



Sire by sex and sire by management unit interactions in Simmental cross calves  
by Robert Lars Friedrich

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE  
in Animal Science

Montana State University

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Abstract:

Field records from the American Simmental Association representing creep fed (CF) and non-creep fed (NCF) progeny from approximately 100 different purebred sires were analyzed using least squares mixed model procedures. Non-creep fed and creep fed data sets were subdivided into 1/2 and 3/4 Simmental cross populations, (NCF 1/2, CF 1/2, NCF 3/4 and CF 3/4, respectively) with 1,185, 4,033, 4,106 and 8,612 progeny per population, respectively, and analyzed separately due to confounding with management unit. Dependent variables were birth weight, preweaning average daily gain (ADG) and weaning weight. Independent variables were management unit (weaning weigh date within breeder number), sire, sex (bull or heifer), age of dam (2 through 5 years or older), sex by age of dam and sire by sex in Model I and sire by management unit in Model II.

Under Model I, birth weight, ADG and weaning weight were significantly affected by management unit, sire, sex, age of dam and sire by sex in all populations. Estimates of the percent of the total variation for sire and sire by sex for birth weight were 5.7, 1.5; 7.2, 4.7; 2.8, .4 and 4.8, .5% for NCF 1/2, CF 1/2, NCF 3/4 and CF 3/4, respectively. The percent of the total variation for ADG and weaning weight were essentially identical for both sire and sire by sex and were 2.7, 1.8; 1.4, 1.7; 2.4, .3 and 2.5, .6% for the NCF 1/2, CF 1/2, NCF 3/4 and CF 3/4 populations, respectively.

The genetic correlations (r<sub>ge</sub>) of the sires' progenys performance within the two sexes for NCF 1/2, CF 1/2, NCF 3/4 and CF 3/4 were .77, .51, .82 and .89 for birth weight; .41, .33, .82 and .67 for ADG and .49, .27, .88 and .77 for weaning weight, respectively.

Only NCF 1/2 and NC 3/4 data were analyzed under Model II. Birth weight, ADG and weaning weight were significantly affected by management unit, sire, sex and age of dam in both populations. Sire by management unit was significant for all traits in the NCF 3/4 data only. The percent of the total variation in the NCF 3/4 data for sire and sire by management unit were 3.9, 6.6; 3.7, 3.3 and 4.0, 3.6% for birth weight, ADG and weaning weight, respectively. The r<sub>ge</sub> for the NCF 3/4 data were .37, .53 and .53 for birth weight, ADG and weaning weight, respectively. The significance of the sire by sex and sire by management unit interactions and the r<sub>ge</sub>'s suggest that in some cases sires may be changing rank in the different environments. The presence of these significant interactions would indicate that more work in the area of genotype by environment interaction may be necessary for the future improvement of the beef industry.

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SIRE BY SEX AND SIRE BY MANAGEMENT UNIT INTERACTIONS  
IN SIMMENTAL CROSS CALVES

by

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A thesis submitted in partial fulfillment  
of the requirements for the degree

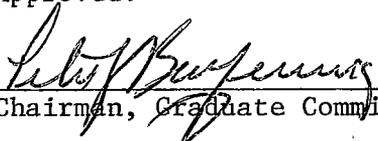
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## ABSTRACT

Field records from the American Simmental Association representing creep fed (CF) and non-creep fed (NCF) progeny from approximately 100 different purebred sires were analyzed using least squares mixed model procedures. Non-creep fed and creep fed data sets were subdivided into 1/2 and 3/4 Simmental cross populations, (NCF 1/2, CF 1/2, NCF 3/4 and CF 3/4, respectively) with 1,185, 4,033, 4,106 and 8,612 progeny per population, respectively, and analyzed separately due to confounding with management unit. Dependent variables were birth weight, preweaning average daily gain (ADG) and weaning weight. Independent variables were management unit (weaning weigh date within breeder number), sire, sex (bull or heifer), age of dam (2 through 5 years or older), sex by age of dam and sire by sex in Model I and sire by management unit in Model II.

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The genetic correlations ( $r_{ge}$ ) of the sires' progenys performance within the two sexes for NCF 1/2, CF 1/2, NCF 3/4 and CF 3/4 were .77, .51, .82 and .89 for birth weight; .41, .33, .82 and .67 for ADG and .49, 2.7, .88 and .77 for weaning weight, respectively.

