February 21, 1972

To the Graduate Council:

I am submitting herewith a thesis written by William Ray Stricklin entitled "An Analysis of the Responses of Young Beef Cattle to Restraint in a Squeeze Chute." 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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# AN ANALYSIS OF THE RESPONSES OF YOUNG BEEF CATTLE TO RESTRAINT IN A SQUEEZE CHUTE

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A Thesis

Presented to

the Graduate Council of

The University of Tennessee

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In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

William Ray Stricklin

March 1972

ACKNOWLEDGMENT

The author would like to express his appreciation to Dr. Robert R. Shrode, Professor, Animal Husbandry-Veterinary Science, for his guidance and support of this research project. He also conveys appreciation to Dr. Robert L. Murphree, Professor, Animal Husbandry-Veterinary Science, and Dr. J. B. McLaren, Associate Professor, Animal Husbandry-Veterinary Science, for their assistance. Further acknowledgment is extented to Mr. Steve Hammack, Graduate Assistant, Animal Husbandry-Veterinary Science, for his assistance in scoring and many helpful suggestions.

The author expresses a special appreciation to his wife, Cheryl, for her patience, assistance and encouragement in this endeavor.



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## ABSTRACT

Two hundred and eight Angus calves and 140 Hereford calves were subjectively scored on a discrete scale from one to five for resistance to restraint in a squeeze chute. Calves of the 1970 crop were scored at an average age of 375 days (postweaning). The 1971 calves were scored at average ages of 142 (preweaning) and 241 (weaning) days.

Location and breed effects on score for restraint resistance (or chute behavior) were completely confounded since the Angus were at one branch experiment station and the Herefords at another. The Angus calves had the highest average score at all observation times with the smallest difference between the two groups occurring at postweaning.

Least-squares means for heifer behavior scores were higher than those for bulls at each observation time. There appeared to be a trend for behavior score to increase with age in the preweaning calves. The opposite trend was found in the older age groups.

Partial correlations of behavior with weight, type, condition and average daily gain were mostly negative. However, none of the correlations calculated were significantly different from zero.

Estimates of heritability of behavior score in the two groups averaged together were 0.091, 0.298 and 0.384 for preweaning, weaning and postweaning, respectively. These estimates appear to be in the same range as those reported for reproductive traits which are, as is the trait studied here, hormonally influenced.

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# CHAPTER I

## INTRODUCTION

Without knowledge of animals, man would have become extinct long ago. Man has always been interested in the behavior of animals although probably not consciously at first. Without some familiarity with the habits of animals, man could not have domesticated them.

Recently there has been an increase in interest in the area of animal behavior. Confinement feeding, use of mechanical feeding devices and the further removal of the animal from its natural environment have been subjected to study from a behavioral viewpoint. Because of the possibility of relationships among learning, behavior and production, behavior and temperament have been given attention in animal science research.

Naturalists have long studied the fauna in its natural environment. Behavior patterns have been recognized in farm animals, but little attempt has been made to evaluate quantitatively the relationships among learning, temperament and production. Man has more or less taken for granted the behavior of domesticated animals. He has recognized behavior but has made little effort until recently to measure and record this phenomenon. Those working directly with farm animals, if asked, would probably be nearly unanimous in favoring a mild, nonbelligerent temperament in animals because such animals are much easier to handle. However, it is essential that correlations between temperament and productivity

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be known before emphasizing efforts to make average temperament more mild.

Farm animals have had to cope with environments vastly different from the habitats to which their ancestors were adapted. Crowding, loud noises, concrete and slatted floors, artificial light and food are just a few of the man-made changes to which domesticated animals are subjected and have learned to tolerate but, undoubtedly, with varying degrees of success.

## I. STATEMENT OF THE PROBLEM

This study was undertaken to estimate correlations of temperament of cattle with various production traits and to estimate the heritability of behavior of cattle. Chute behavior, subjectively scored for resistance to restraint, was used as the measure of temperament and was correlated with average daily gain, type score and condition score at "preweaning" (average age of 120 days), "weaning" (average age of 230 days), and "postweaning" (average age of 375 days).

## II. LIMITATIONS OF THE STUDY

This study involved calves from two different herds and breeds (Angus and Hereford) at different locations and under different management. Therefore, the breeds cannot be justifiably compared since breed would be completely confounded with all other effects associated with location.

A further limitation is that relatively few data have thus far been collected. Data from more generations scored at more frequent intervals need to be obtained to give more accurate estimates of heritability and of correlations.

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# CHAPTER II

## REVIEW OF LITERATURE

A review of published literature failed to bring to light any published estimate of heritability of behavior in cattle. Very few reports have been published concerning relationships among animal behavior and production traits. Dominance-rank (or peck-order) has been studied to a limited extent in cattle but more thoroughly in chickens.

Sexual behavior in cattle has been studied more extensively than other patterns of behavior. Hafez (1969) in The Behavior of Domestic Animals presented an excellent and thorough discussion of the sexual and maternal behavior of cattle. The present review does not cover sexual behavior.

This review covers general behavior, dominance-rank and conditioning studies in cattle. Because no studies pertaining to selection for behavioral characteristics in cattle were found, literature published on this subject involving chickens, swine and laboratory animals are reviewed. Correlations of behavior with production traits also are reported.

### I. BEHAVIOR AND LEARNING ABILITY STUDIES IN CATTLE

#### Behavior Studies

In one of the most recent studies of cattle behavior, Schake and Riggs (1970) studied the activity patterns of confined beef calves

observed for 24-hour periods once each month for five months. Calves were maintained in six groups of seven head each and observed for frequency of defecation and urination, distance walked and minutes devoted to standing, lying, eating, nursing, ruminating and drinking. All criteria measured differed significantly between day and night observations. Level of feed intake of dam did not significantly influence calf behavior. Distance walked by calves each day was about two-thirds that walked by their confined dams.

Earlier Schake and Riggs (1969) studied the daily activities of mature lactating beef cows in confinement at three levels of feed intake. Cows were observed five times at monthly intervals for 24-hour periods. Their behavior patterns differed markedly from those of range cows and also varied significantly between feed intake levels and portion of day. Cows receiving the least feed (1.5 percent of body weight) spent the most time in nonproductive activities such as idling, licking and walking. Cows fed the highest level of feed intake (2.5 percent of body weight) were observed to eat, stand, ruminate, and defecate most. Cows given an intermediate level of feed tended to be intermediate in nearly all criteria observed. These confined cows walked only 610 meters per day, roughly one-tenth the distance recorded for range cows.

Dominance Order Studies

Hafez, Schein and Ewbank (1969) reported that when cattle are penned or pastured together, they immediately establish a hierarchy which remains stable for long periods. Schein and Fohrman (1955) stated that simple gestures such as movements of the head or "threat" posture

apparently suffice to establish the social ladder of the group. However, Schake and Riggs (1970) failed to find a social rank in confined beef calves through 325 days of age.

