

SOME FACTORS AFFECTING WEANING WEIGHT  
IN AN INBRED SHORTHORN HERD

by

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## INTRODUCTION

In the continuous effort to improve beef cattle through breeding, selection has proven to be the most effective method. To aid in the selection process, researchers have established certain production traits as indicators of merit. Weaning weight is one of the important traits, not only in the evaluation of the calf itself, but also as an indicator of the value of the parents of the calf.

To insure the most beneficial use of a production trait as a criterion in selection it is necessary to know as much about it as possible. This information enables one to judge how much confidence can be placed in the trait as a criterion. The more confidence one can place in the trait, the more valuable it becomes in selection.

It is well known that many factors must be considered when evaluating weaning weight as a criterion for selection. The principal factors are: (1) the genetic and environmental variables affecting weaning weight, (2) the phenotypic and genotypic relationships between weaning weight and other criteria of selection, (3) the degree to which weaning weight is heritable, and (4) the degree to which weaning weight is repeatable as a characteristic of the dam or the sire.

The purpose of this study was to appraise the above factors in data obtained on two inbred lines of Shorthorn cattle.

## REVIEW OF LITERATURE

## Variables Affecting Weaning Weight

There are several variables which can affect the weaning weight of any given beef calf. The principal ones have been found to be: (1) the degree of inbreeding of the calf and its dam, (2) the sex of the calf, (3) the sire, (4) the lactating ability of the dam, (5) the age of the dam, (6) the age of the calf, and (7) the year. The first three variables can be considered as being primarily under genetic control while the latter three are primarily under environmental control. The fourth variable, the lactating ability of the dam, is both genetic and environmental in nature.

Degree of Inbreeding. It is generally agreed that as the degree of inbreeding increases, there is a corresponding reduction in vigor, size and fertility. Burgess et al. (4) computed constants of -1.75 pounds for each increase of one per cent in the inbreeding coefficient of the calf and -1.15 pounds for a one per cent increase in inbreeding of the dam. The degree of inbreeding was relatively low during their five year study, averaging about 15 per cent for the calf and 8 per cent for the dam.

Koch (13) reported regressions of weaning weight on per cent inbreeding to be -2.54 pounds for inbreeding in the dam and -0.48 pound in the calf. During Koch's ten-year study the mean inbreeding coefficients were 6 per cent for the dams and 12 per cent for the calves.

McCleery and Blackwell (25) calculated negative partial regression coefficients of weaning weight on inbreeding of calf. They were -0.74 pounds for each one per cent increase in inbreeding of the calf when inbreeding of dam was held constant and -1.19 pounds when inbreeding of dam was included. The

inbreeding coefficients in their data ranged from 0 to 25 per cent for calves and from 0 to 16 per cent for dams.

In a comparable study with dairy cattle, Woodward and Graves (35) reported that birth weight and rate of growth decreased as inbreeding became more intense. Several calves were deformed at birth and the mortality of inbred calves after birth was greater than for non-inbreds. However, neither milk production nor fertility declined despite inbreeding coefficients greater than 50 per cent.

Sex of Calf. There is practically unanimous agreement that male calves are heavier than female calves at birth and they maintain this advantage up to weaning. However, there is disagreement concerning the size of this advantage.

Brinks et al. (2) found highly significant sex differences in birth weight, suckling gain and weaning weight. Heifers weighed seven per cent less than bulls at birth, and five per cent less than steers and six per cent less than bulls at weaning. The suckling gain of heifers was five per cent less than steers and six per cent less than bulls.

Koger and Knox (19) reported a significant difference of 32 pounds in favor of steers over heifers at weaning, based on over 800 observations. A partial explanation of this may be the accompanying fact that bull calves had a five day longer gestation period than heifers.

Koch et al. (14) reported that bull calves averaged 5.2 pounds heavier at birth and gained 0.113 pound per day more than heifers. This finding was based on approximately 3,000 observations.

Koch and Clark (15) found that male calves averaged 5.6 pounds heavier at birth and 26.2 pounds heavier at weaning than heifer calves. These

results were based on approximately 6,000 observations.

Burgess et al. (4) calculated these deviations from the average weaning weight (in pounds): bull, +14; steer, -6; heifer, -8.

Sire. The influence of the sire is important from a practical standpoint, though this influence is often difficult to express in terms of specific values. Sire effects are often confounded with other variables and most researchers state only that their analyses showed the effect of the sire was significant. However, progeny tests have clearly shown that there are marked differences in transmitting ability among sires and those of proven genetic superiority are valuable economic assets.

Brown (3) calculated least-square estimates of the influence of sire on the weight of beef calves at several ages and at 180 days of age the estimates ranged from +17 pounds to -65 pounds. Also, for three different purebred herds, the percentages of the variance associated with sires were 7.0, 2.8 and 0, the first two being significant at the one per cent level.

Pahnish et al. (26) found significant differences among sires within ranches and years. Sire differences accounted for 5 per cent and 12 per cent of the total variance in weaning weights among bull and heifer calves, respectively.

