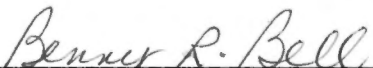
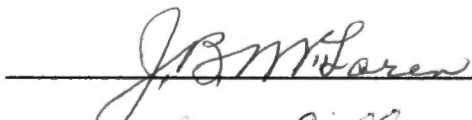
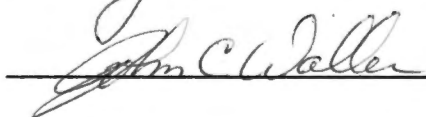


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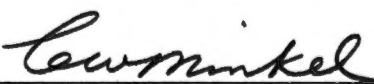
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Benny R. Bell, Major Professor

We have read this thesis
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COMPARISON OF METHODS OF SELECTION TO INCREASE
WEANING WEIGHT OF BEEF CATTLE

A Thesis
Presented for the
Master of Science
Degree
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ABSTRACT

Weaning records of 10,979 calves from the Hereford and Angus herds of the University of Tennessee were analyzed to compare different selection methods to increase weaning weight of beef cattle. Records were collected over a 25-year period from 1959 to 1984. Variables recorded were date of birth, sex, birth weight, breed of dam and sire, weaning age and weaning weight. Weaning weights were adjusted for sex, age of calf at weaning, and age of dam. Selection decisions were made on a within-herd-year basis.

Three methods of selection were compared. Objectives were to determine the effects on weaning weights when selection of replacement females was based on (1) age of her dam, (2) average daily gain as a calf, and (3) most probable producing ability of her dam and granddam.

Linear regression of progeny weaning weights on age of dam yielded substantial positive results ($b=0.69$). Negative estimates, however, resulted when progeny weaning weight was regressed on the age of granddam when the dam was born. Least-square means indicated that selecting females from immature dams was more effective in increasing weaning weights than selection from other age groups.

Similar inverse dam-offspring relationships were observed when regression of progeny weights on MPPA were utilized. Due to the negative estimates being relatively small, selection of replacement females from dams with lower MPPA values did not maximize weaning weights. Weaning weights declined dramatically, however, from one generation to another.

Comparison of least-square means of quartiles when selection was based on the average daily gain, likewise, yielded similar results to the other two selection systems. Selection of females from dams with the highest average daily gain significantly increased weaning weights. Females selected from dams of lower average daily gain quartiles weaned calves at weights lower than when no selection was practiced.

Analysis revealed the existence of a possible negative genetic and/or environmental relationships between preweaning growth and subsequent maternal effects. With the exception of selection from immature dams, the magnitude of this antagonistic effect did not seem to overwhelm the direct genetic component for growth.

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CHAPTER I

INTRODUCTION

The Tennessee beef industry is composed primarily of commercial cow-calf producers whose principal income is derived from the total weight of calves sold at weaning. In order for these producers to maximize weaning weights, they must evaluate the breeding potentials of the females at an early age. Since phenotype is a partial indicator of genotype, one might expect females exhibiting superior preweaning growth to be genotypically superior. However, the phenotype is due to both direct and maternal effects. The maternal effect is from two components, the dams genes for maternal ability and the environment the dam received as a calf. Therefore, producers who have based their selection systems solely on phenotypic values have had difficulty in increasing weights due to adverse environmental and/or genetic correlations.

Research has shown that selecting replacements that exhibit superior preweaning growth can be detrimental due to an antagonistic effect between early growth rate and subsequent maternal ability. This antagonistic effect exists due to excess adipose deposition in the mammary system. This deposition hinders the secretory tissue development of the replacement individual causing her milk producing ability to be decreased. Therefore, it is the purpose of this research to (1) compare alternative female selection schemes with the intention of increasing weaning weights and (2) to evaluate these alternative strategies to determine their economic consequences.

CHAPTER II

REVIEW OF LITERATURE

I. Maternal Influences on Calf Preweaning Performance

Age of Dam

Numerous researchers have reported that age of dam is a major contributor to variation in weaning weight of beef calves (Christian et al., 1965; Botkin and Whatley, 1953; Minyard and Dinkel, 1965; Koch and Clark, 1955; Cundiff et al., 1966; Elzo et al., 1987). The age of dam effect upon weaning weight is the result of differing levels of milk production of immature or very old dams when compared to mature dams at peak producing ages. A summary of age of dam effects on weaning weights is shown in Table I.

Minyard and Dinkel (1965a) investigated the effects of age of dam on productivity as measured by weaning weight of purebred Angus and purebred Hereford calves. Their study reported that maximum weaning weights were obtained when the dam was 8 years of age. Koch and Clark (1955) reported 6 years of age, Anderson and Wilham (1978) reported 6 to 9 years of age, and Nelms and Bogart (1956) reported 6 to 10 years as the age of maximum performance. Minyard and Dinkel further reported that the largest change in weaning weight occurred between 2 and 3 years of age.

