EFFECTS OF INBREEDING

ON

POSTWEANING CATTLE PERFORMANCE

by
MICHAEL H. HALL

A.A., Modesto Junior College, 1970
B.S., California Polytechnic State University, 1973

A MASTER'S THESIS

Submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Science and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1975

Approved by:

Walter H. Smith
Major Professor

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

The author wishes to express sincere appreciation to Mr. Walter H. Smith, Major Professor, for his guidance and inspiration during the author's masters program. The author also expresses appreciation and special thanks to Dr. Robert R. Schalles for assistance and preparation of analysis of data and guidance through his graduate program.

Thanks is also expressed to Dr. Earl A. Farmer for serving on the graduate committee and reviewing the manuscript.

The author is indebted to Dr. George A. Milliken and Dr. E. K. Kemp for their generous assistance in statistical analysis and computer application.

To the members of the Staff and Graduate Students of the Department of Animal Science and Industry, Kansas State University, the author wishes to express appreciation for their assistance and fellowship.

Finally, I wish to thank my wife, Ann, for her encouragement, patient assistance and understanding throughout my graduate program. Also, a very special thanks to my parents, Mr. and Mrs. Donald M. Hall, for their continual support and encouragement.

INTRODUCTION

Breeders of all forms of domestic animals have long known that inbreeding depresses performance of most traits and causes a deterioration in vigor and health. Lethals and other undesirable traits appear more frequently when inbreeding is practiced. This is caused by an increased proportion of homozygous loci. Inbreeding is the mating of relatives. The two related partners have common ancestors and may have received from them some genes that are alike. This increase in homozygosity resulting from mating individuals that are more closely related than the average in the population to which they belong is measured by the coefficient of inbreeding that was derived by Wright (1921) as the correlation between uniting gametes. The major effect of inbreeding is to increase the probability that the two alleles at a particular locus in an individual are identical by descent.

Inbreeding has been known to have been practiced during the early days of civilization. The objective of this study is to describe the effects of inbreeding in cattle on various growth traits during the postweaning stage. The progressive cattleman can no longer be satisfied with adequate growth up to weaning. He must be striving to produce the most pounds in the cheapest manner up to a satisfactory, marketable weight and grade.

REVIEW OF LITERATURE

Records show that cattle were first domesticated in Europe and Asia during the New Stone Age. The beginning of breeds and animal breeding had its start with work done by Robert Bakewell in England during the late 1700's. Modern day genetics had its start in 1865 when the Austrian Monk, Gregory Mendel published his work on the inheritance of certain traits in plants.

The founders of present day breeds practiced inbreeding to hasten genetic purification and improve the breeds. Following the work to determine the genetic effect of inbreeding by Wright (1921), mendalian analysis was made of the purebreeds of livestock. Wright (1923), McPhee and Wright (1925) found intensive inbreeding had occurred in the development of Shorthorn cattle with a high relationship to the bull Favorite and in 1920 the coefficient of inbreeding was about 26%. Willham (1937) found inbreeding in Herefords to be 8.1% as of 1930, Stonaker (1943) reported 14.2% inbreeding for Angus in 1930. Warwick (1958) reported inbreeding had occurred in all the purebreeds of beef cattle during the formative stages with increases averaging under 1% per generation.

Wright (1922) defined the coefficient of inbreeding (F), as the correlation between gametes, or more closely that between their genic values. Malécot (1948) defined the coefficient of inbreeding in a simpler term as the probability that two genes at the same locus are identical by descent.

EVERY PAGE OF THIS BOOK HAS A MARK IN THE SAME SPOT CAUSED BY THE PRINTER USED ON THE ORIGINAL PRODUCTION.

THIS IS AS RECEIVED FROM CUSTOMER.

REVIEW OF LITERATURE

Records show that cattle were first domesticated in Europe and Asia during the New Stone Age. The beginning of breeds and animal breeding had its start with work done by Robert Bakewell in England during the late 1700's. Modern day genetics had its start in 1865 when the Austrian Monk, Gregory Mendel published his work on the inheritance of certain traits in plants.

The founders of present day breeds practiced inbreeding to hasten genetic purification and improve the breeds. Following the work to determine the genetic effect of inbreeding by Wright (1921), mendalian analysis was made of the purebreeds of livestock. Wright (1923), McPhee and Wright (1925) found intensive inbreeding had occurred in the development of Shorthorn cattle with a high relationship to the bull Favorite and in 1920 the coefficient of inbreeding was about 26%. Willham (1937) found inbreeding in Herefords to be 8.1% as of 1930, Stonaker (1943) reported 14.2% inbreeding for Angus in 1930. Warwick (1958) reported inbreeding had occurred in all the purebreeds of beef cattle during the formative stages with increases averaging under 1% per generation.

Wright (1922) defined the coefficient of inbreeding (F), as the correlation between gametes, or more closely that between their genic values. Malécot (1948) defined the coefficient of inbreeding in a simpler term as the probability that two genes at the same locus are identical by descent.

Although the growth rates of certain laboratory species are apparently little affected by inbreeding, the average effect of inbreeding is to depress growth rate. King (1919) in working with 2 lines of inbred rats for 25 generations found no inbreeding depression and in some cases inbred lines surpassed growth in the random bred control stock. Intense selection was given as a reason for this improvement. Bowman (1960) reported that after inbreeding of mice reached 81%, three lines were crossed and litters produced by the crossbred progeny were larger than the non-inbred control. Tantawy and Reeve (1956) investigated the relation between performance and inbreeding in Drosophila by inbreeding at different rates, mating full-sibs, half-sibs and double cousins. Their results indicate that depression of body size and egg number was larger at higher degrees of inbreeding than at lower levels. Tebb (1957) reported production decreased by one egg for each 1 percent increase in inbreeding in a closed line of chickens selected for egg production. Stephenson, et al (1953) reported inbreeding depression in performance was more rapid at low degrees of inbreeding (up to 0.25) than at higher degrees in a number of inbred chicken lines. In early phases of inbreeding, selection tended to eliminate those lines that respond most severely.

In working with Peppin Merinos, Doney (1957) found inbreeding without selection reduced body size. Treating inbred lambs with crude pituitary extracts increased growth rate to ten weeks of age. He suggested that the effect of inbreeding was due in part to a reduction in pituitary activity. Brown, et al (1961) reported all inbred lambs on test weighed less at 120 days and inbreeding of dam had less effect than inbreeding of the lamb.

Hayes (1919) in comparing inbred to crossbred matings found that mortality was higher and litter size smaller in inbreds than crossbred pigs. McPhee, et al. (1931) reported a strain of Poland China, inbred by brother-sister matings, failed in the second generation due to decreased fertility and high mortality. In the first generation of inbreeding, litter size did not significantly decrease, but by the second generation litter size was much reduced and vigor of the pigs greatly decreased. In comparing inbred sows to inbred boars in an outcross, Willham (1938) found pigs out of inbred dams by an outcross boar did not gain as other pigs until they were approximately 180 days of age. Comstok (1944) reported that litter size is much more difficult to maintain in inbred lines than is growth rate. In a project to compare performance of inbred lines and linecross litters with inbreeding ranging from 23 to 42 percent, Dickerson et al (1947) found for each 10 percent rise in inbreeding, independent of age and inbreeding of dam, the average decline in litter size was 0.2 pigs at birth, 0.4 pigs at 21 days and 0.5 pigs at 56 and 154 days. Hetzer (1950) in a similar study found comparable results. For each 10% increase in inbreeding, litter size declined 0.57 pigs at birth, 0.70 pigs at 21 and 0.71 pigs at 56 days and litter weight decreased by 1.0, 7.4, and 26.5 pounds at these ages. Chambers and Whatley (1950) reported from weaning to 225 pounds, single cross pigs fed in dry lot gained .03 of a pound per day more and required six pounds less feed per 100 pounds gain than did the inbreds. No over-all significant mean differences were found by Durham et al (1952) between mating systems in size of litters farrowed, weaned, alive at 5 months of age, or in percentage viability from birth to 5 months.

Craft (1953) concluded lines generally became differated genetically in respect to performance characters when inbred 25 to 35 percent. Litter size had shown some decline by the time inbreeding reached 25 to 35 percent. Growth rates declined in most lines, while economy of gain showed improvement. Apparently economy of gain is affected less by inbreeding than are litter size and growth rate.

Dickerson et al (1954) reported selection favored less inbred pigs and dams, with 8 to 12 percent of the variance in total performance being due to variation in level of inbreeding between lines. Bradford et al (1958) found an increase of 10% in litter inbreeding resulted in decreases of approximately 0.2 pigs farrowed per litter, .45 pigs raised per litter, 6 lb. in individual pig weight at 5 months and 75 lb. in total litter weight at this age. The selection practiced for performance traits, adjusting for inbreeding effect apparently was ineffective.

Bartlett et al (1939), (1942), (1944) studied height at withers, body weight, and heart girth of Holstein heifers with coefficients of inbreeding ranging from 0 percent to over 20 percent. He concluded that cattle could be inbred without decreasing weight or size, provided inbreeding did not rise above 20 percent. More highly inbred females developed normally to about the first calving, then development became abnormal. Baker et al (1945) determined at one percent increase in inbreeding, height at withers decreased 0.0859 cm., body weight decreased 0.1235 lb. and heart girth decreased by 0.0303 cm. Margolian and Bartlett (1945) found Holstein dairy cattle could be inbred without causing a decrease in body weight or size at any stage, from birth to maturity provided inbreeding did not exceed 20%. Females inbred greater than 0.20 developed normally to approximately first calving age but showed abnormal development thereafter.

Woodward and Graves (1946) found inbreeding depressed birth weights, retarded growth, increased mortality, and reduced the size, vigor, and production of cows. The harmful effects became apparent when inbreeding exceeded 25 percent. The average effect of inbreeding declined as age increased to 24 months.

