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To the Graduate Council:

I am submitting herewith a thesis written by Jimmy David Faulk entitled "The Influence of Sex and Age of Dam on Some Economic Characteristics in Beef Cattle." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

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THE INFLUENCE OF SEX AND AGE OF DAM ON SOME ECONOMIC CHARACTERISTICS IN BEEF CATTLE

A THESIS

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INTRODUCTION

For many years, the criteria for selection of beef animals has been based largely on visual standards of excellence. Visual appraisal standards as reflected in type scores do have a place in selection of replacement individuals in a herd but should not be the sole criterion taken into consideration. It has been generally recognized that individual ability of an animal to produce with respect to other performance traits and the records of the animal's offspring also should be considered.

It is fairly well established that there are significant differences in weaning weights and other characteristics of calves due to age of cow and sex of calf. If performance selection is to be used most effectively the producer needs adjustment factors that will correct calf records for differences in ages of cows and the sex of their offspring. These differences apparently vary in degree because of variations in environmental conditions in herds in different locations. This indicates the necessity, where possible, of using adjustment factors developed for specific herds or locations.

Much of the previous work in this field has been with range cattle. Although the reported observations in range herds are in fairly close agreement with the estimates reported in Southeastern herds, adjustment factors are needed that have been derived from herds in Tennessee and can be applied to other herds in this state.

It is hoped that the results of this study will provide the beef cattle producer in Tennessee with a set of correction factors for sex of calf and age of dam and that will enable him to use performance testing more effectively as a basis for selection and culling.

LITERATURE REVIEW

Reported estimates of the influence of age of dam and sex of calf on birth weight, daily gain, weaning weight and type scores of beef calves vary somewhat because of differences in environmental conditions under which the estimates were made. There is some disagreement as to the degree of the influence but most of the results indicate that these characteristics are significantly affected by sex and age of dam. There are other variables, such as location and year, which affect these traits, but when selection is made within location and within year, no adjustments are needed for these factors.

Burris and Blunn (1952) reported that males were 4.5 pounds heavier than females at birth. The mean birth weight was 69.9±0.97 pounds for males and 65.4±0.82 pounds for females. About 10 per cent of the sex difference was attributed to difference in gestation length. The mean birth weight was 63.5 pounds when the dams calved at 2-3 years of age and increased steadily to 76.2 pounds when the dams calved at 9 and 10 years of age. The regression of birth weight on age of dam was a highly significant figure of 1.04 pounds.

Over a period of eight years, Koger and Knox (1947) observed a highly significant sex difference of 32 pounds (corrected to 205 days) at weaning in favor of steer calves in high grade Hereford range cattle. In another report, Knox and Koger (1945) stated that the mean weaning weight of calves increased with the age and weight of their dam until the cows were 6 to 8 years of age. They suggested the close correlation between weight of calf and weight of dam strongly indicated the relationship of production to plane of nutrition.

Using 546 Hereford calves, Burgess et al. (1954) observed that bulls were considerably heavier than steers and heifers at weaning. The effect of age of dam in pounds as deviations from the average weaning weight was: 2-years, -15; 3 to 5 years, 5; 6 to 8 years, 21; 9 years and over, -10. For sex of calf the effect was: steer, -6; bull, 14; and heifer, -8. The year of birth of the calf also had an effect on the weaning weight of the calves, but this would only be considered when comparing calves born during different years.

Working with Polled Hereford calves, Southwell and Warwick (1952) reported male calves to be 5.3 pounds heavier at birth and 41 pounds heavier at 210 days than female calves. In general, calf weights at birth and 210 days increased with the age of the cow to eight years. They found that from 35 to 43 per cent of the variance in 210 day calf weights could be accounted for by cow differences.

With range Hereford cows, Koch (1951) observed that the males (average of bulls and steers) weaned 23 pounds heavier than the females.

Knapp et al. (1940) using both beef and milking Shorthorn cows observed that in the former the males averaged 4.7 pounds heavier and in the latter 3.5 pounds heavier than the females at birth. The difference in the former was highly significant. Differences due to sex accounted for only 6.5 per cent of the total variance in birth weights in the beef Shorthorns and 2.1 per cent in the milking Shorthorns. The influence of calving sequence on birth weight indicated that the first calves were considerably lighter than subsequent calves, but beyond this point the trend was not consistent.

It was reported by Gregory et al. (1950) that there was a significant difference in the birth weight between sexes but very little difference for weaning weight. The male calves were five pounds heavier at one station and four pounds heavier at another. The weight of the dam had a significant influence on the birth weight and on the weaning weight in one herd but had a negative effect in the other.

Dawson et al. (1947) reported that birth weights of calves tended to increase at the rate of 0.23 pounds for each month of increase in the age of dam until the dams were six years old; after this age there was no effect. Correlation between age of dam and birth weight of calf was 0.45 for male and 0.35 for female calves. When birth weights were adjusted to the basis of 6-year-old dams, males averaged 4.2 pounds heavier than females.

Woodward et al. (1942) observed that when calves from large and small type Hereford cows of various age groups were compared, the calves from large type cows were heavier at birth and made larger daily gains from birth to weaning. Also, the type of their sire and dam affected the birth weights of calves more than the ration fed their dams.

Studies by Knapp and Black (1941) indicated that during the suckling period, milk consumption had the greatest influence on the rate of gain followed by consumption of hay and grain. These three variables accounted for 41 per cent of the variation in the rate of gain during this period. Sex was found to have a significant influence on the rate of gain.

Dahmen and Bogart (1952) found that bulls gained faster than heifers with the average daily gain for bulls during the test being 2.3 pounds and 2.0 pounds for the heifers. They also found that bulls were more efficient feed utilizers than heifers. The bulls required an average of 391 pounds TDN (total digestable nutrients) to gain 100 pounds body weight during the test, while the heifers required an average of 483 pounds TDN per 100 pounds gain. Birth weight had a significant effect on both rate and economy of gain.

Sawyer et al. (1948) found that 2-year-old heifers weaned calves that were 75 pounds lighter than those from mature cows. Weaning weights increased with increasing age of dam through 8 years but then declined. Evidence was found that heifer calves were heavier at weaning than steer calves; however, the difference lacked significance.

Work at Miles City, Montana, by Knapp et al. (1942) showed that the average birth weight of all calves was 74.0 pounds. For male calves it was 76.9 pounds and for female calves it was 71.1 pounds. Calves from 2-year-old cows were much smaller at birth than calves from mature cows and increased until cows were 4 years old. There was a gradual reduction in birth weight of calves after cows reached 5 years of age. The average weaning weight for the group was 366 pounds at approximately 6 months age. The male calves averaged 377 pounds and the females averaged 355 pounds.

Guill (1953) using data from a grade Hereford cow herd at the Tobacco Experiment Station of the University of Tennessee found the mean birth weight to be 73 pounds for males and 67 pounds for females, a

difference of 6.0 pounds in favor of the males. The average 180-day weight was 403.2 pounds for the males and 377.4 pounds for the females. The difference of 25.8 pounds in favor of the males was significant. At the Plateau Experiment Station of the University of Tennessee, he found the mean birth weight was 73.1 pounds for the males and 66.5 pounds for the females, with an advantage of 6.6 pounds for the males. The 180-day weight was 460 pounds for the males and 409 pounds for the females. The 51.0 pounds difference in favor of the males was highly significant.

Using weaning weights adjusted to 240 days, Rollins and Guilbert (1954) found that bull calves were 68 pounds heavier than heifer calves at weaning. The optimum age range for cow productivity was from 7 to 10 years of age.

Paysinger (1953) found the mean birth weight was 73.1 pounds for males and 70.4 pounds for females, a difference of 2.7 pounds in favor of the males. The effect of age of dam on calf birth weights was erratic and did not show a definite trend. The average weaning weight was 417.0 pounds for males and 393.5 pounds for females. The males had a 23.5 pound advantage at weaning.