Schein and Fohrman (1955) found significant correlations of dominance order with both age and weight in a "closed" dairy herd, that is, a herd to which new members are added almost exclusively by being born into the herd. They interpreted these correlations as coincidental, rather than caused, and suggested that seniority, which also is correlated with both age and weight, is the crucial factor in closed herds.

Guhl and Atkeson (1959) also showed a high correlation between social rank and seniority, while data of Dickson, Barr and Wieckert (1967) showed a significant correlation between dominance order and weight. McPhee, McBride and James (1964) reported that height at withers may be more important than weight or chest girth in the establishment of dominance order.

Schein and Fohrman (1955) found little, if any, relationship between breed and social rank in comparing Jerseys with zebu-Jersey crosses. However, Wagnon et al. (1966) found that Angus tend to dominate Shorthorns, which in turn tend to dominate Herefords. This difference did not appear to be due to size alone but appeared to result from breed behavioral characteristics.

## Learning Ability Studies

One well known example of stimulus-response conditioning is that of milk let-down of dairy cattle. However, as pointed out by Quinn (1966) no complete determination has yet been made as to all that is involved

in the conditioning stimulus for the milk ejection response. Kudryzvizev (1962) as reported by Hafez (1969) used visual, auditory and olfactory cues to obtain conditioned responses in dairy cows in classical conditioning experiments.

In an operant conditioning experiment, Albright et al. (1966) used a tape recorder attached to the necks of dairy and beef cows and found it to be an effective means to deliver an auditory stimulus for conditioning a homing response. In other instrumental conditioning tests, Kudryzvizev (1962) reported no significant individual differences in speed of conditioning, but Dickson (1967) reported that calves do differ in their ability to remember and form visual associations. Dickson used the T-maze apparatus reported by Wieckert et al. (1966).

Wieckert et al. (1966) studied learning ability of six-month-old dairy heifers in a modified T-maze. The calves were able to discriminate to obtain a food reward and attained a performance level of 80 percent correct after three sessions of ten trials each.

In an attempt to increase feed intake of yearling dairy heifers through conditioning, Offord, Satten and Wieckert (1969) used heifers which had been conditioned to expect a limited amount of feed with noise from a feed machine. These heifers were exposed to a sham feed-machine and ad libitum feeding. The conditioned animals' average feed intake was only slightly greater than that of the controls.

## II. LEARNING ABILITY STUDIES IN SWINE

The first report of avoidance learning in swine was made by Karas et al. (1962). They conditioned 21-day-old pigs to avoid foot-shock by

responding to a warning buzzer. They concluded that pigs reached levels of performance in avoidance learning comparable to other species and that 30 trials, 10 per day, gave a convenient and sufficiently sensitive measure of learning.

Willham et al. (1963) used procedures described by Karas et al. (1962) to measure the avoidance learning of 587 pigs 21 days old. Willhalm reported heritability estimates of avoidance learning in pigs of .52 ± .20 and .46 ± .12 based upon the correlation between paternal half-sibs and full-sibs, respectively. The following factors were investigated as possible causes of variation in the avoidance learning scores: sex (females vs. castrated males), number of littermates, starting age (18 to 24 days), season of testing, bodyweight and age of dam. Only age of dam accounted for more than 2 percent of the total variation. Willham et al. (1964) with more data and more classes of age of dam reported no important differences due to age of dam.

Similar heritabilities were found by Kratzer (1965) in an analysis of avoidance learning scores from 2,089 pigs measured with the apparatus and procedures described by Willham et al. (1963). It was concluded that no significant amounts of variance could be attributed to the factors mentioned.

Kratzer (1969) investigated the relationship between age and avoidance learning ability in pigs. The ages, 40, 80 and 150 days, were selected as representative of preweaning, postweaning and early maturity stages of development. These results were compared with Kratzer's (1965) study of characteristics of learning at 21 days of age.

Kratzer (1969) found that heavier pigs within the litters studied were the better avoidance learners. Duroc pigs were better learners than Hampshire pigs at all ages tested. The achieved level of learned responses decreased 0.16 percent per day during the test, as shown in Figure 1. Estimates of heritability of avoidance learning ability calculated by Kratzer (1969) are listed in Table I.

## III. SELECTION FOR BEHAVIORAL CHARACTERISTICS

Komai, Craig and Wearden (1959) used domestic chickens in order to estimate the extent of genetic variation in social aggressiveness. Six strains from four breeds were used in the study. Two hundred eighty-eight pullets and their 131 dams supplied data for heritability estimates. Repeatability of social status of strains was calculated on the basis of mean social rank of 16 and 24 pullets from each strain in intermingled flocks in the first and second years of the study, respectively. At five months of age, eight pullets from each strain were selected at random and placed with an intermingled flock. Birds were ranked using fights, pecks, threats and avoidances for estimating social status of each pullet. The mean intrastrain heritability estimates of 0.30 and 0.34 for percentile and ordered social ranks, respectively, indicate that selection should be effective in changing aggressiveness level within a strain. It was reported also that strains tend to repeat their social standing to intermingled flocks from year to year, the estimate of repeatability being 0.857. The data from high-rank strains yielded low heritability estimates while high estimates were obtained from data from low-rank

