THE INFLUENCE OF DAY OF BIRTH ON
WEANING WEIGHT IN BEEF CATTLE

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INTRODUCTION

Preweaning growth indicates the genetic growth potential of the calf and mothering or nursing ability of the cow. Calf weaning weight is about .30 heritable and of major economic importance. Measuring preweaning growth by average daily gain of the calf is one method of evaluating his genetic growth potential and the productivity of beef cows. Birth weights, weaning weights and average daily gain have been used as methods of indicating preweaning growth. Measuring genetic growth potential of calves by any of these methods is complicated by a number of sources of environmental variations. Weaning weights are influenced by the age of calf, age of dam, management systems, sex of calf, years, and time of birth within years.

Two methods of reducing environmental variation are available to the breeder. One is physical control of the environment and the other more practical one is statistical control using adjustments for known sources of variation. Evidence exists that season of birth has an effect on preweaning growth.

This study was initiated to determine if day of birth within the spring season has any appreciable association with preweaning growth in calves. If so, should 205 day adjusted weaning weights in a spring calving program be further adjusted for day of birth within years, or should an adjustment common to all years be used?

REVIEW OF LITERATURE

DAY OF BIRTH

The effect of season and month of birth on weaning weight of calves has been reported by several studies. A search of the literature revealed no reports on the day of birth influence on weaning weight within a given season or month. A review of studies done in this country is presented first followed by results reported from foreign countries. Reports of interaction of age of dam with season of birth and year with season of birth are listed last in this review.

Nelms and Bogart (1956) studied the effect of time of birth in 20 day periods with spring born calves and their results indicated that early calves gained at a faster rate than calves born later even though the breeding season was restricted to 90 days. Month of birth differences on preweaning growth have been reported by Clum (1956), Reynolds et al. (1958), Marlowe (1962), Thrift (1964) and Cundiff (1966). Seasonal effects of preweaning growth were reported by Marlowe and Gaines (1958), Vernon et al. (1964), Loganathan et al. (1965), and Brown (1961).

Research done in foreign countries also indicates seasonal influences on preweaning growth as reported by Lawson and Peters (1964), Ragab and El-Salam (1962), Haiger (1964), Neiman and Heydenrych (1965), and Donaldson and Larkin (1963).

Brown (1961) reported fall calves lighter than spring calves and less seasonal differences in the herd which had a higher level of nutrition. His work also indicated a consistent increase in the difference between fall and spring calves up to 180 days then a decline to 240 days in the herds which had a lower level of nutrition. His results indicated season by management and season by age of calf interactions.

Marlowe and Gaines (1958) analyzed data from 4,166 noncreep-fed and 2,007 creep-fed calves in the Virginia performance testing program over a four year period 1953-56 inclusive. Approximately 75 percent of the calves in this study were purebred and dropped in all seasons of the year. Noncreep-fed calves born during June through December grew about 0.1 pound per day slower than those born February through May. All calves were pooled into these two season groups and a six percent correction factor was applied to the second group to adjust them to the first group. To check the reliability of the estimates obtained in this study they were used to adjust average daily gains of 3,147 noncreep-fed calves weighed in 1957. The six percent correction applied to the June to December calves to adjust them to the January through May season of calving was not large enough to equalize these groups.

Rollins and Guilbert (1954) reported seasonal variation in weaning weights which were grouped in seasons by the way the cow herd was fed. Highest weaning weights of calves were from those born in the spring and lowest for those born in the fall.

Reynolds *et al*. (1958) reported that weaning weights of calves in Florida born during the months of April, May and June were lighter than the average of calves born during January, February and March.

Vernon *et al*. (1964) found that seasonal differences among least squares means of 180 day weights were highly significant for Brahman-Angus and for the Africander-Angus breed groups studied.

Neville (1955) reported that for each day later in the winter calving season that birth occurred, calves weighed 0.3 pound more at four months of age. The apparent adverse effect of early environment was not permanent since it was negligible and non-significant by eight months of age.

Koch and Clark (1955) reported that regression of rate of gain on weaning age was -.04 pounds per day which was not significant. This indicates that calves born early in the season did not grow quite as rapidly as calves born later.

Swiger *et al*. (1962) reported a quadratic effect of age of calf on gain from 130 days to weaning. They stated that seasonal environmental effects confounded with growth curves of the calves may introduce bias when adjusting weaning weight for the regression of weight on age. Their study indicated that computing gain during the first 130 days and last 70 days of the suckling period separately, adjusting gains made in the last period for age, and combining these with birth weight would be the most accurate appraisal of weaning weight. The simpler procedure of adjusting weaning weight to a standard 200 day age by subtracting birth weight from weaning weight and dividing the difference by days of age then multiplying by 200 and adding the birth weight was correlated nearly perfectly (0.99) with this more complex procedure.

Marlowe (1962) studied data collected from Virginia B.C.I.A. performance testing program. These results demonstrate that the month in which calves are born had a large influence on preweaning gain. Over 21,000 calf records were summarized to determine the effectiveness of the growth adjustment factors used in the Virginia B.C.I.A. program in equalizing the subgroup means. The results show that calves born from June through October had lower daily gain than calves born in the other months.

Thrift (1964) studied data from 28,493 calves in the Georgia B.C.I.A. for the years of 1958 to 1964 inclusive. The mean weaning weight and age of the calves were 403 pounds and 212 days respectively. Less than 2.5 percent of all the calves were born in June, July, and August so calves born in these months were excluded from the analysis. Results of this study indicated September calves were lightest and February calves heaviest. November, January, February and March calves were comparable in weaning weight and heavier than December, April and October calves.

Cundiff (1966) studied calf records obtained from 13,937 Hereford and Angus calves in the Oklahoma Beef Cattle Improvement Program from 1959 through 1962. His results indicated that month of birth had an important influence on weaning weights of calves raised in Oklahoma. Analysis indicated that the effect of month of birth is dependent on type of pasture utilized (native or improved). Interaction was also present between month of birth and whether or not the calves were creep-fed.

Loganathan et al. (1965) analyzed the records of 471 purebred and 196 grade Hereford calves, born during the months of January to April. Average daily gains were studied from birth to weaning, birth to the month of July and from July to weaning. They found that the effect of the month of birth on average daily gain was larger for the period from birth to weaning than from birth to July, however, year to year differences were considerable for the two periods.

Marlowe et al. (1965) studied records from 17,294 Angus and 11,663 Herefords in the Virginia Beef Cattle Improvement Association during 1957 through 1962. Least squares estimates of the effects of sex, age, month of birth, year of record, age of dam and weaning were obtained by breed group and creep-fed or noncreep-fed groups separately. Least squares estimates of the effects of month of birth on gain indicate that season or month has an important effect on average daily gain with March, April and May born calves being the fastest gainers.

Lawson and Peters (1964) analyzed data collected between 1957 and 1960 on 219 calves of Highland and Hereford breeds and their reciprocal crosses. Birth weights and weaning weights of the calves were significantly affected by date of birth.

Ragab and El-Salam (1962) studied data on 109 male and 126 female Egyptian cattle. Month of calving significantly affected body weight of cattle at four and six months in male calves and twelve months in female calves.

Haiger (1964) studied data from 11,000 bull calves and 12,000 heifer calves from dual purpose breeds. The growth rate of bulls born in March to July was greater than that of bulls born in other months. The growth rate of heifers was not affected by season of birth.

