August 7, 1958

To the Graduate Council:

I am submitting herewith a thesis written by Kaki Malliah entitled "Heritability of Some Preweaning Traits in Angus and Hereford 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.

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# HERITABILITY OF SOME PREWEANING TRAITS IN ANGUS AND HEREFORD CATTLE

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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

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by

Kaki Malliah

August 1958

28
#75

ACKNOWLEDGMENT

The writer wishes to express his sincere appreciation to Dr. H. J. Smith for his guidance and technical assistance in helping to conduct this study.

Kaki Malliah

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# CHAPTER I

## INTRODUCTION

During recent years there has been greatly increased interest on the part of many research workers in studying items of performance in Angus and Hereford cattle and other farm animals. Through the application of this information it is hoped that breeding and selection programs may be set up that will result in the development of more productive and profitable livestock. A necessary background for the development of such programs is a knowledge of the variability expected in various performance traits, the importance of heredity on the expression of such traits and the magnitude of the influence of environmental factors on them.

Variation among animals for such performance traits as size, rate of growth, conformation, and many others is the result of both hereditary and environmental influences. The improvement in performance characteristics of economic importance through breeding methods depends upon effective use of the genetic variation existing in cattle herds. A knowledge of the extent to which the magnitude of hereditary and environmental influences are comparable in most cattle and to what extent they are peculiar to herds of specific hereditary backgrounds maintained under a certain set of environmental conditions is necessary in order to know whether breeding programs found satisfactory in one herd are likely to be satisfactory in another. Studies on many herds in many areas are needed to accumulate such information. Systematic evaluation of animals for traits of economic performance through performance testing has increased

rapidly in recent years. In order to evaluate the usefulness of performance items, as criteria for selection, more information is needed on the genetic and environmental relationships between and within such characteristics. At present, estimates of heritability are the best measure of the relative importance of heredity and environment as causes of variation in a population. Heritability in the narrow sense is the fraction of the phenotypic variance which is due to the average effects of the genes of the individual members of the population. Its magnitude is important in choosing the method of selection and the breeding plan, in determining the relative amount of emphasis to be placed on each trait when selecting breeding stock, in estimating the breeding value of individual animals and in estimating the rate of progress to be expected in a breeding program.

In order to be profitable, cattle must have the inherent ability to grow rapidly and to produce a desirable product. A knowledge of methods and the relative accuracy of methods of evaluating animals for these performance traits would be very helpful in livestock improvement.

The purpose of this study was to obtain estimates of heritability for some preweaning performance characteristics in Angus and Hereford cattle including daily gain from birth to weaning, type grade or conformation and weaning selection index. It is hoped that the results of this study will add to the background of information necessary for the development of effective breeding programs.

# CHAPTER II

## REVIEW OF LITERATURE

Most quantitative characters, like the traits included in this study, are influenced by many pairs of genes and, also, are influenced a great deal by environmental variations. Estimates of heritability of various traits in Angus and Hereford cattle are relatively limited. It is only recently that procedures for determining the importance of genetic and environmental causes of differences among individuals have been applied to studies of cattle. The long generation interval and the expense of maintaining experimental herds have contributed to the slow accumulation of data suitable for this type of study. Heritability estimates for traits of economic importance have considerable significance to the livestock breeder. They provide some indication of the rate and amount of progress which can be expected from selection and are useful in determining what breeding methods are likely to be most effective in livestock improvement. The emphasis in selection that should be placed upon a particular character depends upon its economic importance, its heritability and the level of performance already attained in a herd or flock. If heritability is high, individual selection should be effective and progeny testing would be used only to make selection more accurate. On the other hand, if heritability is low, progeny testing would assume the dominant role in selection and individual selection would be less important. Thus, the degree of heritability of traits would influence the methods and procedures to be used in a breeding program.

A survey of the literature indicates considerable range in the estimates of heritability for preweaning growth and type score in Angus and Hereford cattle. Available estimates of heritability together with the method by which these estimates were derived for weaning weight, daily gain from birth to weaning and type score are summarized in Table I. The estimates for weaning weight vary from zero to 100 per cent. However, most of the values appear to fall within a range of about 20 to 30 per cent. Fewer estimates of heritability for rate of gain from birth to weaning have been reported but are similar in magnitude to estimates for weaning weight. These estimates vary from 7 to 45 per cent with most estimates around 20 per cent.

Estimates of heritability for weaning score or grade vary from zero to 50 per cent with most estimates falling within a range of 15-30 per cent. Considerable variation in the estimates of heritability as shown in Table I is to be expected when estimates are obtained from populations of cattle of different genetic composition and maintained under a wide variety of environmental conditions.

