ENVIRONMENTAL FACTORS AFFECTING CONTINUOUS GROWTH AND YEARLING TYPE IN BEEF CATTLE

by

Gary Andrew Waugh

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APPROVED:

Chairman, Dr. T. J. Marlowe

Professor G. W. Litton

Dr. J. A. Gaines

Dr. B. Harshbarger

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INTRODUCTION

Progress through performance testing and subsequent selection for economic traits in beef cattle can be accelerated by recognition of the major environmental factors which obscure genetic differences among animals. Since genetic improvement of any trait depends in part on the heritability of that trait and since heritability is increased by reducing the environmental variation, adjusting for known environmental effects should make selection more effective.

Very little research has been conducted solely to obtain correction factors for these environmental influences in yearling cattle. The purpose of this study was to estimate the magnitude of as many as possible of the non-genetic or environmental influences on average daily gain (ADG) and grade of yearling cattle of the Angus and Hereford breeds. The sources of variation studied were: herd, year, age of dam, month of birth, age of animal and pre- and postweaning management practices. Selected interactions were also included.

REVIEW OF LITERATURE

Herd

Since most studies of this type have been done on a within-herd basis, no pertinent literature was found.

Year

Brown (1961) found the effect of years on weight in Hereford and Angus cattle to be most apparent between 300 and 420 days of age. Year effects among calves were smaller and not always significant.

Neville *et al*. (1962) reported that ADG of stockers on test, ADG on fattening tests, and slaughter weights were significantly different for different years.

Cunningham and Henderson (1965) reported significant year effects on ADG and grade of both Hereford and Angus calves.

Schalles and Marlowe (1967) reported a significant year effect on 365-day weight of performance tested bulls. Polled Hereford bulls had greater increases in 365-day weight than Angus and Hereford bulls over the several years.

Age of Dam

Cows influence the preweaning growth of their calves both by the genes transmitted to the calf and by the maternal environment provided to weaning. Presumably, changes in size, weight and physiological function which accompany aging in cows might be expected to influence this environment and consequently have a direct effect on birth and weaning weight. Because the maternal environment which affects weaning weight may also influence yearling weight and grade, the influence of age of dam on these traits was considered.

To evaluate factors affecting performance, the records of 532 calves from purebred and grade Polled Hereford herds, maintained at the Georgia Coastal Plain Experiment Station, were used by McCormick *et al*. (1956). Age of dam was found to have a significant effect on birth and 210-day weights of the calves. Calves out of two-year-old cows in the purebred herd were 107 pounds lighter and calves out of three-year-old cows were from 63 to 73 pounds lighter than those out of eight-year-old cows. The trend was the same up through the eight-year-old dams; above eight years of age, the weaning weights fluctuated irregularly. A similar pattern was observed in the grade herd. Weight differences after a 140-day feed test were approximately the same.

Koch and Clark (1955), using the records of 5,952 Hereford calves raised at the U. S. Range Livestock Experiment Station, Miles City, Montana, during the period 1926 through 1951, used two methods in estimating the influence of age of dam on fall yearling weights and grades. Method A compared averages of all records made at each age and method B compared records made by the same cow at two different ages. In general, the age of dam effects were larger when calculated by method B. Fall yearling weights increased with age of dam through seven-year-olds and then declined. They found less difference in weight among different age of dam groupings at yearling age than at weaning age. They stated that the smaller differences probably illustrate the tendency of calves to grow more rapidly following periods of limited feed supply. In addition, correction of fall yearling grade does not seem to be large enough to be of any practical importance.

Swiger (1961) reported on genetic and environmental influences on gain of beef cattle during various periods of life. His age of dam constants showed a tendency for the calves of younger and older cows to gain more in the first of five postweaning periods. Their advantage was overcome in the second and third periods, however, and reversed toward the end of the test. He suggested that the net effect of age of dam on postweaning gains depended on the length of the feeding period and does not necessarily diminish after a few weeks. He indicated that taking into account the age of dam permits more accurate evaluation of animals for postweaning gain.

Swiger et al. (1963) reported no important effects of age of dam on postweaning gains and grades. They concluded that age of dam adjustments for weaning weight are appropriate for any weight to 550 days of age. This insignificant effect of age of dam on postweaning gains concurs with the results of Hitchcock et al. (1955) based on data from grade Hereford cattle at the Squaw-Butte-Harney Experiment Station in Oregon.

Brown (1961) studied the weight records of 287 purebred Hereford calves, 334 purebred Aberdeen-Angus calves and 271 purebred Aberdeen-

Angus calves in three different herds at 60-day intervals from 60 to 480 days of age. The age of dam effect was significant in the Hereford and one of the Angus herds at all ages; however, in the other herd, it was not significant after 240 days. There was an increase in weight of calves associated with an increase in age of dam during the early years of production and a subsequent decline in calf weight following the years of peak production. The Hereford herd and one Angus herd reached their maximum production in the third or fourth lactation, whereas, the other Angus herd did not reach a peak until the fifth or sixth lactation. In all herds, the average age of calving was between two and one-half and three years. His observations support the recommendation that age of dam correction factors be developed under environmental conditions similar to those where they are to be applied.

This agrees with the results of Brinks et al. (1962) based on the records of 1,029 performance tested Hereford bulls collected over a 20-year period. Age of dam had a significant effect on birth weight, 180-day gain, 180-day weaning weight and weaning score, but had no significant effect on a 196-day postweaning gain test. Least squares constants were negative for both the younger and older age of dam groupings. They postulated that if there is a compensatory effect in gain during the postweaning period due to differences in preweaning maternal environment, it should be present in the age of dam constants for the 196-day gains. Their results showed age of dam constants for final weight to be very similar to those for weaning weight.

Neville *et al*. (1962) found no significant effect due to age of dam differences in postweaning performance of Hereford calves. Offspring from four-year-old dams were generally the best performers while those from three-year-old dams were consistently the poorest performers. In their analyses, age of dam differences were adjusted for weight of dam and milk production.

Data on 633 bulls performance tested at Culpeper, Virginia, and analyzed by Schalles and Marlowe (1967) showed that age of dam had a significant positive effect on the 365-day weight of bulls. The same trend was present in lifetime ADG and test ADG. End-of-test type score was essentially unaffected by age of dam. Other data on 364 bulls performance tested at the Beef Cattle Research Station at Front Royal, Virginia, failed to show any significant effect of age of dam on lifetime ADG, test ADG, 365-day weight or end-of-test type score.

Taylor (1967), using the records of 2,650 Hereford cattle, reported a general rise in 200- and 400-day weights of bull and heifer calves as the age of the dam increased. Dams reached their peak performance at seven years of age and declined thereafter. A difference of over 50 pounds between the 200-day weights of bulls and heifers from three-year-old and seven-year-old dams was found which was probably due to the size and/or milking ability of the cow. This trend was still apparent in the postweaning 400-day adjusted weights and emphasized the importance of an adequate milk supply in the preweaning stage of the calves' lives. He indicated that postweaning growth does not always adequately compensate for poor preweaning growth.

Age of Animal

The growth rates of animals vary with age. Growth starts at conception and continues until maturity is reached. Because of probable differences in growth rate as an animal grows older, age of animal effects were considered.

Dahmen and Bogart (1952) found that age-put-on test had a significant effect on rate of gain during the test period of 74 Angus and Hereford heifers and bulls. They stated that older calves have a greater proportion of skeletal growth than the younger animals when put on test and consequently have a greater opportunity for the production of additional body substance. They obtained a regression coefficient of 0.0046, indicating that each 10-day increase in age when put on test resulted in 0.046 pounds per day difference in gain while on test.

Swiger et al. (1963), using weights and grades of 1671 calves from the Fort Robinson Beef Cattle Research Station and the Nebraska Agricultural Experiment Station, studied the effect of age of calf on postweaning gains. They concluded that the effect of age of calf on ADG from 200 to 590 days of age for bulls, heifers and steers was small enough that neglecting to adjust for it would have no significant effect on adjusted 550-day weights. According to their results, bulls plateau in growth at about one year of age, while heifers plateau at approximately 250 days of age. The effects of age of calf on score were consistent for all groups of calves and about the same magnitude for all sexes. Their scoring scale ranged from 1 to 15 with the higher scores most desirable. Most of their animals scored between 8 and 13.

The effect of age on both 200- and 396-day scores was approximately 0.015 of a unit per day of age, whereas, the effect of age on final score was smaller than on earlier scores. Adjusting score for age of calf differences resulted in only an occasional change of one unit.

Age of calf effects were significant only for final weight in a study conducted by Brinks _et al_. (1962). Age of calf had no significant effect on 180-day gain, 180-day weaning weight, 196-day postweaning gain, or weaning score. The regression coefficient of 1.89 pounds for final weight on days of age was similar to that of 1.94 pounds for preweaning daily gain.

Data on bulls in the Virginia Beef Cattle Improvement Association were analyzed by Marlowe (1962). As the age of the bulls when starting record of performance test increased, their lifetime gains decreased and their end-of-test type score increased. Both younger and older bulls grew slower than the intermediate groups.