Rollins et al (1949) reported inbreeding in Jerseys had its greatest effect at 6 months with an increase of one percent in inbreeding causing a decrease of 0.47 percent in mean weight, 0.15 percent in mean heart girth, and 0.16 percent in mean height. At 4½ years the decrease was 0.10 percent in mean weight, 0.01 percent in mean heart girth, and 0.01 percent in mean height. Tyler et al (1949) in a study of the effects of inbreeding on body measurements and milk production found only heart girth measurement to be significantly depressed. Inbreeding caused a significant average decrease of 74 lb. of milk and 2.3 lb. of butterfat for each one percent increase in inbreeding.

Nelson and Lush found inbreeding slows the rate of growth at early ages but permits rapid growth to continue longer, so that mature size is not decreased and may be increased in dairy cattle. Hawk et al (1954) found inbreeding delayed age at puberty and retarded calfhood growth significantly. A highly significant negative correlation was found between age at puberty and weight at 3 or 6 months of age with level of inbreeding.

Laben et al (1954) using a pooled intra-sire regression coefficients of production on inbreeding found significant declines of -209.8 lb. of milk, -4.9 lb. of butterfat, and -131.0 lb. of fat corrected milk in dairy cattle. A significant .008% increase in butterfat test per degree increase in inbreeding was found to accompany the decline in milk yield. Von Krosigk and Lush (1958) also using an intra-sire regression analysis found -1.74 ± 0.57 lb. of butterfat, -54 ± 17 lb. of milk, and 0.003% of butterfat for each percent increase in inbreeding. Mi et al (1965) reported differences between outbreds and inbreds of 1,313 lb. actual milk, 35 lb. actual fat, 1,761 lb. mature equivalent fat, and 48 lb. first lactation milk in favor of outbreds.

Sutherland and Lush (1962) concluded that a one year-old animal with 12½% inbreeding could be expected to average 22 lb. lighter, 1.2 cm. lower wither height, 0.8 cm. shallower chest, 1.5 cm. shorter body length, 3.3 cm. less heart girth, 1.3 cm. less paunch girth, and about 1/9th of a class lower in type rating. Voelker and Tucker (1965) reported the effect of inbreeding on growth at 3, 6, 12, 18, 27, and 63 months of age. Regressions of body weight on percent inbreeding at the respective ages in the females were -.20, -1.06, -1.68, -3.06, -3.93, -3.56, and -9.52 lb. Wither height and heart girth had a lower negative correlation with inbreeding than body weight. Calf mortality was higher in the higher inbreds (25.8% loss) compared to the outbreds (10.8% loss) and lower level inbreds (15.8% loss).

In a small closed Guernsey herd with inbreeding as high as 34% and an average of 6.4%, Hillers and Freeman (1964) found the intra-sire regressions of production per percent of inbreeding were -36 and -51 lb.

.of milk, -1.7 and -2.3 lb. of milk fat, and .001 and .002 % test. The regressions of weight in pounds on percent inbreeding were -0.3 at birth, -0.7 at six months, -1.5 at one year, -1.9 at two years, -1.4 at three years, -4.5 at four years, and -3.2 at five years.

Cupps and Laben (1965) using calves that average 25% inbred found mortality of 38% was nearly double mortality of outbred calves. The unthrifty surviving calves showed a decreased growth rate, low fertility, and delayed development of male secondary sex characters.

Young *et al* (1969) reported inbreeding of dairy cattle in the North Central Region depressed milk production by an average of 50 lbs. and 1.5 pounds of fat per .01 increase in inbreeding. Weights at birth, 6, 12, 24, 36, and 48 months were reduced by approximately 0.25, 1.0, 1.5, 3.0, and 5.0 pounds, respectively, per .01 increase in inbreeding. No effect of inbreeding was found on mature weights. Inbreeding resulted in reduced conception to first service, more services per conception, and delayed puberty.

Dayton (1969) reported the rate of growth of inbred Jerseys was slower than non-inbreds from birth to 18 months but tended to increase after 18 months. Intra-sire regressions, using the average of each cow's records, were -.75 ± .74 lbs. of fat, -21 ± 13 pounds of milk and .005 ± .004% milk fat for each increase of one percent in inbreeding.

Burgess *et al* (1954) found weaning weight of Hereford calves decreased by 1.75 per one percent inbreeding of calf and 1.15 per one percent inbreeding of dam. Significant effects on weaning weights were attributed to inbreeding, sex, and age, and should be considered in comparing calves, dams, and sires.

Amestin (1957), Gootileb (1962), and Akinokun (1968), working with Shorthorns, reported inbreeding was significantly negatively correlated with feed efficiency. As inbreeding of calf increased by 1%, gain on test and final type score decreased by 1.17 lb. and 0.02 points, respectively. A one percent increase in inbreeding of dam increased gain on test by 0.73, while it did not have significant effect on final type score in the post weaning study. Krishna (1973) working with Shorthorns in Kansas had an average annual inbreeding coefficient of calves range from 0 to 38% with an average of 15.4% at a rate of 1.0% increase per year. Inbreeding did not significantly depress performance, but was negatively correlated. Partial regression coefficient of inbreeding of calf revealed 1% increase in inbreeding of calf reduced weaning weight by 0.2 and 3.1%, preweaning ADG by 1.3 and 3.8% and weaning type score by 1.5 and 2.5% in non-repeat and repeat mating data sets respectively. One percent increase in inbreeding of dam caused a decline of 0.2, 1.1, 0.9, and 1.7% in calf birth weight, pre-weaning ADG, weaning weight and weaning type score respectively.

Cundiff (1968) reported performance in most economically important traits declined with inbreeding. Fertility and mothering ability showed the greatest decline, while the effects of inbreeding on growth and carcass characteristics were less severe in beef cattle.

Krehbiel (1969) found significant partial linear regressions of fertility on inbreeding of mating, cow and service sire, but some reduction in fertility could be expected in certain lines and an overall reduction with increased inbreeding. Scarsi (1971) found the effects of inbreeding, calculated from several divergent genetic populations, did not accurately estimate the effects for individual lines. The combination of inbreeding with selection can yield positive improvement for growth in beef.

Dinkel et al (1972) reported fertility of non-inbred cattle averaged 0.08 (P<.005) more calves per mating than the inbred and 0.07 (P<.10) difference in livability in favor of the non-inbred calves. Results indicate that rather intense inbreeding could be practiced so long as reproduction was satisfactory.

The intensity and effectiveness of selection for several economic traits in a closed Hereford line under a breeding system that combined mild inbreeding and selection was studied by Brinks et al (1965). The inbreeding averaged 16.1% over the entire period. Increased inbreeding had a detrimental effect on weights, gains and body scores from birth through maturity. The effect on weight reached a peak at 18 months of age in heifers and declined somewhat at mature weights. Final weight off test (12 to 13 months) was affected more by increased inbreeding than earlier weights of bulls. Increases in inbreeding of dam had detrimental effects on growth from birth to weaning and on weight, presumably through decreased milk production. This effect was completely compensated for at the 18-month weight in both sexes. There was a differential response to inbreeding by sex of calf and inbreeding of dam in weanling traits. Inbreeding of calf had a more pronounced effect upon females, whereas inbreeding of dam affected the bulls greater. Bulls, having a greater growth potential, maybe held back more than heifers by decreased milk supply of their inbred dams.

Reproduction, growth, feed utilization and grades were compared for inbred and outbred Hereford cattle by Stonaker (1954). The inbreds averaged 30% for the calves and 20% for the cows. Outbred matings exceeded inbred matings 30% in number of calves raised to weaning and 18% in average weaning weights. On 112 day postweaning test outbred bulls significantly exceeded inbreds 14% in yearling grade, 7% in final weight, and 3% in daily gain, but required 3% more feed per pound of gain.

Alexander and Bogart (1961) showed inbreeding of calf to have a significant depressing effect on suckling gain of beef calves but not on postweaning rate of gain and feed efficiency. The failure of inbreeding to depress postweaning performance was considered to be due to the compensation of selection for the expected inbreeding depression.

Inbreeding results reported by Swiger (1961) differed at the Fort Robinson and Lincoln, Neb. stations. Inbreeding coefficients varied between the two stations for the calves and dams; at Lincoln 0.13 and 0.10 and at Fort Robinson average 0.05 and 0.03, respectively. In general, calves with higher than average inbreeding coefficients were below average in performance. The effect of inbreeding of the dam was negative for all traits at Lincoln, but positive for most traits at Fort Robinson. Generally increased inbreeding lead to decreased feed consumption and growth rate.

Flower et al (1963) reported comparisons between linecross Herefords and the mean of the parental inbred lines results indicated an average hybrid advantage of 0.1, 4.6, 4.3 and 4.7% for birth weight, weaning weight, postweaning average daily gain, and final weight, respectively.

Hoornbeck and Bogart (1966) published histograms showing that low levels of inbreeding in Herefords and Angus were associated with higher preweaning performance and low postweaning performance, with the opposite being true for higher levels of inbreeding. As inbreeding increased, postweaning performance declined. Heterozygous state at certain loci may have been the object of selection during the postweaning growing period. If this were true, then higher levels of inbreeding would have fixed some of these loci in the homozygous state and resulted in decreased performance.

Dinkel et al (1968) reported inbreeding of calf and inbreeding of dam effects appeared to be more important on weaning traits than on postweaning traits, although significant linear and quadratic effects of inbreeding were found at both ages. The lack of significant inbreeding effect on postweaning average daily gain for both sexes indicated that the effect on growth must be restricted to the preweaning growth period, and the effects of final weight are a carryover from the preweaning period.

Harwin (1963) stated that inbreeding regressions indicated inbreeding of dam had a greater effect on calf weight than inbreeding of calf in Hereford cattle. Relatively high correlation (r=.60) was evident between yearling weight and weaning weight. Inbreeding effect was not significant for any of the postweaning traits, but yearling weight declined from approximately 40 lbs. above the mean at the 15% inbreeding to approximately 20 lbs. below the mean at 40% inbreeding. Yearling daily gain decreased approximately .16 lbs. with an increase in inbreeding of calf from 15-50%.

The effect of inbreeding on the individual diminished with increasing age up to 3½ years.

