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Response of beef calves to handling and restraint in a chute

Gwendolyn S. Light

To the Graduate Council:

I am submitting herewith a thesis written by Gwendolyn S. Light entitled "Response of beef calves to handling and restraint in a chute." 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 Science.

Robert R. Shrode, Major Professor

We have read this thesis and recommend its acceptance:

Robert L. Murphee, Desmond G. Goyle

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

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We have read this thesis and recommend its acceptance:

R L Murphree

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RESPONSE OF BEEF CALVES TO HANDLING AND RESTRAINT IN A CHUTE

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Gwendolyn S. Light
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ABSTRACT

Ninety-eight Polled Hereford calves, averaging 215.13 ±1.96 days of age at weaning and 92 Polled Hereford calves averaging 381.17 ± 1.98 days at postweaning were the subjects of an investigation of behavioral responses at the Tobacco Experiment Station (TES). At the Plateau Experiment Station (PES), 82 purebred Angus calves averaging 386.14 ± 1.83 to 223.66 ± 1.93 days at weaning and 91 purebred Angus calves averaging 386.14 ± 1.83 days at postweaning, also were included in the study. At weaning, three variables, pulse rate, respiration rate and visual score of behavior, were recorded for each calf in an approach chute and in a squeeze chute. At postweaning, body temperature also was measured. The differences in approach chute and squeeze chute values, as well as the means of the approach chute and squeeze chute values, were examined as to their correlation to production.

In general, the means of the variables seemed to be more informative with respect to response of the calves than did the differences. This is believed to be due to an elevated response in the approach chute, such that further elevations in response to psychological stress were limited.

The relationship of the variables to each other and to production traits differed between stations and times. However, age as an effect could only be examined within weaning and postweaning times, and breed differences could not be examined, since time, breed and station were confounded. At TES, the variable with the treatest relationship to production seemed to be mean respiration rate. At PES, mean pulse rate

appeared to be the most important variable at weaning. At postweaning, the calves responded differently to being worked. It can be hypothesized that the responses at postweaning were reflective of environmental stimuli other than psychological stress. Possibly at postweaning, the response to being worked was a response to mild psychological stress and that other physiological factors, such as sex, may in that case, over-ride the effect of a stress response.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Interest in domestic animal behavior has been increasing over the last several years. More information about the physiological correlations between production and behavior has become available, and has stimulated considerable interest in the effect of behavior on production in all commercial domestic species. Thus, under conditions of increased production demands and economic feasibility, modification of the behavior of animals through selection programs has been examined as a method of increasing productivity, given that management practices employed are sound. For example, broodiness in laying hens has been decreased through selection. If a production trait in question is determined to be associated with a behavioral characteristic, and that behavioral characteristic is determined to be responsive to selection, alertness for undesirable ramifications of selecting for the trait should be maintained. For example, the "pale soft exudative syndrome" in pork has been related to the intensive management and selection practices presently employed in the swine industry.

This study was undertaken to determine the relationship between production and a few defined behavioral characteristics (respiration rate, pulse rate and visual score), believed to be indicative of temperament in beef cattle, and to estimate the heritability of those behavior characteristics. Breed differences unfortunately could not be examined since the Angus and Hereford herds are located in different areas of the state's experimental farm system, and, thus, breed is confounded with location. The effect of age can be examined only within weaning and postweaning times since age is confounded with time.

CHAPTER II

REVIEW OF LITERATURE

Researchers in behavior of domestic animals are concerned with the effect behavior (particularly maladaptive behavior) can have on production. In addition to problems associated with the handling and working of difficult animals, there is some evidence that behavior can affect production. Bryant (1972, p. 355) states:

> Suppression of economic performance may also be attributable to behavioral causes. The effect of social organization in highly competitive situations may be to deprive the members of lower social rank of vital resources. It would be expected in such situations, not only would the economic performance of individuals be lowered but also that of the mean performance of the group.

With increased production and intense selection, animals are being subjected to conditions differing greatly from their original or natural habitat. It becomes increasingly important that animals adapt easily to changing environments. Our farm animals were domesticated prior to the advent of Mendelism and development in the area of population genetics. The question arises as to what characteristics were important in the choice of species for domestication as well as what basis was used for choosing breeding animals. The importance of behavior in domestication is suggested by Fuller (1969, p. 56): "The greater docility of domestic species, their early maturity, and their adaptability to conditions of restraint can all be ascribed to selection in pre-scientific days."

There are two methods of altering adaptability to novel environments: changing behavior through learning, which applies to individuals; and changing gene frequency, which applies to a population (Kratzer, 1971). Of these two methods, the one of primary importance in this review is that of changing gene frequency. Prior to considering altering gene frequency by artificial selection as a method of effectively changing the adaptability of an organism, it is necessary to determine to what extent the behavioral characteristics are heritable, and to what extent a change in behavior will affect other aspects of the individual or vice versa. In a system of artificial selection for a given trait, the possibility exists for concommitant changes in seemingly unrelated traits as well as related characteristics. It is therefore reasonable that care should be taken prior to instigating a selection program. A strong statement indicating that fitness may be affected was made by Fuller (1969, p. 59):

> Selection for extreme phenotypic characters ordinarily does result in some decrease of fitness. This is understandable from the fact that wild species and well-established domestic species are the outcome of many generations of selection. Their genotype has been balanced or coadapted in the sense that diverse physiological and behavioral phenotypes operate at levels which maximize survival value. This balance is readily disturbed by too rapid and intense selection.

Areas of behavior potentially affecting production which will be discussed in this review include dominance order, which is a form of interaction among animals of the same species, temperament, which is an evaluation of an animal's disposition, and response to stressors, such as those encountered in normal management practices, such as, for example, trucking. Where possible, the review will be confined to the bovine species.

I. DOMINANCE AND TEMPERAMENT

The first consideration in examining dominance is to determine when dominance rank is established. Schake and Riggs (1970) observed the behavior of confined calves for 24-hour periods at monthly intervals to determine time spent in normal activity. They determined that through 325 days, these calves did not establish a social rank, although their dams were easily ranked.

The structure of dominance order also has received attention. McPhee, McBride and James (1964), using classes of 2-year-old Brahman and Hereford crosses, 2-year-old Hereford and 3-year-old Hereford yarded steers determined dominance ranking by bunting encounters. A linear social order, of a fairly stable nature, was apparent from their observations. Brantas (1968) also reported on the stability of dominance ranking in Dutch-Friesian cows. Beilharz and Mylrea (1963a) found a stable dominance structure in 41 dairy heifers of mixed breeding, utilizing transformed data to determine a dominance value. The percentages of "wins" out of all encounters were transformed to angles (arc sin). This method quantitates the differences between individuals, making for a more nearly normal, continuous distribution, rather than just ranking individuals (Beilharz and Mylrea, 1963a). Several bunting circles disrupted the linear nature of the dominance structure. For example, a bunting circle would be formed if a cow A dominated cow B and cow B dominated C, but C dominated A.

McPhee, McBride and James (1964) examined weight, chest girth and wither height in relation to social rank, and, using adjusted data, by removing the effects of other variables, found that only wither height was significantly ($P<0.01$) related to social rank. The importance of height at withers in determining social rank was interpreted as giving a psychological advantage to the taller cows. The results of McPhee, McBride and James' (1964) research, indicated no relation between dominance rank and production. The feeding regime in their experiment was such that all animals lost weight, but there was not a significant difference between weight loss of socially high- and low-ranking animals. High-ranking individuals spent significantly ($P<0.05$) more time feeding than did low-ranking individuals, but there was no significant difference in growth rate. High-ranking individuals also fed longer between interruptions ($P<0.05$). Within classes, the crossbred calves' interval of feeding was shorter ($P<0.05$). Aggressiveness, as determined by bunting, differed significantly ($P<0.01$) among classes, with the crossbred class bunting most and the 3-year-old Hereford class least.

Wagnon <u>et al.</u> (1966) found a significant ($P<0.01$) breed difference in dominance rank in a herd of 30 beef cows (10 Angus, 10 Shorthorn and 10 Hereford) averaging 46 months of age at the beginning of the experiment, with the Angus being the most dominant and the Herefords the least. Within breed, size was positively correlated with rank, however, this was not the case among breeds. Observations in two consecutive years, revealed a relatively stable and linear social order, although there were cases of lower ranking cows dominating higher ranking cows.

Arave *et al.* (1977) working with Holsteins, found a -0.54 correlation ($P<0.05$) of average body weight with dominance rank and suggested this to be indicative of increased aggressiveness in heavier cows. The negative coefficient of correlation results from the highest rank having the lowest numeric value. The experiment was designed so that dominance rank would be forcibly changed for at least half the cows. This was accomplished by creating an aggressive group and a docile group from the upper and lower halves of two previous groups. They found a significant ($P<0.01$) relationship between weight change (independent variable) and dominance rank change (dependent variable); body weight tended to decrease as rank decreased. Non-significant independent variables in the analysis were age and total corticoid change. Body weight change and dominance rank change had a correlation of 0.36 ($P<0.05$).