Month of Birth

It is generally true that beef calves born in late winter and early spring grow at a faster rate. Koch and Clark (1955) regressed various traits on weaning age to determine the effect of season of birth. They reported that calves born later in the calving season were slightly heavier at birth. The regression of gain from birth to weaning on weaning age was -0.04 pounds per day and the regression of weaning score on weaning age was 0.01 unit per day indicating that early calves tend to score a little better than those born later in the season. They concluded that none of the regressions were of practical importance. The shortness of their calving season (April and May) could have affected their conclusions.

Marlowe and Gaines (1958) studying factors affecting preweaning growth and type of beef calves found season of birth to be of practical and statistical importance for growth rate of non-creep-fed calves. The effect was of no practical importance on growth rate of creep-fed calves or type score of either group. They stated that creep feeding appeared to have an important influence in equalizing type scores over all seasons.

Brown (1961) found that supplemental feeding during the preweaning period in a herd of Hereford calves overcame the effects of season of birth. Fall calves were lighter than spring calves at all ages to 480 days (60-day intervals) in two other herds. However, the seasonal differences during the postweaning period were approximately the same for all herds. The largest differences were observed at 180 days in the preweaning period and 480 days during the postweaning period. He concluded that even though the seasonal effects were relatively large during the postweaning period, the use of correction factors did not appear justified.

Neville *et al*. (1962), using data collected over a three-year period on 129 Hereford calves born between December 15 and March 15, found that late born calves had significantly higher postweaning daily gains during fattening tests and higher weight per day of age at slaughter than early born calves.

In another report Neville (1962) stated that for each day later in the calving season that birth occurred, calves weighed 0.3 pounds more at four months of age. This significant effect was not present at eight months of age, however. Cunningham and Henderson (1965) found no significant effect due to month of birth.

Marlowe *et al*. (1965) reported that calves born during March and April made the fastest gains, whereas calves born during August and September made the slowest gains. The difference was approximately 0.25 pounds per day for non-creep-fed calves and 0.17 pound per day for the creep-fed calves. Creep feeding partially offset the magnitude of these differences.

Taylor (1967) found spring born calves tended to be above average weight at 200 days of age but below average weight at 400 days of age. On the other hand, autumn born calves were below average weight at 200 days of age, but were above average weight at 400 days of age. Winter born calves were consistently the best and summer born calves consistently the poorest growers.

Preweaning Management Practice

It has been found that the nutrition of the calf up to the time of weaning affects weaning weights and grades. Marlowe and Gaines (1958) reported that on the average creep feeding of calves appeared to increase their growth rate approximately 0.1 pound per day and their type score approximately 1/7 of a grade. Creep feeding decreased the differences in growth rate and grade of calves born in different months of the year.

Not only did summer and fall calves grow faster when creep-fed, but their type scores were more nearly equal over all seasons.

Taylor (1967) found an advantage of 20 pounds at 200 days of age for both bull and heifer calves in favor of creep feeding, while at 400 days of age the differences were 50 and 35 pounds, respectively. There was approximately 30 pounds difference in weaning and postweaning weights in favor of those calves which received supplementary milk (nurse cow) and creep feed. The benefits of higher planes of nutrition prior to weaning were still evident at 400 and 500 days of age.

Postweaning Management Practice

No accounts of the effects of postweaning management on growth rate or grade were found in the literature.

Environmental Interactions

Very little work has been conducted concerning environmental interactions. Swiger (1961) placed Hereford calves on 140-day feed test divided into 28-day periods and tested for interactions between age of calf and year, age of calf and sex, age of calf and age of dam, age of dam and year and age of dam and sex. The interaction between age of dam and year was consistently significant across the five postweaning periods (with the exception of period two). The age of calf x sex of calf interaction had a significant effect on weaning weight and also on weight at the end of the fifth postweaning period. Age of dam x sex of calf was significant during period three only.

Cunningham and Henderson (1965) plotted the two-way interactions among sex, age of dam, and year. In subsequent analyses, the sex x year interaction was found to be significant.

Schalles and Marlowe (1967) tested selected interactions among performance tested bulls. They were breed x year, year x dwarfism status, breed x masculinity, and dwarfism status x preweaning type score. The only significant interactions were breed x year and breed x masculinity.

OBJECTIVES

The objectives of this study were to estimate the magnitude of as many as possible of the non-genetic or environmental influences on ADG and grade of yearling cattle of the Angus and Hereford breeds and to obtain appropriate correction factors for these effects.

MATERIALS AND METHODS

The data used in this study came from several sources. They included 635 records on yearling bulls that went through a 140-day performance test at Culpeper, sponsored by the Virginia Beef Cattle Improvement Association (BCIA); 307 bulls that went through a similar 168-day test at the Beef Cattle Research Station, Front Royal; and 1,845 bulls performance tested in 38 private herds in Virginia. The heifers included 288 head raised in the Bland Correctional Farm herd; 909 head raised in the research herds at Front Royal; 160 head raised in the research herd at Middleburg; and the remainder raised in 56 private herds throughout the state. There were 1,498 Angus bulls, 2,217 Angus heifers, 1,289 Hereford bulls and 1,402 Hereford heifers in the complete study.

All records were coded according to herd, year, age of dam, month of birth, age of animal, and pre- and postweaning management practice. Each breed-sex group was treated separately in the statistical analyses. The effects of herd, year, age of dam, month of birth, age of animal and pre- and postweaning management practice were treated as independent variables, whereas ADG and grade were the dependent variables. The ADG was computed by subtracting an individual's birth weight from his final weight and dividing by his age in days. Since actual birth weights were not available for all animals, breed averages were used whenever necessary. The values used were 65, 60, 70 and 65 pounds for Angus bulls and heifers and Hereford bulls and heifers, respectively. The type scoring system (grade) ranged from 3 to 17 and was described by Marlowe _et al_. (1958). It divides each grade into three values with 15-17 for Fancy, 12-14 for Choice, 9-11 for Good, etc.

In addition, all animals were grouped into three categories as to preweaning management practice: (1) non-creep-fed, (2) creep-fed, and (3) on nurse cow. Because of the small number of observations, the third group was eliminated in the analyses. Furthermore, all animals were grouped into three categories as to postweaning management practice: (1) those receiving no grain supplement, (2) those receiving limited grain, and (3) those receiving full feed during the latter growth period. Because of the small number of bulls falling into the first category, it was not included in the bull analyses.

Prior to any statistical analyses, the data were examined and any herd with incomplete records or other inconsistencies was discarded. Also, any incomplete or inconsistent individual records were removed.

Statistical Procedures

The least squares method of fitting constants, as described by Harvey (1960), was used in the analysis of these data. The model for preliminary analyses was

$$Y_{ijklmnop} = \mu + H_i + A_j + M_k + D_l + C_m + P_n + Q_o + e_{ijklmnop}$$

where

$Y_{ijklmnop}$ = the p^{th} individual, with the o^{th} postweaning treatment, the n^{th} preweaning treatment, in the m^{th} age of animal grouping, with a dam from the l^{th} age of dam grouping, born in the k^{th} month, weighed in the j^{th} year, and from the i^{th} herd,

μ = the overall mean or effect common to all animals,

H_i = the effect common to all animals from the i^{th} herd,

A_j = the effect common to all animals weighed in the j^{th} year,

M_k = the effect common to all animals born in the k^{th} month,

D_l = the effect common to all animals whose dams were in the l^{th} age of dam grouping,

C_m = the effect common to all animals in the m^{th} age of animal grouping,

P_n = the effect common to all animals receiving the n^{th} preweaning treatment,

Q_o = the effect common to all animals receiving the o^{th} postweaning treatment,

$e_{ijklmnop}$ = random effect. The e's were assumed to be from a normally distributed population with $E(e) = 0$ and variance σe^2.

Those independent variables having no significant influence on ADG were not included in the final analyses, except in two instances where a nonsignificant variable was part of a significant interaction with another variable.

A t-test was performed to determine which of the partial regression coefficients within each submatrix were significantly different from the other partial regression coefficients using the equation

$$t_{(\hat{a}_i - \hat{a}_j)} = \frac{\hat{a}_i - \hat{a}_j}{\sqrt{(C^{ii} + C^{jj} - 2\,C^{ij})\,\sigma_e^2}}$$

where $\hat{a}_i$ and $\hat{a}_j$ are estimates of the i^{th} and j^{th} constants within a subset and C^{ii} and C^{jj} are the corresponding inverse diagonal elements. C^{ij} is the covariance of $\hat{a}_i$ and $\hat{a}_j$ and σe^2 is the error mean square. Classifications within a subset were combined in later analyses when no statistical differences were present and there was no apparent biological reason for not combining them. In other cases combining was done solely for biological reasons.

