June 21, 1968

To the Graduate Council:

I am submitting herewith a thesis written by Merrill D. Austin entitled "Factors Influencing Weaning Performance of Beef Calves on the Plateau Area of 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.

Dale M. Jamison
Major Professor

We have read this thesis and recommend its acceptance:

Robert R. Shrode

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Accepted for the Council:

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FACTORS INFLUENCING WEANING PERFORMANCE OF BEEF CALVES ON THE PLATEAU AREA OF 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

Merrill D. Austin

August 1968

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ABSTRACT

The birth-to-weaning performance records of 1869 non-creep fed and 791 creep fed calves were utilized in this study. These data were collected from purebred and high grade commercial cow herds in the Tennessee Beef Cattle Improvement Program in the Cumberland Plateau area of Tennessee. The data were collected over a 3-year period (1964-66). Two traits of economic importance, viz., average daily gain from birth to weaning and type score at weaning, were used in these analyses. The objective of this study was to evaluate the effects of age of dam, sex of calf, season or month of birth and age of calf on average daily gain to weaning and type score at weaning of calves produced on the Cumberland Plateau in Tennessee.

The effects of age of dam on average daily gain from birth to weaning were highly significant ($P<.01$) for both non-creep and creep fed calves. A cow's individual performance was lowest at 2-, 3-, 4-, and 12-years of age for non-creep fed calves. Whereas, in the creep fed group, 2- and 3-year-old dams produced calves with the lowest average daily gains.

Age of dam had a small but significant effect on type score of non-creep fed calves. The maximum type score of a cow's calves were obtained when she was within the range of 3 to 8 years, and decreased as she became older. No significant differences among the type scores of creep fed calves were observed.

Sex of calf had a significant effect on average daily gain of both non-creep and creep fed calves. Non-creep fed bull calves gained 0.17 pound more than heifers, and steers gained 0.04 pound less than bull calves. In the creep fed group, the estimates were 0.20, 0.15 and -.05 for bulls, steers and heifers, respectively.

Sex of calf influenced type score of non-creep fed calves. Bull calves graded significantly higher than steers and heifers. Whereas, there was no significant difference between steers and heifers.

Sex of calf had a significant influence on the creep fed calves. Bulls had a type score significantly higher than steers, and the type score of steers was significantly higher than heifers.

August-born calves were inferior in performance to calves born in other months. Generally, calves born in February, March, April, May, June and October appear to be desirable for the area sampled in these analyses.

Month of birth had no apparent effect on type score of creep fed calves. Non-creep fed calves born in January, February, March and August graded significantly lower than calves born in any other month. However, from these data it appears that some adjustment for month of birth is warranted.

Age of calf was one of the most important sources of variation in average daily gain and type score. The average daily gain of calves decreased in a linear manner; whereas, type score increased as the calf's age increased within the limits of these data.

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CHAPTER I

INTRODUCTION

Beef cattle production on the Cumberland Plateau in Tennessee is comprised predominantly of the commercial production of feeder calves, with a few purebred herds and a limited amount of feeding, mostly as a warm-up operation for the feed lots north of Tennessee or in other cattle feeding areas. These calves are produced largely by mating purebred bulls of approved merit, preferably bulls with recommended performance records, to high grade commercial dams. The success of the feeder calf enterprise depends upon improvements that can be made in breeding, along with proper feeding and management, to bring about improved rates and gains and type score.

There has been a feeling among livestock leaders and others for some time that there was sufficient difference in environmental influences, such as soil type and climatic variations, affecting beef cattle production in a twelve-county area on the Cumberland Plateau, from that of East Tennessee or the rest of the state, to warrant a separate investigation of these effects.

The objectives of beef cattle producers are to produce fast gaining calves of sufficient type and quality, as efficiently as possible, that will go into the feed lot and perform in such a manner as to efficiently produce a product of superior quality to hold its place in the highly competitive retail food markets of the present day.

Therefore, the cattle breeder must continuously exercise care and diligence in selection if he is to achieve the necessary improvement in performance of his breeding stock to meet the needs of the beef cattle industry. Selection, based on the animal's appearance has been used for many years. In recent years, research has shown that performance records and their use can provide an effective tool which can be used by cattle breeders as an aid in selection for growth rate, carcass quality and type of conformation.

It is generally recognized that environmental factors have a direct influence on variations in birth weight, average daily gain and type score. Information is needed on the type and magnitude of these effects in order to adjust performance records before selections are made.

The purpose of this investigation was to evaluate the effects of age of dam, sex of calf, season or month of birth and age of calf on average daily gain to weaning and type score at weaning of calves produced on the Cumberland Plateau in Tennessee.

CHAPTER II

REVIEW OF LITERATURE

Much has been written in regard to the influence of season or month of birth, age of dam, age of calf and sex of calf on the average daily gain of calves from birth to weaning and type score at weaning. However, the very magnitude of the environmental factors, and number of breeds of cattle involved in these studies make many of them not directly pertinent to the immediate problem. Therefore, only a brief summary of the work reported by other investigators will be given here.

I. EFFECT OF AGE OF DAM ON AVERAGE DAILY GAIN

In a study involving nearly 10,000 Tennessee calves, age of dam, sex of calf and month of birth had highly significant ($P<.01$) effects on average daily gain of calves as reported by Barker (1964). This was true for both creep fed and non-creep fed calves. Similar highly significant age of dam, sex of calf and season of birth ($P<.01$) effects on average daily gain were reported by Jamison (1966) from a study of 1272 Angus and 2231 Hereford calves at the Main Station of the Tennessee Agricultural Experiment Station and six branch stations over a seven-year period (1956-1963).

These data show that a cow's individual performance was lowest at ages 2, 3, 4 and 11 years. These estimates are in general agreement with those of Marlowe and Gaines (1958), Rollins and Guilbert (1954),

Blackwell, Knox and Hurt (1958) and Koger and Knox (1954) who found that cows within a 6-to-10-year range weaned calves with higher average daily gain. Also, their estimates for correction factors needed to adjust for age of dam in these years were comparable to those reported by Jamison (1966). His estimates for these adjustment factors were 0.23, 0.14 and 0.08, respectively.

Many estimates for the effects of age of dam on average daily gain of calves from birth to weaning have been made by several investigators. The more recent estimates for these effects were summarized by Jamison (1966) and Butts (1966).

Barker (1964), in an analysis of the performance test records for 8,956 calves, concluded that: (1) age of dam could contribute to a difference of as much as 0.23 pounds per day in average daily gain of calves from 2-to-10-year-old cows; (2) age of dam has very little effect on average daily gain of calves out of dams 4 through 11 years of age. Two-, 3- and 12-year-old dams produced the lowest gaining calves; and 8-, 9- and 10-year-old dams produced calves whose average daily gain were not greatly different.

In Barker's (1964) study, 9-year-old cows produced the heaviest calves. These data imply that average daily gain of calves increased progressively with age of dam up to nine years, then a gradual decline in average daily gain was noted for calves from dams 9 through 12 years of age and over. These findings are in very close agreement with work done by Marlowe and Gaines (1958).

Rollins and Guilbert (1954) found that cows 7 to 10 years of age

produced the fastest gaining calves up to four months of age, and were heaviest at 240 days of age. Also, cows in the optimum age range produced calves that gained 0.17 pound per day more than calves from 3-year-old cows, 0.10 pound per day 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, respectively.

II. EFFECT OF AGE OF DAM ON TYPE SCORE

Jamison (1966) reported that age of dam had little, if any, effect on type score of calf at weaning. Whereas, Barker (1964) reported a small but significant age-of-dam effect on type score. They were in general agreement that maximum type score of calf occurred at ages of dam 3 through 7 years, when determined on a between-cow basis. These findings were in agreement also with observations reported by Marlowe and Gaines (1958) and Lehmann et al. (1961).

Loganathan (1962) concluded that calves out of 2- and 3-year-old dams graded 1.0 and 0.8 points lower, respectively, than those from older cows. He observed a linear association between age of dam and calf grade, as age of dam increased from 2 through 7 years of age.

Marlowe and Gaines (1958) found age of dam to be the most important source of variation in type score. The average type score of calves from 2-, 3-, 4-, 5,- 6-, 7-, 8-, 9-, and 10-year-old dams were 10.91, 11.37, 11.45, 11.66, 11.67, 11.77, 11.70, 11.46 and 11.15, respectively. There was an increase in type score of calf with age of dam up to

seven years, but it remained about the same until age of dam passed ten years.

