8-1950

An objective method of measuring swine

Paul E. Smith

To the Graduate Council:

I am submitting herewith a thesis written by Paul E. Smith entitled "An objective method of measuring swine." 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:

Harold J. Smith, L. N. Skold

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 25, 1950

To the Committee on Graduate Study:

I am submitting to you a thesis written by Paul E. Smith entitled "An Objective Method of Measuring Swine". I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Nutrition.

Charles J. Hobbs
Major Professor

We have read this thesis and recommend its acceptance:

Harold J. Smith

L N Skold

Accepted for the Committee

E. A. Waters
Dean of the Graduate School

AN OBJECTIVE METHOD OF MEASURING SWINE

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

by

Paul E. Smith

August 25, 1950

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ACKNOWLEDGMENT

The writer wishes to express his sincere appreciation to Dr. Harold J. Smith for his guidance and material help in collecting the data for this investigation and valuable criticism during the writing of this thesis.

To Dr. Everett J. Warwick for his help in setting up the methods used in the statistical analysis of the investigation.

To Mr. Almon J. Sims under whose direction the pictures for this investigation were developed and printed.

To Dr. Charles S. Hobbs for his assistance in planning this thesis.

CHAPTER I

INTRODUCTION

With the changes in type of swine which have been produced in the past fifty years little effort has been made to determine accurately what makes up these types. Swine have been classified largely as rangy, intermediate, or chuffy. In recent years another classification, meat type, has been added.

Research work with swine directed toward the development of indices of the various types has been with linear body measurements of the same kinds used with cattle. A scaling instrument with which the ratios of size of various body parts are obtained has been used experimentally but has not proven satisfactory.

Similar difficulties have been encountered in the linear measurement of swine that have been encountered in the measurement of cattle. An animal seldom stands in a constant position when measurements are being taken and when several measurements are to be made the animal changes position several times before all of the measurements can be made. Also, some animals are nervous, making it extremely difficult to take linear body measurements at all. Cattle, to some extent, can be trained to stand while this is practically impossible with swine. For these reasons taking linear body measurements is very time consuming and single measurements on the same hog are apparently not highly repeatable.

With the use of photographs the difficulties of taking body measurements, to a great extent, are removed. Photographs provide an objective, permanent, visual record of an animal.

At the present time various studies are being made to determine the relationship between live animal measurements and carcass score. When a method for measuring live animals is furnished that is as repeatable and as accurate as the average of linear live animal measurements, the studies involving body types and the work concerning the relationship between live animal measurements and carcass score will proceed more rapidly.

CHAPTER II

OBJECTIVES

This investigation was initiated in order to obtain information relative to the value of photographs as an objective permanent record of swine. The primary emphasis of the study was placed on a comparison of the relative accuracy and repeatability of body measurements made on the live animal and body measurements taken from photographs.

CHAPTER III

REVIEW OF LITERATURE

Until recently little work of any kind pertaining to methods of obtaining body measurements of swine has been published.

Kelley (1933) reported on a livestock scaling instrument. This instrument was used to estimate quantitively the type of animals by obtaining various ratios of body parts. This method of determining type, investigated in Australia, did not develop further than the semi-experimental stage.

Phillips and Dawson (1936) completed a study to establish indices of type that would be useful in classifying hogs that are to be used in investigations in which body type is to be considered. They reported on the accuracy of three methods for obtaining body measurements of swine. The three methods were: (1) direct measurement with calipers and a tape measure, (2) measurement with a livestock scaling instrument as described by Kelley, and (3) measurement from photographs of hogs projected to life-size. Phillips and Dawson calculated the analysis of variance, and these analyses were used to judge the relative accuracy of the three methods studied. Their report indicated that measurements obtained by use of the livestock scaling instrument and the photographic projection methods have the disadvantage of not being able to take circumference measurements.

Hetzer et. al. (1950) reporting on the relationship between certain body measurements and carcass characteristics in swine stated that the relative accuracy of the various measurements was largely a function of the interaction components and that differences between the same measurements by two men as well as time differences were too small in most cases to be on any importance. In regard to the repeatability of measurements, the average of four measurements of the same item on an animal gave a higher repeatability than that based on single measurements. Hetzer et. al. used the method described by Phillips and Dawson in obtaining body measurements of the eight items studied.