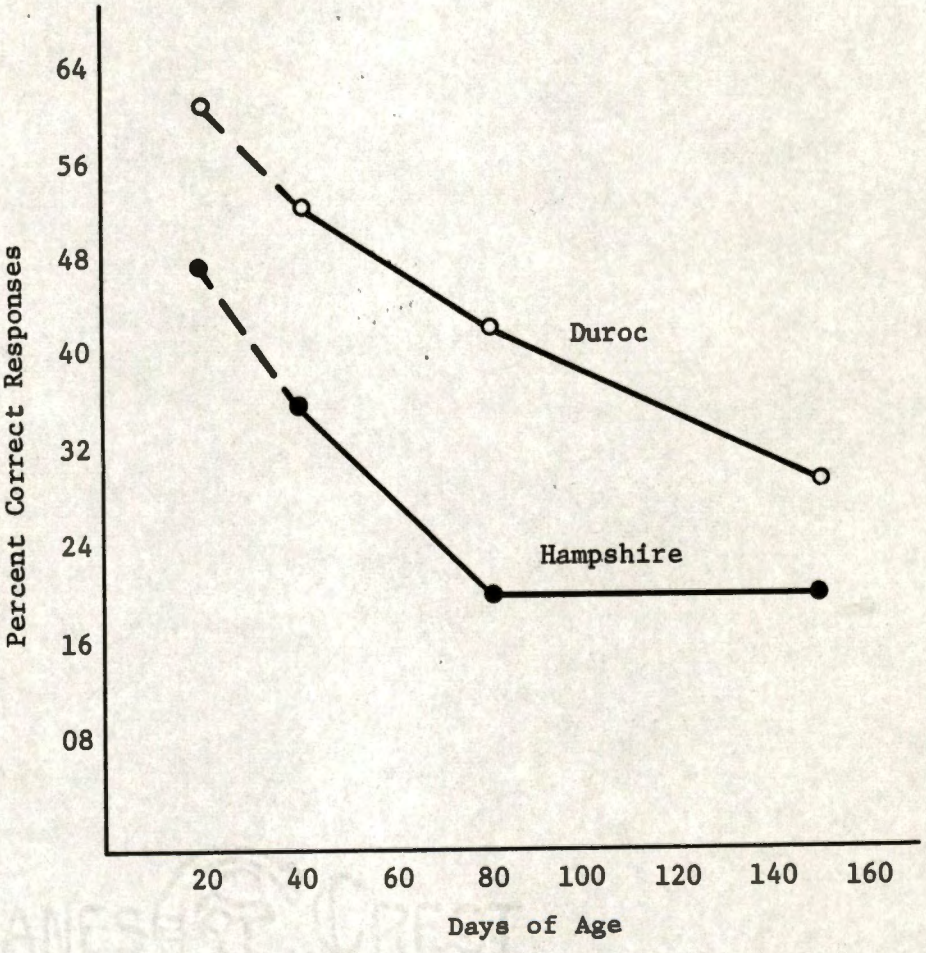



Figure 1. Relation of avoidance learning ability to age.

Source: Kratzer, D. D. 1969. Effects of age of avoidance learning in pigs. J. Anim. Sci. 28:175.

TABLE I

ESTIMATES OF HERITABILITY OF AVOIDANCE LEARNING IN SWINE (BASED ON FULL-SIB CORRELATIONS)[a]

| Age In Days | Heritability Estimates | Standard Errors |
|---|---|---|
| 21 | 0.50 | 0.08 |
| 40 | 0.41 | 0.22 |
| 80 | 0.27 | 0.22 |
| 150 | 0.28 | 0.22 |

[a]Statistics taken from: Kratzer, D. D. 1969. Effects of age of avoidance learning in pigs. J. Anim. Sci. 28:175.

strains. This finding led these researchers to suggest that selection for aggressiveness may have inadvertantly occurred in those strains showing high social rank and that such selection had reduced genetic variation in this trait.

Guhl and Eaton (1958) found that after one generation of selection for aggressiveness, results failed to indicate aggressiveness to be inherited. There seemed to be little or no relationship between relative aggressiveness of parent and that of offspring.

Later, in a more thorough study, Guhl, Craig and Mueller (1960) used White Leghorn chickens to determine if two strains differing in average aggressiveness could be produced by selective breeding. Peck-orders were determined in both flocks for each sex, and chickens were ranked according to the number of chickens each dominated. Social order and encounters won were used to rank males, and males receiving high scores were mated to females of high social rank. Males receiving low scores were mated to females ranking low in the social order. Selection was carried to the fourth generation. Beginning with the second generation, the two lines showed significant differences in percentages of encounters won and lost as well as in rank in the peck-order. Heritability estimates of 0.22 and 0.18 were obtained based on the percentage of contests won and number of chickens dominated, respectively.

Selection for behavioral characteristics in larger animals has not been studied; whereas, these studies have been attempted with laboratory animals. Frings and Frings (1953) used mice to select successfully for sensitivity to sound-induced seizures. Laboratory animals have been

selected also for their activity in a rotating cage (Rundquist, 1933), maze learning (Heron, 1941) and emotionality (Hall, 1938). Fuller (1969) pointed out that change from selection for behavior is reasonably rapid, significant effects being evident in one or two generations, and that experiments with laboratory animals provide good models to be followed with large animals.

## IV. CORRELATIONS OF BEHAVIOR WITH PRODUCTION TRAITS

Few attempts have been made to correlate behavior and production in cattle, but as stated by Kratzer (1971),

> The literature is limited but obviously in agreement that dairy cows can be conditioned in simple and complex learning situations. Speed of learning in classical conditioning experiments [is] indirectly correlated with milk production through nervousness. But, no quantitative estimates of the correlations [have been] reported.

Baryshnikov and Kokorina (1964) reported a negative relationship between nervousness and milk production. However, Dickson (1967) found that in a sample of 1,017 cows from 27 herds neither temperament nor dominance value was significantly correlated with milk production. Schein and Fohrman (1955) and Beilharz et al. (1965) also failed to find a relationship between rank order and milk production. Guhl and Atkeson (1959) found little, if any, relationship between social rank and production in cattle under adequate husbandry conditions.

McPhee, McBride and James (1964) used two-year-old Brahman X Hereford crossbreeds, two-year-old Herefords and three-year-old Herefords and found fairly stable linear social orders which appeared to depend mainly on height. The crossbreeds dominated the three-year-old Herefords

who in turn dominated the two-year-old Herefords. Although high ranking animals had priority at the feed trough, there was no relationship between social rank and growth, even though animals in the high social stratum spent more time feeding than low-stratum animals. Animals entered the crush at the scales in significant ($P < 0.05$) nonrandom orders. There was little or no linear relation between an animal's social rank and its order of movement into the crush.

Guhl (1953) reported a correlation of 0.26 ($P<0.01$) between number of eggs laid and number of birds pecked in the peck-order. Position in the peck-order was shown to be correlated with a number of variables such as priorities at the food trough, nests and roosting places.

McBride (1964) found peck-order position by assessing aggressiveness scores for birds housed intensively on deep litter on the floor and birds housed in cages. Scores were found to be correlated with egg weight, egg numbers and egg mass in the floor birds but not in the caged birds. The correlation between egg weight and egg number was higher in the flock on the floor than in the caged flock. This appeared to be due to a significant position correlation among the lowest scoring birds on the floor.

Guhl and Eaton (1948) reported that females who composed the top half of the peck-order in chickens had higher egg production. Males who ranked high socially sired more chicks than their less aggressive pen mates.

McBride (1958) reported that in swine there is some evidence that under poor husbandry practice there is an increased regression of

production on social rank. He further suggested that in chickens the regression of egg production on social rank is increased under conditions of poor husbandry.

## V. SUMMARY

There appears to be no reported study of an attempt to calculate an estimate of heritability of behavior in cattle. Komai, Craig and Wearden (1959) found an estimate of 0.34 for heritability of social order in chickens. Guhl (1948, 1953, 1959 and 1960) has studied the peck-order and aggressiveness in chickens. He reported a relationship between dominance and egg production. Most workers have found little or no correlation among dominance and production traits in cattle. Milk production studies have been the most commonly studied trait in attempts to find relationships between behavior and production in cattle.

Schake and Riggs (1969 and 1970) reported on the behavior of beef cows and calves in confinement. Hafez (1969) and other researchers have studied sexual behavior, but this subject was not covered in this review.

# CHAPTER III

## EXPERIMENTAL PROCEDURE

### I. SOURCE AND DESCRIPTION OF DATA

The data in this study were collected over a two-year period (1970-71) from two herds of cattle belonging to The University of Tennessee, a Hereford herd located near Greeneville and the other an Angus herd at the Plateau Experiment Station near Crossville.

