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Factors influencing weaning performance of beef calves in commercial and purebred herds in Tennessee

Jesse Edward Barker

To the Graduate Council:

I am submitting herewith a thesis written by Jesse Edward Barker entitled "Factors influencing weaning performance of beef calves in commercial and purebred herds in Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

E.R. Lidvall Jr, Major Professor

We have read this thesis and recommend its acceptance:

Lauren L. Christian, Harold J. Smith

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

August 3, 1964

To the Graduate Council:

I am submitting herewith a thesis written by Jesse Edward Barker entitled "Factors Influencing Weaning Performance of Beef Calves in Commercial and Purebred Herds in Tennessee." 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.

E. R. Sidwell
Major Professor

We have read this thesis
and recommend its acceptance:

L. L. Christian

Harold J. Smith

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

FACTORS INFLUENCING WEANING PERFORMANCE OF BEEF CALVES IN COMMERCIAL AND PUREBRED HERDS IN TENNESSEE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Jesse Edward Barker

August 1964

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CHAPTER I

INTRODUCTION

The future existence of the beef cattle industry depends upon its ability to compete with other livestock and food products. This competition can be met only if the beef producer constantly strives to economize his operation.

Tremendous strides have been made during the past century in improving the type and quality of beef cattle. The historic Longhorn has been replaced with a modern early maturing type of beef animal which produces a carcass with excellent eating qualities.

In the past, beef cattle were selected primarily on the basis of external appearance. In recent years, however, the use of performance records as an aid to selection has been introduced. Performance testing of beef cattle simply provides information which producers may use in selecting herd replacements and culling low producers. It is a method of comparing the producing ability of cattle raised under the same environmental conditions on one farm.

The beef cattle breeders are interested in retaining the excellent type that has been developed in many herds. In addition to type and conformation, breeders are also interested in improving the rate and efficiency of gain. Experimental results indicate that these two characteristics are independent and, therefore, one can be improved without sacrificing the other; desirable type and rapid gaining ability

can be developed in one animal. The work of Swiger and Hazel (1961) demonstrated that the same genes affect gain in weight of beef cattle during early parts of the growing period up to a year of age. It is well known that environmental factors influence variation in birth weight, average daily gain, and type score. By adjusting for these influences, phenotypic measurements should more closely approximate the breeding value of an individual and, through selection, result in progeny of superior merit. Therefore, estimates of the magnitude of non-genetic effects are of prime interest to the beef cattle industry.

I. OBJECT OF STUDY

This study seeks to evaluate the influence of age of dam, sex of calf, age of calf, and month of birth on:

1. Birth weight
2. Average daily gain
3. Type score.

CHAPTER II

REVIEW OF LITERATURE

Birth Weight

The age of dam has a marked effect on birth weight of calves. Marlowe (1962) reported there was an increase of 1.66 pounds per year in birth weight in calves from Angus and Hereford dams from 2 to 7 years and decreased thereafter.

Knapp et al. (1942) found that calves from first calf heifers were 10 pounds lighter than calves from more mature cows. The maximum birth weight was obtained from cows that were four to six years of age.

Dawson et al. (1947) reported that 212 male calves were on the average 0.23 pounds heavier and 190 females were 0.20 pound heavier at birth for each increase of one month in the age of dam up to six years of age. The smallest calf weighed 40 pounds at birth and the heaviest 109 pounds at birth.

Burris and Blunn (1952) in a study of 502 calves found that birth weight of calves from two and three year old cows averaged 4.7 pounds less for Angus, 4.9 pounds for Hereford and 6.0 pounds for Shorthorn than for older cows. A greater increase in birth weight was found in those calves out of cows between two and three years of age than for any other age difference. The highest birth weight was not reached until cows were nine and ten years of age. Koch and Clark (1955) reported that the birth weight of calves increased steadily as the

cows' age increased from three to six years of age and then started to decline.

The influence of sex is known to be an important source of variation in birth weights of cattle. Brinks (1961) reported that bull calves weighed 7 per cent more than heifer calves at birth. These data were taken on 2,151 heifer calves at the U.S. Livestock Experiment Station, Miles City, Montana. These results are in agreement with those of Koch et al.(1959), McCormich et al. (1956), Koch et al. (1955), Botkin and Whatley (1953), Gregory et al. (1950) and Dawson et al. (1947).

Clark et al. (1958) reported on records of 7,346 calves from 2,131 Hereford cows taken in 1926-53 at the U.S. Range Livestock Experiment Station, Miles City, Montana. Birth weights of all calves averaged 76 pounds. About 71 per cent of the calves weighed between 66 and 85 pounds and about 95 per cent weighed 56 and 95 pounds. Since the cows in the study were highly selected, the average birth weights may be slightly higher than should be expected on the average. Bull calves averaged 79 pounds and heifer calves 74 pounds at birth, or a difference of five pounds in favor of males.

Burris and Blunn (1952) observed that bull calves of the Angus breed weighed 67.1 pounds at birth and heifers 61.8 pounds, or a difference of 5.3 pounds. Hereford bull calves weighed 69.9 pounds at birth and heifers 65.4 pounds, or a difference of 4.5 pounds. Shorthorn bull calves at birth weighed 66.7 pounds and heifers 61.8 pounds, or a 4.9 pound difference. MacDonald and Bogart (1955) found that male

Angus calves weighed 12.2 pounds less than Hereford females. Meade et al. (1959) reported that the average weight of both sexes of Angus calves was 61.6 pounds and Herefords 66.5 pounds, or a difference of 4.9 pounds. Foot et al. (1960) reported that the birth weight of Angus calves ranged from 30 to 79 pounds with an average of 56.2 pounds. Shorthorns ranged from 41 to 82 pounds and averaged 59.9 pounds.

Research workers are in general agreement that age of dam, and sex of calf have a definite influence on birth weight. There is some variation due to breed differences. Generally, Hereford calves have the highest birth weight, followed by Shorthorn and Angus.

Average Daily Gain

Work done by Sawyer et al. (1958) demonstrated that two year old dams weaned calves that were 75 pounds lighter than calves of mature cows. The weaning weight of calves increased with increasing age of dams through eight years of age and then declined.

Rollins and Guilbert (1954) reported on 159 calvings in California. They found that two and three year old dams produced calves that were 21 pounds lighter for bull and 13 pounds for heifer calves at weaning than did dams of seven to ten years of age. Cows in this study reached their highest production at six years of age.

Koch and Clark (1955) found that on weaning weight records, cow productivity increased steadily from three to six years of age and then declined. Knox (1951) stated that the age of dam effect was a linear function with maximum weaning weights expected from six year old cows, with a gradual decline in weaning weight from six to eleven years.

Knapp (1942) postulated a ten year old cow may be expected to produce about the same size calf as a two year old heifer.

The following correction factors were given by Koch and Clark (1955) to adjust for age of dam effects on weaning weight.

Age of Dam (years)	Weaning Weight (pounds)
3	41
4	18
5	6
6	0
7	3
8	6
9	12
10	24

Clark et al. (1958) reported the average weaning weight increased as the age of dam advanced from three to five years. There was very little difference from six to eight years of age. Calves from first calf heifers averaged 44 pounds less than calves from more mature dams. The actual deviations from the average weaning weight of calves from cows seven years of age due to age of dam are as follows.

Age of Dam (years)	Deviation (pounds)
3	-44
4	-19
5	- 7
6	0
7	+ 3
8	+ 3
9	+ 1

Sex is known to be an important source of variation in average daily gain of beef calves.

Differences in average daily gain between males and females ranging from .1 to .3 pound have been reported by several workers (Dahman and Bogart, 1952; Rollins and Guilbert, 1954; Koch and Clark, 1955; Marlowe and Gaines, 1958; Clark et al., 1958; Koch et al., 1959; Brinks et al. 1961).