Neiman and Heydenrych (1965) studied data on preweaning performance of two groups consisting of 173 and 448 calves representing all Africanders. Birth weight was significantly correlated with the date of birth (0.65), the weight increasing by 0.33 pounds for each week that the date of birth was later than October 1. A large percentage of the total variation in weaning weight was accounted for by season of birth.

Donaldson and Larkin (1963) studied the growth from birth to weaning of beef calves in coastal northern Queensland. Crossbred calves born in the dry season (July to September) grew faster than those born in the wet season (January to March). The overall highest average adjusted weaning weight (382 pounds) was found in calves born in July and the lowest (294 pounds) in February calves.

<u>Interaction with Season of Birth</u>. Cooper <u>et</u> <u>al</u>. (1965) published results indicating an age-of-dam by season interaction. Nelms and Bogart (1956) studied age of dam effects in a 90 day breeding season. Their results indicated two year old dams calving earlier in the season produced calves which gained better than those calving later. Cooper also reported a year by season and sex by season interaction.

Cundiff (1966) found no year by season of birth interaction in his analysis.

MATERIALS AND METHODS

The data used in this study were records from 914 purebred Hereford calves from the years 1951 to 1965 inclusive and 459 purebred Angus calves from the years 1951 to 1962 inclusive from the Fort Reno Livestock Research Station. These calf records were a part of project 670 which was designed to study "Improvement of Beef Cattle by the Application of Breeding Methods."

The cow herds for this experiment were on native grass from March 10 until fall at which time they were placed on wheat pasture until the following March. Cows received supplemental hay on wheat pasture, when needed, and alfalfa hay from March 10 to April 10 from 1951 to 1960. From 1960 until 1965 cows received $1\frac{1}{2}$ to 2 pounds cottonseed meal and $1\frac{1}{2}$ to 4 pounds of ground milo depending on the age and condition of the cow. Two year old cows received silage every other day in addition to protein and grain. From 1961 to 1965 long yearling heifers that were to calve in the spring were taken off wheat pasture in early January and put on native grass where they received $1\frac{1}{2}$ pounds of cottonseed meal and 1 to 2 pounds of ground milo per head per day plus alfalfa hay during severe weather. After calving these young cows received 2 pounds cottonseed meal and four pounds of ground milo per head per day until approximately April 10.

Wheat pasture conditions were poor in 1951 and 1956. In 1955 and 1956 the fall grass was good so cows received no supplemental feed until mid-winter.

At the beginning of this study the native pastures had been badly overgrazed and by controlled grazing the condition of the native grass has improved during the 15 years.

Severe weather which may have influenced weaning weights was encountered in the following years: 1952, very hot and dry summer; 1953, hot and dry summer; 1954, dry summer; 1956 most severe drouth and lack of subsoil moisture for grass; 1957, dry during July and August; 1960, cold weather in calving season with the first 12 days of February not getting above 32^{o}F. and many calving problems encountered; 1961, cold spring and lost several calves.

Changes which involved a substantial percentage of the cow herd occurred in 1958 when many of the small type Hereford cows were removed and in 1959 several Hereford cows were added from another herd. Changes in herdsmen handling these cows occurred in 1952, 1956, 1959, 1960, and 1963.

The calves were weighed and tattooed within 24 hours after birth and weighed at weaning. This analysis was restricted to calves born from January 1 to June 30 and weaned in October. (See Figure 1)

Weaning weights of the calves were adjusted for age, sex, and age of dam by following the procedure recommended

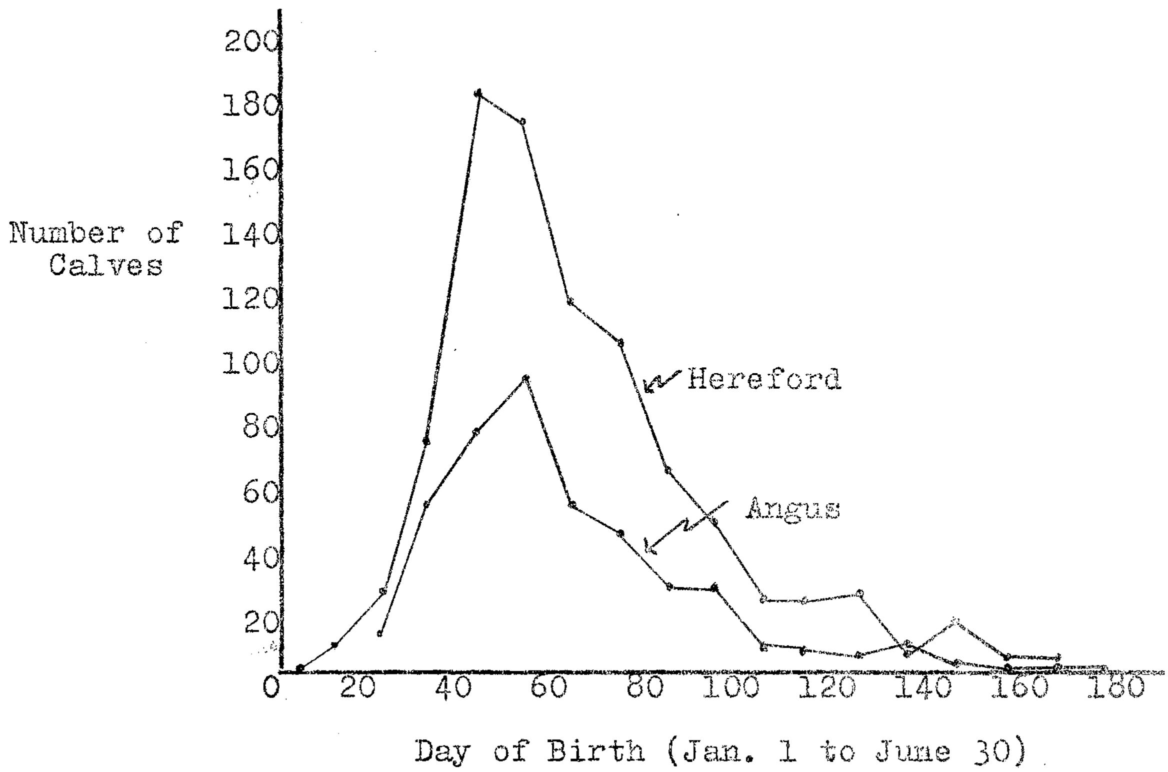

Figure 1. Frequency Polygon

by the United States Beef Cattle Improvement Committee (1965). Weaning weights were adjusted to a standard 205 day age by subtracting birth weight from weaning weight and dividing the difference by days of age then multiplying by 205 and adding the birth weight. Age of dam adjustments consisted of multiplying each calf's adjusted 205 day weaning weight by the following factor for the appropriate age of their dam: 1.15, two year old dam; 1.10, three year old dam; 1.05, four year old dam; no adjustment, five to ten year old dam; and 1.05 for eleven and older age of dam. Heifer and bull weaning weights were converted to a steer equivalent by multiplying their adjusted 205 day weight by 1.05 and 0.95 respectively.

The frequency polygon in Figure 1 indicates that the largest number of calves were born in February and March. The small number of calves born before the 20th day or after the 130th day does not give an adequate representation in this study of early and late calves but it does represent the normal spring calving pattern in a herd.