Most of the available estimates of heritability have been derived by the paternal half-sib correlation method. The accuracy of this method is limited largely by the number of degrees of freedom which are available for estimating differences between sires, as well as the number of offspring per sire group. A small number of sires from which sire components are estimated would tend to increase the probability of the occurrence of large sampling errors.

TABLE I

HERITABILITY ESTIMATES FOR SOME PREWEANING TRAITS IN CATTLE

| Authority | Method of estimation[a] | Heritability per cent |
|---|---|---|
| | Weaning weight | |
| Knapp and Nordskog, 1946 | 1 | 12 |
| Ibid | 3 | 0 |
| Ibid | 3 | 30 |
| Dawson et al., 1954 | 2 | 10 |
| Knapp and Clark, 1950 | 1 | 28 |
| Gregory et al., 1950 | 1 | 26 |
| Ibid | 1 | 52 |
| Kidwell, 1954 | 1 | 100 |
| Shelby et al., 1955 | 1 | 23 |
| Kock and Clark, 1955 | 1 | 24 |
| Ibid | 2 | 11 |
| Ibid | 3 | 25 |
| Brown, 1958 | 1 | 26 |
| Ibid | 1 | 11 |
| McCormick et al., 1956 | 1 | 33 |
| Ibid | 1 | 26 |
| Ibid | 1 | - 6 |
| Ibid | 1 | 49 |
| Rollins and Wagnon, 1956 | 1 | 9 |
| Ibid | 1 | 54 |
| Ibid | 2 | 54 |

TABLE I

HERITABILITY ESTIMATES FOR SOME PREWEANING TRAITS IN CATTLE (Continued)

| Authority | Method of estimation[a] | Heritability per cent |
|---|---|---|
| **Daily gain, birth to weaning** | | |
| Gregory, et al., 1950 | 1 | 45 |
| Kock and Clark, 1955 | 1 | 21 |
| Ibid | 2 | 7 |
| Ibid | 3 | 17 |
| Dawson et al., 1955 | 1 | 19 |
| **Weaning score or grade** | | |
| Knapp and Nordskog, 1946 | 1 | 50 |
| Ibid | 3 | 0 |
| Knapp and Clark, 1950 | 1 | 28 |
| Koger and Knox, 1952 | 1 | 30 |
| Ibid | 2 | 50 |
| Ibid | 2 | 23 |
| Ibid | 1 | 24 |
| Knapp and Clark, 1951 | 1 | 31 |
| Kock and Clark, 1955 | 1 | 18 |
| Ibid | 2 | 16 |
| Ibid | 3 | 15 |
| Rollins and Wagnon, 1956 | 1 | 36 |

[a]Method of estimating heritability:

1. Paternal half-sib correlation.
2. Regression of offspring on dam.
3. Regression of offspring on sire.

# CHAPTER III

## OBJECTIVE

The objective of this study was to determine estimates of heritability by paternal half-sib correlation methods for some preweaning performance traits in Angus and Hereford cattle including average daily gain from birth to weaning, type grade or score and weaning index.

### Source of Data

The data used in this study were the average daily gains, type scores and weaning indices of calves obtained from the performance records of Angus and Hereford cattle herds of the Tennessee Agricultural Experiment Station at three different locations in Tennessee. These herds are located at Crossville on the Cumberland Plateau and at Alcoa and Oak Ridge in East Tennessee. The cattle at Crossville are purebred Angus and those at Alcoa and Oak Ridge include both purebred and grade Hereford. Complete performance records for a five-year period (1953-57 inclusive) were available for 225 calves by 15 sires at Crossville, and 569 calves by 35 sires at Alcoa. Data were available for 977 calves by 71 sires at Oak Ridge for the years 1952-57 inclusive.

### Herd Management

Although the soil and climatic conditions are somewhat different at the various locations, most of the breeding, feeding, and management practices were very similar for all locations during the years included in this study.

The cows at the various locations were on a spring calving basis. Cows were pasture bred each year for a period of approximately 90 days, usually from about April 5-20 to July 5-20. Calves were dropped from late January to about May 1 each year.

The cattle were maintained on pasture during late spring, summer and early fall without supplemental feed except for extremely dry periods when hay or silage was used to supplement summer pasture. The principal permanent pastures at the various locations consisted of orchardgrass-Ladino clover mixtures. At Alcoa, alfalfa was included in the mixture. At some locations sudan grass was available for supplemental grazing during dry summer periods. During the winter months the cows were fed silage or hay (or both) on permanent pasture sods with limited amounts of protein supplement as needed. During some of the years, a limited amount of winter pasture was available for the cattle.

At Crossville the calves were weighed at birth and at 28-day intervals from birth to weaning. At other locations only birth and weaning weights were taken. Calves were weaned at all locations about November 1 each year and were graded or scored for type and condition at that time.

