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The repeatability of cow performance in beef cattle

Charles Middleton Walthall

To the Graduate Council:

I am submitting herewith a thesis written by Charles Middleton Walthall entitled "The repeatability of cow performance in 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.

Harold J. Smith, Major Professor

We have read this thesis and recommend its acceptance:

Eric W. Swanson, Charles M. Kincaid

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

December 18, 1957

To the Graduate Council:

I am submitting herewith a thesis written by Charles Middleton Walthall entitled "The Repeatability of Cow Performance in Beef Cattle." 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 Husbandry.

Harold J. Smith
Major Professor

We have read this thesis
and recommend its acceptance:

Eric W. Swanson

C M Vincent

Accepted for the Council:

Dale Wantling
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THE REPEATABILITY OF COW PERFORMANCE IN BEEF CATTLE

A THESIS

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

---

by
Charles Middleton Walthall
December 1957

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CHAPTER I

INTRODUCTION

The repeatability of a character has been defined as the degree of likeness of repeated records. This degree of likeness is the correlation between records of the same animal. The characteristics investigated in this study for their repeatability were the birth weight, adjusted daily gain from birth to weaning and type grade of offspring.

The earliest age at which low producing cows can be identified and culled from the herd is of the utmost importance to the breeder of beef cattle. If it can be determined with some degree of confidence that the average cow will repeat her calf performance each year, then this information would be very useful in deciding which cows might be culled at an earlier age than might otherwise be possible.

The majority of repeatability estimates have been obtained in studies with western range Hereford cattle; however, the reported observations in range herds are in fairly close agreement with the estimates thus far reported for general farm herds. Differences may be attributed to herd management, culling practices, climatic conditions and grazing facilities.

Visual appraisal of cattle with respect to type and quality have a definite place in the selection of replacement individuals but should be considered along with the ability of animals to produce repeatedly and the record of their offspring.

It is hoped that the results of this study will be helpful in indicating the average repeatability of these performance characteristics in beef cattle.

CHAPTER II

REVIEW OF LITERATURE

Estimates of repeatability reported by a limited number of investigators for calf birth and weaning weights, daily gain and type score are in fair agreement. The major differences may be due to specific factors involved at various locations and different methods used to make adjustments in the determination of repeatability estimates.

Over a period of eight years, Koger and Knox (1947) observed in high grade Hereford range calves a highly significant sex difference of 32 pounds (corrected to 205 days) at weaning in favor of steer calves. In another report, Knox and Koger (1945) stated that the mean weaning weight of calves increased with the age and weight of their dam until the cows were 6 to 8 years of age. They suggested the close correlation between weight of dam and weaning weight of their calves strongly indicated the relationship of production to plane of nutrition.

Using 546 Hereford calves, Burgess et al. (1954) observed that bulls were considerably heavier than steers and heifers at weaning. For sex of calf the effect in pounds as deviations from the average was: steers, - 6; bulls, + 14; and heifers, - 8. The effect of age of dam in pounds as deviations from the average weaning weight was: 2-year-old dams, - 15; 3 to 5, + 5; 6 to 8, + 21; and 9 and over, - 10. The year of birth of the calves had an effect on the weaning weight of the calves, but this would only be considered when comparing calves born during different years.

Burris and Blumn (1952) reported that males were 4.5 pounds heavier than females at birth. The mean weight for males was 69.9 ± 0.97 and for females 65.4 ± 0.82 pounds. About 10 per cent of the sex difference was attributed to differences in gestation length. The mean birth weight was 63.5 pounds when the dams calved at 2-3 years of age and increased steadily to 76.2 pounds when the dams calved at 9-10 years of age. The regression of birth weight on age of dam was a highly significant figure of 1.04 pounds.

Koch (1951) observed, working with range Hereford cattle, that the male calves (average of bulls and steers) weaned 23 pounds heavier than the females.

Using range Hereford cattle, Botkin and Whatley (1952; 1953) found repeatability estimates by intraclass correlation between weights of calves produced by the same cow to be 0.43 for weaning and 0.18 for birth weight. Estimates obtained by regression of later records from the first toward the herd average were 0.49 for weaning and 0.14 for birth weight. For a group of cows that began calving at two years of age the correlation between the records of the first and second calves was 0.25 for birth weight and 0.66 for weaning weight.

Working with Polled Hereford calves, Southwell and Warwick (1952) reported male calves to be 5.3 pounds heavier at birth and 41 pounds heavier at 210 days than female calves. In general, calf weights at birth and 210 days increased with the age of the cow to eight years. They found that from 35 to 43 per cent of the variance in 210 day calf weights could be accounted for by cow difference. The overall correlation between successive

calves from the same cow was 0.44 and the regression coefficient was 0.36.

Dawson et al. (1946) reported that birth weights of calves tended to increase at the rate of 0.23 pounds for each month of increase in the age of the dam until the dams were 6 years old; after which, there was no effect. Correlation between age of dam and birth weight of calf was 0.45 for male and 0.35 for female calves. When birth weights were adjusted to the basis of 6-year-old dams, males averaged 4.2 pounds heavier than females.

Woodard et al. (1942) observed that when calves from large and small type Hereford cows of various groups were compared, the calves from large type cows were heavier at birth and made larger daily gains from birth to weaning. Also, the type of their sire and dam affected the birth weights of calves more than the ration fed their dams.

Knapp et al. (1940) using both beef and milking Shorthorn cows observed that in the former the males were 4.7 pounds heavier and in the later 3.5 pounds heavier than the females at birth. The difference in the former was highly significant at the 0.01 level. Differences due to sex accounted for only 6.5 per cent of the variance in birth weights in the milking Shorthorns. The influence of calving sequence on birth weights indicated that the first calves were considerably lighter than subsequent calves, but beyond this point the trend was not consistent. A correlation of 0.21 was derived between birth weight and calving sequence.

Studies by Knapp and Black (1941) indicated that during the suckling period, milk consumption had the greatest influence on the rate of

gain followed by consumption of hay and grain.