The data were analyzed by the Abbreviated Doolittle Method[1] using a regression model. All analyses were made within the two herds which were Hereford and Angus. The first analyses were made to study the association between weaning weight and day of birth common to all years after

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[1]This routine from the Computer Library was adapted for the IBM 7040 by Robert Easterling, Graduate Assistant, Mathematics and Statistics Department, Oklahoma State University.

the reduction due to the mean and year effects. This study was to determine the relationship between weaning weight and day of birth and if an adjustment common to all years should be made in weaning weights for calves with different days of birth in a spring calving program.

The following model was used:

$$Y_{ij} = \mu + a_i + B_1 (X_{ij} - \bar{X}_{i.}) + B_2 (X_{ij}^2 - \bar{X}_{i.}^2) + E_{ij}$$

Y_{ij} = weaning weight of the j^{th} calf in the i^{th} year adjusted to a 205 day standard age, mature dam and steer equivalent by standard procedures.

μ = the mean common to all observations.

a_i = is the effect of the i^{th} year as a deviation from the mean.

B_1 = linear regression of weaning weight on day of birth common to all years.

X_{ij} = day of birth of the j^{th} calf in the i^{th} year.

B_2 = quadratic regression of weaning weight on day of birth common to all years.

E_{ij} = random error.

In this Abbreviated Doolittle Method the sequence in which a component appears in the model may affect the reduction in sums of squares due to that component.

This results because the preceding components in the model are allowed to account for all the variation possible. The reduction in sums of squares due to a component fitted after any preceding components of the model is reduced by any interaction which may be present between this component and the preceding components. This sequence was selected because of the large year effect on weaning weight reported in the literature.

The second analyses were made to determine the year by linear day of birth and quadratic day of birth interaction on weaning weight. The following model was used:

$$Y_{ij} = \mu + a_i + B_1 (X_{ij} - \overline{X}_{i.}) + B_{2i} (X_{ij} - \overline{X}_{i.}) + B_3 (X_{ij}^2 - \overline{X}_{i.}^2) + B_{4i} (X^2_{ij} - \overline{X}_{i.}^2) + E_{ij}$$

Y_{ij} = weaning weight of the j^{th} calf in the i^{th} year adjusted to a 205 day standard age, mature dam and steer equivalent by standard procedures.

μ = is the mean common to all observations.

a_i = is the effect of the i^{th} year as a deviation from the mean.

B_1 = linear regression of weaning weight on day of birth common to all years.

B_{2i} = linear regression of weaning weight on day of birth for the i^{th} year.

X_{ij} = day of birth of the j^{th} calf in the i^{th} year.

B_3 = quadratic regression of weaning weight on day of birth common to all years.

B_{4i} = quadratic regression of weaning weight on day of birth for the i^{th} year.

E_{ij} = random error.

In the analyses a linear day of birth regression line was fitted to each year after the reduction in sums of squares due to the effect of the i^{th} year when the calf was born and the average linear regression of weaning weight on day of birth common to all years was fitted. This method was a way of analysing the possible interaction of years with linear day of birth effect. A quadratic day of birth regression line was fitted to all years, after the reduction in sums of squares due to the preceding components of the model, to determine the interaction of years with quadratic regression of weaning weight on day of birth.

A third set of analyses using multiple regression for each year were made to determine the number of years that there was a significant association between weaning weight and day of birth.

The following model was used:

$$Y_j = \mu + B_1 (X_j - \bar{X}.) + B_2(X_j^2 - \bar{X}.^2) + E_j$$

Y_j = weaning weight of the j^{th} calf adjusted to a 205 day standard age, mature dam and steer equivalent by standard precedures.

μ = the mean common to all observations.

B_1 = linear regression of weaning weight on day of birth.

X_j = day of birth of the j^{th} calf.

B_2 = quadratic regression of weaning weight on day of birth

E_j = random error.

RESULTS AND DISCUSSION

Data from 914 Hereford calves from 1951 through 1965 and 459 Angus calves from 1951 through 1962 born during the months of January through June were used in this study to determine the association between day of birth and weaning weight in beef cattle. The data for each calf were day of birth, birth weight, sex, age of dam, weaning date, weaning weight and year of birth. Weaning weights were adjusted to a 205 day, mature dam, steer equivalent using standard adjustments. The associations between day of birth and weaning weights were investigated with the abbreviated Doolittle procedure using a regression model. Three separate analyses within the Hereford and Angus herds were made. The first analyses were made to study the association between weaning weight and day of birth common to all years. The second analyses were made to determine if a possible year by day of birth interaction was present. The third analyses were made within years to determine in which years there were significant ($P<.05$) associations between day of birth and weaning weight. Rainfall, temperature and other sources of variation were investigated to try to detect possible causes of year by day of birth interaction.

Results of the first analyses of the association between day of birth and weaning weights is indicated in Table I for the Hereford herd. Year of birth was a highly significant ($P<.01$) source of variation in weaning weight. This is in agreement with reports in the literature since there is variation in environmental influence from year to year. Some of the sources of variation that may influence weaning weight are differences in rainfall, temperature, and the grass available to the cow and calf. Yearly differences may be caused by inadequate adjustment factors if there is a larger than average number of two year old cows in the herd and the adjustments for this age group is not adequate. Another factor may be different herd sires from year to year.

This year of birth difference was present in both herds and in all three analyses. The Angus herd did not have as large a reduction in the sum of squares as did the Hereford herd but highly significant differences ($P<.01$) were present in both herds.

The data were analyzed for the association between weaning weights and day of birth after the reduction in sums of squares due to year effect. In the Hereford herd linear regression of weaning weights on day of birth common to all years was not significant ($P>.05$). This would indicate that if the data for weaning weights were plotted on a graph with weaning weights indicated in pounds on the vertical (Y) axis and day of birth as indicated by the date born after January 1 on the horizontal (X) axis a linear re-

TABLE I

ANALYSIS OF VARIANCE OF ADJUSTED WEANING WEIGHTS FOR THE HEREFORD HERD[a]

Source	df	SS	MS
Total (Corrected)[b]	913	3,659,080	
a_i[c]	14	595,383	42,527**
B_1[d]	1	6,377	6,377
B_2[e]	1	1,205	1,205
Error	897	3,056,120	3,407

** $P<.01$

a Model described on page 14 and adjustment procedure described on page 13 in the Materials and Methods Section.

b The total sums of squares minus the mean.

c Year of birth effect after the mean.

d Linear day of birth effect common to all years after the mean and year effect.

e Quadratic day of birth effect common to all years after the preceding components of the model.

gression line of weaning weight on day of birth common to all years would be nearly parallel to the horizonal axis.

The quadratic regression of weaning weight on day of birth was not significant. The association between weaning weight and day of birth indicated that neither a linear nor quadratic line fitted to the data accounts for a significant amount of variation. From these results it would appear that a day of birth adjustment common to all years does not need to be made on weaning weight. When either a linear or quadratic regression line is plotted on a graph with the weaning weight on the vertical (Y) axis and the day of birth on the horizontal(X) axis the regression lines would be nearly parallel to the horizontal(X) axis. In Figure 2 a quadratic regression of weaning weight on day of birth is shown. This indicated that regardless of the day of birth of a calf in the spring calving program he would probably have an equal opportunity to have the average adjusted weaning weight.