# CHAPTER IV

# PROCEDURE

## Animals

Weanling data on 1771 calves by 121 sires were available at the various locations for the years 1952-57 inclusive. In the analysis of variance and subsequent estimate of heritability, if a sire was used in more than one year he was considered as a different sire each time used. Some sires at the various locations were excluded from the study because of the limited number of offspring in sire progenies.

Complete weaning performance records, including average daily gain from birth to weaning, type grade and weaning index were available for 225 calves (15 sire progenies) at Crossville, 569 calves (35 sire progenies) at Alcoa, and 977 calves (71 sire progenies) at Oak Ridge.

## Adjustment of Data

As the initial step in the analysis of variance and subsequent calculation of the heritability estimate, the average daily gains from birth to weaning of all calves were adjusted for sex of calf and age of dam. Year and line effects at Crossville and year effects at Alcoa and Oak Ridge were controlled statistically.

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

The actual record was multiplied by the appropriate correction factor for sex and age of dam to correct to a mature dam, male (steer) equivalent basis.

Type grades were not adjusted for sex or age of dam. The type grades and their numerical values used in this study were:

| Type Grade | Numerical Value |
|---|---|
| High Fancy | 17 |
| Fancy | 16 |
| Low Fancy | 15 |
| High Choice | 14 |
| Choice | 13 |
| Low Choice | 12 |

| | |
|---|---|
| High Good | 11 |
| Good | 10 |
| Low Good | 9 |
| High Medium | 8 |
| Medium | 7 |
| Low Medium | 6 |

The weaning selection index for each calf was constructed by using adjusted daily gain and type grade. Equal emphasis, determined from economic value of the traits and available estimates of heritability, was placed on each of these traits in the construction of the index. The standards of performance used in the index were 1.70 pounds for adjusted daily gain and 10.0 (Good) for type score. These values represent about average performance for beef calves at weaning from good herds as shown by research in Tennessee and other states. To give daily gain and grade equal importance in the index, it was necessary to make a unit of variation (standard deviation) in each the same value. This was done by making one-fourth pound per day worth 10 points and two-thirds of a full grade worth 10 points. The following formulas were used to obtain index values:

Index for gain = (40 x adjusted daily gain) - 18

Index for grade = 5 x grade

Total index = index for gain + index for grade

## Analysis of Data

Heritability of traits included in this study were estimated from paternal half-sib correlations. The paternal half-sib correlation estimated from analysis of variance was multiplied by four to obtain the heritability

estimate. Statistical methods were by standard techniques as outlined by Snedecor (1956). Analysis of data was necessarily limited to years in which two or more sires were used. In the analysis, if the same sire was used in different years, he was considered as a different sire each time used.

In the analysis of variance for the Crossville data, the sources of variation considered were: (1) between years, (2) between lines within years, (3) between sires within lines, and (4) within sires. Line effects were removed in these data since two distinct lines of breeding were presented in the Angus herd at this location.

At Alcoa and Oak Ridge the sources of variation considered in the analysis of variance were: (1) between years, (2) between sires within years, and (3) within sires. The average number of calves per sire ($n_o$) for each location used in deriving variance components was determined by the following formula:

$$n_o = 1/a\text{-}1 \left(n - \frac{n_i^2}{n}\right)$$

where a represents the total number of sire progenies, n = the total number of calves and $n_i^2$ = the sum of the squares of the number of calves in each individual sire progeny.

The mean square for sires within years was divided into its theoretical components by the formula: $\sigma_e^2 + n_o\sigma_s^2$, where $\sigma_e^2$ = variance between calves within sires and $\sigma_s^2$ = variance due to sires.

The paternal half-sib correlation was computed using the ratio: $\frac{\sigma_s^2}{\sigma_e^2 + \sigma_s^2}$ Heritability was estimated by multiplying the paternal half-sib

correlation by 4. The accuracy of this method of estimation depends to a large extent on the number of degrees of freedom available for estimating the differences between sires. It is limited by the fact that errors due to sampling or incorrect estimation of environmental influences are multiplied by 4.

Nutritional treatment and management practices were similar at the various locations. However, because different breeds were represented at the various locations and because of possible differences in genetic composition of the herds, the data were analyzed separately for each location.

# CHAPTER V

## RESULTS AND DISCUSSION

The yearly average for the various locations for adjusted daily gain, type grade and weaning index are presented in Table II along with the standard deviations and coefficients of variation. Differences between years for all traits within locations were statistically significant in all cases. (Tables IV - XII). These yearly differences within locations could result from variation among years in climatic, feeding and management conditions as well as the average genetic composition of the herd.