Lactating Ability of Dam. This variable, like the influence of the sire, is considered very important from a practical point of view. It is determined not only by the genetic make-up of the animal but by environmental influences such as the age of the animal and the feed and management practices. From the standpoint of the calf, the milk production of its dam is primarily an environmental factor. While it is difficult to express the importance of lactating ability in specific values, the livestock producer

is well aware of the value of a dam that consistently produces a sufficient supply of milk to meet the needs of her growing calf.

From their study, Rollins and Guilbert (27) concluded that "the lactating ability of a cow makes a major contribution to the growth of the calf throughout the entire suckling period." Koch and Clark (18) reached a similar conclusion from the results of their work.

Gregory et al. (7) found that the cows making the smallest gains while nursing a calf tended to produce calves that made the largest gains from birth to weaning. The explanation offered was that "more of their nutrients and energy were going into the production of milk than into body flesh. Thus, the more rapid gains made by these calves probably were largely the result of the higher milk producing ability of their dams."

Knapp, Jr. et al. (10) pointed out the similarity between the relationship of milk production with age of cow and that of weaning weight of calf with age of dam.

Age of Dam. There is considerable agreement concerning the effect of the age of the dam on the weaning weight of her calf. Sawyer et al. (30) found that two-year old cows weaned calves 75 pounds lighter than mature cows. The weaning weight of calves increased with age of dam through eight-year olds, but then declined.

Burgess et al. (4) reported a highly significant effect for age of dam upon calf weaning weight. The effects, in pounds, expressed as deviations from the average weaning weight were: two-year olds, -15; three to five-year olds, +5; six to eight-year olds, +21; nine-year olds and over, -10.

Marlowe and Gaines (24) attributed most of the variation in growth rates and type scores among calves to differences in age of the dams. The

largest difference was between the calves produced by two and three-year old dams. Maximum production was exhibited by the six to ten-year age group.

Koch and Clark (15) reported that the dam's production, with regard to her calf's birth weight, weaning weight and weaning score, increased steadily from three to six years of age and thereafter declined.

Swiger (34) found a marked effect of age of dam when he compared the weaning weights of calves of young cows with those of mature cows. The average weaning weights of calves of two, three and four-year old cows were 320, 380 and 410 pounds, respectively, while calves from cows five through twelve years of age ranged from 440 to 460 pounds.

Age of Calf. It is obvious that the weaning weight of a calf should increase as its age increases. The cattleman should realize that though all his calves were born in the same season, there may be as much as three months difference in their ages, if they are weaned at the same time.

Burgess et al. (4) found a regression of weaning weight on weaning age of 1.67 pounds per day of age. Koch (13) reported a regression of weight on age of 2.27 pounds per day, while Hamann et al. (9) found a regression of 1.4 pounds.

Swiger (34) found a nearly linear relationship between weaning age and weaning weight. At 150 days of age, the average weaning weight was 320 pounds, while at 250 days of age, it was 480 pounds, indicating a regression of weight on age of 1.6 pounds.

Year. No two years for a given location are exactly alike and can often be quite different. This largely uncontrollable variable, e.g., weather conditions and their effects on feed supply, can be responsible for a considerable portion of the total variability between records for different years.



Brown (3) calculated least-square estimates of the influence of year on the weight of beef calves at several ages. During his nine-year study the estimates ranged from -31 pounds to +33 pounds for 180-day old calves. The percentages of the total variance in the weight of these calves accounted for by year effects in three purebred herds were 7.0, 2.0 and 2.1.

Burgess et al. (4) expressed the effect of year as a deviation from the overall average weaning weight. These deviations ranged from -24 pounds to +20 pounds during their five year study.

With the use of the least-squares procedure, Hamann et al. (9) fitted constants of -9, +6 and +3 for 1957, 1958 and 1959, respectively, in their three-year study.

#### Relationship of Weaning Weight to Other Criteria

A review of the literature has shown considerable disagreement concerning the relationship between weaning weight and other criteria of selection. This disagreement clearly indicates the need for more work in this area to help clarify the situation.

Carter and Kincaid (6) found a genetic correlation between pre-weaning growth rate and post-weaning gain of .69 for steers and .51 for heifers. However, from their data, Knapp and Black (11) concluded that there was little or no relationship between pre-weaning and post-weaning gain.

Rollins and Wagnon (29) found a within-year correlation of .42 between weaning weight and weaning grade. However, Lehmann et al. (21) concluded that "growth and type are essentially genetically independent." They also concluded that a selection index combining traits was preferable to selecting

on the basis of a single trait.

An interesting study was conducted by Lindholm and Stonaker (23) in which a multiple correlation analysis, using net income per hundredweight as the dependent variable, indicated that weaning weight was the most important trait affecting net income. Other important traits included daily gain, slaughter grade, feed per pound of gain and 18-month weight of dam, the latter two being negatively correlated with net income. Their study indicated that weaning weight alone was an accurate basis for selecting for increased net income.