Clark et al. (1958) reported differences in weaning weight between sexes to be highly significant. Weaning weights of bulls, steers and heifers averaged 418, 382, and 368 pounds, respectively. On the average, bulls exceeded heifers in weaning weight by 50 pounds and steers outgained heifers by 14 pounds.

Knapp et al. (1942) studied the records on 770 calves from 712 cows and found bull calves were 22 pounds heavier at weaning (180 days) than heifer calves. The males averaged 377 pounds and the females 355 pounds. Koch (1961) reported bull calves outweighed heifers by 44 pounds and steers outweighed heifers by 13 pounds at weaning. The average difference between male calves and females was found to be 23 pounds. This work agrees with the 24.6 pound difference reported by Botkin and Whatley (1953). Rollins and Guilbert (1954) reported bulls to weigh 68 pounds more than heifers at weaning (240 days).

Burgess et al. (1954) reported bull calves outweighed heifers by 22 pounds and steers by 20 pounds at weaning. Steer calves weighed 20 pounds more than heifers at time of weaning. McCormich et al. (1956)

reported that bull calves weighed 38 pounds more than heifer calves at 210 days of age.

Marlowe and Gaines (1958) in a study of 6,173 calves in Virginia herds found that bull calves grew 5 per cent faster than steer calves, and that steer calves outgrew heifers by 8 per cent up to weaning time. Brinks et al. (1961) in a study of 2,157 heifer, 2,281 steer, and 390 bull calves at Miles City found that at 180 days, steers outweighed heifers by 15.5 pounds, and bull calves outweighed heifers by 19.2 pounds. The heifers gained 5 per cent less than steers and 6 per cent less than bulls.

Brown (1960) found the average difference between male and female calves to be 37 pounds at 240 days of age in favor of the males. Pahnish et al. (1961) found over a six year period that bull calves outweighed heifers by 54.6 pounds at 270 days of age.

Meade et al. (1959) reported Hereford bull calves weighed 386.4 pounds and Angus 413.6 pounds at 205 days of age. Hereford heifers weighed 362.1 pounds and Angus 389.3 pounds at the same age.

Brown (1960) found weight differences between bull and heifer calves at 240 days of 57, 33, and 22 pounds in one Hereford and two Angus herds.

Gerlaugh et al. (1951) analyzing eight years' work, reported that Angus bulls at weaning averaged 486.2 pounds while Angus females averaged 419.7 pounds. Hereford bull calves averaged 393.7 pounds and females 385.7 pounds at weaning.

Age of calf has some influence on average daily gain of calves.

Marlowe (1958) found the average daily gain to be about the same when the weight was taken within a 90 to 240 day range. In this study Marlowe also found a rapid decrease in average daily gain when the calves were weighed after 240 days of age. Koch and Clark (1955) found the regression of gain from birth to weaning on weaning age to be -.05 pounds per day. Rollins et al. (1952) found the regression of weight on age for the period from birth to four months to be 1.90 pounds per day and from four to eight months of 1.81 pounds per day. Koch (1951) found that weight increased 2.27 pounds with each additional day of age; whereas Burgess et al. (1954) found that calves increased at the rate of 1.67 pounds per day. These findings gave some indication that preweaning growth of calves was essentially linear.

Work done by Marlowe et al. (1958) proved that season of birth was an important source of variation in average daily gain and weaning weight. They found that when season of birth was broken down by months that calves born in February, March, April, and May had the highest growth rate followed by calves born in January, June, and July.

From a study involving 5,952 Hereford calves, Koch and Clark (1955) found April and May calves to grow at approximately the same rate until weaning time.

Type Score

Marlowe et al. (1958) found that the most important source of variation in type score was due to age of dam. In this study Marlowe found that type score for calves out of two, three, four, five, six,

seven, eight, nine, and ten year old cows was 10.91, 11.37, 11.45, 11.66, 11.67, 11.77, 11.70, 11.46, and 11.5. The type score increased up to seven years where it remained about the same until the cow had passed ten years of age.

There have been few reports on the influence of sex on type score. Koch and Clark (1955) found the difference in weaning type score due to sex was negligible. The work of Marlowe and Gaines (1958) is in agreement with these findings. Koch and Clark (1955), from a study of 5,982 April and May Hereford calves, found the regression of type score on weaning age to be .01 $\pm$ .005. This indicated that early calves tended to score a little higher than those born later in the season.

Marlowe et al. (1958) reported type scores highest for January, February, March, April and May calves. These workers found very little difference in type score of calves born from November 1 through March 31.

Lehman et al. (1961) in their work at Front Royal, Virginia, on 1,987 calves including purebred and grade herds concluded that selection on weaning weights alone should give better results than selection on the basis of daily gain alone. An equal emphasis index using weaning weight and type score should result in more genetic and economic improvement than an equal emphasis using average daily gain and type score.

There is very little information concerning the influence of age of calf on type score. Marlowe et al. (1958) reported a small but significant effect of age of calf on type score when the age was broken down into thirty day intervals from 90 to 300 days of age.

CHAPTER III

EXPERIMENTAL PROCEDURE

Nature of Data

The performance testing program in Tennessee was begun in 1956 as a joint project between the Tennessee Agricultural Experiment Station (Animal Husbandry-Veterinary Science Department) and the University of Tennessee Extension Service. The Extension Service was given the responsibility for the field work and collection of the data, and the Experiment Station was responsible for processing and analyzing the data.

Average daily gain and type score were available on 8,956 animals produced on 96 farms located throughout the state, and represented each of the 5 extension districts. Thirty-six per cent or 3,263 calves were creep fed and the remainder raised by their dams only. Data on the calves included in this study were collected during the period 1960 through 1963. The breeds represented were Angus, Hereford, and Shorthorn.

Only calves weighed and graded between 120 and 299 days of age were included in this study. The standard U.S.D.A. grade for feeder steers were used with each grade being divided into three parts and a numerical grade assigned each animal. Average daily gain of individual calves was calculated by subtracting an actual or estimated birth weight from the observed weaning weight and dividing by the days of age.

Method of Analysis

Herd and year differences were certain to exist; therefore these two sources of variation were absorbed in all analyses. Only a single breed was represented on each farm and thus absorption of herd also implies absorption of breed differences. This procedure assumes that interaction of these factors with other sources of variation included in the analysis are negligible.

Creep feeding was thought to alter the growth pattern of calves, and since unbiased comparisons of creep and non-creep feeding were not possible on an intra-herd basis, these data were divided into separate analyses for creep and non-creep fed calves.

Calves born in each month were represented in these data. Numerous breeders weighed calves on their farms several times in each year. As a result of this practice age of calf and month of birth were not completely correlated and thus independent estimates of these effects on both type score and average daily gain were possible.

The calves included in this study ranged in age from 120-299 days at weaning. A linear growth curve was not considered to adequately describe the growth pattern and thus age of calf was divided into 18 discrete classes of 10 days each and the effect of calf age at each of these periods determined.

Since cows older than 12 years of age were rare in these data and undoubtedly highly selected, ages of dams 12 years and above were classified as a single group. Hence, only 11 age of dams groups (2-12 years) were considered.

Disproportionate subclass numbers caused the classes of effects to be nonorthogonal and necessitated use of the method of Least Squares (Harvey 1960).

An additive model was considered appropriate for the analysis of weaning average daily gain, and type score.

This was:

$$Y_{ijklmno} = \mu + h_i + b_j + a_k + s_l + c_m + d_n + e_{ijklmno}$$

where:

$Y_{ijklmno}$ = observed type score or average daily gain of an individual calf

μ = overall mean when equal numbers exist in the subclasses

h_i = effect of the i_{th} herd class

b_j = effect of the j_{th} year class

a_k = effect of the k_{th} age of dam class

s_l = effect of the l_{th} sex class

c_m = effect of the m_{th} month class

d_n = effect of n_{th} age of calf class

$e_{ijklmno}$ = random errors

The age of dam by sex of calf interaction was included in the analyses of both weanling and birth traits but was omitted when its contribution was found to be non-significant. The age of calf by sex of calf interaction was tested in the analysis of average daily gain and type score was omitted for the same reason. Other interactions were not tested and were assumed negligible.