CHAPTER IV

PROCEDURE

A. Equipment. A photographic cage was used in taking photographs of each animal (Figures 1 and 2). The cage was constructed on three inch angle iron runners with a 3/16 inch sheet metal floor. The four corner uprights were 2 1/4 inch angle iron, 57 inches long. A strap iron 3 inches wide around the top with three two inch straps across the cage the narrow way formed the top of the cage. Three-eighths inch plywood doors were hung at each end of the cage. The front of the cage was constructed of 3/8 inch rods welded to form a grid, 51 inches by 64 inches, with the mesh measuring 3 inches vertically and 6 inches horizontally. The side opposite the grid (the back) was made of 3/8 inch plywood with pegs which fit into holes in the floor of the cage. By lifting the back and sliding it forward to the next row of holes the width of the floor of the cage could be reduced from 24 inches to 6 inches by 6 inch intervals. The holes were in rows parallel to the bottom edge of the gird. The top edge of the back was equipped with chains which could be fastened to the top edge of the grid. When a photograph was being taken the back was fastened so as to be parrallel with the grid. This movable back made it possible to minimize photographic distortion as it could be moved to the front to hold the animal against the grid.

Figure 1. Shoat in the photographic cage.

Figure 2. Gilt in the photographic cage.

All photographs used in this study were taken with the same Speed Graphic "45" camera (4 x 5 inches) with wide angle lens. A Kodak Super XX high speed panchromatic film pack containing 12 negatives was used. All photographs were taken inside as preliminary work indicated the necessity of avoiding shadows and inclement weather. Artificial lights were used and consisted of a single set (two units of three bulbs each) of projector flood lights. These lights were equipped with a transformer which could increase the power of par 38 projector flood bulbs from a low of 150 watts each to a high of 750 watts each. The artificial lighting unit had a trade name "Colortran" and was manufactured by the Colortran Convertor Company, Los Angeles, California.

The lights were set up at a standard distance from the cage and in such a manner as to minimize shadows.

Live animal measurements were taken with wooden linear calipers one meter long, divided into centimeters and millimeters.

Photographic measurements were made with a six inch rule divided into 1/32.

All live animal measurements were taken with the animal standing on a level wooden platform. The platform was six feet square with panels three feet high around the edge.

B. Animals. Ten gilts and ten shoats were used in this study. Large and small gilts were used to be sure of variations. The gilts were purebred Hampshires which were to be added to the University of Tennessee college herd. The shoats were taken from the spring pig crop.

C. Method of obtaining photographs and measurements. Preliminary work showed that the pigs would have to be slightly hungry in order to work satisfactority in the photographic cage and to be handled while live animal measurements were being made. The gilts were taken off feed 12 to 15 hours and the shoats 24 hours before they were to be used.

The photographic cage was set up in an alleyway in such a way as to make it convenient to move the hogs one at a time through the cage for photographing.

The camera was set up thirteen feet from the grid of the cage and with the lens focoused on the mid-point of the horizontal length of the cage and eighteen inches above the floor.

The "f" stop of the camera was set within a range of from 5.6 to 7.3. The exact setting each time photographs were made depended on the amount of light other than that from the artificial lights. The shutter speed at all times was a twenty-fifth of a second.

The data were collected in two series. A series consisted of four photographs and four measurements of each animal. The series was broken down into morning and afternoon photographs and measurements.

The photographs were taken with the hog in a natural a position as possible, standing squarely on its legs with its head down. A small amount of feed was placed on the floor of the cage in an area which would tend to cause the hog to stand approximately in the middle of the grid. As soon as the hog was driven into the cage, the doors were fastened and the back was moved forward to place the hog against the grid. The top of the back was then fastened to make the back parallel with the grid. The photograph was taken when this was completed and the hog had taken a natural position. The hog was then made to move and when it came back to a natural position the second photograph was taken. Live animal measurements were made immediately following this procedure for all of the hogs being photographed at that time. Because of the time involved a series of both the gilts and shoats was not completed on the same day. However, a complete series of the group being worked with was always completed on the same day. Approximately a week lapsed between series for each group.

The live animal measurements were made by each of two men, once each in the morning and once each in the afternoon. The second series was completed in the same manner.

There was no known tendency for the men to remember the measurements of each other and no particular order was observed in obtaining various measurements.

The items measured were: (1) height at the shoulders, (2) height at the back, (3) depth of the chest, and (4) length from the shoulder to tail. The height at the shoulder measurement was taken with the rule of the calipers parallel to the hog's leg and the arm of the calipers resting on the top of the shoulders. The height of the back measurement was taken with the rule perpendicular to the platform and with the arm of the calipers resting on the back of the hog in as nearly the center of the back as could be estimated. Depth of chest was measured with the stationery arm of the calipers placed on the chest of the hog and the sliding arm placed just back of the top of the shoulders. The length from shoulder to tail was measured by placing the stationery arm of the calipers on the point of the shoulder and the sliding arm on the tail setting. The fly sheet when laying on when laying on Figure 1 shows the positions of the calipers for taking these various measurements.