Data from 48 inbred lines from 10 experiment stations located in eight western states participating in the W-1 Regional Beef Cattle Breeding Project were analyzed and reported by Brinks, et al (1975). The average inbreeding per line were 13.9 percent for sires, 12.2 percent for dams, and 18.5 percent for calves. Large variation was present among stations and lines. Traits studied were divided into fitness traits and growth traits. Increased inbreeding of calf had a greater effect than inbreeding of dam for all fitness traits except percent open cows. A partial regression of traits on inbreeding of calf were .1287, .0045, .0775, .0825, .1645 for percent open, percent aborted, percent dead at birth, percent that died between birth and weaning, and percent weaned, respectively. Corresponding regressions on inbreeding of dam were: .2094, .0081, .0255, .0734, and -.1070. Increased inbreeding of calf had a detrimental effect for all growth traits when only the linear effect of inbreeding was considered. Partial regression coefficients for bulls of traits on inbreeding in pounds per percent inbreeding were -.0934, -.0027, -.6370, -.4574, -.0035, -.9687 for birth weight, preweaning daily gain, weaning weight, initial test weight, test daily gain, and final weight, respectively. Corresponding values for females were -.0661, -.003, -.6715, -.1283, -.0033, -.555. Increased inbreeding of dam had a detrimental effect for all the traits in the males, and in all but birth weight and post-weaning growth in female calves. The partial regression coefficients for males corresponding traits previously listed were: -.170, 0.005, -.881, -.417, -.002, -.678. For females the coefficients were: .002, -.002, -.529, -.012, .002, and 2.95. A postweaning analysis revealed that a detrimental preweaning effect was compensated for in postweaning daily gain in which 64 percent of the partial regression in males and 70 percent in females were favorable from the reporting stations.

MATERIALS AND METHODS

The Shorthorn beef cattle inbreeding project was established with a base population of 39 cows at Kansas State University in 1949. Inbreeding was initiated in 1949 in the Wernacre Premier line and in 1952 in the Mercury line, and has been continued in both lines by half-sibbing. Preweaning performance of 506 calves born between 1950 and 1967 were used. Postweaning test average daily gain (ADG), weight per day of age (WDA), kg. of TDN (total digestible nutrients) per kg. of gain, and final type score (yearling score) following a 182-day test were evaluated. Twenty sires were used over the eighteen year period.

The Wernacre Premier line produced 149 calves with average inbreeding coefficients of 22.5 for bulls and 23.0 for heifers. The sires and dams in the Premier line had coefficients averaging 17.7 and 14.7, respectively. The Mercury line produced 304 calves and had average inbreeding coefficients of 13.7 for bulls, 13.8 for heifers, 5.9 for sires and 7.0 for dams. There were 53 line cross calves analyzed in the study.

The females in the project produced calves in the spring and early summer as a result of pasture breeding. Calves were weighed at birth and allowed to suckle without creep. All calves were weaned, weighed and scored for conformation at approximately 182 days of age. After a three week weaning period, the calves were weighed again and placed in an individual feeding trial. The full-feed ration for bulls and steers consisted of 75 percent cracked corn and 25 percent chopped alfalfa hay. The heifers received 55 percent corn and 45 percent chopped alfalfa hay. All calves were again weighed and scored after the 182 day test. Selection in the herd was based primarily on weight per days of age and conformation score following the test.

Until 1957 approximately a random half of the males in each calving season were castrated and fed as steers; thereafter none were castrated.

Feed efficiency was determined by calculating the kg. of TDN (Morrison, 1962) required per kg. of gain on test. Final type score was the conformation grade as determined by visual observation at the end of test. A seventeen point scoring system (Marlow, Kincaid and Litton, 1958) was used in the analysis. Conformation was scored by the same individual throughout the 18 year period.

In a closed herd inbreeding increases as the years increase; therefore, inbreeding and year, or systematic environmental effects, are confounded. The genetic variance within a full-sib group shifts proportionately to between matings with increased inbreeding. In a completely inbred population there will be no genetic variation within a full sib group. Because this phenomenon tended to bias environmental effects, the matrix of within mating type relationships was used in a weighted analysis to unconfound the environmental and inbreeding effects (Bement et al 1974). The records of 311 calves from repeat matings produced 117 full sib groups and were analyzed using the weighted analysis. Repeat matings span 2 to 8 years.

The independent variables consisted of line, sex, cow age, calf birth year, inbreeding of cow, inbreeding of calf, test at at the beginning of test and initial weight on test. Line Crosses were considered as a third line. Age of cow was divided into 5 discrete groups as follows: 2 years or less, 3, 4, 5-10, and over 10 years. Test age and initial weight at the start of test were used as covariants. The inbreeding of dam and calf were calculated by means of covariance charts as described by Wright (1922). The inbreeding coefficients were in the model as linear and quadratic effects. Quadratic effects were later withdrawn from the model, since they had non-significant effect. Constants were fitted by least square analysis using multiple classification model with regression and unequal subclasses (Kemp, 1972).

Selection differentials were calculated using phenotypic as deviations from the mean of contemporaries and accumulated over generations.

Phenotypic change was calculated using no correction for environment or genetic change. Environmental deviations were arrived from differences between individuals within repeat matings (intra-block analysis). Change due to selection was obtained from least squares means after adjusting for environmental and inbreeding effects. Partial least square regression coefficients of inbreeding of calf and average inbreeding per year were obtained.

RESULTS AND DISCUSSION

Progeny in this study had average inbreeding coefficients of 0.158 ± .009. The Wernacre Premier line was started a year preceeding the Mercury line and thus had higher levels of inbreeding of calves. Wernacre Premier calves had average inbreeding of 22.8%, while the Mercury line averaged 13.8% inbreeding (Table 1). The average inbreeding coefficients of sires and dams was 11.8% and 10.9% respectively.

Inbreeding increased at a rate of .731% per year for the Wernacre line and 1.252% for the Mercury line. This was a 3.4% and 5.6% inbreeding increase per generation of the Wernacre and Mercury lines respectively. Brinks et al (1965) reported an increase in inbreeding of little under 1% per year in Montana. Brinks et al (1975) summarized the overall average inbreeding increase of 2.1% per year for all lines of the reporting stations in the W-1 breeding project.

Intensity of selection was measured as percent calves saved and added to the breeding herd. An average of 13.74% of the bull and 57.25% of the heifers were selected. Selected progeny were .7% less inbred in the Wernacre line and .5% more inbred in the Mercury line. Selected bull and heifer calves were .006 and .008 less inbred than the average of the population. Selected calves came from cows .6 and 2.7% more inbred than the average in Wernacre and Mercury lines, respectively. Thus, a calf that was less intensely inbred coming from a more intensely inbred mother and which weighed and scored better after post-weaning test had a better chance of being selected. Hoornbeck and

Bogart (1966) concluded that the heterozygous state at certain loci was the object of selection during the postweaning growing period. Brinks et al (1965) found the same results in a study of Montana Herefords.

Accumulated selection differentials were calculated for each trait as within year deviation of selected calves from the average of the total calf crop of that year plus the average selection differential of the parent. Bulls had a higher selection differential compared to heifers in all traits because of a higher selection intensity. Selected bulls had accumulated selection differentials of 144 g. TDN/gain, 2.36 pt. score, 149 g. ADG, and 199 g. WDA, while heifer calves had 33 g., 1.97 pt., 55 g., 104 g. selection differentials for the same growth traits (Table 2). Regression analysis of selection differentials revealed a 9.9 and 2.1 g. increase in TDN/gain per year of bulls and heifers. The same regression analysis showed selection differentials of bulls and heifers increased 0.004 and 0.165 pt. score, 4.3 and 13.3 g. ADG, 12.0 and 9.9 g. WDA per year. Bull calves had higher selection differentials for all four traits, but the selection differential of the heifer calves was increasing more rapidly for the traits through the 18 year period. Regression lines of heifers and bulls are given in Figures 1-4.

Wernacre calves had 31 g. heavier WDA ($P<.003$) and gained 31 g. faster per day on test than the Mercury calves. The Mercury calves scored 1.64 points higher ($P<.001$) than Wernacre calves. No difference was found between the lines in TDN/gain.

Less than one percent heterosis was found in postweaning traits studied. Flower _et al_ (1963) found a hybrid advantage in final weight of 4.7% in Hereford range cattle. Studying inbred and outbred Hereford cattle, Stonaker (1954) found outbred bulls exceeded inbreds 14% in yearling grade, 7% in final weight, and 3% in daily gain, but required 3% more feed per pound of gain in a postweaning test.

No significant age of dam effects were found for postweaning growth traits. There was some increased gain and conformation score for those calves from younger dams and cows over 10 years age. This might have been a compensatory effect from the slightly inferior weaning weight. Krishna (1973) working with the same group of calves found cows between the ages of 5 and 9 years, weaning calves 6.1% heavier which grew 7.5% faster in the preweaning than the average. Swiger _et al_ (1963) in evaluating postweaning gain in beef concluded that age of dam had no appreciable effect on postweaning gain or score. Factors influencing postweaning growth traits and their least square means are given in Appendix table A.

Brinks _et al_ (1975) reported the results from the W-1 inbreeding studies and noted an inbreeding depression of -.0035 lb. for test daily gain and -.9687 lb. for final weight per percent inbreeding of bulls and -.0033 lb. and -.5548 lb. for heifers. He also found a compensating postweaning gain for a low preweaning effect. Alexander and Bogart (1961) found inbreeding of calf had a significant depressing effect on suckling gain but not on postweaning rate of gain and efficiency. Hoornbeck and Bogart (1966) concluded that zero and low levels of inbreeding were associated with higher preweaning performance and low postweaning performance, with the opposite being true for higher levels of inbreeding. In the present study, partial regression coefficients of inbreeding of calf on TDN/gain was a non-significant 0.009 kg. per 10% inbreeding. Inbreeding depression was -.350 pt. for score ($P<.002$) and -.014 kg. for WDA ($P<.005$) per 10% increase in inbreeding. Test ADG showed depression of -.016 kg. ($P<.054$) per 10% inbreeding. The quadratic term of inbreeding of calf was non-significant.