A similar model was used for analysis of birth weight except age of calf was deleted. Actual birth weights were available on 1,758 calves. Duncan's Multiple Range Test as modified by Kramer (1957) was used for mean separation when significance due to a particular classification was observed.

CHAPTER IV

RESULTS AND DISCUSSION

Birth Weight

In this study birth weights on 1,758 calves were analyzed to determine the influence of age of dam, sex of calf and month of birth. Analysis of variance (Table I) indicates that each of these factors have a highly significant ($P < .01$) effect on birth weight. As was expected, two year old dams produced calves with the lowest birth weights. There was no significant difference in birth weight of calves from dams 3, 5 and 12 years of age. The birth weight of calves from 5, 6, 7 and 9 year old dams were also similar. There was a significant difference between 9 and 10 year old dams. In this study 10 year old cows produced the heaviest calves at birth, and dams 2, 3, 4 and 12 years old or older produced the lightest calves at birth.

The least squares constants for age of dam effects (Table II) are negative for dams 2, 3, 4 and 12 years old and over. These dams produced calves 1 to 5 pounds lighter than calves from 5, 6, 7, 8, 9, 10 and 11 year old dams.

These findings in this study are in general agreement with those reported by Knapp et al. (1942), Dawson et al. (1947), Burris and Blunn (1952). However, these results are not in agreement with the work of Rollins and Guilbert (1954) and also Koch and Clark (1955). These latter workers reported heaviest birth weights from cows seven years of age.

TABLE I

ANALYSIS OF VARIANCE FOR AGE OF DAM, SEX OF CALF, AND MONTH OF BIRTH EFFECTS ON BIRTH WEIGHT

Source	d.f.	S.S.	M.S.	F
Age of dam	10	7,146.97	714.70	13.44**
Sex of calf	1	2,081.70	2,081.70	39.15**
Month of birth	11	1,694.33	154.02	2.90**
Residual	1606	85,399.97	53.18	

**$P < .01$.

TABLE II

LEAST SQUARES CONSTANTS[a] OF AGE OF DAM AND SEX OF CALF EFFECTS ON BIRTH WEIGHT

Age of dam (years)	No. of calves	Constants
2	212	-5.36
3	293	-2.85
4	239	-1.07
5	214	.06
6	162	1.31
7	155	.86
8	154	1.19
9	94	1.78
10	89	3.35
11	62	2.51
12 and over	84	-1.78
Sex of calf		
Male	896	2.23
Female	862	-2.23

[a]Constants are deviations from the overall adjusted mean when equal numbers exist per age of dam and sex class. The overall unadjusted mean of birth weight was 63.1 pounds.

The overall unadjusted arithmetic mean for birth weight of calves in this study was 63.1 pounds. Although this mean was calculated over all herds, years and breeds, it nevertheless is considered to be the most reliable estimate available from these data. Five year old cows produced calves that more closely approached the mean than any other age of dam group; therefore if adjustment to a common base is desired, a 5 year old basis seems practical.

An additive adjustment factor of 5 pounds would be needed for the birth weight of calves from 2 and 3 year old cows. Four pounds should be subtracted from the birth weight of calves from 10 and 11 year old dams to equal a 5 year old. No adjustment appears necessary for cows ranging in age from 4-9 years of age.

As reported by most other workers, sex of calf influences birth weight more than any other single factor. Results of this study indicate that sex of calf can cause as much as a 5 pound differential between bulls and heifers in favor of bulls. Brinks et al. (1961), Koch et al. (1959), Clark et al. (1958), McCormick et al. (1956), Clark et al. (1956) have all reported similar differences.

Very little information is available on the effects of month of birth on birth weight. The least squares constants for month of birth effects (Table III) indicate that calves born in July have the lowest birth weight. Calves born in April, May and June had birth weights significantly heavier than those born in all the other months. Due to the small number of calves born in July this estimate is very likely to be influenced by sampling error. Test of significance shows that

TABLE III

LEAST SQUARES CONSTANTS[a] FOR MONTH OF BIRTH EFFECTS ON BIRTH WEIGHT

Month of birth	No. of calves	Constants
January	292	0.54
February	328	-.96
March	200	0.26
April	147	2.11
May	78	2.94
June	14	2.01
July	15	-5.29
August	29	-.97
September	64	-.74
October	179	-.26
November	232	0.87
December	180	-.51

[a]Constants are deviation from the overall adjusted mean when equal number exist per month of birth class. The overall adjusted mean of birth weight was 63.1 pounds.

there is no significant difference in birth weight of calves born in January, February, March, August, September, October, November, and December.

Average Daily Gain

The analysis of variance (Tables IV and V) shows that age of dam, sex of calf, month of birth, and age of calf have a highly significant ($P<.01$) effect on average daily gain. This was true for both creep and non-creep fed calves.

Age of dam was one of the most important causes of variation in average daily gain. Least squares constants for age of dam effects were all negative for 2, 3, and 4 year old cows. The least squares constants for dams 5 through 12 years were all positive.

The results of this study show that 2 and 3 year old dams produce calves that have the lowest average daily gains in both creep and non-creep fed herds. In the creep fed calves there was no significant difference in 4, 5, 6, 7, 11 and 12 year old dams as far as average daily gain was concerned. Eight, nine, and ten year old dams produced calves whose average daily gain is essentially the same.

Age of dam effects were similar among creep fed calves with the exception that no significant differences were noted in calves from 4 and 12 year old dams. The calves from 5, 6, 7, 9, 10, 11 and 12 year old dams had approximately the same average daily gain when no creep feeding was practiced.

Calves from dams 5 through 12 years of age had the highest average daily gain as shown by the least squares constants in Table VI.

TABLE IV

ANALYSIS OF VARIANCE FOR AVERAGE DAILY GAIN AND TYPE SCORE FOR CREEP FED CALVES

Source	Average Daily Gain				Type Score		
	d.f.	S.S.	M.S.	F.	S.S.	M.S.	F.
Age of dam	10	12.78	1.28	24.60**	33.54	3.35	2.72**
Sex of calf	2	34.56	17.28	332.57**	6.87	3.43	2.78**
Month	11	5.00	0.46	8.76**	46.88	4.26	3.45**
Age of calf	17	2.93	0.17	3.32**	109.33	6.43	5.21**
Residual	3,048	158.35	0.05		3,759.98	1.23	

*P < .05.

**P < .01.

TABLE V

ANALYSIS OF VARIANCE FOR AVERAGE DAILY GAIN AND TYPE SCORE FOR NON-CREEP FED CALVES

Source	Average Daily Gain				Type Score		
	d.f.	S.S.	M.S.	F.	S.S.	M.S.	F.
Age of dam	10	19.28	1.93	37.65**	142.23	14.22	10.45*
Sex of calf	2	24.24	12.12	237.68**	52.41	26.20	19.26**
Month	11	5.38	0.48	9.44**	43.90	3.99	2.93**
Age of calf	17	3.65	0.21	4.19**	65.43	3.85	2.83**
Residual	4,406	225.64	0.05		5,995.14	1.36	

*P<.05.

**P<.01.

TABLE VI

LEAST SQUARES CONSTANTS[a] OF AGE OF DAM EFFECTS OF AVERAGE DAILY GAIN TO WEANING OF CREEP AND NON-CREEP FED CALVES

Age of dam (years)	No. of calves	Creep	No. of calves	Non-creep
2	395	-.150	565	-.181
3	484	-.090	697	-.088
4	440	-.030	676	-.022
5	393	0.006	535	0.016
6	327	0.014	448	0.030
7	256	0.035	414	0.030
8	310	0.062	434	0.058
9	196	0.073	281	0.031
10	162	0.065	229	0.049
11	145	0.025	183	0.043
12 and over	255	0.005	232	0.034
Sex of calf				
Bull	1,300	0.124	1,404	0.081
Heifers	1,620	-.110	2,416	-.088
Steers	343	-.014	874	0.007

[a]Constants are deviations from the overall adjusted mean when equal numbers exist per age of dam and sex class. The overall unadjusted mean was 1.74 and 1.60 lb. per day for creep and non-creep fed calves.