Several estimates of age-of-dam effects on type score at weaning have been made in recently reported studies. A summary of recent estimates of these effects on type score was reported by Butts (1966).

Jamison (1966), in his study of factors affecting intra-cow variation, found that calves from dams 2 and 9 years of age and older were scored lower for weaning type than were calves out of dams 3 through 8 years of age. Loganathan (1962) found age-of-dam effects on weaning condition score to be similar to those on type score.

III. EFFECT OF SEX OF CALF ON AVERAGE DAILY GAIN TO WEANING

Jamison (1966) reported that sex of calf had a highly significant ($P<.01$) effect on average daily gain from birth to weaning, noting that male calves had an average daily gain of 0.16 pounds greater than that of female calves. This estimate is well within the range of findings of other workers: 0.12 pounds by Marlowe and Gains (1958), 0.11 pounds by Koch et al. (1959), 0.24 pounds by Taylor et al. (1960), 0.12 pounds by Marlowe (1962) and 0.17 pounds by Loganathan (1962).

Brinks et al. (1961) reported that heifer calves gained 5 percent less from birth to weaning than did steers and 6 percent less than did bulls.

Differences in average daily gain ranging from 0.1 and 0.3 pounds daily between males and females 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 ($P<.01$). 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.

Baker and Quessenberry (1942) found average weight of bull calves to be 22 pounds greater than that of heifer calves at weaning (180 days). Koch (1951) reported that bull calves outweighed heifers by 44 pounds at weaning. The average difference in gain between male and female calves was found to be 23 pounds. Botkin and Whatley (1953) reported a similar difference of 24.6 pounds.

Burgess, Landblom and Stonaker (1954) reported a gain difference of 22 pounds in favor of bulls over heifers and a gain difference of 20 pounds between steers and heifers at weaning. McCormick and Warwick (1956) reported that bull calves weighed 38 pounds more than heifer calves at 210 days of age.

Marlowe and Gaines (1958) found that bull calves gained 5 percent faster to weaning than steer calves and that steer calves outgained heifers by 8 percent.

Rollins and Guilbert (1954) estimated that bull calves, on the average, gained .13 pounds per day more than heifer calves from birth to four months of age. With respect to 240-day weaning weight, bull calves were 68 pounds heavier than heifers.

Petty and Cartwright (1966) reported that bull calves gained 0.15 pounds per day faster from birth to weaning than did heifer calves, and 0.06 pounds per day faster than steer calves. Sex differences ranging from 0.11 to 0.22 pounds per day from birth to weaning were reported in this study.

Marlowe, Mast, and Schalles (1965) reported estimates for non-genetic influences on calf performance, based on records of 17,294 Angus and 11,663 Hereford calves. The genetic and environmental situations in which these data were collected are believed to be quite similar to those found in Tennessee. Non-creep fed Angus bull calves gained 0.22 pounds per day more from birth to weaning than heifer calves and 0.11 pounds per day more than steer calves. Creep fed Angus bull calves gained 0.26 and 0.14 pounds per day more than heifers and steers, respectively. Comparable estimates for Hereford calves were 0.21 and 0.10 pounds per day for non-creep fed and 0.28 and 0.09 pounds for creep fed calves.

IV. EFFECT OF SEX OF CALF ON TYPE SCORE AT WEANING

Koch and Clark (1955) in a study involving 5,962 Hereford calves concluded that sex influence on type score at weaning was negligible. Sex differences observed in weaning type score by Marlowe and Gaines (1958), Taylor et al. (1960), Lehman et al. (1961), and Marlowe (1962) were 0.5, 0.3, 0.9, and 0.5 units, respectively, in favor of heifer calves. Loganathan (1962) and Jamison (1966), working with Tennessee data, found male calves to have been scored higher than heifers for weaning type.

Pahnish et al. (1964) reported average weaning condition scores of 10.0 and 10.5, respectively, for heifer and bull calves. Standard deviations of 1.06 for heifers and 0.82 for bull calves were found. These findings were substantiated by Synar (1958) in other Arizona work.

Jamison (1966) in two analyses observed that sex of calf had little influence on type score at weaning, reporting a value of 0.04 for the effect of sex of calf on type score at weaning in both analyses. A limited number of studies on the effect of sex of calf on type score at weaning indicate that this effect is negligible.

Barker (1964) reported a significant effect of sex of calf on type score. Bull calves typed slightly higher than heifers. The mean type scores were 12.42, 12.37, and 12.32 for bulls, steers and heifers, respectively.

Marlowe and Gaines (1958) at the Virginia Station, reported that bull calves graded 0.6 unit higher than heifers and steers and 0.5 unit higher than heifer calves.

V. EFFECT OF SEASON OR MONTH OF BIRTH ON AVERAGE DAILY GAIN

Marlowe and Gaines (1958) proved that season of birth was an important source of variation in average daily gain for non-creep fed calves. They found that calves born in February, March, April and May had the highest growth rate, followed by calves born in January, June and July. Koch and Clark (1955) found April and May calves to grow at approximately the same rate until weaning.

Barker (1964) reported month-of-birth effects on average daily

gain to be highly significant ($P<.01$). He pointed out that January, February, March, April and May calves consistently gained faster than those born in other months. Calves born in August gained 0.41 pounds per day less than those born in January through May. It is evident from this study that January, February, March, April and May calving is desirable in Tennessee. Marlowe and Gains (1958) and Flock, Carter and Priode (1962) reported similar findings.

Jamison (1966) found no significant season-of-birth effect on average daily gain from birth to weaning. The repeatability estimate for average daily gain was 0.45. This estimate was of sufficient magnitude that a cow raising a first calf with a low average daily gain could be culled with relatively little chance of culling a cow that might be a high producer in later years.

The least-squares constants for month-of-birth effects on average daily gain for creep and non-creep fed calves were summarized by Barker (1964). These data suggest that creep feeding compensates somewhat for the lower average daily gain of calves born in August. If creep feeding is used, tests of significance imply that calves born between June and November are similar and have the lowest average daily gain.

Average daily gains of calves born in January, February and March were significantly higher ($P<.01$) than those born in other months.

The least-squares constants indicate that creep feeding definitely reduces the influence of month of birth on weaning weight. The creep fed calves deviated significantly less from this mean than those that were not creep fed when born in January, February, March, April, June and August.

Advantages of creep feeding were greater for calves born in the fall than spring, and calves born during the summer benefited even more.

VI. EFFECT OF SEASON OR MONTH OF BIRTH ON TYPE SCORE

Jamison (1966) found no significant season-of-birth effect on type score. Repeatability estimate for type score at weaning was 0.26. This estimate for type score indicates that this trait is less repeatable than average daily gain, and a cow cannot be culled on the basis of the type score of her first calf with as much reliability as culling on daily gain.

Barker (1964) reported significant month-of-birth effects on type score. Least-squares estimates were positive for all months except August, September, October and November. Perhaps this reflects the unfavorable weaning time, lack of bloom, and poor condition of summer and fall born calves. Calves born in August had the lowest type score, regardless of types of feeding. There was little month-of-birth effect on type score with the exception on August. These findings tend to substantiate the data of Koch and Clark (1955), Marlowe and Gaines (1958), and Lehman et al. (1961).

VII. EFFECT OF AGE OF CALF ON AVERAGE DAILY GAIN

Barker (1964) reported a highly significant ($P<.01$) effect of age of calf on average daily gain. This was true for both creep and non-creep fed calves.

Average daily gain was highest during the early stages of growth,

(120 to 179 days of age), and gradually declined as age progressed to 300 days. Creep feeding tended to stabilize the growth pattern of calves in the 210-to-300-day age range, but did not appear to affect the relationship at younger ages. These findings were in general agreement with those reported by Marlowe and Gaines (1959), Koch and Clark (1955), Rollins, Guilbert and Gregory (1952), Koch (1951) and Burgess, Landblom and Stonaker (1954).