Since the restriction $\sum_i \hat{a}_i = 0$ was imposed, one row and one column were deleted from each subset in the inverse matrix. The deleted elements of the inverse matrix for the constant obtained by subtraction were computed as follows:

$$C^{1(p+1)} = -\,(C^{12} + C^{13} + \dots + C^{1p})$$

$$C^{2(p+1)} = -\,(C^{22} + C^{23} + \dots + C^{2p})$$

$$\vdots \qquad\qquad \vdots$$

$$C^{(p+1)\ (p+1)} = -\,(C^{1(p+1)} + C^{2(p+1)} + \dots + C^{p(p+1)}).$$

Standard errors of the constants were computed using the formula

$$s_{\hat{c}_i} = \sqrt{C^{ii}\sigma^2_e}$$

In addition to the preliminary least squares analyses, simple phenotypic relationships were computed between pairs of the several independent variables and between each of the independent variables and the two dependent variables within each breed-sex group. Since most of these relationships were quite low and none greater than 0.5, they could all be included together in the least squares models to obtain their individual and combined effects on the dependent variables.

Standard errors were computed for the simple correlations using the formula

$$\sigma_z = \frac{1}{\sqrt{n - 3}}, \text{ (Hoel, 1960)},$$

where n is the total number of observations in a particular breed-sex group. To test the hypothesis that the correlation coefficients equal zero, the formula

$$t = \frac{r}{\sqrt{\frac{1 - r^2}{n - 2}}}, \text{ was used (Steel and Torrie, 1960).}$$

Since the analyses were done on a within breed and within sex basis, they are discussed separately.

<u>Angus Bulls</u>

The Angus bull data were collected at Culpeper, Front Royal and from 17 herds participating in the Virginia BCIA, over the years 1956-1967 (Table I). Roughly 50% of the 391 Culpeper bulls were creep-fed, whereas of the 177 Front Royal bulls, only the 44 raised during the years 1960-1963 were creep-fed. Creep feeding was practiced in 9 of the 17 BCIA herds. No BCIA herd was included that did not contribute more than 20 observations.

Dams of the Angus bulls ranged from 2 to 14 years of age and, based on preliminary analyses, were grouped as follows: 2 year-olds, 3-5 year-olds and 6-14 year-olds. Also, the preliminary analyses suggested the following groupings for age of bulls: 10-13 months, 14 months, 15 months, 16 months and 17-19 months.

Therefore, the final model was

$$Y_{ijlmnop} = \mu + H_i + A_j + D_l + C_m + P_n + Q_o + (PQ)_{no} + (AP)_{jn} + e_{ijlmnop}$$

$i = 1, \ldots, 19$ $\quad m = 1, \ldots, 5$

$j = 1, \ldots, 12$ $\quad n = 1, 2$

$l = 1, 2, 3$ $\quad o = 1, 2$

where

$Y_{ijlmnop}$ = the p^{th} individual, with the o^{th} postweaning treatment, the n^{th} preweaning treatment, the m^{th} age of animal grouping, with a dam from the l^{th} age of dam grouping, born in the j^{th} year, and from the i^{th} herd,

$(PQ)_{no}$ = the effect of the no^{th} PQ subclass after the average effects of P and Q have been removed,

$(AP)_{jn}$ = the effect of the jn^{th} AP subclass after the average effects of A and P have been removed,

$e_{ijlmnop}$ = random effect. The e's were assumed to be from a normally distributed population with E(e) = 0 and variance σ_e^2.

The other effects were defined previously (p. 16).

Angus Heifers

The records of 2,217 Angus heifers, distributed over the years 1955-1967, were collected and analyzed. These data came from Front Royal, Middleburg and 34 herds participating in the Virginia BCIA (Table I). To determine the significance of selected interactions, herds in the preliminary analyses were combined on the basis of unadjusted means into 9 logical categories and recoded.

While none of the Front Royal heifers were creep-fed, approximately 2% of the Middleburg heifers received creep feed. In addition, 40% of the BCIA herds were creep-fed.

No BCIA herds with less than 20 observations were included in the preliminary analyses. Furthermore, the preliminary analyses revealed certain logical groupings of the independent variables. For age of dam they were 2 and 3 year-olds, 4 and 5 year-olds, 6-11 year-olds and 12-15 year-olds; and for age of animal they were 10-13 months, 14 months, 15 and 16 months and 17-19 months.

The final model used to analyze the Angus heifer data was

$$Y_{ijlmnop} = \mu + H_i + A_j + D_l + C_m + P_n + Q_o + (AP)_{jn} + e_{ijlmnop}$$

$i = 1, \ldots, 36$ $\quad$ $m = 1, \ldots, 4$

$j = 1, \ldots, 13$ $\quad$ $n = 1, 2$

$l = 1, \ldots, 4$ $\quad$ $o = 1, 2, 3$

where

$Y_{ijlmnop}$ = the p^{th} individual, with the o^{th} postweaning treatment, the n^{th} preweaning treatment, in the m^{th} age of animal grouping, with a dam from the l^{th} age of dam grouping, weighed in the j^{th} year, and from the i^{th} herd,

$(AP)_{jn}$ = the effect of the jn^{th} AP subclass after the average effects of A and P have been removed,

$e_{ijlmnop}$ = random effect. The e's were assumed to be from a normally distributed population with $E(e) = 0$ and variance σ_e^2.

The other effects were defined previously (p. 16).

TABLE I. ADG AND GRADE OF ANGUS BULLS AND HEIFERS BY HERDS

Bulls				Heifers			
Herd	Number of Observations	Unadjusted Means ADG	Unadjusted Means Grade[1/]	Herd	Number of Observations	Unadjusted Means ADG	Unadjusted Means Grade[1/]
1014	30	2.03	12.3	1006	20	1.27	13.7
1024	31	1.92	13.4	1007	30	1.26	12.0
1026	47	1.77	12.6	1009	45	1.36	12.2
1029	40	2.05	13.5	1014	51	1.43	11.7
1032	16	1.82	13.6	1015	35	1.17	11.7
1034	137	2.03	13.1	1017	20	1.37	11.5
1055	34	1.71	10.7	1018[4/]	160	1.23	11.5
1073	32	2.00	13.3	1020	22	1.26	12.6
1076	34	2.05	13.9	1024	38	1.50	12.9
1078	54	2.01	13.1	1025	75	1.22	12.5
1080	20	1.72	12.6	1026	71	1.19	11.4
1096	147	1.94	13.1	1029	34	1.58	13.4
1097	137	1.96	13.0	1030	34	1.43	11.9
1105	62	2.04	13.9	1032	63	1.23	12.8
1144	36	1.71	12.0	1035	29	1.22	12.8
1195	37	1.95	13.0	1040	49	1.35	12.8
1214	36	1.88	12.7	1041	22	1.18	11.8
1500[2/]	391	2.15	13.0	1044	31	1.21	11.6
1999[3/]	177	2.20	11.7	1055	195	1.10	10.5
				1062	52	1.29	12.5
				1063	57	1.17	11.2
				1069	29	1.07	11.9
				1073	42	1.46	13.2
				1075	25	1.38	12.0
				1076	36	1.62	14.0
				1078	127	1.37	13.0
				1082	39	1.64	13.5
				1090	21	1.27	12.5
				1094	74	1.03	12.0
				1095	51	1.19	12.9
				1096	35	1.58	13.4
				1097	57	1.49	12.5
				1141	32	1.15	12.6
				1180	21	1.04	13.1
				1212	26	1.30	13.3
No. of herds & weighted means				1999[3/]	469	1.49	11.9
19	78.8	2.00	12.8	36	61.6	1.32	12.1

1/ Fancy = 15 to 17, Choice = 12 to 14, Good = 9 to 11, etc.
2/ Composite group of bulls tested at Culpeper
3/ Beef Cattle Research Station herd, Front Royal
4/ Northern Virginia Pasture Research herd, Middleburg

Hereford Bulls

Observations on 130 Front Royal bulls of which 50 were creep-fed during the years 1960-63, 244 Culpeper bulls of which approximately 50% had been creep-fed, and 915 bulls in 19 BCIA herds of which 11 herds practiced creep feeding, comprised the Hereford bull data (Table II). No BCIA herds with less than 15 animals were included in the study.

In preliminary analyses, statistical tests among age of dam constants suggested 3 groupings: 2,3 year-olds, 4,5 year-olds and 6-14 year-olds. Age of animal groupings were 10-12 months, 13,14 months, and 15-19 months.

In the final analysis the model was

$$Y_{ijlmnop} = \mu + H_i + A_j + D_l + C_m + P_n + Q_o + e_{ijlmnop}$$

$i = 1, \ldots, 21$ $\qquad m = 1, 2, 3$

$j = 1, \ldots, 13$ $\qquad n = 1, 2$

$l = 1, 2, 3$ $\qquad o = 1, 2$

where

$Y_{ijlmnop}$ = the p^{th} individual, with the o^{th} postweaning treatment, the n^{th} preweaning treatment, the m^{th} age of animal grouping, with a dam in the l^{th} age of dam grouping, weighed in the j^{th} year, and from the i^{th} herd,

$e_{ijlmnop}$ = random effect. The e's were assumed to be from a normally distributed population with E(e) = 0 and variance σ_e^2.