These findings are in reasonable agreement with other published reports. Mangus and Brinks (1971) reported that heifers from 2-, 3-, 4-, and 12-year old and older dams have lower weaning weight averages

TABLE I
A SUMMARY OF ESTIMATED EFFECTS OF AGE OF DAM ON WEANING WEIGHTS^{ab}

Author	Ages of Dam									
	2	3	4	5	6	7	8	9	10	11
Botkin and Whatley (1953)	---	-35.0	-15.0	---	---	---	---	---	---	---
Koch and Clark (1955a)	---	-41.0	-18.0	-6.0	0.0	-7.0	-6.0	-12.0	-24.0	---
Minyard and Dinkel (1965)	-69.0	-33.0	-21.0	-13.0	-4.0	-3.0	0.0	-9.0	-23.0	-24.0
Kress and Burfening (1972)	-32.0	-19.0	-11.0	-6.0	-2.0	-1.0	-2.0	0.0	-2.0	-6.0
Anderson and Wilham (1978)	-18.0	-9.0	-4.0	-1.0	0.0	0.0	0.0	0.0	-4.0	---

^aKilograms

^bAge of dam effects expressed as deviations from mature dams.

than those from 5- through 11-year old dams. Christian et al. (1965) and Kress and Burfening (1972) reported weaning weights were lower for calves from 2-year old dams.

Lush and Shrode (1950) have shown that the actual age of dam effects may be biased when culling based on production records have been practiced. They suggest that such biases may lead to over adjustment of younger cows and under adjustment of older cows.

Milk Producing Ability

A large source of variation in weaning weights is from differences in milk producing ability of the dam (Gregory et al., 1950; Koger and Knox, 1947; Neville, 1962; Drewry et al., 1959). Neville (1962) reported that 66% of the variation in weight at 8 months of age was due to milk consumption. Drewry et al. (1959) reported that 60% of variation in 6 month weight was due to differences in milk yield of the dams. Other workers (Christian et al., 1965; Gifford, 1953) have shown correlations ranging from 0.5 to 0.8 between total milk production and gain from birth to weaning. Such correlations indicate that higher milk producing dams will have progeny that have more rapid gains and wean at heavier weights.

Koch and Clark (1955) and Drewry et al. (1959) reported that milk production increases with age up to the approximate age of maturity, which varies from herd to herd. Once maturity is reached, the milk producing ability of the dam shows a gradual decline.

Several studies, however, have indicated negative estimates for the relationships between the preweaning environments of dam and

offspring (Christian, 1965; Koch, 1969; Mangus and Brinks, 1971; Holloway and Totusek, 1973; Koch and Clark, 1955). These negative covariances suggest that the amount of milk consumed by the beef heifer will have an inverse influence on her subsequent milk producing ability. Such an antagonistic association between the level of milk production of dams and future maternal ability of female progeny suggest that selection based solely on phenotype is of little value as a selection criterion.

Performance of First Lactation Dams

Christian et al. (1965) and Koch and Clark (1955) suggested that a negative genetic or enviromental correlation, or both, existed between preweaning performance of the dam and the maternal enviroment provided to her calf. This hypothesis is supported by Swanson (1960), who studied the effects of rearing twin dairy heifers on normal and high levels of nutrition. High nutritional levels during early growth period of the heifer resulted in decreased lifetime milk production, as compared to milk production of normally reared heifers. Christian et al. (1965) further suggested that if such a relationship does exist, then selecting replacement heifers superior in weaning weight would result in increased genetic value for growth, but accompanied by decreased milk production.

Mangus and Brinks (1971), studying the factors affecting weaning weight of beef heifers and subsequent producing ability, reported that heifers reared by young dams produced heavier calves at weaning than heifers reared by mature dams. They concluded that low levels of milk

supplied by the younger dams had a beneficial effect on future maternal ability. Conversely, the relatively high preweaning level of nutrition supplied by mature dams created a detrimental effect on subsequent productivity. Similar observations have been reported by other researchers (Totusek, 1968; Koch, 1969; Ferrell et al., 1976; Kress and Burfening, 1972; Christian et al., 1965).

Considerable data have been gathered confirming an antagonism between maternal phenotype of the dam on future maternal phenotypes of her daughters. Bertrand and Benyshek (1987) reported a genetic correlation between direct and additive maternal effects of $-.30$ and $-.29$ for weaning weights of Limousin and Brangus calves, respectively. Cantet et al. (1988) reported a negative correlation between $-.65$ and $-.75$ for direct and additive maternal effects for Hereford calves. Bruckner and Slinger (1986) likewise reported a negative correlation between additive maternal and direct effects for weaning weight ($-.41$ to -1.12). The consistently negative values observed between the additive genetic direct and maternal effects on weaning weights gives an indication why progress toward increasing weaning weights is slow. Progress made by additional genetic effects is offset by a reduction in the additive maternal components.

II. Preweaning Performance and Subsequent Producing Ability

Timing of Gain on Mammary Development

Sinha and Tucker (1969) reported that the mammary gland undergoes an accelerated growth period known as allometric mammary growth. According to their study, mammary secretory tissue grows approximately

3.5 times faster than body surface tissue during this time. Sinha and Tucker further reported that this allometric growth occurs between the ages of 3 and 9 months; or until puberty is reached. Other authors have shown also that 3 to 9 months of age is an accurate assessment of this allometric growth period (Johnsson and Obst, 1984; Johnsson and Morant, 1984; Sejrsen, 1982).