#### Heritability and Repeatability

The higher heritability and repeatability are for a trait, the more valuable this trait becomes in a selection scheme. While there is more agreement among workers regarding estimates of heritability and repeatability of individual pre-weaning traits than there is regarding correlations between certain pre-weaning traits, a considerable range in heritability estimates is found in the literature.

Repeatability is usually defined as the average correlation between repeated observations on the same individual. Since a calf can have only one weaning weight, repeatability in the usual sense does not apply here. However, in the references cited below, repeatability refers to the average correlation between the weaning weights of the calves of a given cow.

Koger and Knox (20) found highly significant positive correlations between early and subsequent records. The average correlation between weaning weights of all adjacent calves of a cow was .49. The correlation between the weight of the first calf and that of the second was .66. When

the weaning record of the first calf was compared with the average of the weaning weights of various subsequent calves, the correlation coefficients varied from .51 to .53. Comparable correlations for weaning score were about half as high. The data indicated that considerable progress could be made by selecting dams on the basis of first calf records.

Rollins and Wagnon (28) studied the effects of optimum and sub-optimum nutritional levels for cows on estimates of heritability and repeatability. The heritability estimate was .3 under both conditions, but the repeatability estimate was .51 in the optimum group and .34 in the sub-optimum group, the difference being significant. These estimates were based on paternal half-sib correlations.

Carter and Kincaid (5) demonstrated how three different methods of estimating heritability resulted in three different estimates for weaning grade. Using paternal half-sib correlations, the estimates were .41 for steers and .51 for heifers. Using the regression of progeny average on the sire's records, the estimates were .18 and .63, respectively for the steers and heifers. For intra-sire regression of offspring on dam the respective estimates were .07 and 0. Also, the heritability estimate of weight at six months of age was only .08 for steers but was .69 for heifers, using paternal half-sib correlations.

Using two methods, the intraclass correlation between calves by the same cow, and regression of subsequent records on earlier records by the same cow, Botkin and Whatley, Jr. (1) reported repeatability estimates of .43 and .49 for weaning weight, .18 and .14 for birth weight, respectively, and .38 for suckling gain. They also reported correlations between first and second records of .66 for weaning weight, .25 for birth weight and .69

for suckling gain. They concluded, as did Koger and Knox (20), that cows could be selected on the basis of first calf records; however, the desired herd size, the cost of raising a heifer to reproductive age and other factors influencing actual rather than adjusted production records should be considered in cow herd culling practices.

Using paternal half-sib correlations, Knapp, Jr. and Clark (12) obtained heritability estimates of .53 for birth weight and .28 for weaning weight and weaning score. Shelby et al. (32) obtained heritability estimates of .72 for birth weight and .23 for weaning weight using the same method.

Using paternal half-sib correlations for estimating heritability and maternal half-sib correlations for estimating repeatability, Koch and Clark (16) computed the following respective estimates: .35 and .26 for birth weight; .24 and .34 for weaning weight; .21 and .34 for suckling gain and .18 and .22 for weaning score. In a similar study, using the correlations between offspring and dam and offspring and sire, Koch and Clark (17) obtained these respective heritability estimates: birth weight, .44 and .35; weaning weight, .11 and .25; suckling gain, .07 and .17; and weaning score, .16 and .15.

## MATERIALS AND METHODS

### Materials

The data analyzed in this study were obtained from two inbred lines of purebred Shorthorn beef cattle maintained at Kansas State University. Since 1949, these lines of cattle have been used in a North Central Regional Project NC-1, entitled "The Improvement of Beef Cattle Through Breeding

Methods." The two inbred lines were established from different foundation stocks in 1949 and have been kept as closed lines since that date. The Wernacre Premier line is in the fourth generation of inbreeding and the present generation is the third for the Mercury line. In the Wernacre Premier line, four bulls have been used including the foundation sire, two of his sons and one grandson. In the Mercury line, six bulls have been used including the foundation sire, three of his sons, and two grandsons, which were half-sibs.

The selection of sires was based on several factors including yearling weight, growthiness and type. Though weaning weight was not used as a basis of selection, the two sons and grandson of the Wernacre Premier foundation sire all had higher than average weaning weights for the bulls in their respective years. In the Mercury line, however, two sires were above average, two were below average while one was average, with respect to the weaning weights of the bulls in their respective years. No selection of consequence was practiced with regard to matings and it was concluded that the degree of selection practiced did not significantly affect the results of this study.

Summer pasture breeding was practiced in order to produce a spring calf crop. The weight of each calf was taken immediately after the time of calving. The calves were not creep-fed during the suckling period. Some male calves were castrated at weaning. Calves were weaned, weighed and scored for type when they were approximately six months old.