Dahmen and Bogart (1952) found that bulls gained faster than heifers with the average daily gain for bulls during the test being 2.3 pounds and 2.0 pounds for the heifers. The bulls required an average of 391 pounds of TDN (total digestible nutrients) to gain 100 pounds body weight during the test, while the heifers required 483 pounds of TDN per 100 pound gain. Birth weight had a significant effect on both rate and economy of gain.

Sawyer et al. (1948) found that two-year-old heifers weaned calves that were 75 pounds lighter than those from mature cows. Weaning weights increased with increasing age of dam through eight years but then declined. Evidence was found that heifer calves were heavier at weaning than steer calves; however, the difference lacks significance.

Work at Miles City, Montana, with Hereford cattle by Knapp et al. (1942) showed that the average birth weight for all calves was 74.01 pounds. For male calves the average birth weight was 76.87 pounds and for female calves 71.08 pounds. Birth weights of calves from 2-year-old cows were much smaller than from mature cows and increased until cows were 4 years old. There was a gradual reduction after cows reached 5 years of age. The average weaning weight for the group was 366 pounds at approximately 6 months age. The male calves averaged 377 pounds and the females averaged 355 pounds.

Guill (1953), studying data from a grade Hereford cow herd at the Tobacco Experiment Station of the University of Tennessee, found that the mean birth weight was 73 pounds for males and 67 pounds for the females, a difference of 6.0 pounds in favor of the males.

The average 180-day weight for the males was 403.2 pounds and 377.4 pounds for the females. The difference of 25.8 pounds in favor of the males was significant. At the Plateau Experiment Station of the University of Tennessee, he found the mean birth weight of males was 73.1 pounds and 66.5 pounds for the females, with an advantage of 6.6 pounds for the males. The 180-day weight for the males was 460.0 pounds and 409.0 pounds for the females. The 51.0 pounds difference in favor of the males was highly significant. Repeatability estimates at the Tobacco Experiment Station obtained by intraclass correlation and correlation between successive performance records were 0.61 and 0.62 for weaning weights, and 0.39 and 0.28 for type grade, respectively. At the Plateau Experiment Station repeatability estimates by intraclass correlation and correlation between successive performance records were 0.21 and 0.25 for weaning weights and 0.11 and 0.16 for type grade, respectively.

Using weaning weights of calves adjusted to 240 days, Rollins and Guilbert (1954) found that bull calves were 68 pounds heavier than heifer calves at weaning. The optimum age range for cow production was found to be from 7 to 10 years of age. Differences between cows accounted for 34 per cent and 48 per cent of the variance in daily gain from birth to four months of age and 240-day weaning weights, respectively.

Paysinger (1953) found the mean birth weight was 73.1 pounds for males and 70.4 pounds for females, a difference of 2.7 pounds in favor of the males. The effect of age of dam on calf birth weights was erratic and did not show a definite trend. The average weaning weight was 417.0 pounds for males and 393.5 pounds for females. The males had a 23.5 pounds

advantage at weaning. Repeatability estimates obtainedby intra-class correlation and correlation between successive performance records were 0.43 and 0.59 for weaning weights and 0.04 and 0.09 for type grades, respectively.

McCormick, Southwell and Warwick (1956) using data from Polled Hereford and grade Polled Hereford cows, reported the heritability of birth weight was relatively low (0.11). Repeatability of 210-day weight in the two herds as estimated by two different methods was 0.42 and 0.38. Heritability of feed lot gain was 33 per cent for grade steers, 55 per cent for purebred heifers, and zero for purebred bulls. Heritability of conformation scores and carcass grades was less than 15 per cent in all groups.

Nelms and Bogart (1956), using data from purebred Hereford and Angus cattle, found that the difference in the suckling gain exhibited by the two sexes was due to a difference in birth weight. The age of the dam and time of birth differentially affected the gains made by calves of the respective sexes. The males were heavier at birth and carried this advantage through the suckling period. For every 10 pounds change in birth weight, there was associated a difference in rate of gain of 0.115 pounds per day. Thus, it appeared that bulls and heifers of the same birth weight gained at approximately the same rate during the suckling period. There appeared to be a large difference between calves of 2-year-old dams and those of older cows.

A genetic analysis was made by Rollins and Wagnon (1956) of weaning weights of calves from two herds of range cows of similar

breeding. These herds were managed in a similar manner except that in one herd the cows were fed supplemental feed during the fall and winter when the range was nutritively deficient, while the cows in the other herd were not supplemented. The data were standardized for differential effects of pasture, year, sex, age of calf at weaning and age of dam. Heritability of weaning weight was estimated to be 0.30. The experimental evidence indicated that the difference in nutritive level of the two herds did not influence heritability of weaning weight. Repeatability of weaning weight was estimated to be 0.51 in the herd which received supplemental feed and 0.34 in the herd that did not receive supplemental feed.

Koch and Clark (1955) compared the theoretical composition of paternal and maternal half-sib correlations, the correlations between offspring and dam, and offspring and sire with observed values to estimate the influence of maternal environment. These comparisons suggested that maternal environment from conception to birth and from birth to weaning had a large influence on birth weight, gain from birth to weaning and weaning score, but small influence on yearling gain and yearling score. Selecting cows which produce heavy calves would place greater emphasis on milking ability than on growth response so far as the genetic value of the cow is concerned. Selecting on the basis of gain from weaning to yearling age will increase the genic value for yearling gain but will cause a small loss in genic value for milking ability. Heritability estimates taking maternal environment into account were: birth weight, 0.42; weaning weight, 0.19;

weaning gain, 0.12; weaning score, 0.16; yearling gain, 0.40; and yearling score, 0.27.

This literature review indicates that sex of calf and age of dam significantly affect calf birth weights, daily gains from birth to weaning, weaning weights and type grade, and shows that calf records of various age cows must be adjusted to an equivalent age of dam and sex basis for repeatability analyses. It further emphasizes the importance of using, where possible, correction factors developed for a specific area or herd in which the factors will be used.