VIII. EFFECT OF AGE OF CALF ON TYPE SCORE

Barker (1964) reported that age of calf significantly ($P<.01$) influenced the type score of calves. He reported that younger calves consistently have lower scores than older calves. These data suggest that a more accurate estimate of progeny performance could be made if calves were typed when between 180 and 270 days of age, regardless of creep or non-creep feeding.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. NATURE OF DATA

The data used in this study were collected over a 3-year period (1964-66) from purebred and high grade commercial cow herds in 12 counties on the Cumberland Plateau (Figure 1). This area consists largely of a high plateau (approximately 2000 feet elevation) favored with excellent summer temperature and rainfall patterns. Calf gains recorded at the Plateau Experiment Station, near Crossville, have been consistently higher or near the highest among the eight experiment stations throughout the state.

Average daily gain and type score data were available on 2531 calves produced on 78 farms located throughout the 12-county area (Jackson, Overton, Fentress, Putnam, White, Cumberland, Pickett, Warren, Van Buren, Bledsoe, Grundy, Sequatchie) on the Cumberland Plateau and represented two Agricultural Extension Service districts. About 70 percent of the 2531 calves were non-creep fed, and the remainder creep fed. The breeds represented were Angus, Hereford and Shorthorns.

Only calves between 120 and 299 days of age were considered in the study. Federal-State standards for grades of feeder cattle were used as a basis for the grading except that each grade was sub-divided into thirds. Each calf was classified as being in the upper, middle

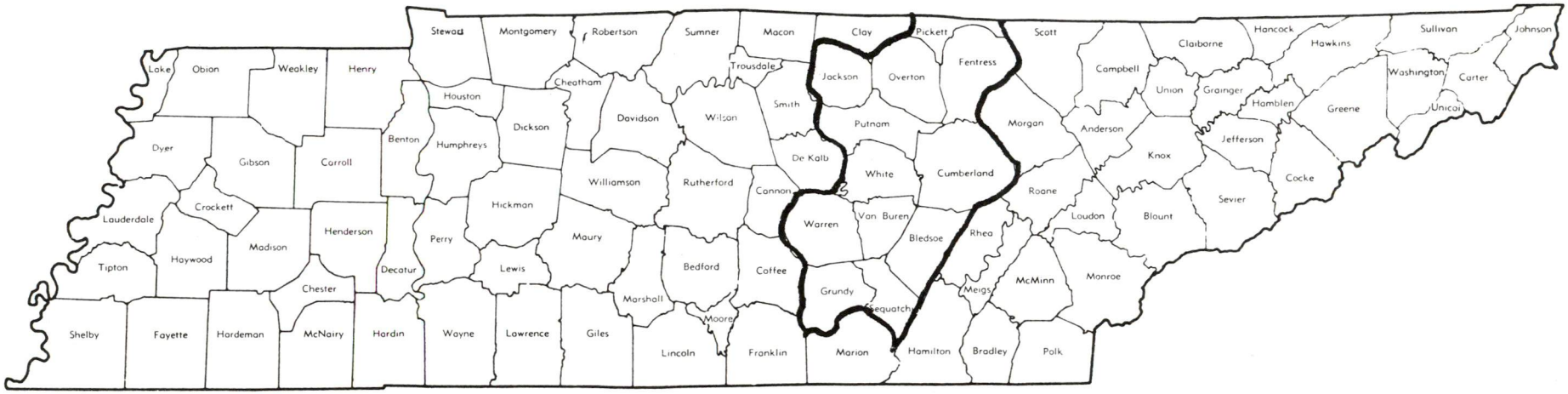

Figure 1. Counties included in this study.

or lower third of the grade. The grades were coded by giving a numerical value of 10 to middle good and adding or subtracting one (1) for each one-third of a grade above or below middle good.

The numerical codes were: fancy plus (17), fancy (16), fancy minus (15), choice plus (14), choice (13), choice minus (12), good plus (11), good (10) (usually referred to verbally as "middle good"), good minus (9), medium plus (8), medium (7) and medium minus (6).

The average daily gain for each individual calf was calculated by subtracting an actual or estimated birth weight from the recorded weaning weight and dividing this weight by age in days.

II. METHOD OF ANALYSIS

In order to reduce the variations within and between the factors under analysis to a comparable basis for purpose of this study, it was necessary to assume that herd and year differences were certain to exist; therefore, these two sources of variation were absorbed in all analyses. And since each farm was represented by only one breed of cattle, absorption of breed difference was allowed. This procedure assumes that interaction of these factors with other sources of variation included in this analysis are negligible.

Since few producers had both creep fed and non-creep fed calves, intra-herd estimates of the influence of creep feeding were impossible. Therefore, it was necessary to divide these data into separate analyses for creep fed and non-creep fed calves.

In this study calves were born each month of the year, and

several farmers weighed calves in more than one month each year. As a result of this practice, age-of-calf and month-of-birth were not completely correlated; therefore, independent estimates of these effects on both type score and average daily gain were necessary.

The age of the calves at weaning ranged from 120 to 299 days. Therefore, it was felt that a linear growth curve would not adequately portray the growth pattern. Thus, age of calf was divided into 18 discrete classes of 10 days each and the effect of age of calf at each of these periods determined.

It was observed that cows over 12 years of age were rare and undoubtedly highly selected. So, ages of dam 12 years and above were classified as a single group. Hence, only 11 age-of-dam groups (2-12 years) were considered in these analyses.

Because of the disproportionate subclass frequencies, least-squares methods as described by Harvey (1960) were used in the analyses to obtain estimates of the effects of sex of calf, month of birth and age of dam on average daily gain from birth to weaning and on type score at weaning.

A study of the unadjusted means indicated that there were no significant interactions among classes of effects.

Since year effects were not of primary interest, the analyses were conducted on an intra-year basis.

The assumed model considered appropriate for the analysis was:

$$Y_{ijklm} = u + s_i + m_j + d_k + c_l + e_{ijklm}$$

$i = 1, 2, 3$

$j = 1, \ldots 12$

$k = 2, \ldots 12$

$l = 1, \ldots 18$

When:

$Y =$ observed type score or average daily gain of the m^{th} calf of the l^{th} age of calf of the k^{th} age of dam, born in the j^{th} month and of the i^{th} sex.

$u =$ overall mean when equal numbers exist in the subclasses.

$s =$ the effect of sex with 3 classifications.

$m =$ the effect of month of birth with 12 classifications.

$d =$ the effect of age of dam with 11 classifications.

$c =$ the effect of age of calf with 18 classifications.

$e_{ijklm} =$ random error.

The least-squares estimates of means were compared to see if they were significantly different according to the procedure outlined by Duncan and modified by Kramer (1957).

CHAPTER IV

RESULTS AND DISCUSSION

The analyses of variance for average daily gain to weaning and type score at weaning for non-creep and creep fed calves are presented in Tables I and II, respectively.

I. AGE OF DAM

The least-squares estimates of the environmental effects on average daily gain from birth to weaning and on type score at weaning for non-creep and creep fed calves are presented in Tables III and IV, respectively.

In these analyses age of dam was considered a discrete variable, since it was thought that neither a straight line nor a quadratic curve would describe biologically the aging process.

The effects of age of dam on growth rate from birth to weaning in both analyses were highly significant ($P<.01$). These data show that a cow's individual performance in non-creep fed herds was lower at 2-, 3-, 4- and 12 years of age. The calves from 5-, 6-, 7-, 8-, 9-, 10- and 11-year-old dams had approximately the same average daily gain when no creep feeding was practiced.

These data indicate that 2- and 3-year-old dams produce calves that have the lowest average daily gains in creep fed herds.

These data imply that average daily gain of calves increased with

TABLE I

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

Source	d.f.	Average Daily Gain		Type Score	
		M.S.	F	M.S.	F
Sex of Calf	2	5.103	77.318**	11.313	7.691**
Month	11	.322	5.030**	11.863	8.065**
Age of Dam	10	.775	11.742**	5.474	3.721**
Age of Calf	17	.148	2.242**	6.258	4.254**
Residual	1804	.066		1.471	

**P < .01.

TABLE II

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

Source	d.f.	Average Daily Gain		Type Score	
		M.S.	F	M.S.	F
Sex of Calf	2	4.468	60.38**	14.743	9.41**
Month	11	.189	2.55**	1.730	1.10
Age of Dam	10	.262	3.54**	2.092	1.34
Age of Calf	17	.179	2.42**	3.721	2.38**
Residual	727	.074		1.566	

**P < .01.

TABLE III

LEAST-SQUARES ESTIMATES[a] OF AGE-OF-DAM EFFECTS ON AVERAGE DAILY GAIN TO WEANING AND ON TYPE SCORE OF NON-CREEP CALVES

Age of Dam (yrs.)	No. of Calves	Avg. Daily Gain	Type
2	153	-.168	-.226
3	261	-.093	0.058
4	268	0.002	0.138
5	256	0.016	0.162
6	202	0.042	0.320
7	173	0.050	0.137
8	154	0.065	0.111
9	105	0.037	-.095
10	80	0.035	-.170
11	75	0.032	-.169
12 and over	142	-.018	-.266
Sex of Calf			
Bull	429	0.074	0.198
Heifer	971	-.099	-.053
Steer	469	0.025	-.145

[a]Estimates are deviations from the overall adjusted mean when equal numbers exist in subclasses. The overall arithmetic means were 1.62 lb. per day for gain and 11.63 for type score.