A total of 265 usable records, 98 in the Wernacre Premier line and 167 in the Mercury line, were obtained during the 11-year period, 1950 through 1960. Data concerning the few line crosses, which resulted from

the mating of Mercury line bulls to cows in the Wernacre Premier line, during periods when a Wernacre Premier line bull was infertile, were eliminated from the analysis. Each calf was identified with a tattoo number, and the following information was obtained: birth date, birth weight, dam's number and age, sire, inbreeding of calf, inbreeding of dam, weaning date, weaning weight and weaning score.

#### Methods

All analyses were conducted separately for the two inbred lines. This was done because of the differences between the animals in the two lines; the foundation animals in the Wernacre Premier line were larger and more upstanding and the calves in this line were significantly larger, heavier and more variable than the Mercury calves.

Before valid comparisons between weaning weights could be made, it was necessary to adjust the weaning records to a standard. The first adjustment was for the age of the calf. This was done by using the simple regression coefficient as described by Snedecor (33). Coefficients were calculated for each year and tested for homogeneity by employing the analysis of covariance as described by Snedecor (33). Homogeneity was found within each line so that a pooled regression value was used to correct for age of calf.

Adjustments were also made for sex of calf and age of dam using Searle's (31) simplified herd-level correction factors. This method is much easier to calculate than the least-squares method and the constants obtained by both methods may compare quite closely, as shown by Hamann (8). Using Searle's method to correct for age of dam involved selecting the mature

age group with the highest average weaning weight (corrected for age of calf). The other cow age group averages were then compared to this mature group and appropriate multiplicative correction factors were calculated. To correct for sex of calf, the average weaning weight of the heifers was compared to that of the bulls and the correction factor was similarly calculated. These correction factors are specific and are applicable only to a given herd, or in this case, the respective inbred line.

Analyses of variance were performed to determine if weaning weight was significantly affected by inbreeding of calf or inbreeding of dam. To test the within-year effect of inbreeding, the degrees of inbreeding were arbitrarily divided into groups with increments of five per cent: 0 to 5, 5 to 10, 10 to 15, 15 to 20, 20 to 25 and over 25 per cent.

Simple correlation coefficients were computed to determine the relationship between: (1) birth weight and average daily gain from birth to weaning, (2) birth weight and weaning weight, and (3) weaning score and weaning weight.

Heritability estimates were computed for birth weight, suckling gain, weaning weight and weaning score, using the half-sib correlation method in all cases. These estimates were corrected for the degree of inbreeding in the population. Since inbreeding should reduce the variance within lines, the half-sib correlation is lowered and thus the heritability estimate based on this correlation becomes biased downward. The following correction, as devised by Lerner (22), was employed:

$$\frac{(1-F)h^2}{1-Fh^2} = h_I^2$$

where  $F$  = the average inbreeding coefficient of the offspring

$h^2$  = the estimate of heritability in a random mating population

$h_I^2$  = the estimate of heritability in the inbred population.

For example, in the Wernacre Premier line:  $F = .18$  and  $h_I^2$  for birth weight = .66 (paternal half-sib correlation).

$$\text{Thus, } \frac{(1-.18)h^2}{1-.18h^2} = .66$$

$$\text{so } .82h^2 = .66 - .12h^2$$

$$.94h^2 = .66$$

$$h^2 = .70$$

#### RESULTS AND DISCUSSION

The analyses of data indicated that age of calf, sex of calf and age of dam all had a considerable effect on the weaning weight of the calves in both of the inbred lines of Shorthorn cattle. The differences in the values of the correction factors between the Wernacre Premier line and the Mercury line justified resorting to separate inbred line analyses.

The pooled regression coefficient of weight on age (in days) was 1.79 pounds in the Wernacre Premier line and 1.21 pounds in the Mercury line. The difference of almost .6 pound per day of age resulted in the considerably larger size at weaning of the Wernacre Premier calves. The average actual weaning weight and the average age of the calf were 378 pounds and 187 days for the Wernacre Premier line and 339 pounds and 185 days for the Mercury line. However, the range in age within most of the years was considerable.

In the Wernacre Premier line, the extreme within-year range in weaning age was from 146 days to 217 days among only six observations in 1960. In 1959 the range in age among 19 calves in the Mercury line was 131 to 244 days. When the correction factor was applied the adjusted weight of the 131-day old calf was increased from 322 pounds to 388 pounds while the weight



of the 244-day old calf was reduced from 335 pounds to 262 pounds by the adjustment. Thus, a comparison of these two calves, ignoring their weaning age, would lead to false conclusions. While this was an exceptional example, the minimum range for any year was 20 days in the Mercury line and 25 days in the Wernacre Premier line, and in most years the range was about 50 days. In practice, within most herds the range in weaning age of calves is probably 60 to 90 days for any given year. Thus, it can be concluded that the age of the calf is an important factor affecting the weaning weight of the calf.

Using Searle's multiplicative factor method to adjust for sex of calf, 61 pounds were added to the heifers' weaning weight to equate it with the bulls' weaning weight in the Wernacre Premier line, while 18 pounds were added to the heifers' weight in the Mercury line. This showed there was over three times as much difference between the sexes in the Wernacre Premier line. The adjustment in the Mercury line agreed closely with that reported by Brinks et al. (2) and Koch and Clark (15), while the adjustment in the Wernacre Premier line fell within the range reported by Pahnish et al. (26).