In this study nine year old cows produced the heaviest weaning calves. These data imply that average daily gain increased with increase of age up to 9 years of age, and then a gradual decline was noted in average daily gain from cows 9 through 12 years and over (Figure 1). These findings are in very close agreement with work done by Marlowe et al. (1958). This report is in slight disagreement with Koch and Clark (1955) who reported that when the influence of age of dam was determined by averaging the production records for each cow within years, the maximum production for weaning weight appeared to be six years of age. These differences could be attributed to an age differential in the two studies. The cows' ages in their study ranged from 3 to 10 years of age, and the dams' age in this study ranged from 2 to 12 years of age and over.

Rollins and Guilbert (1954) found that cows within the age range of 7 to 10 years produced the fastest growing calves up to four months of age and were heaviest at 240 days of age. They also reported cows in the optimum age range produced calves that grew 0.17 pound per day more than calves from 3 year old cows, 0.10 pound more than calves from 4 year old cows and 0.15 pound per day more than calves from cows 12 to 14 years of age during the first four months, and weighed 21, 31, and 18 pounds more at 240 days of age.

This study disagrees somewhat with the work of Knox et al. (1951) who stated the age of dam effect was a curve with maximum weaning weights expected from six year old cows with a gradual decline from six to eleven years. There is some disagreement with work done by

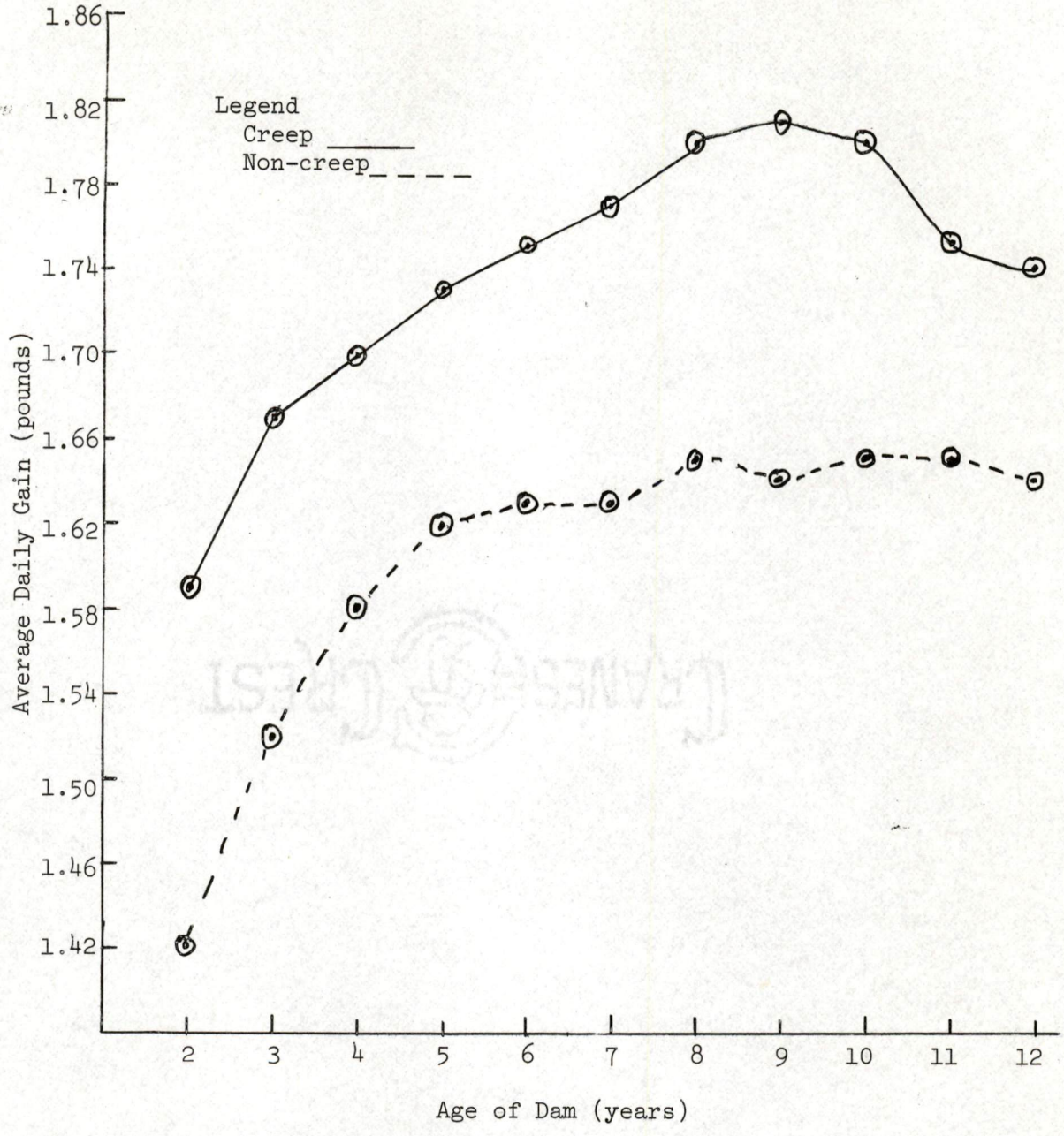

Figure 1. Effects of Age of Dam on Average Daily Gain

Roubicek et al. (1956) who reported that a ten year old cow may be expected to produce about the same size calf at weaning as a two year old heifer.

Marked deviations in nutritional, environmental, and selection standards may greatly influence the effect of age of dam on average daily gain. Thus, it would seem the most appropriate adjustments for a particular herd or region would come from herds of similar genotype, and managed under similar conditions within the region.

Sex of calf had a significant ($P<.01$) effect on average daily gain. Least squares constants for bull calves in this study were 0.12, steers 0.01 and -.11 for heifers. These findings agree very closely with work done by Dahman and Bogart (1952) who reported that bull calves gained 0.13 pound per day more than females to weaning age. These findings also agree closely with work done by Rollins and Guilbert (1954), Koch and Clark (1955), Marlowe and Gaines (1958), Clark et al. (1958), Brinks et al. (1961), Gifford (1953), Knapp et al. (1942), and Burgess et al. (1954). Koch (1951) reported that bull calves outweighed heifers by 44 pounds and steers outweighed heifers by 13 pounds at weaning. Thus, these data further substantiate reports of other workers that bulls have a higher average daily gain than steers, and steers gain faster than heifers. However, the comparisons of steers with the other sexes in this study may be biased by selection, since the lower type and gaining bull calves within herds were probably steered.

Age of calf and average daily gain were highly significant in this study ($P<.01$). Tests of significance indicated that calves 120

through 179 days of age had a higher average daily gain than those from 180 to 300 days of age. These data suggest that if calves are weighed only once and adjusted to 180 days of age, an adjustment would be necessary for calves from 180 to 300 days of age so as to give an unbiased estimate of their performance, since they are not considered to be genetically inferior to younger calves. The data presented in Table VII and Figure 2 demonstrates a gradual decline in average daily gain from 120 to 300 days of age.

There is some evidence in this study that creep feeding tended to stabilize the growth pattern of calves in the age range of 210 to 300 days of age. These findings are in close agreement with work done by Marlowe (1958), Koch and Clark (1955), Rollins et al. (1952), Koch (1951), and Burgess et al. (1954).

The least squares constants for month of birth effects on average daily gain given in Table VIII and Figure 3 suggests that creep feeding compensates somewhat for the lower average daily gain of August born calves. If creep feeding is used, tests of significance imply that calves born between June and November are similar and have the lowest average daily gains.