Numerous researchers have shown that rapid early growth of heifers during this period is inversely related to subsequent milk producing ability (Christian, 1965; Mangus and Brinks, 1971; Koch, 1972; Holloway and Totusek, 1973). Swanson (1960), utilizing dairy heifers, showed that this antagonistic effect is a result of decreased secretory tissue development for heifers reared on high planes of nutrition. Findings of Sjersen (1982) are in general accordance with Swanson's earlier work.

Further studies involving dairy heifers (Swanson, 1960; Swanson and Hinton, 1964) showed that overfeeding produced heifers which were fatter and heavier than those reared normally or subnormally, but produced significantly less milk over all lactations. Similar results were reported by Johnsson and Obst (1984) utilizing beef heifers. They showed that regardless of postweaning rate of gain, heifers reared on high levels of nutrition prior to weaning consistently produced less milk than normally reared heifers. They reported also that heifers reared on low levels of nutrition prior to weaning, followed by moderate or normal rearing postweaning, produced more milk than heifers from all other treatments.

Rate of Gain

Kress and Burfening (1972), after studying preweaning growth on subsequent most probable producing ability, suggested that the optimum growth rate which would maximize producing ability may never be correctly known due to differences in breeds and management systems. Nevertheless, several experiments have shown that heifers exposed to poorer preweaning environments were subsequently the best producers (Kress and Burfening, 1972; Johnsson and Obst, 1984; Sejrsen, 1978; Mangus and Brinks, 1971; Koch, 1972).

Sejrsen (1978) discussed the evidence of a critical upper limit for average daily gain in dairy heifers. His study reported that gains beyond 0.8 kg/day significantly reduced dairy heifers subsequent milk producing ability.

Totusek (1968) compared weaning weights of calves out of heifers raised on low, medium, and high planes of nutrition prior to 240 days of age. He reported that dams raised on the low plane of nutrition weaned calves weighing 8 to 10 kg more than calves weaned by medium and high planes of nutrition, respectively.

In a study by Johnsson and Obst (1984), Hereford heifers restricted to a growth rate of 0.55 kg/day until 8 months of age produced greater milk yields and weaned heavier calves than heifers reared to gain 0.7 kg/day or 0.9 kg/day. According to their study, these rates of gain correspond to low, normal, and high rates of gain, respectively.

Similar results were reported by Koch (1972). He reported that

British breeds reared on normal rates of gain can be expected to gain from 0.75kg/day to 1.0kg/day. Thus, the data suggests that heifers of British breeds weaned to gain below 0.75kg/day should express superior subsequent producing ability.

Estimates of Weaning Weight

A knowledge of repeatability estimates for weaning weight is needed when selection or culling of females is based on current performance records. Repeatability estimates essentially indicate the probability that a certain dam will tend to repeat performance based on past performance. Since weaning weights of beef calves is directly correlated with the milk production of the dam, repeatability estimates for weaning weights is actually a repeatability estimate for the milk producing ability of the dam. Thus, the repeatability of weaning weights can be considered as the repeatability of the performance of the dam, expressed through the calf, rather than the performance of the calf (Gregory et al., 1950, Koger and Knox, 1947). Furthermore, researchers (Botkin and Whatley, 1953; Minyard and Dinkel, 1965b) report that repeatability estimates will be at least as great, and probably greater, than heritability estimates because some of the permanent differences among cows may be environmental in origin.

Botkin and Whatley (1953) estimated repeatability of weaning weights by two methods described as follows:

1. The regression of subsequent weaning records on earlier weaning records by the same cow.
2. The intraclass correlation between calves by the

same cow. This was calculated as the ratio of variance among cows (σ_c^2) to the total variance ($\sigma_c^2 + \sigma_e^2$).

Their calculations yielded repeatability estimates of 0.49 and 0.43, respectively.

These estimates of repeatability are in close agreement with those from other researchers. Koch (1951), utilizing intraclass correlation between calves by the same cow, estimated repeatability of weaning weight as 0.52. Koger and Knox (1947) reported a repeatability estimate of 0.49 when one year's calf weight was compared to weights from all ages of the dam, and 0.66 when the first year's calf weight was correlated with the second year's calf weight. Thus, with repeatability estimates as high as these reports, low producing cows can be culled without much risk in culling superior milk producing dams.

Most Probable Producing Ability

Mangus and Brinks (1971) investigated the relationship of factors affecting the beef heifer's weaning weight to her subsequent producing ability as measured by the weaning weights of her progeny. The factors which reflected the preweaning environment of the beef heifer were of particular interest in the study.