CHAPTER III

OBJECTIVE

The objective of this study was to determine the repeatability of cow performance in beef cattle through a comparison of the birth weights, daily gains from birth to weaning, and grades for type at weaning of two or more calves from the same cow.

Source of Data

The data employed in this study were the birth weights, daily gains from birth to weaning and type grades of calves obtained from beef cattle herds at seven different locations in Tennessee for the years of 1952-1956 inclusive. The herds used are located at Knoxville, Alcoa, Oak Ridge, Greeneville, Crossville, Springfield and Spring Hill. Most of the cattle used in the study were purebred with the exception of grade Hereford cattle at one location. The cattle at Alcoa, Greeneville, Springfield and Spring Hill were purebred Hereford. At Oak Ridge both purebred and grade Herefords were included. Cattle at Knoxville and Crossville were purebred Angus.

Herd Management

The seven locations from which cattle were used in this study are located throughout Tennessee. Springfield and Spring Hill are located in Middle Tennessee. Those located in East Tennessee are

Knoxville, Alcoa, Oak Ridge and Greeneville. Crossville is on the Cumberland Plateau. Although the soil and climatic conditions are somewhat different at the various locations most of the management and breeding practices were very similar for all locations during the years included in this study.

All cows from the various locations included in the study were on a spring calving basis. Cows were pasture bred each year for a period of about 90 days, usually from about April 20 to July 20.

During the summer the cattle were maintained on pasture. The principal forages used in the pastures were Ladino Clover, Orchard grass, Alfalfa, Fescue, and Kentucky Bluegrass. Sudan Grass was available at some of the stations for supplemental grazing during the summer. In years when the season was very dry, hay or silage was used to supplement the pasture. During the winter months the cows were fed silage or hay on permanent pasture sods. In some years there was a limited amount of winter pasture available. All cattle were supplied adequate water with salt and a mineral mixture available free choice.

At some locations the calves were weighed at birth and at approximately 28-day intervals until weaning. At other locations only birth and weaning weights were taken. The calves at Oak Ridge were not weighed at birth. All calves were weaned about November 1 each year and at that time were graded for type and condition. The calves were not creep fed.

CHAPTER IV

PROCEDURE

Animals

Only cows dropping two or more calves were used in analysis of variance and subsequent intraclass correlation. Twins were excluded since it was not known what effect twinning might have on the repeatability estimate.

Data on 1235 calves from 440 cows were used in the analysis of variance of the calf birth weights. These represented both live births and full term stillbirths. For the analysis of variance of adjusted daily gains from birth to weaning, 1631 calf weights from 608 cows were usable. There were 1636 calves from 591 cows available for analysis of variance of type grades. In the correlation analyses, only data from cows which calved in successive years were usable.

Adjustment Factors

As the initial step in both analysis of variance and correlation analysis, the birth weights, daily gains from birth to weaning and type grades of all calves were adjusted for sex of calf and age of dam. Year effects were controlled statistically.

Correction factors used to adjust calf records for sex and age of dam were those derived by Faulk (1957) from analysis of data from the same herds used in this study.

Birth weights were adjusted to a male basis by adding approximately 7 per cent to the birth weights of female calves. Adjustments

for age of dam effects on birth weights were made by adding an additional 7 per cent to the birth weights of calves from 2-year-old cows and 3 per cent to the birth weights of calves from 3-year-old cows. Birth weights of calves from cows 4-years old and older were not adjusted for age of dam.

Daily gains of calves were adjusted for sex and age of dam using the following correction factors:

Age of Dam	Males	Females
2	1.15	1.22
3	1.10	1.17
4	1.06	1.13
5	1.03	1.10
6	1.00	1.07
7	1.00	1.07
8	1.00	1.07
9	1.00	1.07
10	1.00	1.07
11	1.02	1.09
12	1.05	1.12
13 +	1.08	1.15

To adjust the actual daily gain to a mature dam, male equivalent basis, the actual record was multiplied by the appropriate correction factor for sex and age of dam.

To adjust type grades for age of dam, an additional 0.5 of a grade was added to the type grades of calves from cows 2, 11, 12 and

and 13 or more years of age. Type grades of calves from cows 3 to 10 years of age were not adjusted. Type grades were not adjusted for sex of calf.

Statistical Methods

The characteristics studied including birth weight, adjusted daily gain from birth to weaning, and type grade were subjected to analysis of variance and to correlation analysis.

In the analysis of variance, the sources of variation considered were (1) between years in which the calves were dropped, (2) between cows and (3) within cows. Methods of analysis were those outlined by Snedecor (1956).

The effective number of calves per cow was derived by the following formula:

$k_o = \frac{1}{n-1}\left(Sk - \frac{Sk^2}{Sk}\right)$ with Sk representing the total number of calves and Sk^2 the sum of the squares of the calves per cow. With k_o determined, the mean square between cows was divided into its theoretical components by the formula: $\sigma^2_w + k_o \sigma^2_c$, where σ^2_w = within cow variance and σ^2_c = the additional variance due to cow differences.

The percentage of the total variance due to differences between cows was determined by the ratio of the two variances, $\frac{\sigma^2_c}{\sigma^2_w + \sigma^2_c}$ = intraclass correlation.

Correlation analysis was limited to calves of cows calving in successive years. Calf records of cows were classified within locations for correlation analysis as follows: 1952 with 1953 record; 1953 with 1954 record; 1954 with 1955 record; and 1955 with 1956 record.

Because of possible differences in breeding, nutritional treatment and to some extent in management practices at the various locations, the data were analyzed separately for each location.

CHAPTER V

RESULTS AND DISCUSSION

Birth Weights

The analysis of variance of birth weights of calves from cows at the seven locations used in this study indicated that from 9.4 per cent to 38.3 per cent of the variance could be attributed to differences between cows (Tables I, II and V). The average of the repeatability estimates derived from the herds at the various locations was 0.218 (Table I). The intraclass correlations obtained are in close agreement with those observed by other investigators. Paysinger (1953) observed an intraclass correlation for differences between cows for calf birth weights of 0.30. Botkin and Whatley (1952) obtained a repeatability estimate of 0.18 by intraclass correlation for birth weights of calves produced by the same cow.