Average daily gains of calves born in January, February and March were significantly higher ($P < .01$) than those born in other months. April, May and December calvings were found to be similar, and were intermediate to the high and low.

Marlowe et al. (1958) and Flock (1962) reported similar differences in their study. It is evident that from this study that January,

TABLE VII

LEAST SQUARES CONSTANTS[a] OF AGE OF CALF EFFECTS ON AVERAGE DAILY GAIN TO WEANING OF CREEP AND NON-CREEP FED CALVES

Age in days	No. of calves	Creep	No. of calves	Non-creep
120	49	0.096	83	0.070
130	60	0.084	122	0.064
140	76	0.018	177	0.089
150	104	0.030	198	0.088
160	173	0.053	226	0.069
170	182	0.040	297	0.058
180	202	-.007	337	0.061
190	274	0.006	345	0.021
200	267	0.003	329	0.014
210	313	-.006	360	-.005
220	337	-.030	426	-.022
230	297	-.035	359	-.048
240	257	-.025	299	-.031
250	202	-.001	301	-.064
260	171	-.098	340	-.073
270	139	-.024	211	-.102
280	108	-.039	171	-.058
290	52	-.060	113	-.130

[a]Constants are deviations from the overall adjusted mean when equal numbers exist per age of calf class. The overall unadjusted mean was 1.74 and 1.60 lb. per day for creep and non-creep fed calves.

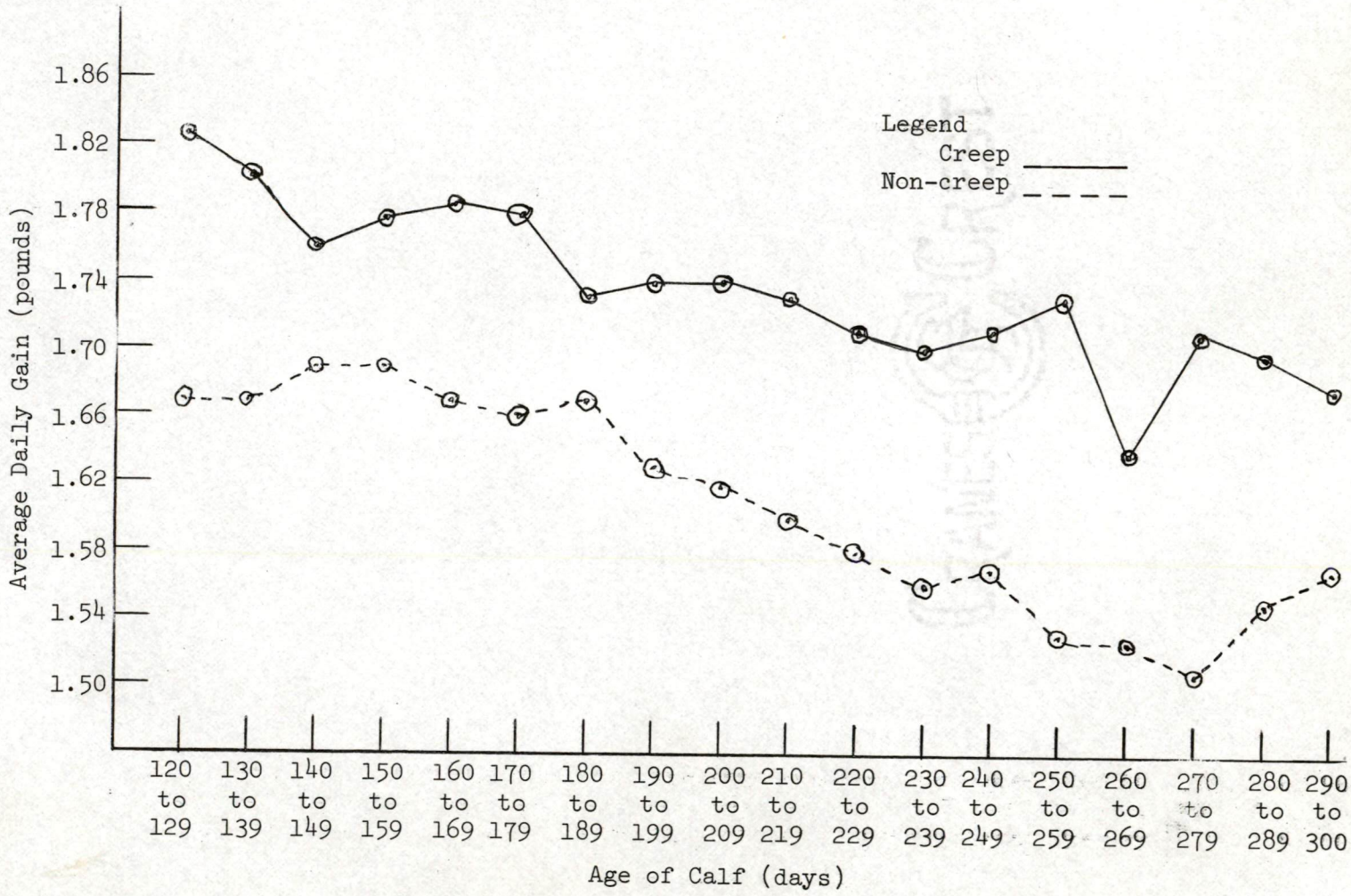

Figure 2. Effects of Age of Calf on Average Daily Gain

TABLE VIII

LEAST SQUARES CONSTANTS[a] OF EFFECT OF MONTH OF BIRTH ON AVERAGE DAILY GAIN TO WEANING OF CREEP AND NON-CREEP FED CALVES

Month of birth	No. of calves	Creep	No. of calves	Non-creep
January	480	0.089	833	0.074
February	435	0.077	1,070	0.077
March	441	0.085	795	0.060
April	304	0.036	622	0.099
May	190	0.013	295	0.015
June	117	-.044	88	0.032
July	96	-.050	34	-.025
August	71	-.080	53	-.146
September	306	-.061	180	-.093
October	273	-.057	208	-.062
November	284	-.028	175	-.054
December	266	0.030	341	-.067
Sex of calf				
Bulls	1,300	0.124	1,404	0.081
Heifers	1,620	-.014	2,416	-.088
Steers	343	-.110	874	0.007

[a]Constants are deviations from the overall adjusted mean when equal numbers exist per month of birth and sex class. The overall unadjusted mean was 1.74 and 1.60 lb. per day for creep and non-creep fed calves.