The two stations are situated in different geographic regions of Tennessee. Crossville is on the Cumberland Plateau, elevation about 2,000 feet, and is favored with excellent summer temperature and rainfall patterns. Greeneville is located in the Ridge and Valley Region of the Appalachian Range. It too has favorable climatic conditions for beef production.

Dams of calves were provided good permanent or supplemental annual pasture starting at approximately April 1. The cow herds were wintered on hay and silage. Calves were not creep fed.

The calves at both locations were subjectively scored for behavior while they were restrained in a squeeze chute at regular intervals for the collection of data on various variables of experimental interest in a beef cattle breeding research project. Activity prior to entry into the chute was not considered in the scoring. After the animal had been secured in the head squeeze, it was measured around the heart girth,

along the back, loin and rump. Height at hip was also measured. After these body measurements were recorded, an area about four inches square was sheared on the left side of the animal's midline over the 12th and 13th ribs, and subcutaneous back-fat thickness was measured ultrasonically.

One scorer made all the body measurements, and the other made the fat thickness measurement as the last step prior to the animal's release. However, both observers scored the animal over the entire time interval it spent in the chute. Average time in the chute per observation per animal was about 5-7 minutes.

Three different chutes were used in the study. The chutes were of different brands, but all were similar in design. The same chute for all observations was used at the Greeneville station.

The calves were scored by two staff members of the Animal Husbandry-Veterinary Science Department of The University of Tennessee. All scoring at each interval was done by these two men.

Calves of 1970 were scored only once at postweaning when the calves averaged 375 days of age with a 25-day standard deviation. The 1971 calves were scored at preweaning (approximately 142 days of age) and again at weaning (about 241 days of age). Calves at Greeneville were three, four and thirteen days older than the Crossville calves at periods PRW, W and POW, respectively, where PRW is preweaning, W is weaning and POW is postweaning.

In this experiment 425 calves were studied. Of these, 227 were bulls and 198 were heifers. There were 285 Angus and 140 Herefords. These cales were sired by 33 bulls, 7 Hereford and 26 Angus. Even though

fewer Herefords were included in the study, the number of offspring per sire was less variable. Table II lists the distribution of offspring by sire.

The calves were scored on a discrete scale from one to five as shown in Table III. Individuals very resistant to the confinement within a squeeze chute were scored five. Animals that offered little or no resistance to being restrained were assigned the score of one. Calves that showed degrees of activity within these extremes were scored accordingly.

Average daily gain (ADG) in this study is lifetime ADG. It is corrected for age of dam and sex. Weight, condition score and type score were recorded at the time calves were scored for behavior. Type score was determined by using the conventional subjective appraisal of body shape (Fancy = 15-17, Choice = 12-14, Good = 9-11, et cetera). Condition score, a subjective estimate of overall fatness, was made using the same numerical scoring system as used for type.

## II. ESTIMATES OF HERITABILITY AND GENETIC CORRELATION

Heritability was estimated using correlations among paternal half sibs. Least-squares methods of analysis of data with disproportionate subclass numbers as described by Harvey (1960) were used to obtain estimates of the required components of variance. The formula for an estimate of heritability ($\hat{h}^2$) in the narrow sense as calculated in this study is:

$$h^2 = \frac{4\,\hat{\sigma}s^2}{\hat{\sigma}s^2 + \hat{\sigma}w^2}$$

TABLE II

NUMBER OF BULLS AND HEIFERS PER SIRE AT GREENEVILLE AND CROSSVILLE

| | 1971[a] | | | | | 1970[b] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sire No. | No. ♂♂ | No. ♀♀ | Total | | Sire No. | No. ♂♂ | No. ♀♀ | Total |
| Greeneville | | | | | | | | | |
| | 4218 | 14 | 4 | 18 | | 4137 | 8 | 7 | 15 |
| | 4307 | 9 | 10 | 19 | | 4177 | 9 | 5 | 14 |
| | 4348 | 9 | 5 | 14 | | 4218 | 5 | 8 | 13 |
| | 4999 | 6 | 8 | 14 | | 4301 | 7 | 3 | 10 |
| | 4189 | 10 | 5 | 15 | | 4348 | 2 | 6 | 8 |
| Totals | 5 | 48 | 32 | 80 | Totals | 5 | 31 | 29 | 60 |
| Crossville | | | | | | | | | |
| | 5088 | 4 | 3 | 7 | | 5038 | 4 | 6 | 10 |
| | 5108 | 8 | 9 | 17 | | 5048 | 0 | 3 | 3 |
| | 5126 | 2 | 7 | 9 | | 5088 | 5 | 7 | 12 |
| | 5129 | 13 | 4 | 17 | | 5108 | 5 | 6 | 11 |
| | 5158 | 10 | 3 | 13 | | 5126 | 4 | 9 | 13 |
| | 5338 | 5 | 9 | 14 | | 5166 | 7 | 4 | 11 |
| | 5417 | 0 | 2 | 2 | | 5205 | 5 | 1 | 6 |
| | 5418 | 6 | 6 | 12 | | 5398 | 7 | 3 | 10 |
| | 5438 | 3 | 5 | 8 | | 5438 | 7 | 4 | 11 |
| | 5488 | 2 | 3 | 5 | | 5478 | 5 | 6 | 11 |
| | 5659 | 1 | 1 | 2 | | 5528 | 3 | 3 | 6 |
| | 5738 | 2 | 1 | 3 | | 5536 | 4 | 6 | 10 |
| | 5748 | 5 | 2 | 7 | | 5598 | 4 | 6 | 10 |
| | 5838 | 4 | 3 | 7 | | 5748 | 7 | 3 | 10 |
| | 5878 | 9 | 4 | 13 | | 5878 | 1 | 3 | 4 |
| | 5913 | 3 | 1 | 4 | | 5913 | 3 | 3 | 6 |
| Totals | 16 | 78 | 62 | 140 | Totals | 16 | 71 | 73 | 144 |

[a]Preweaning and weaning

[b]Postweaning

TABLE III

DESCRIPTION OF NUMERIC BEHAVIOR SCORES GIVEN CALVES RESTRAINED IN A SQUEEZE CHUTE

| Numeric Score | Description |
|---|---|
| 1 | Very Docile |
| 2 | Docile |
| 3 | Average Activity |
| 4 | Active |
| 5 | Very Active |

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where: $\hat{\sigma}_s^2$ is the estimate of the component of variance due to difference between sires,

$\hat{\sigma}_w^2$ is the estimate of the component of variance due to differences among paternal half-sibs.

Estimates of genetic correlation ($r_g$), or the ratio of the genetic covariance between two traits and the product of the square roots of their genetic variances, were computed as follows:

$$r_g = \frac{Cov_{S(XY)}}{\sqrt{s^2_{S(X)} \; s^2_{S(Y)}}}$$

where: $Cov_{S(XY)}$ = sire component of covariance of traits X and Y

$s^2_{S(X)}$ = sire component of variance of the trait X

$s^2_{S(Y)}$ = sire component of variance of the trait Y.