In contrast to the work of McPhee, McBride and James (1964) in beef cattle, Beilharz and Mylrea (1963a) found chest girth (independent of wither height), rather than height at withers to be more important in determining dominance value in dairy heifers. Brantas (1968) reported significant ($P<0.001$) correlations of 0.43, 0.52, 0.50 and 0.54 of dominance value with height at withers, body length, chest width and weight, respectively. During three periods, the correlations of age with dominance values were 0.70 ($P<0.05$), 0.67 ($P<0.001$) and 0.63 ($P<0.001$). As expected, the physical measurements also were correlated with age. Results of Dickson *et al.* (1970), with Holsteins, also indicate age and weight (as estimated by heart girth) to be more highly related to dominance than other variables studied. Correlations of 0.21 and 0.19

of age and weight with dominance were reported. Arave et al. (1973) reported correlations of dominance with fat corrected milk (0.25), age (0.30), body weight (0.51), height at withers (0.49) and number of social encounters (0.48).

In addition to examining factors important in determining dominance rank and the effect dominance rank may have on production, dominance rank has been investigated as it relates to free and forced movement of cattle. Tulloh (1961a) suggested that non-random weighing order will result in the first animals appearing to weigh more than they should relative to the last animals weighed due to loss of fill, and that such a difference will not be removed by repeated weighings. Tulloh (1961a) conducted an investigation of weighing order with Hereford calves. The mean age of the calves at the beginning of the experiment was 156 days, and the mean age at the end of the experiment was 324 days. During four periods of study, the order in which the calves entered the scales was recorded and averaged for each period. This average was called mean weighing order. Using a ranking test, it was determined that mean weighing order for the last three periods and for all periods of the experiment considered together was significant ($P<0.01$). Mean weighing order was not related to weight, sex, hornedness or weaning effect. Neither was it related to behavioral score based on ease of entry into scales, one being no hesitation and four being difficult entry.

Although Tulloh (1961a) did not determine dominance rank of the cattle, he concluded that weighing order is probably not related to dominance rank. The basis for his conclusion was the fact that dominance rank has been reported to be associated with physical characteristics of cattle, none of which did he find to be significantly related to weighing order. He further suggested that leadership may be a determinant in weighing order, but unrelated to dominance rank. McPhee, McBride and James (1964) determined that order of entering a weighing crush in 2-year-old Herefords and crossbreds was non-random, but concluded it was unrelated to dominance rank. One indication that rank is possibly a factor in movement, came from the work of Beilharz and Mylrea (1963b) in which it was found that the dominant animal did not lead in either forced or free movement. In general, their conclusions were that in free movement, medium- and high-ranking animals led, whereas, in forced movement, the lowest ranking animals led. A suggested reason for the reversal in leadership was that the lower ranking animals moved forward to avoid bunting under conditions of forced movement.

Behavior in the crush (squeeze chute) has been used by researchers to assess temperament. Ewbank (1961) described the behavior of cattle in crushes which had a guillotine trap, dividing it into four patterns of behavior: docile, alarmed, greatly alarmed and submissive. Interestingly, as the behavior patterns are characterized, the submissive pattern is placed after the greatly alarmed pattern. The reason appears to be related to the ease of working the cattle; for example, a submissive cow was described as having a lowered extended head, and striking such an animal might cause the animal to kneel and appear more stubborn. The discussion of behavior of cattle in crushes is related to managment practices in general, in which the design of equipment is fitted to a theoretical animal which is basically calm and agreeable. Ewbank (1961) pointed out that the practical aspects of working cattle differ from theoretical aspects of a calm and unhurried routine, and that improvement in design of equipment based on the normal behavior of cattle may lessen the difficulty associated with routine management practices.

Stricklin (1972), in an attempt to assess temperament in calves of the Polled Hereford and Angus breeds, used a visual scoring system to divide calves according to activity level in a squeeze chute. The scores ranged from 1, very docile to 5, very active. The calves were scored at preweaning, weaning and postweaning. Estimates of heritability of visual score averaged over the two breeds, determined by paternal half-sib analysis were 0.091, 0.298 and 0.384 for preweaning, weaning and postweaning.

This method differs from that of Ewbank (1961) in that activity level is the criterion on which scoring is based. As noted earlier, Ewbank (1961) places the submissive or stubborn animal at the top of his scale. In Stricklin's (1972) method, a stubborn animal could have an activity level of 1 to 5. It should be noted also that Ewbank (1961) allows only four catagories, whereas Stricklin (1972) uses five.

Tulloh (1961b) utilized a chute to study temperament in beef cattle of the Hereford, Shorthorn and Aberdeen Angus breeds. Twenty-four cattle of each breed, with equal numbers of steers and heifers, were utilized. Castration of bull calves and dehorning of heifer calves occurred at 4 months. Observation began at a mean age of 320 days and continued for 12 months. Prior to observation, cattle were given opportunity to adjust to working procedures. Behavioral scores were taken at four stages: entering the scales, the crush and the bail (head restraining device) and in the bail. Behavioral scores ranged from 1 to 4 (1 being the most desirable) for movement of the animals. Behavior in the bail (temperament) was scored from 1 to 6 (1 being docile). Behavior scores for entering the scales and the crush were not related to each other or to temperament score. Significantly ($P<0.01$) higher scores were found for entering the bail than those for entering the scales or the crush. Breed differences were found for: (1) entering the crush, Herefords scoring higher ($P<0.01$) than Angus and Shorthorns, (2) entering the bail, Herefords scoring higher ($P<0.01$) than Shorthorns, and (3) in the bail, Herefords being lower ($P<0.01$) than Shorthorns and Angus being lower ($P<0.05$) than Shorthorns. No sex differences were found. It was concluded that movement of cattle may not be reflective of temperament since the animal's purpose in being hesitant or quickly movable cannot be determined.

Tulloh (1961b) grouped the animals into desirable temperament (≤ 2) and undesirable temperament (>2) classifications and divided them also according to positioning above or below the mean live weight in order to test the significance of the relation between temperament and live weight, using χ^2 with Yates' correction. A significant ($P<0.05$) relation was observed.

It is interesting to note that mean temperament scores did not decrease with exposure to handling (Tulloh, 1961b). In order to get a reliable estimate of temperament of individuals, it was suggested that five recordings of behavior be made.

Tulloh (1961b, p. 29) concluded, "The relation between temperament and live weight indicates that animals which are generally docile grow better than animals which are restless, nervous, wild or aggressive." Based on the lack of relation between scores for movement of cattle and temperament, Tulloh (1961b, p. 29) further concluded,

> cattle which are difficult to handle need not have bad temperament. These implications are important for the registered breeders as it is likely that selection based on live weight gain may simultaneously lead to improvement in temperament . . . selection based on ease of handling in yards may make the herd easier to handle but it will not necessarily improve herd temperament.

An interesting conclusion with respect to dominance value and handling ease was drawn by Beilharz and Mylrea (1963a). On one occasion during their experiment, the heifers were held in an area half the size of the usual observation yard, and attempts to break away from other heifers were recorded. The regression of dominance value on the number of break attempts was significant ($P<0.01$), more attempts being made by heifers with lower dominance values. Brantas (1968) described the behavior of one cow in his experiments which behaved abnormally. The cow appeared to be uneasy in the presence of other cows, both dominant and submissive, and actually escaped the enclosure five times. In later trails, however, the same problem did not exist.

Both dominance and temperament were studied in Holstein cows by Dickson _et al._ (1970). One thousand seventeen cows from 27 Holstein Friesian herds were included in the study. In common, the herds had artificial insemination (AI) backgrounds with available Dairy Herd Improvement Association (DHIA) production records. Milking temperament was scored on a basis of 1 to 4 (1 being docile); dominance value was analyzed by least-squares procedures. Mean temperament score was 1.9. The coefficients of correlation of dominance with seven variables and temperament with seven variables are shown in Table I. Significance of these correlations was not indicated in the paper.

In Dickson's (1970) study, dominance appeared to be related to age and weight; temperament appeared to be related to height at withers. Dominance and temperament showed little relationship to other variables studied or to each other.

Paternal half-sib correlations were used as one method of calculating estimates of heritabilities of adjusted temperament score and adjusted dominance score. The estimates of 0.53 (adjusted temperament) and 0.07 (adjusted dominance value) indicated milking temperament to be a selectable trait, whereas, dominance value was not: Dickson et al. (1970, p. 907) concluded that, ". . . the additive genetic variance for temperament score in Holstein cows is large enough for selection to be effective." One aspect which differs in this study from other reported studies on temperament is that farmers scored their own cows which may have allowed a greater possibility for bias.

There has been little success in determining a relation between production and behavioral traits in studies using subjective scoring or ranking procedures. Also, there is little evidence as to what physical characteristics are important in behavioral traits such as leadership and temperament.

TABLE I. Coefficients of correlation of dominance value and temperament rating with seven variables[a]

Variable	Dominance Value	Temperament Rating
Age	0.21	-0.12
Weight	0.19	-0.11
Height at withers	0.13	-0.18
Stage of lactation	0.05	-0.04
Daily milk yield	0.02	-0.05
Yearly milk yield	-0.02	-0.03
Temperament rating	-0.05	--
Dominance value	--	-0.05

[a]Source: Dickson et al. 1970. Social dominance and temperament of Holstein Cows. J. of Dairy Sci. 53:904.