The photographic prints were made from the exposed film packs under the direction of the Editor of the University of Tennessee Extension Service.

An 8 x 10 inch enlargement was made of each 4 x 5 negative with the use on an Omega enlarger which had a Wolensak lens. Preliminary studies had shown that 4 x 5 prints were too small for detailed measuring. Each of the two men measured one morning photograph and one afternoon photograph for each of the two series.

Photographic and enlargement distortion was taken into account and two correction factors were calculated for each individual photograph, one vertical correction factor and one horizontal correction factor. These factors were calculated by measuring the actual distance between two points on the cage grid, then measuring the number of thirty-seconds of an inch with the rule between these same two points and the number of thirty-seconds as read from the rule divided into the inches represented by the cage grid. Both vertical and horizontal correction factors were obtained from points that would enclose the hog being measured.

Photographic measurements were made of the same items that were measured on the live animal: (1) height at the shoulders, (2) height at the back, (3) depth of the chest, and (4) length from the shoulder to tail. As only side view photographs of the hogs were taken in this study, third dimensional measurements could not be taken.

CHAPTER V

RESULTS AND DISCUSSION

The means and standard deviations of the live animal and photographic measurements of the two age groups and the various items studied are shown in Table I. The differences between live animal and photograph measurements in the case of the gilts were not significant for any of the items studied. With the shoats, the differences between depth of chest measurements in both series was significant. The difference between the live animal measurements and the photographic measurements for height at the shoulders for the shoats in series one was also significant. Repeatability was higher for photographic measurements in all cases except with the shoats, the two items, depth of chest and shoulder to tail, had a higher repeatability with live measurements (Table III).

Correlation coefficients between the averages of various combinations of morning and afternoon photographic and live animal measurements seem to indicate that the two methods may not be measuring exactly the same thing as far as length from shoulder to tail setting in swine is concerned.

None of the differences between methods of measurements for the gilts were significant. In the case of the

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: Live-animal measurements: Mean	Live-animal measurements: Standard deviation	Photographic measurements: Mean	Photographic measurements: Standard deviation[1]	Difference live-animal photographic measurements[2]
Gilts:					
Height at shoulder	64.0	2.97	65.9	3.00	-1.9
Height at back	72.0	2.69	72.9	2.51	-0.9
Depth at chest	40.9	1.98	42.8	2.11	-1.9
Shoulder to tail	83.8	2.49	82.9	2.75	-0.9
Shoats:					
Height at shoulder	43.7	2.00	46.4	2.35	-2.7*
Height at back	51.0	1.93	51.9	2.33	-0.9
Depth of chest	24.3	.90	26.8	1.48	-2.5*
Shoulder to tail	55.8	2.50	52.2	2.25	-3.6
	Second series				
Gilts:					
Height at shoulder	65.2	2.89	66.6	2.93	-1.4
Height at back	73.1	2.94	73.4	2.60	-0.3
Depth at chest	42.1	1.90	43.1	1.83	-1.0
Shoulder to tail	84.6	2.52	83.5	2.41	1.1
Shoats:					
Height at shoulder	45.6	3.98	46.5	1.68	-0.1
Height at back	52.4	1.92	52.5	2.05	-0.1
Depth of chest	24.4	.90	26.5	1.67	-2.1**
Shoulder to tail	56.8	1.98	56.4	2.32	0.4

*Significant at the .05 level.

**Significant at the .01 level.

[1]Standard deviation between animals.

[2]All measurements and differences are in centimeters.

shoats the photographic measurements of height at shoulders and depth of chest in series one, and depth of chest in series two were significantly greater than live animal measurements. In all cases except the measurement, shoulder to tail setting in both gilts and shoats in series two, photographic measurements were greater than live animal measurements.

To determine the relative accuracy and repeatability of the various measurements obtained from the live animals and from the photographs, the correlation or repeatability of single measurements on the same animal was calculated for each measurement. The general form of the analysis used to determine the relative accuracy of the various body measurements obtained by different methods involved the segregation of the specific sources of variance and the principles involved in intra-class correlation in the same manner used by Hertzer et. al. (1950) in their study of the relationship between body and carcass characteristics of which method of obtaining measurements is most reliable and provide a method of determining the number of observations necessary to arrive at reasonably accurate estimates of a body characteristic. An example of the method used is given in Table II, which shows the analysis of variance for

TABLE II

ANALYSIS OF VARIANCE FOR DEPTH OF CHEST, LIVE-ANIMAL MEASUREMENTS, FOR TEN GILTS 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

Source of variation	Degrees of freedom	Mean squares	Composition of mean squares	
Total	79	4.40		
Series	1	26.50**	A+40E	E = .64
Time of day	1	1.80	A+40D	D = .02
Men	1	1.30	A+40C	C = .01
Animals	9	29.56**	A+ 8B	B = 3.60
Error	67	.78	A+	A = .78

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 =

$$\frac{B}{A\ B\ C\ D\ E} = .713$$

*Significant at the .05 level.