The form of the analysis of variance used to obtain the estimates of variance components for use in estimating heritability from paternal half-sib correlation is as presented in Table IV. Components of covariance were obtained in a similar manner using mean products instead of mean squares.

## III. STATISTICAL MODEL

The model on which analyses were based is as follows:

$$Y_{ijkl} = \mu + s_i + g_j + a_k + b(X_{ijkl} - \bar{X}) + e_{ijkl}$$

TABLE IV

FORM OF THE ANALYSIS OF VARIANCE USED TO OBTAIN ESTIMATES OF HERITABILITY FROM PATERNAL HALF-SIB CORRELATION

| Source of Variation | Degrees of Freedom | Composition of Mean Square |
|---|---|---|
| Between sires | (S-1) | $s_w^2 + k\, s_s^2$ |
| Within sires | (k. - S) | $s_w^2$ |

Where: S = number of sires

k. = total number of offspring

$s_w^2$ = variance due to differences between offspring of same sire

$s_s^2$ = variance due to sire differences

$k = \frac{\Sigma k_i}{S} - \frac{s_k^2}{\Sigma k_i}$ where $\sum_{i=1}^{s} k_i = k.$ , $k_i$ being number of offspring of the $i^{th}$ sire

$s_k^2$ = variance of number of offspring per sire.

where: $Y_{ijkl}$ = average daily gain, condition grade, weight, type grade or behavior score

$\mu$ = overall mean

$s_i$ = effect of $i^{th}$ sire

$g_j$ = effect of $j^{th}$ sex, j = 1,2

$a_k$ = effect of $k^{th}$ age of dam

b = partial regression of Y on X

$X_{ijkl}$ = age of $l^{th}$ calf in $k^{th}$ age of dam group, of $j^{th}$ sex, and $l^{th}$ sire group

$e_{ijkl}$ = random error associated with the observation of an individual calf.

To avoid confounding of breed and location and to eliminate year differences, data from each location at each period were analyzed according to the above model. The method of fitting constants as described by Harvey (1960) was used to remove possible bias caused by partial confounding of certain effects as a result of frequencies among subclasses.

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# CHAPTER IV

## RESULTS AND DISCUSSION

### I. SUBCLASS FREQUENCIES AND MEANS

Numbers of calves, least-squares means and standard errors for the various location, sire, sex and observation-time subclasses are shown in Table V to give a general impression of the distribution of the data and the nature of the variables included in the statistical analyses. The observation times were preweaning (PRW), weaning (W) and postweaning (POW). Only POW observations of behavior score were recorded for 1970 calves, and only PRW and W observations of this variable on 1971 calves were available for this study. The POW observations will be recorded in March 1972.

### II. PARTIAL CORRELATIONS

Partial correlations involving weight (WT), type score (T), condition score (C), average daily gain (ADG) and behavior (B) are shown for Greeneville and Crossville in Tables VI and VII, respectively. The values in parentheses following the partial correlation values are the probabilities of chance occurrence when the hypothesis that Rho = 0 is tested. Each of the correlations in these tables have been computed with effects of sex, sire and age of calf having been adjusted for or held constant. In other words, r in Tables VI and VII is $r_{XY}$ on a

TABLE V

LEAST-SQUARES MEANS AND STANDARD ERRORS OF DEPENDENT VARIABLES

| | Sex Ratio (♂♂/♂♂) | Weight | Average Daily Gain | Type Score | Condition Score | Behavior Score |
|---|---|---|---|---|---|---|
| Greeneville | | | | | | |
| Preweaning[a] | 48/32 | 325.83 ±7.39 | 1.81 ±0.049 | 12.93 ±0.139 | 7.84 ±0.131 | 2.29 ±0.191 |
| | | 300.38 ±9.23 | 1.75 ±0.061 | 12.72 ±0.174 | 7.90 ±0.163 | 2.77 ±0.238 |
| Weaning[a] | 48/32 | 494.82 ±9.23 | 1.80 ±0.037 | 12.98 ±0.131 | 8.66 ±0.144 | 1.45 ±0.160 |
| | | 432.24 ±11.52 | 1.64 ±0.046 | 12.95 ±0.210 | 9.55 ±0.179 | 2.31 ±0.199 |
| Postweaning[b] | 31/29 | 738.64 ±11.87 | 1.74 ±0.029 | 13.48 ±0.229 | 9.72 ±0.212 | 2.56 ±0.241 |
| | | 578.99 ±11.85 | 1.34 ±0.029 | 12.79 ±0.229 | 10.40 ±0.211 | 2.97 ±0.241 |
| Crossville | | | | | | |
| Preweaning[a] | 77/63 | 324.28 ±6.22 | 1.93 ±0.048 | 12.99 ±0.162 | 7.76 ±0.133 | 2.69 ±0.165 |
| | | 298.63 ±6.15 | 1.89 ±0.048 | 13.01 ±0.160 | 7.99 ±0.132 | 2.82 ±0.163 |
| Weaning[a] | 77/63 | 503.55 ±6.67 | 1.91 ±0.030 | 12.94 ±0.168 | 8.36 ±0.130 | 2.78 ±0.157 |
| | | 453.47 ±6.60 | 1.81 ±0.029 | 12.58 ±0.166 | 9.23 ±0.128 | 3.11 ±0.156 |
| Postweaning[b] | 71/73 | 677.59 ±7.19 | 1.68 ±0.019 | 12.69 ±0.137 | 9.44 ±0.093 | 2.31 ±0.152 |
| | | 596.55 ±7.49 | 1.46 ±0.019 | 12.95 ±0.143 | 9.86 ±0.098 | 2.65 ±0.158 |

[a]1971 calves

[b]1970 calves

TABLE VI

PARTIAL CORRELATIONS AMONG DEPENDENT VARIABLES AT GREENEVILLE

| | Weight | Type Score | Condition Score | ADG | Behavior Score |
|---|---|---|---|---|---|
| Weight | 1.0000 (0.0000) | 0.6081[a] (0.0001)[d] | 0.6259 (0.0001) | 0.9374 (0.0001) | -0.0404 (0.7427) |
| | | 0.6116[b] (0.0001) | 0.5427 (0.0001) | 0.9631 (0.0001) | -0.1683 (0.1667) |
| | | 0.3184[c] (0.0311) | 0.5430 (0.0003) | 0.9874 (0.0001) | -0.0366 (0.8063) |
| Type Score | | 1.0000 (0.0000) | 0.4186 (0.0007) | 0.5639 (0.0001) | -0.1088 (0.6191) |
| | | | 0.3952 (0.0012) | 0.5923 (0.0001) | -0.0007 (0.9912) |
| | | | 0.1173 (0.5512) | 0.3215 (0.0295) | 0.0136 (0.9266) |
| Condition Score | | | 1.0000 (0.0000) | 0.6358 (0.0001) | 0.0834 (0.5061) |
| | | | | 0.5848 (0.0001) | -0.0251 (0.8336) |
| | | | | 0.5487 (0.0002) | -0.0652 (0.6738) |
| ADG | | | | 1.0000 (0.0000) | -0.0147 (0.9012) |
| | | | | | -0.1918 (0.1132) |
| | | | | | -0.0273 (0.8527) |
| Behavior Score | | | | | 1.0000 (0.0000) |

[a]Preweaning.

