy. The correlations obtained between average morning and afternoon measurements within a method of measurement

tend to be higher than correlations obtained from various combinations of time between methods. This indicates that between the two methods of measurement there was fairly close agreement, but does show that there is some variation. It is indicated that in the case of length of body for the cows that there may be a difference in the items measured.

SUMMARY

In this study of repeatability of live-animal and photographic methods of measurements of beef cattle, forty three animals representing three age groups were used. Analysis of the data was made to determine estimates of repeatability of single measurements. Body measurements of length of body from shoulder point to pin bones, depth of body at the heart girth, height of the withers and a round measurement from patella to patella were used. Estimates of repeatability for the three age groups varied from .546 to .898 for body length in the live-animal measurements and from .726 to .844 for body length in photographic measurements. The height at the withers repeatability estimates ranged from .888 to .906 for live-animal measurements and .908 to .927 for photographic measurements. The depth at heart girth ranged from .784 to .914 for live-animal measurements and .807 to .908 for photographic measurements. Repeatability estimates for the patella to patella measurement were lower than either of the other live-animal measurements and ranged from .463 for the cows to .769 for the yearlings.

Size of animals did not appear to have any influence upon the errors of measurement, although the difference between methods for the length measurement had a tendency to be greater for larger animals. The estimates of repeatability including both methods of measurement ranged from .546 to .918 for the cows, .762 to .914 for the yearlings and .807 to .927 for the calves. This excludes the patella to patella measurements which could only be obtained by the live-animal measurement method.

Estimates of repeatability were slightly higher for photographic measurements in six of the nine comparisons studied with the greatest differences occurring in the length of body measurements for the cows. The three live-animal measurements that gave higher estimates were for length of body in calves and depth at heart girth for calves and yearlings. The patella to patella measurement gave the lowest estimate of repeatability but was obtained from live-animal measurements only.

Correlation coefficients between the various combinations of time of day and method of measurement indicated that the two methods of measurement measured the same thing in a majority of the cases. However, the two methods of obtaining length of body measurements for the cows could have been measuring different things. There was some indication that the correlation coefficients were slightly greater within methods than between methods.

Differences between measurements by men were too small to be of significance in nineteen out of twenty-one cases. Differences between times of day were significant in only one out of twenty-one cases. There were significant differences between series measurements for calves and yearlings which would be expected in growing animals.

This study indicates that photographs obtained by the method used will provide a permanent, objective, visual record of individuals and/or progeny. These photographs will furnish certain body measurements that will be as repeatable or slightly more repeatable than live-animal measurements. Observations indicate that photographic measurements may be obtained with less expense and effort when large

numbers of untrained nervous, and excitable cattle are to be measured.

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