Differences between sires within years for all locations were statistically significant for all characteristics except weaning index at Crossville. At this location the mean square for calves within sires was greater than the mean square for sires within years. This gave a small negative estimate for the heritability of weaning index (Table VI).

The variability of the data, as indicated by the standard deviations and coefficients of variation agreed quite closely with the variabilities reported in other studies. Within-year and sire standard deviations for adjusted daily gains of calves were 0.19, 0.22, and 0.33 for Crossville, Alcoa and Oak Ridge, respectively. Coefficients of variation among locations ranged from 10.5 per cent at Crossville to 18.8 per cent at Oak Ridge indicating considerable differences in variability within-year and sire progenies at the various locations. Standard deviations and coefficients of variation for type grades at the various locations were

TABLE II

MEAN AND VARIABILITY OF TRAITS

| Location | Year | Traits: Adjusted daily gain Mean | Adjusted daily gain Standard deviation[a] | Adjusted daily gain Coef. of variability | Type grade Mean | Type grade Standard deviation[a] | Type grade Coef. of variability | Index Mean | Index Standard deviation[a] | Index Coef. of variability |
|---|---|---|---|---|---|---|---|---|---|---|
| | | lbs. | lbs. | per cent | units | units | per cent | units | units | per cent |
| a. Crossville | | | | | | | | | | |
| | 1953 | 1.86 | 0.21 | 11.3 | 12.3 | 1.10 | 8.90 | 120.0 | 9.2 | 7.6 |
| | 1954 | 1.67 | 0.20 | 12.0 | 12.2 | 1.20 | 9.80 | 110.4 | 11.9 | 10.7 |
| | 1955 | 1.67 | 0.18 | 10.7 | 12.5 | 0.81 | 6.40 | 111.7 | 9.0 | 8.0 |
| | 1956 | 1.97 | 0.21 | 10.6 | 12.2 | 1.00 | 8.20 | 121.7 | 11.9 | 9.8 |
| | 1957 | 1.86 | 0.13 | 6.9 | 12.0 | 1.40 | 11.66 | 116.8 | 10.6 | 9.1 |
| | Combined | 1.81 | 0.19 | 10.5 | 12.3 | 1.30 | 10.50 | 116.1 | 10.9 | 9.3 |
| b. Alcoa | | | | | | | | | | |
| | 1953 | 1.62 | 0.17 | 10.5 | 11.4 | 0.97 | 8.50 | 103.9 | 9.8 | 9.4 |
| | 1954 | 1.59 | 0.25 | 15.7 | 12.3 | 1.25 | 10.10 | 107.6 | 13.6 | 12.6 |
| | 1955 | 1.67 | 0.23 | 13.8 | 11.5 | 1.00 | 8.60 | 106.8 | 13.0 | 12.2 |
| | 1956 | 1.78 | 0.19 | 10.7 | 12.0 | 1.45 | 12.10 | 113.1 | 13.0 | 12.2 |
| | 1957 | 1.85 | 0.20 | 10.8 | 12.2 | 1.30 | 10.62 | 117.5 | 12.3 | 10.4 |
| | Combined | 1.71 | 0.22 | 12.9 | 12.0 | 1.25 | 10.40 | 110.4 | 13.1 | 11.9 |

TABLE II

MEAN AND VARIABILITY OF TRAITS (Continued)

| Location | Year | Traits | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Adjusted daily gain | | | Type grade | | | Index | | |
| | | Mean | Standard deviation[a] | Coef. of variability | Mean | Standard deviation[a] | Coef of variability | Mean | Standard deviation[a] | Coef. of variability |
| | | lbs. | lbs. | per cent | units | units | per cent | units | units | per cent |
| c. Oak Ridge | | | | | | | | | | |
| | 1952 | 1.66 | 0.40 | 24.1 | 11.2 | 1.52 | 13.50 | 104.4 | 19.1 | 18.3 |
| | 1953 | 1.67 | 0.37 | 22.2 | 10.8 | 1.10 | 10.20 | 103.1 | 16.8 | 16.3 |
| | 1954 | 1.89 | 0.32 | 16.9 | 10.6 | 1.60 | 15.15 | 110.8 | 17.6 | 11.9 |
| | 1955 | 1.78 | 0.27 | 15.2 | 10.6 | 0.86 | 8.08 | 106.3 | 13.4 | 12.6 |
| | 1956 | 1.69 | 0.24 | 14.2 | 10.7 | 1.29 | 12.03 | 103.4 | 12.6 | 12.2 |
| | 1957 | 1.76 | 0.27 | 15.3 | 10.8 | 1.19 | 11.04 | 106.4 | 15.2 | 14.3 |
| | Combined | 1.75 | 0.33 | 18.8 | 10.6 | 1.14 | 10.80 | 105.6 | 15.4 | 14.6 |

[a]Standard deviations were calculated on a within-sire basis. Standard deviations for all years were calculated on a within-year and sire basis.

quite similar (Table II) although there were considerable differences between mean values at the different locations for this trait. Coefficients of variation for weaning index varied from 9.3 per cent for Crossville to 14.6 per cent for Oak Ridge.