[b]Weaning.

[c]Postweaning (1970).

[d]Level of significance for Ho: Rho=0.

TABLE VII

PARTIAL CORRELATIONS AMONG DEPENDENT VARIABLES AT CROSSVILLE

| | Weight | Type Score | Condition Score | ADG | Behavior Score |
|---|---|---|---|---|---|
| Weight | 1.0000 (0.0000) | 0.2899[a] (0.0001)[d] | 0.3529 (0.0003) | 0.9530 (0.0001) | -0.0201 (0.8279) |
| | | 0.3615[b] (0.0003) | 0.3236 (0.0008) | 0.9617 (0.0001) | -0.0859 (0.6287) |
| | | 0.2522[c] (0.0066) | 0.0789 (0.5936) | 0.9780 (0.0001) | -0.0756 (0.5729) |
| Type | | 1.0000 (0.0000) | 0.0338 (0.7239) | 0.2899 (0.0023) | 0.1546 (0.0996) |
| | | | -0.1497 (0.1111) | 0.3401 (0.0005) | -0.0109 (0.9051) |
| | | | 0.0070 (0.9387) | 0.2616 (0.0050) | -0.0059 (0.9482) |
| Condition Score | | | 1.0000 (0.0000) | 0.3292 (0.0007) | -0.1042 (0.2737) |
| | | | | 0.3833 (0.0001) | -0.0201 (0.8282) |
| | | | | 0.0981 (0.2973) | 0.0830 (0.6187) |
| ADG | | | | 1.0000 (0.0000) | -0.0568 (0.5592) |
| | | | | | -0.0633 (0.5147) |
| | | | | | -0.0833 (0.6201) |
| Behavior Score | | | | | 1.0000 (0.0000) |

[a]Preweaning.

[b]Weaning.

[c]Postweaning.

[d]Probability of chance occurrence with Ho: Rho = 0.

within sire, sex, age of calf subclass basis where X and Y represent two-variable combinations of WT, T, C, ADG or B.

Partial correlations of B with WT, T, C and ADG were not significant at any observation time; whereas, many of the correlations involving variables other than behavior score were significant, with probabilities of chance occurrence considerably less than 0.05. Most correlations of behavior score with the other variables were negative.

## III. RELATIONSHIP OF AGE AND BEHAVIOR SCORE

The relationship of average B with age at the two locations at the three observation times is shown in Figure 2. Crossville calves had higher average B at each observation time. However, the trend with increasing age at the two locations at the three observation times appears to be different when averages are graphed as in Figure 2. Crossville scores increased from PRW to W and then decreased, on the average, at POW. Greeneville calves, on the average, were lowest at W and were near the same average score found at Crossville at POW. The greatest difference in average score between locations was at W. More work is needed to determine if the location and breed differences are smaller when animals are observed later in life than the ages represented in this study.

Even though there was a difference in the trends of average B with age at the two locations, when the coefficient of regression of individual B on individual age were calculated at each location, these regressions were not significantly different, and none of the regression

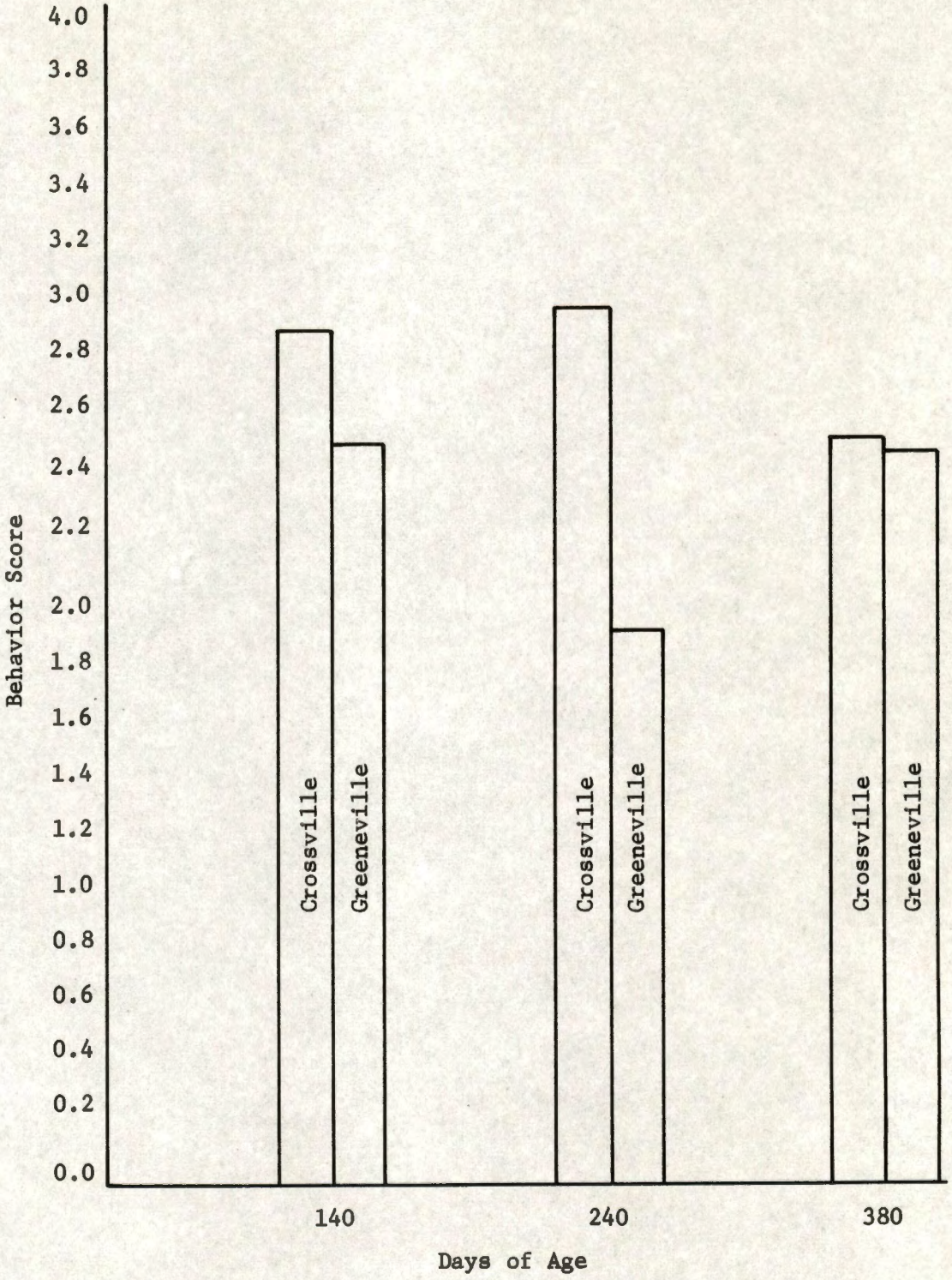



Figure 2. Average behavior scores recorded at Greeneville and Crossville.

coefficients were significantly greater than zero, as shown in Table VIII. However, if the change in sign of the regression from PRW to later observations, as observed in these data, is not due to sampling, then older calves in the range of 120 to 180 days tend to be more active when restrained than do the younger ones in this age range. Also, calves older than 220 days of age appear more likely to score lower as their age increases. This observation may be due to older calves becoming more accustomed to being restrained since they have been subjected to this treatment a greater number of times.