II. QUANTITATING BEHAVIOR IN RESPONSE TO STRESSORS

In an attempt to quantitate behavior, objective parameters have been investigated in addition to the methods of visual scoring and ranking. Bryant (1972, p. 354) stated, "Detectable physiologic indicators of 'stress' in the animal apparently arise from adaptive reactions mainly through the pituitary-adreno-cortical axis." Research has been conducted to determine reliable methods of measuring these physiological responses to stress. Selye (1949) described the General-Adaptation-Syndrome (GAS) which results from chronic exposure to stress. The prominent characteristics in the GAS are

> enlargement of the adrenal cortex with increased corticoid-hormone secretion, involution of the thymus and other lymphatic organs, gastro-intestinal ulcers, certain metabolic changes and variations in the resistance of the organism (Selye, 1949, p. 837).

Many of the adaptive reactions have been described and measured. Ivan Pavlov's orientation reflex in response to novel stimuli as reported by Levine (1975, p. 220) involves

> increased electrical activity in the brain, a reduction of blood flow to the extremities, changes in the electrical resistance of the skin, a rise in the level of adrenal-steroid hormones in the blood and some overt motor activity of the body.

With respect to the pituitary-adrenal system, Levine (1975, p. 223) stated, "Its reactions to moderate stress may contribute greatly to the behavioral effectiveness and stability of the organism." The ability of an animal to respond to stressful environments depends on the integrity of the hypothalamus-pituitary-adrenocortical system. For these reasons, the pituitary-adrenocortical system has been the subject of research concerned with stress. Dvořák (1971) determined by use of the insulin test that the pituitary-adrenocortical system of calves is already functioning soon after birth, which indicates that calves are born with the ability to respond to stressors. Levine (1975), in fact, states that there is perhaps an optimum level of stress required early in life for later behavior to be effective.

Corticosteroids have been used as indicators of stress with varying degrees of success. Arave et al. (1977) tried to discern a relationship between dominance rank and total corticoids. As stated earlier, there was no evidence of a significant relationship between total corticoids and dominance rank. It was the authors' contention that this was reasonable, ". . . since organization of animals into a social order probably evolved as a result of a need to reduce stress" (Arave et al., 1977, p. 247). No correlation was found between total corticoids and body weight or between total corticoids and age. Arave et al. (1977) concluded that total corticoids were not a good index of social stress and that the possibility exists that change in rank in dairy cattle is not stressful, or sufficiently stressful to alter existing levels of total corticoids. Arave, Erb and Albright (1973) had previously reported a correlation coefficient of 0.09, indicating little relationship between dominance rank and total corticoids.

Franzmann, Flynn and Arneson (1975) examined blood serum 11-hydroxycorticosteroids in Alaskan moose, in an attempt to determine excitability classes from analysis of blood samples. It was believed that handling stress could lead to rapid changes in blood chemistry, and, therefore, that blood samples from animals in the same excitability class could be more readily compared. They found significant ($P<0.01$) differences in the level of corticosteroid in all the excitability classes except 4 and 5. The mean 11-hydroxycorticosteroid level increased from 26.6 μg/100 ml in class 1 to 114.5 μg/100 ml in class 5. Excitability classes ranged from 1, not excited, to 5, highly excited. Excitability was a subjective score based on observation before and during immobilization and handling. It is important to note that handling stress relative to wild animals may not be simply an extreme form of reaction to handling in domestic animals, but may be determined by different physiological functions.

Willet and Erb (1972) measured cortisol, corticosterone and total corticoids less progestins in cannulated Holsteins and suggested that total corticoid level is perhaps the best measure of mild stress. An attempt was made to reduce sampling stress by extending the cannulae to the rear of the animals, thereby, avoiding approaching the head area during collection. They determined also that at least one other steroid is being released in psychological stress. There was a relationship in 4 of 5 heifers between outward expression of excitement and increased plasma corticoids in response to removal of companion animals. Individual variation in response was great. Friend, Polan and Gwazdauskas (1977), also working with Holsteins, determined that basal corticoid concentrations varied greatly.

The effects of weaning, trucking and handling were examined by

Crookshank et al. (1976). Three groups of 50 calves each were divided into 10 subgroups. The major groups were: weaning two weeks prior to the experiment, weaning at the time of experiment, and weaning and immediate trucking for 12 hours. Subgroups were formed in each group such that one subgroup was sampled at 0, 12, 24, 48, 96, 168, 264, and 384 hours and the other subgroups were sampled at only one of the times. Weaning produced a slight increase in blood cortisol, which returned to base level within 48 hours. The increase in trucked calves took 4 to 7 days to decrease to base level. There was a gradual reduction in the cortisol in animals sampled at each interval. Weight loss was small in weaned animals and larger in trucked animals. In animals sampled at each interval, weight losses were increased.

Trucking was examined also by Johnston and Buckland (1974). Holstein calves were subjected to transportation at 4 days, transportation at 5 months, 48-hour water deprivation at 3 months, and castration and dehorning at 4 months. Plasma hydrocortisone levels were determined at 4 times: before, immediately following, 24 and 48 hours following each stressor. Significant responses to transportation and to castration and dehorning were found; age was found not to affect resting plasma hydrocortisone levels. Johnston, Buckland and Kennedy (1974) found no sire effect in resting and stress response plasma hydrocortisone levels with Holstein calves, except for transportation stress at 5 months.

Effects of movement, elapsed time, and collection site (tail vein, venipuncture or cannula) on blood cortisol levels of crossbred yearling steers were examined by Ray et al. (1972). Samples were taken in the pen by jugular cannula, in the chute by jugular cannula, in the chute from the tail vein, and in the chute by jugular venipuncture, in that order. The samples from the jugular venipuncture were significantly higher than the cannula samples in the pen and chute. In another trial, in which time in the chute was investigated, three cannulae samples were taken, one in the pen, one upon arrival in the chute, and one 10 minutes after that sample. Half of the steers were sampled from the tail vein after the first sample in the chute, and half were sampled by tail vein after the second cannula sample in the chute. Fifteen minutes after being returned to the pen, another cannula sample was taken. The last samples taken in the chute, both from cannula and by tail vein, were significantly elevated, and it was concluded that time in the chute was important in the elevation. The decline of corticoid level in the group of animals, bled from the tail vein after the second cannula sample in the chute, was delayed.

The quality of meat also is important. Investigations into the effect of rearing environment on carcass quality has dealt mainly with swine. Judge (1969) stated that similar preslaughter treatments result in pale soft exudative pork and dark cutting beef, although their etiologies differ. In preslaughter stressed beef animals, glycogen reserves can be depleted in muscle, thus impairing glycolysis after slaughter and restricting the normal decline in pH. Duchesne and Perry (1975) reported the incidence of dark cutting beef in steer and heifer carcasses to be low (1-2% annually) and in beef bull carcasses to be about 10% annually with higher peaks. They reasoned that since dark cutting beef can be induced by subcutaneous adrenalin injection in the 24-hour antemortem period, ". . . stresses such as ill treatment during handling on the farm or in lairage or fighting amongst animals may induce the condition." Lairage refers to penning of animals at the slaughterhouse prior to slaughter, for example, overnight lairage. Duchesne and Perry (1975), working with Friesian and Hereford-Friesian cross bulls, determined that activity was not necessarily related to dominance rank nor to aggressiveness toward humans. Friesians were reported as being more active than Hereford-Friesian crosses. Increased pH in the longissimus dorsi was found to be positively correlated with increased activity in lairage (r=0.72). No significant correlations were found of pH with absolute activity levels, dominance status, or aggressiveness.

Moreton (1977) reports an additional year of information on the experiment of Duchesne and Perry (1975). The results viewed together indicate that lairage overnight of unfamiliar bulls increases the incidence of dark cutters and that mixing the bulls on the farm 48 to 72 hours, possibly 24 hours, prior to lairage, is sufficient to eliminate dark cutters (Duchesne and Perry, 1975; Moreton, 1977). Less antagonistic activity occurs when animals are mixed on the farm as opposed to mixing in lairage (Moreton, 1977). If adequate space is available in mixing in lairage (small groups in normal size pens), pH remains normal. Moreton (1977) believes that the reason is the availability of space for effective avoidance behavior.

The adrenal-cortical system has been implicated in other areas of production. Christian (1963) as cited by Bryant (1972) suggests that activation of the pituitary-adrenocortical system may affect growth by the suppression of growth hormone and mitosis.

As far as reproductive behavior is concerned, Wieckert (1971) indicated that sexual activity in females may become undesirable, as it relates to production, in that sexual behavior may interfere with attempts to control reproduction. With increased information available with respect to reproductive phenomena, control of the estrous cycle and ultimately reproduction, is coming under the direction of man.

Christensen, Hopwood and Wiltbank (1974), using three non-lactating Angus cows, 4, 4 and 12 years old, determined that corticosteroid levels differed between cows, but not between days of estrous cycle. Sampling was done every two hours for 60 days using cannulas. It was suggested that this sampling was not as stressful as that of Sprague et al. (1971), and that, under normal conditions, adrenal corticoids are not involved in regulating the estrous cycle. Christensen, Hopwood and Wiltbank (1974) did not, however, discount the work of Sprague et al. (1971).