Inbreeding of cow had a non-significant effect on postweaning performance as well as the quadratic term of inbreeding of cow. The estimates of regression coefficients for both inbreeding of calf and dam are presented in Table 5.

The observed phenotypic variance is composed of a variance caused by different genotypes of individual animals and by various environmental influences. Yearly phenotypic changes are presented in Tables 2-3. These estimates are phenotypic changes since cycles of selection generation and inbreeding also advance with years. Estimates of phenotypic changes between years were highly significant in all post-weaning traits. A regression analysis upon year showed an 11.567 g., 0.018 pt., 2.807 g., and 0.474 g. increase per year in TDN/gain, score, ADG, WDA respectively.

Environmental changes in the population were obtained as average deviation among years within full-sib groups weighted by the level of inbreeding and relationship among full sibs. A least square regression analysis showed -.094 kg. and -.142 kg. depression per year upon TDN/gain and yearling score, while ADG and WDA exhibited an 0.061 kg. and 0.005 kg. increase per year. Feed efficiency (TDN/gain), ADG and WDA increased because of environmental effects through the 18 year period, while yearling score decreased (Figure 5).

Genetic change through selection was calculated as the deviation between phenotypic change and environmental change, holding inbreeding at zero, and would include genetic drift. Effective population size was calculated to be approximately 7.5 per year (Gowe et al 1959). Genetic change through selection between years was highly significant for all postweaning traits studied. Rate of genetic change per year due to selection was 0.055 kg. TDN/gain, 0.208 pt. score, -.022 kg. ADG, -.0007 kg. WDA. Yearling score had genetic improvement, while the other three traits deteriorated genetically.

SUMMARY

The Shorthorn cattle breeding project was started with the Wernacre Premier line in 1949 and the Mercury line in 1950. Three hundred eleven calves of 117 repeat matings were used in the matrix of within mating type relationship in a weighted analysis to determine environmental effects. Environment was shown to have an annual depressing effect upon yearling score of -.142 points, while TDN/gain, ADG on postweaning test and WDA exhibited a -.094 kg., 0.061 kg. and 0.005 kg. improvement per year, respectively. Average inbreeding coefficients of calves range from 0 to 38% with an 18 year average of 15.8% and a rate of 1% increase per year or 4.5% per generation. There was a significant line difference with the Wernacre Premier line having higher ADG and WDA, while the Mercury line scored higher on the postweaning test. There was little heterosis effect for any of the postweaning traits.

The average selection intensity of bull and heifer calves were 13.74 and 57.25% respectively. Bull calves had higher selection differentials for all four traits, but the selection differentials of the heifer calves were increasing at a higher rate through the 18 year period. Selected bull and heifer calves were .6 and .8% less inbred than the population average, and came from 2.1 and .4% more inbred cows than the population average. A male or female calf that was less inbred coming from a more inbred dam and which weighed and scored better after postweaning test had a better change of being selected.

Inbreeding of calf had a significant depressing effect on yearling score and WDA and test ADG. Partial regression coefficient of inbreeding

of calf revealed 10% increase in inbreeding of calf reduced yearling score by -.350 pt., WDA by -.014 kg., and test ADG by -.016 kg. Inbreeding of calf showed a non-significant depressing effect on TDN/gain. Inbreeding effect of cow was non-significant for all traits. The quadratic term for both the effects for inbreeding of calf and dam were non-significant.

CONCLUSION

The results of this study are in general agreement with previous reports. Increased inbreeding is detrimental to performance in postweaning growth traits. Even though inbreeding effect of calf showed a significant depressing effect for yearling score, test ADG and WDA, growth depression was very minor. Inbreeding of dam had no significant effect for any of the traits studied. However, a slight compensatory increase in test ADG and WDA was evident.

From an observational standpoint, inbred lines can be developed and maintained without detrimental effects of observed fitness traits. Even though inbreeding depresses postweaning growth rate, the depressing effect does not appear to be prohibitive if the use of inbred lines of mild levels of inbreeding is warranted in the production of seed stock in beef cattle.

TABLE 1. AVERAGE LEVELS OF INBREEDING OF PARENTS AND PROGENY[a]

	WERNACRE LINE					MERCURY LINE				
	Parents		Progeny			Parents		Progeny		
Year	Sire	Dam	Bulls	Heifers	No. of Calves	Sire	Dam	Bulls	Heifers	No. of Calves
Mean	17.7	14.7	22.5	23.0	8.3	5.9	7.0	13.7	13.8	17.9
1950	0	0	9.9	14.9	20	--	--	--	--	--
1951	0	0	12.1	11.9	11	0	0	0	0	14
1952	0	0	11.2	17.2	14	0	0	0	0	10
1953	7.0	7.8	24.6	12.9	6	0	0	6.8	2.4	13
1954	--	--	--	--	6	0	0	8.3	6.1	13
1955	14.9	4.7	32.0	19.6	9	0	0	9.6	11.5	18
1956	14.9	10.2	23.7	22.9	8	0	0	14.6	10.8	15
1957	14.9	5.0	11.5	29.2	5	0	5.0	11.8	12.1	26
1958	32.0	--	--	--	--	5.9	8.2	16.3	21.2	17
1959	32.0	19.1	29.2	32.0	9	13.8	7.8	19.3	20.6	17
1960	32.0	22.0	--	31.4	6	5.8	7.6	16.3	16.2	23
1961	32.0	19.0	21.8	30.7	8	7.5	8.5	15.6	16.6	15
1962	12.3	21.2	19.6	20.2	5	9.3	12.4	17.5	17.2	25
1963	30.4	32.2	37.4	37.7	8	10.3	12.3	18.9	17.1	24
1964	18.7	29.6	27.4	25.9	6	10.5	13.2	17.9	22.7	23
1965	18.7	21.3	23.1	17.6	10	11.0	13.3	19.8	17.0	16
1966	18.8	24.4	27.1	17.6	11	11.8	12.7	20.2	19.1	17
1967	22.8	18.9	20.9	26.5	7	14.6	18.2	20.5	23.2	18
			No. of bull calves		73					155
			No. of heifer calves		76					149

[a]Values of inbreeding coefficients are percentages
Steers were not included in inbreeding values

TABLE 2. ACCUMULATED SELECTION DIFFERENTIALS

Year	Percent Saved		TDN/Gain (kg.)		Yearling Score (pt.)		ADG (kg.)		WDA (kg.)	
	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers
Mean	13.74	57.25	.144	.033	2.355	1.966	.149	.055	.199	.104
1950	14.3	62.5	.212	-.102	3.412	.999	.341	-.001	.336	.054
1951	50	31.3	.305	.013	1.901	.345	.054	-.034	.038	.027
1952	33.3	50	.033	-.005	2.082	.916	.158	-.011	.015	-.020
1953	0	63.6	--	-.057	--	-.544	--	.095	--	.194
1954	0	100	--	.054	--	1.188	--	-.147	--	.062
1955	20	75	-.054	.079	2.244	1.959	-.035	.061	.125	.114
1956	40	84.6	.050	.088	2.856	1.708	.251	.029	.212	.062
1957	16.7	68.8	.092	.045	1.540	1.190	.079	-.071	.094	.012
1958	0	61.5	--	.069	--	2.391	--	.067	--	.063
1959	5.9	38.5	.089	.219	2.328	3.946	-.052	.098	.050	.097
1960	0	100	--	.078	--	1.336	--	.031	--	.077
1961	14.3	43.8	-.124	-.098	2.607	2.030	.160	.065	.320	.119
1962	11.8	52.9	.034	.141	1.945	1.392	.212	.024	.363	.096
1963	5.6	12.5	.298	-.124	1.171	6.101	-.147	.021	-.024	.074
1964	11.8	37.5	-.037	.253	2.219	2.250	.236	.048	.258	.141
1965	5.6	53.8	.084	-.021	4.324	3.197	.066	.105	.063	.150
1966	6.3	47.1	.393	.125	.018	3.387	.518	.328	.537	.315
1967	11.8	47.1	.638	.163	4.316	1.591	.243	.280	.399	.240

TABLE 3. PHENOTYPIC, ENVIRONMENTAL AND GENETIC CHANGES IN TDN/GAIN AND YEARLING SCORE
Least Square Means

	TDN/GAIN (g.)				YEARLING SCORE			
	Phenotypic[a]	Environmental	Genetic Change		Phenotypic[a]	Environmental	Genetic Change	
Year	Change	Change	Selection	Inbreeding	Change	Change	Selection	Inbreeding
Mean	-1.333	1.722	1.50	11.22	.001	0	.0005	-.446
1950	197	797	-567	2	.546	2.561	-2.465	-.081
1951	345	848	-501	1	-1.021	.905	-2.437	-.060
1952	-99	225	-316	2	-.034	1.347	-1.861	-.095
1953	-190	141	-346	5	-1.157	-.371	-1.086	-.179
1954	-150	238	-399	7	.056	.456	-.585	-.291
1955	-186	-50	-136	10	.342	-.608	.181	-.396
1956	-192	-86	-120	11	.499	.979	-.478	-.452
1957	-45	-112	58	10	.326	-.103	.401	-.385
1958	-115	-254	137	13	.386	.175	.309	-.494
1959	-69	-320	249	15	.289	-.403	.882	-.613
1960	-311	-397	94	14	.178	-.099	.405	-.554
1961	-108	-270	158	15	.669	.027	.854	-.596
1962	0	-103	117	15	.110	-.478	.752	-.568
1963	13	-289	315	17	.006	-.279	.500	-.673
1964	45	-191	243	17	-.586	-1.214	.911	-.680
1965	2	-177	198	15	-.313	-1.330	1.191	-.592
1966	433	63	366	17	.385	-.456	1.154	-.666
1967	406	-32	477	16	.012	-1.108	1.381	-.648

[a] Model included line, year born, sex of calf
[b] Obtained from weighted analysis of repeat mating progeny