McCormick et al. (1956), working at the Georgia Costal Plain Experiment Station with Polled Herefords, found that the birth weight of the males in the purebred herd exceeded that of the females by 4.5 pounds. The calves from 2, 3, and 4-year-old dams weighed approximately 10, 6, and 2 pounds less, respectively, than those of 5-year-old dams.

Weights of calves from dams more than 5 years old exhibited no consistent trends. In the grade herd, bull calves were only 2.1 pounds heavier than heifers and this difference was not statistically significant. About the same effect of age of dam on birth weight was observed in the grade herd as in the purebred herd. In the purebred herd, bulls outweighed heifers by 38 pounds at 210 days of age. This difference was statistically significant. Age of dam affected weaning weights in that the weights increased rather consistently up to 8 years of age, and then fluctuated irregularly through ages 9, 10, and 11, and thereafter dropped rather sharply. The 210-day sex-adjusted weaning weight was adjusted to an 8-year-old dam basis by adding the following correction factors: 2-year-old dam, 107 pounds; 3-year-old, 68 pounds; 4-year-old, 42 pounds; 5-year-old, 22 pounds; 6-year-old, 17 pounds; 7-year-old, 10 pounds; 8-year-old, 0 pounds; 9-year-old, 0 pounds; 10-year-old, 0 pounds; 11-year-old, 0 pounds; 12-year-old, 31 pounds; 13-year-old, 41 pounds; 14-year-old, 77 pounds; and 15-year-old, 57 pounds. When the calves were creep-fed the correction factor for age of dam was slightly larger up to 8 years of age for the creep-fed calves. Birth weight, either unadjusted or adjusted for age of dam, was positively correlated with daily gain from birth to weaning and with 210-day weight. The regressions indicated that for each additional pound at birth (unadjusted), the average calf was from 0.86 pound (for the group with lowest correlation) to 2.93 pounds (for the group with the highest correlation) heavier at 210 days of age.

Nelms and Bogart (1956), using purebred Hereford and Angus cattle, reported that the difference in suckling gains of the two sexes was largely due to a difference in birth weight. The males were heavier at birth and carried the advantage through the suckling period. The larger calves at birth gained more rapidly during the suckling period. The regression coefficient of rate of gain during the suckling period on birth weight was 0.0115. This indicated that for each change of 10 pounds in birth weight there was associated a difference in rate of gain of 0.115 pound per day. Bulls and heifers of the same birth weight gained at approximately the same rate during the suckling period. There was a large difference between the daily gains of calves of 2-year-old dams and those of older cows. However, the effect of age of dam on rate of gain during the suckling period only approached significance. The calves from 2-year-old dams were born late in the season when the pastures were less productive, and this could explain why their calves had the lowest gains. The time of birth seemed to have an equal or greater effect on rate of suckling gains of the calves than age of dam when the younger dams were selected for this trait and compared with older cows.

Rollins and Wagnon (1956), working in California, observed that nutritive level had little influence on heritability of weaning weight. Using two herds of Herefords, a comparison was made between Herd A in which the cows were supplemented during the fall and winter when the range was nutritively deficient and Herd B in which the cows were not supplemented. The correction factors used to adjust for age of dam in Herd A were: 3-year-old cow, 50 pounds; 4-year-old cow, 32 pounds; 5-year-old cow, 17 pounds; 6-year-old cow, 7 pounds; 7-year-old cow,

1 pound; 8-year-old cow, 0 pounds; 9-year-old cow, 3 pounds; 10-year-old cow, 11 pounds. In Herd B the factors used were: 3-year-old cow, 48 pounds; 4-year-old cow, 29 pounds; 5-year-old cow, 14 pounds; 6-year-old cow, 4 pounds; 7-year-old cow, 0 pounds; 8-year-old cow, 0 pounds; 9-year-old cow, 6 pounds; 10-year-old cow 17 pounds. Operating a herd under sub-optimum nutritional conditions in this experiment did not affect the heritability of weaning weight. Repeatability of weaning weight was estimated to be 0.51 in Herd A and 0.34 in Herd B.

Koch and Clark (1955) studied data from 5,952 Hereford calves and found that male calves were 5.6 pounds heavier at birth and 26.2 pounds heavier at weaning than heifer calves. There was a very small sex difference in weaning score. Age of dam had a marked influence on both birth weight and weaning weight. Cow productivity with regard to birth weight, weaning weight, and weaning score increased steadily from 3 to 6 years and then declined. The correction factors used to adjust for age of dam were: 3-year-old dam, 41 pounds; 4-year-old dam, 18 pounds; 5-year-old dam, 6 pounds; 6-year-old dam, 0 pound; 7-year-old dam, 3 pounds; 8-year-old dam, 6 pounds; 9-year-old dam, 12 pounds; and 10-year-old dam, 24 pounds.

OBJECTIVE

The objectives of this study were (1) to evaluate the quantitative effect of sex of calf and age of dam on birth weight, gain from birth to weaning, weaning type score and weaning condition score, (2) to derive correction factors for adjusting calf records for sex and age of dams so that weanling calves and cows may be compared as to their relative merit for herd replacements and (3) to obtain estimates of variance in these characteristics which may be used in formulating selection indexes.

History of the Herds

The major part of the cattle used in this study was purebred. However, there were some high grades included at three of the eight locations. Data from the purebred and grade cattle were not seperately analyzed in the study but were combined.

The cattle at Alcoa, Oak Ridge and Crossville included both purebreds and grades. Both the purebred cattle and grade cattle at Oak Ridge and Alcoa were of Hereford breeding while those at Crossville were Angus breeding. The cattle at Greenville, Spring Hill and Springfield included only purebred Herefords. Only purebred Angus were included for Ames. The cattle at Knoxville consisted of both purebred Angus and Hereford.

Herd Management

The eight locations from which cattle were used in this study are located throughout Tennessee. Ames Plantation is located in West Tennessee. Spring Hill and Springfield are located in Middle Tennessee. Other stations located in East Tennessee are at Knoxville, Alcoa, Oak Ridge, Greenville, and Crossville, which is on the Cumberland plateau. Although the soil and climatic conditions are somewhat different at the various locations most of the management and breeding practices were very similar for all locations during the years included in the study.

During the summer the cattle were maintained on pasture. The principal forages used in the pastures were Ladino Clover, Orchard Grass, Alfalfa, Fescue, and Kentucky Bluegrass. Sudan Grass was available at some of the stations for supplemental grazing during the summer. In years when the season was very dry, hay or silage was used to supplement the pasture. During the winter months the cows were fed silage or hay on permanent pasture sods. In some years there was a limited amount of winter pasture available. All cattle were supplied adequate water with salt and a mineral mixture available free choice.

Calf Management

At some locations the calves were weighed at birth and at approximately 28-day intervals until weaning. At other locations only birth and weaning weights were taken. The calves at Ames Plantation and the

grade calves at Oak Ridge were not weighed at birth. All calves were weaned about November 1 each year and at that time were graded for type and condition. The calves were not creep fed.

PROCEDURE

Animals

Calves from beef cattle herds of the College of Agriculture of the University of Tennessee at eight different locations were used in this study. Included in these eight locations were herds at Alcoa, Ames, Crossville, Greenville, Knoxville, Oak Ridge, Springfield and Spring Hill. The years covered in the study were 1953, 1954, 1955, and 1956. Records of calves at Ames Plantation were available for only 1955 and 1956. All the calves used were purebred or high grade.