TABLE IV

LEAST-SQUARES ESTIMATES[a] OF AGE-OF-DAM EFFECTS ON AVERAGE DAILY GAIN TO WEANING AND ON TYPE SCORE OF CREEP CALVES

Age of Dam (yrs.)	No. of Calves	Avg. Daily Gain	Type
2	114	-.13	0.13
3	157	-.08	0.12
4	92	-.05	-.21
5	69	0.01	-.02
6	75	0.01	0.03
7	73	-.02	-.16
8	42	0.06	0.28
9	52	0.04	0.18
10	36	0.04	-.04
11	32	0.03	0.09
12 and over	49	0.09	-.40
Sex of Calf			
Bull	266	0.18	0.19
Heifer	359	-.08	0.21
Steer	166	-.10	-.40

[a]Estimates are deviations from the overall adjusted mean when equal numbers exist in subclasses. The overall arithmetic means were 1.74 lb. per day for gain and 12.33 for type score.

increasing age of dam up to 8 years of age, and then a gradual decline was noted in average daily gain of calves from cows 9 through 12 years of age and older (Figure 2). Whereas, Rollins and Guilbert (1954) reported that cows in the age range of 7 to 10 years produced the fastest growing calves up to 4 months of age, and their calves were heaviest at 240 days.

These findings are in close agreement with those of Barker (1964), and in general agreement with those of Marlowe and Gaines (1958), Rollins and Guilbert (1954), Blackwell, Knox and Hurt (1958), and Koger and Knox (1954), and similar to those of Jamison (1966). This report is in slight disagreement with that of Koch and Clark (1955), who reported that the maximum production year of age for weaning weight appeared to be the sixth year. These differences could be attributed to an age differential in the data used in the two studies. The age span used in this study was 3 to 10 years, while that used in the present investigation was 2 through 12 years and over.

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

In this study, age of dam had a small but significant effect on type score of non-creep fed calves. The least-squares estimates were all positive with the exception of those for 2-, 9-, 10-, 11- and 12-year-old dams. Non-creep fed calves's type score by age-of-dam groups,

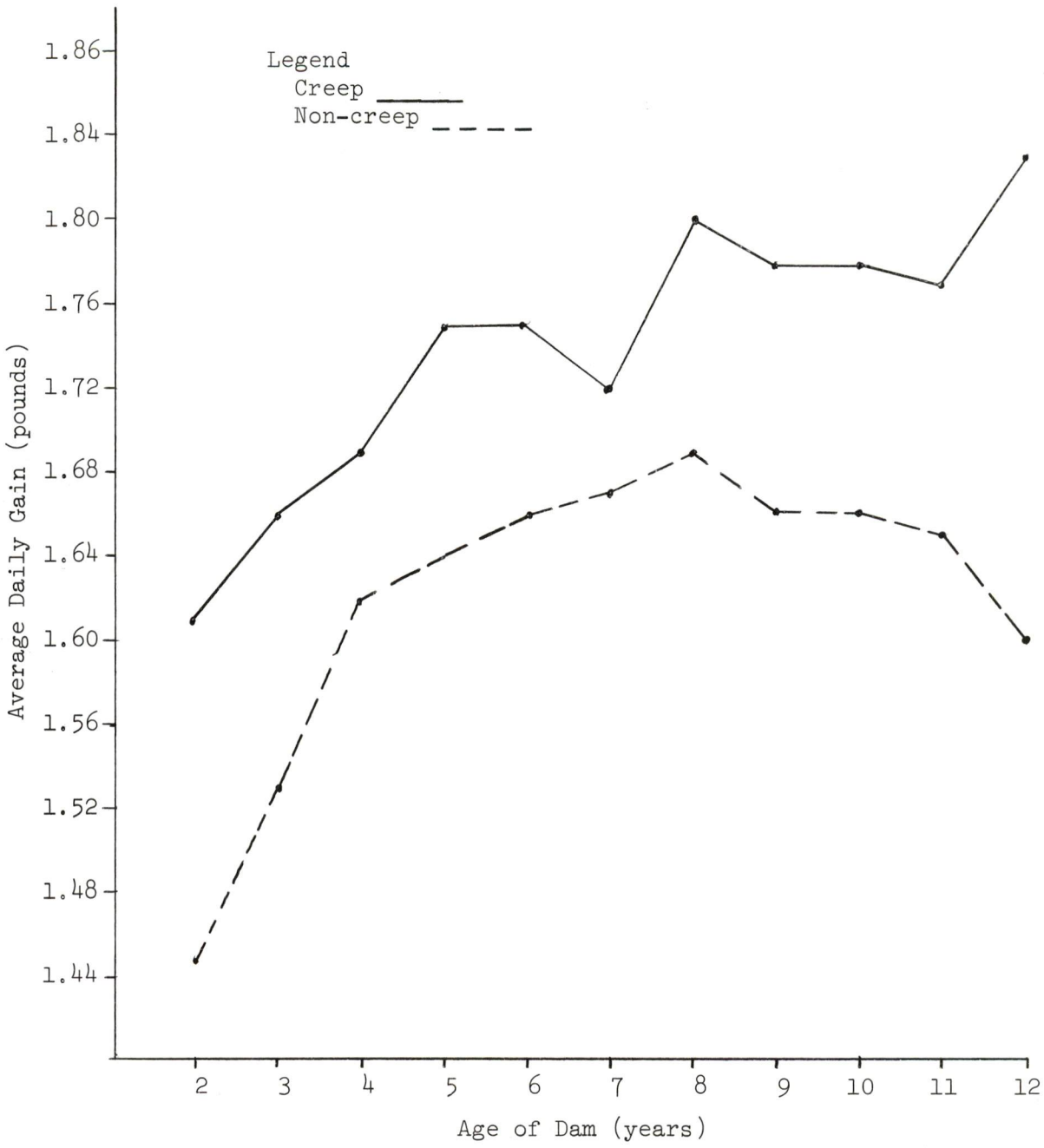

Figure 2. Effects of age of dam on average daily gain.

Figure 3, ranged from 11.36 to 11.95. These data indicate that the maximum type score of a cow's calves were obtained when she was within the age range of 3 to 8 years and decreased as she became older.

These findings are in close agreement with those of Jamison (1966), and Barker (1964), Marlowe and Gaines (1958), and Lehman et al. (1961). A slight discrepancy for maximum type score was shown by Barker (1964), who stated that the type score remained almost the same for calves from dams 3 through 10 years of age, which is in direct agreement with work reported by Marlowe and Gaines (1958).

This wider range in age of dams for maximum production might be attributed to climatic and managerial variance encountered from the different geographic areas of this investigation.

These data indicate no significant differences among the type scores of creep fed calves. Type score by age-of-dam groups for creep fed calves ranged from 11.93 to 12.61.

These data suggest that creep fed calves' type was scored higher than that of non-creep fed calves. This suggests that condition of the calf has an influence on the grader's decision.

II. SEX OF CALF

Sex of calf had a significant ($P<.01$) effect on average daily gain of both non-creep and creep fed calves. Least-squares estimates were for bull calves, 0.07; steers, 0.3 and -.10 for heifers in the non-creep analysis. Whereas, in the creep fed group the estimates were 0.20, 0.15 and -.05 for bulls, steers and heifers, respectively.