Sprague et al. (1971) also worked with beef cattle: 1 Angus, 2 Herefords and 4 Shorthorns. In contrast to Christensen, Hopwood and Wiltbank (1974), the non-lactating cows were bled daily, beginning on day 16 of the estrous cycle. At estrus, blood was taken every four hours until ovulation and then daily until next estrus. Prior to the experiment, all seven cows were cycling normally. Three of the 7 cows did not cycle, and one cow returned to estrus after bleeding was stopped. Sprague et al. (1971, p. 101) stated, "It is not conclusive that the elevated corticoid levels in cows failing to cycle are responsible for this behavior, but it is highly suggestive that the frequency or method of drawing blood contributed to the failure . . ." In cycling cows, during estrus, corticoid levels were elevated.

Bryant (1972, p. 355) summarizes the effects adaption can have on reproduction:

> In the male there may be a decrease in spermatogenesis and a reduction in the secretion of androgens, as indicated by atrophy of the seminal vesicles, prostrate [sic] and preputial glands. In the female, oestrus may be reduced or suppressed. There may be a complete failure t conceive, either because of failure of ovulation or a failure of the shed ova to implant in the uterus. If pregnancy is achieved, there may be a marked increase in foetal mortaility, and finally, if the offspring are born, there may be a failure of lactation.

As can be seen from the experiments cited in this review, interest in behavior and its implications in all areas of production is increasing. A well defined relationship between behavior and production is not yet available. Lack of methods for reliably evaluating behavior is probably the greatest limitation.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. DATA

This study was conducted at the Tobacco Experiment Station (TES) near Greenville, Tennessee, and the Plateau Experiment Station (PES) near Crossville, Tennessee. Data were collected at two times, weaning and postweaning, in conjunction with routine procedures associated with maintenance of the records of the breeding herds. At TES, 98 purebred Polled Hereford calves, averaging 215.13 days of age with a standard error of 1.96 days were included at weaning and 92 purebred Polled Hereford calves, averaging 381.17 days of age with a standard error of 1.98 days at postweaning. At PES, 82 purebred Angus calves, averaging 223.66 days of age with a standard error of 1.93 days were included at weaning and 91 purebred Angus calves averaging 386.14 days of age with a standard error of 1.83 days at postweaning.

Measurements were taken in an approach chute and in a squeeze chute. At TES, the appraoch chute was an area of the runway which was closed in such a manner as to prevent escape but also allow accessability and some freedom of movement. This approach chute could be occupied by one or more animals. At PES the measurements for the approach chute were taken in the weighing scales. At TES the same squeeze chute was used at weaning and postweaning. At PES, two squeeze chutes and two approach chutes, of similar design, were used at weaning but only one approach and one squeeze chute at postweaning. All squeeze chutes were of similar design having a front release, a trap for restraint of the head, and adjustable sides.

All behavioral measurements in the approach chute were taken by one observer while another animal was being worked with in the squeeze chute. In most cases behavioral measurements in the squeeze chute were taken by one of two observers, after the height, length, chest girth and fat thickness measurements were recorded. At weaning and postweaning at PES, some of the calves also were being checked and "pour-on" treated with trichlorfon for *Hypoderma bovis* after the recording of behavioral measurements. At postweaning at PES, eye washes were administered concurrently with measurement of behavioral characteristics.

At weaning, three values were recorded. Heart rate was determined by palpation of the caudal or saphenous artery. Pulse was counted for 20 seconds and adjusted to beats per minute for recording. Flank movement has been used as a reliable measure of respiration rate (Simms, 1971; Ames and Arehart, 1972; Westervelt *et al.*, 1976). Respiration rate was determined by counting flank movements for 30 seconds and converting this to respirations per minute for recording. A visual score was assigned for behavior, assessed over the entire time in the chute. The basis for the scoring was an evaluation of the animal's restlessness and resistance to restraint. The scoring system employed was a modification of that used by Stricklin (1972) and is described in Table II.

At postweaning, the three values previously described were

TABLE II. Visual scores assigned in approach chute and squeeze chute

Visual Score	Description
1	Very docile
2	Docile, some activity
3	Restless, average activity
4	Excited, very active
5	Aggressive or vigorous

recorded. Respiration rate was determined in some cases by the method described above but more often, as the weather permitted, the observers counted the visible vapor condensations at expiration for 30 seconds and converted this to respirations per minute. A Markson® digital thermometer with a rectal probe and three glass rectal thermometers were used to measure body temperature at postweaning. The glass thermometers were left in the rectum for three minutes before the reading of temperature.

II. STATISTICS

Separate analyses were conducted for each time and each location. Data were analyzed using procedures found in the 1976 version of the Statistical Analysis System (SAS) (Barr et al., 1976; Helwig, 1977).

The estimates of variance components were calculated by Harvey's procedure available in SAS (Helwig, 1977). Estimates of genetic correlations were determined by the formula:

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

®Markson Science Incorporated, Model Number 707.

where Cov_{XY} is the estimate of the sire component of covariance for two trai X and Y, and $s^2_{S(X)}$, $s^2_{S(Y)}$ are the estimates of the sire components of variance for the two traits being examined. The effects of μ (overall mean), sex, age of dam, and age of calf were adjusted for by including them in the model.

Estimates of heritability in the narrow sense were determined by the formula:

$$h^2 = \frac{4s^2_S}{s^2_S + s^2_W}$$

where s^2_S is the estimate of the sire component of variance and s^2_W is the error variance. The effects of μ, sex, age of dam, and age of calf were adjusted for by including them in the model.

Correlations were calculated within sex, age-of-dam, sire and age-of-calf subclasses.

The statistical models employed were:

$$Y_{ijkl} = \mu + g_i + a_j + s_k + b(X_{ijkl}-\overline{X}) + e_{ijkl}$$

where: Y_{ijkl} = behavioral characteristic, weaning weight, average daily gain (ADG), weaning height, weaning heart girth, postweaning weight, postweaning ADG, lifetime ADG, postweaning height or postweaning heart girth.

μ = overall mean

g_i = effect of ith sex

a_j = effect of jth age of dam

s_k = effect of kth sire

b = partial regression of Y on X

X_{ijkl} = age of lth calf in the ith sex of jth age of dam class and kth sire class

e_{ijkl} = random error

$$Y_{ijklm} = \mu + g_i + a_j + s_k + b_1(X_{ijkl}-\overline{X}) + b_2(Z_{ijkm}-\overline{Z}) + e_{ijklm}$$

where: Y_{ijklm} = weaning weight, weaning ADG, postweaning weight, postweaning ADG or lifetime ADG.

μ = overall mean

g_i = effect of ith sex

a_j = effect of jth age of dam

s_k = effect of kth sire

b_1 = partial regression of Y on X

b_2 = partial regression of Y on Z

Z_{ijkm} = behavioral characteristic of mth calf in ith sex of jth age of dam class and kth sire class

e_{ijklm} = random error

and, $Y_i = \mu + b(Z_i-\overline{Z}) + e_i$

where: Y_i = behavioral characteristic

μ = overall mean

b = partial regression of Y on Z

Z_i = behavioral characteristic

Two types of 2x2 chi-square (χ^2) analyses were conducted according to the formula:

$$\left[X^2 = \Sigma \frac{(O-E)^2}{E} \right]$$

where O is the observed number and E is the expected number. In the analysis in which mean behavior scores were used, two groupings were made such that animals were divided into classes less than or equal to the overall mean response and greater than the overall mean response. In the other type of analysis, the difference in behavior score from approach chute to squeeze chute was grouped as being less than or equal to zero, meaning a decrease or no change from the approach chute to the squeeze chute, or greater than zero, meaning an increase from the approach chute to the squeeze chute. Both types of grouping were compared to physical characteristics divided into groups of greater than the mean or, less than or equal to the mean, except in the case of sex, in which groups were male or female.

Paired t tests were conducted comparing the approach chute values to the squeeze chute values, the differences in behavioral score from approach to squeeze chute at weaning to those at postweaning, and the means of behavioral scores at weaning to those at postweaning, according to the formula:

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{s^2_{X_1}}{n_1} + \frac{s^2_{X_2}}{n_2}}}$$

where $\overline{X}_1$ is the overall mean of the approach chute values, the overall mean of weaning means or the overall mean of weaning differences and $\overline{X}_2$ is the overall mean for the squeeze chute values, the overall mean for the postweaning means or the overall mean for the postweaning differences. The variances of the two variables being compared are $s^2_{\overline{X}_1}$ and $s^2_{\overline{X}_2}$ and n_1 and n_2 are the sample sizes.

CHAPTER IV

RESULTS AND DISCUSSION

I. MEANS AND STANDARD ERRORS

For a general description of the herds at TES and PES, the means and standard errors of the behavioral variables in the approach chute and squeeze chute at weaning and postweaning are presented in Table III. The overall means and standard errors of the differences between the squeeze chute and approach chute values and the means of the squeeze chute and approach chute values are presented in Table IV. The overall means and standard errors of physical traits are presented in Table V.