TABLE 4. PHENOTYPIC, ENVIRONMENTAL AND GENETIC CHANGES IN TEST ADG AND WDA
Least Square Means

	TEST ADG (g.)				WDA (g.)			
	Phenotypic[a]	Environmental	Genetic Change		Phenotypic[a]	Environmental	Genetic Change	
Year	Change	Change	Selection	Inbreeding	Change	Change	Selection	Inbreeding
Mean	.222	-6	4	-20.39	.5	2.5	.111	-18.11
1950	-24	-178	151	-4	-8	24	-49	-3
1951	-69	-278	197	-3	-26	-35	-28	-2
1952	-29	-205	163	-5	-10	-63	8	-4
1953	-20	-181	163	-8	-6	7	0	-7
1954	44	-172	218	-13	22	23	51	-12
1955	-64	-129	69	-18	-27	-54	24	-16
1956	-24	-53	41	-21	-8	30	-17	-19
1957	58	-53	83	-18	30	46	8	-16
1958	-16	0	-15	-23	-5	-47	57	-20
1959	-93	5	-93	-28	-39	0	-29	-25
1960	-41	-41	1	-25	-16	-29	16	-23
1961	138	152	-7	-27	69	59	35	-24
1962	66	135	-73	-26	36	12	18	-23
1963	97	231	-142	-31	48	5	16	-27
1964	81	201	-119	-31	41	48	-5	-28
1965	50	212	-171	-27	25	24	-18	-24
1966	-1	169	-165	-30	-31	9	-13	-27
1967	-157	78	-235	-29	-86	-14	-12	-26

[a]Model included line, year born, sex of calf
[b]Obtained from weighted analysis of repeat mating progeny

TABLE 5. PARTIAL REGRESSION COEFFICIENTS PER 10% INCREMENT OF INBREEDING ON PERFORMANCE OF CALVES

	F of Calf	F of Calf^2	F of Dam	F of Dam^2
TDN/Gain	0.009	0.079	-.001	0.094
(kg.)	P<.668	P<.543	P<.951	P<.513
Score	-.350**	0.361	-.058	-.056
(pt.)	P<.002	P<.606	P<.557	P<.943
Test ADG	-.016*	-.003	0.011	-.017
(kg.)	P<.054	P<.950	P<.141	P<.760
WDA	-.014**	0.019	0.002	-.012
(kg.)	P<.005	P<.540	P<.613	P<.739