There were 1,234 male and 1,168 female birth weights useable from the eight locations. This included 1,040 Hereford males, 998 Hereford females and 194 Angus males and 170 Angus females. Birth weights were used only when dams of the same age dropped calves within the same location and year. In the analysis of variance for average daily gain 2,601 calves were used. This included all the Angus and Hereford calves that were weaned. Two thousand three hundred and eleven calves were used in the analysis of variance for type grade. This included all animals at each of the locations though there may not have been both males and females from the same age dams within location and year. The difference between the number of calves used in the analysis of variance for average daily gain and type grade was due to the fact that the calves at Ames were not given a type grade for 1955; also, some type grades were missing in some years at other locations. There were 1,072 males and 1,088 females with type grades available for use when

only those calves from the same age dam within location and year were considered. This group contained 1,023 males and 1,023 females with condition grades that were useable.

Methods of Analysis

The data used in this study were analyzed according to techniques applicable to data with disproportionate sub-class numbers as described by Snedecor (1956).

I. Effect of Sex. The data for birth weights, average daily gains, weaning, type, and condition grades were classified according to location, year of birth of dam, year of birth of calves, and sex of calves. Average differences between males and females were then computed for each age dam on a within location and year basis. Since there were disproportionate numbers in male and female sub-classes within location, age of dam, and year, each difference was weighted according to the formula $\frac{n_1 n_2}{n_1+n_2}$, where n_1 is the number of males and n_2 is the number of females in each sub-class. Sex differences for the various characteristics were then computed for each age of dam by pooling data from all locations.

Because no consistent trends in the average differences between sexes with increasing age of dam were apparent for any of the traits, the sex influence was computed over all ages of dams using the weights calculated from the formula, $\frac{n_1 n_2}{n_1+n_2}$, for each within location, age of dam, and year difference between sexes.

The data were subjected to analysis of variance techniques as described by Snedecor (1956).

II. Effect of Age of Dam. Techniques similar to those used in the analyses of sex effects on the various traits were employed in the evaluation of age of dam effects. The data were classified according to location, year of birth of dam, year of birth of calves, and sex of calves. For analysis of birth weights female calves were adjusted to a male basis by adding 4.3 pounds to the actual birth weights of female calves. For average daily gain, female calves were adjusted to a male basis by multiplying average daily gain of females by 1.07 since it was found that male calves gained approximately 7 per cent faster than female calves. Type grades were not adjusted for sex since the difference between sexes for type scores were very small and not significant.

The effect of age of dam on daily gain was first estimated by computing the average sex-adjusted difference in daily gain of calves for successive ages of cows calving within location and year (Table VI). This difference was calculated by pooling data from all locations, each within location and year difference weighted according to the formula $\frac{n_1 n_2}{n_1+n_2}$. Since nonlinear regression was indicated a second degree polynomial, $Y = a + bX + cX^2$, was found to fit the data satisfactorily. The regression equation $\hat{Y} = -.155410 + .096312X_1 - .005916X_2$ was derived from this data and was used to estimate age effects among various ages of dams.

Analysis of variance techniques as described by Snedecor (1956) were used to determine significance of age of dam effects and estimate variances for the different traits.

RESULTS AND DISCUSSION

Average Daily Gain

The average daily gain for calves at all locations was 1.59±.009 pounds for males and 1.49±.008 pounds for females. With a difference of 0.10±.012 pound in favor of the males (Tables IV and V). This difference represents approximately a 7 per cent advantage for the males. No consistent trend in the average differences between the sexes with increasing age of dam was observed for average daily gain. However, the smallest difference between sexes was found in the 2-year-old dams (Table V). Koch (1951) observed that males weaned 23 pounds heavier than females. McCormick et al. (1956) found males were 38 pounds heavier than females at 210 days of age.

The results obtained in this study show that the peak in cow productivity was reached between the ages of 6 to 10 years. This is in agreement with results obtained by other workers. Rollins and Wagnon (1956) found 8-year-old dams to be the most productive. Koch and Clark (1955) reported that 6-year-old dams were the most productive. The average daily gain of calves (Table V) increased with the age of dam up to a maximum at about 7 to 8 years of age. However, there were very small differences in average daily gains for calves from dams 6 to 10 years of age (Table VII). After 10 years of age there was a decline in average daily gain with increasing age of dam.

Culling on the basis of cow productivity was practiced in the herds included in this study, and for this reason there was a larger number of calves from young dams than from dams over 10 years of age.

Also, there was an (Table V and Figure 2) apparent increase in average daily gains observed for calves of dams after they reached 10 years of age. This was apparently a result of selection practices and limited numbers of cows in the older ages. Culling was practiced and cows with low producing ability were culled at each age and this resulted in each succeding age group containing a larger share of high producing cows and a smaller share of low producing cows than of the younger ages. The smaller number of older cows also yielded a larger sampling error. By the time the dams had reached 10 years of age only the very best producing cows remained. There were (Table V) only 40 calves useable from dams 12 years of age as compared to 493 calves from dams 3 years of age. In the analysis of age of dam effects only cows were used when calves from successive ages were represented within location and year. This further reduced the number of older cows available for analyses. On the basis of this analysis cow productivity decreased with increasing age of dam after 10 years of age (Table VII and Figure 3).

When a curvlinear regression equation was fitted to the data for defferences in daily gains the results (Table VII) showed that the peak in cow productivity was reached between 6 to 10 years of age. Percentage correction factors for age of dam are presented in Table VII based on a sex-adjusted average daily gain of 1.67 pounds for calves from 8-year-old dams.

Some location effects were found for average daily gains (Table IV). Whether these effects were due to breeding, nutrition, or management

were not determined in this study. Angus calves in this study had a slightly higher daily gain than did the Hereford calves. The Angus male calves (Table IV) had an average daily gain of 1.64 pounds as compared to 1.57 pounds for the male Hereford calves. The Angus female calves had an average daily gain of 1.51 pounds as compared to 1.48 pounds for Hereford females.

Birth Weights

The mean birth weight by sex for the five year period, 1952-56 inclusive, for all Hereford calves from six locations (Table I), was 70.4 pounds for males and 66.2 pounds for females, a difference of 4.2 pounds in favor of the males. This difference is about the same as that found by other workers. McCormick et al. (1956) found that male Herefords outweighed females at birth by 4.45 pounds, and Burris and Blumn (1952) reported that males were 4.5 pounds heavier than females at birth.

For Angus calves the mean birth weight by sex for the five year period, including all Angus calves from two locations (Table I), was 65.7 pounds for males and 60.9 pounds for females, a difference of 4.8 pounds in favor of the males. The results of this study showed that Herefords were heavier than Angus at birth. There was a difference of 4.7 pounds in the birth weights of Hereford males and Angus males in favor of the Herefords. A difference of 5.3 pounds in favor of Hereford females over Angus females was found. When the birth weights of both Hereford and Angus calves at all locations were used, the mean birth weight (Table I) was 69.7 pounds for males and 65.4 pounds for females,

a difference of 4.3 pounds in favor of the males. The analysis of variance of birth weights of all calves from all locations indicated there was a highly significant ($P = 0.01$) difference between sexes for birth weight. No consistent trend in the average difference between the sexes with increasing age of dam was found for birth weight (Table II). However, the effect of age of dam on birth weight approached significance. Mean sex-adjusted birth weights of calves tended to increase up to 4-year-old dams and then varied irregularly (Table III). This is shown graphically in Figure 1.

Grades

The results obtained in the analysis of variance of type grades (Table XIII) indicated there was little difference in type grade due to sex. Using Hereford calves Koch and Clark (1955) observed only a small difference representing less than one-tenth of a grade, in weaning type scores of the male and female calves.

The mean type grade at all locations (Table X) was 11.38±.035 for all males and 11.46±.033 for all females. Calves were used in this analysis only when there were both males and females dropped from the same age dam within year and location. The advantage of 0.08±.003 grade in favor of the females, according to the method of scoring calves for type grade (Table XVI), represents about one-tenth of one-third of a full grade. The slight advantage in weaning type grade observed for females may possibly be accounted for by the effect of condition on subjective evaluation of type grade since the female calves averaged

0.8 grade higher in condition (Table XV). The type grade for Angus calves (Table X) was slightly higher than that for Hereford calves. The mean type grade was 11.31 for Hereford males and 11.68 for Angus males. The type grade was 11.41 for Hereford females and 11.63 for Angus females.