II. T STATISTICS

T statistics were calculated for the behavioral measurements in a comparison of the approach chute vs. the squeeze chute values at TES and PES. At TES, the respiration rate (approach chute value larger) was found to be significantly ($P<0.01$) different at weaning and the pulse rate (squeeze chute value larger), respiration rate (approach chute value larger), and temperature (squeeze chute value larger) were significantly ($P<0.01$) different in the two chutes at postweaning, as well as the visual score (approach chute value larger) being significantly ($P<0.05$) different. At PES, the pulse rate (squeeze chute value larger) and respiration rate (approach chute value larger) were significantly ($P<0.01$) different in the two chutes at weaning. Pulse rate (squeeze chute value larger) and respiration rate (approach chute value larger) also were significantly

TABLE III. Means and standard errors of behavioral variables in the approach chute and the squeeze chute for TES and PES

		Weaning				Postweaning			
		Approach Chute		Squeeze Chute		Approach Chute		Squeeze Chute	
Station	Variable	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
TES	Pulse rate (beats/min)	88.29	1.64	86.26	1.43	90.49	1.62	97.66	1.27
	Respiration rate (breaths/min)	84.71	2.01	60.20	1.40	66.39	1.58	59.80	1.41
	Visual score	3.10	0.07	3.06	0.10	3.09	0.11	2.79	0.10
	Temperature (°C)	--	--	--	--	39.16	0.03	39.59	0.03
PES	Pulse rate (beats/min)	75.51	1.57	103.21	1.77	80.70	2.02	96.58	1.55
	Respiration rate (breaths/min)	70.98	1.78	58.00	1.51	53.63	1.53	41.28	1.11
	Visual score	3.27	0.09	3.22	0.10	2.62	0.10	2.59	0.11
	Temperature (°C)	--	--	--	--	38.60	0.07	38.80	0.07

TABLE IV. Overall means and standard errors of means[a] and differences[b] of behavioral variables for TES and PES

	TES		PES	
	Overall Mean	Standard Error	Overall Mean	Standard Error
Weaning				
Difference in pulse rate (beats/min)	- 2.03	2.27	27.70	2.48
Difference in respiration rate (breaths/min)	-24.51	1.74	-12.98	1.45
Difference in visual score	- .04	0.11	- .05	0.13
Average pulse rate (beats/min)	87.27	1.04	89.36	1.12
Average respiration rate (breaths/min)	72.46	1.50	64.49	1.48
Average visual score	3.08	0.07	3.24	0.07
Postweaning				
Difference in pulse rate (beats/min)	7.17	1.69	15.88	2.32
Difference in respiration rate (breaths/min)	- 6.59	1.80	-12.35	1.58
Difference in visual score	- .29	0.13	- .02	0.14
Difference in temperature (°C)	0.43	0.04	0.20	0.06
Average pulse rate (beats/min)	94.08	1.18	88.64	1.38
Average respiration rate (breaths/min)	63.10	1.20	47.45	1.07
Average visual score	2.94	0.09	2.60	0.08
Average temperature (°C)	39.37	0.03	38.70	0.06

[a]Squeeze chute value - approach chute value

[b](Squeeze chute value + approach chute value)/2

TABLE V. Overall means and standard errors of physical characteristics for TES and PES

	TES		PES	
	Overall Mean	Standard Error	Overall Mean	Standard Error
Weaning				
Weaning weight (kg)	185.93	3.03	206.75	3.49
ADG (kg/day)	0.73	0.01	0.80	0.01
Height at withers (cm)	97.82	0.43	96.90	0.42
Heart girth (cm)	131.35	0.73	136.63	0.80
Weaning age	215.13	1.96	223.66	1.93
Postweaning				
Yearling weight (kg)	284.39	4.47	296.22	3.85
ADG (kg/day)	0.59	0.01	0.54	0.01
Lifetime ADG (kg/day)	0.67	0.01	0.69	0.01
Height at withers (cm)	106.85	0.38	107.93	0.46
Heart girth (cm)	155.95	0.83	159.27	0.70
Yearling age	381.17	1.98	386.14	1.83

(P<0.01) different in the two chutes at postweaning as well as temperature (squeeze chute value larger) (P<0.05).

At TES, the mean behavioral values for pulse rate (postweaning value larger) and respiration rate (weaning value larger) at weaning were significantly (P<0.01) different from the mean postweaning values for pulse and respiration rates. The differences in pulse and respiration rates at weaning also were significantly (P<0.01) different from those at postweaning at TES (pulse rate increased more at postweaning; respiration rate decreased more at weaning). At PES, the mean weaning visual scores and the mean weaning respiration rates differed significantly (P<0.01) from those at postweaning (mean weaning scores larger than mean postweaning scores), whereas, only the differences in pulse rate from weaning to postweaning were significantly (P<0.01) different (pulse rate increased more at weaning).

III. PHENOTYPIC CORRELATIONS AND REGRESSION ANALYSES

With respect to the differences in the three parameters measured at weaning, little relationship was shown between differences in pulse and differences in respiration or difference in respiration and difference in visual score. The coefficients of correlation between the difference in pulse rate and the difference in visual score were 0.02 at TES and 0.19 at PES. With respect to the means of the three parameters examined at weaning, the strongest relationships at TES existed between mean pulse rate and mean visual score (r=0.15) and between mean respiration rate and mean visual score (r=0.15). At PES, the strongest relationships were between mean pulse rate and mean respiration rate (r=0.30) and between mean pulse rate and mean visual score (r=0.20).

The relationship at weaning between the differences of the two scores for each parameter and the means of the two scores for each value appear in Table VI.

At postweaning, the relationship between the differences of the two scores for the four variables measured at TES and PES are presented in Table VII. The relationships of the means of the two scores for the four variables appear in Table VIII. At TES, the coefficients of correlation between the difference in pulse rate and the mean of pulse rate was -.33 at postweaning. No relationship between the difference in respiration and the mean of respiration, the difference in visual score and the mean of visual score or the difference in temperature and the mean of temperature was demonstrated at postweaning at TES. At PES at postweaning, the coefficients of correlation between the difference values and the mean values of pulse rate, respiration rate, visual score and temperature were -.25, -.32, 0.12, and -.21, respectively.

Because many of the observed correlations were extremely small, a brief discussion of only those showing some relationship, even though quite small, is all that seems worthwhile. At TES, heart girth at weaning was negatively related to the difference in pulse rate (r=-.18) and the difference in visual score (r=-.24). At PES, the difference in respiration was negatively related to weaning weight (r=-.24), ADG (r=-.22) and heart girth (r=-.24) at weaning. The mean respiration rate was related to many physical characteristics at weaning at TES. The coefficients of correlation of mean respiration rate and weaning weight, ADG, height at withers and

TABLE VI. Coefficients of correlation between differences and means of behavioral measurements recorded in the approach chute and squeeze chute at weaning

	TES	PES
Variables	Coefficient of Correlation	Coefficient of Correlation
Difference in pulse rate and mean of pulse rate	-.19	0.16
Difference in respiration rate and mean respiration rate	-.43	-.19
Difference in visual score and mean visual score	0.34	0.17

TABLE VII. Coefficients of correlation of differences between two values of four variables at postweaning

	Difference in pulse rate	Difference in respiration rate	Difference in visual score	Difference in temperature
Difference in pulse rate	1.00	0.06[a] -.17[b]	0.26 -.28	-.18 0.17
Difference in respiration rate		1.00	0.20 0.35	0.23 -.07
Difference in visual score			1.00	0.03 -.09
Difference in temperature				1.00

[a]TES

[b]PES

TABLE VIII. Coefficients of correlation of mean behavioral responses at postweaning

	Mean Pulse Rate	Mean Respiration Rate	Mean Visual Score	Mean Temperature
Mean Pulse Rate	1.00	0.09[a] 0.19[b]	0.12 0.23	-.22 0.30
Mean Respiration Rate		1.00	0.23 0.41	0.02 0.51
Mean Visual Score			1.00	0.04 0.44
Mean Temperature				1.00

[a]TES

[b]PES

heart girth were 0.21, 0.24, 0.23, and 0.20, respectively. Mean weaning pulse rate was less closely related to heart girth at TES, the coefficient of correlation being 0.15. Mean weaning pulse rate was the most closely related to physical characteristics at PES, coefficients of correlation for mean weaning pulse rate and weaning weight, ADG, height at withers, and heart girth being -.19, -.20, -.21, and -.21, respectively.

At TES, weaning age was related to the difference in pulse rate (r=0.19) and the difference in visual score (r=-.13), whereas, weaning age with mean pulse rate, mean respiration rate, and mean visual score had coefficients of correlation of -.13, 0.19, and 0.19, respectively. At PES, the only variable with respect to differences, showing a relationship to weaning age was the difference in visual score (r=0.10), whereas, two of the coefficients of correlation of the variables with respect to mean values, with weaning age showed some relationship, the coefficient of correlation between mean pulse rate and weaning age being -.17 and between mean visual score and weaning age being -.17.