An average correlation coefficient within locations of 0.176 was obtained between birth weights of calves from the same cow calving in successive years at the seven locations (Tables I, VIII and XV). The repeatability estimates for birth weights were very similar for both Hereford and Angus calves (Table XV). These values are in fair agreement with Paysinger (1953) who observed a correlation coefficient of 0.25 for birth weights of adjacent calves and Knapp et al. (1940) who obtained a correlation coefficient of 0.21 between birth weights and calving sequence.

Adjusted Daily Gains from Birth to Weaning

At the seven locations used in this study, the analyses of variance and subsequent intraclass correlations for adjusted daily gains from birth to weaning showed that from 39.6 per cent to 75.8 per cent of the variance in calf gains at various locations could be attributed to cow differences (Tables I, III and VI). All estimates were highly significant ($P < .01$). The average estimate for all locations was 54.2 per cent. Repeatability estimates for adjusted daily gains from birth to weaning were very similar for both Hereford and Gnus calves (Table XV). These correlations are very similar to the figures reported by Koger and Knox (1947) and Koch (1951) who found that 51 and 52 per cent, respectively, of the variance in weaning weights of calves (not creep fed) could be accounted for by permanent differences between cows. Southwell and Warwick (1952) observed that 35 to 43 per cent of variance in 210-day weaning weights of calves could be attributed to differences between cows. Some of the differences in estimates of repeatability reported by different investigators may be due to breeding, nutritional treatment, management and to other varying environmental conditions between geographical sections.

The average correlation coefficient within locations for adjusted daily gain from birth to weaning for calves from the same cow calving in successive years was 0.365 (Tables I, IX and XV). This was highly significant ($P < .01$). This correlation, however, is somewhat lower than the average correlation of 0.49 for one year's calf with the next reported by Koger and Knox (1947).

Type Grades

Intraclass correlation coefficients for type grades for the various locations ranged from 0.003 to 0.564, with a pooled average of 19.4 per cent for the seven locations (Tables I, IV and VII). The repeatability estimates for type grade were also very similar for both Hereford and Angus calves (Table XV). This is in fair agreement with Guill (1953) who reported correlations for type grade of 0.28 and 0.39 for calves from the same cow at the Tobacco and Plateau Experiment Stations, respectively, but is larger than the correlation of 0.04 observed by Paysinger (1953) between type grades of calves from the same cows.

The average correlation coefficient within locations for both Hereford and Angus for type grade was 0.306 (Table XV). Correlation coefficients within locations varied from 0.103 to 0.731 (Tables I, X and XV).

The results obtained for repeatability of cow performance in the herds involved in this study show considerable differences among locations in the repeatability estimates for birth weights, type grades, and adjusted daily gains from birth to weaning. The reasons for these location differences are not readily apparent but may be partially explained by difference in the cow herds influenced by origin and culling practices as well as environmental and sire influences. Repeatability estimates were somewhat lower for herds which have been culled most severely in recent years and indicates that future selection would be relatively less effective.

The results of this study indicate that the repeatability of pre-weaning growth and weaning type grade of calves from the same cow is sufficiently high so that considerable improvement could be made in these traits in a beef cattle herd by culling cows which produce inferior calves on the basis of a single record or an average of two records. This is of great importance in performance testing since superior brood cows may be located and kept for additional breeding use and inferior individuals may be culled at younger ages.

CHAPTER VI

SUMMARY

The repeatability of calf birth weights, adjusted daily gains from birth to weaning and type grades for cows from herds at seven locations were studied. Estimates of repeatability were derived by analysis of variance and subsequent intraclass correlation and by correlation between adjacent records from the same cow.

The intraclass correlations derived from analysis of variance for birth weights at the seven locations ranged from 0.094 to 0.383 with an average of 0.218 for all locations. For adjusted daily gains from birth to weaning, intraclass correlations varied from 0.396 to 0.758 with an average estimate of 54.2 per cent for the seven locations. The range of correlation coefficients for type grades was 0.003 to 0.564 with an average of 0.194 for the seven locations.

The correlations coefficients within locations between records of calves from the same cow calving in successive years were 0.176 for birth weights, 0.365 for adjusted daily gains from birth to weaning and 0.306 for type grades. Estimates of repeatability for all characteristics were highly significant.

The results of this study indicate that the performance record of a cow's first calf will provide a good indication of her future transmitting ability providing environmental conditions are adequate and similar for the conditions and years to be considered. Cows producing

first calves which are slow gainers or grade low on type can be expected, on the average, to produce in a similar manner in later years. Cows producing fast gaining, good type first calves can be expected to produce, on the average, fast gaining good type calves in later years under similar conditions.

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APPENDIX

TABLE I

REPEATABILITY ESTIMATES AT VARIOUS LOCATIONS

Locations	Breed	Birth Weight	Adjusted daily gain	Type Grade
a. Estimated by intraclass correlation.				
Crossville	Angus	.094	.424**	.030
Knoxville	Angus	.129	.461**	.224
Alcoa	Hereford	.211**	.396**	.114*
Oak Ridge	Hereford	-	.758**	.003
Oak Ridge	Gr. Hereford	-	.482**	.219**
Greeneville	Hereford	.383**	.683**	.264*
Springfield	Hereford	.367**	.606**	.564**
Spring Hill	Hereford	.124	.528**	.134
Average		.218	.542	.194
b. Estimated by correlation between performance in successive years.				
Crossville	Angus	.154	.378**	.277**
Knoxville	Angus	.249	.550	.113
Alcoa	Hereford	.191**	.100	.200**
Oak Ridge	Hereford	-	.622**	.103
Oak Ridge	Gr. Hereford	-	.595**	.277**
Greeneville	Hereford	.324*	.520**	.731**
Springfield	Hereford	.250	.403*	.249
Spring Hill	Hereford	.113	.621**	.237
Average		.176**	.365**	.306**