Regarding adjusting for age of dam, the 8-year olds had the highest average calf age-corrected weaning weight of 432 pounds in the Wernacre Premier line. Using Searle's multiplicative factor method, the following constants were obtained for the other ages in comparison to the 8-year olds: 2-year olds, 153 pounds; 3-year olds, 72 pounds; 4-year olds, 80 pounds; 5-year olds, 55 pounds; 6-year olds, 53 pounds; 7-year olds, 25 pounds; 9-year olds, 33 pounds; 10-year olds, 65 pounds; 11-year olds, 69 pounds; 12-year olds, 59 pounds; and 13-year olds, 39 pounds.

In the Mercury line, all ages were corrected to the 9-year old dams, which had an average calf weaning weight of 384 pounds. The following constants were obtained: 2-year olds, 90 pounds; 3-year olds, 63 pounds; 4-year olds, 40 pounds; 5-year olds, 40 pounds; 6-year olds, 27 pounds; 7-year olds, 15 pounds; 8-year olds, 27 pounds; 10-year olds, 42 pounds; 11-year olds, 35 pounds; and 13-year olds, 5 pounds. There were no 12-year old dams in the Mercury line.

The above figures illustrate several facts. First, the trends in the two lines were approximately the same; namely, the very young dams produced the lightest calves, there was a gradual rise in production with a peak being reached during middle age and lastly, a gradual decline in production as the cows reached old age. The largest increase occurred between the 2 and 3-year olds. These results are in agreement with work reported by Marlowe and Gaines (24), Burgess *et al.* (4) and Sawyer *et al.* (30).

A comparison of the constants for both lines again illustrated the larger size and greater variation among the calves in the Wernacre Premier line. The failure of either line to follow the above mentioned trend more exactly can largely be attributed to chance, as a result of very few observations; e.g., there were only two calves by 13-year old dams in Wernacre Premier line and just four calves by 13-year old dams in the Mercury line.

An analysis of variance (Table 1)<sup>\*</sup> showed that the within-year effect of inbreeding of the calf on weaning weight was nonsignificant, but the year effect was highly significant in both lines. The explanation offered for this is simply that there was not a good distribution of observations among the five per cent inbreeding groups in most years, but rather a concentration in two or three groups as the degree of inbreeding within the lines gradually

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\* All tables appear in Appendix.

increased; e.g., in the Mercury line, all the observations in the first two years were in the 0 to 5 per cent group, while in the last year 17 of the 23 observations were in the 15 to 20 per cent group.

The within-year correlation between adjusted weaning weight and inbreeding of calf was negligible, being .08 in the Wernacre Premier line and .02 in the Mercury line. The within-year correlation of adjusted weaning weight and inbreeding of dam was also negligible, being -.06 in the Wernacre Premier line and .08 in the Mercury line. The reason for three of these four correlations being positive is attributed to chance, due to the small number of observations.

Due to the confounding of year effects with inbreeding effects, the effect of inbreeding on weaning weight can probably best be shown in this study by an examination of the yearly averages for weaning weight, inbreeding of calf and inbreeding of dam as listed in Table 2. A general trend of decreased weaning weight in conjunction with increased degree of inbreeding is evident in both lines. The notable exceptions of 1956 and 1957 are attributable largely to year effects; e.g., 1956 was a dry year, which would ordinarily cause an adverse effect on weaning weight. The level of inbreeding, especially that of the dam, was relatively low and this, together with the limited number of observations, must be taken into account in a consideration of the results.

Unfortunately, the attempt to determine the effect of the sire was found impractical due to its confounding with several other variables. Because so few sires were used (four Wernacre Premier bulls and six Mercury bulls) and never more than two per line in any year, sires could only rarely be compared on a within-year basis. They also could not be compared on a

between-year basis due to the confounding with year effects and inbreeding effects. In addition, the numbers of progeny for the sires were very unevenly distributed in both lines. A summary of the sire data is given in Tables 3 and 4. The confounding with degree of inbreeding is readily seen as the sires used in the first years of the study sired calves with the highest average weaning weight while the sires used in the later years produced calves with the lowest average weaning weight.

The significance of other pre-weaning traits was determined from analyses of variance and the relationship of these traits to each other was expressed as simple correlations. The analyses of variance in birth weights and average daily gains to weaning for the Wernacre Premier and Mercury lines are given in Table 5. For the Wernacre Premier line, the year effect on birth weight was nonsignificant, but for average daily gain from birth to weaning the year effect was highly significant. In the Mercury line, the year effect was highly significant for both traits. The within-year correlation between birth weight and average daily gain to weaning was highly significant and almost exactly the same for both lines, .33 and .34.