Using weaning weight adjusted for sex of calf, age of dam, and age at weaning, they calculated a Most Probable Producing Ability (MPPA) for each cow having one or more records to estimate the relative productivity of each cow. The index used to calculate MPPA

was as follows:

$$100 + 100 * \frac{nr}{1 + (n - 1) r} * \Sigma \frac{\frac{\text{calf record}}{\text{herd-year mean}} - 1.0}{n}$$

where : n is the number of progeny for the dam
 r is the repeatability of weaning weight

The use of MPPA was especially useful in comparing the producing ability of dams when there was a difference in the number of progeny records.

The dam's MPPA value was significantly affected by her weaning weight ($P < .05$). Regressing the MPPA on weaning weight yielded a coefficient of 0.0262. The size of the coefficient further indicates that the weaning weight of the dam is a poor predictor of her subsequent milk producing ability.

Mangus and Brinks (1971) reported also that a negative relationship did exist between age of dam and MPPA values of subsequent heifer progeny. Heifers from 2-, 3-, 4-, and 12-year old and older dams had higher MPPA means than did heifers from 5- through 11-year-old dams. This was in contrast to actual weaning weight means, in which 2-, 3-, 4-, and 12-year old and older dams wean progeny at lower weights. Thus, further evidence is shown that an antagonistic relationship between preweaning growth and subsequent producing ability does exist.

Kress and Burfening (1972), studying the relationship between weaning weight and subsequent MPPA in Hereford cows, reported similar

findings in that the relationships between various measures of early growth and subsequent MPPA were negative. The effect of the age of the cow's dam showed a negative relationship between the cow's weaning weight and her MPPA for weaning weight. This age of the female's dam effect on her 180-day MPPA value was significant ($P < .01$) in the quadratic and cubic models, and approached significance ($P < .08$) in a linear model. The model also took into consideration the year of birth and degree of inbreeding of the dam. The regression of MPPA, classified by age of dam, on 180-day weight was $-.05 (+-.08)$. The correlation between 180-day weaning weight and subsequent MPPA was significant ($P < .01$). The magnitude of the correlation, however, 0.15, indicated that the relationship between 180-day weight and MPPA was small.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. Source of Data

Data used in this study were from weaning weights of 10,979 calves born from 1959 to 1984 in the Hereford and Angus herds of the University of Tennessee. The number of calves by herd and sex are given in Table II. The records were collected from non-creep-fed calves and included identification of calf, dam and sire, birth dates of calf and dam, birth weight, sex, weaning age, and weaning weight of the calves. Ninety-six percent of the calves were sired by registered bulls. The remaining 4% were sired by crossbred Angus and Hereford sires. The majority of the calves had registered dams, while the remainder were from high grade cows.

The management schemes were similar at all locations. Cows were maintained on native Tennessee forages throughout the year and fed protein supplement and hay during the winter months. Calves were born throughout the year; however, most cows were bred during April, May, and June in order to calve in January, February, and March (Table III). Calves were reared on the dam and weaned at approximately 230 $\pm$ 29 days of age.

Cows were bred to calve first as a 2-year old. The distribution of calves by age of dam is given in Table III. Culling of cows have been based primarily on factors other than performance. These factors

TABLE II

DISTRIBUTION OF CALVES BY SEX AND LOCATION

Herd	Males	Females	
Blount	518	493	
Alcoa	1638	1640	
Oak Ridge	605	550	
Greeneville	511	511	
Crossville	1085	920	
Highland Rim	394	387	
Middle Tennessee	171	164	
Ames Plantation	736	656	
Total	5658	5321	10979

TABLE III

DISTRIBUTION OF CALVES BY AGE OF DAM AND MONTH OF BIRTH

Source	Number of Calves
Age of Dam	
<2	5
2	1673
3	1931
4	1755
5	1445
6	1205
7	921
8	655
9	454
10	309
11	210
12	165
13	115
>13	136
Month of Birth	
January	3679
February	3673
March	1824
April	654
May	88
June	12
July	7
August	15
September	315
October	297
November	251
December	164

include, but are not limited to, non-pregnancy, old age, illness, lameness, dwarfism, injuries, or temperament.

All records were adjusted according to procedures as described by Minyard and Dinkel (1965a) for sex of calf, age of dam, and age at weaning. The age at weaning was adjusted to a 205-day basis.

II. Method of Analysis

Three methods of selection were utilized in this study. In order to maintain clarity and uniformity throughout the study, the selection strategies were considered as Method I, II, or III. The objective of Method I was to determine the effects on weaning weights when selection of females was based exclusively on the age of her dam. The objective of Method II was to determine if rate of gain from birth to weaning would significantly effect the calf's subsequent milk producing ability. The objective of Method III was to evaluate female replacement selection based upon the most probable producing ability (MPPA) of her dam.