The results of the first analysis with the Angus herd is listed in Table II. In this study year effect was highly significant. The linear day of birth association with weaning weight, after the reduction due to the mean and year effect, did not account for a significant amount of variation. These results are similar to those obtained in the Hereford herd.

There was a significant ($P<.05$) difference found in the quadratic regression of weaning weight on day of birth

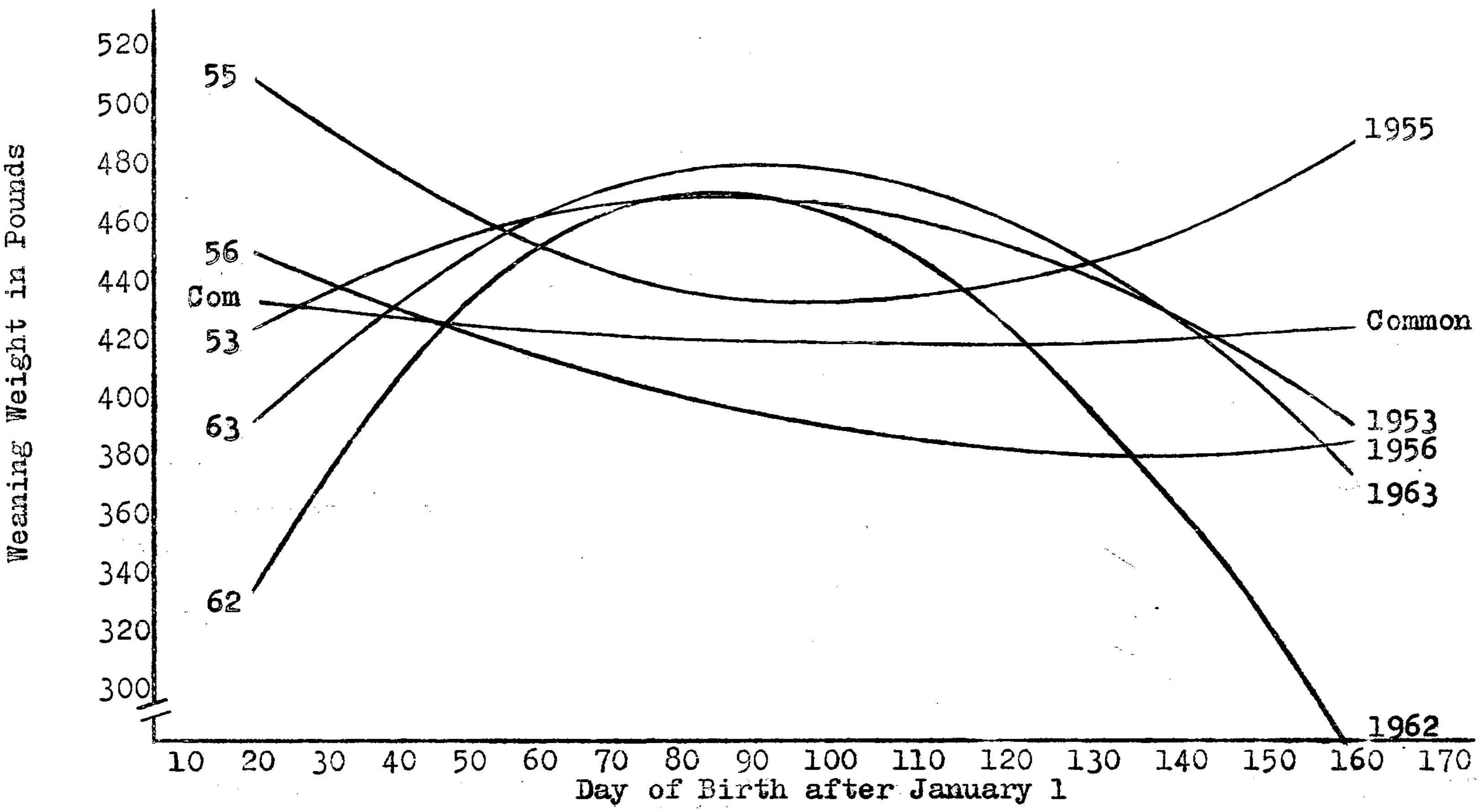

Figure 2. Multiple Regression Lines of Weaning Weights on Day of Birth in Years when Significant Differences (P<.05)were Present for the Hereford Herd

TABLE II

ANALYSIS OF VARIANCE OF ADJUSTED WEANING WEIGHTS FOR THE ANGUS HERD[a]

Source	df	SS	MS
Total (corrected)[b]	458	1,518,545	
a_i [c]	11	229,757	20,887**
B_1 [d]	1	326	326
B_2 [e]	1	23,988	23,988*
Error	445	1,264,474	2,841

* P<.05

** P<.01

a Model described on page 14 and adjustment procedure described on page 13 in the Material and Methods Section.

b The total sums of squares minus the mean.

c Year of birth effect after the mean.

d Linear day of birth effect common to all years after the mean and year effect.

e Quadratic day of birth effect common to all years after the preceding components of the model.

as indicated in Figure 3. These results differ from those obtained with the Hereford herd and show that calves born during mid season may have a slightly heavier adjusted weaning weight on the average over all years.

Results of these analyses with the Angus herd are in more agreement with the studies reported by Marlowe and Gaines (1958), Marlowe (1962), Thrift (1964) and Marlowe et al. (1965) than are the results from the Hereford herd. Each of these studies reported a month of birth effect on weaning weight with the months of February and March having the highest month of birth effect.

The standard error after the reduction in sums of squares due to the mean, year and the multiple regression of weaning weight on day of birth was 58.4 and 53.3 for the Hereford and Angus herd respectively. The standard error after the reduction in sums of squares due to the mean and year was 58.4 and 53.7 in the Hereford and Angus herd respectively. When each method of computing standard error is compared the differences present are of little practical importance. The error mean square was reduced by 2.2 percent by the multiple regression of weaning weight on day of birth in the Angus herd and less in the Hereford herd. This would indicate the amount of variation accounted for by day of birth association with weaning weight is small and adjustment for day of birth effect may be of little practical importance.