* P<.05
** P<.01

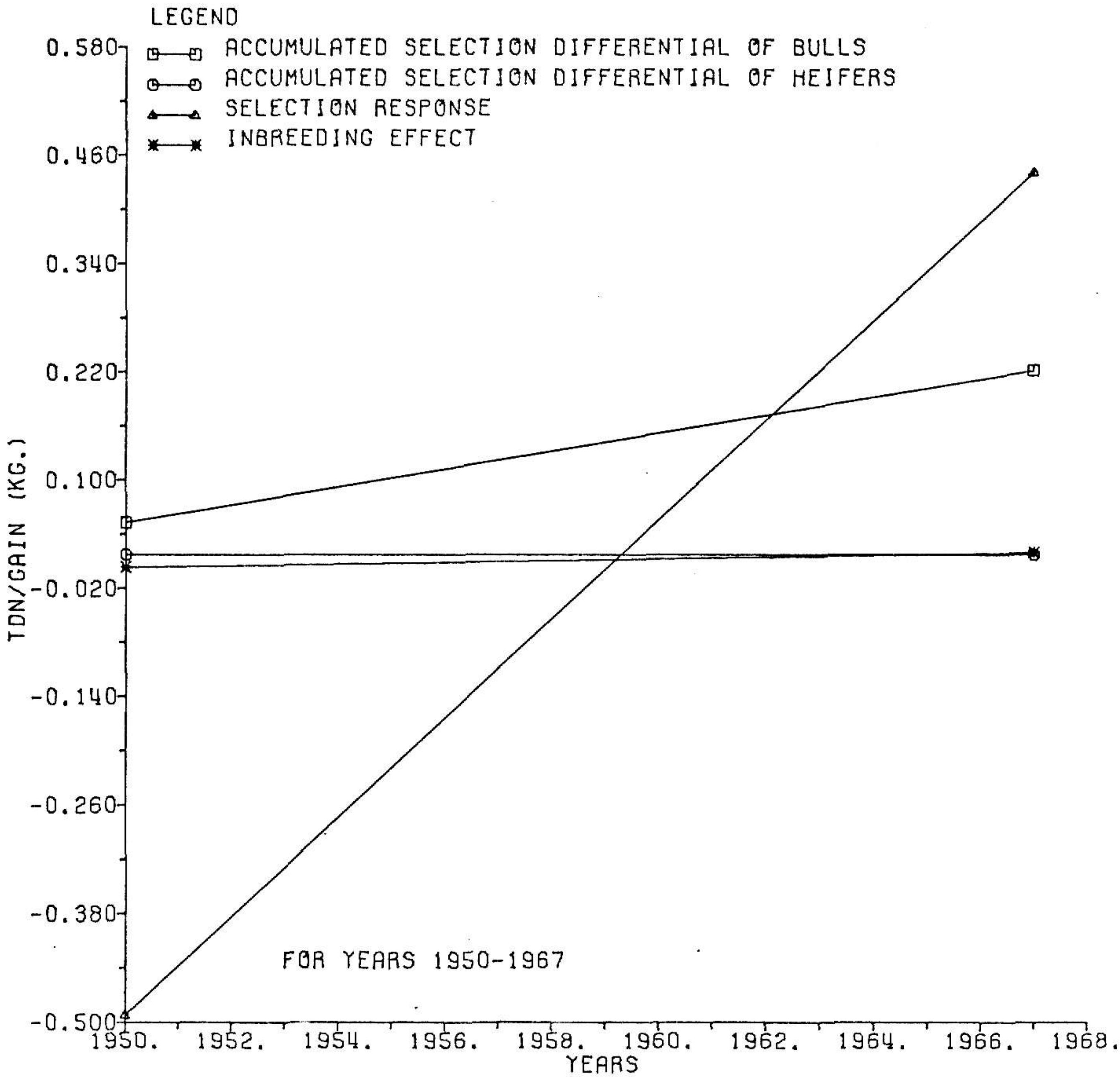

FIGURE 1. LINEAR CHANGE OVER YEARS IN TDN/GAIN

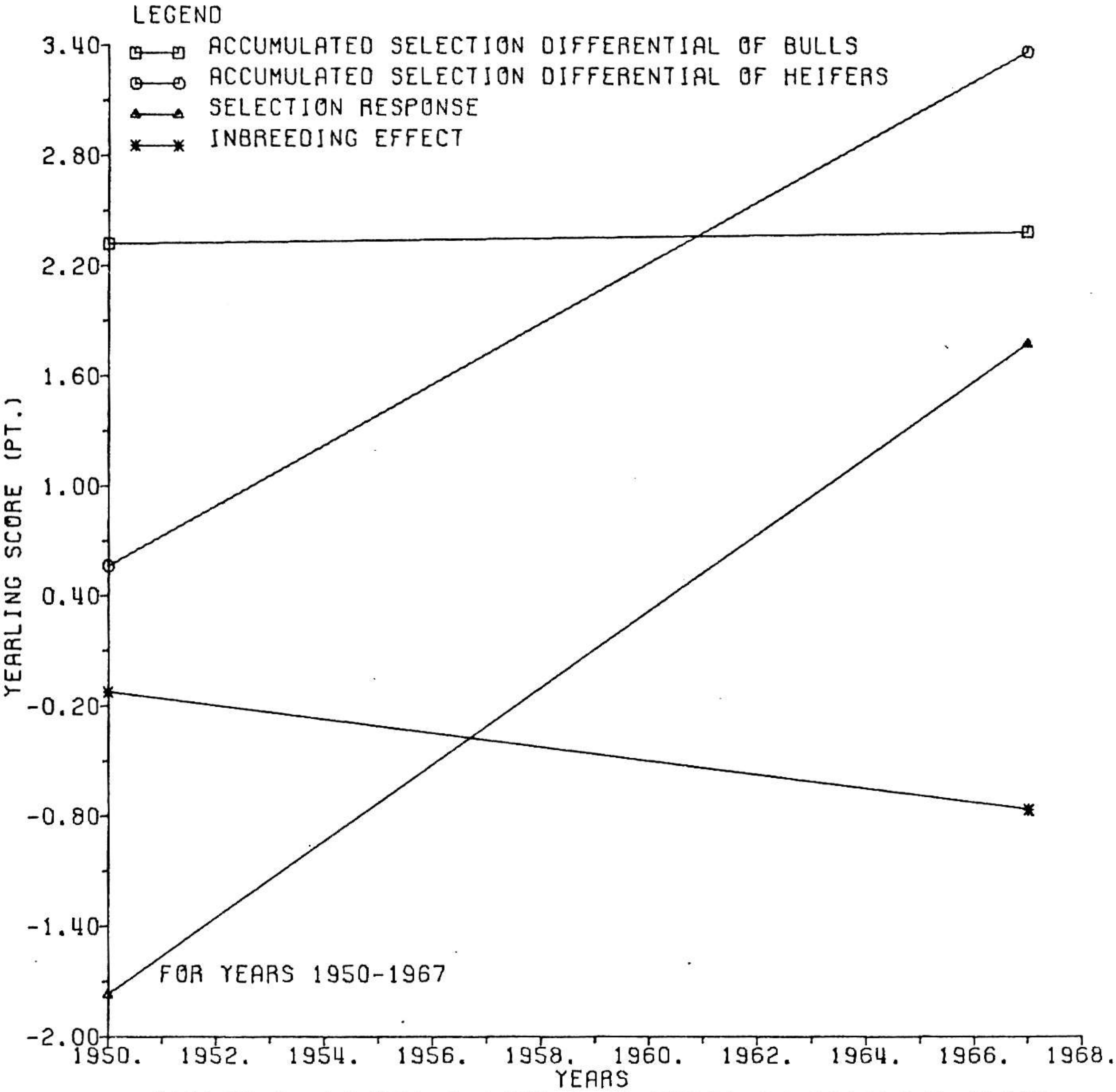

FIGURE 2. LINEAR CHANGE OVER YEARS IN YEARLING SCORE

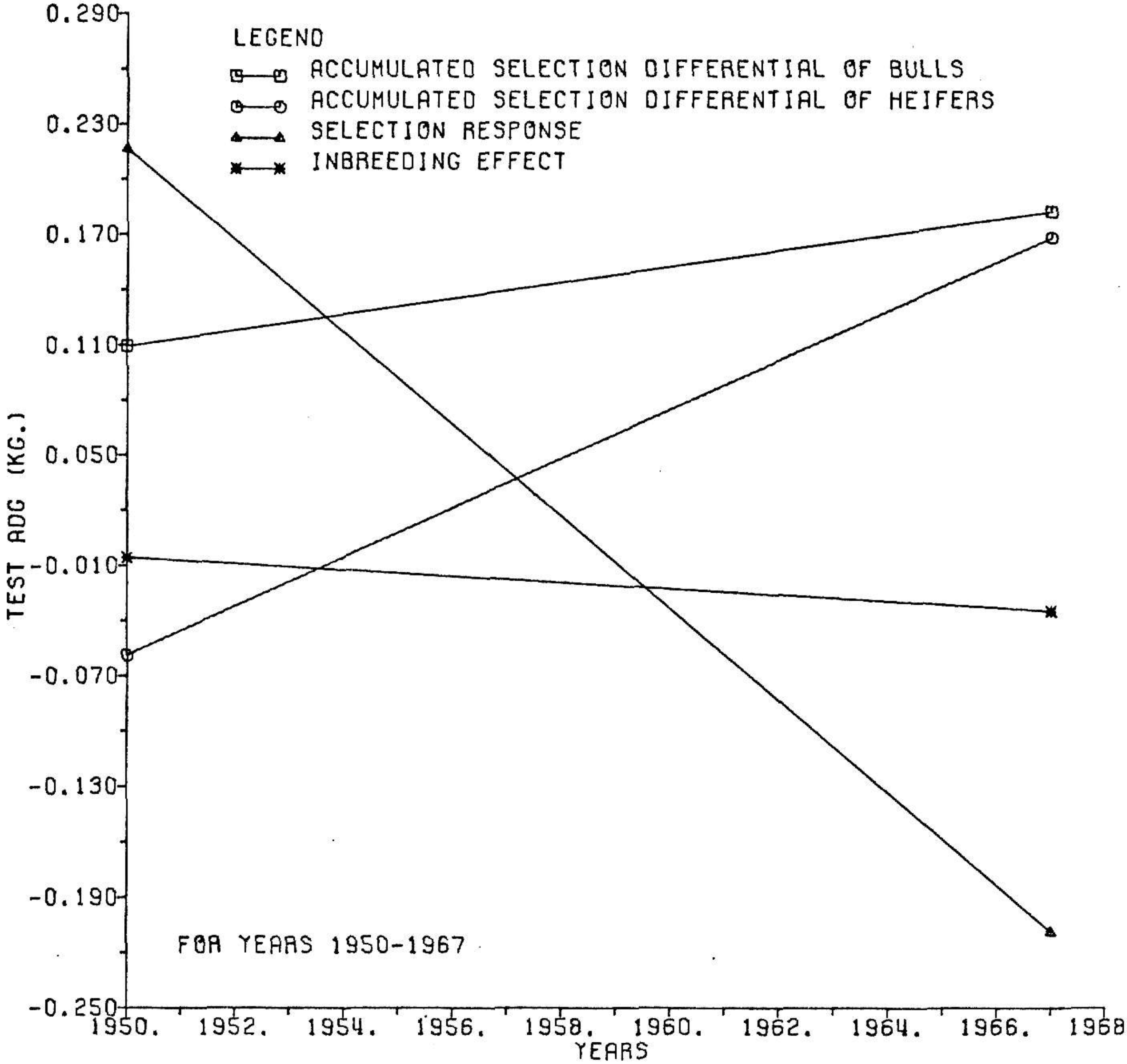

FIGURE 3. LINEAR CHANGE OVER YEARS IN TEST ADG

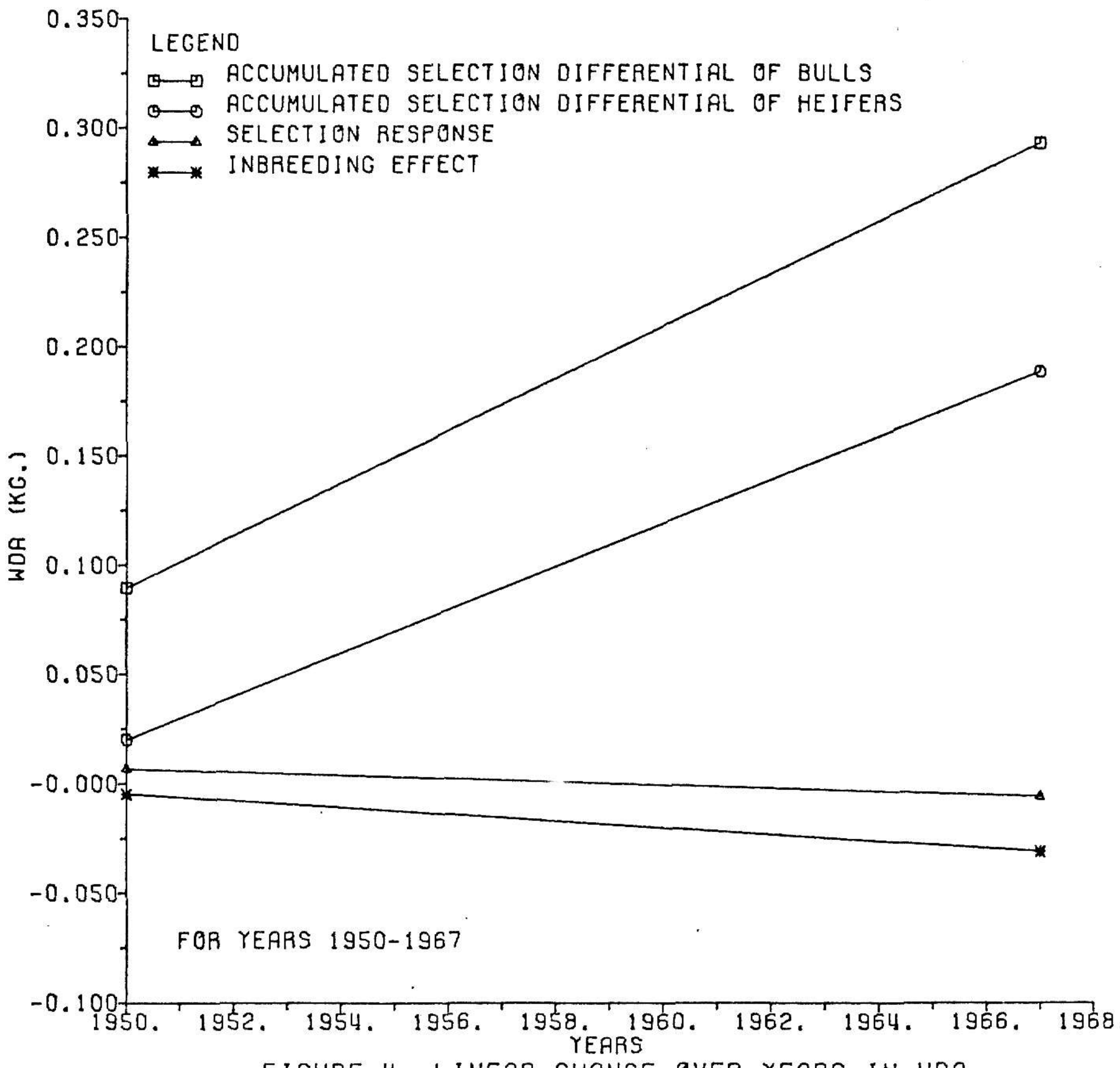

FIGURE 4. LINEAR CHANGE OVER YEARS IN WDA

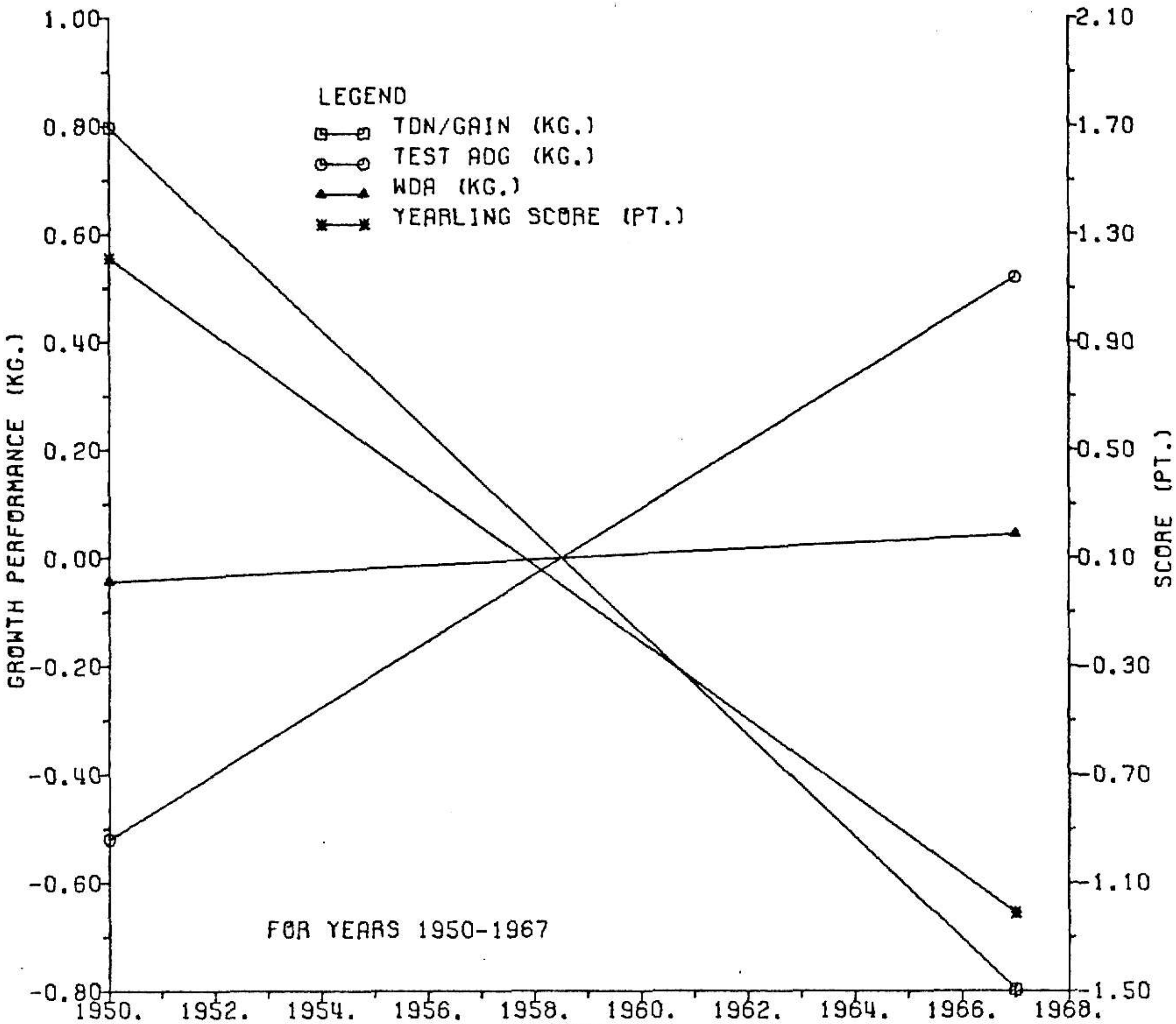

FIGURE 5. LINEAR CHANGE OVER YEARS IN ENVIRONMENT

LITERATURE CITED

Akinokum, J. 1968. A study of some production traits in an inbred herd of Shorthorn cattle. Master's Thesis. Kansas State University, Manhattan.

Alexander, G. I. and Ralph Bogart. 1961. Effect of inbreeding and selection on performance characteristics of beef cattle. J. Anim. Sci. 20:702.

Amestin, W. 1957. Feed efficiency studies in beef cattle. Master's Thesis. Kansas State University, Manhattan.

Baker, G. A., S. W. Mead and W. M. Regan. 1945. Effect of inbreeding on the growth curves of height at withers, weight, and heart girth of Holstein females. J. Dairy Sci. 28:607.

Bartlett, J. W., R. P. Reece, J. P. Mixner. 1939. Inbreeding and outbreeding Holstein-Friesian cattle in an attempt to establish genetic factors for high milk production and high fat test. N.J. Agr. Exp. Sta. Bull. 667:31.

Bartlett, J. W., R. P. Reece, C. L. Lepard. 1942. The influence of inbreeding on birth weight, rate of growth and type of dairy cattle. J. Anim. Sci. 1:206.

Bartlett, J. W., and S. Margolin. 1944. A comparison of inbreeding and outbreeding in Holstein-Friesian cattle. N. J. Agr. Exp. Sta. Bull. 712:28.

Bement, T. R., V. J. Krishna, G. A. Milliken, R. R. Schalles. 1974. Estimation in the general incomplete block design with applications to the analysis of mating structure. Theoretical and Applied Genetics 45:110.

Bowman, J. C. and D. S. Falconer. 1960. Inbreeding depression and heterosis of litter size in mice. Genetical Research 1:262.

Bradford, G. E., A. B. Chapman, and R. H. Grummer. 1958. Effects of inbreeding, selection, linecrossing and topcrossing in swine. I. Inbreeding and selection. J. Anim. Sci. 17:426.

Brinks, J. S., R. T. Clark and N. M. Kieffer. 1965. Evaluation of response to selection and inbreeding in a closed line of Hereford cattle. U.S. Dept. Agr. Tech. Bull. 1323.

Brinks, J. S. and B. W. Knapp. 1975. Effects of inbreeding on performance traits of beef cattle in the western region. W-1 Tech. Bull. 123.

Brown, C. J., C. A. Bangus and S. Sabin. 1961. Evaluation of factors affecting the growth of spring lambs. Bull. Ark. Agr. Exp. Sta. No. 646.

Brown, C. J. and M. Gacula. 1964. Estimates of heritability of beef cattle performance traits by regression of offspring on sire. J. Anim. Sci. 23:321.

Burgess, J. B., N. L. Landblom and H. H. Stonaker. 1954. Weaning weights of Hereford calves as affected by inbreeding, sex and age. J. Anim. Sci. 13:843.

Chambers, D. and J. A. Whatley, Jr. 1950. Heterosis in crosses of inbred lines of Duroc swine. J. Anim. Sci. 9:635. (Abstr.)

Comstok, K. E. and L. M. Winters. 1944. A comparison of the effects of inbreeding and selection on performance in swine. J. Anim. Sci. 3:380.

Craft, W. A. 1953. Results of swine breeding research. U.S.D.A. Circular no. 916.

Cundiff, L. V. and K. E. Gregory. 1968. Improvement of beef cattle through breeding methods. Summary of results from regional project NC-1. North Central Regional Research Publication 120.

Cupps, P. T. and R. C. Laben. 1965. Physiological changes accompanying decreased vigor in a group of inbred calves. J. Dairy Sci. 48:792. (Abstr.)

Dayton, A. D. 1969. The effects of inbreeding on heritable traits in a herd of Jersey cattle. Ph.D. Thesis. Michigan State University, East Lansing.