The coefficients of correlation for the differences in behavioral variables recorded at postweaning with physical characteristics and age and the coefficients of correlation of the means of behavioral variables scored at postweaning with physical characteristics and age appear in Table IX.

A regression analysis indicated that mean postweaning visual score could be predicted from mean weaning visual score at both TES and PES. Though significant (P<0.01) at both TES and PES, the coefficients

TABLE IX. Coefficients of correlation of differences in behavioral postweaning variables and of means of behavioral postweaning variables with physical characteristics at postweaning

	Yearling Weight	Postweaning ADG	Lifetime ADG	Height at Withers	Heart Girth	Postweaning Age
Difference in pulse rate	0.10[a] -.06[b]	0.03 -.16	0.09 -.05	0.12 -.10	0.08 0.06	-.03 -.11
Difference in respiration rate	0.14 -.06	0.00 -.04	0.13 -.06	0.18 0.12	0.16 -.01	-.08 -.18
Difference in visual score	-.06 0.00	-.04 0.10	-.06 0.01	0.02 0.01	-.05 0.06	-.01 0.01
Difference in temperature	-.03 0.24	-.14 -.02	-.04 0.23	0.01 0.15	0.04 0.17	-.03 -.02
Mean pulse rate	0.03 -.16	0.16 0.10	0.05 -.16	0.03 -.23	0.11 -.16	-.04 0.04
Mean respiration rate	0.17 -.25	0.11 0.03	0.17 -.26	0.22 -.22	0.24 -.20	-.08 -.19
Mean visual score	-.06 -.16	-.02 0.03	-.06 -.19	0.13 -.12	0.00 0.03	-.01 0.04
Mean temperature	-.11 -.31	0.00 -.08	-.10 -.30	-.08 -.26	-.06 -.20	-.03 -.07

[a]TES

[b]PES

of determination were small, 0.103 at TES and 0.203 at PES. The intercept value for TES was 1.696 and for PES was 0.913; the coefficient of regression for TES was 0.398 and for PES was 0.497.

IV. CHI-SQUARE ANALYSES

As an alternative to correlation, chi-square was used to assess the association between variables. The observed chi-square value at PES with respect to sex and difference in postweaning pulse rate was significant ($P<0.01$); more animals of both sexes increased in pulse rate from the approach to the squeeze chute than decreased or stayed the same, but proportionately, more males than females decreased or stayed the same. At PES, a significnat ($P<0.01$) chi-square was found also for sex and difference in temperature; more males than females decreased in temperature or stayed the same, and more females than males increased in temperature. With respect to mean values and physical characteristics the levels of significance of chi-square values are presented in Table X. At TES, the mean weaning respiration rate and weaning weight and the mean weaning pulse rate and ADG were distributed such that the majority of animals which were greater than the mean of the production characteristics also were grouped as greater than the overall mean in mean behavioral response, and those individuals which were equal to or less than the mean in the production trait were largely in the less-than-or-equal classification for overall behavioral response. With respect to sex and mean weaning pulse rate at TES, more males were located in the greater-than-overall-mean-pulse response group, whereas, more of the females were located in the

TABLE X. Results of 2 x 2 chi-square analyses where mean behavior variables were classified as less than or equal to and greater than overall mean behavior and physical characteristics, except for sex, where classification was greater than and less than or equal to mean physical characteristics

Station-Time	Combination of Variables	Significance Level
TES-weaning	Mean respiration rate and weaning weight	$P<0.05$
TES-weaning	Mean pulse rate and ADG	$P<0.01$
TES-weaning	Mean pulse rate and sex	$P<0.01$
PES-weaning	Mean pulse rate and weaning weight	$P<0.05$
PES-weaning	Mean visual score and weaning weight	$P<0.10$
TES-postweaning	Mean pulse rate and yearling weight	$P<0.05$
TES-postweaning	Mean pulse rate and postweaning ADG	$P<0.05$
TES-postweaning	Mean pulse rate and lifetime ADG	$P<0.01$
TES-postweaning	Mean pulse rate and sex	$P<0.01$
TES-postweaning	Mean respiration rate and sex	$P<0.01$
PES-postweaning	Mean visual score and postweaning ADG	$P<0.05$
PES-postweaning	Mean temperature and lifetime ADG	$P<0.10$

less-than-or-equal classification according to overall mean pulse rate. At PES, the distribution according to mean weaning pulse rate and weaning weight was such that 24 of 45 animals having weaning weights greater than the mean, had mean pulse rates less than or equal to the overall mean pulse rate and 26 of 37 animals having weaning weights less than or equal to the mean, had mean weaning pulse rates greater than the overall mean.

At postweaning at TES, the distribution obtained by the grouping of the mean behavioral responses and the production traits were similar in all cases, with the groupings, mean behavioral response less than or equal to overall mean and greater than average production trait, and mean behavioral response greater than overall mean and less than or equal to mean production trait, being relatively small percentages. At TES, groupings with respect to mean postweaning pulse rate and sex and mean postweaning respiration rate and sex had similar distributions, the males having a greater percentage in the greater-than-overall-mean response group and the males having a smaller percentage than the females in the less-than-or-equal-to-overall-mean response group.

At postweaning at PES, the distribution with respect to mean visual score and postweaning ADG was such that approximately 43% of the animals were grouped as being less than or equal to the overall mean visual score and also less than or equal to the overall mean of postweaning ADG, and the other three cells ranged from approximately 18% to 21%.

V. ANALYSES OF VARIANCE

Analyses of variance of performance variables with sex, dam age, sire, weaning or postweaning age (as a continuous variable) and one behavioral variable as independent variables showed mean respiration rate to be a significant ($P<0.10$) effect on weaning weight and ADG ($P<0.05$) at TES and respiration rate difference to be a significant ($P<0.10$) effect on weaning weight and ADG at PES.

At postweaning at TES, none of the behavioral variables were significant effects on performance variables. However, in postweaning data at PES, temperature difference was a significant ($P<0.05$) effect on yearling weight and lifetime ADG ($P<0.10$). Mean postweaning temperature at PES was a significant ($P<0.01$) effect on yearling weight and lifetime ADG ($P<0.05$). Mean postweaning respiration at PES was a significant ($P<0.05$) effect on lifetime ADG and yearling weight ($P<0.10$).

Analysis of variance with the behavioral variables as dependent variables and sex, age of dam, sire and weaning or postweaning age as independent variables, showed significant differences with respect to some behavioral variables at TES, at weaning and postweaning and at PES at postweaning. The results are presented in Table XI.

VI. HERITABILITY AND GENETIC CORRELATION

Due to large sampling variance, in many cases, the estimates of heritabilities were greater than 1.0 or negative. Likewise, many genetic correlations were greater than 1.0 or less than -1.0. Because of the large number of unreasonable estimates, all estimates of heritability and genetic correlation appear in the Appendix as a matter of record.

TABLE XI. Results of analysis of variance with independent variables sex, age of dam, sire and weaning or postweaning age

Station	Dependent Variable	Significance Level of Reduction in Sum of Squares	Significance Levels of Independent Variables
TES	Mean weaning pulse rate	$P<0.01$	Sex ($P<0.01$) Sire ($P<0.05$)
TES	Mean weaning visual score	$P<0.01$	Sire ($P<0.01$)
TES	Mean postweaning pulse rate	$P<0.01$	Sex ($P<0.01$)
PES	Mean postweaning respiration rate	$P<0.05$	Sex ($P<0.01$)
PES	Mean postweaning temperature	$P<0.05$	Sex ($P<0.05$)

VII. DISCUSSION OF DIFFERENCES AND MEANS

As stated earlier, measurements were taken on each calf, both in the approach chute and in the squeeze chute. Since differences were observed at both weaning and postweaning between the approach chute and squeeze chute values of some of the variables, it would seem that some physiological mechanism is responsible for the change. It was thought, in designing the experiment, that the differences in the values between approach chute and squeeze chute might be a good indication of the animals' general temperament and adaptability in that values in the approach chute should reflect a calmer state, since only behavioral measurements were being taken and only loose restraint employed, and the squeeze chute values would reflect an anxious state since the head was being manipulated and several measurements being recorded. It was felt also that coefficients of correlation between the differences in approach and squeeze chute values and production traits might provide some insight into relationships between temperament and production. As data were collected, however, it became evident that differences in values would not be as informative as originally expected. In the approach chute, the calves were clearly agitated and did not reflect a resting state. Possible reasons for this will be discussed later. In addition, it was difficult to assess the degree of stress imposed by the squeeze chute. It was believed that, although significant differences between approach chute and squeeze chute values were obtained for some variables, the differences did not reflect as much information as to the metabolic level of the calves as did the mean of the approach chute and squeeze chute value. Comparison of the behavioral values obtained here with those available in the literature was not possible since the latter are mostly values for older animals and there are no published values for animals at these precise ages and weights. If the approach chute values had in fact been reflective of a calm state, the magnitude of the variables may not have been important. But, as it was, by considering the values in approach and squeeze chute to be indicative of different levels of stress and by averaging the two scores, an indication of overall response to stress was gained, and in many cases, would contain more information than the differences themselves, which did not take into account, for example, whether a calf was starting with an extremely high or low value for one of the variables.