Results of the second set of analyses are indicated in

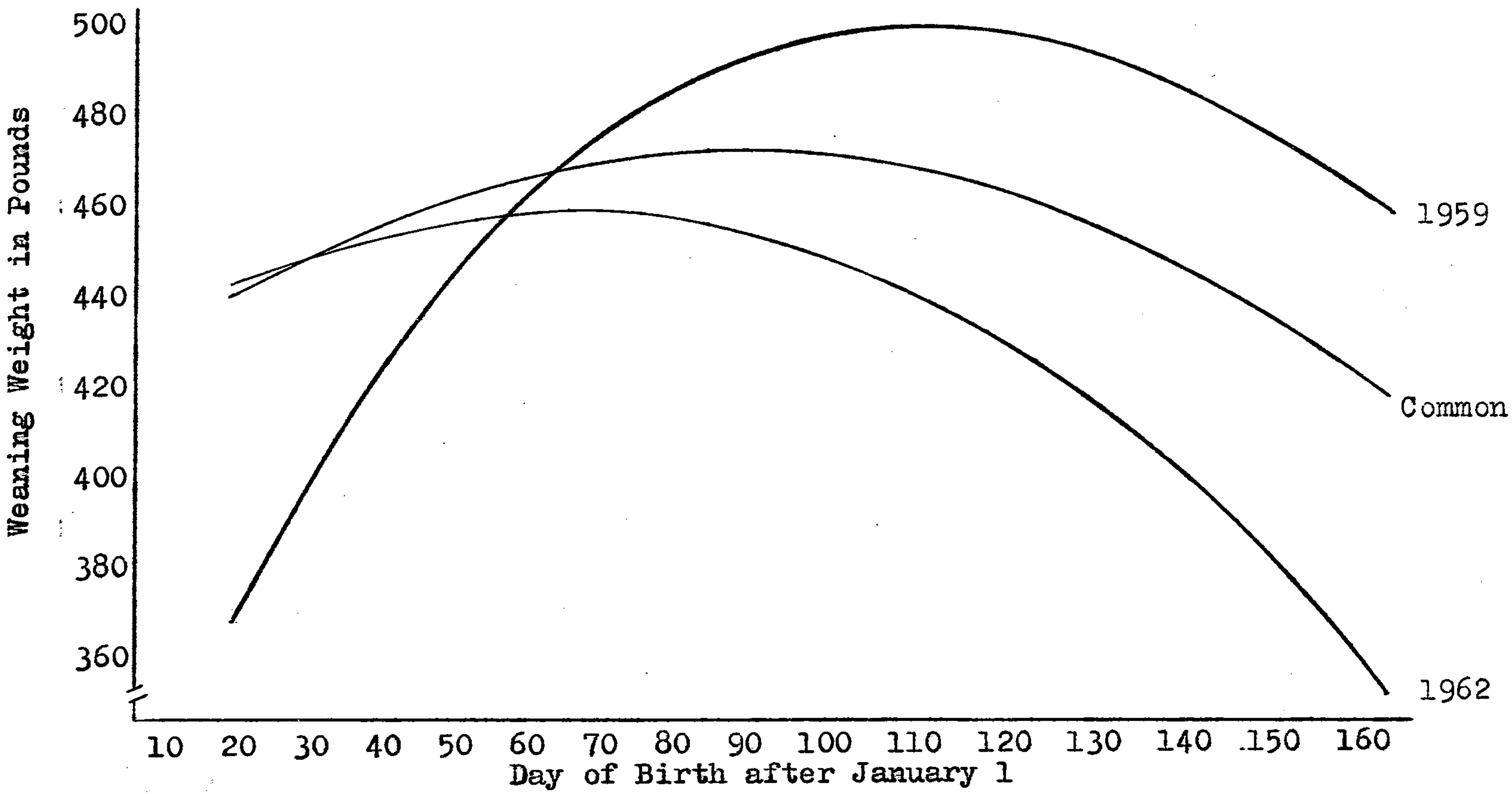

Figure 3. Multiple Regression Lines of Weaning Weights on Day of Birth in Years when Significant Differences(P<.05) were Present for the Angus Herd

Tables III and IV. These analyses were made to determine if there was a year by day of birth interaction. This interaction would indicate that the yearly regression lines fitted to the data were not parallel. If there was no day of birth association with weaning weight present, these regression lines would be parallel to the horizonal axis.

The results of this second analysis in the Hereford herd shows the same highly significant year association with weaning weight. The linear regression of weaning weight on day of birth common to all years was not significant.

After the reduction in sums of squares due to years and linear regression of weaning weight on day of birth common to all years, the within year linear regression of weaning weight on day of birth was significant ($P<.05$). This indicates that during some of the 15 years the within year regression line differed significantly from the regression line common to all years. These results show that an adjustment for day of birth effect on weaning weight common to all years would not account for as large an amount of the variation as adjustments for day of birth effect on weaning weight for individual years.

Similar results were present in the Angus herd as indicated in Table IV. A regression line common to all years was not significant but regression lines fitted to individual years after the linear regression line common to all years were significant.

TABLE III

ANALYSIS OF VARIANCE OF ADJUSTED WEANING WEIGHTS FOR THE HEREFORD HERDS[a]

Source	df	SS	MS
Total (Corrected)[b]	913	3,659,080	
a_i [c]	14	595,380	42,527**
B_1 [d]	1	6,377	6,377
B_{2i} [e]	14	113,130	8,080
B_3 [f]	1	1,961	1,961
B_{4i} [g]	14	75,750	5,410
Error	870	2,866,490	3,294

* P<.05

** P<.01

a Model described on page 15 and adjustment procedures for weaning weight described on page 13 of the Material and Methods Section.
b Total sums of squares minus the mean.
c Year effect after the mean.
d Linear day of birth effect common to all years after the mean and year effect.
e Linear day of birth effect for the i^{th} year after the mean, year and linear day of birth effect common to all years (year by day of birth interaction)
f Quadratic day of birth effect common to all years after the preceding components of the model.
g Quadratic day of birth effect for the i^{th} year after the preceding components of the model.

TABLE IV

ANALYSIS OF VARIANCE OF ADJUSTED WEANING WEIGHTS FOR THE ANGUS HERD[a]

Source	df	SS	MS
Total (Corrected)[b]	458	1,518,545	
a_i[c]	11	229,757	20,887**
B_1[d]	1	326	326
B_{2i}[e]	11	61,718	5,610*
B_3[f]	1	13,157	13,157*
B_{4i}[g]	11	28,116	2,556
Error	423	1,185,471	2,802

* $P<.05$

** $P<.01$

a Model described on page 15 and adjustment procedure for weaning weight described on page 13 of the Material and Methods Section.
b Total sums of squares minus the mean.
c Year effect after the mean.
d Linear day of birth effect common to all years after the mean and year effect.
e Linear day of birth effect for the i^{th} year after the mean, year and linear day of birth effect common to all years (year by day of birth interaction).
f Quadratic day of birth effect common to all years after the preceding components of the model.
g Quadratic day of birth effect for the i^{th} year after the preceding components of the model.

After the reduction in sums of squares due to the mean, years, linear regression of weaning weight on day of birth common to all years and linear regression of weaning weight on day of birth within years, the quadratic regression of weaning weight on day of birth common to all years were analyzed. As in the first analyses the quadratic regression was not significant in the Hereford herd but was significant (P<.05) in the Angus herd.

To further study the interaction of years with day of birth association with weaning weight a quadratic regression line common to all years was fitted. This quadratic regression of weaning weight on day of birth within years after the reduction due to the previous components of the model was not significant in either herd. The results of these second analyses shows that there is evidence to indicate a year by day of birth interaction.

To further study this day of birth by year interaction a third set of analyses were made of the association of adjusted weaning weights and day of birth within years. The results of this study are indicated in Tables V and VI. The constants for the multiple regression equations are shown in Tables VII and VIII. There were significant differences five years in the Hereford herd and two years in the Angus herd. In the Hereford herd there was a highly significant (P<.01) linear association between day of birth and weaning weight in 1955 and a significant association (P<.05) in 1956. There was a significant (P<.05)

TABLE V

ANALYSIS OF VARIANCE OF ADJUSTED WEANING WEIGHTS WITHIN YEARS FOR THE HEREFORD HERD[a]

Year	df	Total (Corrected) Sum of Squares	Mean Squares B_1[b]	B_2[c]	Error
1951	9	56,887	13,768	4,717	5,485
1952	38	164,950	14,063	926	4,165
1953	62	224,384	1,868	21,465*	3,350
1954	56	123,983	1,229	424	2,265
1955	76	405,503	35,556**	8,166	4,888
1956	86	392,604	21,658*	625	4,408
1957	87	276,145	11,981	6,536	3,030
1958	93	338,976	1,551	2,705	3,760
1959	64	166,975	46	99	2,690
1960	24	57,255	5,080	3,048	2,232
1961	23	31,244	2,162	175	1,376
1962	70	278,256	4,779	16,773*	3,775
1963	69	172,833	190	11,988*	2,397
1964	49	172,128	5,538	36	3,543
1965	95	201,646	42	29	2,167

* $P<.05$

** $P<.01$

a Model described on page 16 and adjustment procedures for weaning weight described on page 13 of the Material and Methods Section.

b Linear day of birth effect after the mean.

c Quadratic day of birth effect after the mean and linear day of birth effect.