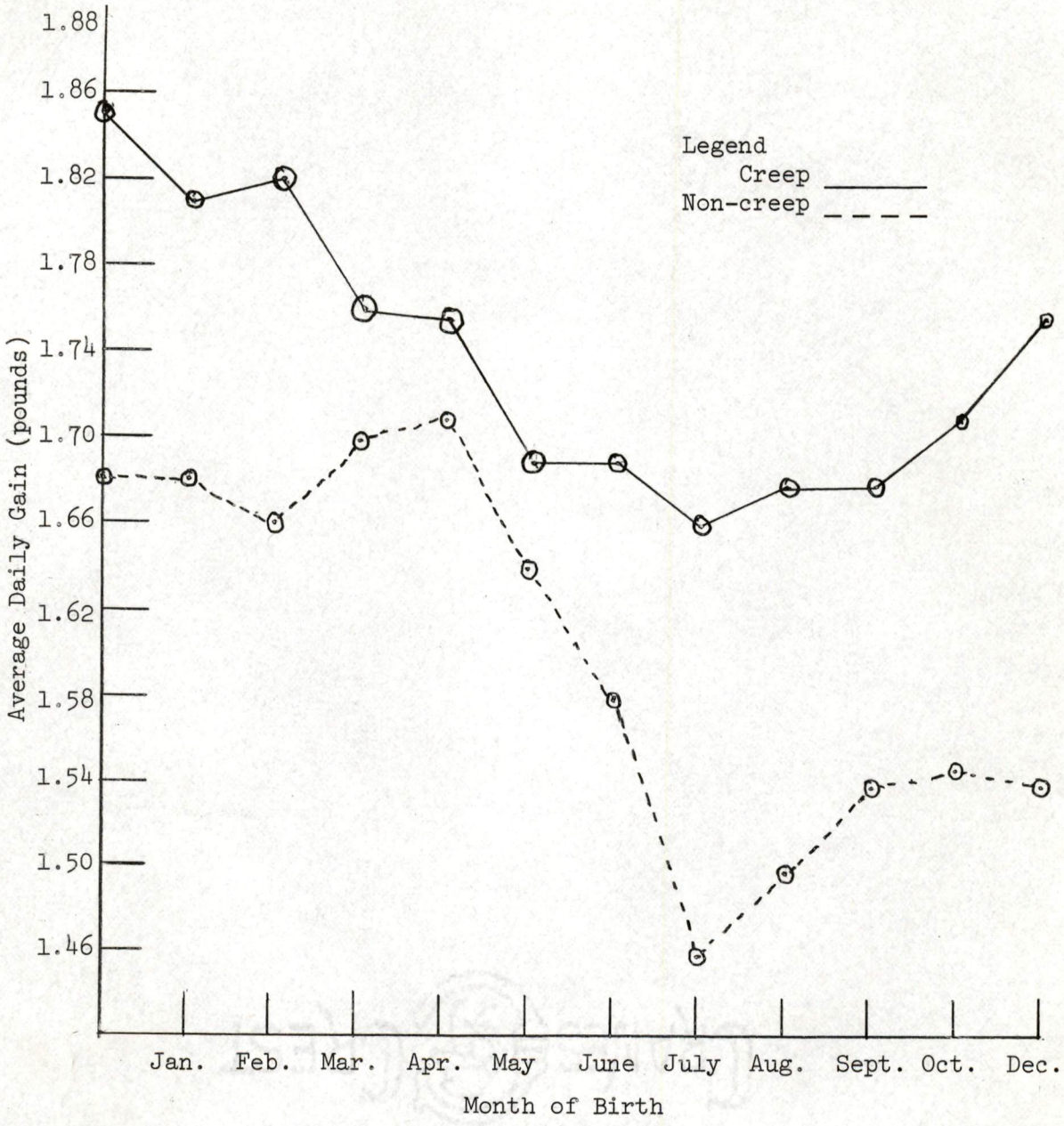

Figure 3. Effects of Month of Birth on Average Daily Gain.

February, March, April and May calvings are desirable in Tennessee.

Type Score

In this study, age of dam had a small but significant effect on type score. The least squares constants for creep fed calves were all positive with the exception of 2, 3, 11 and 12 year old dams which were negative (Table IX).

As shown by Figure 4, creep fed calves type score by age of dam group ranged from 12.20 to 12.47. The type score remained almost the same for dams 3 through 10 years of age which is in direct agreement with work reported by Marlowe (1958).

Non-creep fed calves type scores by age of dam group ranged from 11.58 to 11.70. This is one-third of a grade lower than creep fed calves, however there is some bias, since these comparisons are across herds, and therefore represent different cattle and perhaps different management conditions except for supplemental feeding of the calves.

The findings reported in this study suggest that creep fed calves type score higher than those that have not been creep fed. This suggests that condition of the calf may have an influence on the grader's decision.

Sex of calf influenced type score very little, however the influence was significant ($P < .01$). Bulls typed slightly higher than steers, and steers higher than heifers. The mean type scores were 12.42, 12.37, and 12.32 for bulls, steers and heifers respectively. This possibly reflects the earlier sexual development of bulls or a preference of certain graders for male calves.

TABLE IX

LEAST SQUARES CONSTANTS[a] OF AGE OF DAM EFFECTS ON TYPE SCORE TO WEANING OF CREEP AND NON-CREEP FED CALVES[b]

Age of dam (years)	Creep	Non-creep
2	-.062	-.329
3	-.059	-.012
4	0.057	0.186
5	0.146	0.184
6	0.064	0.337
7	0.097	0.138
8	0.110	0.100
9	0.081	-.096
10	0.083	-.153
11	-.227	-.121
12	-.246	-.234
Sex of calf		
Bulls	0.055	0.141
Heifers	-.059	-.120
Steers	0.004	0.021

[a]Constants are deviations from the overall adjusted mean when equal numbers exist per age of dam and sex class. The average type score for creep fed calves was 12.37 and for non-creep 11.32.

[b]Number of calves per age of dam and sex group are the same as those shown in Table VI, page 23.

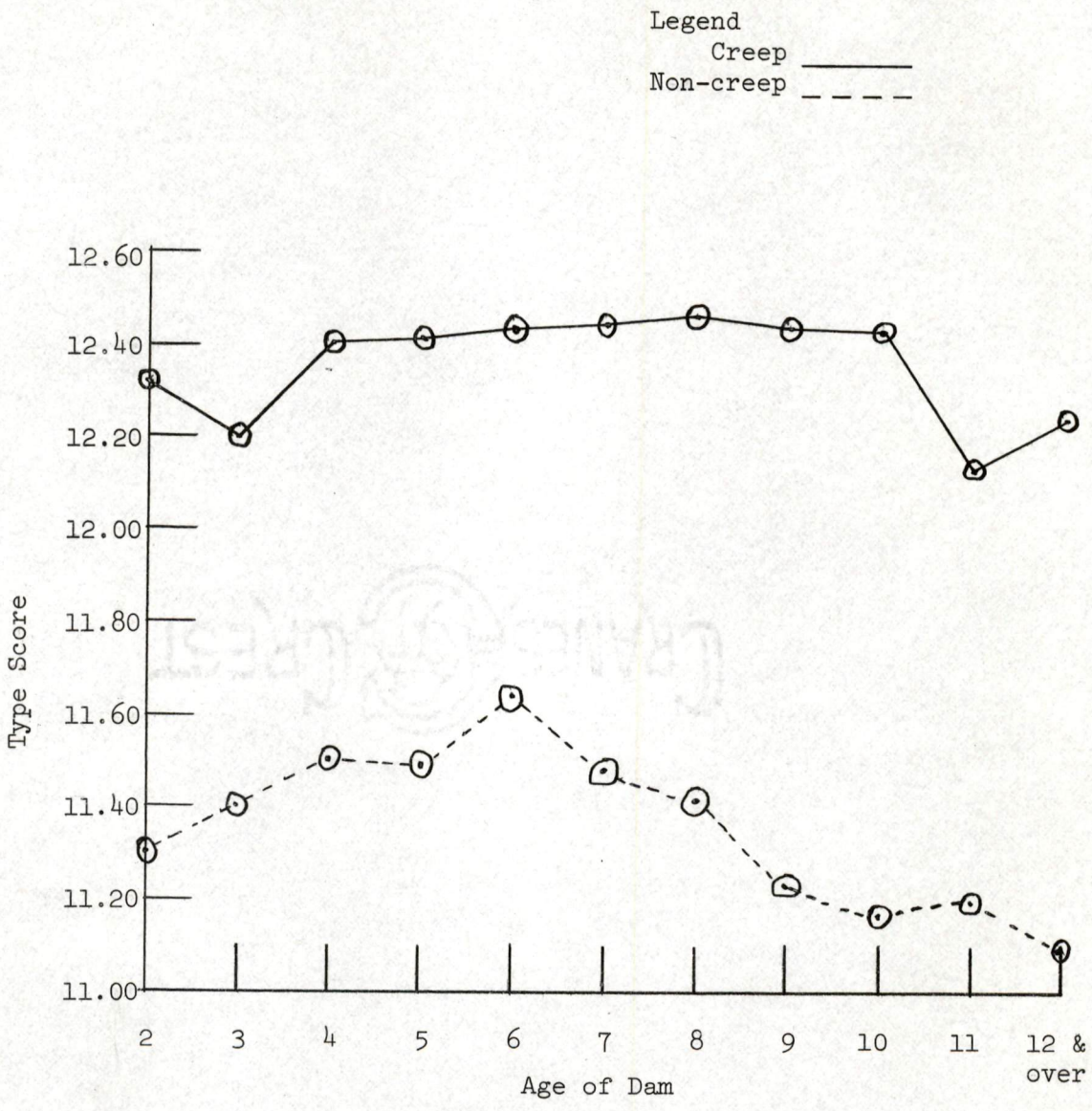

Figure 4. Age of Dam Effects on Type Score.