TABLE II. ADG AND GRADE OF HEREFORD BULLS AND HEIFERS BY HERDS

Bulls				Heifers			
	Number of	Unadjusted Means[1]			Number of	Unadjusted Means[1]	
Herd	Observations	ADG	Grade	Herd	Observations	ADG	Grade
2003	351	2.09	13.3	2003	45	1.62	13.4
2005	16	2.08	13.5	2004	41	1.25	12.1
2006	70	2.04	13.2	2005	16	1.00	10.6
2008	42	2.28	13.0	2006	17	1.35	12.7
2025	131	1.97	12.6	2008	22	1.65	12.6
2048	15	2.24	12.8	2014	40	1.02	10.4
2088	15	1.84	12.5	2020	47	1.50	11.9
2090	51	2.06	12.8	2025	29	1.44	12.6
2095	23	1.95	13.2	2041	19	1.52	11.0
2111	15	2.11	13.1	2048	70	1.49	12.7
2117	17	1.77	12.9	2052	15	1.36	12.5
2124	16	2.09	12.5	2055	26	1.22	11.4
2127	32	2.14	13.7	2058	62	1.23	11.7
2129	18	1.70	12.1	2063	50	1.16	10.3
2131	38	1.76	13.0	2064	21	1.53	12.6
2151	15	1.94	13.3	2080	20	1.27	11.9
2157	17	1.76	12.4	2111	24	1.45	12.8
2158	18	1.97	13.4	2127	30	1.59	13.6
2159	15	2.16	13.2	2141	34	1.22	12.8
2500[2]	244	2.18	12.9	2044	28	1.15	12.0
2999[3]	130	2.18	11.4	2071	18	1.34	12.8
				2401[4]	288	1.01	10.1
				2999[3]	440	1.37	11.3
No. of herds & weighted means							
21	61.4	2.08	12.9	23	61.0	1.29	11.4

1/ Fancy 15 to 17, Choice 12 to 14, Good 9 to 11, etc.
2/ Composite group of bulls tested at Culpeper
3/ Beef Cattle Research Station herd, Front Royal
4/ Bland Correctional Farm herd

The other effects were defined previously (p. 16).

<u>Hereford Heifers</u>

The Hereford heifer data consisted of 440 animals in the Front Royal research herd and 288 animals in the Bland Correctional Farm herd, none of which were creep-fed, and 674 animals in 21 BCIA herds of which 7 herds were creep-fed (Table II). Only BCIA herds with 15 or more observations were included in the analyses. Again, due to computer limitations, herds in the preliminary analyses were combined on the basis of unadjusted means into 9 logical categories and recoded.

Based on statistical tests among the least squares constants, obtained from preliminary analyses, the age of dam groupings selected were 2 and 3 year-olds, 4-6 year-olds and 11-14 year-olds. Likewise, the age of animal groupings selected were 10 months, 11-15 months, 16-18 months and 19 months of age.

The model for the final analysis was

$$Y_{ijlmnop} = \mu + H_i + A_j + D_l + C_m + P_n + Q_o + (AP)_{jn} + e_{ijlmnop}$$

$i = 1, \ldots, 23$ $\qquad m = 1, \ldots, 4$

$j = 1, \ldots, 13$ $\qquad n = 1, 2$

$l = 1, \ldots, 4$ $\qquad o = 1, 2, 3$

where

$Y_{ijlmnop}$ = the p^{th} individual, with the o^{th} postweaning treatment, the n^{th} preweaning treatment, in the m^{th} age of animal grouping, with a dam in the l^{th} age of dam grouping, weighed in the j^{th} year, and from the i^{th} herd,

$(AP)_{jn}$ = the effect of the jnth AP subclass after the average effects of A and P have been removed,

$e_{ijlmnop}$ = random effect. The e's were assumed to be from a normally distributed population with E(e) = 0 and variance σ_e^2.

The other effects were defined previously (p. 16).

RESULTS AND DISCUSSION

Tables are used to present the data in pictorial form. Table III shows the simple phenotypic relationships among the independent variables and between each independent and the two dependent variables as expressed by their correlation coefficients. The standard errors associated with the four breed-sex groups were 0.03, 0.02, 0.03 and 0.03, respectively. Since most of these relationships were quite low and none greater than 0.5, all of the independent variables could be included in the same least squares model.

Based on the results of preliminary analyses, certain variables were dropped in later analyses and the subdividions of other variables were regrouped. The regroupings were based on statistical and/or biological relationships. The results of the reduced models are given in Tables IV, V, VI, and VII of the appendix. If the signs of the partial regression coefficients were reversed, they would serve as correction factors. These partial regression coefficients were computed from those obtained in the least squares analyses by selecting a base within each submatrix of the indepedent variables, setting it equal to zero and adding the regression coefficient for that base to the other regression coefficients in the same submatrix. The least squares analyses of variance are presented in Tables VIII and IX, and the effects of selected interactions obtained from the preliminary analyses are presented in Tables X and XI.

The effects of each independent variable on the two dependent variables within each breed-sex group are presented and discussed individually.

Herds and Years

Both herd and year effects on ADG and grade were highly significant. In general, gains and grades in the years 1963-1967 were higher except in Hereford heifers. In contrast to the other breed-sex groups, the highly significant negative correlations between postweaning management and years (-.24) and preweaning management and years (-.07) indicate lower nutritional levels for the Hereford heifers in later years. Even so, it is not recommended that adjustment be made for these effects. Rather, it is recommended that comparisons and selections be made within herds and years.

Age of Dam

Age of dam was a significant source of variation on ADG in all groups. Yearling cattle out of 2 and 3 year-old dams had the slowest lifetime (birth to final weight) growth rate, whereas those out of mature dams (6-11 year-olds) had the fastest growth rate. This effect was slightly different for bulls and heifers, however. The growth rate of yearling heifers out of 12-15 year-old dams was significantly lower than those out of 6-11 year-old dams. This was not true for the bulls. This would indicate that the older cows producing calves that were kept as bulls were a more highly select group. McCormick et al. (1956), Swiger (1961) and Brown (1961) also found age of dam to be a significant source of variation on ADG. On the other hand, Swiger *et al*. (1963), reported no significant effects of age of dam on postweaning gains and grades. The insignificant effect of age of dam on postweaning gains concurs with the results of Hitchcock *et al*. (1955), Brinks *et al*. (1962), and Neville *et al*. (1962).

Since all of the animals used in this study were weaned prior to being performance tested, the age of dam effect is during the pre-weaning stage of the calves' lives. Therefore, it appears that post-weaning growth does not always adequately compensate for a poor preweaning environment. These findings agree with Taylor (1967).

The age of the dam had little influence on the grade of yearling cattle and was significant only among the Angus heifers. The range in average grades among the age of dam groups was less than 0.2 of a grade point among the bulls and approximately 0.5 of a grade point among the heifers. These values are too small to justify correction factors for age of dam effects. Koch and Clark (1955) and Schalles and Marlowe (1967) also found that correction of yearling grade for age of dam does not seem to be large enough to be of any practical importance.

Age of Animal

ADG was significantly influenced by the age of the animals in all groups. Short yearlings (10-13 months of age) had the highest ADG with ADG decreasing in each successive age group. Furthermore, the highly significant negative correlations between age of animal and ADG indicated that the older animals grew at a slower rate. These correlations were

-.25, -.45, -.16 and -.41 for Angus bulls, Angus heifers, Hereford bulls, and Hereford heifers, respectively. The correlation between age of animal and postweaning management was significant in all breed-sex groups. The relationships were in opposite directions for bulls and heifers, however. These coefficients suggest that the nutritional level of bulls increased as the bulls increased in age, whereas the reverse was true among the heifers. Swiger et al. (1963) concluded that the effect of age of animal on ADG from 200 to 590 days of age for bulls, heifers and steers was negligible. Since the animals in this study ranged from 300-600 days of age and lifetime ADG was a dependent variable and since Brinks et al. (1962) reported age of calf to have a significant effect on final weight, it appears that adjusting lifetime ADG for age of animal is justified.

The age of the animal when graded was not an important source of variation in grades. The range of grade differences among the various age groups was only 0.19, 0.29, 0.10 and 0.11 for the Angus bulls, Angus heifers, Hereford bulls and Hereford heifers, respectively. These differences were significant only for the Hereford bulls and even then they were too small to be of any practical importance. Swiger et al. (1963), adjusting grade for age of animal, reported only an occasional change of one unit in grade.

Month of Birth

In contrast to it's effect on ADG of weanling calves, month of birth appeared to have no significant influence on the ADG of yearling cattle. Therefore, this variable was not included in the reduced models. On the other hand, it significantly influenced the grade in all breed-sex groups. The general trend was for animals born during February through July to grade lower than those born during August through January. This might be a result of more creep feeding in the latter group as indicated by the small but significant positive correlations between month of birth and preweaning management practice (Table III). Koch and Clark (1955), Brown (1961), Neville (1962) and Cunningham and Henderson (1965) reported season of birth to be of no significant practical importance in adjusting ADG. Neville et al. (1962), on the other hand, reported higher postweaning daily gains during fattening tests and higher weight per day of age at slaughter for late born calves. The small number of calves (129) and the shortness of the calving season (December 15 - March 15) may limit the generality of their results.