The effect of age of dam on type grade as shown by analysis of variance (Table XIII) was significant (P = 0.01). Calves from 2, 11, 12, 13, and 14-year-old dams graded approximately one-sixth of a full grade lower than calves from cows 3 to 10 years of age (Table XI). Average grades of calves from cows 3 to 10 years of age varied irregularly with no consistent trend although grades tended to be slightly higher for 7 and 8-year-old cows.

For condition grade there was a highly significant (P = 0.10) effect for age of dam. Condition grades increased with increasing age of dam up to 4-year-old dams, and then remained fairly constant to 13-year-old dams. Sex had a highly significant (P = 0.10) effect on condition grade. Female calves had a consistent advantage over the males for all ages of dams. The mean condition grade (Table XIV) at all stations was 9.86 for the females and 9.04 for the males, an advantage of 0.82 grade for the females. Angus calves had a slightly higher mean condition grade than did the Hereford calves. The Angus males (Table XIV) graded 10.04 and the females 10.69 as compared to 8.84 for the Hereford males and 9.70 for the females.

SUMMARY

Influence of age of dam and sex of calf on average daily gain, birth weight, condition grade, and type grade was studied. Cattle from eight locations in Tennessee were included in the study. There were 2,601 calves from cows at all locations useable for this study. The actual numbers used in each analysis varied according to the requirements for statistical analysis, deaths, and missing information.

The average birth weights for calves from the cow herds at all stations was 69.7 pounds for males and 65.4 pounds for females with a difference of 4.3 pounds in favor of the males. Data for Hereford and Angus birth weights were analyzed separately and results showed that the Hereford males outweighed the Angus males by 4.7 pounds while the Hereford females had an advantage of 5.3 pounds over the Angus females. Analysis of variance of birth weights at all locations indicated highly significant effects for sex and age of dam. Birth weights of calves gradually increased up to 4 years of age for dams and were erratic for cows above that age with no consistent trend.

Results of this study showed that males had a significantly higher average daily gain than did females. The mean average daily gain for males from all locations was 1.59 pounds and 1.49 pounds for females. This was a difference of 0.10 pounds or approximately 7 per cent advantage for the males.

Angus calves with an average daily gain of 1.64 pounds for the males and 1.51 pounds for the females had a higher average daily gain than the Hereford calves with 1.57 pounds for the males and 1.48 pounds for the females.

Dams from 6 to 10 years of age produced calves with the highest average daily gains. Results of this study indicate that to adjust 2-year-old dams calves to an 8-year-old dam basis, 0.23 pounds must be added to the average daily gain of the calves. An addition of 0.16, 0.10, 0.06, 0.03, and 0.01 pounds must be added to the records of calves from 3, 4, 5, and 6-year-old dams, respectively. To 9, 10, 11, 12, and 13-year-old dams, 0.01, 0.02, 0.05, 0.09, and 0.14 pounds, respectively, must be added to adjust to an 8-year-old basis. A percentage correction factor also was calculated to correct for age of dam. To correct gains of calves to an 8-year-old dam basis, the following percentage of the average daily gain would be added: 2-year-olds, 16.0; 3-year-olds, 10.6; 4-year-olds, 6.4; 5-year-olds, 3.7; 6-year-olds, 1.8; 7-year-olds, 0.6; 9-year-olds, 0.6; 10-year-olds, 1.2; 11-year-olds, 3.1; 12-year-olds, 5.7; and 13-year-olds, 9.2.

The results of this study indicated that there was very little sex effect on type grade at weaning. The mean type grade for males from all locations was 11.38 and 11.46 for females. Age of dam effects on type grades were significant with calves from 2-year-old cows and cows 11 years of age and older grading lower than calves from cows 3 to 10 years of age.

Females had a definite advantage over males for condition grade at weaning. The mean condition grade for females was 9.86, and for males it was 9.04. This was an advantage of 0.82 grade for the females and was highly significant. Dams between the ages of 4 and 7 years tended to produce calves with the highest condition grade. Condition grades of calves increased up to 4 years of age for dam and gradually decreased after 7 years of age.

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APPENDIX

TABLE I

INFLUENCE OF SEX ON BIRTH WEIGHT FOR CALVES FROM VARIOUS LOCATIONS[a]

Location	Males		Females		Difference
	No.	Av. wt.	No.	Av. wt.	
		Hereford			
		(pounds)		(pounds)	(pounds)
Oak Ridge	385	73.4	391	68.6	4.8
Alcoa	417	67.3	359	64.2	3.1
Springfield	38	77.4	32	69.3	8.1
Greenville	89	71.8	94	67.3	4.5
Spring Hill	75	68.4	73	63.0	5.4
Knoxville	36	66.2	49	62.4	3.8
Total	1040	70.4	998	66.2	4.2
		Angus			
Knoxville	44	63.8	43	57.4	6.4
Crossville	150	66.3	127	61.9	4.4
Total	194	65.7	170	60.9	4.8
Combined (H&A)	1234	69.7	1168	65.4	4.3

[a]Calves were included in this analysis only when there were male and female calves dropped from the same age dam within year and location. Birth weights within age of dam, year, and location were weighted according to $\frac{n_1 n_2}{n_1+n_2}$, where n_1 = number of males and n_2 = number of females.

TABLE II

INFLUENCE OF SEX ON BIRTH WEIGHT FOR CALVES FROM COWS OF VARIOUS AGES[a]

Age of cow	Males		Females		Av. difference
	No. of calves	Av. birth weight	No. of calves	Av. birth weight	
(years)		(pounds)		(pounds)	(pounds)
2	109	65.8	128	61.5	4.3
3	253	68.6	247	63.8	4.8
4	260	70.2	201	66.9	3.3
5	181	69.4	160	64.4	5.0
6	110	69.6	121	66.0	3.6
7	55	70.4	50	66.7	3.7
8	74	68.9	76	65.3	3.6
9	57	72.0	68	68.4	3.6
10	48	71.2	51	63.4	7.8
11	48	70.9	32	65.4	5.5
12	21	69.1	15	69.1	0.0
13	11	73.4	7	70.0	3.4
14	4	62.9	8	66.8	-3.9
Total	1231	69.6	1164	65.4	4.2

[a]Calves were included in this analysis only when there were calves dropped from the same age dam within year and station. Birth weights were not taken at all stations in all years. Birth weights within age of dam, year, and station were weighted according to $\frac{n_1 n_2}{n_1+n_2}$, where n_1 = number of males and n_2 = number of females.

TABLE III

INFLUENCE OF AGE OF DAM ON BIRTH WEIGHT
ADJUSTED TO MALE BASIS

Age of dam	Number of calves	Av. sex adjusted birth weight[a]
(years)		(pounds)
2	237	65.7
3	500	68.3
4	461	70.6
5	341	69.0
6	231	69.9
7	105	70.6
8	150	69.2
9	125	72.3
10	99	69.3
11	80	70.4
12	36	70.8
13	18	73.7
14	12	68.3

[a]Birth weights of females were adjusted to male basis by adding 4.2 pounds.