Method I

Least-squares procedures were utilized to fit general linear models to the data. The model, in which weaning weight was the dependent variable, is as follows:

$$Y_{ijklmnopqr} = u + G_i + D_j + S_k + ST_l + B_m + YD_n + M_o + BD_p + P_q + E_{ijklmnopqr}$$

where: $Y_{ijklmnopq}$ = weaning weight for an individual observation

u = overall mean

G_i = effect of the i^{th} age of granddam

D_j = effect of the j^{th} age of dam

S_k = effect of the k^{th} breed of sire

ST_l = effect of the l^{th} station

B_m = effect of the m^{th} birth year of the calf

YD_n = effect of the n^{th} birth year of dam

M_o = effect of the o^{th} month of birth for the dam

BD_p = effect of the p^{th} breed of dam

P_q = effect of the q^{th} dam parity

$E_{ijklmnopqr}$ = random error associated with an
individual observation

As noted previously, researchers have shown that an inverse relationship exists between milk production of the dam and the subsequent producing ability of the calf. In order to determine if such a relationship was prevalent for this herd, the cows were divided into 4 groups depending upon their age at parturition. These groups should be indicative to the milk producing ability of the dams, with milk production increasing with age to maturity followed by a gradual decline. Heifer calves born to dams which were 2-, 3-, or 4 years of age were considered born to immature dams. Heifer calves born to dams ranging in age from 5 through 8 years of age were considered to be born to mature dams. Heifer calves born to dams ranging in age from 9 to 10 years of age or 11 years of age or older were considered born to old or very old dams, respectively.

Heifers were bred to calve first at two-years of age and then

every 12 to 13 months until culling. The effects due to selection was measured by the changes in weaning weights for each age of dam group. Weights were recorded for each calf at weaning and adjusted to a constant 205-day and sex of calf basis.

Statistical tests performed with this model were analysis of variance, regression of environmental variables on weaning weight, contrasts, and Student-Newman-Keuls mean separation procedures.

Method II

According to researchers (Swanson 1960; Sinha and Tucker, 1969), calves with high rates of gain from birth to weaning will have depressed milk producing ability because of adipose deposition in the mammary system.

Cows were placed in one of four quartiles depending upon their average daily gain from birth to weaning (Table IV). The division of the quartiles were on a within-herd-year basis. Although some variation in average daily gain may occur due to differences in the genetic potential for growth, the differences in average daily gain were considered attributable due to variation in the maternal environment. In order to determine the progress made due to selection, each quartile was contrasted to the remainder of the herd.

Weaning weights of all progeny were utilized to determine the mean weights for the selected group and the remainder of the herd. Least-squares procedures were used to fit a general linear model to determine effects of average daily gain on subsequent maternal performance. The model used to determine components of variance was

TABLE IV
CLASSIFICATION OF QUANTILES FOR METHOD II

Quantile	Average Daily Gain(kg)
1	> 1.01
2	0.67 - 1.00
3	0.33 - 0.66
4	< 0.33

as follows:

$$Y_{ijklmnopqr} = u + ST_i + X_j + B_k + S_l + WA_m + D_n + W_o + BY_p + Q_q + E_{ijklmnopqr}$$

where: $Y_{ijklmnopqr}$ = weaning weight for an individual
observation

u = overall mean

ST_i = effect of the i^{th} station

X_j = effect of the j^{th} sex of calf

B_k = effect of the k^{th} birth year of the calf

S_l = effect of the l^{th} sire breed

WA_m = effect of the m^{th} age at weaning

D_n = effect of the n^{th} age of dam

W_o = effect of the o^{th} birth weight of the calf

BY_p = effect of the p^{th} birth year of the dam

Q_q = effect of the q^{th} quartile

$E_{ijklmnopqr}$ = random error associated with an individual
observation

Contrasts and Student-Newman-Keuls mean separation procedures were utilized to determine if significant differences existed between groups, and between the selected groups versus the remaining three groups.

Method III

The formula used to calculate the MPPA index is as follows:

$$MPPA = (\text{Herd-year} + ((n * r) / (1 + (n-1))) * (\text{Her Avg} - \text{Herd-Year}))$$

Mean

Mean

where: n = Number of progeny records per dam

r = repeatability

A standard value of .50 was used for repeatability.

The herd was sorted into four groups depending on their MPPA, which was calculated on a within-herd-year basis. Group 1 consisted of dams whose MPPA values were greater than 213. Group 2 consisted of dams whose MPPA values were between 183 and 213. Group 3 consisted of dams whose MPPA were between 154 and 183. Group 4 consisted of dams whose MPPA was less than 154.

Regression procedures were used to evaluate the effect of the dam's MPPA on weaning weight of her progeny and the dam's MPPA on weaning weight of her daughters progeny. Least-squares procedures were used in order to best fit the linear regression model. The model used was as follows:

$$Y_{ijklmnop} = u + GM_i + M_j + D_k + BY_l + ST_m + DA_n + GA_o + E_{ijklmnop}$$

where: $Y_{ijklmnop}$ = weaning weight for an observation

u = overall mean

GM_i = MPPA of granddam

M_j = MPPA of dam

D_k = effect of the k^{th} age of dam

BY_l = effect of the l^{th} birth year of the dam

ST_m = effect of the m^{th} station

DA_n = effect of the n^{th} ADG of the dam

GA_o = effect of the o^{th} ADG of the granddam

$E_{ijklmnop}$ = random error associated with an individual
observation

Mean values were calculated for each group in order to perform Student-Newman-Keuls mean separation procedures to test for significant differences among groups.