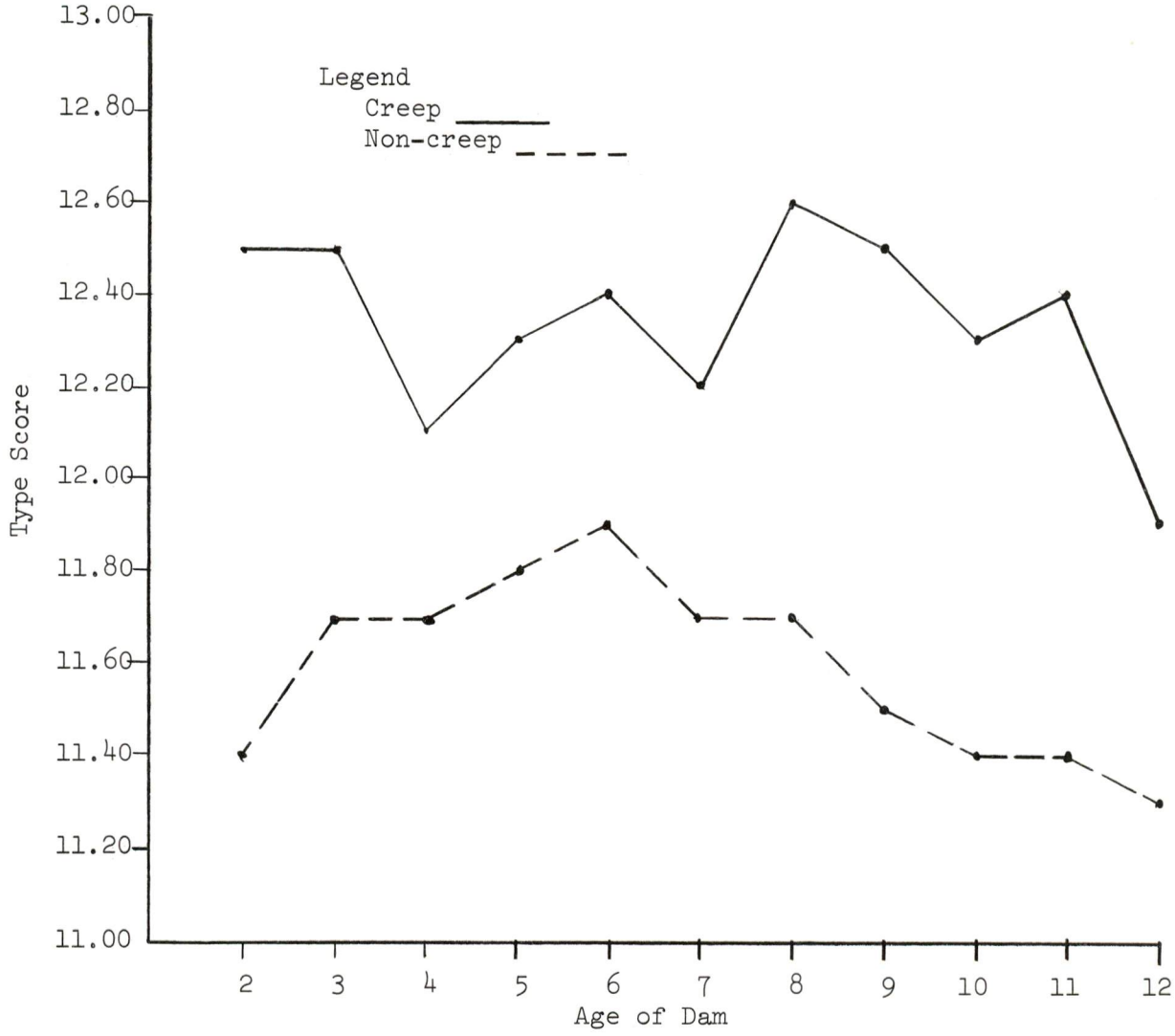

Figure 3. Age of dam effects on type score.

These data are in very close agreement with those of Jamison (1966), Barker (1964), and Dahman and Bogart (1952), and well within the range of estimates reported by Marlowe and Gaines (1958), Koch et al. (1959), Taylor et al. (1960), Marlowe (1962), and Loganathan (1962).

Differences in average daily gain ranging from 0.1 and 0.3 pounds daily between male and female calves 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) and Brinks et al. (1961).

Other workers in general agreement include Knapp, Baker and Quessenberry (1942), Burgess, Landblom and Stonaker (1954), Marlowe, Mast and Schalles (1965), and Petty and Cartwright (1966).

These data further substantiate reports of others workers that bulls have a higher daily gain than steers, and steers gain faster than heifers. The comparison of steers with the other sexes in this study may be biased by selection since the lower type and gaining bull calves within each herd were probably steered.

Sex of calf influenced type score of non-creep fed calves. Bull calves graded significantly higher than steers and heifers. Whereas, there was no significant difference between steers and heifers.

Sex of calf had a significant influence on the creep fed calves. Bulls had a type score significantly higher than that of steers and the type score of steers was significantly higher than that of heifers.

The results of studies by Jamison (1966), Barker (1964), Koch and Clark (1955), Marlowe and Gaines (1958), and Loganathan (1962)

were all in general agreement that there was some influence of sex on type score, though slight or negligible. But the observed rank of the three sexes was the same.

Pahnish et al. (1964) found average condition scores at weaning to be 10.9 and 10.5 for heifers and bulls, respectively, which was not greatly different from the finding of Marlowe (1962), Lehman et al. (1961) and Taylor et al. (1960).

The fact that male calves graded higher in both analyses than females may reflect the earlier sexual development of bulls or a preference of the grader for male calves.

III. MONTH OF BIRTH

The least-squares estimates of month-of-birth effects on average daily gain and type score for non-creep and creep fed calves are given in Tables V and VI, respectively.

Average daily gains of creep fed calves born in February, March, April, May, June and October were significantly higher ($P<.01$) than those of calves born in other months. Jamison (1966) found no significant month-of-birth effect on average daily gain from birth to weaning. He observed that a cow whose first calf had a low average daily gain could be culled with relatively little chance of culling a cow that might be a high producer in later years.

These data are in general agreement with those of Barker (1964) whose work showed that the average daily gains of creep fed calves born in January, February, March, April, May and December were significantly

TABLE V

LEAST-SQUARES ESTIMATES[a] OF MONTH-OF-BIRTH EFFECTS ON AVERAGE DAILY GAIN TO WEANING AND ON TYPE SCORE ON NON-CREEP CALVES

Month of Birth	No. of Calves	Avg. Daily Gain	Type
January	430	0.027	-.533
February	423	0.055	-.548
March	311	0.074	-.303
April	243	0.099	0.078
May	150	0.078	0.355
June	67	0.108	0.685
July	34	-.087	0.171
August	19	-.248	-.363
September	24	-.082	0.242
October	17	0.068	0.358
November	26	-.038	0.035
December	125	-.054	-.177

[a]Estimates are deviations from the overall adjusted mean when equal numbers exist in subclasses. The overall arithmetic means were 1.62 lb. per day for gain and 11.63 for type score.

TABLE VI

LEAST-SQUARES ESTIMATES[a] OF MONTH-OF-BIRTH EFFECTS ON AVERAGE DAILY GAIN TO WEANING AND ON TYPE SCORE OF CREEP CALVES

Month of Birth	No. of Calves	Avg. Daily Gain	Type
January	158	0.09	-.07
February	122	0.09	-.07
March	100	0.06	0.09
April	87	-.03	0.17
May	70	-.01	-.03
June	40	0.03	-.02
July	22	-.09	0.27
August	29	-.07	-.19
September	39	0.03	0.07
October	28	0.04	-.13
November	16	-.10	0.44
December	80	-.04	-.53

[a]Estimates are deviations from the overall adjusted mean when equal numbers exist in subclasses. The overall arithmetic means were 1.74 lb. per day for gain and 12.33 for type score.

higher ($P<.01$) than those of calves born in other months. Flock, Carter and Priode (1962), and Marlowe and Gaines (1958) reported similar differences in their studies. Whereas, Koch and Clark (1955) found April and May calves to grow at approximately the same rate until weaning.

Calves born in January, July, September, November and December were found to be similar. Whereas, Barker (1964) found April, May and December calvings to have similar average daily gains, though intermediate between the high and low.