There were significant month of birth effects on type score (Tables IV and V, pages 21 and 22). Least squares constants were positive for all months except August, September, October and November (Table X). Perhaps this reflects the unfavorable weaning time, lack of bloom, and the poor condition of summer and fall born calves. Calves born in August had the lowest type score regardless of creep feeding. As shown in Figure 5, there is little effect of month of birth on type score with the exception of August. These findings tend to substantiate the data of Koch and Clark (1955), Marlowe et al. (1958) and Lehman et al. (1961).

It is obvious from this study that under Tennessee conditions August calvings are least profitable. The rainfall in Tennessee during July, August, and September is generally critically low and pastures are usually short and unpalatable. The mothering ability of the cow during this period is restricted, and places her at a disadvantage.

Age of calf significantly influenced type score of calves in this study ($P < .01$). Younger calves consistently have lower type scores than older calves. The least squares constants presented in Table XI are all negative for calves typed when they are 120 through 190 days of age. This means that calves typed at a younger age are at a considerable disadvantage when compared to calves that are typed closer to weaning. Type scoring of calves ranging in age from 120-190 days would underestimate their "true" type considerably. A more accurate estimate of progeny performance could be arrived at if calves were typed between 180 and 270 days of age.

TABLE X

LEAST SQUARES CONSTANTS[a] OF EFFECT OF MONTH OF BIRTH ON TYPE SCORE TO WEANING ON CREEP AND NON-CREEP FED CALVES

Month of birth	Creep	Non-creep
January	0.048	0.098
February	0.043	0.043
March	0.264	0.094
April	0.069	0.265
May	0.218	0.089
June	0.058	0.252
July	0.081	-.070
August	-.590	-.752
September	-.116	-.090
October	0.141	-.010
November	0.025	-.052
December	0.041	0.133
Sex of calf		
Bulls	0.055	0.141
Heifers	-.059	-.120
Steers	0.004	-.021

[a]Constants are deviations from the overall adjusted mean when equal numbers exist per month of birth and sex class. The average type score for creep fed calves was 12.37 and for non-creep 11.32.

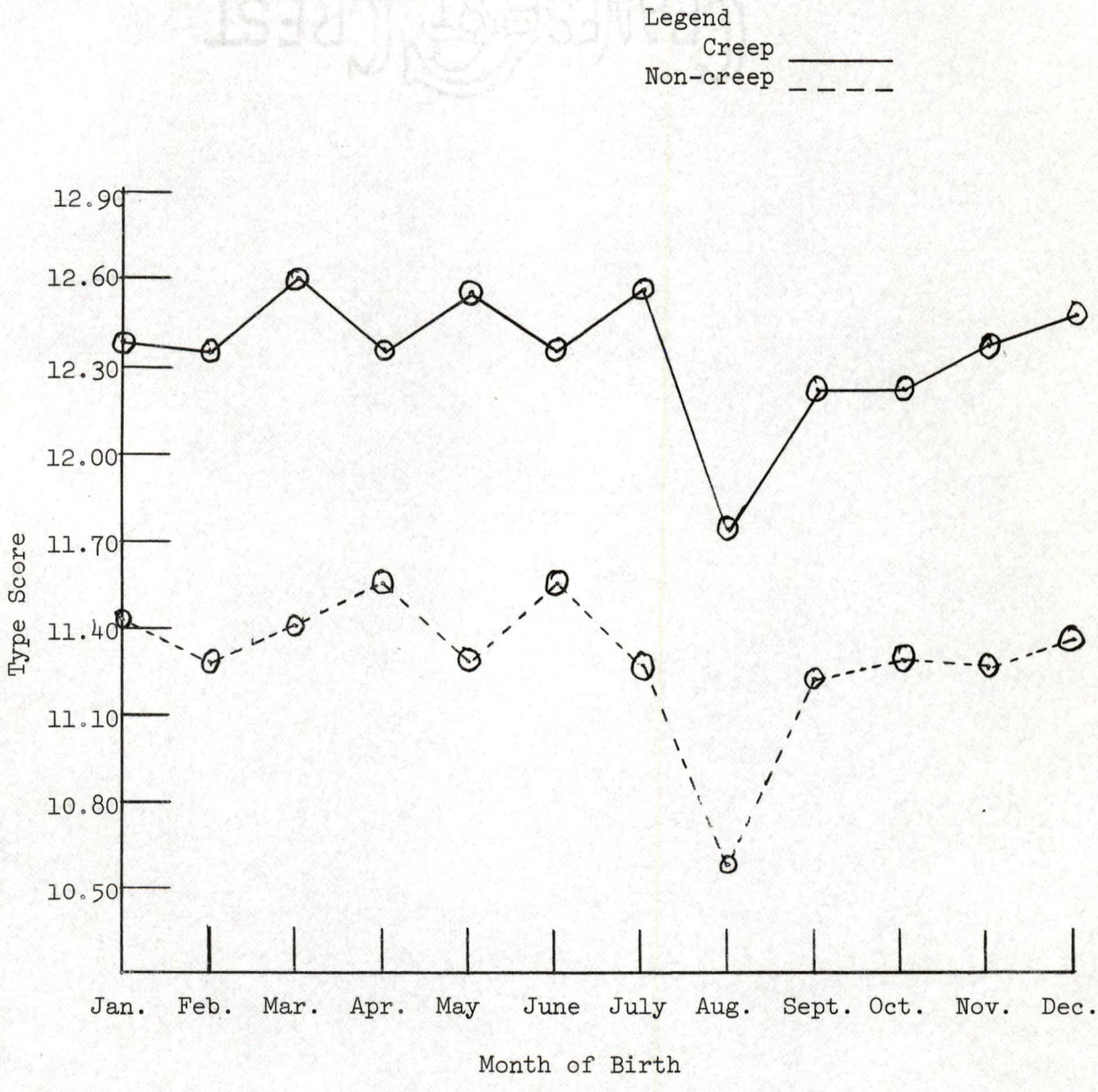

Figure 5. Effects of Month of Birth on Type Score.

TABLE XI

LEAST SQUARES CONSTANTS[a] FOR EFFECTS OF AGE OF CALF ON TYPE SCORE TO WEANING OF CREEP AND NON-CREEP FED CALVES

Age in days	Creep	Non-creep
120	-.641	-.540
130	-.390	-.496
140	-.496	-.423
150	-.408	-.260
160	-.205	-.046
170	-.258	-.104
180	-.233	0.003
190	-.082	-.144
200	0.084	0.023
210	0.009	0.023
220	0.223	0.112
230	0.355	0.118
240	0.223	0.209
250	0.522	0.110
260	0.093	0.288
270	0.403	0.463
280	0.403	0.331
290	0.039	0.333

[a]Constants are deviations from the overall adjusted mean when equal numbers exist per age of calf class. The average type score for creep fed calves was 12.37 and for non-creep 11.32.

Figure 6 shows that age of calf and type score to be essentially linear. Creep feeding does have some influence on type score and, again, this can be correlated with condition. The difference in creep and non-creep is approximately one-third of a grade, however since the analysis involved different herds, little significance can be attached to this difference.