Dickerson, G. E., J. L. Lush, M. L. Baker, J. A. Whatley, Jr. and L. M. Winters. 1947. Performance of inbred lines and linecrosses in swine. J. Anim. Sci. 6:477.

Dickerson, G. E., C. T. Blunn, A. B. Chapman, R. M. Kottman, J. L. Krider, E. J. Warwick, J. A. Whatley, Jr. 1954. Evaluation of selection in developing inbred lines of swine. Summary of results from regional projects NC-1. Missouri Ag. Exp. Res. Bull. 551.

Dinkel, C. A., D. A. Busch, J. A. Minyard and W. R. Trevillyan. 1968. Effects of inbreeding on growth and conformation of beef cattle. J. Anim. Sci. 27:313.

Dinkel, C. A., L. M. Anderson, W. R. Parker and W. R. Trevillyan. 1972. Effects of inbreeding on fertility and livability in beef cattle. J. Anim. Sci. 35:725.

Doney, J. M. 1957. Effects of inbreeding on four families of Peppin Merinos. Australian J. Agric. Res. 8:299.

Durham, R. M., A. B. Chapman, R. H. Grummer. 1952. Inbred versus non-inbred boars used in two sire herds on Wisconsin farms. J. Anim. Sci. 11:134.

Flower, A. E., J. S. Brinks, J. T. Urick and F. S. Wilson. 1963. Comparison of inbred lines and line crosses for performance traits in Hereford range cattle. J. Anim. Sci. 22:914.

Gottileb, H. 1962. Some factors affecting weaning weight in an inbred Shorthorn herd. Master's Thesis. Kansas State University, Manhattan.

Gowe, R. S., A. Robertson, and B. D. H. Latter. 1959. Environment and poultry breeding problems. 5. The design of poultry control strains. Poultry Sci. 38:462.

Harvey, W. R. 1960. Least squares analysis of data with unequal subclass numbers. ARS - 20 - 8 USDA.

Harvin, G. O. 1963. The effect of inbreeding and environmental factors on the weaning weight and postweaning growth of range Hereford cattle. Ph.D. Thesis. Colorado State University, Fort Collins.

Hawk, H. W., W. J. Tyler and L. E. Casida. 1954. Some factors affecting age at puberty in Holstein-Friesian heifers. J. Dairy Sci. 37:252.

Hayes, F. A. 1919. Inbreeding animals. Delaware Agr. Expt. Sta. Bull. 123.

Hetzer, H., O. G. Haukins, J. H. Zeller. 1950. Performance of crosses between six inbred lines of swine. J. Anim. Sci. 9:638. (Abstr.)

Hillers, J. and A. E. Freemen. 1964. Effects of inbreeding and selection in a closed Guernsey herd. J. Dairy Sci. 47:894.

Hoornbeck, F. K. and R. Bogart. 1966. Amount of selection applied and response of traits in four inbred lines of beef cattle. Oregon Agr. Exp. Sta. Tech. Bull. 96.

Kemp, E. K. 1972. Least squares analysis of variance, a procedure, a program, and examples of their use. Research paper 7. Kansas Agr. Exp. Station, Kansas State University, Manhattan.

King, H. D. 1919. A further study of the effects of inbreeding on the growth and variability in the body weight of the albino rat. J. Exp. Zoology 29:71.

Krehbiel, E. V., R. C. Carter, K. P. Bovard, J. A. Gaines and B. M. Priode. 1969. Effects of inbreeding and environment on fertility of beef cattle matings. J. Anim. Sci. 29:528.

Krishna, V. J. 1973. Effects of inbreeding on cattle performance. Ph.D. Thesis. Kansas State University, Manhattan.

Laben, R. C., P. T. Cupps, S. W. Mead and W. M. Regan. 1954. Some effects of inbreeding and evidence of heterosis through outcrossing in a Holstein-Friesian herd. J. Dairy Sci. 38:525.

Margolian, S. and J. W. Bartlett. 1945. The influence of inbreeding upon the weight and size of dairy cattle. J. Anim. Sci. 4:3.

Marlowe, R. J., C. M. Kincaid, G. W. Litton. 1958. Virginia beef cattle performance testing program. Va. Agr. Expt. Sta. Bull. 489.

Mi, M. P., A. B. Chapman and W. J. Tyler. 1965. Effects of mating system on production traits in dairy cattle. J. Dairy Sci. 48:77.

Malécot, G. 1948. Les Mathématiques de l' Hérédité. Masson & Cie., Paris.

McPhee, H. C., E. Z. Russel and J. Zeller. 1931. An inbreeding experiment with Poland China swine. J. of Heredity 22:393.