* P = < .05 > .01

** P = < .01

TABLE II

ANALYSIS OF VARIANCE AND REPEATABILITY ESTIMATES OF BIRTH WEIGHTS FOR ANGUS CALVES AT KNOXVILLE AND CROSSVILLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Composition of Mean Square
a. Crossville				
Total	176	10421		
Between Years	4	246	61.50	
Between Cows	52	3478	72.08	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	120	6427	53.05	σ^2_w
$k_o = 3.32$	$\sigma^2_w = 53.06$		$\sigma^2_c = 5.56$	
Intraclass Correlation = $\frac{5.56}{53.06 + 5.56}$ = .094				
b. Knoxville				
Total	103	8280		
Between Years	4	380	95.00	
Between Cows	32	3253	101.66	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	67	4647	69.36	σ^2_w
$k_o = 3.14$	$\sigma^2_w = 69.36$		$\sigma^2_c = 10.29$	
Intraclass Correlation = $\frac{10.29}{69.36 + 10.29}$ = .129				

TABLE III

ANALYSIS OF VARIANCE AND REPEATABILITY ESTIMATES OF ADJUSTED DAILY GAINS FROM BIRTH TO WEANING FOR ANGUS CALVES AT KNOXVILLE AND CROSSVILLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Composition of Mean Square
a. Crossville				
Total	158	8.77		
Between Years	4	2.88	.720	
Between Cows	49	3.59	.073**	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	105	2.30	.022	σ^2_w
$k_o = 3.17$	$\sigma^2_w = .022$	$\sigma^2_c = .016$		
Intraclass Correlation = $\frac{.016}{.022 + .016} = .424$				
b. Knoxville				
Total	77	8.04		
Between Years	4	1.07	.268	
Between Cows	27	4.64	.172**	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	46	2.33	.051	σ^2_w
$k_o = 2.77$	$\sigma^2_w = .051$	$\sigma^2_c = .044$		
Intraclass Correlation = $\frac{.044}{.051 + .044} = .461$				

** P = <.01

TABLE IV

ANALYSIS OF VARIANCE AND REPEATABILITY ESTIMATES OF TYPE GRADES FOR ANGUS CALVES AT KNOXVILLE AND CROSSVILLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Composition of Mean Square
a. Crossville				
Total	160	218.52		
Between Years	4	3.10	.775	
Between Cows	50	73.55	1.471	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	106	141.87	1.338	σ^2_w
$k_o = 3.15$	$\sigma^2_w = 1.338$	$\sigma^2_c = .042$		
Intraclass Correlation = $\frac{.042}{1.338 + .042} = .030$				
b. Knoxville				
Total	32	66.56		
Between Years	4	5.50	1.375	
Between Cows	14	37.90	2.707	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	14	23.16	1.654	σ^2_w
$k_o = 2.20$	$\sigma^2_w = 1.654$	$\sigma^2_c = .479$		
Intraclass Correlation = $\frac{.479}{1.654 + .479} = .224$				

TABLE V

ANALYSIS OF VARIANCE AND REPEATABILITY ESTIMATES OF BIRTH WEIGHTS FOR HEREFORD CALVES AT VARIOUS LOCATIONS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Components of Mean Square
a. Alcoa				
Total	633	68106		
Between Years	4	2993	784.25	
Between Cows	222	31903	143.71**	$\sigma_w^2 + k_o \sigma_c^2$
Within Cows	407	33210	81.60	σ_w^2
$k_o = 2.84$	$\sigma_w^2 = 81.60$		$\sigma_c^2 = 21.87$	
Intraclass Correlation = $\frac{21.87}{81.60 + 21.87} = .211$				
b. Greeneville				
Total	135	11348		
Between Years	4	1209	302.25	
Between Cows	56	6583	117.55**	$\sigma_w^2 + k_o \sigma_c^2$
Within Cows	75	3556	47.41	σ_w^2
$k_o = 2.38$	$\sigma_w^2 = 47.41$		$\sigma_c^2 = 29.47$	
Intraclass Correlation = $\frac{29.47}{47.41 + 29.47} = .383$				

TABLE V (continued)

ANALYSIS OF VARIANCE AND REPEATABILITY ESTIMATES OF BIRTH WEIGHTS FOR HEREFORD CALVES AT VARIOUS LOCATIONS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Components of Mean Square
c. Springfield				
Total	78	8456		
Between Years	4	1552	388.00	
Between Cows	30	4340	144.67**	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	44	2573	58.48	σ^2_w
$k_o = 2.54$	$\sigma^2_w = 58.48$		$\sigma^2_c = 33.93$	
Intraclass Correlation = $\frac{33.93}{58.48 + 33.93}$ = .367				
d. Spring Hill				
Total	131	13059		
Between Years	4	831	207.75	
Between Cows	47	5494	116.89	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	80	6734	84.81	σ^2_w
$k_o = 2.74$	$\sigma^2_w = 84.81$		$\sigma^2_c = 11.94$	
Intraclass Correlation = $\frac{11.94}{84.81 + 11.94}$ = .124				

** P = <.01

TABLE VI

ANALYSIS OF VARIANCE AND REPEATABILITY ESTIMATES OF ADJUSTED DAILY GAINS FROM BIRTH TO WEANING FOR HEREFORD CALVES AT VARIOUS LOCATIONS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Components of Mean Square
a. Alcoa				
Total	542	33.19		
Between Years	4	1.75	.438	
Between Cows	208	19.78	.095**	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	330	11.66	.035	σ^2_w
$k_o = 2.60$	$\sigma^2_w = .035$		$\sigma^2_c = .023$	
Intraclass Correlation = $\frac{.023}{.035 + .023} = .396$				
b. Oak Ridge (Purebred)				
Total	41	4.56		
Between Years	4	.86	.215	
Between Cows	16	3.21	.201**	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	21	.49	.023	σ^2_w
$k_o = 2.46$	$\sigma^2_w = .023$		$\sigma^2_c = .072$	
Intraclass Correlation = $\frac{.072}{.023 + .072} = .758$				