It is suggested from this data that a common adjustment factor for age of calf variation on type score could be used for both creep and non-creep, since the slope of the age effects are essentially parallel and linear from 120 to 250 days of age.

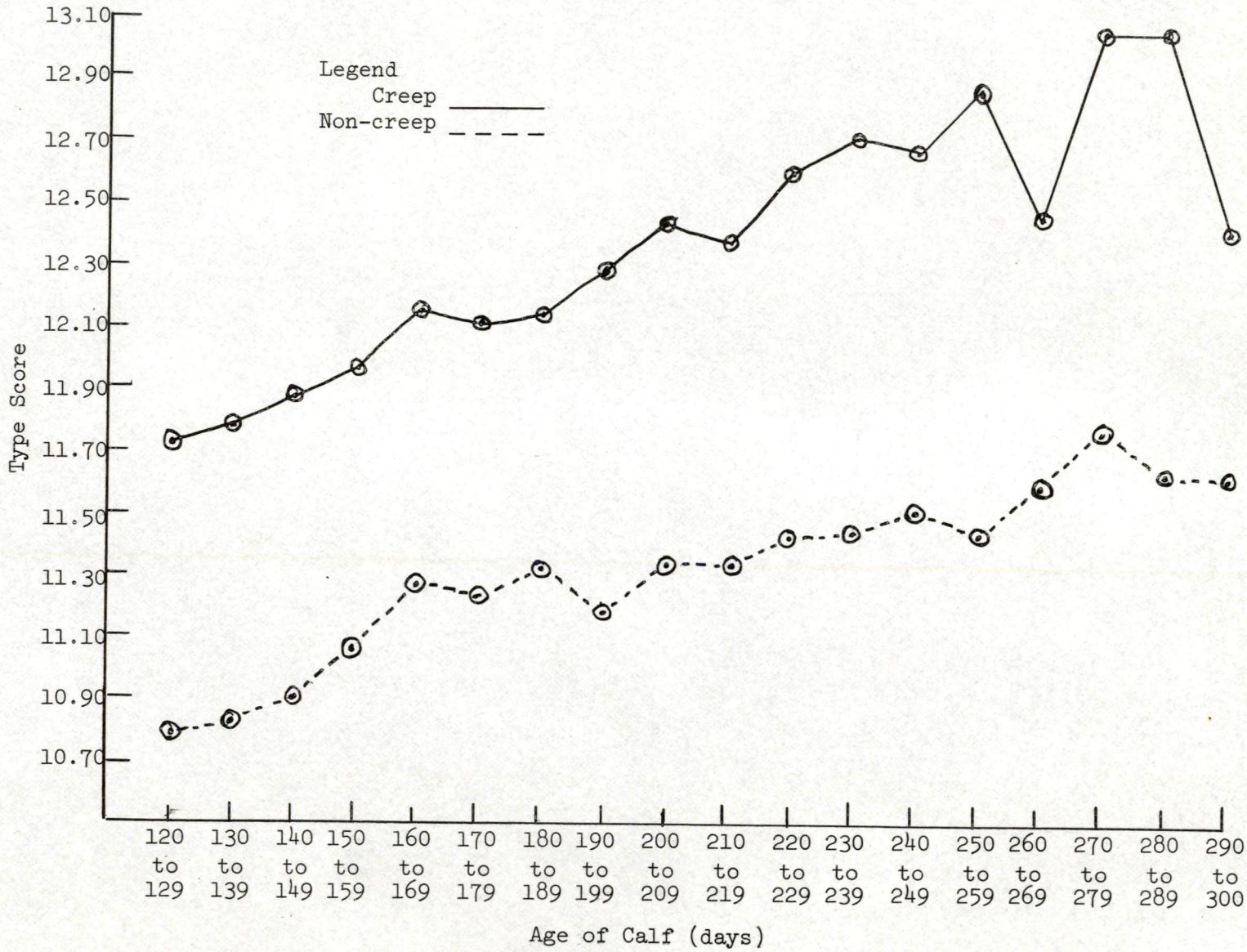

Figure 6. Effects of Age of Calf on Type Score.

CHAPTER V

CONCLUSIONS

Based on the results of this study the following inferences seem warranted:

1. Calves out of 2, 3, 4 and 12 year old cows would be approximately 5 pounds lighter at birth than those from 5, 6, 7, 8, 9, 10 and 11 year old cows. The lowest birth weight was from two and three year old dams.

2. Sex of calf was the most important source of variation in birth weight. Bull calves were as much as 5 pounds heavier at birth than heifer calves.

3. Calves born in July had the lowest birth weight; however, due to the small numbers, it is felt that this does not give an accurate estimate of month of birth effects.

4. Age of dam can contribute to a difference of as much as 0.23 pounds per day in average daily gain of calves from 2 and 10 year old dams.

5. Age of dam has very little effect on average daily gain of calves out of dams four through eleven years of age. Two, three and twelve year old dams produced the lowest gaining calves.

6. Sex of calf has a highly significant effect on average daily gain. Bulls were 0.12 unit above the average, heifers -.11 unit, and steers intermediate between bulls and heifers.

7. Age of calf has a pronounced effect on average daily gain. Average daily gain is highest during the early stages of growth, and gradually declines to 300 days of age. Creep feeding appeared to stabilize the growth pattern of calves in the 210 to 300 day old age range, but did not appear to affect the relationship at younger ages.

8. Month of birth effects on average daily gain are highly significant ($P < .01$). January, February, March, April and May calves consistently gained higher than those born in the other months. August born calves gained 0.41 pound per day less than those born in January, February, March, April and May. Therefore, it is apparent, that adjustment should be made for the month of birth influence on this trait.

9. Age of dam had a small but significant effect on type score. The type score of calves out of cows 3 through 6 years of age were approximately the same. The type score of creep fed calves ranged from 12.20 to 12.47, and non-creep ranged from 11.58 to 11.70. Very little significance can be attached to the observed difference in type score of creep versus non-creep fed calves due to the fact that this comparison was made between herds rather than on a within herd basis. However, in both creep and non-creep herds, calves from 2, 3, 11 and 12 year old dams exhibited some tendancy to type lower than calves from dams ranging in age from 4 to 10 years.

10. Sex of calf exerted some influence on type score. Bulls typed highest with a type score of 12.42, steers 12.37, and heifers intermediate with a type score of 12.32.

11. Month of birth effects on type score and average daily gain are almost commensurate. August born calves typed lowest regardless of creep feeding. Very little difference was noted in type score regardless of month of birth with the exception of August. August born calves typed one-third of a grade lower than calves born during the other months.

12. Age of calf is an important source of variation. Calves typed at 120 to 190 days of age were at a disadvantage. The relationship between type score and age of calf is essentially linear.

13. Creep feeding did exert some influence on type score. Creep fed calves typed higher; however, due to the nature of the analysis it is believed that these differences in type score are insignificant as far as creep and non-creep are concerned.

CHAPTER VI

SUMMARY

The records of 8,956 performance tested calves were analyzed to determine the (1) effects of age of dam, sex of calf, and month of birth on birth weight, (2) the effects of age of dam, sex of calf, age of calf, and month of birth on average daily gain, (3) and the effects of age of dam, sex of calf, age of calf, and month of birth on type score.

Age of dam effects were significant for all the traits considered. Generally, two and three year old dams produced calves which were lighter at birth, gained more slowly from birth to weaning, and received lower type scores than did older cows. There was some suggestion of a decrease in cow productivity after 11 years for average daily gain and type score.

August born calves were inferior in performance to calves born in most other months. Generally, calves born between January and June had the highest birth weights, average daily gains and type scores. It is apparent some adjustment for month of birth is warranted under Tennessee conditions.

The average daily gain of calves decreased in a linear manner, whereas type score increased similarly as the calf's age increased at ten day intervals from 120 to 300 days of age. For example, calves 120 days of age had an average daily gain of approximately 0.10 pound greater and a type score of one-third of grade less than calves 250 days of age.

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