McPhee, H. C. and S. Wright. 1925. Mendelian analysis of the pure breeds of livestock. J. of Heredity 16:205.

Morrison, Frank B. 1962. Feeds and Feeding. The Morrison Publishing Company. Clinton, Iowa. 22nd Ed.

Nelson, R. H. and J. L. Lush. 1950. The effects of mild inbreeding on a herd of Holstein-Friesian cattle. J. Dairy Sci. 33:186.

Rollins, W. C., W. W. Mead, W. M. Reagan and P. W. Gregory. 1949. The effect of inbreeding upon growth in Jersey cattle. Genetics 34:724.

Scarsi, J. C. 1971. Effects of inbreeding and estimation of genetic progress upon preweaning traits in beef cattle. Ph.D. Thesis. Virginia Polytechnic Institute, Blacksburg.

Sutherland, R. M. and J. L. Lush. 1962. Effects of inbreeding on size and type in Holstein-Friesian cattle. J. Dairy Sci. 45:390.

Stephenson, A. G., A. J. Wyatt, and H. W. Nordskog. 1953. Influence of inbreeding on egg production in the domestic fowl. Poultry Sci. 32:510.

Stonaker, J. H. 1954. Observations on reproduction, growth, feed utilization and grade of inbred and outbred Hereford cattle. J. Anim. Sci. 14:963. (Abstr.)

Stonaker, J. J. 1943. The breeding structure of the Aberdeen Angus breed. J. of Heredity 34:333.

Swiger, L. A., K. E. Gregory, R. M. Koch, and V. A. Arthaud. 1961. Effect of inbreeding on performance traits of beef cattle. J. Anim. Sci. 20:626.

Swiger, L. A., K. E. Gregory, R. M. Koch, W. W. Rowden, V. H. Arthaud and J. E. Ingalls. 1963. Evaluating postweaning gain of beef calves. J. Anim. Sci. 22:514.

Tantawy, A. O. and E. C. R. Reeve. 1956. Studies in quantitative inheritance. IX. The effects of inbreeding at different rates in Drosophila melanogastes. Z. Indukt. Abst. Vererbungslehre 87:648.

Tebb, G. 1957. Inbreeding effects contrary to the direction of selection in a poultry flock. Poultry Sci. 36:402.

Tyler, W. J., A. B. Chapman, and G. E. Dickerson. 1949. Growth and production of inbred and outbred Holstein-Friesian cattle. J. Dairy Sci. 32:247.

Voelker, H. H., and W. L. Tucker. 1965. Effects of inbreeding Holstein-Friesian cattle on growth rates. J. Dairy Sci. 48:792. (Abstr.)

Von Krosigk, C. M., and J. L. Lush. 1958. Effects of inbreeding on production in Holsteins. J. Dairy Sci. 41:105.

Warwick, E. J. 1958. Fifty years of progress in breeding beef cattle. J. Anim. Sci. 17:922.

Willham, L. S. 1937. A genetic history of Hereford cattle in the United States. J. of Heredity 28:283.

Willham, O. S. 1938. Inbred sows vs. inbred boars in outcross. Proc. of the American Society of Animal Production. Nov. 25-27.

Woodward, R. E. and R. R. Groves. 1946. Results of inbreeding grade Holstein-Friesian cattle. U.S.D.A. Tech. Bull. 927:1-39.

Wright, A. 1921. Systems of mating Genetics 6:111-178.

Wright, S. 1922. Coefficients of inbreeding and relationship. Amer. Nat. 56:330.

Wright, S. 1923. Mendelian analysis of the pure breeds of livestock. J. Heredity 14:339.

Young, C. W., W. J. Tyler, A. E. Freeman, H. H. Boilker, L. D. McGilliard and T. M. Ludwick. 1969. Inbreeding investigations with dairy cattle in the North Central Region of the United States. North Central Regional Research Publication 191.

APPENDIX

APPENDIX A

FACTORS INFLUENCING TDN/GAIN, SCORE, ADG, WDA
Least Square Means (kg.)[a]

Parameter	TDN/GAIN Means	YEARLING TYPE SCORE Means	AVERAGE DAILY GAIN Means	WEIGHT PER DAY OF AGE Means
Line	P<.925	P<.0001	P<.087	P<.003
Premier	2.251 ± .033	11.155 ± .176	.961 ± .013	.870 ± .008
Mercury	2.264 ± .024	12.795 ± .130	.930 ± .010	.839 ± .006
Linecross	2.253 ± .054	11.904 ± .290	.952 ± .021	.853 ± .013
Cow Age	P<.595	P<.280	P<.552	P<.671
2 Years	2.302 ± .042	12.221 ± .226	.938 ± .017	.845 ± .010
3 Years	2.262 ± .036	12.052 ± .196	.960 ± .015	.861 ± .009
4 Years	2.269 ± .037	12.019 ± .200	.951 ± .015	.858 ± .009
5-10 Years	2.234 ± .028	11.733 ± .152	.936 ± .011	.852 ± .007
>10 Years	2.212 ± .054	11.731 ± .295	.954 ± .022	.855 ± .013
Sex	P<.000	P<.0001	P<.0001	P<.0001
Bull	2.030 ± .027	12.152 ± .145	1.081 ± .011	.920 ± .006
Heifer	2.442 ± .024	13.091 ± .133	.793 ± .010	.781 ± .006
Steer	2.295 ± .050	10.062 ± .271	.969 ± .020	.862 ± .012
Test Age[b]	P<.292 b = .001	P<.569 b = -.002	P<.995 b = .000	P<.0001 b = -.002
Starting Test Wt.[b]	P<.003 b = .003	P<.0001 b = .012	P<.002 b = .001	P<.0001 b = .002

[a]Environmental effects have been removed

[b]Partial regression coefficients

APPENDIX A (Continued)

Parameter	TDN/GAIN Means	YEARLING TYPE SCORE Means	AVERAGE DAILY GAIN Means	WEIGHT PER DAY OF AGE Means
Year	P<.0001	P<.0001	P<.0001	P<.0001
1950	1.689 ± .076	9.486 ± .413	1.099 ± .030	.805 ± .018
1951	1.755 ± .074	9.514 ± .402	1.145 ± .029	.826 ± .018
1952	1.940 ± .080	10.090 ± .434	1.111 ± .032	.862 ± .019
1953	1.910 ± .069	10.865 ± .376	1.111 ± .028	.854 ± .017
1954	1.857 ± .076	11.366 ± .411	1.166 ± .030	.905 ± .018
1955	2.120 ± .060	12.132 ± .323	1.017 ± .024	.878 ± .015
1956	2.136 ± .065	11.473 ± .353	.989 ± .026	.837 ± .015
1957	2.314 ± .052	12.352 ± .282	1.031 ± .021	.862 ± .013
1958	2.393 ± .059	12.261 ± .316	.933 ± .023	.911 ± .014
1959	2.505 ± .055	12.833 ± .298	.855 ± .022	.825 ± .013
1960	2.350 ± .060	12.356 ± .324	.949 ± .024	.870 ± .015
1961	2.414 ± .064	12.804 ± .346	.941 ± .025	.889 ± .015
1962	2.373 ± .054	12.703 ± .294	.875 ± .022	.872 ± .013
1963	2.571 ± .057	12.451 ± .307	.806 ± .023	.870 ± .014
1964	2.499 ± .055	12.862 ± .296	.829 ± .022	.849 ± .013
1965	2.454 ± .058	13.142 ± .309	.777 ± .023	.836 ± .014
1966	2.622 ± .055	13.105 ± .296	.783 ± .022	.841 ± .013
1967	2.703 ± .055	13.332 ± .297	.713 ± .022	.782 ± .013

[a]Environmental effects have been removed

EFFECTS OF INBREEDING

ON

POSTWEANING CATTLE PERFORMANCE

by

MICHAEL H. HALL

A.A., Modesto Junior College, 1970
B.S., California Polytechnic State University, 1973

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTERS OF SCIENCE

Department of Animal Science and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1975

Effect of inbreeding on postweaning growth traits in two inbred lines of Shorthorn beef cattle was studied. The Wernacre Premier line was established in 1949 and the Mercury in 1950 at Kansas State University. A total of 506 calves in 18 years were used. One hundred seventeen repeat matings produced 311 calves which were used in a weighted analysis to obtain environmental changes. Average yearly inbreeding coefficients of calves ranged from 0 to 38% with an 18 year average of 15.8% and a rate of 1% increase per year or 4.5% per generation. Significant line differences were found with the Wernacre Premier line having 31 g. higher ADG and 31 g. higher WDA than the Mercury line. The Mercury line scored a significant 1.64 points higher on the yearling score. No significant heterosis was found in linecrosses for any of the traits studied.

Inbreeding of calf had a significant effect for yearling score, WDA and test ADG. Partial regression coefficient of inbreeding of calf revealed 10% increase in inbreeding of calf reduced yearling score by -.350 pt., WDA by -.014 kg., and test ADG by -.016 kg. Inbreeding of calf showed a non-significant depressing effect on TDN/gain of .009 kg. per 10% inbreeding. Inbreeding effect of cow was non-significant for all traits. Regression coefficients of inbreeding of cow was -.001 kg. on TDN/gain, -.058 pt. on score, 0.011 kg. on ADG and 0.002 kg. on WDA. The quadratic term for both the effects for inbreeding of calf and dam were non-significant.

Intensity of selection increased with years averaging 13.74% for bulls and 57.25% for heifers. Bull calves had higher selection

differentials for all four traits, but the selection differentials of the heifer calves increased at a higher rate through the 18 years. Selected bull and heifer calves were .6 and .8% less inbred than the population average and came from 2.1 and .4% more inbred cows. A male or female calf that was less inbred coming from a more inbred dam and which weighed and scored better after postweaning test had a better chance of being selected.

Environment had an annual depressing effect upon yearling score of -.142 points, while TDN/gain, ADG on postweaning test and WDA exhibited a -.094 kg., 0.061 kg. and 0.005 kg. increase per year, respectively.