VIII. INTERRELATIONSHIP OF VARIABLES

In examining the results, it is important to determine the interrelationship of the variables studied. Whether or not pulse rate, respiration rate, visual behavior score and temperature were measuring the same response, or which of the four variables is most informative as to the response, becomes critical. Only weak to moderate phenotypic correlations were found among the variables studied. It was difficult to determine, from the variables examined in this study, exactly what physiological mechanism was responsible for the observed changes in those variables. In a stress response in which epinephrine is released, heart rate should increase (Wilson, 1972). Except for TES at weaning, the heart rate did increase from the approach to the squeeze chute. As for respiration rate, contractions of the abdominal wall and thoracic muscles act to increase the depth of breathing under conditions of stress (Wilson, 1972). Since measurements in this experiment were on respiration rate and not volume, it may be that the consistent decrease in rate from approach to squeeze chute was a result of taking fewer but deeper breaths in the squeeze chute. There are other possible explanations for the observed decrease in respiratory rate. Baroreceptors are probably more important in regulating circulation than respiration, but if blood pressure increases, the effect on respiratory rate is one of inhibition through stimulation of baroreceptors (Wilson, 1972). Although blood pressure was not measured in this study, if an epinephrine response was illicited it would affect blood pressure. The influence of epinephrine should increase blood pressure (Goodman and Gilman, 1970). The effects of epinephrine on respiratory rate are not as pronounced, and the increase in respiratory rate is brief (Goodman and Gilman, 1970). Another possible explanation for the decrease in respiratory rate is that prior to entry of the animal into the approach chute and while in the approach chute if the respiratory rate was increased sufficiently to produce a respiratory alkalosis, the decrease in rate observed in the squeeze chute may have been a compensatory response mediated through the medulla. In an acid or base disturbance, a compensatory response begins within minutes; however, for complete restoration several hours are required (Houpt, 1977). But these explanations are only speculative and require further experimentation. The visual scores tended to be higher in the approach chute than in the squeeze chute, but only significantly higher at one time. This is probably attributable to the greater freedom of movement allowed the animals in the approach chute. Even at TES, where more than one animal could be in the approach chute simultaneously without having the heads restrained, the animals were allowed more room in which to move about. This may be a consideration in future studies with respect to the basis for visual scoring. The problem is one, in part, of assessing the activity or restlessness of restrained animals and comparing this to animals allowed some freedom of movement.

IX. DISCUSSION OF RESULTS BY STATION AND TIME

The results at each station and each time, at first examination appear inconsistent. Several factors should be considered prior to a general discussion. As stated earlier, breed and location are completely confounded. In addition to managerial and nutritional differences which are likely to exist at different stations, the facilities in which the cattle were worked differed; at PES, the cattle were worked in an enclosed area and at TES the cattle were worked outside. Although the squeeze chutes in all cases were similar, the approach chutes differed considerably. Another important consideration in the analysis is time. At postweaning, the cattle were worked in freezing weather, and since three of the behavioral measurements are concerned with homeostasis, they were possibly influenced by ambient atmospheric conditions. The calves at postweaning also were in a different metabolic state with respect to growth rate. At weaning in which growth is almost linear, the metabolism of the calves would differ from postweaning at which time the calves are usually at the inflection point of a growth curve. Another consideration at postweaning would be that of learning. The calves at postweaning had been exposed to the squeeze chute at least once more than at weaning. At both weaning and postweaning, it appeared that the calves were excited in the approach chute, the small increases in response seen may have not been reflective of the total response due to the fact that a threshold response had previously been reached. The animals would, in that case, not be as easily differentiated as they might be if considering the difference between a truly resting state and an excited state. There may have been some habituation over the extended time the animals were being observed. From the initial observation in the approach chute to the time the calves were being measured in the squeeze chute, a large response may have begun to subside.

At TES, the largest and most consistent coefficients of correlation, ranging from 0.20 to 0.24 were between mean respiration rate and the physical characteristics, weaning weight, ADG, height and heart girth. In a chi-square analysis also it appeared that animals maintaining a relatively high respiration rate tended to be above mean weaning weight, whereas, those with low mean respiration rates tended to be below mean weaning weight. Analysis of variance also indicated mean respiration rate to be a significant effect on weaning weight. These results are not inconsistent with the possibility that an animal more sensitive to stress may decrease in respiration rate. An analysis of variance indicated mean weaning respiration rate to be a significant effect on ADG. The significance in the chi-square analysis of mean weaning pulse and ADG is more difficult to explain. However, since the difference in pulse rate at weaning was small and nonsignificant, it may be that pulse rate at TES tended to be a more stable variable and the significant distribution a reflection of the unstressed metabolic state of the animals, meaning that animals of higher pulse rate tend to grow more rapidly. Since a chi-square analysis of sex and mean weaning pulse rate was significant with males tending toward higher pulse, the significance of mean weaning pulse rate and ADG may indicate that males, having a higher pulse rate, have higher ADG. Analysis of variance also indicated sex difference to be a significant cause of variation in weaning pulse rate.

At PES weaning, differences in respiration rate were negatively related to weaning weight, ADG, and heart girth, meaning that as the difference decreased, the physical characteristics tended to increase. In an analysis of variance, the difference in respiration rate was a significant ($P<0.10$) effect on weaning weight and ADG. The mean pulse rate was negatively related to physical characteristics (r ranging from -.19 to -.21), and, in chi-square analysis, the distribution of weaning pulse rate classified by weaning weight, indicated that animals lower than or equal to the overal mean pulse rate were heavier than those above the overall mean pulse rate. The chi-square analysis of mean weaning visual score and weaning weight approached significance ($P<0.10$) with a distribution similar to that of mean weaning pulse rate and weaning weight.

Pulse and respiration rate means and differences differed significantly ($P<0.01$) from weaning to postweaning at TES. At postweaning, mean respiration rate was still positively correlated with production traits, the lowest coefficient of correlation being for postweaning ADG (r=0.11) and the others ranging from 0.17 to 0.24. At postweaning a chi-square analysis indicated that males tended to have higher respiration rates than females. Smaller positive coefficients of correlation were found between the differences in respiration rate and yearling weight, lifetime ADG, height at withers and heart girth, ranging from 0.13 to 0.18. The strongest relationship between postweaning ADG and any of the variables studied was that between postweaning ADG and mean postweaning pulse rate (r=0.16). A positive coefficient of correlation was found also between mean postweaning pulse rate and heart girth (r=0.11), which agrees closely with that found at weaning for mean pulse rate and heart girth (r=0.15). Chi-square analysis indicated mean postweaning pulse rate and yearling weight, postweaning ADG and lifetime ADG to be related in that animals above the overall mean pulse rate tended to be above the mean of the production trait and those less than or equal to the mean pulse rate tended to be less than or equal to the mean production trait. There are several possible explanations for this. As at weaning, the chi-square analysis of mean postweaning pulse rate and sex was significant, and analysis of variance indicated sex to be a significant factor in postweaning pulse rate. It may be that animals with higher pulse rates tended to be male and grew more rapidly. However, it may be attributable to the fact that the overall mean pulse rate was quite elevated and possibly reflective of, or compounded by, a factor in the environment, such as freezing weather, rather than the response to psychological stress. Even though the difference between approach chute and squeeze chute values was significant, the magnitude of the difference was relatively small with a relatively small standard error. If the pulse rate was elevated in the approach chute due to maintenance of body temperature, the extent to which pulse rate would further increase due to psychological stress would be limited, and possibly not be useful for differentiating calves according to stress response.

At PES, visual score and respiration rate means differed from weaning to postweaning, and pulse differences differed from weaning to postweaning. At postweaning at PES, several negative coefficients of correlation of nearly the same magnitude were found between the mean behavioral variables and yearling weight, lifetime ADG, height at withers and heart girth, indicating that decreasing mean values of behavioral traits are associated with increasing physical characteristics. A significant chi-square analysis of mean visual score at postweaning classified by postweaning ADG indicated that animals with mean visual scores higher than the overall mean gained more rapidly. The results of an analysis of variance indicated mean postweaning respiration rate to be important in lifetime ADG ($P<0.05$) and yearling weight ($P<0.10$). Mean postweaning temperature was a significant ($P<0.01$) effect on yearling weight and lifetime ADG ($P<0.05$), and the difference in temperature was a significant ($P<0.05$) effect on yearling weight and in lifetime ADG ($P<0.10$). Chi-square analysis of mean postweaning temperature classified by lifetime ADG also was significant ($P<0.10$) with a distribution indicating animals with mean temperatures less than or equal to the overall mean temperature gained more rapidly, whereas, those with greater than mean temperature tended to have average or less than average lifetime ADG.

Considering all the results together, it appears that the total picture at weaning is different from that at postweaning. There is little evidence to state conclusively that the responses of calves at weaning were due to psychological stress. Assuming that the responses were reflective of stress at weaning, the possibility exists that at postweaning, the responses were due to another phenomenon, since responses become more inconsistent at postweaning. The distinction between situations in which an animal will have an advantage in competition due to aggressiveness, and those in which efficiency is lowered due to restlessness and nervousness becomes more important at postweaning than at weaning. As stated earlier, at postweaning, the rate of growth is changing which implies a change in metabolism. To the extent the change in metabolism and the change in growth rate will effect the response has yet to be determined. Also, the calves appeared calmer at postweaning, in which case the responses at postweaning may differentiate between calves on a different basis than originally hypothesized.