It is evident from these data that non-creep fed calves born in February, March, April, May, June and October are desirable for the area covered in these analyses. These data indicate that creep feeding could be profitable for calves born in July, August and September (Figure 4). These findings are in close agreement with the work of Barker (1964).

The effects of month of birth on creep fed calves were not significant in this analysis. However, as shown by Figure 5, calves born in December had the lowest type scores.

Non-creep fed calves born in January, February, March and August graded significantly lower ($P<.01$) than calves born in any other month. Calves born in June had higher type scores than calves born in any other month.

Jamison (1966) reported no significant effect of season of birth on type score.

Barker (1964) reported significant effects of month of birth on type score. His study tended to substantiate the data of Lehmann

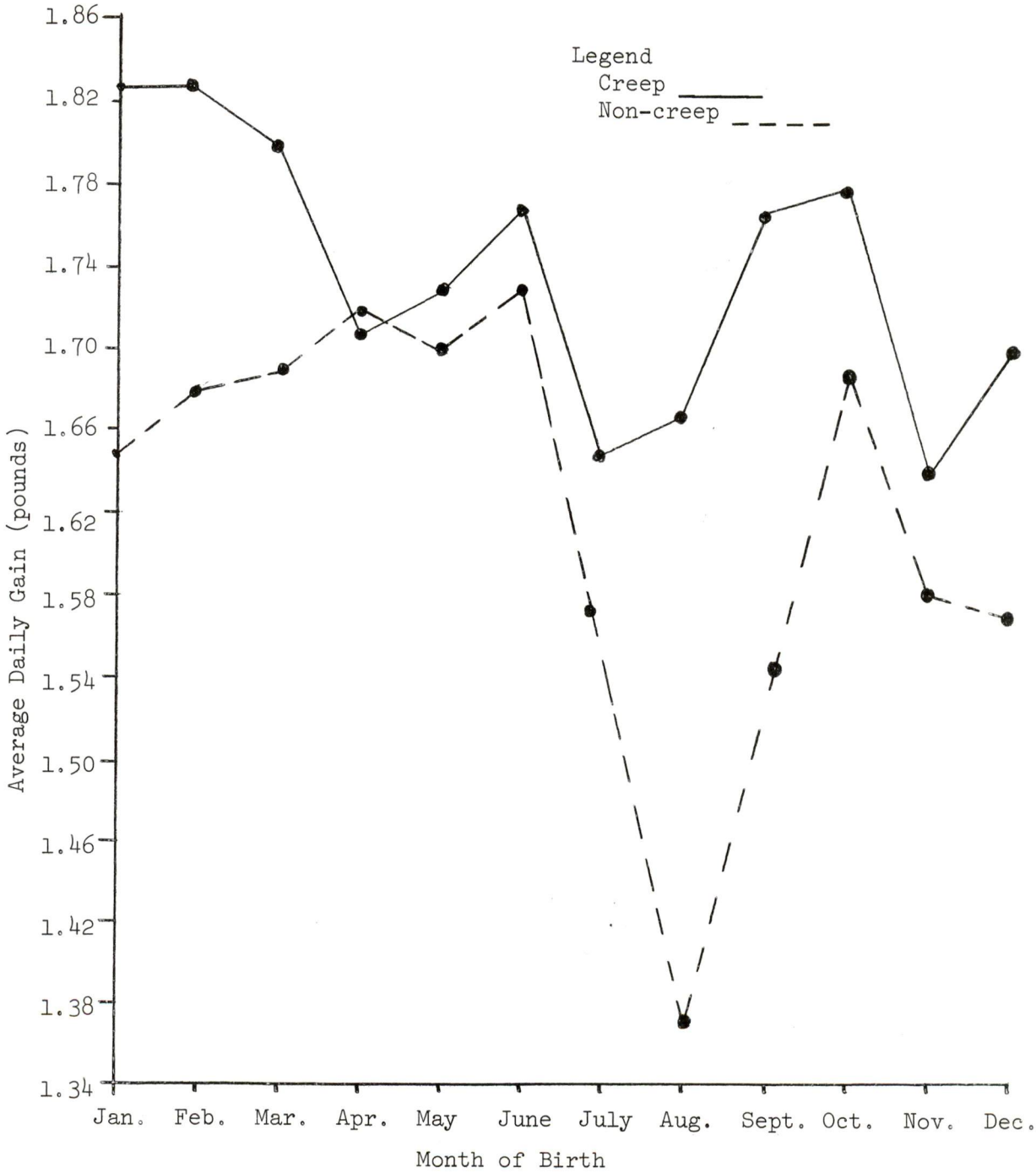

Figure 4. Effects of month of birth on average daily gain.

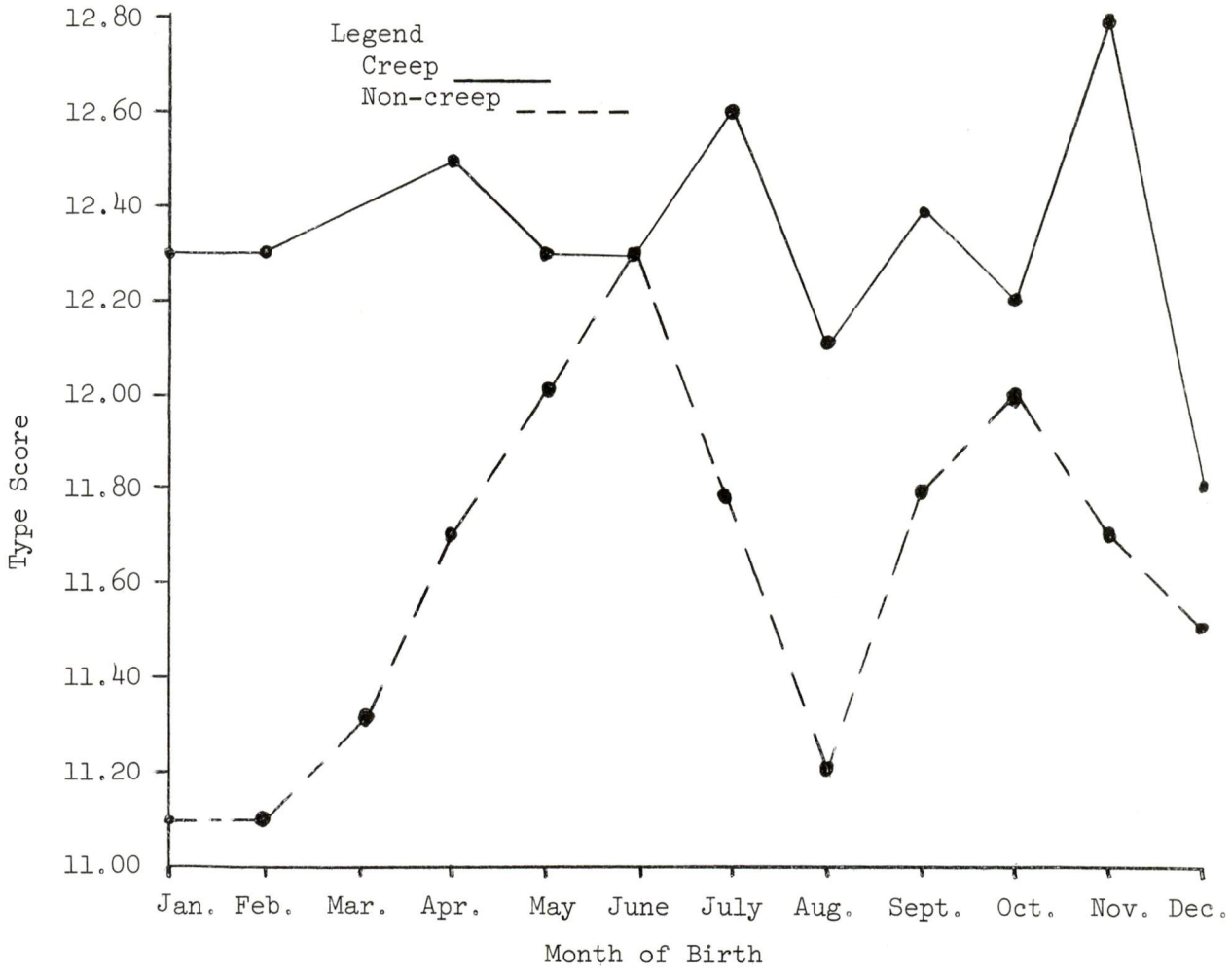

Figure 5. Effects of month of birth on type score.

et al. (1961), Marlowe and Gaines (1958), and Koch and Clark (1955). He reported that August calves type the lowest, regardless of type of feeding; however, creep feeding did exert some influence on type score. The least-squares constants were positive for all months except August, September, October and November.