The heritability estimates obtained from paternal half-sib correlations at the various locations for adjusted daily gain, type grade and weaning index are given in Table III. These estimates were calculated from variance components obtained by analysis of variance. The analyses of variance for traits at each location are given in Tables IV through XII. The heritability of adjusted daily gain for the Angus calves at Crossville was 34.1 per cent. For the Alcoa and Oak Ridge Hereford herds, the heritability estimates for adjusted daily gain were 52.3 and 40.6 per cent, respectively. These estimates are within the range of estimates reported by other workers using paternal half-sib correlation methods (Table I). However, they tend to be somewhat higher than the majority of such estimates. Higher estimates obtained in this study may be due to differences in the variability existing in the herds as compared to estimates obtained in other herds located in different geographical areas and subjected to different intensities of selection. Highly significant differences between sires within years were obtained in most herds at all locations involved in this study. Also, little selection for performance was practiced in the herds in the first two or three years of the period covered in the study.

Heritability estimates for type grade at the various locations were very similar in magnitude to the estimates of heritability for adjusted

TABLE III

HERITABILITY ESTIMATES AT VARIOUS LOCATIONS

| Location | Breed | Heritability estimates[a] | | |
|---|---|---|---|---|
| | | Adjusted daily gain | Type grade | Index |
| | | (Per cent) | | |
| Crossville | Angus | 34.1 | 35.1 | - 2.0 |
| Alcoa | Hereford | 52.3 | 54.8 | 40.9 |
| Oak Ridge | Hereford | 40.6 | 49.8 | 36.5 |

[a]Estimated by paternal half-sib correlation.

TABLE IV

ANALYSIS OF VARIANCE AND HERITABILITY ESTIMATE
OF ADJUSTED DAILY GAIN FOR ANGUS CALVES
AT CROSSVILLE FOR THE YEARS 1953-57

| Source of variation | Degrees of freedom | Sum of squares | Mean square | Composition of mean square | Variance components |
|---|---|---|---|---|---|
| Total | 224 | 11.4591 | | | |
| Years | 4 | 3.3091 | .8273** | | |
| Lines within years | 5 | 0.2981 | .5621** | | |
| Sires within years | 5 | 0.4238 | .0848* | $\sigma_e^2 + n_o\sigma_s^2$ | .0033 |
| Within sires | 210 | 7.4277 | .0354 | $\sigma_e^2$ | .0354 |

$n_o = 14.79$ $\quad \sigma_e^2 = .0354$ $\quad \sigma_s^2 = .0033$

Half-sib correlation $= \frac{.0033}{.354 + .0033} = \frac{.0033}{.0387} = .0853$

$(.0853 \times 4) \times 100 = 34.12$ per cent as estimate of heritability

*P < .05

**P < .01

TABLE V

ANALYSIS OF VARIANCE AND HERITABILITY ESTIMATE
OF TYPE GRADE FOR ANGUS CALVES AT
CROSSVILLE FOR THE YEARS 1953-57

| Source of variation | Degrees of freedom | Sum of squares | Mean square | Composition of mean square | Variance components |
|---|---|---|---|---|---|
| Total | 224 | 321.29 | | | |
| Years | 4 | 15.07 | 3.76* | | |
| Lines within years | 5 | 15.33 | 3.07* | | |
| Sires within lines | 5 | 15.89 | 3.18* | $\sigma_e^2 + n_o\sigma_s^2$ | .1264 |
| Within sires | 210 | 275.00 | 1.31 | $\sigma_e^2$ | 1.31 |

$n_o = 14.79$ $\qquad \sigma_e^2 = 1.31$ $\qquad \sigma_s^2 = .1264$

$$\text{Half-sib correlation} = \frac{.1264}{1.31 + .1264} = \frac{.1264}{1.4364} = .0880$$