TABLE IV

INFLUENCE OF SEX ON AVERAGE DAILY GAIN FOR CALVES FROM VARIOUS LOCATIONS

Location	Males		Females		Difference
	No.	Av. daily gain	No.	Av. daily gain	
		Hereford			
		(pounds)		(pounds)	(pounds)
Oak Ridge	401	1.64	461	1.54	0.10
Alcoa	350	1.58	311	1.47	0.11
Springfield	28	1.48	25	1.60	-0.12
Greenville	80	1.50	79	1.40	0.10
Spring Hill	58	1.36	58	1.26	0.10
Knoxville	27	1.27	25	1.42	-0.15
Total	944	1.57	959	1.48	0.09
		Angus			
Knoxville	30	1.62	33	1.45	0.17
Crossville	132	1.77	133	1.61	0.16
Ames	86	1.47	78	1.38	0.09
Total	248	1.64	244	1.51	0.13
Combined (H&A)	1192	1.59	1203	1.49	0.10
Standard error		±0.009		±0.008	±0.012

[a]Calves were included in this analysis only when there were male and female calves dropped from the same age dam within year and location. Average daily gains within age of dam, year, and location were weighted according to $\frac{n_1 n_2}{n_1+n_2}$, where n_1 = number of males and n_2 = number of females.

TABLE V

INFLUENCE OF SEX ON AVERAGE DAILY GAIN FOR CALVES FROM COWS OF VARIOUS AGES[a]

Age of cow	Males		Females		Av. difference
	No. of calves	Av. of daily gain	No. of calves	Av. of daily gain	
(years)		(pounds)		(pounds)	(pounds)
2	100	1.39±.03	137	1.34±.02	0.05
3	240	1.52±.02	253	1.42±.02	0.10
4	254	1.59±.02	194	1.50±.02	0.09
5	158	1.61±.03	148	1.51±.02	0.10
6	104	1.72±.03	119	1.56±.02	0.16
7	65	1.73±.02	63	1.57±.04	0.16
8	74	1.67±.04	88	1.56±.04	0.11
9	59	1.66±.05	69	1.56±.02	0.10
10	51	1.57±.05	62	1.44±.04	0.13
11	46	1.66±.04	32	1.49±.04	0.17
12	21	1.68±.07	19	1.55±.08	0.13
13	13	1.72±.11	8	1.61±.02	0.11
14	5	1.62±.08	8	1.75±.11	-0.13
Total	1190	1.59±.009	1200	1.49±.008	0.10±.012

[a]Calves were included in this analysis only when there were calves dropped from the same age dam within year and station. Average daily gains within age of dam, year, and station were weighted according to $\frac{n_1 n_2}{n_1+n_2}$, where n_1 = number of males and n_2 = number of females.

TABLE VI

DIFFERENCES IN AVERAGE DAILY GAINS OF CALVES FOR SUCCESSIVE AGES OF COWS[a]

Ages of cows	Difference
	(pounds)
3-2	.101
4-3	.053
5-4	-.010
6-5	.058
7-6	.056
8-7	-.025
9-8	-.024
10-9	.004
11-10	-.017
12-11	-.017
13-12	-.104

[a]Estimated on a within station and year basis. Daily gain of all calves were adjusted to a male basis.

TABLE VII

INFLUENCE OF AGE OF DAM ON AVERAGE DAILY GAIN

Age of dam	Estimate based on accumulative differences between successive ages of cows	Estimate from curvilinior regression equation[a]	Percentage correction factor[b]
(years)	(pounds)	(pounds)	
2	0.258	0.23	16.0
3	0.157	0.16	10.6
4	0.104	0.10	6.4
5	0.114	0.06	3.7
6	0.056	0.03	1.8
7	0.000	0.01	0.6
8	0.025	0.00	0.0
9	0.049	0.01	0.6
10	0.045	0.02	1.2
11	0.062	0.05	3.1
12	0.079	0.09	5.7
13	0.183	0.14	9.2

[a] $\hat{Y} = -.155410 + .096312X_1 - .005916X_2$

[b] Based on a sex adjusted average daily gain of 1.67 pounds for calves from mature dams (8 years).

TABLE VIII

MEANS AND WITHIN YEAR MEAN SQUARES AND STANDARD DEVIATIONS OF DAILY GAINS AT THE VARIOUS LOCATIONS[a]

Location	Av. daily gain		Degrees of freedom	Within year mean squares	Standard deviation
	Males	Females			
	(pounds)	(pounds)			
Oak Ridge	1.64	1.54	855	0.106	0.33
Alcoa	1.58	1.47	672	0.045	0.21
Springfield	1.48	1.60	85	0.062	0.25
Greenville	1.50	1.40	160	0.051	0.23
Spring Hill	1.36	1.26	132	0.074	0.27
Knoxville	1.54	1.44	159	0.116	0.34
Crossville	1.77	1.61	332	0.064	0.25
Ames	1.47	1.38	167	0.111	0.33
Total	1.59	1.49	2562	0.079	0.28

[a]All calves that were weaned at each location were included in this analysis.

TABLE IX

ANALYSIS OF VARIANCE OF DAILY GAIN FOR CALVES AT ALL LOCATIONS[a]

Source	Degrees of freedom	Sums of squares	Mean square	F
Total	2600	260.53		
Age of dam	12	18.45	1.547	16.92*
Sex	1	5.30	5.300	58.92*
Within sub-classes	2587	236.78	0.092	

[a]All calves at the various locations that were weaned were included in this analysis.

*P = < .01

TABLE X

INFLUENCE OF SEX ON TYPE GRADE FOR CALVES FROM VARIOUS LOCATIONS[a]

Location	Males		Females		Difference
	No.	Grade	No.	Grade	
		Hereford			
Oak Ridge	401	10.74	461	10.80	-0.06
Alcoa	316	11.86	269	11.98	-0.12
Springfield	28	11.14	25	11.94	-0.80
Greenville	80	11.63	79	11.84	-0.21
Spring Hill	49	10.68	52	10.91	-0.23
Knoxville	15	11.86	18	10.58	0.28
Total	889	11.31	904	11.41	-0.10
		Angus			
Knoxville	18	11.11	21	11.49	-0.38
Crossville	132	12.04	133	12.03	0.01
Ames	33	10.62	30	10.02	0.60
Total	183	11.68	184	11.63	0.05
Combined (H&A)	1072	11.38	1088	11.46	-0.08
Standard error		±0.035		±0.033	±0.003

[a]Calves were included in this analysis only when there were male and female calves dropped from the same age dam within year and location. Type grades within age of dam, year, and location were weighted according to $\frac{n_1 n_2}{n_1+n_2}$, where n_1 = number of males and n_2 = number of females.

TABLE XI

INFLUENCE OF SEX ON TYPE GRADE FOR CALVES FROM COWS OF VARIOUS AGES[a]

Age of cow	Males		Females		Av. difference
	No. of calves	Av. type grade	No. of calves	Av. type grade	
(years)					
2	87	10.8±.18	123	10.9±.05	-0.1
3	240	11.4±.09	228	11.2±.09	0.2
4	227	11.3±.09	198	11.5±.08	-0.2
5	129	11.4±.08	115	11.5±.11	-0.1
6	93	11.4±.06	111	11.4±.14	0.0
7	64	11.7±.15	58	11.6±.15	0.1
8	61	11.3±.11	75	11.9±.08	-0.6
9	51	11.0±.19	59	11.4±.16	-0.4
10	44	11.3±.26	59	11.5±.16	-0.2
11	40	10.7±.24	27	11.0±.27	-0.3
12	19	10.7±.43	15	10.8±.27	-0.1
13	10	10.8±.36	7	11.2±.52	-0.4
14	3	10.9±.29	7	10.7±.64	0.2
Total	1068	11.3±.035	1082	11.4±.033	-0.1±.003

[a]Calves were included in this analysis only when there were calves dropped from the same age dam within year and station. Type grades within age of dam, year, and station were weighted according to $\frac{n_1 n_2}{n_1+n_2}$, where n_1 = number of males and n_2 = number of females.