Preweaning Management Practice

Creep feeding as calves significantly increased the lifetime ADG of yearling Hereford cattle. On the other hand, it had no significant effect on the yearling Angus cattle included in this study. This probably came about from the greater milk supply provided by the Angus cows. Hereford yearlings that were creep-fed as calves had a 0.12

pound advantage in lifetime ADG among the bulls and a 0.06 pound advantage among the heifers over the non-creep-fed cattle. Taylor (1967), using the records of 2,650 Hereford cattle also found a significant effect due to preweaning management practice and reported an advantage of 50 pounds for bull and 35 pounds for heifer creep-fed calves at 400 days of age. The significant preweaning management effect in Herefords again indicates that there is not always sufficient compensatory growth in the postweaning phase to justify a low level of nutrition in the preweaning phase of growth. If a full expression of growth potential is to be realized, calves must be fed on a high level of nutrition both before and after weaning.

Although there was a significant positive correlation of 0.2 to 0.3 between preweaning management practice and yearling grade in all groups, creep feeding had no practical significant influence on yearling grades of any of the breed-sex groups. The least squares analyses also indicated a 0.2 to 0.3 grade point advantage for the creep-fed cattle but was not statistically significant.

Postweaning Management Practice

The kind of postweaning treatment used had a significant effect on ADG of all groups, with growth rate being higher for the better fed animals. This difference amounted to 0.04 of a pound for Angus bulls and 0.12 of a pound for Hereford bulls in lifetime ADG between limited-fed and full-fed animals. Differences in heifers amounted to 0.15 of a pound for the Angus and 0.24 of a pound for the Herefords between the full-fed and no-grain groups.

The kind of postweaning treatment received had a significant effect on yearling grade of the Angus heifers and Hereford bulls only, but the trend was similar for the other groups.

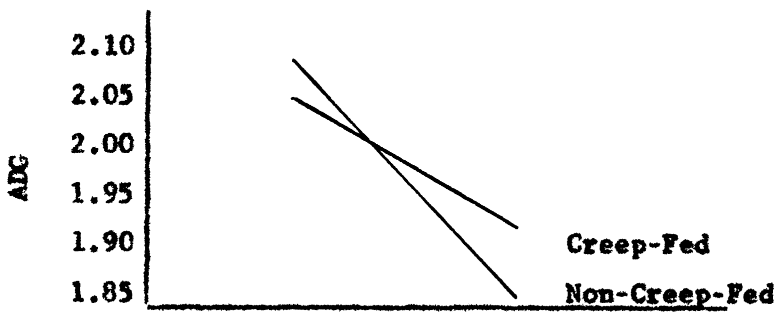
The data revealed some inconsistencies in the coding of animals as to postweaning management practice. Full feed to one breeder may not mean the same level of nutrition as full feed to another. Therefore, it would be difficult to accurately adjust for postweaning management practice when the animals come from different herds. On the other hand, under research conditions or on a within herd-within year basis, adjusting for postweaning management would probably be accurate.

Environmental Interactions

The significant interactions are presented in the least squares analyses of variance tables (Tables VIII and IX) and in Figures 1 through 6. The non-significant interactions, tested in preliminary analyses, are presented in Tables X and XI.

The significant preweaning x postweaning management practice interaction effect on ADG of Angus bulls came about because non-creep-fed bulls grew at a faster rate than creep-fed bulls when on full feed performance tests, whereas the reverse was true for bulls on limited feed performance tests. Therefore, there was some compensatory growth in non-creep-fed bulls during the postweaning full feed performance tests. On the other hand, growth rates of non-creep-fed bulls on limited feed performance tests were lower than those of creep-fed bulls. Since the milking ability of Angus cows is the probable cause of the nonsignificant effect of creep feeding on ADG in their calves, this would indicate that Angus bulls should receive high levels of nutrition at least in postweaning performance tests to allow a full expression of growth potential.

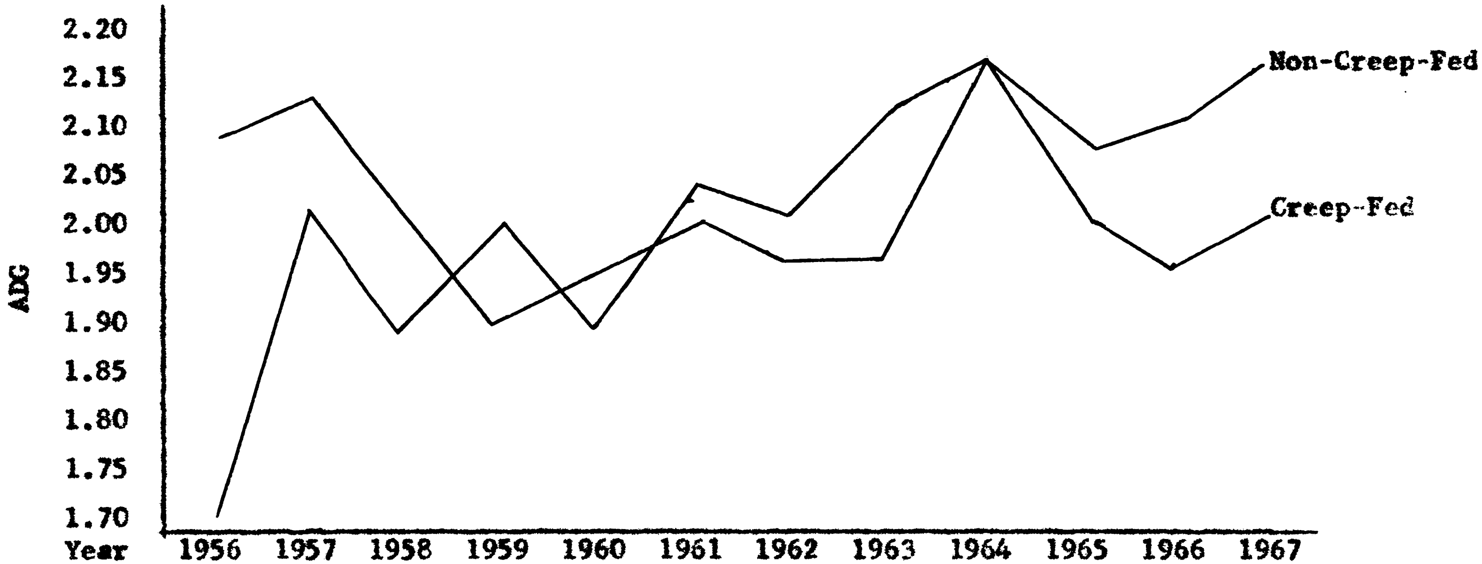
The significant preweaning management practice x year interaction effect on ADG of Angus bulls, Angus heifers and Hereford heifers and on grade in Angus bulls and Hereford heifers probably indicates the advantage of creep feeding during dry or otherwise adverse years. During optimum years creep- and non-creep-fed animals grew at about the same rate and graded about the same. In some of the more favorable years, non-creep-fed animals performed better than creep-fed animals. Among the Hereford heifers, the differences in growth rates and grades of creep- and non-creep-fed animals were much larger. This reflects the poorer milk producing ability of Hereford cows and the compensation by creep-fed calves. Since herds in geographically different areas have different climatic conditions and since climatic conditions within a year affect creep- and non-creep-fed animals differently, it would be difficult to accurately adjust for differences in preweaning management practice. On the other hand, under research conditions or on a within herd-within year basis, adjusting for preweaning management practice would probably be accurate.



Postweaning Management Practice	Full-Fed	Limited-Fed
Non-Creep-Fed[1/]	520	226
Creep-Fed[1/]	644	108

[1/] Number of observations at each level

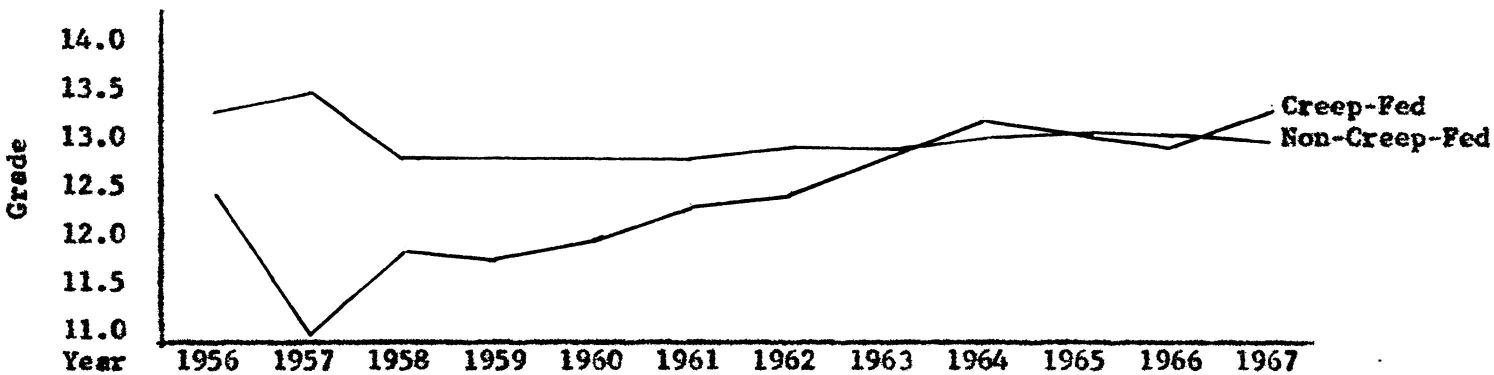
FIGURE 1. PREWEANING X POSTWEANING MANAGEMENT PRACTICE INTERACTION EFFECT ON ADG OF THE ANGUS BULLS