TABLE VI

ANALYSIS OF VARIANCE OF ADJUSTED WEANING WEIGHTS WITHIN YEARS FOR THE ANGUS HERD[a]

Year	df	Total (Corrected) Sum of Squares	Mean Squares B_1[b]	B_2[c]	Error
1951	5	2,165	313	1	620
1952	11	30,642	2,039	3,159	2,826
1953	18	61,395	6,847	2,913	3,227
1954	22	39,721	382	553	1,939
1955	21	71,294	2,283	176	3,622
1956	34	105,743	295	2,615	3,213
1957	28	136,746	98	21	5,254
1958	34	82,138	1,214	3,549	2,417
1959	45	141,964	29,786**	3,742	2,521
1960	55	167,692	1,470	4,554	3,050
1961	57	158,522	7	9,215	2,714
1962	117	290,752	17,312*	10,774*	2,284

* $P<.05$

** $P<.01$

a Model described on page 16 and adjustment procedures for weaning weight described on page 13 of the Material and Methods Section.

b Linear day of birth effect after the mean.

c Quadratic day of birth effect after the mean and linear day of birth effect.

quadratic effect of day of birth on weaning weight in 1953, 1962 and 1963 in this herd. This would indicate that adjustments for day of birth effect on weaning weight within years could be important in five of the fifteen years in the Hereford herd.

In the Angus herd the within years linear day of birth effect on weaning weight was highly significant (P<.01) in 1959 and significant (P<.05) in 1962. The quadratic effect was also significant (P<.05) in 1962. In Figures 2 and 3 the results are illustrated of the regression curve fitted to the data in the years where significant differences were obtained. These regression curves can be compared with the multiple regression of weaning weights on day of birth common to all years. In the Hereford herd early calves appear to be heavier than those born during the middle of the spring calving season in 1955 and 1956. In 1953, 1962 and 1963 the calves born in the middle of the spring calving season appear to be heavier. Results of the analysis with the Angus herd indicates the calves born in mid-season appear to be heavier in 1959 and 1962 when significant differences were found as shown in Figure 3.

Results of this third set of analyses confirms the results found in the second analyses where a year by day of birth interaction was indicated, and indicates in which years the associations were different. This study would indicate that if adjustment factors for day of birth on weaning weight were used that they should be used on within year basis rather than a common adjustment for all years.

Cooper et al. (1965) reported a year by season of birth interaction. A search of the literature revealed no other reports of a year by day of birth or season of birth interaction. Interaction analyses reported by Cundiff (1966) indicated that the effect of month of birth is dependent on type of pasture. Interaction was also present between month of birth and whether or not the calves were creep fed.

Some possible sources of environmental variation which may have caused the year by day of birth interaction were temperature, rainfall, and wheat pasture conditions. Wheat pasture conditions were poor in 1954 and 1956.

The relationship between rainfall and day of birth was investigated. Rainfall average by month is listed in Table IX in the Appendix for the years from 1951 through 1965. Figures 4 and 5 indicate rainfall by months in the years when significant ($P<.05$) day of birth association with weaning weight was present. The normal rainfall for the month of August was 2.51 inches. Each year when a significant day of birth effect on weaning weight was present, in both herds, rainfall for the month of August was less than two inches. Significant ($P<.05$) association between weaning weights and day of birth appeared only in 1962 in both herds. Rainfall for July was 1.32 inches and August was 0.92 inches which was the lowest of any year