TABLE XII

MEANS AND WITHIN YEAR MEAN SQUARES AND STANDARD DEVIATIONS OF TYPE GRADE AT THE VARIOUS LOCATIONS[a]

Location	Av. type grade		Degrees of freedom	Within year mean squares	Standard deviation
	Males	Females			
Oak Ridge	10.74	10.80	892	1.271	1.13
Alcoa	11.86	11.98	581	1.378	1.17
Springfield	11.14	11.94	82	1.466	1.21
Greenville	11.63	11.84	159	1.757	1.32
Spring Hill	10.68	10.91	121	1.849	1.36
Knoxville	11.40	12.00	90	4.477	2.12
Crossville	12.04	12.03	321	0.903	0.95
Ames	10.62	10.02	64	2.559	1.60
Total	11.38	11.46	2310	1.478	1.22

[a]All calves at the various locations that were graded for type at weaning were included in this analysis.

TABLE XIII

ANALYSIS OF VARIANCE OF TYPE GRADE FOR CALVES AT ALL LOCATIONS[a]

Source	Degrees of freedom	Sums of squares	Mean square	F
Total	2310	4079.45		
Age of dam	12	102.23	8.519	4.92*
Sex	1	2.78	2.780	1.61
Within sub-classes	2297	3974.44	1.730	

[a]All calves at the various locations that were graded for type at weaning were included in this analysis.

*P = < .01

TABLE XIV

INFLUENCE OF SEX ON CONDITION GRADE FOR CALVES FROM VARIOUS LOCATIONS[a]

Location	Males		Females		Difference
	No.	Grade	No.	Grade	
		Hereford			
Oak Ridge	352	8.62	396	9.58	-0.96
Alcoa	316	9.31	269	10.20	-0.89
Springfield	28	8.13	25	9.92	-0.79
Greenville	80	9.37	79	10.14	-0.77
Spring Hill	49	7.00	52	7.19	-0.19
Knoxville	15	9.26	18	8.05	0.81
Total	840	8.84	839	9.70	-0.86
		Angus			
Knoxville	18	8.80	21	10.32	-1.52
Crossville	132	10.40	133	11.12	-0.72
Ames	33	9.30	30	9.19	0.11
Total	183	10.04	184	10.69	-0.65
Combined (H&A)	1023	9.04	1023	9.86	-0.82

[a]Calves were included in this analysis only when there were male and female calves dropped from the same age dam within year and location. Condition grades within age of dam, year, and location were weighted according to $\frac{n_1 n_2}{n_1+n_2}$, where n_1 = number of males and n_2 = number of females.

TABLE XV

INFLUENCE OF SEX ON CONDITION GRADE FOR CALVES FROM COWS OF VARIOUS AGES[a]

Age of cow	Males		Females		Av. difference
	No. of calves	Av. cond. grade	No. of calves	Av. cond. grade	
(years)					
2	85	8.4	120	8.9	-0.5
3	231	8.8	228	9.6	-0.8
4	215	8.9	167	10.2	-1.3
5	120	9.5	111	10.0	-0.5
6	93	9.1	111	10.0	-0.9
7	64	9.9	58	10.1	-0.2
8	57	9.4	70	10.0	-0.6
9	42	9.2	42	10.0	-0.8
10	44	9.2	59	9.8	-0.6
11	36	8.7	24	10.0	-1.3
12	19	9.0	15	10.2	-1.2
13	10	8.1	7	9.7	-1.6
14	3	7.5	7	8.2	-0.7
Total	1019	9.0	1019	9.8	-0.8

[a]Calves were included in this analysis only when there were calves dropped from the same age dam within year and station. Condition grades within age of dam, year, and station were weighted according to $\frac{n_1 n_2}{n_1 + n_2}$, where n_1 = number of males and n_2 = number of females.

TABLE XVI

METHOD OF SCORING FOR TYPE AND CONDITION GRADES AT WEANING

Type		Condition		Legend	
Symbol	Number	Symbol	Number		
HF	17	HP	17	F	= Fancy
F	16	P	16	P	= Prime
LF	15	LP	15	C	= Choice
HC	14	HC	14	G	= Good
C	13	C	13	M	= Medium
LC	12	LC	12	Co.	= Common
HG	11	HG	11	Com.	= Commercial
G	10	G	10	Ut.	= Utility
LG	9	LG	9	Cut.	= Cutter
HM	8	HCom.	8	Can.	= Canner
M	7	Com.	7		
LM	6	LCom.	6	H	= High
HCo.	5	HUt.	5	L	= Low
Co.	4	Ut.	4		
LCo.	3	Lut.	3		
		Cut.	2		
		Can.	1		