$(.0880 \times 4) \times 100 = 35.12$ per cent as estimate of heritability

*$P < .05$

TABLE VI

ANALYSIS OF VARIANCE AND HERITABILITY ESTIMATES
OF INDEX FOR ANGUS CALVES AT CROSSVILLE
FOR THE YEARS 1953-57

| Source of variation | Degrees of freedom | Sum of squares | Mean square | Composition of mean square | Variance components |
|---|---|---|---|---|---|
| Total | 224 | 31035.44 | | | |
| Years | 4 | 4338.26 | 1084.57* | | |
| Lines within years | 5 | 1087.58 | 217.52 | | |
| Sires within lines | 5 | 551.47 | 110.29 | $\sigma_e^2 + n_o\sigma_s^2$ | - .6105 |
| Within sires | 210 | 25058.13 | 119.32 | $\sigma_e^2$ | 119.32 |

$n_o = 14.79$ $\quad \sigma_e^2 = 119.32$ $\quad \sigma_s^2 = .6105$

$$\text{Half-sib correlation} = \frac{-.6105}{119.32 + (-.6105)} = \frac{-.6105}{118.71} = -.0051$$

$(-.0051 \times 4) \times 100 = -2.0$ per cent as estimate of heritability

*$P < .05$

TABLE VII

ANALYSIS OF VARIANCE AND HERITABILITY ESTIMATE
OF ADJUSTED DAILY GAIN FOR HEREFORD CALVES
AT ALCOA FOR THE YEARS 1953-57

| Source of variation | Degrees of freedom | Sum of squares | Mean square | Composition of mean square | Variance components |
|---|---|---|---|---|---|
| Total | 568 | 40.80 | | | |
| Years | 4 | 8.16 | 2.0400** | | |
| Sires within years | 30 | 5.68 | 0.1893** | $\sigma_e^2 + n_o\sigma_s^2$ | .0076 |
| Within sires | 534 | 26.96 | 0.0505 | $\sigma_e^2$ | .0505 |

$n_o = 18.34$ $\quad \sigma_e^2 = .0505$ $\quad \sigma_s^2 = .0076$

Half-sib correlation = $\frac{.0076}{.0076 + .0505} = \frac{.0076}{.0581} = .1308$

$(.1308 \times 4) \times 100 = 52.32$ per cent as estimate of heritability

**$P < .01$

TABLE VIII

ANALYSIS OF VARIANCE AND HERITABILITY ESTIMATE
OF TYPE GRADE FOR HEREFORD CALVES AT
ALCOA FOR THE YEARS 1953-57

| Source of variation | Degrees of freedom | Sum of squares | Mean square | Composition of mean square | Variance components |
|---|---|---|---|---|---|
| Total | 568 | 1098.66 | | | |
| Years | 4 | 70.17 | 17.54** | | |
| Sires within years | 30 | 185.62 | 6.18** | $\sigma_e^2 + n_o\sigma_s^2$ | .2508 |
| Within sires | 534 | 843.07 | 1.58 | $\sigma_e^2$ | 1.58 |

$n_o = 18.34$ $\quad \sigma_e^2 = 1.58$ $\quad \sigma_s^2 = .2508$

Half-sib correlation = $\frac{.2508}{.2508 + 1.58} = \frac{.2508}{1.8308} = .1369$

$(.1369 \times 4) \times 100 = 54.76$ per cent as estimate of heritability

**$P < .01$

TABLE IX

ANALYSIS OF VARIANCE AND HERITABILITY ESTIMATE
OF INDEX FOR HEREFORD CALVES AT ALCOA
FOR THE YEARS 1953-57

| Source of variation | Degrees of freedom | Sum of squares | Mean square | Composition of mean square | Variance components |
|---|---|---|---|---|---|
| Total | 568 | 12098.96 | | | |
| Years | 4 | 13036.29 | 3259.07** | | |
| Sires within years | 30 | 15962.96 | 532.09** | $\sigma_e^2 + n_o\sigma_s^2$ | 19.6226 |
| Within sires | 534 | 91959.65 | 172.21 | $\sigma_e^2$ | 172.21 |

$n_o = 18.34$ $\quad \sigma_e^2 = 172.21$ $\quad \sigma_s^2 = 19.6226$

$$\text{Half-sib correlation} = \frac{19.6226}{172.21 + 19.6226} = \frac{19.6226}{191.8326} = .1022$$

$(.1022 \times 4) \times 100 = 40.88$ per cent as estimate of heritability

**$P < .01$

TABLE X

ANALYSIS OF VARIANCE AND HERITABILITY ESTIMATE
OF ADJUSTED DAILY GAIN FOR HEREFORD CALVES
AT OAK RIDGE FOR THE YEARS 1952-57

| Source of variation | Degrees of freedom | Sum of squares | Mean square | Composition of mean square | Variance components |
|---|---|---|---|---|---|
| Total | 976 | 103.84 | | | |
| Years | 5 | 5.19 | 1.08** | | |
| Sires within years | 65 | 15.21 | 0.2340** | $\sigma_e^2 + n_o\sigma_s^2$ | .0104 |
| Within sires | 906 | 83.44 | 0.0921 | $\sigma_e^2$ | .0921 |