**Highly significant at the .01 level.

[1]This estimate includes the variance due to difference between series and may underestimate the true value if part of the difference between series is due to growth.

for depth of chest (live animal measurement) for the 10 gilts which were each measured twice by each of two men, once each in the morning and once each in the afternoon for each of two series separated by approximately one week.

The estimates of repeatability and variance components for the measurements studied are given in Table III. Estimates of repeatability for height at shoulders varied from .902 for the gilts to .827 for shoats. Repeatability of photographic measurements for height at shoulders was slightly higher than those for live animal measurements with both gilts and shoats. For height at back, repeatability varied from .818 to .904 with the repeatability of live animal measurements exceeding those for photographic measurements of both gilts and shoats. Depth of chest measurements were more repeatable with live animal measurements than with photographic measurements. Repeatability estimates for measurements of length from shoulder to tail were higher for photographic measurements in the case of both gilts and shoats.

Inspection of the data in Table III shows that there is apparently little difference in repeatability of the various measurements from gilts and shoats. When the difference between repeatability of live animal measurements was large the repeatability of photograph measurements was always the largest.

A study of the variance components in Table III shows that the relative accuracy of the various measurements was a function of the interaction components (error). Differences between measurements of the two men were significant in four out of sixteen cases. Differences due to time of day were too small in all but three cases to be of any significance. The relatively large component of variance for difference between measurements of the two series for both gilts and shoats may be explained partially on the basis of growth and development made during the one week interval between series.

The correlation coefficients between the averages for the various itmes measured by different methods and time of day are shown in Table IV. In all cases, the correlation coefficients of average A. M. measurements and P. M. measurements from photographs were highly significant. In most cases the correlation coefficient of average A. M. and P. M. measurements from photographs was larger than the correlation coefficient obtained from A. M. live animal measurements and P. M. live animal measurements or from various combinations of the average of A. M. and P. M. measurements between the two different methods.

All correlation coefficients were significant or highly significant except those for the length from shoulder to tail measurement. This indicates fairly close agreement

TABLE III

VARIANCE COMPONENTS AND REPEATABILITY ESTIMATES

Age and item measured	E	D	C	B	A	Repeatability: Both series[2]	Repeatability: Average Series I Series II
Live-animal measurements							
Gilts:							
Height at shoulder	.31**	- .01	-.03	7.82**	1.50	.815	.890
Height at back	.52**	1.11**	.00	7.82**	.45	.790	.904
Depth at chest	.64**	.02	.01	3.60**	.78	.713	.798
Shoulder to tail	.44**	-0.6	.23*	5.37**	2.71	.618	.696
Shoats:							
Height at shoulder	1.89**	- .10	-.13*	4.17**	6.30	.402	.827
Height at back	.96**	0.0	-.02	3.61**	.89	.665	.818
Depth at chest	.05**	.20**	.01	.58**	.13	.598	.794
Shoulder to tail	.41**	.17*	.04	5.92**	1.62	.836	.492

(continued)

TABLE III (continued)

Age and item measured	Variance components[1]					Repeatability	
	E	D	C	B	A	Both series[2]	Average series I series II
Photographic measurements							
Gilts:							
Height at shoulders	.25**	.02	-.02	8.39**	1.01	869	902
Height at back	.12*	.03	-.02	5.94**	1.10	828	892
Depth at chest	.02	-.02	.01	3.63**	.67	842	790
Shoulder to tail	.12*	.00	.02	6.02**	.99	842	734
Shoats:							
Height at shoulder	-.03	.10*	.00	3.53**	1.37	710	836
Height at back	.09*	.03	.03	5.47**	.95	832	844
Depth at chest	.02	.00	.06*	1.86**	.54	534	671
Shoulder to tail	.88**	.03	.07	5.30**	1.26	703	680