III. Economic Data

The relative economic values utilized in this study were recorded from the Tennessee Agricultural Statistics Annual Bulletins. The data were collected over the 25 year period from 1959 to 1984 from sales representing all geographic areas of Tennessee.

The values consist of yearly averages for the price per hundred weight (cwt) received by farmers for their calves. These averages do not differentiate between males and females, but rather the average of all calves. A tabulation of these values are given in Table V.

The value of a pound increase in weight was estimated by finding the average price per pound received by farmers for all calves sold during the 25-year period from 1959 to 1984. The value of a pound increase was estimated to be \$0.41.

TABLE V

AVERAGE PRICE PER HUNDREDWEIGHT (CWT.) RECEIVED BY FARMERS, 1959-1984

Year	Avg. Price / CWT.	Year	Avg. Price / CWT.
1959	26.30	1973	54.73
1960	22.60	1974	39.96
1961	23.40	1975	27.65
1962	24.60	1976	35.09
1963	23.85	1977	37.10
1964	21.09	1978	57.80
1965	22.02	1979	85.30
1966	25.91	1980	70.40
1967	29.71	1981	57.10
1968	28.54	1982	54.30
1969	32.46	1983	55.90
1970	34.79	1984	54.10
1971	35.75		
1972	41.97	Avg. Price / CWT.	40.90

CHAPTER IV

RESULTS AND DISCUSSION

I. Method I

Results of analysis of variance for the effect of various factors on weaning weight are shown in Table VI. In accordance with expectations from other research (Kress and Burfening, 1972; Cundiff et al., 1966), all variables were found to be highly significant sources of variation ($P < 0.01$). Twenty-six percent of total variation in weaning weight was explained by factors in the model (R^2). Age of dam and age of granddam effects are both shown to be highly significant ($P < 0.01$) influences on weaning weights of calves. Least square means obtained for progeny from dams and granddams, respectively, are shown in Table VII.

The mean values tends to support the conclusions of other researchers (Mangus and Brinks, 1971; Koch, 1972; Christian, 1965). These means tend to suggest the occurrence of a cyclic pattern for weaning weights. For instance, as age of dam increased, weaning weights of calves also tended to increase. Once the dam reached peak maturity, which appears to be approximately 10 years of age for this study, weaning weights of calves tended to decrease. Conversely, as age of granddam increased, weaning weight of her grandprogeny tended to decline. Therefore, results tend to suggest that selecting replacement heifers from very young dams or very old dams should increase long-term weaning weights.

TABLE VI

ANALYSIS OF VARIANCE OF PREWEANING PERFORMANCE OF ALL CALVES

Source	df	Mean Square
Birth year of calf	24	43638.1*
Birth year of dam	24	29224.2*
Age of dam	15	17788.9*
Birth month of dam	11	27541.7*
Age of dam's dam at parturition	16	24057.8*
Station	7	485762.8*
Parity of dam	13	18123.2*
Breed of dam	4	145070.8*
Breed of sire	4	19619.8*
Prewaning ADG of dam	153	10729.2*
Error	10625	3657.5

*P < .01

 $R^2 = 0.26$

TABLE VII

LEAST-SQUARES MEANS FOR 205-DAY ADJUSTED WEANING WEIGHTS FOR
AGE OF DAM AND AGE OF GRANDDAM^a

Age of Dam, Granddam (Years)	205-Day Adjusted Weaning Weights for Dam (kg)	Granddam (kg)
2	187.3	185.7
3	189.9	187.8
4	191.7	187.5
5	194.3	186.0
6	191.2	185.8
7	192.6	187.6
8	194.5	185.9
9	194.9	185.9
10	197.6	182.6
11	197.2	182.6
12	191.2	182.4
13	190.8	190.0
14	190.4	180.8
15	182.4	197.6
16	174.4	193.4
17	186.2	204.7
18	145.5	184.9

^aAdjusted for sex, age of dam and age of calf.

Results of the model in which the age of granddam and age of dam were regressed on weaning weight of grandprogeny and progeny, respectively, are shown in Table VIII. Regressions suggest that weaning weights of calves increase as age of dam increases; and decline as age of granddam when the dam was born increases. These data further suggest that the maternal environment provided by the granddam to the dam from birth to weaning has a direct, negative influence on subsequent maternal ability of female offspring. Therefore, direct, negative influence from dam on permanent maternal environment of female offspring could explain the inability for producers to consistently increase weaning weights.

In an attempt to illustrate the effect age of dam has on selection of replacement females, the data was divided into four groups depending on the age of replacement female's granddam at parturition. The divisions were classified as females born to immature dams, mature dams, old dams, or very old dams. Mean weaning weight values for dams and progeny according to age of dam divisions are shown in Table IX. Results of utilizing Student-Newman-Keuls mean separation procedures for determining significant differences ($P < 0.05$) among the divisions are listed also in Table IX.