$n_o = 13.69$ $\quad \sigma_e^2 = .0921$ $\quad \sigma_s^2 = .0104$

Half-sib correlation = $\frac{.0104}{.0104 + .0921} = \frac{.0104}{.1025} = .1015$

(.1015 x 4) x 100 = 40.60 per cent as estimate heritability

**P < .01

TABLE XI

ANALYSIS OF VARIANCE AND HERITABILITY ESTIMATE OF TYPE GRADE OF HEREFORD CALVES AT OAK RIDGE FOR THE YEARS 1952-57

| Source of variation | Degrees of freedom | Sum of squares | Mean square | Composition of mean square | Variance components |
|---|---|---|---|---|---|
| Total | 976 | 4750.99 | | | |
| Years | 5 | 2905.60 | 581.12** | | |
| Sires within years | 65 | 321.62 | 4.95** | $\sigma_e^2 + n_o\sigma_s^2$ | .2389 |
| Within sires | 906 | 1523.77 | 1.68 | $\sigma_e^2$ | 1.68 |

$n_o = 13.69$ $\quad \sigma_e^2 = 1.68$ $\quad \sigma_s^2 = .2389$

Half-sib correlation = $\frac{.2389}{1.68 + .2389} = \frac{.2389}{1.9189} = .1245$

(.1245 x 4) x 100 = 49.80 per cent as estimate of heritability

**$P < .01$

TABLE XII

ANALYSIS OF VARIANCE AND HERITABILITY ESTIMATE
OF INDEX OF HEREFORD CALVES AT OAK RIDGE
FOR THE YEARS 1952-57

| Source of variation | Degrees of freedom | Sum of squares | Mean square | Composition of mean square | Variance components |
|---|---|---|---|---|---|
| Total | 976 | 259760.58 | | | |
| Years | 5 | 6482.13 | 1296.42** | | |
| Sires within years | 65 | 36853.13 | 566.97** | $\sigma_e^2 + n_o\sigma_s^2$ | 23.9657 |
| Within sires | 906 | 216425.32 | 238.88 | $\sigma_e^2$ | 238.88 |

$n_o = 13.69$ $\quad \sigma_e^2 = 238.88$ $\quad \sigma_s^2 = 23.9657$

$$\text{Half-sib correlation} = \frac{23.9657}{238.88 + 23.9657} = \frac{23.9657}{262.8457} = .0912$$

$(.0912 \times 4) \times 100 = 36.48$ per cent as estimate of heritability

**$P < .01$

daily gain. The estimates of heritability were 35.1, 54.8, and 49.8 per cent for the calves at Crossville, Alcoa and Oak Ridge, respectively. Heritability estimates based on paternal half-sib correlations ranging from 18 to 52 per cent have been reported by other investigators (Table I). The estimates obtained in this study tend to be higher than most estimates reported by other workers and may be due in part to the amount and causes of variability existing in the herds and to the selection practiced in the herds. Other factors which also may contribute to such relatively high estimates are confounding of maternal genetic influence with sire influence and large sampling errors may occur where the number of sires represented is limited.

The heritability estimates for weaning selection index were -2.0, 40.9, and 36.5 per cent for calves at Crossville, Alcoa and Oak Ridge, respectively. The estimate of -2.0 per cent for the Crossville calves was obtained from data in which sire differences within lines and years was non-significant. At this location there was more variation within than between sire progenies leading to a negative heritability estimate. Average indices for sires within lines and years at this location were quite similar even though differences between sires for the individual traits included in the index were highly significant. However, sires producing calves with significantly higher adjusted daily gains did not, in general, produce calves with the highest type grades. This inverse relationship would tend to make weaning indices similar for sires within lines and years. Heritability estimates for weaning index at Alcoa and Oak Ridge were similar and approached in magnitude the heritability

estimates obtained for adjusted daily gain and type score. No estimates of heritability are available in the literature on weaning indices to compare with the estimates obtained in this study.

The magnitude of heritability estimates influences the decision of a cattle breeder in the choice of an effective selection and breeding program. They determine the relative amount of emphasis to be given a trait in selecting replacements and in evaluating the breeding value of individual animals. In order to estimate the rate of progress and the relative value of various criteria of selection it is necessary to know the approximate heritability of the traits in question. If estimates of heritability for economic traits are sufficiently high more emphasis in selection can be placed on individual performance.