	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
Non-Creep-Fed[1/]	18	14	21	76	42	49	79	87	49	105	120	92
Creep-Fed[1/]	7	10	40	47	72	84	90	44	49	84	121	98

[1/] Number of observations at each level

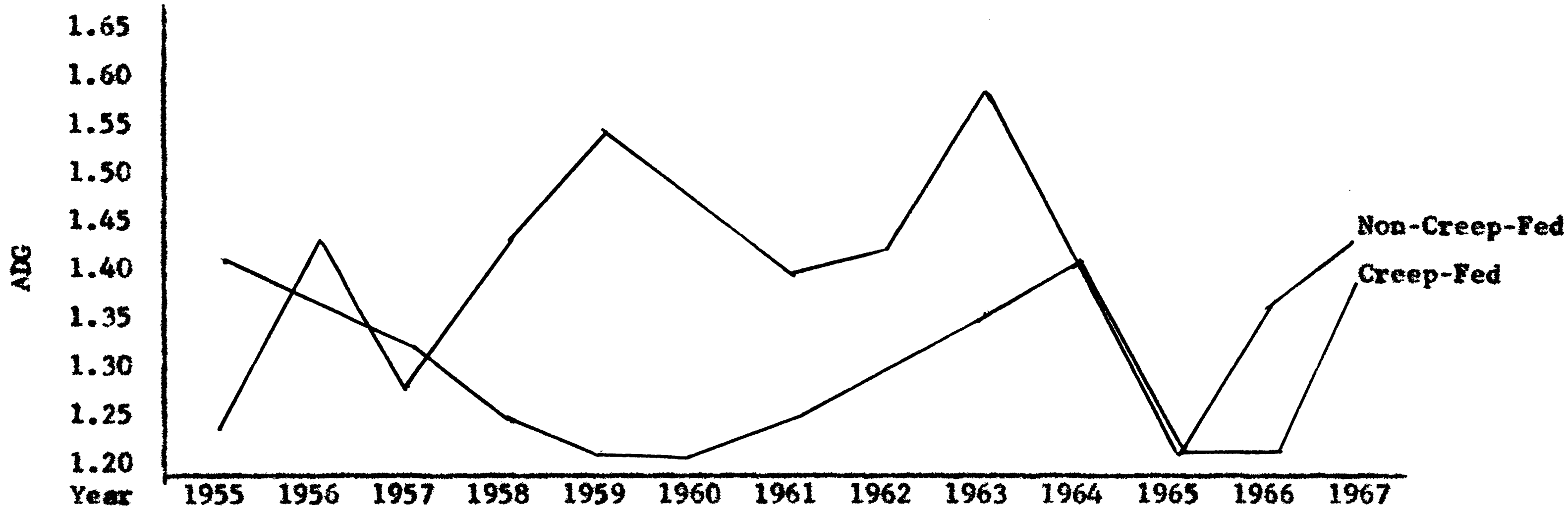
FIGURE 2. PREWEANING MANAGEMENT PRACTICE X YEAR INTERACTION EFFECT ON ADG OF THE ANGUS BULLS



	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
Non-Creep-Fed[1/]	18	14	21	76	42	49	79	87	49	105	120	92
Creep-Fed[1/]	7	10	40	47	72	84	90	44	49	84	121	98

[1/] Number of observations at each level

FIGURE 3. PREWEANING MANAGEMENT PRACTICE X YEAR INTERACTION EFFECT ON GRADE OF THE ANGUS BULLS



Non-Creep-Fed[1/]	81	165	92	305	180	165	158	106	102	90	149	104	85
Creep-Fed[1/]	3	20	59	89	65	37	14	57	11	17	12	15	36

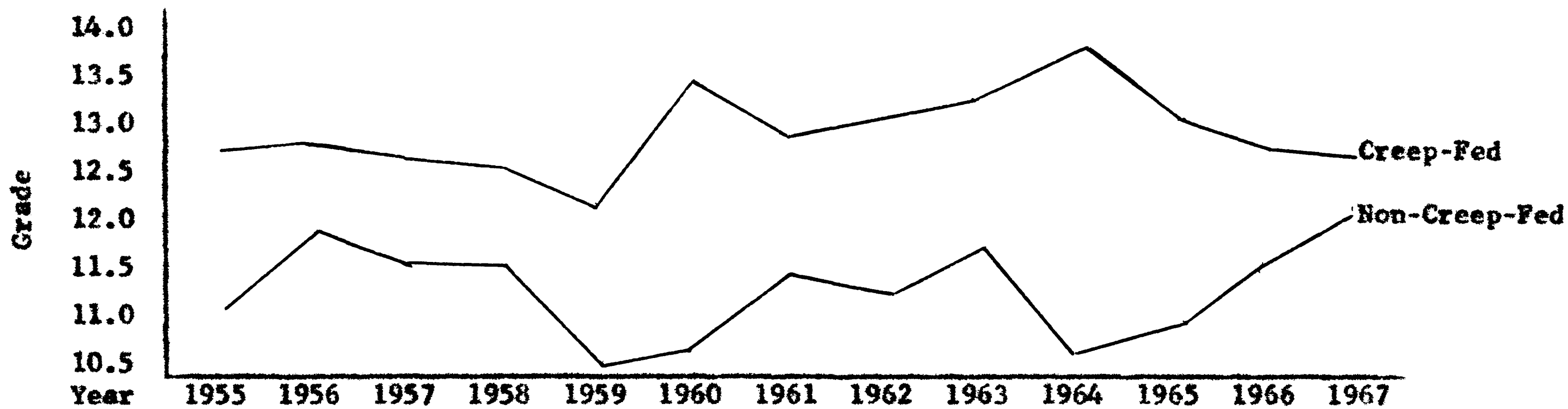
[1/] Number of observations at each level

FIGURE 4. PREWEANING MANAGEMENT PRACTICE X YEAR INTERACTION EFFECT ON ADG OF THE ANGUS HEIFERS

	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
Non-Creep-Fed[1]	42	56	72	114	96	99	106	84	56	101	119	160	129
Creep-Fed[1]	10	15	21	6	15	12	6	12	12	16	14	17	12

1/ Number of observations at each level

FIGURE 5. PREWEANING MANAGEMENT PRACTICE X YEAR INTERACTION EFFECT ON ADG OF HEREFORD HEIFERS



	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
Non-Creep-Fed[1/]	42	56	72	114	96	99	106	84	56	101	119	160	129
Creep-Fed[1/]	10	15	21	6	15	12	6	12	12	16	14	17	12

[1/] Number of observations at each level

FIGURE 6. PREWEANING MANAGEMENT PRACTICE X YEAR INTERACTION EFFECT ON GRADE OF HEREFORD HEIFERS

SUMMARY

Data for this study came from records of yearling cattle performance tested at Culpeper, sponsored by the Virginia BCIA; the Beef Cattle Research Station, Front Royal; the Bland Correctional Farm; the Virginia Forage Research Station at Middleburg; and private herds that participated in the Virginia BCIA performance testing program. There were 1,498 Angus bulls, 2,217 Angus heifers, 1,289 Hereford bulls and 1,402 Hereford heifers in the complete study. The effects of herd, year, age of dam, month of birth, age of animal, and pre- and postweaning management practice were independent variables, whereas ADG and grade were dependent variables. The data were analyzed by least squares procedures.

Not only did herds and years significantly affect ADG and grade in all analyses, but also age of dam and age of animal were significant sources of variation on ADG in all breed-sex groups. Yearling cattle out of two- and three-year old dams had the slowest lifetime growth rate, whereas those out of mature dams (6-11 years old) hadthe fastest growth rate. Furthermore, short yearlings (10-13 months of age) had the highest ADG with ADG decreasing in each successive age group. In contrast to it's effect on ADG of weanling calves, month of birth appeared to have no significant influence on ADG of yearling cattle. However, it significantly influenced the grade in all breed-sex groups.

Creep feeding as calves significantly increased the lifetime ADG of yearling Hereford cattle and the kind of postweaning treatment used had a significant effect on ADG of all groups, with growth rate being higher for the better fed animals. However, it appears that there is not always sufficient compensatory growth in the postweaning phase of growth to justify a low level of nutrition in the preweaning phase of growth.