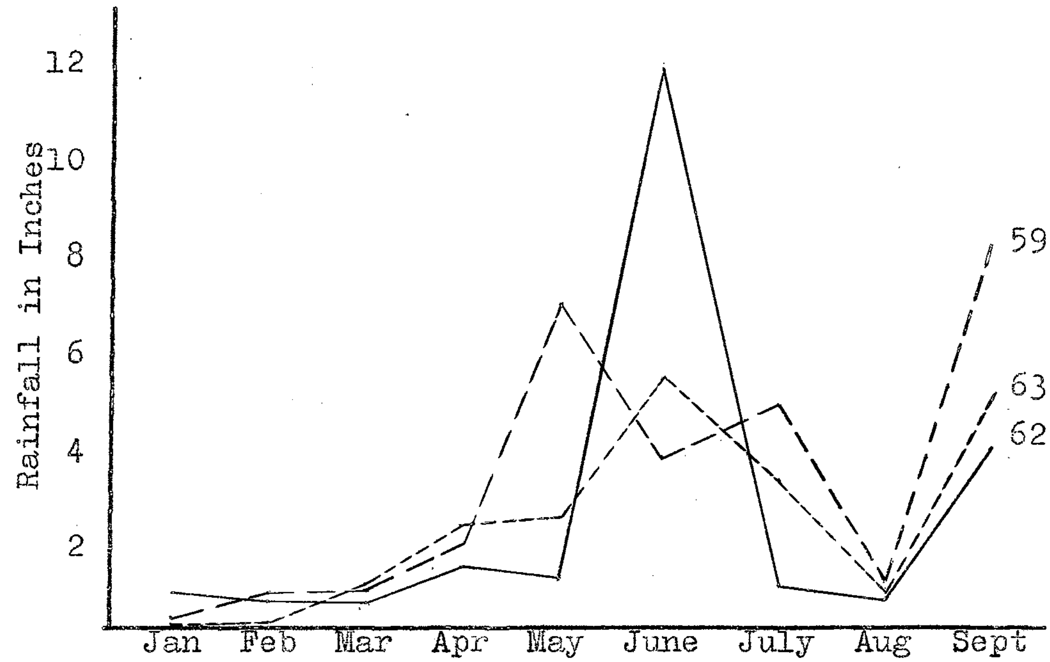

Figure 4. Monthly Rainfall in 1959, 1962 and 1963

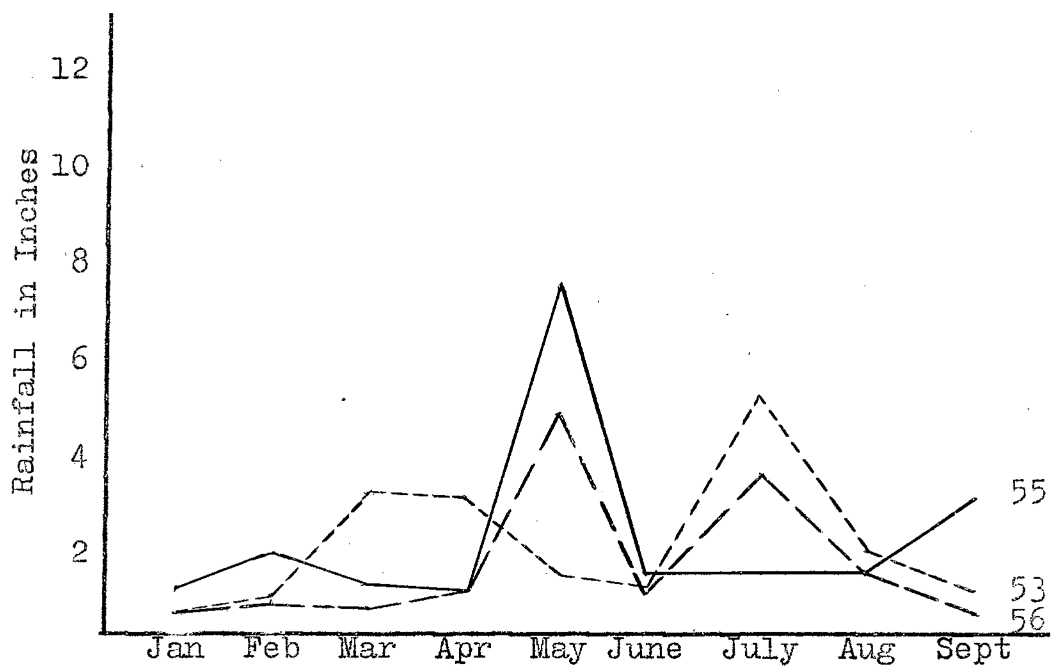

Figure 5. Monthly Rainfall in 1953, 1955 and 1956

from 1951 through 1965 except 1957. The average weaning weights for both herds in 1957 was the lowest yearly average in this study.

By comparison of the multiple regression lines in Figures 2 and 3 with the line charts in Figures 4 and 5 it would appear that low rainfall late in the grazing season reduced the adjusted weaning weights of calves born late in the spring calving season. In the Hereford herd late spring calves had lower than average weaning weights in 1953, 1956, 1962 and 1963 as indicated by the regression lines in Figure 2. In 1953 and 1956 August and September rainfall was below normal. In 1963 July and August rainfall was below normal.

In 1955 rainfall was below normal during June, July and August. It would appear that calves born during March and April had lighter weaning weights than those born early in the season.

In the Angus herd calves born late in the spring of 1959 and 1962 had lighter than average weaning weights and August rainfall was less than normal in these years.

These results would indicate that less than average rainfall during the month of August may decrease adjusted weaning weights of calves born late in the spring. This is illustrated in 1962 when a significant day of birth effect on weaning weight was reported in both herds.

Reports in the literature indicate that there is a high correlation between weight and lower milk production of the dam. Drouth conditions late in the grazing season probably reduced milk production of all the cows. Calves born late in the spring were more dependent on milk and had lower adjusted weaning weights. The calves born during February, March and April probably had reduced gains later in the grazing season but still had a good adjusted weaning weight because of good early gains.

The multiple regression curve common to all years for the Angus herd shown in Figure 3 indicates a decline in weaning weight for calves born late in the season. The regression curve of weaning weight on day of birth common to all years for the Hereford herd indicates a slight increase in average weaning weight of the late calves. This may be why there were more years when significant ($P<.05$) differences were present in the Hereford herd because the late spring calves appear to be more affected by drouth conditions in August.

Monthly average temperatures for the years from 1951 to 1965 are listed in Table X in the Appendix. Higher than average temperatures during the month of August and September in 1956 combined with low rainfall during these months may have further reduced the production of grass and weaning weights of late calves. In 1953 above average monthly temperatures were reported in September which may have reduced grass production and weaning weights. No other monthly average temperatures appeared to affect the association between weaning weight and day of birth.

The Angus and Hereford herd which produced the calves from which these data were collected were handled under good management conditions. These cows were on native grass from March 10 until fall at which time they were placed on wheat pasture until the following March. Cows received supplemental hay on wheat pasture, when needed, and alfalfa hay or grain and cottonseed meal from March 10 to April 10. Under these management and feeding conditions there may not have been as much variation in weaning weights associated with day of birth as in commercial cow herds in this state. There are not a large percentage of the commercial cow herds which are on wheat pasture in the fall and winter in Oklahoma.

The majority of the calves used in this study were born during February and March as indicated in Figure 1. This represents the normal spring calving pattern in a herd under good management condition. Under management and feeding conditions less desirable a wider variation in age of calves would be expected.

Marlowe et al. (1965) reported that as calves increased in age their gains decreased. Swiger et al. (1962) reported a significant ($P<.05$) curvilinear regression of weaning weight on age from 130 to 200 days. Thrift (1964) also reported a curvilinear association of weaning weight and age. He suggested adjustment factors of 1.01, 1.00, 1.01, 1.02 and 1.05 for 205 day weaning weights of calves born from January through May respectively. The data used in his study were weaning weights of 34,610 calves accumulated over a seven year period in Georgia.

In this study all spring calves were weighed and weaned about October 10. The standard 205 day age of calf weaning weights used in this study was computed by subtracting birth weight from weaning weight, computing average daily gain, multiplying average daily gain by 205 and adding the birth weight. From the literature just previously mentioned it would appear that as calves increased in age their gains decreased.

The association between day of birth and weaning weight may have had an opposite influence on weaning weight than that of age of calf at weaning. In the literature there are reports of calves born in February and March having the highest adjusted weaning weight. This day of birth effect on weaning weight may have been decreased by the fact that these February and March calves were older calves when all spring calves were weaned about October 10.

To adequately study this effect of age at weaning on adjusted weaning weight and the opposite influence of day of birth on weaning weight for calves born in the spring, monthly weights of the calves would need to be obtained. These data were not available for this study.

Application of these results to herds on a lower plane of nutrition or managed under less favorable conditions should be done with reservation. There are few commercial herds of sufficient size which have adequate records to adjust weaning weights within years for day of birth effect. These results indicate that only a small amount of the variation in weaning weight can be accounted for by a multiple regression of weaning weight on day of birth common to all years. Without adjustments common to all years for the association between weaning weight and day of birth and the small number of calves born within years in most herds it would appear that present standard adjustment factors will have to suffice without further adjustment for day of birth.

The results of these analyses are similar to those reported by Rollins _et al_. (1954), Vernon _et al_. (1964), Marlowe and Gaines (1958) and Marlowe (1962). Each of these reports indicated that one adjustment factor was adequate for grouping of calves born in a two to three month period.

SUMMARY

The data used in this study were records from 914 Hereford and 459 Angus calves from the Fort Reno Livestock Research Station. The data for each calf were day of birth, birth weight, sex, age of dam, weaning date, weaning weight and year of birth. The analyses were restricted to calves born from January 1 to June 30. Weaning weights were adjusted for age, sex, and age of dam by the procedure recommended by the United States Beef Cattle Improvement Committee (1965).

The association of day of birth with adjusted weaning weights in a spring calving program were analyzed by the Abbreviated Doolittle Method using a regression model within each herd. The greatest reduction in sums of squares was due to year effect on weaning weights which was highly significant ($P<.01$) in each herd. The sums of squares removed by fitting separate curves for each year were compared with the sums of squares removed by fitting a common curve. When separate regression curves for day of birth effect on adjusted weaning weight were fitted for each year, significant ($P<.05$) differences were present five years in the Hereford herd and two years in the Angus herd. Significant differences ($P<.05$) were present in 1962 in both herds.