Two factors which have not been thoroughly discussed are sex and age. As can be seen by the coefficients of phenotypic correlation of age with the behavioral variables, the results are inconsistent. Analysis of variance did not indicate age to be a significant effect on any of the behavioral variables within weaning or postweaning time. As stated earlier, at TES at weaning, as revealed by chi-square analysis, the males tended toward higher pulse rates and females toward lower pulse rates. At TES postweaning, a similar distribution with respect to sex and mean respiration rate was observed. At PES at postweaning, both males and females increased in pulse rate from approach to squeeze chute, but, proportionately, more females than males increased. In temperature, males tended toward constant or decreasing temperature and females tended toward increase in temperature. In an analysis of variance, with the behavioral variables as the dependent variables, sex was a significant ($P<0.01$) effect on mean weaning pulse rate and mean postweaning pulse rate at TES. At PES, sex was a significant ($P<0.01$) effect on mean postweaning respiration and also ($P<0.05$) on mean postweaning temperature ($P<0.05$).

Although the data gathered indicate that the calves were responding to being worked, it has not been clearly established that the procedure was stressful in nature, particularly at postweaning, and, if it was stressful, it cannot be determined what variables were actually a result of that stressful situation. Most importantly, though, it has not been determined if individual response is closely enough related to production, or in what direction, to be useful in evaluating individual animals. However, certain general trends were exhibited by the data, and it may be possible in future research, using procedural modifications based on the experience reported here, to find ways to use reliably the behavioral variables recorded here to differentiate between individual animals with respect to stress responses.

CHAPTER V

SUMMARY

Ninety-eight Polled Hereford calves, averaging 215.13 $\pm$ 1.96 days at weaning and 92 Polled Hereford calves averaging 381.17 $\pm$ 1.98 days at postweaning were the subjects of an investigation of behavioral responses at the Tobacco Experiment Station (TES). At the Plateau Experiment Station (PES), 82 purebred Angus calves averaging 223.66 $\pm$ 1.93 days of age at weaning and 91 purebred Angus calves averaging 386.14 $\pm$ 1.83 days at postweaning, also were included in the study. At weaning, three variables, pulse rate, respiration rate and visual score of behavior were recorded for each calf in an approach chute and in a squeeze chute. At postweaning, body temperature also was measured. The differences in appraoch chute and squeeze chute values, as well as the means of the approach chute and squeeze chute values, were examined as to their correlation to production.

In general, the means of the variables seemed to be more informative with respect to response of the calves than did the differences. This is believed to be due to an elevated response in the approach chute, such that further elevations in response to psychological stress were limited.

The relationship of the variables to each other and to production traits differed between stations and times. However, age as an effect could only be examined within weaning and postweaning times and breed differences could not be examined, since time, breed, and station are confounded. At TES, the variable with the greatest relationship to production seemed to be mean respiration rate. At PES, mean pulse rate appeared to be the most important variable at weaning. At postweaning, the calves responded differently to being worked. It can be hypothesized that the responses at postweaning were reflective of environmental stimuli other than psychological stress. Possibly at postweaning, the response to being worked was a response to mild psychological stress and that other physiological factors, such as sex, may in that case, over-ride the effect of a stress response.

There are several possible approaches which might lend some insight into the nature of the response actually being measured as calves pass through a chute. One possibility is to divide paternal half-sibs into a control group, which would be adjusted to the procedure, and an experimental group, which would be exposed to the procedure a minimum number of times. A comparison of the two groups should indicate the extent to which calves' responses to being worked are indicative of stress. If the response is found to be reflective of stress, then, within the experimental group, the behavioral variables most reflective of the stress response could be possibly determined, as well as their relation to production. Once such guidelines are available, it would be possible to design a large scale project with sufficient numbers of animals to estimate heritabilities and genetic correlations.

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APPENDIX

TABLE AI. Estimates of heritabilities and genetic correlations of differences[a] in behavioral values and production traits at weaning

	Mean of pulse rate	Mean of respiration rate	Mean of visual score	Weaning weight	ADG	Height at withers	Heart girth
Difference in pulse rate	0.16[b] 1.03[c]	0.33 1.03	0.00 0.06	-2.30 0.00	-1.21 - .07	0.00 3.28	0.00 0.65
Difference in respiration rate		0.30 0.78	0.00 - .20	1.01 1.34	- .79 1.25	0.00 5.21	0.00 0.62
Difference in visual score			0.00 0.46	0.00 - .34	0.00 - .37	0.00 - .61	0.00 - .87
Weaning Weight				0.02 0.58	1.29 0.99	0.00 2.85	0.00 0.77
ADG					0.09 0.55	0.00 2.87	0.00 0.84
Height at withers						0.00 0.02	0.00 2.43
Heart girth							0.00 0.46

[a](Squeeze chute value - approach chute value)

[b]TES

[c]PES; only sires with more than five calves were included in this analysis.

TABLE AII. Estimates of heritabilities of mean[a] behavioral values and estimates of genetic correlation between mean behavioral values and production traits at weaning

	Mean of pulse rate	Mean of respiration rate	Mean of visual score	Weaning weight	ADG	Height at withers	Heart girth
Mean of pulse rate	0.38[b] 0.42[c]	0.68 - .32	0.00 0.12	-2.25 0.34	- .92 0.29	0.00 0.88	0.00 0.45
Mean of respiration rate		0.25 0.65	0.54 0.27	2.16 - .42	1.16 - .35	0.00 - .80	0.00 - .83
Mean of visual score			0.58 0.85	0.94 - .40	0.46 - .55	0.00 - .32	0.00 - .29

[a](Squeeze chute value + approach chute value)/2

[b]TES

[c]PES; only sires with more than five calves were included in this analysis.

TABLE AIII. Estimates of heritabilities and genetic correlations of differences[a] in behavioral values and production traits at postweaning

	Mean of pulse rate	Mean of respiration rate	Mean of visual score	Mean of temperature	Yearling weight	Postweaning ADG	Lifetime ADG	Height at withers	Heart girth
Difference in pulse rate	0.01[b] 0.00[c]	0.00 0.00	7.97 0.00	0.00 0.00	0.00 0.00	1.63 0.00	0.00 0.00	0.00 0.00	10.16 0.00
Difference in respiration rate		0.00 0.53	0.00 - .79	0.00 0.00	0.00 - .10	0.00 - .10	0.00 - .01	0.00 - .61	0.00 - .21
Difference in visual score			0.05 0.24	0.00 0.00	0.00 - .75	1.87 - .43	0.00 - .76	0.00 - .91	- .59 - .94
Difference in temperature				0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
Yearling weight					0.00 1.15	0.00 0.89	0.00 1.00	0.00 0.62	0.00 1.04
Postweaning ADG						0.23 0.54	0.00 0.96	0.00 0.18	-4.92 1.14
Lifetime ADG							0.00 1.11	0.00 0.43	0.00 1.04
Height at withers								0.00 0.17	0.00 0.57
Heart girth									0.00 0.81

[a](Squeeze chute value - approach chute value)

[b]TES

[c]PES; only sires with more than five calves were included in this analysis.

TABLE AIV. Estimates of heritabilities of mean[a] behavioral values and estimates of genetic correlation between mean behavioral values and production traits at postweaning

	Mean of pulse rate	Mean of respiration rate	Mean of visual score	Mean of temperature	Yearling weight	Post-weaning ADG	Life-time ADG	Height at withers	Heart girth
Mean of pulse rate	0.29[b] 0.00[c]	0.00 0.00	- .39 0.00	0.00 0.00	0.00 0.00	- .81 0.00	0.00 0.00	0.00 0.00	-2.35 0.00
Mean of respiration rate		0.00 0.45	0.00 1.48	0.00 0.91	0.00 0.94	0.00 0.49	0.00 0.89	0.00 1.51	0.00 0.87
Mean of visual score			0.09 0.07	0.00 2.17	0.00 0.69	0.20 1.25	0.00 0.67	0.00 2.10	6.63 0.54
Mean of temperature				0.00 0.53	0.00 0.38	0.00 0.38	0.00 0.26	0.00 1.65	0.00 0.31

[a](Squeeze chute value + approach chute value)/2

[b]TES

[c]PES; only sires with more than five calves were used in this analysis.

VITA

Gwendolyn Sue Light was born July 13, 1954, in Kingsport, Tennessee. She attended elementary and Jr. High School in Kingsport and graduated from Francis C. Hammond High School, Alexandria, Virginia, in 1971. She entered Vassar College, Poughkeepsie, New York and graduated in May 1975 with an Arts Bachelor degree in Bio-psychology. In September 1975, she entered The University of Tennessee as a special student, and in 1977 was admitted to candidacy by the Graduate School at The University of Tennessee. In December 1978, she received her Master of Science degree in Animal Science.