Even though grade of yearling cattle was significantly affected by some of the independent variables, the effects were in no case large enough to be of practical importance.

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APPENDIX

TABLE III. SIMPLE PHENOTYPIC CORRELATION COEFFICIENTS AMONG TRAITS

Variables	Breed-Sex Group[1/]	Age of Dam	Month of Birth	Years	Age of Animal	Preweaning Management	ADG	Grade
Postweaning Management	AB	.03	-.21**	.21**	.10**	-.19**	.27**	-.02
	AH	.01	-.22**	.04	-.32**	.13**	.42**	.11**
	HB	.05	-.23**	.10**	.09**	.01	.22**	.05
	HH	-.04	-.19**	-.24**	-.41**	.17**	.48**	.12**
Age of Dam	AB		.00	-.03	-.08**	-.04	.16**	-.01
	AH		.00	.07**	.01	.05	.07**	.02
	HB		.03	.05	-.03	-.03	.18**	.02
	HH		-.05	.06*	.13**	-.03	.01	-.04
Month of Birth	AB			.01	.28**	.10**	-.11**	.10**
	AH			-.08**	-.17**	.20**	-.08**	.02
	HB			.00	.01	.11**	.04	.13**
	HH			.01	-.30**	.26**	.11**	.20**
Years	AB				.09**	-.01	.16**	.23**
	AH				.05	-.02	.01	.16**
	HB				-.03	-.02	.08**	.27**
	HH				.24**	-.07**	-.21**	.05
Age of Animal	AB					.02	-.25**	.07**
	AH					-.03	-.45**	.05
	HB					.12	-.16**	.04
	HH					-.08	-.41**	-.15**
Preweaning Management	AB						.08**	.17**
	AH						.21**	.24**
	HB						.15**	.20**
	HH						.35**	.32**

[1/] AB = Angus bulls, AH = Angus heifers, HB = Hereford bulls, HH = Hereford heifers

* P < .05

** P < .01

TABLE IV. EFFECTS OF AGE OF DAM, AGE OF ANIMAL, POSTWEANING MANAGEMENT PRACTICE AND YEARS ON ADG AND GRADE OF ANGUS BULLS

Effect	Number of Observations	Unadjusted Means ADG	Unadjusted Means Grade[2/]	Part. Reg. Coefficients[3/] ADG	Part. Reg. Coefficients[3/] Grade
Age of Dam in years					
2	153	1.92	12.8	-.11±.01[a]	-.03±.06[a]
3-5	612	2.02	12.9	-.04±.01[b]	0.11±.04[a]
6-14[1/]	733	2.06	12.8	0.00±.01[c]	0.00±.04[a]
Means[4/]	499.3	2.03	12.8	1.86±.04	12.9±.20
Age of Animal in months					
10-13[1/]	1045	2.06	12.8	0.00±.01[a]	0.00±.05[a]
14	200	2.02	13.0	-.05±.02[b]	0.05±.08[a]
15	115	2.00	13.0	-.11±.02[c]	-.02±.09[a]
16	68	1.92	13.1	-.14±.02[c,d]	0.07±.11[a]
17-19	70	1.78	13.0	-.19±.02[d]	0.17±.11[a]
Means[4/]	299.6	2.03	12.9	1.86±.04	12.9±.20
Postweaning Management					
Full Fed[1/]	1164	2.07	12.8	0.00±.01[a]	0.00±.05[a]
Limited Fed	334	1.91	12.9	-.04±.01[b]	-.18±.05[a]
Means[4/]	749.0	2.03	12.8	1.86±.04	12.9±.20
Year					
1956	25	1.99	12.8	-.12±.05	0.14±.23
1957	24	2.10	12.1	0.01±.04	-.40±.21
1958	61	1.94	12.6	-.08±.03	-.24±.14
1959	123	1.95	12.1	-.04±.02	-.47±.10
1960	114	1.92	12.6	-.07±.02	-.42±.10
1961	133	2.04	12.7	-.01±.02	-.27±.10
1962	169	2.00	12.8	-.01±.02	-.03±.09
1963	131	2.03	12.7	-.03±.02	0.09±.10
1964	98	2.19	13.2	0.09±.02	0.41±.11
1965	189	2.06	13.1	0.05±.02	0.30±.08
1966	241	2.04	13.0	0.07±.02	0.38±.08
1967	190	2.08	13.2	0.08±.03	0.52±.09
Means[4/]	124.8	2.03	12.8	1.86±.04	12.9±.20

[1/] Selected base
[2/] Fancy = 15 to 17, Choice = 12 to 14, Good = 9 to 11, etc.
[3/] Values with different superscripts are significantly different (P<.05)
[4/] Weighted or least squares means

TABLE V. EFFECTS OF AGE OF DAM, AGE OF ANIMAL, POSTWEANING MANAGEMENT PRACTICE AND YEARS ON ADG AND GRADE OF ANGUS HEIFERS

Effect	Number of Observations	Unadjusted Means ADG	Unadjusted Means Grade 2/	Part. Reg. Coefficients 3/ ADG	Part. Reg. Coefficients 3/ Grade
Age of Dam in years					
2,3	654	1.30	12.0	-.06±.01[a]	-.12±.06[a]
4,5	579	1.33	12.1	-.01±.01[b]	0.06±.06[b]
6-11 1/	876	1.35	12.2	0.00±.01[b]	0.00±.05[b,c]
12-15	108	1.29	11.9	-.05±.01[c]	-.42±.10[c]
Means 4/	554.3	1.33	12.1	1.34±.03	12.7±.26
Age of Animal in months					
10-13 1/	1271	1.42	12.1	0.00±.01[a]	0.00±.08[a]
14	251	1.29	11.8	-.06±.01[b]	-.14±.12[a]
15,16	281	1.22	12.2	-.16±.01[c]	0.15±.11[a]
17-19	414	1.14	12.3	-.26±.02[d]	0.11±.12[a]
Means 4/	554.3	1.33	12.1	1.34±.03	12.7±.26
Postweaning Management					
Full Fed 1/	140	1.54	13.3	0.00±.01[a]	0.00±.12[a]
Limited Fed	966	1.41	12.0	-.12±.01[b]	-.63±.09[b]
No Grain	1111	1.23	12.1	-.15±.01[c]	-.63±.08[b]
Means 4/	739.0	1.33	12.1	1.34±.03	12.7±.26
Year					
1955	84	1.43	12.2	0.02±.05	0.02±.38
1956	185	1.38	12.2	0.11±.02	0.15±.17
1957	151	1.32	12.3	-.43±.02	-.13±.12
1958	394	1.30	11.9	-.03±.01	-.40±.10
1959	245	1.32	11.5	0.02±.01	-.63±.11
1960	202	1.27	11.6	-.04±.02	-.32±.13
1961	172	1.28	11.6	-.09±.02	-.65±.19
1962	163	1.37	12.3	-.02±.01	-.19±.12
1963	113	1.39	12.5	-.03±.03	-.26±.22
1964	107	1.41	12.6	0.02±.02	0.44±.18
1965	161	1.19	12.6	0.02±.02	0.50±.20
1966	119	1.34	12.9	0.02±.02	0.95±.19
1967	121	1.43	12.8	0.04±.02	0.51±.15
Means 4/	170.5	1.33	12.1	1.34±.03	12.7±.26

1/ Selected base
2/ Fancy = 15 to 17, Choice = 14 to 16, Good = 9 to 11, etc.
3/ Values with different superscripts are significantly different (P .05)
4/ Weighted or least squares means

TABLE VI. EFFECTS OF AGE OF DAM, AGE OF ANIMAL, PRE- AND POSTWEANING MANAGEMENT PRACTICES AND YEARS ON ADG AND GRADE OF HEREFORD BULLS

Effect	Number of Observations	Unadjusted Means ADG	Unadjusted Means Grade[2/]	Part. Reg. Coefficients[3/] ADG	Part. Reg. Coefficients[3/] Grade
Age of Dam in years					
2,3	328	2.00	12.8	-.10±.01[a]	-.03±.05[a]
4,5	387	2.10	12.9	-.02±.01[b]	0.12±.04[a]
6-14[1/]	574	2.13	12.9	0.00±.01[c]	0.00±.04[a]
Means[4/]	429.7	2.09	12.9	1.93±.05	12.7±.21
Age of Animal in months					
10-12[1/]	660	2.12	12.8	0.00±.01[a]	0.00±.05[a]
13,14	421	2.09	12.9	-.04±.01[b]	0.04±.06[a,b]
15-19	208	1.98	13.0	-.14±.01[c]	0.10±.06[b]
Means[4/]	429.7	2.09	12.9	1.93±.05	12.7±.21
Preweaning Management					
Creep-Fed	793	2.12	13.1	0.12±.01[a]	0.16±.04[a]
Non-Creep-Fed[1/]	496	2.03	12.6	0.00±.01[b]	0.00±.04[a]
Means[4/]	644.5	2.09	12.9	1.93±.05	12.7±.21
Postweaning Management					
Full-Fed[1/]	1041	2.12	12.9	0.00±.01[a]	0.00±.05[a]
Limited-Fed	248	1.96	12.8	-.12±.01[b]	-.26±.05[a]
Means[4/]	644.5	2.09	12.9	1.93±.05	12.7±.21
Year					
1955	25	1.92	11.0	-.19±.06	-.46±.30
1956	27	2.02	11.9	-.10±.06	0.19±.29
1957	34	2.01	12.3	0.02±.04	-.41±.18
1958	50	2.08	12.5	0.04±.03	-.18±.15
1959	96	2.04	12.4	-.04±.02	-.52±.11
1960	111	2.02	12.6	-.03±.02	-.35±.11
1961	73	2.14	12.4	0.00±.03	-.31±.12
1962	129	2.12	12.7	-.03±.02	-.33±.10
1963	180	2.04	13.1	0.02±.02	0.22±.09
1964	102	2.15	13.3	0.02±.02	0.41±.11
1965	153	2.14	13.3	0.04±.02	0.31±.09
1966	162	2.10	13.1	0.13±.02	0.72±.10
1967	147	2.08	13.1	0.11±.02	0.78±.10
Means[4/]	99.2	2.09	12.9	1.93±.05	12.7±.21