Similar analyses were made for birth weight and weaning weight (corrected for age of calf) as shown in Table 5. As already mentioned, the year effect on weaning weight was highly significant in both lines. The within-year correlation between birth weight and age-corrected weaning weight was also highly significant and very similar for both lines, being .51 (Wernacre Premier) and .47 (Mercury). Since birth weight is a part of weaning weight a significant correlation between the two traits is not surprising; however, correlations as high as these suggest that it might be

beneficial to practice some selection on the basis of birth weight.

Analyses of variance in actual weaning weights and weaning scores are presented in Table 7. The year effect on weaning score was highly significant in both lines. The within-year correlation of actual weaning weight and weaning score was again highly significant and fairly similar in the two lines, being .40 (Wernacre Premier) and .57 (Mercury). These results were approximately the same as the value of .42 found by Rollins and Wagnon (29), and may indicate a relationship between growth and type. It could indicate, if the largest calves were also the fattest, an association between condition and type score. This association probably exists.

Heritability estimates were calculated for birth weight, suckling gain, weaning weight and weaning score by quadrupling the paternal and maternal half-sib correlations. The analyses of variance are presented in Tables 8 through 11. These estimates of heritability were corrected for the degree of inbreeding as described by Lerner (22); however, due to the relatively low levels of inbreeding, especially in the Mercury line, the corrections were quite small. Also, corrections were not made for estimates above 1.0, the theoretical maximum. The following corrected heritability estimates were calculated:

<u>Line</u>	<u>Birth Weight</u>	
	<u>Paternal Half-sib</u>	<u>Maternal Half-sib</u>
Wernacre Premier	.70	1.2
Mercury	.12	1.3

<u>Line</u>	<u>Paternal Half-sib</u>	<u>Maternal Half-sib</u>
	<u>Suckling Gain</u>	
Wernacre Premier	1.3	.05
Mercury	1.6	0
	<u>Weaning Weight (age corrected)</u>	
Wernacre Premier	1.4	.23
Mercury	1.6	.30
	<u>Weaning Score</u>	
Wernacre Premier	.83	0
Mercury	.67	.10

The reason several of the heritability estimates were larger than 1.0 was undoubtedly attributable to the small numbers which allowed chance to be important. However, most of the other estimates agreed rather closely with those reported in the literature.

#### SUMMARY

A study of several of the factors that can affect the weaning weight of beef calves was made. The genetic and environmental variables studied included: (1) the degree of inbreeding of the calf and its dam, (2) the sex of the calf, (3) the sire, (4) the age of the dam, (5) the age of the calf, and (6) the year. Also, the correlations between various pre-weaning traits and heritability estimates of these traits were calculated.

The data analyzed in this study were obtained from two inbred lines of purebred Shorthorn beef cattle maintained at Kansas State University, which were established from different foundation stocks in 1949 and have been kept

as closed lines since that date. The Wernacre Premier line is in the fourth generation of inbreeding and the present generation is the third for the Mercury line. A total of 265 usable records were obtained, 98 in the Wernacre Premier line and 167 in the Mercury line, during the 11-year period 1950 through 1960. All analyses were conducted separately for the two inbred lines because the Wernacre Premier calves were significantly larger, heavier and more variable than the Mercury calves.

The analyses of data indicated that age of calf, sex of calf and age of dam all had a considerable effect on the weaning weight of the calves in these two inbred lines. The pooled regression coefficient of weight on age (in days) was 1.79 pounds in the Wernacre Premier line and 1.21 pounds in the Mercury line. The average calf weaning age was 187 days and 185 days in the Wernacre Premier and Mercury lines, respectively; however, the range in age within most years was approximately 50 days.

Searle's method of simplified herd level correction factors was used to adjust for sex of calf and age of dam. For sex of calf, 61 pounds and 18 pounds were added to the heifers' weaning weight in the Wernacre Premier and Mercury lines, respectively.

In adjusting for age of dam, the 8-year olds had the highest average calf age-corrected weaning weight of 432 pounds in the Wernacre Premier line. Using Searle's multiplicative factor, the following constants (in pounds) were obtained for the ages 2 through 13, in comparison to the 8-year olds: +153, +72, +80, +55, +53, +25, +33, +65, +69, +59, and +39. In the Mercury line, all ages were corrected to the 9-year olds, which had an average calf weaning weight of 384 pounds. The following constants (in pounds) were obtained for the ages 2 through 13, omitting 12-year olds: +90, +63,

+40, +40, +27, +15, +27, +42, +35 and +5.

An analysis of within line variance showed that the within-year effect of inbreeding of the calf was nonsignificant, but the year effect was highly significant in both lines. The within-year correlations between adjusted weaning weight and inbreeding of calf and inbreeding of dam were all negligible in both lines. However, an examination of the yearly averages for weaning weight, inbreeding of calf and inbreeding of dam clearly indicated a general trend of decreased weaning weight in conjunction with increased degree of inbreeding in both lines.