TABLE VI (continued)

ANALYSIS OF VARIANCE AND REPEATABILITY ESTIMATES OF ADJUSTED DAILY GAINS FROM BIRTH TO WEANING FOR HEREFORD CALVES AT VARIOUS LOCATIONS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Components of Mean Square
c. Oak Ridge (Grades)				
Total	573	51.66		
Between Years	4	2.08	.052	
Between Cows	203	33.13	.163**	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	366	16.45	.045	σ^2_w
$k_o = 2.82$	$\sigma^2_w = .045$		$\sigma^2_c = .042$	
Intraclass Correlation = $\frac{.042}{.045 + .042} = .482$				
d. Greeneville				
Total	112	7.57		
Between Years	4	.67	.168	
Between Cows	48	5.50	.114**	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	60	1.40	.023	σ^2_w
$k_o = 2.30$	$\sigma^2_w = .023$		$\sigma^2_c = .050$	
Intraclass Correlation = $\frac{.050}{.023 + .050} = .683$				

TABLE VI (continued)

ANALYSIS OF VARIANCE AND REPEATABILITY ESTIMATES OF ADJUSTED DAILY GAINS FROM BIRTH TO WEANING FOR HEREFORD CALVES AT VARIOUS LOCATIONS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Components of Mean Square
e. Springfield				
Total	63	7.38		
Between Years	4	1.70	.425	
Between Cows	24	4.40	.183**	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	35	1.28	.037	σ^2_w
$k_o = 2.55$	$\sigma^2_w = .037$		$\sigma^2_c = .057$	
Intraclass Correlation = $\frac{.057}{.037 + .057} = .606$				
f. Spring Hill				
Total	102	10.76		
Between Years	4	3.72	.930	
Between Cows	38	6.77	.178**	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	60	.27	.045	σ^2_w
$k_o = 2.64$	$\sigma^2_w = .045$		$\sigma^2_c = .050$	
Intraclass Correlation = $\frac{.050}{.045 + .050} = .528$				

** P < .01

TABLE VII

ANALYSIS OF VARIANCE AND REPEATABILITY ESTIMATES OF TYPE GRADES FOR HEREFORD CALVES AT VARIOUS LOCATIONS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Composition of Mean Square
a. Alcoa				
Total	445	643.77		
Between Years	3	68.76	22.92	
Between Cows	177	269.13	1.52*	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	265	305.88	1.15	σ^2_w
$k_o = 2.50$	$\sigma^2_w = 1.15$		$\sigma^2_c = .148$	
Intraclass Correlation = $\frac{.148}{1.15 + .148} = .114$				
b. Oak Ridge (Purebred)				
Total	41	50.56		
Between Years	3	4.29	1.43	
Between Cows	16	19.62	1.23	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	22	26.65	1.21	σ^2_w
$k_o = 2.46$	$\sigma^2_w = 1.21$		$\sigma^2_c = .004$	
Intraclass Correlation = $\frac{.004}{1.21 + .004} = .003$				

TABLE VII (continued)

ANALYSIS OF VARIANCE AND REPEATABILITY ESTIMATES OF TYPE GRADES FOR HEREFORD CALVES AT VARIOUS LOCATIONS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Components of Mean Square
c. Oak Ridge (Grades)				
Total	570	1042.98		
Between Years	4	28.31	7.08	
Between Cows	203	507.06	2.50**	$\sigma_w^2 + k_o \sigma_c^2$
Within Cows	363	507.61	1.40	σ_w^2
$k_o = 2.80$	$\sigma_w^2 = 1.40$		$\sigma_c^2 = .393$	
Intraclass Correlation = $\frac{.393}{1.40 + .393} = .219$				
d. Greeneville				
Total	113	186.97		
Between Years	4	11.13	2.78	
Between Cows	49	105.17	2.15	$\sigma_w^2 + k_o \sigma_c^2$
Within Cows	60	70.67	1.18	σ_w^2
$k_o = 2.29$	$\sigma_w^2 = 1.18$		$\sigma_c^2 = .424$	
Intraclass Correlation = $\frac{.424}{1.18 + .424} = .264$				

TABLE VII (continued)

ANALYSIS OF VARIANCE OF REPEATABILITY ESTIMATES OF TYPE GRADES FOR HEREFORD CALVES AT VARIOUS LOCATIONS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Theoretical Components of Mean Square
e. Springfield				
Total	61	151.84		
Between Years	4	63.65	15.91	
Between Cows	23	65.70	2.86**	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	34	22.49	.66	σ^2_w
$k_o = 2.57$	$\sigma^2_w = .66$		$\sigma^2_c = .856$	
Intraclass Correlation = $\frac{.856}{.66 + .856}$ = .564				
f. Spring Hill				
Total	87	139.43		
Between Years	4	4.52	1.13	
Between Cows	33	64.67	1.96	$\sigma^2_w + k_o \sigma^2_c$
Within Cows	50	70.24	1.40	σ^2_w
$k_o = 2.58$	$\sigma^2_w = 1.40$		$\sigma^2_c = .217$	
Intraclass Correlation = $\frac{.217}{1.40 + .217}$ = .134				

* P = <.05 >.01

** P = <.01

TABLE VIII

REPEATABILITY OF BIRTH WEIGHTS OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
a. Crossville Angus					
1952-53	20	1249	152	1389	0.115
1953-54	17	842	102	562	0.148
1954-55	27	1597	299	1983	0.168
1955-56	39	2502	406	2345	0.168
Sums	103	6190	959	6279	0.154
b. Knoxville Angus					
1952-53	7	474	10	792	0.699
1953-54	17	1265	428	975	0.386
1954-55	19	1461	470	1153	0.362
1955-56	17	485	167	2128	0.164
Sums	60	3685	1075	5048	0.249