From the standpoint of growth rate and type score, according to the estimates from these data, August calves are the least profitable. It is generally accepted that during July, August and September pastures are somewhat restricted. The milking ability of the cow as a result of somewhat restricted intake places her calf at a disadvantage.

IV. AGE OF CALF

Age of calf was one of the most important sources of variations in average daily gain and type score. This was true for both non-creep and creep fed calves. Least-squares estimates are presented in Tables VII and VIII.

Tests of significance indicate ($P<.01$) that non-creep fed calves weighed between 120 and 240 days of age had a higher daily gain than those from 240 to 300 days of age. Figure 6 indicates that growth from 120 to 160 days of age is almost linear. However, according to these data, if calves are weighed only once and adjusted to 205 days of age, an appropriate adjustment factor for calves weighed between 240 and 300 days would be desirable. It is interesting to note that the least-squares estimates of age-of-calf effects on average daily gain to weaning are negative from 230 through 290 days of age.

TABLE VII

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

Age in Days	No. of Calves	Avg. Daily Gain	Type
120-129	38	0.102	-.703
130-139	58	0.026	-.657
140-149	75	0.053	-.543
150-159	103	0.068	-.100
160-169	103	0.089	-.123
170-179	123	0.038	-.134
180-189	152	0.015	0.064
190-199	170	0.024	0.041
200-209	147	0.007	0.283
210-219	133	0.017	0.531
220-229	177	0.010	0.345
230-239	104	-.010	0.336
240-249	107	-.086	0.185
250-259	104	-.023	0.360
260-269	108	-.079	0.116
270-279	66	-.122	0.160
280-289	57	-.083	-.076
290-299	44	-.046	-.085

[a]Estimates are deviations from the overall adjusted mean when equal numbers exist in subclasses. The overall arithmetic means were 1.62 lb. per day for gain and 11.63 for type score.

TABLE VIII

LEAST-SQUARES ESTIMATES[a] OF AGE-OF-CALF EFFECTS ON AVERAGE DAILY GAIN TO WEANING AND ON TYPE SCORE OF CREEP CALVES

Age in Days	No. of Calves	Avg. Daily Gain	Type
120-129	8	-.02	-.54
130-139	20	0.07	-.42
140-149	25	0.16	0.28
150-159	24	0.11	-.13
160-169	32	0.05	-.22
170-179	48	0.04	-.63
180-189	64	0.09	-.06
190-199	65	0.01	-.12
200-209	57	0.03	-.11
210-219	80	0.05	-.06
220-229	72	-.01	0.08
230-239	68	-.07	0.05
240-249	63	-.01	0.58
250-259	41	-.03	0.26
260-269	45	-.14	0.62
270-279	30	-.04	0.32
280-289	32	-.09	-.13
290-299	17	-.20	0.23

[a]Estimates are deviations from the overall adjusted mean when equal numbers exist in subclasses. The overall arithmetic means were 1.74 lb. per day for gain and 12.33 for type score.

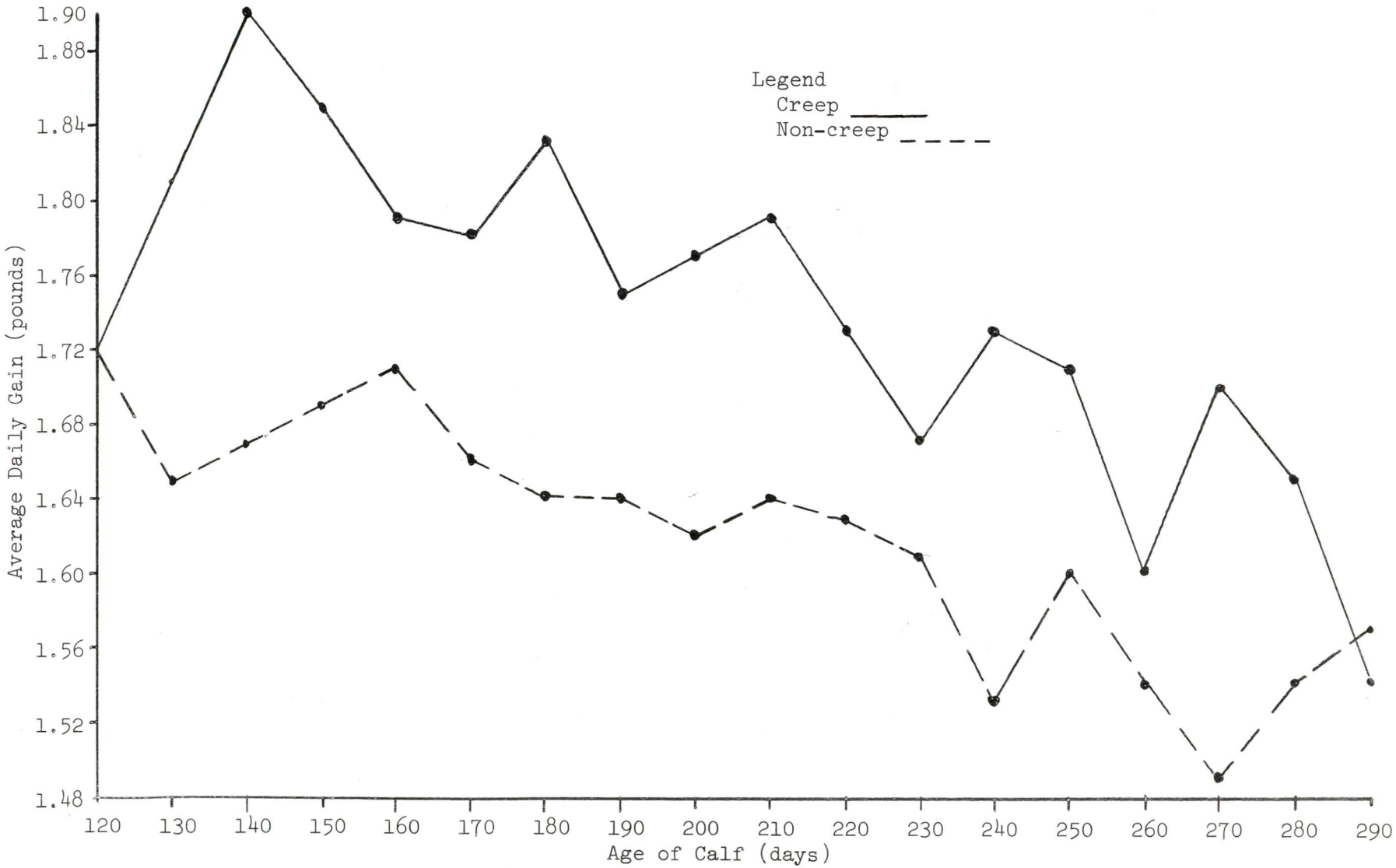

Figure 6. Effects of age of calf on average daily gain.

These findings are in general agreement with those of Barker (1964) who reported that highest average daily gains occurred between 120 and 179 days, and the necessity of an adjustment factor for calves from 180 to 300 days of age; whereas, the findings of this study showed 120 to 240 days and 240 to 300 days to be the highest in gain, respectively. These variances, though expected, could be the result of managerial and climatic conditions prevailing in the plateau area of Tennessee.

The same pattern of growth was observed in the creep fed calves. Calves weighed at 140, 150 and 180 days grew significantly faster than calves evaluated at 260 and 290 days of age. Creep feeding did tend to stabilize the growth pattern of calves in the age range of 230 to 290 days of age. The age span was 210 to 240 days as reported by Barker (1964) whose findings were in close agreement with work done by Marlowe and Gaines (1958), Koch and Clark (1955), Burgess, Landblom and Stonaker (1954) and Koch (1951).

The non-creep fed calves in the age range of 120 to 180 days graded significantly lower than calves evaluated at a later age. These data indicate that perhaps the calf has not developed sufficiently or that the grader is unable to recognize indications of conformation at an early age.