In agreement with other researchers (Mangus and Brinks, 1971; Kress and Burfening, 1972) these findings suggest that heifers born to dams 2-, 3-, or 4-years of age will produce more milk, and thereby, wean progeny that are heavier than calves reared by older dams. A comparison of the 205-day weights of replacement females and their progeny born to old dams lends further evidence to the existence of a

TABLE VIII

REGRESSION OF AGE AS DAM AND AGE AS GRANDDAM ON 205-DAY ADJUSTED
WEIGHTS OF PROGENY

Source	Regression Coefficient (kg)
Age as granddam	- 0.21*
Age as dam	0.69*

* (P < .01)

TABLE IX
ADJUSTED 205-DAY WEIGHT MEANS BY AGE OF DAM DIVISION^a

Females born to:	205-Day Weight of Dam as Calf(kg)	SNK ^b	Avg. 205-Day Progeny Weight(kg)	SNK ^b
Immature dams	188.26	C	190.94	A
Mature dams	191.63	B	190.10	AB
Old dams	194.55	A	188.27	B
Very old dams	190.60	BC	189.20	AB

^a($P < .05$)

^bMeans with the same letter are not significantly different by Student-Newman-Keuls procedure.

negative relationship between preweaning performance of dam and her subsequent producing ability as measured by weaning weights of her calves. Thus, these data suggest that selection of replacement females at weaning due to their superior maternal ability of dam is a poor indicator of their subsequent productivity.

II. Method II

Results of selecting replacement females depending upon their own preweaning performance is considered in this section. Criteria for division of the herd into quartiles is given in Table IV.

Analysis of variance is shown in Table X. All variables were highly significant ($P < 0.01$). The R^2 values utilizing factors in this model was 0.408.

Mean values and results from linear contrasts of the selected group versus the remaining three groups are given in Table XI and Table XII, respectively. Contradictory to Method I, these mean values tend to suggest that selecting replacement females with the highest rates of daily gain from birth to weaning may cause an increase in weaning weights. With the exception of quartile 1, the mean 205-day weights from the unselected groups were higher than the mean of the selected population.

Linear contrasts of first quartile (top 25%) versus the remaining quartiles indicated that weaning weights were significantly increased when the top 25% of females in the herd were retained for replacements. Progeny from females in Quartiles 2, 3 and 4 weaned at weights significantly lower than the remainder of the herd ($P < .01$).

TABLE X

ANALYSIS OF VARIANCE FOR PREWEANING VARIABLES ON WEANING WEIGHTS^a

Source	df	Mean Square
Birth year of calf	24	384.4
Birth year of dam	24	4.1
Age of dam	15	627.9
Station	7	402.7
Sex of calf	2	7437.1
Breed of sire	7	274.4
Age at weaning	233	10211.5
Birth weight	54	2312323.5
ADG quartile	7	88.6
Error	44709	4756.6

^aAll variables significant at ($P < .01$) $R^2 = 0.408$

TABLE XI

ADJUSTED 205-DAY WEIGHT MEANS OF SELECTED AND CONTROL QUARTILES

Quartile	Selected(kg) ^a	Remainder of Herd(kg) ^b
1	202.14	189.50*
2	190.19	192.42*
3	176.59	190.97*
4	167.77	190.41*

^aWeaning weights of progeny from selected quartile.^bWeaning weights of progeny from the remainder of herd.*Significant difference between selected and control ($P < .01$)

TABLE XII

CONTRASTS OF PROGENY FROM SELECTED QUARTILE TO REMAINDER OF HERD

Contrasts	Mean Square
Quartile 1 vs remainder of herd	384.78*
Quartile 2 vs remainder of herd	134.19*
Quartile 3 vs remainder of herd	320.04*
Quartile 4 vs remainder of herd	335.99*

*(P < .01)

As average daily gain of replacement females decreased, subsequent productivity of females also tended to show a progressive decline. Contrary to results of other researchers (Martin et al., 1970; Holloway and Totusek, 1973), an antagonistic association between preweaning environment and subsequent maternal ability was not exhibited.

Koch (1972) suggested that a reasonable expectation for average daily gain for British breeds should be from 0.75 kg/day to 1.0 kg/day. According to Kress and Burfening (1972), the optimum growth rate needed to improve subsequent producing ability may never be known due to breed and management differences. Quartiles utilized in this study may have been a poor estimator of the critical average daily gain range which may influence subsequent producing ability. If values indicated by Koch (1972) are an accurate assessment of average daily gains of British breeds, then quartiles II, III and IX contain dams that exhibited below average preweaning growth and thereby influence results.

III. Method III

Results of fitting least-squares estimates to linear regression model is given in Table XIII. The large, positive regression estimate for MPPA on adjusted 205-day weight ($b=1.46$) indicates that dams with higher MPPA values should consistently wean heavier calves. According to the granddam most probable producing ability value (-0.25), selection of replacement heifers from these high indexing dams show a slow decrease in weaning weights, as measured through their calves.

TABLE XIII

LINEAR REGRESSION OF MPPA VALUES ON ADJUSTED
205-DAY WEIGHT^{ab}

Variable	Regression Estimate	S.E.
MPPA	1.46	0.010
GMPPA	-0.25	0.007

^aMost probable producing ability as dam.
Most probable producing ability as granddam.