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The following within-year correlations were calculated for the Wernacre Premier line and the Mercury line, respectively: birth weight and average daily gain from birth to weaning, .33 and .34; birth weight and weaning weight (corrected for age of calf), .51 and .47; actual weaning weight and weaning score, .40 and .57. All of these correlations were highly significant.

Heritability estimates were calculated by quadrupling the paternal and maternal half-sib correlations, and were corrected for the degree of inbreeding in the two lines. The following corrected heritability estimates were calculated:



<u>Line</u>	<u>Paternal Half-sib</u>	<u>Maternal Half-sib</u>
	<u>Birth Weight</u>	
Wernacre Premier	.70	1.2
Mercury	.12	1.3
	<u>Suckling Gain</u>	
Wernacre Premier	1.3	.05
Mercury	1.6	0
	<u>Weaning Weight</u> (age corrected)	
Wernacre Premier	1.4	.23
Mercury	1.6	.30
	<u>Weaning Score</u>	
Wernacre Premier	.83	0
Mercury	.67	.10

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## APPENDIX

Table 1. Analysis of variance of weaning weights.

Source	d.f.	M.S.	F
<u>Wernacre Premier</u>			
Total	97	1869.03	
Years	9	6321.20	4.57**
Inbreeding groups within year	25	1383.49	0.97
Within	63	1422.82	
<u>Mercury</u>			
Total	166	1774.18	
Years	9	10971.18	8.61**
Inbreeding groups within year	25	1273.61	1.03
Within	132	1241.91	

\*\* Significant at .01 level.

Table 2. Yearly averages for weaning weight, inbreeding of calf and inbreeding of dam.

Year	n	Weaning weight (lbs.)	Inbreeding of calf (%)	Inbreeding of dam (%)
<u>Wernacre Premier</u>				
1950	21	496	10.28	0
1951	11	473	11.77	0
1952	14	471	16.28	4.97
1953	9	459	12.89	1.74
1954	6	440	18.63	6.89
1955	9	440	20.73	7.61
1956	8	500	25.51	8.06
1957	5	469	25.23	7.27
1959	9	426	28.36	18.47
1960	6	443	32.34	22.54
Grand averages		460	18.03	6.10
<u>Mercury</u>				
1951	14	424	0	0
1952	10	410	0	0
1953	13	400	3.22	0
1954	13	413	7.17	0
1955	18	385	11.66	0
1956	15	426	11.63	0.21
1957	25	416	11.92	2.73
1958	17	374	18.72	8.14
1959	19	363	19.34	7.49
1960	23	361	16.38	7.77
Grand averages		395	11.25	3.20



Table 3. Average adjusted weaning weights for calves by different sires in the Wernacre Premier line.

Year	Sires							
	#603		#033		#13		#637	
	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$
1950	21	496						
1951	11	473						
1952	7	472	7	471				
1953	8	463	1	430				
1954	3	443	3	438				
1955			7	446	2	422		
1956			8	500				
1957			2	487	3	457		
1959							9	426
1960							6	443
Totals	50	479	28	469	5	443	15	433

Table 4. Average adjusted weaning weights for calves by different sires in the Mercury line.

Year	Sires									
	$\frac{G454}{n \quad \bar{x}}$	$\frac{\#109}{n \quad \bar{x}}$	$\frac{\#25}{n \quad \bar{x}}$	$\frac{\#211}{n \quad \bar{x}}$	$\frac{\#623}{n \quad \bar{x}}$	$\frac{\#501}{n \quad \bar{x}}$				
1951	14	424								
1952	10	410								
1953	10	413	3	357						
1954	4	426	9	408						
1955			18	385						
1956			15	426						
1957			21	419	4	402				
1958			10	369			7	382		
1959			5	377			14	358		
1960			2	357					21	361
Totals	38	418	12	395	4	402	21	366	21	361

Table 5. Analysis of variance in birth weights and average daily gains to weaning.

Source	d.f.	Birth weight Mean square	Av. daily gain Mean square	Covariance $\sum xy$
<u>Wernacre Premier</u>				
Total	97	71.49	0.075	71.20
Years	9	35.00	0.241**	9.48
Within	88	75.22	0.058	61.72
<u>Mercury</u>				
Total	166	61.87	0.07	85.39
Years	9	147.68**	0.46**	-7.07
Within	157	56.95	0.05	92.46

\*\* Significant at .01.

Table 6. Within-line analysis of variance for birth weight and weaning weight (corrected for age of calf).

Source	d.f.	Weaning weight Mean square	Birth weight Mean square	Covariance $\sum xy$
<u>Wernacre Premier</u>				
Total	97	3065.37	71.49	21139.00
Years	9	9392.06**	35.00	2069.71
Within	88	2418.32	75.22	19069.29
<u>Mercury</u>				
Total	166	2485.09	61.87	24011.91
Years	9	12844.81**	147.68**	-126.16
Within	157	1891.22	56.95	24138.07

\*\* Significant at .01.

Table 7. Within-line analysis of variance for actual weaning weight and weaning score.