Collateral relatives and progeny test would be used to supplement individual selection. This could lead to relatively more accurate selection earlier in the life of breeding animals and consequently faster progress. The heritability estimates for adjusted daily gain, type grade and weaning index obtained in this study are sufficiently high to indicate that real progress can be made through the initial selection of replacement animals based on performance in these traits. The use of a weaning selection index should be of significant use in evaluating overall merit and in initial selection of replacements. It may, however, be necessary to set up independent culling levels to use in conjunction with such an index for most effective use.

# CHAPTER VI

## SUMMARY AND CONCLUSIONS

Weaning data available from 225 Angus calves and 1546 Hereford calves at three locations for the period between 1952 and 1957 were studied to determine heritability estimates for daily gain from birth to weaning, type score and weaning selection index. Estimates of heritability for these traits were obtained from paternal half-sib correlations estimated from analysis of variance.

The heritability estimates for adjusted daily gain varied from 34.1 per cent for the Angus calves at Crossville to 52.3 per cent for Hereford calves at Alcoa. The estimate for Hereford calves at Oak Ridge was 40.6 per cent.

Heritability estimates for type grade of calves were 35.1, 54.8, and 49.8 per cent for Crossville, Alcoa, and Oak Ridge, respectively. Estimates of heritability for weaning selection index were -2.0, 40.9, and 36.5 per cent, respectively, for the three locations included in the study. The negative estimate of heritability was obtained from data where differences between sires within years and lines were not significant.

The estimates of heritability for the traits included in this study, are sufficiently high to indicate that real progress can be made in the improvement of these characteristics through selection based on phenotypic performance records. The use of a weaning selection index including both growth rate and type should be of significant value in estimating overall merit and in the initial selection of replacement animals.

## BIBLIOGRAPHY


Brown, C. J. 1958. Heritability of Weight and Certain Body Dimensions of Beef Calves at Weaning. Arkansas Agr. Exp. Sta. Bul. 597.

Faulk, Jimmy D. 1957. The Influence of Sex and Age of Dam on Some Economic Characteristics in Beef Cattle. M.S. Thesis. University of Tennessee Library.

Koger, Marvin, and J. H. Knox. 1952. Heritability of Grade and Type in Range Beef Cattle. Jour. Anim. Sci. 11:361-369.

Dawson, W. M., E. H. Vernon, A. L. Baker, and E. J. Warwick. 1954. Selection for Increased Weights of Six-month-old Beef Calves in a Brahman-Angus Population. Jour. Anim. Sci. 13:556-562.

Dawson, W. M., T. S. Yao, and A. C. Cook. 1955. Heritability of Growth, Beef Characters, and Body Measurements in Milking Shorthorn Steers. Jour. Anim. Sci. 14:208-217.

Gregory, K. E., C. T. Blunn, and M. L. Baker. 1950. A Study of Some of the Factors Influencing the Birth and Weaning Weights of Beef Calves. Jour. Anim. Sci. 9:338-346.

Kidwell, J. F. 1954. Some Growth Relations in Range Cattle. Jour. Anim. Sci. 13:54-60.

Knapp, Bradford, Jr., and R. T. Clark. 1950. Revised Estimates of Economic Characteristics in Beef Cattle. Jour. Anim. Sci. 9:582-587.

Knapp, Bradford, Jr., and Arne W. Nordskog. 1946. Heritability of Growth and Efficiency in Beef Cattle. Jour. Anim. Sci. 5:62-70.

Koch, Robert M., and R. T. Clark. 1955. Genetic and Environmental Relationships Among Economic Characters in Beef Cattle. I. Correlations Among Paternal and Maternal Half-sibs. Jour. Anim. Sci. 14:775-785.

Koch, Robert M., and R. T. Clark. 1955. Genetic and Environmental Relationships Among Economic Characters in Beef Cattle. II. Correlations Between Offspring and Dam and Offspring and Sire. Jour. Anim. Sci. 14:786-791.

Koch, Robert M., and R. T. Clark. 1955. Genetic and Environmental Relationships Among Economic Characters in Beef Cattle. III. Evaluating Maternal Environment. Jour. Anim. Sci. 14:979-996.

McCormick, W. C., B. L. Southwell, and E. J. Warwick. 1956. Factors Affecting Performance in Herds of Purebred and Grade Polled Hereford Cattle. Georgia Agr. Exp. Sta. Tech. Bul. H.S. 5.

Rollins, W. C., and K. A. Wagnon. 1956. A Genetic Analysis of Weaning Weights in a Range Beef Herd Operated Optimum and Sub-optimum Nutritional Regimes. Jour. Anim. Sci. 15:125-133.

Shelby, C. W., R. T. Clark, and R. R. Woodward. 1955. The Heritability of Some Economic Characteristics of Beef Cattle. Jour. Anim. Sci. 14:372-385.

Snedecor, George W. 1956. Statistical Methods. Iowa State College Press.