*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[1]			
	Height at shoulders	Height at back	Depth of chest	Length from shoulder to tail
Gilts:[2]				
Ave. A.M. photo - Ave. P.M. photo	.98	.92	.99	.90
Ave. A.M. photo - Ave. A.M. photo	.96	.68	.72	.62
Ave. A.M. photo - Ave. P.M. meas.	.83	.74	.88	.69
Ave. P.M. photo - Ave. A.M. meas.	.97	.89	.87	.53
Ave. P.M. photo - Ave. P.M. meas.	.81	.70	.81	.62
Ave. A.M. meas. - Ave. P.M. meas.	.81	.94	.91	.80
Shoats:[2]				
Ave. A.M. photo - Ave. P.M. photo	.83	.96	.91	.88
Ave. A.M. photo - Ave. A.M. meas.	.79	.96	.94	.79
Ave. A.M. photo - Ave. P.M. meas.	.91	.86	.92	.69
Ave. P.M. photo - Ave. A.M. meas.	.68	.94	.88	.81
Ave. P.M. photo - Ave. P.M. meas.	.92	.85	.90	.78
Ave. A.M. meas. - Ave. P.M. meas.	.86	.84	.82	.61

(continued)

TABLE IV (continued)

Age groups and items correlated	Second series[1]			
	Height at shoulders	Height at back	Depth of chest	Length from shoulder to tail
Gilts:[2]				
Ave. A.M. photo - Ave. P.M. photo	.95	.94	.90	.93
Ave. A.M. photo - Ave. A.M. photo	.91	.88	.92	.67
Ave. A.M. photo - Ave. P.M. meas.	.91	.86	.83	.50
Ave. P.M. photo - Ave. A.M. meas.	.89	.98	.96	.74
Ave. P.M. photo - Ave. P.M. meas.	.94	.98	.77	.62
Ave. A.M. meas. - Ave. P.M. meas.	.94	.98	.74	.86
Shoats:[2]				
Ave. A.M. photo - Ave. P.M. photo	.99	.98	.93	.92
Ave. A.M. photo - Ave. A.M. meas.	.73	.82	.74	.73
Ave. A.M. photo - Ave. P.M. meas.	.65	.94	.82	.61
Ave. P.M. photo - Ave. A.M. meas.	.94	.81	.73	.69
Ave. P.M. photo - Ave. P.M. meas.	.77	.94	.74	.87
Ave. A.M. meas. - Ave. P.M. meas.	.94	.84	.87	.51

[1]All correlation coefficients were positive.

[2]Value of .632 necessary for significance at .05 level. Value of .765 necessary for significance at .01 level.

between the two methods insofar as measuring the same thing is concerned except in the case of the measurement from shoulder to tail.

CHAPTER VI

SUMMARY

In this investigation on a comparison of the relative accuracy and repeatability of body measurements made from the live animal and from photographs, twenty animals representing two sizes of hogs were used. Analysis of the data to determine estimates of repeatability of single measurements on the same animal were obtained. Body measurements for (1) height at shoulders, (2) height at back, (3) depth of chest, and (4) length from shoulder to tail were used. The estimate of repeatability for height at shoulders in gilts was .890 and in shoats was .827 for live animal measurements and .902 and .836 respectively, for photographic measurements. Repeatability of live animal measurements for height at the back for gilts was .904 and for shoats was .818. The repeatability of photographic measurements for height at the back was .892 for gilts and .844 for shoats. Repeatability for depth of chest was .798 for gilts and .794 for shoats in the case of live animal measurements, repeatability of photographic measurements were .790 and .671 respectively. The repeatability of shoulder to tail measurements made from the live animal were .696 for gilts and .492 for shoats. Repeatability of photographic measurements were .734 and .680 respectively.

Size of the hogs did not appear to have any appreciable influence upon the errors of measurement although they were slightly greater for the shoats. Estimates of repeatability, including both live animal and photographic measurements for all items varied from .696 to .904 for the gilts and .492 to .844 for the shoats.

In comparing live animal measurements and photograph measurements the estimates of repeatability were about the same. When there was a large difference the repeatability of photographic measurements was always larger.

Correlation coefficients between the various combinations of average A. M. and P. M. measurements and method of measurement indicated that the two methods of measurement were measuring the same things except in the case of length from shoulder to tail. There was some indication that the correlation coefficients were slightly greater within methods than between methods.

Differences between measurements by the two men were significant four out of sixteen times and differences between time of day measurements were significant only three out of sixteen times. There were significant differences between series measurements in all cases, except three, which could be partially explained as due to growth and development.

Photographs and photographic measurements obtained by the method used in this investigation provide a permanent, objective, visual record of hogs. The measurements will be as repeatable or more repeatable than measurements taken from the live hog. It was observed that the photographs and photographic measurements could be obtained in less time with less expense than live animal measurements.

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