Source	d.f.	Actual Weaning weight Mean square	Weaning score Mean square	Covariance $\sum xy$
<u>Wernacre Premier</u>				
Total	97	3960.04	21.12	13926.43
Years	9	11700.23**	61.22**	5844.32
Within	88	3168.43	17.02	8082.11
<u>Mercury</u>				
Total	166	2571.24	23.77	24467.43
Years	9	7524.14**	80.71**	5010.37
Within	157	2287.31	20.51	19457.06

\*\* Significant at .01.

Table 8. Within-line analysis of variance of birth weight.

Source	d.f.	Sum of squares	Expected sum of squares
<u>Wernacre Premier</u>			
Total	99	7031.04	
Among sires	3	1051.28	$3E + K'D + K''S$
Among dams within sires	57	4479.94	$57E + KD$
Among full sibs	39	1499.82	39E
D = 24.89			K = 91.91
S = 12.43			K' = 5.65
E = 38.46			K'' = 63.98
<u>Mercury</u>			
Total	166	10270.81	
Among sires	5	553.70	$5D + K'D + K''S$
Among dams within sires	97	7094.83	$97E + KD$
Among full sibs	64	2625.28	64E
D = 19.79			K = 157.43
S = 1.67			K' = 7.35
E = 41.02			K'' = 121.93

Table 9. Within-line analysis of variance of age-corrected weaning weight.

Source	d.f.	Sum of squares	Expected sum of squares
<u>Wernacre Premier</u>			
Total	97	297340.80	
Among sires	3	80587.96	3E + K'D + K"S
Among dams within sires	57	137698.91	57E + KD
Among full sibs	37	79053.93	37E
D = 177.23			K = 89.79
S = 1181.16			K' = 5.74
E = 2136.59			K" = 61.94
<u>Mercury</u>			
Total	166	412524.32	5E + K'D + K"S
Among sires	5	145330.16	
Among dams within sires	97	173519.03	97E + KD
Among full sibs	64	93675.13	64E
D = 200.36			K = 157.43
S = 1119.82			K' = 7.35
E = 1463.67			K" = 121.93

Table 10. Within-line analysis of variance of age-corrected suckling gain.

Source	d.f.	Sum of squares	Expected sum of squares
<u>Wernacre Premier</u>			
Total	97	252498.50	
Among sires	3	67357.41	$3E + K'D + K''S$
Among dams within sires	57	113264.87	$57E + KD$
Among full sibs	37	71876.22	$37E$
D = 28.25			K = 89.79
S = 990.80			K' = 5.74
E = 1942.60			K'' = 61.94
<u>Mercury</u>			
Total	166	373908.32	
Among sires	5	126609.93	$5E + K'D + K''S$
Among dams within sires	97	146799.39	$97E + KD$
Among full sibs	64	100499.00	$64E$
D = -35.06			K = 157.43
S = 976.10			K' = 7.35
E = 1570.30			K'' = 121.93



Table 11. Within-line analysis of variance of weaning score.

Source	d.f.	Sum of squares	Expected sum of squares
<u>Wernacre Premier</u>			
Total	97	2049.06	
Among sires	3	328.92	$3E + K'D + K''S$
Among dams within sires	57	940.65	$57E + KD$
Among full sibs	37	779.49	$37E$
D = -2.88			K = 89.79
S = 4.56			K' = 5.75
E = 21.07			K'' = 61.94
<u>Mercury</u>			
Total	166	3946.31	
Among sires	5	588.95	$5E + K'D + K''S$
Among dams within sires	97	2052.81	$97E + KD$
Among full sibs	64	1304.55	$64E$
D = 0.48			K = 157.43
S = 3.96			K' = 7.35
E = 20.38			K'' = 121.93

SOME FACTORS AFFECTING WEANING WEIGHT  
IN AN INBRED SHORTHORN HERD

by

HARVEY ALLEN GOTTLIEB

B.S., Cornell University, 1960

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AN ABSTRACT OF A MASTER'S THESIS

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requirements for the degree

MASTER OF SCIENCE

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KANSAS STATE UNIVERSITY  
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1962

A study of several of the factors that can affect the weaning weight of beef calves was made. The genetic and environmental variables studied included: (1) the degree of inbreeding of the calf and its dam, (2) the sex of the calf, (3) the sire, (4) the age of the dam, (5) the age of the calf and (6) the year. Also, the correlations between various pre-weaning traits and heritability estimates of these traits were calculated.

The data analyzed in this study were obtained from two inbred lines of purebred Shorthorn beef cattle maintained at Kansas State University, which were established from different foundation stocks in 1949, and have been kept as closed lines since that date. The Wernacre Premier line is in the fourth generation of inbreeding and the present generation is the third for the Mercury line. A total of 265 usable records were obtained, 98 in the Wernacre Premier line and 167 in the Mercury line, during the 11-year period 1950 through 1960. All analyses were conducted separately for the two inbred lines because the Wernacre Premier calves were significantly larger, heavier and more variable than the Mercury calves.

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