TABLE VIII (continued)

REPEATABILITY OF BIRTH WEIGHTS OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
c. Alcoa Hereford					
1952-53	48	4454	555	3478	0.141
1953-54	47	4641	645	4043	0.149
1954-55	146	12531	5576	16227	0.391
1955-56	139	15308	704	17783	0.043
Sums	380	36934	7480	41531	0.191**
d. Greeneville Hereford					
1952-53	5	273	110	269	0.407
1953-54	37	1853	841	3781	0.376
1954-55	9	1088	722	804	0.772
1955-56	20	603	-71	1539	-0.074
Sums	71	3817	1602	6393	0.324**

TABLE VIII (continued)

REPEATABILITY OF BIRTH WEIGHTS OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
e. Springfield Hereford					
1952-53	14	1106	-66	2318	- 0.041
1953-54	9	1608	793	1136	0.587
1954-55	7	586	116	460	0.224
1955-56	12	667	230	710	0.334
Sums	42	3967	1073	4624	0.250
f. Spring Hill Hereford					
1952-53	4	46	-74	585	- 0.451
1953-54	23	4086	784	2727	0.235
1954-55	14	958	28	672	0.035
1955-56	14	788	-137	849	- 0.168
Sums	55	5878	601	4833	0.113

** P = (.01

TABLE IX

REPEATABILITY OF ADJUSTED DAILY GAINS FROM BIRTH TO WEANING OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
a. Crossville Angus					
1952-53	19	69.68	33.53	55.74	0.538
1953-54	15	40.07	33.63	88.71	0.564
1954-55	23	69.60	21.98	91.72	0.275
1955-56	33	77.13	30.74	155.10	0.281
Sums	90	256.48	199.88	391.27	0.378**
b. Knoxville Angus					
1952-53	0	0	0	0	0
1953-54	0	0	0	0	0
1954-55	0	0	0	0	0
1955-56	9	0.20	0.11	0.21	0.550
Sums	9	0.20	0.11	0.21	0.550

TABLE IX (continued)

REPEATABILITY OF ADJUSTED DAILY GAINS FROM BIRTH TO WEANING OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
c. Alcoa Hereford					
1952-53	42	26.26	0.28	23.62	0.011
1953-54	40	15.41	0.74	2.67	0.115
1954-55	119	6.85	2.61	9.16	0.330
1955-56	101	5.14	1.00	4.42	0.210
Sums	302	53.66	4.63	39.87	0.100
d. Oak Ridge Hereford					
1952-53	-	-	-	-	-
1953-54	2	0.68	0.28	0.21	0.800
1954-55	4	0.47	0.34	0.40	0.791
1955-56	12	0.73	0.50	1.13	0.556
Sums	18	1.88	1.12	1.74	0.622**

TABLE IX (continued)

REPEATABILITY OF ADJUSTED DAILY GAINS FROM BIRTH TO WEANING OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
e. Oak Ridge Grade Hereford					
1952-53	21	1.94	1.47	1.72	0.808
1953-54	110	11.02	6.72	12.41	0.575
1954-55	74	4.11	1.98	5.37	0.422
1955-56	126	13.40	7.63	9.85	0.665
Sums	331	30.47	17.80	29.35	0.595**
f. Greeneville Hereford					
1952-53	4	0.31	0.44	1.11	0.759
1953-54	34	0.95	0.77	2.46	0.506
1954-55	7	2.47	1.18	2.49	0.442
1955-56	12	0.76	0.45	0.60	0.672
Sums	57	4.49	2.84	6.66	0.520**

TABLE IX (continued)

REPEATABILITY OF ADJUSTED DAILY GAINS FROM BIRTH TO WEANING OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
g. Springfield Hereford					
1952-53	13	0.92	0.13	1.62	0.106
1953-54	7	0.22	0.14	1.18	0.275
1954-55	5	0.24	0.23	0.48	0.678
1955-56	8	0.64	0.66	0.83	0.906
Sums	33	2.02	1.16	4.11	0.403*
h. Spring Hill Hereford					
1952-53	0	0	0	0	0
1953-54	16	2.03	1.69	2.14	0.812
1954-55	12	0.59	0.13	0.63	0.214
1955-56	11	0.66	0.28	0.73	0.406
Sums	39	3.28	2.10	3.50	0.621**

* $P = <.05 >.01$

** $P = <.01$

TABLE X

REPEATABILITY OF TYPE GRADES OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
a. Crossville Angus					
1952-53	18	23.13	16.20	33.30	0.584
1953-54	16	33.60	2.40	20.16	0.092
1954-55	24	40.04	9.54	15.96	0.378
1955-56	33	19.60	2.43	35.51	0.092
Sums	91	116.37	30.57	104.93	0.277**
b. Knoxville Angus					
1952-53	5	22.23	0.03	18.59	0.001
1953-54	15	39.67	1.04	37.52	0.029
1954-55	11	39.20	0.71	33.00	0.020
1955-56	10	29.82	0.23	37.83	0.070
Sums	41	130.92	2.01	126.94	0.113

TABLE X (continued)

REPEABILITY OF TYPE GRADES OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
c. Alcoa Hereford					
1952-53	0	0	0	0	0
1953-54	31	29.99	- 1.53	29.38	- 0.052
1954-55	115	108.42	23.50	158.44	0.179
1955-56	103	143.03	40.46	160.02	0.268
Sums	249	281.44	62.43	347.84	0.200**
d. Oak Ridge (Purebred)					
1952-53	0	0	0	0	0
1953-54	2	6.50	1.50	0.67	0.704
1954-55	4	4.30	0.70	2.80	0.202
1955-56	13	10.22	- 0.48	9.90	- 0.048
Sums	19	21.02	1.72	13.37	0.103

TABLE X (continued)