Mean Birth Weights for Calves from all Stations

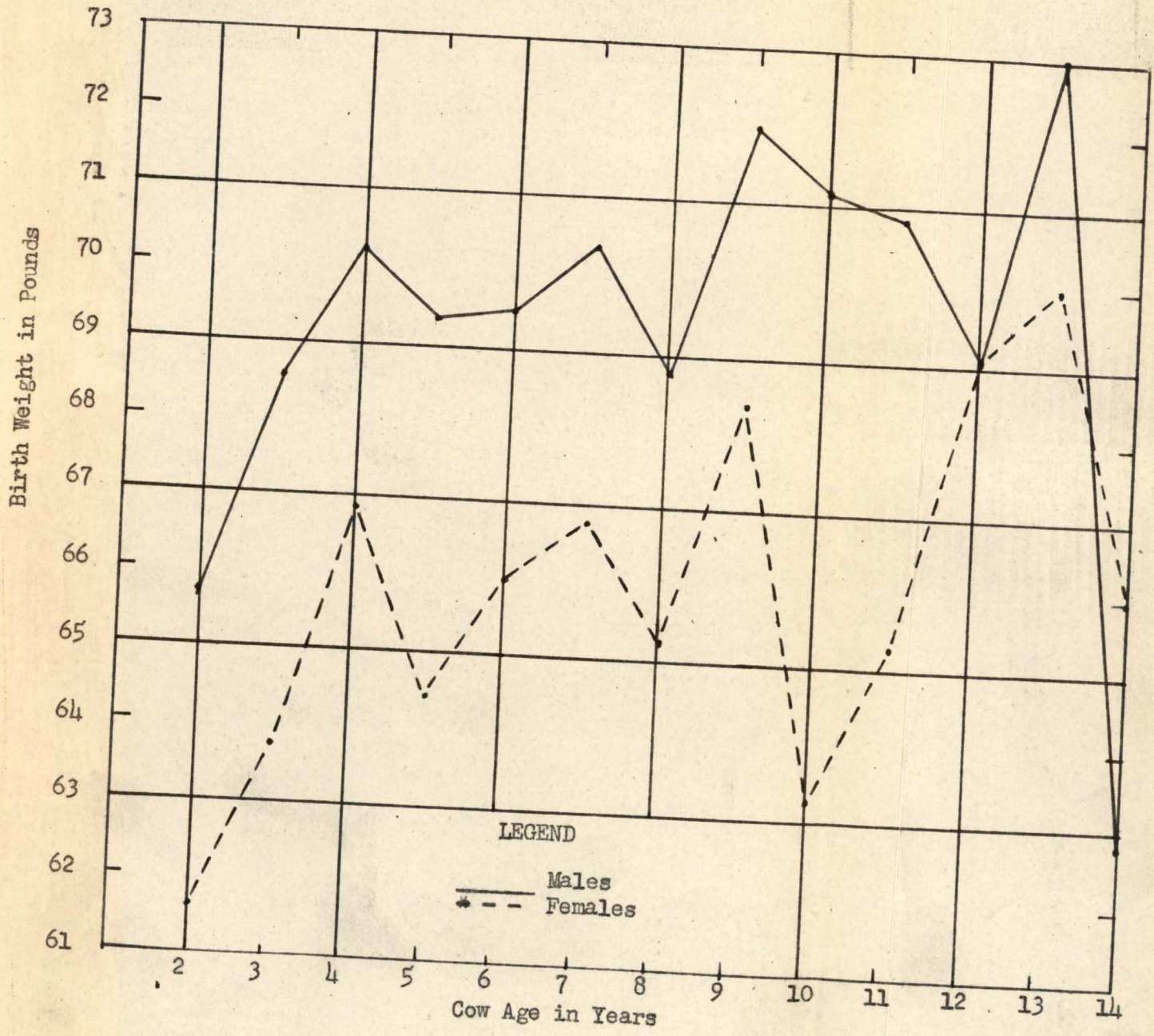

Figure 1

Mean Average Daily Gain for Calves From All Stations

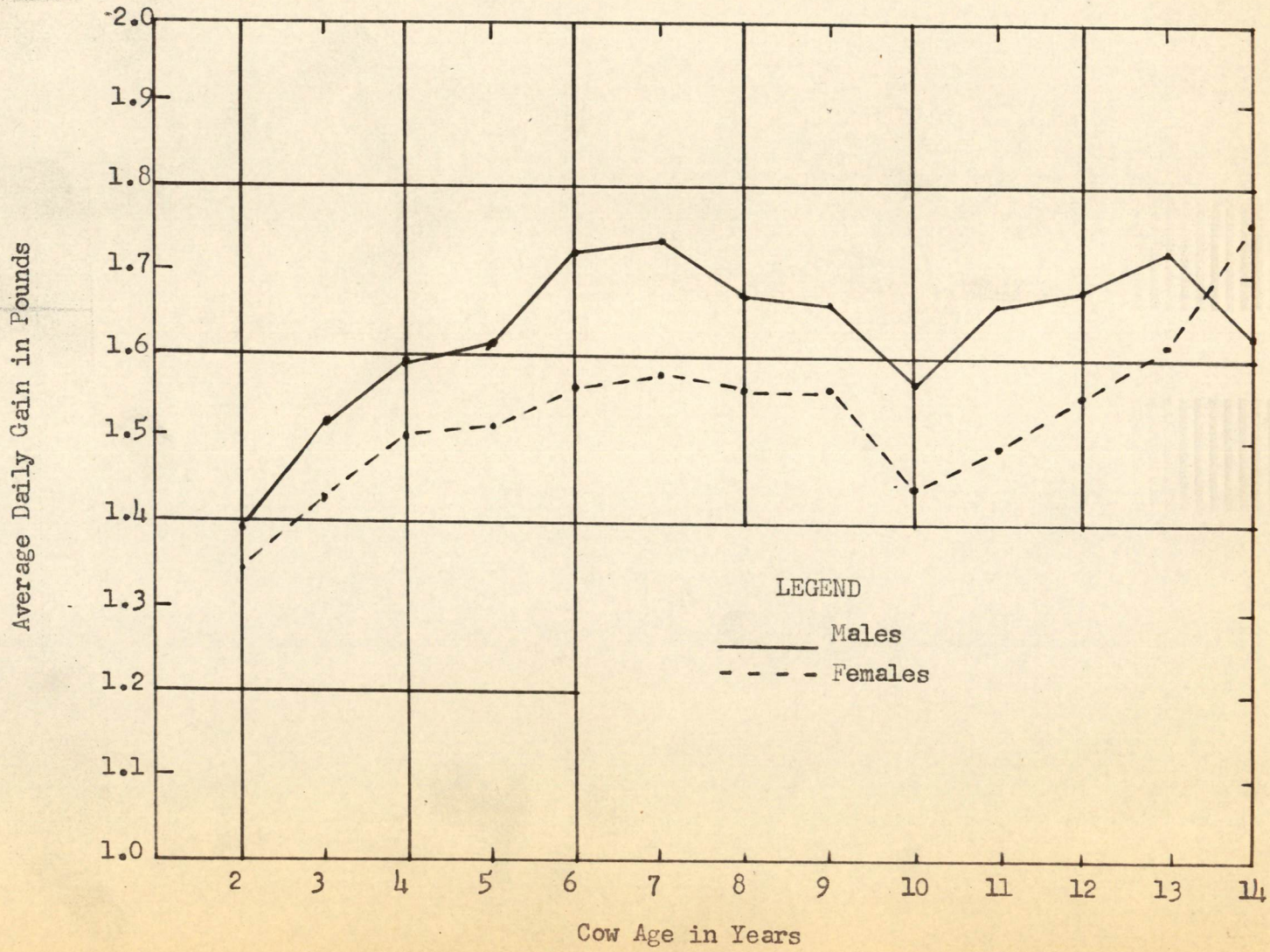

Figure 2

Influence of Age of Cow on Daily Gain of Offspring