^bAdjusted for sex, age of dam and age of calf.

Adjusted 205-day weight means of dam's progeny are given in Table XIV. Adjusted 205-day weight means of progeny born to females selected from these dams (grandprogeny) are given also in Table XIV. Results indicate that selecting dams with the highest MPPA will increase weaning weights. The quartile containing the highest MPPA dams weaned calves 34.54 kilograms heavier than calves from dams of the next high ranking quartile. Means of grandprogeny, however, indicate that females retained from high MPPA cows will wean lighter weight progeny than the previous generation (240.68 vs 206.11). Even though grandprogeny weights from the top 25% quartile are higher than grandprogeny weights from other quartiles, the magnitude of the difference between quartiles was drastically reduced (34.57 vs 10.86, respectively).

Thus, results from this method of selection suggest the existence of a pattern in which heifers selected from dams with high weaning weights produce progeny which wean at low weights. The magnitude of difference between progeny and grandprogeny weaning weights from these high MPPA dams may give some indication to why weaning weight averages for British breeds have not increased dramatically over the long-term. The negative genetic and/or environmental relationships between direct preweaning growth and maternal effects might have been the cause for the observed low dam-progeny weaning weight relationships.

Pertinent Economic Values

The economic value for a pound increase in weaning weight, as

TABLE XIV

MEANS OF ADJUSTED 205-DAY WEIGHTS OF DAM'S PROGENY AND GRANDPROGENY

MPPA of Group	Adjusted 205-Day Weight of Progeny(kg)	Adjusted 205-Day Weight of Grandprogeny(kg)
> 213	240.68	206.11
183 to 213	206.14	195.25
154 to 182	180.95	176.26
<154	168.59	168.59

well as the cost to produce an additional pound, was considered to be the same for all three methods of selection. Since weaning weight averages for this data remained fairly constant over the entire 25-year study period, this assumption seems valid. However, if weaning weight averages for the retained heifers increased each year, then weight at maturity would more than likely increase. Undoubtedly, cost of maintaining these females would also increase causing this assumption to be an invalid.

Comparing the three methods of selection used in this study illustrates that maximum weaning weights can be achieved when selection based on the MPPA of the dam is utilized. Selecting the top 25% of the replacement females from the herd caused weaning weights to average 3.9 kg. heavier than the next best selection system; which was selecting replacement females based on the average daily gain of the dam as a calf.

According to Tennessee Agricultural Statistics Annual Bulletin, a pound increase in weaning weight for all calves over the 25-year study period was \$0.41. Multiplying this value by the additional increase in pounds weaned yielded an extra \$3.51 per calf as compared to selection of females based on the average daily gain of dam as a calf.

Selecting the top 25% based upon average daily gain as replacements was the next best selection alternative. Progeny from this quartile averaged 11.95 kg heavier and \$10.78 more than progeny from the next best quartile.

Selecting replacement females from immature dams was the best selection alternative for Method I. Progeny from females born to

immature dams weaned calves that averaged 2.67 kg. heavier than calves from old dams and 0.84 kg. heavier than calves from mature dams at peak lactation. Calves born to females retained from immature dams were worth \$2.40 more than calves from old dams and \$0.75 more than calves born to mature dams.

CHAPTER V

SUMMARY

Weaning records of 10,979 calves from Hereford and Angus herds of the University of Tennessee were analyzed to compare results of different selection methods to increase weaning weight of beef cattle. Records were collected over a 25-year period from 1959 to 1984. Variables recorded were date of birth, sex, birth weight, breed of dam and sire, weaning age and weaning weight. Data were adjusted for sex, age at weaning, and age of dam at calving. Selection decisions were made on a within-herd-year basis.

Three methods of selection were compared in this study. Objectives of the study were to determine effects on weaning weights when selection of replacement females was based on (1) age of her dam (2) average daily gain (3) most probable producing ability of dam and granddam.

Linear regression of progeny weaning weights on age of dam yielded substantial positive results. Negative estimates, however, resulted when progeny weaning weight was regressed on the age of granddam when the dam was born. Least-square means indicated that selecting females from immature dams was more effective in successively increasing weaning weights than selection from other age groups.

Similar inverse dam-offspring relationships were observed when regression of progeny weights on MPPA were utilized. Due to the negative estimates being relatively small, selection of replacement

females from dams with lower MPPA values did not maximize weaning weights. Weaning weights declined dramatically, however, from one generation to another (240.68 kg. to 206.11 kg.).

Comparison of least-square means of quartiles when selection was based on the average daily gain of dam as a calf, likewise, yielded similar results to the other two selection systems. Selection of females from dams with the highest average daily gain significantly increased weaning weights. Females selected from dams of lower average daily gain quartiles consistently weaned calves at weights lower than when no selection was practiced.

Analysis utilized revealed existence of a possible negative genetic and/or enviromental relationship between preweaning growth and subsequent maternal effects. With the exception of selection from immature dams, the magnitude of this antagonistic effect did not seem to overwhelm the direct genetic component for growth.

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