REPEATABILITY OF TYPE GRADES OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
e. Oak Ridge (Grades)					
1952-53	21	71.15	5.95	15.47	0.179
1953-54	109	212.42	59.47	197.57	0.290
1954-55	74	121.82	12.14	51.80	0.153
1955-56	124	127.91	70.33	270.48	0.378
Sums	328	533.30	147.89	535.32	0.277 **
f. Greeneville Hereford					
1952-53	4	1.87	1.15	9.00	0.280
1953-54	34	34.69	24.75	108.00	0.404
1954-55	7	153.72	133.56	128.23	0.951
1955-56	12	6.65	5.68	14.03	0.589
Sums	57	196.93	165.14	259.26	0.731**

TABLE X (continued)

REPEATABILITY OF TYPE GRADES OF CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS AT VARIOUS LOCATIONS

Years	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
g. Springfield Hereford					
1952-53	12	25.19	0.92	7.73	0.066
1953-54	7	10.88	- 1.60	11.06	- 0.146
1954-55	5	7.31	4.27	8.83	0.537
1955-56	8	16.50	8.07	8.90	0.666
Sums	32	59.88	11.66	36.52	0.249
h. Spring Hill Hereford					
1952-53	0	0	0	0	0
1953-54	14	21.38	12.23	32.69	0.458
1954-55	13	29.92	1.16	11.23	0.063
1955-56	10	4.68	-0.64	7.29	- 0.110
Sums	37	56.43	12.75	51.21	0.237

** P = <.01

TABLE XI

REPEATABILITY OF BIRTH WEIGHTS, ADJUSTED DAILY GAIN FROM BIRTH TO WEANING, AND TYPE GRADE OF ANGUS CALVES FROM THE SAME COW CALVING IN SUCCESSIVE YEARS

Locations	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S\ x^2$	$S\ xy$	$S\ y^2$	
a. Birth Weight					
Crossville	103	6190	959	6279	0.154
Knoxville	60	3685	1075	5048	0.249
Sums	163	9875	2034	11327	0.166*
b. Adjusted Daily Gains from Birth to Weaning					
Crossville	90	256.48	119.88	391.27	0.378
Knoxville	9	0.20	0.11	0.21	0.550
Sums	99	256.68	119.99	391.48	0.378**

TABLE XI (continued)

REPEATABILITY OF BIRTH WEIGHTS, ADJUSTED DAILY GAIN FROM BIRTH TO WEANING, AND TYPE GRADE OF ANGUS CALVES FROM THE SAME COW CALVING IN SUCCESSIVE YEARS

Locations	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S\ x^2$	$S\ xy$	$S\ y^2$	
c. Type Grade					
Crossville	91	116.37	30.59	104.93	0.277**
Knoxville	41	130.92	2.01	136.94	0.113
Sums	132	247.29	32.60	241.87	0.133

* P = <.05 >.01

** P = <.01

TABLE XII

REPEATABILITY OF BIRTH WEIGHTS OF HEREFORD CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS

Locations	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S\ x^2$	$S\ xy$	$S\ y^2$	
Alcoa	380	36934	7480	41531	0.191**
Greeneville	71	3817	1602	6393	0.324**
Springfield	42	3967	1073	4624	0.250
Spring Hill	55	5878	601	4833	0.113
Sums	528	50596	10756	57381	0.200**

** P = <.01

TABLE XIII

REPEATABILITY OF ADJUSTED DAILY GAINS FROM BIRTH TO WEANING OF HEREFORD CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS

Locations	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S x^2$	$S xy$	$S y^2$	
Alcoa	302	53.66	4.63	39.87	0.100
Oak Ridge (Purebred)	18	1.88	1.12	1.74	0.622**
Oak Ridge (Grades)	331	30.47	17.80	29.35	0.595**
Greeneville	57	4.49	2.84	6.66	0.520**
Springfield	33	2.02	1.16	4.11	0.403*
Spring Hill	39	3.28	2.10	3.50	0.621**
Sums	780	95.80	29.65	85.23	0.328**

* P = <.05 >.01

** P = <.01

TABLE XIV

REPEATABILITY OF TYPE GRADES OF HEREFORD CALVES FROM THE SAME COWS IN SUCCESSIVE YEARS

Locations	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		S x^2	S xy	S y^2	
Alcoa	249	281.44	62.43	347.84	0.200**
Oak Ridge (Purebred)	19	21.02	1.72	13.37	0.103
Oak Ridge (Grades)	328	533.30	147.89	535.32	0.277**
Greeneville	57	196.93	165.14	259.26	0.731**
Springfield	32	59.88	11.66	36.52	0.249
Spring Hill	37	56.43	12.75	51.21	0.237
Sums	722	1149.00	401.59	1243.52	0.336**

** P = <.01

TABLE XV

REPEATABILITY OF BIRTH WEIGHTS, ADJUSTED DAILY GAINS FROM BIRTH TO WEANING, AND TYPE GRADE OF ANGUS AND HEREFORD CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS

Breed	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S\ x^2$	$S\ xy$	$S\ y^2$	
a. Birth Weights					
Angus	163	9875	2034	11327	0.166*
Hereford	528	50596	10756	57381	0.200**
Sums	691	60471	12890	88708	0.176**
b. Adjusted Daily Gains from Birth to Weaning					
Angus	99	256.68	119.99	391.48	0.378**
Hereford	780	95.80	29.65	85.23	0.328**
Sums	879	352.48	149.64	476.71	0.365**

TABLE XV (continued)

REPEATABILITY OF BIRTH WEIGHTS, ADJUSTED DAILY GAINS FROM BIRTH TO WEANING, AND TYPE GRADE OF ANGUS AND HEREFORD CALVES FROM THE SAME COWS CALVING IN SUCCESSIVE YEARS

Breed	Degrees of Freedom	Sums of Squares and Products			Correlation Coefficient
		$S\ x^2$	$S\ xy$	$S\ y^2$	
c. Type Grade					
Angus	132	247.29	32.60	241.87	0.133
Hereford	722	1149.00	401.59	1243.52	0.336**
Sums	854	1396.29	440.19	1485.39	0.306**

* P = <.05 >.01

** P = <.01