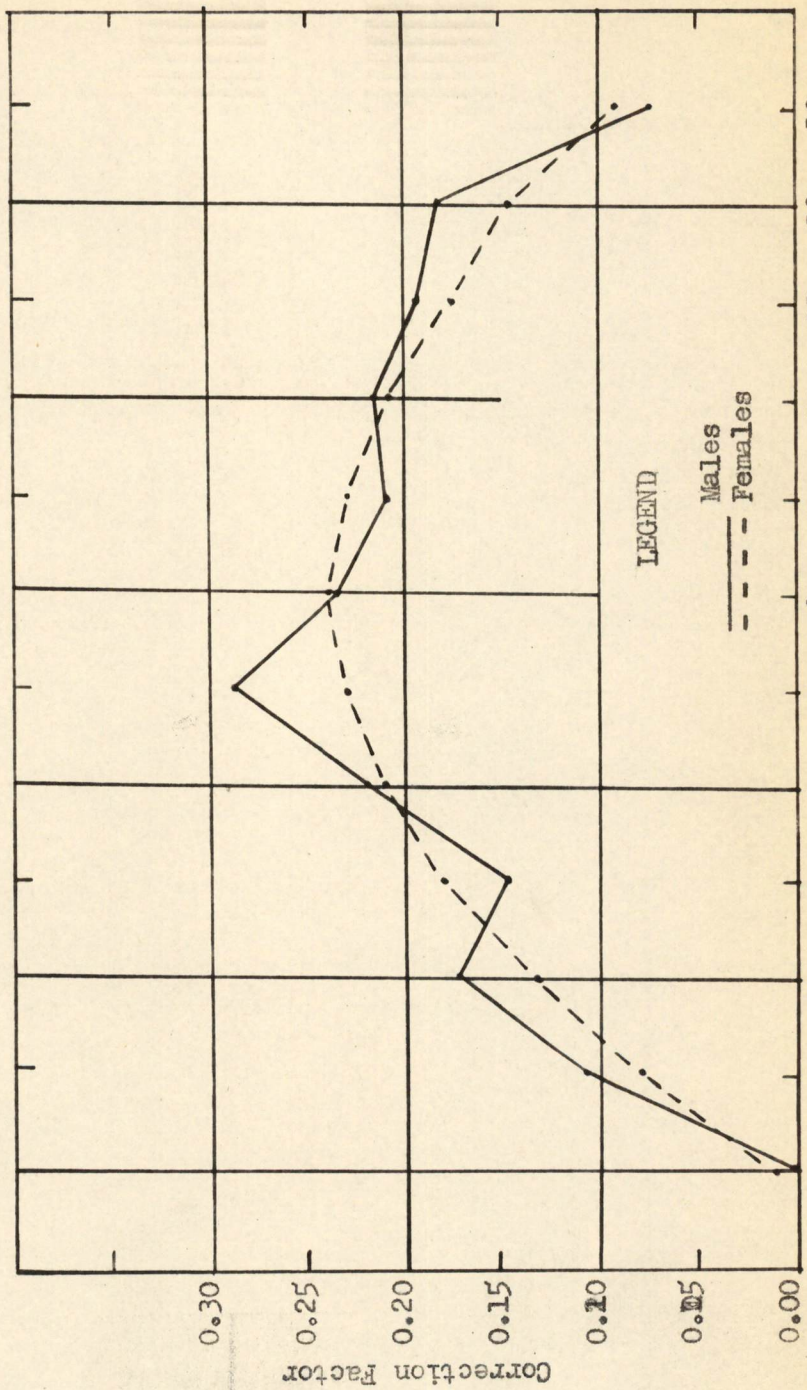

Figure 3

Mean Type Grade for Calves at Weaning from all Stations

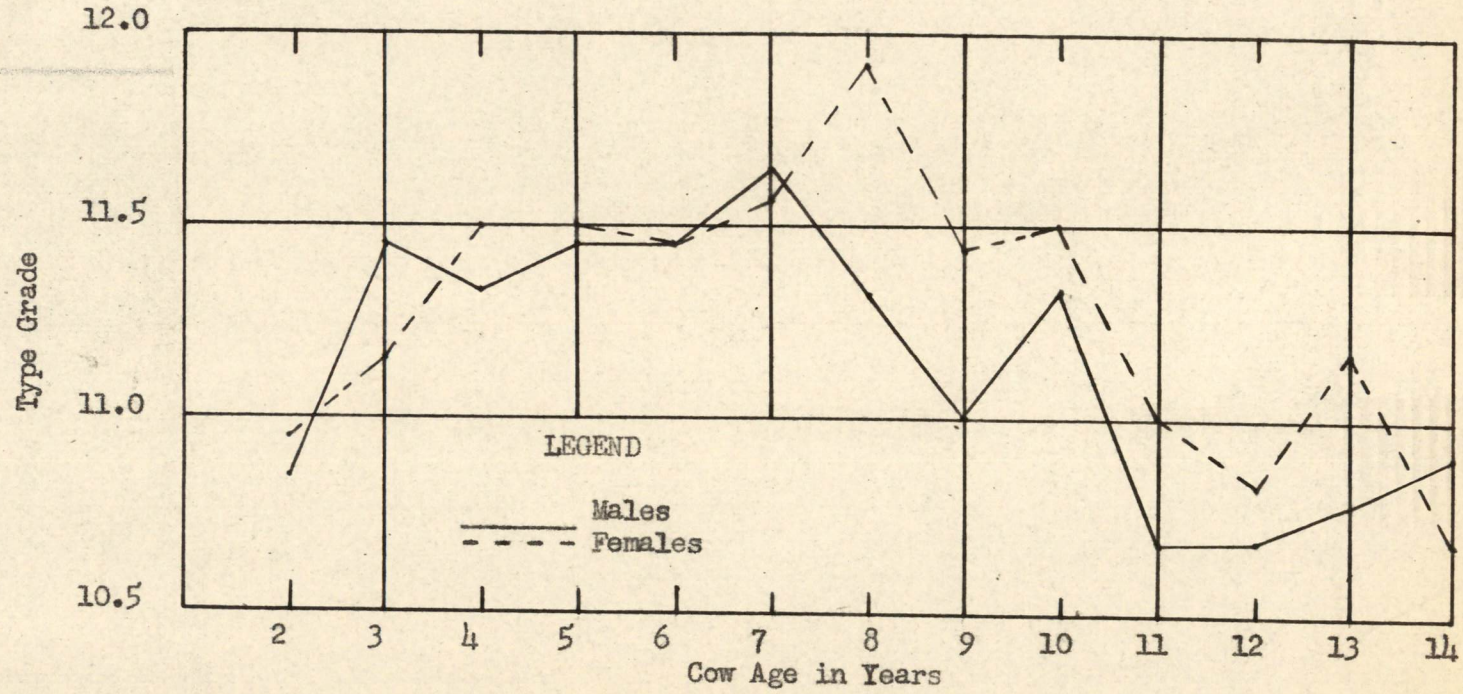

Figure 4

Mean Condition Grade for Calves at Weaning
From All Stations

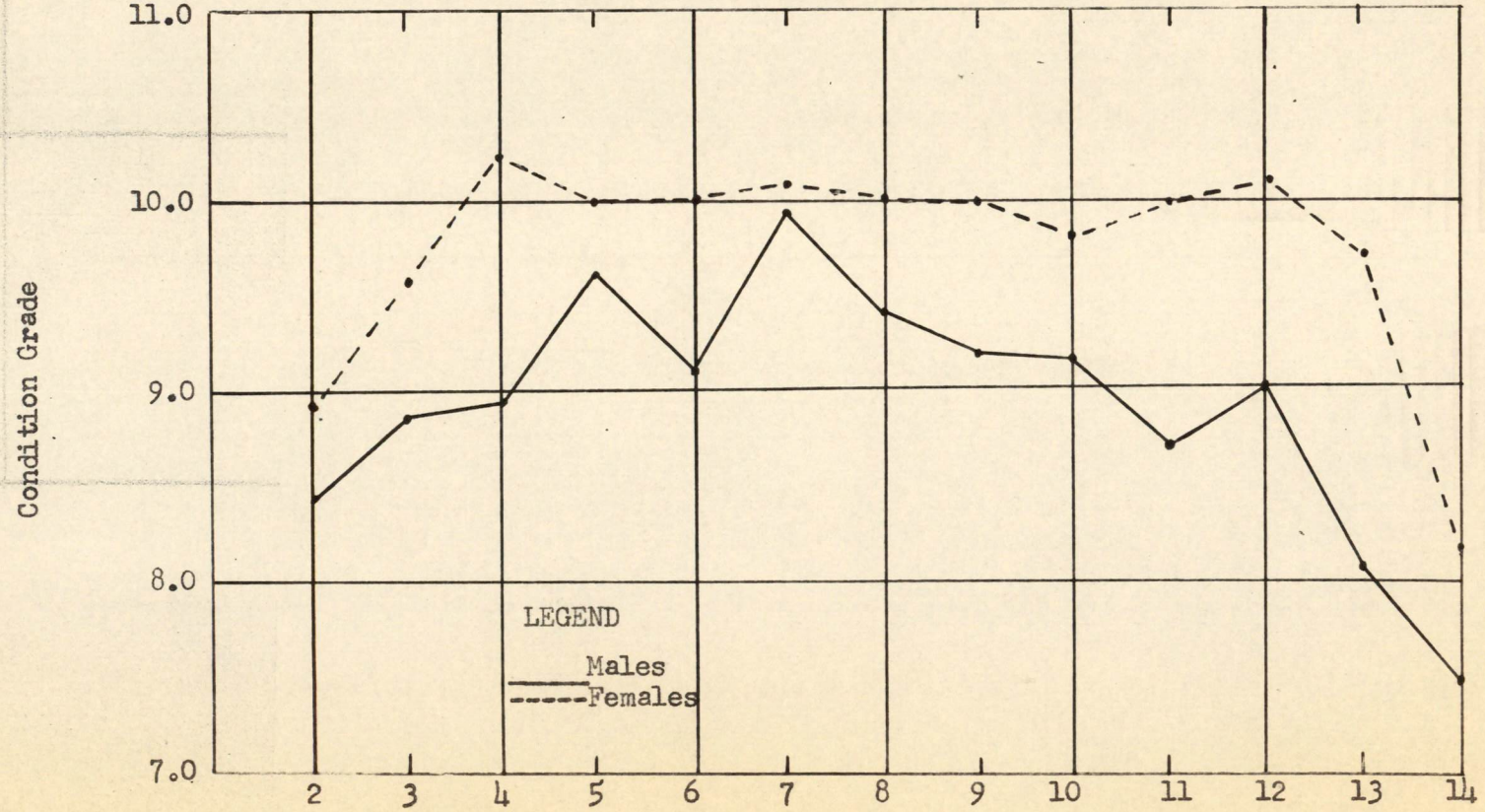

Figure 5