## IV. GENETIC PARAMETERS

Estimates of heritability and of genetic correlations were calculated for WT, ADG, C and B. These estimates are shown in Tables IX and X. Heritability estimates, $h^2$, are shown in the diagonal cells and genetic correlations in the off-diagonal cells.

Heritability estimates when locations were averaged together compare favorably with average values reported in the literature survey of Petty and Cartwright (1966). These comparisons are showin in Table XI. Estimates of heritability of behavior score for Greeneville and Crossville averaged together were 0.091, 0.298 and 0.384 for PRW, W and POW, respectively. If this upward trend with age is true for the population, one can more accurately measure the genetic variation with respect to docility after animals are of weaning age or older.

A genetic correlation of 0.0 in Tables IX and X resulted when one of the variables had a negative estimate of sire variance. Condition

TABLE VIII

COEFFICIENTS OF REGRESSION OF BEHAVIOR SCORE ON AGE

| | B Values | Standard Errors | T to test for Ho:β=0 | Probability Level for t |
|---|---|---|---|---|
| Greeneville | | | | |
| Preweaning | 0.00261113 | 0.00601617 | 0.43402 | 0.669 |
| Weaning | -0.00329376 | 0.00500604 | -0.65796 | 0.519 |
| Postweaning (1970) | -0.00428916 | 0.00664414 | -0.64556 | 0.528 |
| Crossville | | | | |
| Preweaning | 0.00476199 | 0.00497680 | 0.95684 | 0.657 |
| Weaning | -0.00479690 | 0.00475701 | -1.00838 | 0.316 |
| Postweaning (1970) | -0.00696945 | 0.00533299 | -1.30686 | 0.191 |

TABLE IX

ESTIMATES OF HERITABILITY AND GENETIC CORRELATIONS FOR GREENEVILLE

| | Weight | ADG | Type Score | Condition Score | Behavior Score |
|---|---|---|---|---|---|
| Weight | 0.320[a] | 1.049 | 1.099 | 0.0 | 0.079 |
| | 0.157[b] | 1.023 | 1.285 | 0.0 | 0.405 |
| | 0.483[c] | 0.986 | 0.563 | 0.599 | -1.344 |
| ADG | | 0.211 | 0.927 | 0.0 | 0.435 |
| | | 0.127 | 1.357 | 0.0 | 0.799 |
| | | 0.430 | 0.042 | 0.787 | -1.611 |
| Type Score | | | 0.017 | 0.0 | -2.929 |
| | | | 0.089 | 0.0 | -0.777 |
| | | | 0.022 | -5.070 | -0.891 |
| Condition Score | | | | -0.099 | 0.0 |
| | | | | -0.001 | 0.0 |
| | | | | 0.225 | -1.478 |
| Behavior Score | | | | | 0.132 |
| | | | | | 0.344 |
| | | | | | 0.132 |

[a]Preweaning

[b]Weaning

[c]Postweaning

TABLE X

ESTIMATES OF HERITABILITY AND GENETIC CORRELATIONS FOR CROSSVILLE

| | Weight | ADG | Type Score | Condition Score | Behavior Score |
|---|---|---|---|---|---|
| Weight | 0.434[a] | 1.006 | 0.729 | 0.0 | 0.640 |
| | 0.754[b] | 1.007 | 0.486 | 0.441 | -0.080 |
| | 0.495[c] | 0.982 | 0.267 | 0.484 | -0.540 |
| ADG | | 0.489 | 0.380 | 0.0 | 1.069 |
| | | 0.652 | 0.601 | 0.486 | -0.112 |
| | | 0.447 | 0.315 | 0.538 | -0.538 |
| Type Score | | | 0.050 | 0.0 | -1.406 |
| | | | 0.226 | 0.245 | 0.522 |
| | | | 0.036 | 1.159 | 0.037 |
| Condition Score | | | | -0.313 | 0.0 |
| | | | | 0.555 | 0.581 |
| | | | | 0.542 | -0.215 |
| Behavior Score | | | | | 0.049 |
| | | | | | 0.247 |
| | | | | | 0.637 |

[a]Preweaning

[b]Weaning

[c]Postweaning

TABLE XI

COMPARISON OF AVERAGE HERITABILITY ESTIMATES REPORTED BY PETTY AND CARTWRIGHT (1966)[a] AND THOSE CALCULATED FOR GREENEVILLE AND CROSSVILLE

| | Petty and Cartwright | Greeneville | Crossville | Average |
|---|---|---|---|---|
| Gain from birth to weaning | .26 | .127 | .652 | .389 |
| Weaning weight | .31 | .157 | .754 | .389 |
| Weaning score | .32 | .089 | .226 | .157 |
| Pasture gain | .37 | .430 | .447 | .438 |
| Yearling pasture weight | .41 | .483 | .495 | .489 |
| Yearling pasture score | .26 | .315 | .036 | .175 |

[a]Petty, R. R., and T. C. Cartwright. 1966. A summary of genetic and environmental statistics for growth and conformation traits of young beef cattle. Tech. Rpt. Tex. Ag. Exp. Sta. no. 5.

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score (C) was the only variable with a negative estimate of sire variance causing 0.0 genetic correlations involving C and the negative $h^2$ estimates for this trait. The greatest variation of $h^2$ estimates also was among those for C with -0.313 being the lowest and 0.555 being the highest.

## V. BEHAVIOR DIFFERENCES BETWEEN SEXES

As shown in Table V, page 25, least-squares means for heifer behavior scores were higher than those for bulls at each observation time. Sex effect was significant ($P<0.10$) except at Greeneville POW and Crossville PRW.

## VI. ENDOCRINE RELATIONSHIP TO BEHAVIOR SCORES

It is important to note that the docility or pugnacity of an individual while restrained is related to the endocrine system and more specifically the adrenal medulla and its secretion of epinepherine. Since behavior while restrained is a result of hormonal stimulus emanating from the medulla of the adrenal gland, the scores should be related to the rate or amount of secretion and/or size of the gland. Therefore, the $h^2$ estimates obtained can be considered to be similar to those obtained for hormonal physiological traits for which estimates are generally quite small. This may account for the relatively small $h^2$ estimates found in this study.