These results indicated a year by day of birth interaction in the association between day of birth and adjusted weaning weight. Possible causes of this interaction were investigated. Rainfall appeared to be the most important source of environmental variation. The relation between rainfall and weaning weights was studied. August rainfall was below normal when there was a significant association between weaning weight and day of birth in these spring calves in both herds. In 1962 the July and August precipitation was less than average when significant differences ($P<.05$) were present in both herds. Calves born late in the spring calving season appeared to have lighter adjusted weaning weights when drouth conditions were present in mid-summer.

The results of this study indicate that the percentage of variation in adjusted weaning weight associated with day of birth effect is small and dependent on the year the calf was born. Adjustments for the association of adjusted weaning weight and day of birth effect common to all years would be of little practical value. Under most conditions present adjustment procedures for the weaning weight of a calf would be adequate without further adjustment for day of birth.

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APPENDIX

TABLE VII

CONSTANTS FOR THE MULTIPLE REGRESSION OF ADJUSTED WEANING WEIGHT ON DAY OF BIRTH FOR THE HEREFORD HERD

Hereford Year	μ	β_1	β_2	Min. or Max. point on regression curve
1951	619.022	-3.90992	.01558	125*
1952	424.162	-0.24374	.00433	28*
1953	389.197	2.12259	-.01336	79
1954	432.509	-0.53246	.00218	122*
1955	562.209	-2.57669	.01287	100*
1956	478.653	-1.377497	.00482	143*
1957	447.080	-1.92855	.01182	81*
1958	379.289	.77802	-.00369	105
1959	457.597	-0.28842	.00149	93*
1960	523.538	-2.23026	.01753	63*
1961	521.800	-1.33775	.00629	109*
1962	235.563	5.73771	-.03487	82
1963	345.791	3.01014	-.01746	86
1964	491.874	-0.68864	.00151	220*
1965	438.950	.20140	-.00110	101

* Minima

TABLE VIII

CONSTANTS FOR THE MULTIPLE REGRESSION OF ADJUSTED WEANING WEIGHT ON DAY OF BIRTH FOR THE ANGUS HERD

Angus Year	μ	β_1	β_2	Min. or Max. point on regression curve
1951	514.913	.32043	-.00062	242
1952	383.420	2.17409	-.01214	90
1953	516.716	-3.92156	.04933	40*
1954	358.802	1.86833	-.01168	80
1955	469.713	.17770	-.00489	18
1956	381.284	1.99572	-.01278	78
1957	405.912	-0.21912	.00254	43*
1958	380.227	2.52863	-.01750	72
1959	310.640	3.72646	-.01783	104
1960	349.959	2.63237	-.01643	80
1961	588.408	-2.91231	.01775	81*
1962	433.247	1.06469	-.00918	57

* Minima

TABLE IX

RAINFALL AT EL RENO, OKLAHOMA[1]

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1951	1.08		1.17	1.75	8.08	3.38	2.47	3.07	3.55	1.18	-	-	-
1952	.87	1.23	1.82	2.18	5.35	.66	1.27	1.95	.83	.00	1.62	1.58	19.30
1953	.25	.71	3.19	2.89	1.63	1.37	5.62	1.97	1.11	5.89	6.61	1.03	32.27
1954	.15	1.03	.98	2.38	5.50	.76	.02	1.94	.32	.33	.08	1.11	14.60
1955	1.37	1.91	1.00	1.12	7.64	1.70	1.74	1.75	3.02	7.12	.00	.04	28.41
1956	.19	1.22	.69	1.32	4.28	1.32	3.71	1.50	.39	5.75	1.27	1.61	23.25
1957	1.96	.71	3.15	6.26	6.49	6.28	.77	.19	4.64	2.59	1.72	.34	34.70
1958	1.08	.27	3.81	2.98	2.31	5.68	4.77	3.30	2.15	.09	.61	.56	27.01
1959	.09	.83	.91	2.28	7.29	3.58	4.76	1.90	8.19	11.72	.18	3.41	45.14
1960	.88	2.10	1.03	1.42	3.72	2.31	5.50	3.73	1.07	10.34	.92	2.52	35.54
1961	.33	1.44	2.37	.46	1.94	3.96	2.80	2.43	10.29	2.32	2.99	.76	32.09
1962	.69	.60	.52	1.86	1.65	10.78	1.32	.92	4.04	2.97	1.21	.93	27.49
1963	.09	.24	1.47	2.12	2.16	5.00	2.64	1.53	4.94	.50	2.54	.28	23.51
1964	.53	2.39	.62	1.58	7.62	1.46	1.08	4.14	4.08	1.05	4.32	.60	29.47
1965	.56	.65	1.06	1.48	4.04	5.00	1.40	3.29	9.33	1.39	1.65	.80	30.33
Normal	1.15	1.31	1.62	2.85	4.79	3.83	2.48	2.51	2.71	2.85	1.65	1.33	29.08

[1] U.S. Dept. of Commerce Climatological Data, Oklahoma

TABLE X

AVERAGE TEMPERATURES AT EL RENO, OKLAHOMA[1]

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann
1951	39.2	29.4	49.2	58.2	68.2	75.8	81.5	-	-	62.4	43.9	40.4	
1952	45.4	45.5	48.2	56.5	68.2	77.2	82.5	86.5	73.7	59.0	45.7	39.6	
1953	43.1	44.7	55.0	56.9	68.8	84.8	80.1	78.6	76.2	64.0	50.5	41.1	62.0
1954	39.0	52.6	48.2	66.2	63.4	78.9	88.1	86.0	79.6	65.9	52.4	42.7	63.6
1955	40.0	41.9	51.6	65.0	71.0	74.2	84.2	81.7	76.4	62.5	47.7	39.7	61.3
1956	37.2	41.5	51.8	58.7	73.8	79.2	83.2	85.5	77.4	66.5	48.3	43.3	62.3
1957	34.1	45.7	47.4	56.9	66.1	75.1	84.2	82.4	70.5	58.2	46.7	45.2	59.4
1958	40.1	37.1	41.5	56.6	70.0	78.0	81.1	80.8	74.1	63.3	52.2	38.3	59.4
1959	35.2	40.6	50.8	59.9	71.0	76.9	78.0	82.8	74.0	58.8	43.8	44.4	59.7
1960	36.1	34.9	40.3	61.9	65.5	77.6	78.1	79.1	75.1	64.0	51.8	37.1	58.5
1961	36.5	42.4	51.8	59.0	67.9	74.9	79.8	78.8	70.5	62.9	46.2	36.4	58.8
1962	32.5	45.4	48.9	58.3	74.3	75.0	81.8	82.2	72.2	64.6	49.2	40.7	60.4
1963	29.2	41.6	53.6	64.5	70.6	78.9	84.3	83.3	75.3	70.5	51.5	32.6	61.3
1964	40.8	38.7	47.9	63.8	70.7	77.5	86.1	81.5	73.2	60.2	50.2	38.1	60.7
1965	40.1	39.7	40.6	64.8	70.0	76.2	82.9	78.6	73.2	62.7	55.1	47.2	60.9
Avg	38.9	42.4	48.4	59.7	68.6	77.9	82.1	82.6	75.2	62.5	48.3	41.3	60.7

[1]U.S. Dept. of Commerce Climatological Data, Oklahoma (Annual Summaries)

VITA

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