As can be seen from Figure 7, creep feeding did not stabilize type score on creep fed calves. With the exception of calves evaluated at 140 days of age, type scores increased with age at the time of evaluation. These data indicate that calves evaluated at an

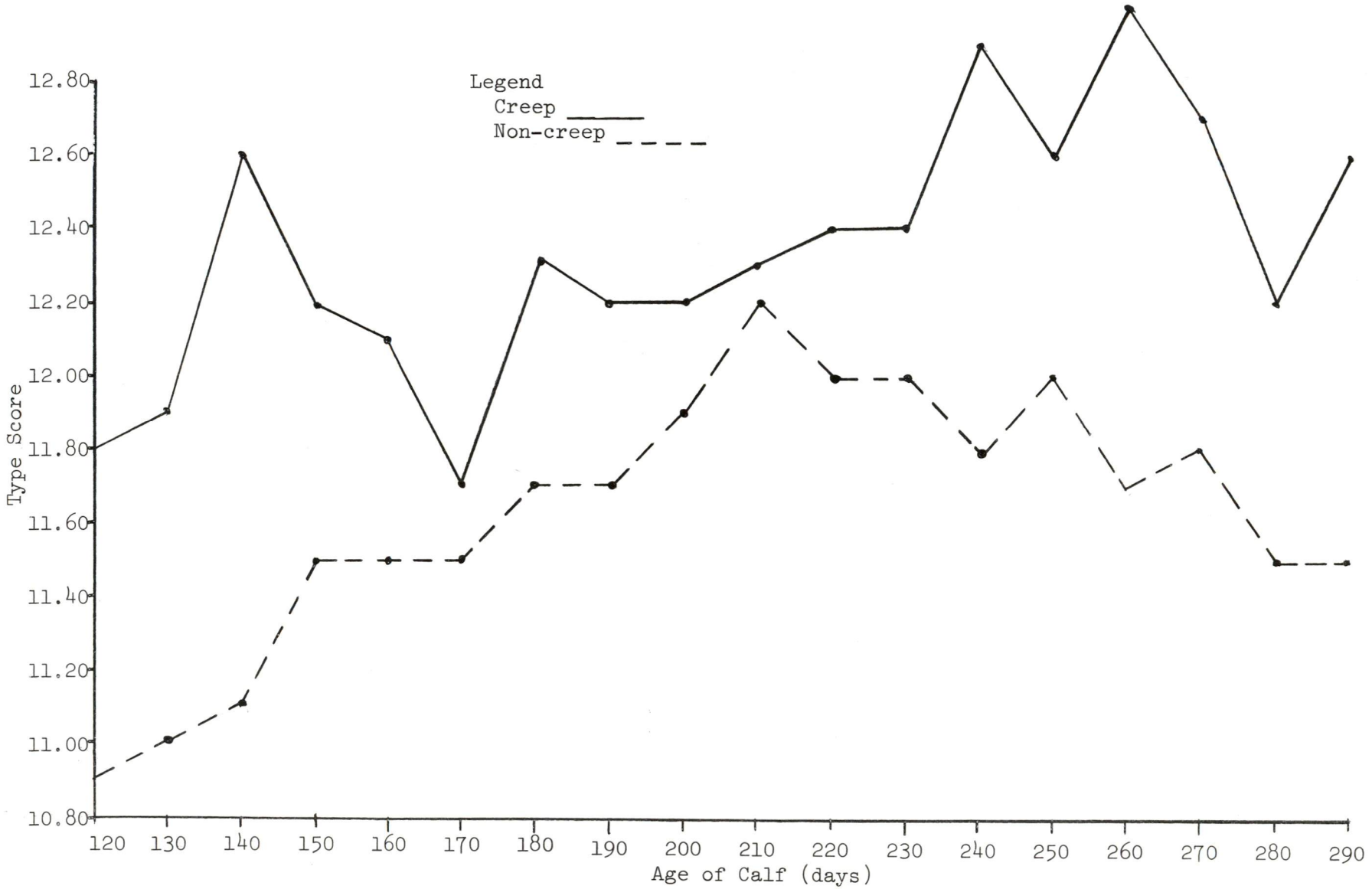

Figure 7. Effects of age of calf on type score.

early age are at a considerable disadvantage when compared to calves that are typed closer to weaning.

These findings are in very close agreement with those of Barker (1964). He reported that creep feeding increased the type score one-third of a grade. However, since the study involved different herds, little significance can be attached to the difference. He suggested that a common adjustment factor for the influence of age-of-calf variation on type score could be used for both creep and non-creep fed calves since the slope of age effects are essentially parallel and linear from 120 to 240 days of age.

There is very little information concerning the influence of age of calf on type score. Marlowe and Gaines (1958) reported a small but significant effect of age of calf on type score when the age was broken down into 30 day intervals from 90 to 300 days of age.

CHAPTER V

SUMMARY

The birth-to-weaning performance records of 1869 non-creep fed and 791 creep fed calves were utilized in this study. These data were collected from purebred and high grade commercial cow herds in the Tennessee Beef Cattle Improvement Program in the Cumberland Plateau area of Tennessee. The data were collected over a 3-year period (1964-66). Two traits of economic importance, viz., average daily gain from birth to weaning and type score at weaning, were used in these analyses. The objective of this study was to evaluate the effects of age of dam, sex of calf, season or month of birth and age of calf on average daily gain to weaning and type score at weaning of calves produced on the Cumberland Plateau in Tennessee.

The effects of age of dam on average daily gain from birth to weaning were highly significant ($P<.01$) for both non-creep and creep fed calves. A cow's individual performance was lowest at 2-, 3-, 4-, and 12-years of age for non-creep fed calves. Whereas, in the creep fed group 2- and 3-year-old dams produced calves with the lowest average daily gains.

Age of dam had a small but significant effect on type score of non-creep fed calves. The maximum type score of a cow's calves were obtained when she was within the range of 3 to 8 years, and decreased as she became older. No significant differences among the type scores of creep fed calves were observed.

Sex of calf had a significant effect on average daily gain of both non-creep and creep fed calves. Non-creep fed bull calves gained 0.17 pound more than heifers, and steers gained 0.04 pound less than bull calves. In the creep fed group, the estimates were 0.20, 0.15 and -.05 for bulls, steers and heifers, respectively.

Sex of calf influenced type score of non-creep fed calves. Bull calves graded significantly higher than steers and heifers. Whereas, there was no significant difference between steers and heifers.

Sex of calf had a significant influence on the creep fed calves. Bulls had a type score significantly higher than steers, and the type score of steers was significantly higher than heifers.

August-born calves were inferior in performance to calves born in other months. Generally, calves born in February, March, April, May, June and October appear to be desirable for the area sampled in these analyses.

Month of birth had no apparent effect on type score of creep fed calves. Non-creep fed calves born in January, February, March and August graded significantly lower than calves born in any other month. However, from these data it appears that some adjustment for month of birth is warranted.

Age of calf was one of the most important sources of variation in average daily gain and type score. The average daily gain of calves decreased in a linear manner; whereas, type score increased as the calf's age increased within the limits of these data.

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LITERATURE CITED

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VITA

Merrill D. Austin was born on February 5, 1915 in Sparta, Tennessee, and was educated in the elementary and secondary schools of White County. Having been reared on a livestock farm, he enrolled in the study of general agriculture in Tennessee Technological University at Cookville, Tennessee, where he received a B. S. degree in 1941.

He was receiving clerk with the Carnation Milk Company at Sparta from 1941 to 1942, and was for the next few years manager-operator of a 600-acre livestock farm. He was employed by the White County Board of Education as an instructor for the Veteran's Farm Training Program from 1947 to 1952, during which time he successfully completed the prescribed work in Vocational Agricultural Education at Tennessee Tech, when he joined the staff of the Agricultural Extension Service, University of Tennessee as County Agricultural Agent. He served Van Buren County in this capacity until 1954 when he transferred to Bledsoe County where he is currently serving in the same capacity.

Mr. Austin is a member of the Alpha Tau Alpha Honorary Society and of the American Society of Animal Science.

Mr. Austin enrolled in the University of Tennessee Graduate School to attain a Master's degree in Animal Husbandry which he expects to receive in the graduation exercises in August 1968.

Mr. Austin was married in 1941 to the former Miss Willie Cameron Clark, also of Sparta. They are the parents of three sons, ages 22, 17, and 14.