Reproductive traits also are hormonally influenced. Estimates of heritability of behavior score obtained in this study are in the same range as those commonly reported for reproductive traits.

## VII. DISCUSSION OF THE SCORING PROCEDURE

Scorer number one's scores averaged higher at all observation times except Greeneville W. Table XII shows the average scores for both scorers at all observation times. Since scorer number one took sonoray measurements of fat thickness and was the last to work with the animals, it is possible that as the animals became tired and more restless scorer number one was more aware of this activity and scored accordingly. Both scorers were scoring the animal for the entire period of restraint. However, it is possible that in the subjective measurements taken in this study, scorer number two may have scored lower because he had completed his observations and measurements on the animals before the other observer, and thus may not have been as impressed by the animals' activity as was scorer number one.

Figure 3 shows the frequency of scores recorded by each scorer in this experiment. Scorer number two assigned 20 more animals the behavior score of one than did scorer number one. Scorer number one scored more animals two and three than did scorer number two.

Due to the variation in frequency of scores and because the average scores found in this study were lower than the numerical average of the range, 3.0, it is suggested that a ten-point scale would be more appropriate for assessing behavior scores of cattle while restrained. This would allow the more extreme animals to be assessed more accurately. Also, if animals of greater age differences are measured, age differences should be more accurately reflected in the scores.

TABLE XII

AVERAGE BEHAVIOR SCORES RECORDED BY SCORERS ONE AND TWO

| | Scorer Number One | Scorer Number Two |
|---|---|---|
| Greeneville | | |
| Preweaning | 2.7250 | 2.3500 |
| Weaning | 1.8875 | 1.9875 |
| Postweaning | 2.6000 | 2.4333 |
| Crossville | | |
| Preweaning | 2.99286 | 2.60714 |
| Weaning | 2.97143 | 2.95714 |
| Postweaning | 2.70833 | 2.40972 |

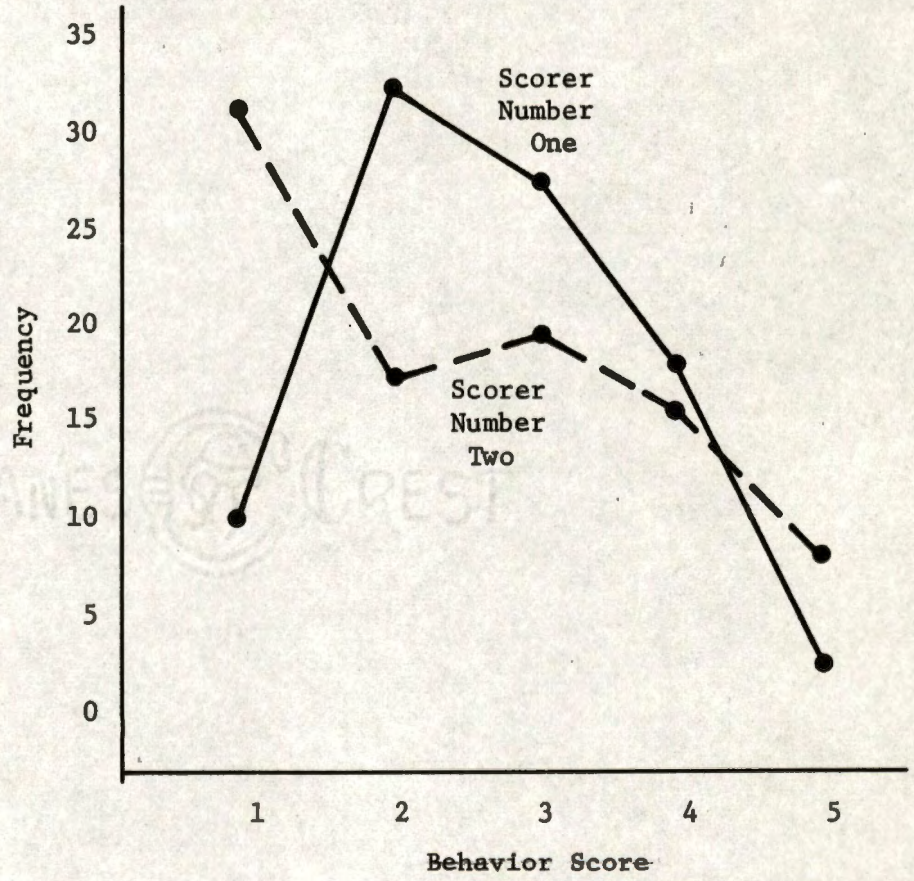



Figure 3. Frequencies of behavior scores given by observers one and two.

# CHAPTER V

## SUMMARY

Two hundred and eight Angus calves at Crossville and 140 Hereford calves at Greeneville were subjectively scored on a discrete scale from one to five for resistance to restraint in a squeeze chute. Calves of the 1970 crop were scored at an average age of 375 days (postweaning). The 1971 calves were scored at average ages of 142 (preweaning) and 241 (weaning) days.

Location and breed effects on score for restraint resistance (or chute behavior) were completely confounded since the Angus were at one branch experiment station and the Herefords at another. The Angus calves had the highest average score at all observation times with the smallest difference between the two groups occurring at postweaning.

Least-squares means for heifer behavior scores were higher than those for bulls at each observation time. There appeared to be a trend for behavior score to increase with age in the preweaning calves. The opposite trend was found in the older age groups.

Partial correlations of behavior with weight, type, condition and average daily gain were mostly negative. However, none of the correlations calculated were significantly different from zero.

Estimates of heritability of behavior score in the two groups averaged together were 0.091, 0.298 and 0.384 for preweaning, weaning and postweaning, respectively. These estimates appear to be in the same

range as those reported for reproductive traits which are, as is the trait studied here, hormonally influenced.

It was concluded that a ten-point scale for behavior scoring should be used when animals of many age groups are being measured. Data from more generations scored at more frequent intervals need to be obtained to give more accurate estimates of heritability and of correlations.

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## LITERATURE CITED


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# VITA

William Ray Stricklin was born on April 17, 1946, in Savannah, Tennessee. He attended elementary school and graduated from Central High School, Savannah, Tennessee, in 1964. He entered The University of Tennessee, Knoxville, Tennessee, and was graduated in June 1968 with a Bachelor of Science degree in Agriculture. In September 1968 he entered the Graduate School at The University of Tennessee.

In January 1969 he was inducted into the United States Army. He completed Basic Training at Fort Campbell, Kentucky, and medical corpsman training at Fort Sam Houston, Texas. For the remainder of his tour of duty he was stationed at Fort Riley, Kansas, where he served as courts and boards clerk with the medical battalions of the 24th and 1st Infantry Divisions. He was selected as 1st Infantry Division Soldier of the Year for the fiscal year 1970.

In January 1971 he returned to The University of Tennessee to continue his graduate work. He received his Master of Science degree in March 1972 with a major in Animal Husbandry.

He is married to the former Cheryl Ann Cheaney.