1/ Selected base
2/ Fancy = 15 to 17, Choice = 12 to 14, Good = 9 to 11, etc.
3/ Values with different superscripts are significantly different (P<.05)
4/ Weighted or least squares means

TABLE VII. EFFECTS OF AGE OF DAM, AGE OF ANIMAL, PRE- AND POSTWEANING MANAGEMENT PRACTICES AND YEARS ON ADG AND GRADE OF HEREFORD HEIFERS

Effect	Number of Observations	Unadjusted Means ADG	Unadjusted Means Grade[2/]	Part. Reg. Coefficients[3/] ADG	Part. Reg. Coefficients[3/] Grade
Age of Dam in years					
2,3	334	1.30	11.7	-.05±.01[a]	-.08±.07[a]
4-6	587	1.31	11.6	-.03±.01[a]	-.07±.06[a]
7-10[1/]	383	1.31	11.6	0.00±.01[b]	0.00±.07[a]
11-14	98	1.30	11.3	-.04±.01[a]	-.40±.06[a]
Means[4/]	350.5	1.31	11.6	1.40±.04	12.0±.35
Age of Animal in months					
10[1/]	254	1.42	12.0	0.00±.01[a]	0.00±.09[a]
11-15	657	1.37	11.6	-.02±.01[a]	0.00±.08[a]
16-18	293	1.17	11.3	-.08±.01[b]	-.09±.08[a]
19	198	1.14	11.3	-.10±.01[b]	-.11±.09[a]
Means[4/]	350.5	1.31	11.6	1.40±.04	12.0±.35
Preweaning Management					
Creep-Fed	168	1.55	13.0	0.06±.01[a]	0.26±.11[a]
Non-Creep-Fed[1/]	1234	1.27	11.4	0.00±.01[b]	0.00±.11[a]
Means[4/]	701.2	1.30	11.6	1.40±.04	12.0±.35
Postweaning Management					
Full-Fed[1/]	59	1.65	12.5	0.00±.02[a]	0.00±.16[a]
Limited-Fed	559	1.41	11.7	-.09±.02[b]	-.22±.13[a]
No Grain	784	1.21	11.5	-.24±.02[c]	-.28±.13[a]
Means[4/]	467.3	1.31	11.6	1.40±.04	12.0±.35
Year					
1955	52	1.40	11.4	-.08±.03	-.49±.24
1956	71	1.36	12.1	-.03±.03	0.02±.20
1957	93	1.43	11.8	0.03±.02	-.31±.19
1958	120	1.34	11.7	0.10±.01	-.07±.27
1959	111	1.32	11.0	0.01±.03	-.61±.20
1960	111	1.39	11.1	0.05±.03	0.08±.21
1961	112	1.39	11.6	0.17±.04	0.13±.27
1962	96	1.26	11.5	-.04±.03	0.12±.23
1963	68	1.37	12.2	-.04±.03	0.24±.24
1964	117	1.15	11.2	-.12±.03	-.09±.22
1965	133	1.11	11.2	-.08±.03	0.19±.24
1966	177	1.29	11.8	-.01±.03	0.25±.22
1967	141	1.34	12.2	0.03±.03	0.54±.28
Means[4/]	107.9	1.31	11.6	1.40±.04	12.0±.35

1/ Selected base
2/ Fancy = 15 to 17, Choice = 12 to 14, Good = 9 to 11, etc.
3/ Values with different superscripts are significantly different ($P<.05$)
4/ Weighted or least squares means

TABLE VIII. ANALYSIS OF VARIANCE OF ENVIRONMENTAL FACTORS AFFECTING ADG AND GRADE OF ANGUS BULLS AND HEIFERS

	Bulls			Heifers		
Source	DF	MS(ADG)	MS(Grade)	DF	MS(ADG)	MS(Grade)
Herds	18	.82**	24.74**	36	2.32**	63.40**
Postweaning Management	1	.13*	3.32	2	.65**	11.82**
Age of Dam	2	.83**	2.44	3	.54**	8.45**
Years	11	.27**	10.49**	12	.17**	15.24**
Age of Animal	4	.82**	.49	3	1.21**	1.73
Preweaning Management	1	.06	.08	1	.07	5.83
Preweaning Management X Postweaning Management	1	.19*	.08			
Preweaning Management X Years	11	.17**	2.02*	12	.07**	2.87
Error	1448	.039	1.01	2147	.027	1.89

*P<.05
**P<.01

TABLE IX. ANALYSIS OF VARIANCE OF ENVIRONMENTAL FACTORS AFFECTING ADG AND GRADE OF HEREFORD BULLS AND HEIFERS

Source	Bulls			Heifers		
	DF	MS(ADG)	MS(Grade)	DF	MS(ADG)	MS(Grade)
Herds	20	.94**	18.26**	22	.67**	42.60**
Postweaning Management	1	1.38**	6.25**	2	.81**	1.05
Age of Dam	2	.92**	2.45	3	.16**	3.80
Years	12	.27**	14.61**	12	.18**	3.72**
Age of Animal	2	.12**	3.96**	3	.28**	.37
Preweaning Management	1	.25**	.63	1	.10*	2.20
Preweaning Management X Years				12	.11**	3.65**
Error	1250	.048	1.03	1346	.029	1.78

*P<.05
**P<.01

TABLE X. INTERACTION EFFECTS ON ADG AND GRADE OF ANGUS BULLS AND HEIFERS

Bulls

Interaction	ADG	Grade
Year x Postweaning Management	-	-
Month of Birth x Postweaning Management	-	-
Age of Dam x Preweaning Management	-	-
Age of Dam x Year	-	-
Age of Animal x Postweaning Management	-	-
Preweaning Management x Postweaning Management	*	-
Year x Preweaning Management	**	*

Heifers

Interaction	ADG	Grade
Year x Preweaning Management	**	-
Age of Animal x Postweaning Management	-	-
Preweaning Management x Postweaning Management	-	-

*P<.05
**P<.01

TABLE XI. INTERACTION EFFECTS ON ADG AND GRADE OF HEREFORD BULLS AND HEIFERS

Bulls

Interaction	ADG	Grade
Preweaning Management x Postweaning Management	-	-
Year x Preweaning Management	-	-
Herd x Postweaning Management	-	-
Age of Animal x Preweaning Management	-	-
Age of Animal x Postweaning Management	-	-

Heifers

Interaction	ADG	Grade
Year x Preweaning Management	**	**
Month of Birth x Postweaning Management	-	-
Preweaning Management x Postweaning Management	-	-
Age of Animal x Postweaning Management	-	-
Month of Birth x Preweaning Management	-	-
Age of Animal x Preweaning Management	-	-

**P<.01

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ENVIRONMENTAL FACTORS AFFECTING CONTINUOUS GROWTH
AND YEARLING TYPE IN BEEF CATTLE

by Gary Andrew Waugh

Abstract

The objective of this study was to estimate the magnitude of the major environmental factors that affect growth rate and grade of yearling beef cattle and to obtain correction factors for their effects. Four breed-sex groups consisting of 1,498 Angus bulls, 2,217 Angus heifers, 1,289 Hereford bulls, and 1,402 Hereford heifers were analyzed separately by least squares methods. The environmental factors of herd, year, age of dam, month of birth, age of animal, pre- and postweaning management practice, and selected interactions were treated as independent variables, whereas ADG and grade were the dependent variables. All of the independent variables except month of birth and preweaning management practice significantly affected the growth rate of Angus cattle and all except month of birth significantly affected the growth rate of Hereford cattle. Growth rate increased with age of dam and level of nutrition and decreased with age of animals on test. Creep feeding as calves significantly affected the lifetime gains of yearling Hereford cattle but not of Angus cattle nor the yearling grades in any of the breed-sex groups. In general, the environmental factors studied had a much smaller effect on grade than on growth of yearling cattle.