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## INTRODUCTION

The objective of a sound animal breeding program would be to change the average genotype of a population as fast as feasible in a direction which would improve the performance of the population. Two elements of knowledge will be required: 1) the environmental influences and their effects on the population must be predicted and 2) selection must be based on the most accurate indicators of the performance of the population in the different environments.

Changes in phenotypic ranking of different genotypes under various environments could hinder the progress of animal breeding programs. Progress becomes increasingly more difficult depending upon the degree of genotypic and environmental interactions present in the various populations.

"The inability to appraise accurately the influences of general feeding and management conditions 'environments' on a sire's proof probably accounts for most of the mistakes in selecting proved sires" (Legates et al., 1956). It is with this thought in mind that the present study was undertaken. The objectives of the study were to examine the effects of several environmental and genotypic influences on the postnatal growth of Simmental cross progeny and to assess the importance of two specific genotype by environment interactions (sire by sex and sire by management unit interactions).

The sire by sex interaction may be important in terms of accurate sire evaluation. It is widely accepted that one of the best procedures for accurate evaluation of beef sires is through progeny testing. Presently, however, the majority of the progeny tests being conducted do not consider the presence of an important sire by sex interaction. Examination of the sire by sex interaction in these data will hopefully aid in answering some of the questions concerning this particular genotype by environment interaction.

The second interaction, sire by management unit, will also be examined to gain additional knowledge about whether or not it is one with which the industry must be aware of and use in the pursuit of the superior genotypes. If the sire by management unit interaction is found to be an important part of the variation associated with the performance traits, it may be necessary to more completely evaluate these interaction effects on the selection programs used in today's beef cattle industry.

## LITERATURE REVIEW

### General

Selection of individuals to be used in any breeding program is the framework for genetic improvement in any species. Certain genetic principles are present in all populations as outlined by Lush (1945).

Some of these properties of Mendelian genetics include:

- a) The genes of a specie are not adaptably modified by their environment.
- b) Observed yields of gene combinations are affected by the environment.
- c) The homozygosity of a population is changed only by selection, inbreeding or crossing of distinct lines. Mutation is rare and genetic drift is slow due to large populations.
- d) Genes will interact with one another.

The above concepts express the basis of selection within a given population. Research has confirmed these principles but the application of them requires much more work in the area of identification of important alleles and the interpretation of the multitude of effects of each allele on the population. Important breakthroughs in chemistry and statistical theory are being made presently in this direction.

The ideas of environmental influences upon population genetics alluded to above has led to some basic philosophies of genotype by environment interactions. Hammond (1947) believed that selection of individuals within a population would be most advantageous if carried

out in the environment which would best favor or enhance the particular trait in question. Upon fulfillment of the selection goals within this environment, the individuals could then be utilized in other less favorable environments for that particular trait. The new environments must, however, be satisfactory for other traits or criteria necessary for the maintenance of the population.

Other work in the area of genotype by environment interactions yielded varying philosophies. Lush (1945) and Falconer (1952) both expressed the view that selection of an individual trait or combination of traits would be best exemplified by selection within the environment the individual would be expected to perform. Dickerson (1962) theorized that in a broad sense there are no "independent" variations in the performances of animals due to their genotype and environment. The phenotypic expression of an individual's genotype requires a relatively fixed sequence of environments. Also, the influence of an environment occurs only as a change in the phenotypic expression of a well integrated genotype.

Dickerson (1962) hypothesized that differences in phenotypes between genotypes could remain constant under differing environments. This would indicate that there are average "genetic" and "environmental" effects contributing to the performance of an individual, as well as additional variation due to the combined effects of genotype and environment. This additional variation is not predictable from the

individuals average effects.

Hull and Gowe (1962), after reviewing the literature, deducted that if a stock of animals from previous generations had been selected for "high" performance in some trait, they could not be expected to do consistently well in all environments. They felt it was fair to assume that optimum performance could only be reached by selection under the conditions that would be prevalent during the future of that particular population.

Several important questions were asked by Robertson et al. (1960):

"Does the environmental level affect the ability to pick the animals of superior genetic merit in that environment?"

In other words "is the heritability different in the different environments?"

"Is the ranking of animals on the basis of genetic merit the same in all environments?"

Or "what is the correlation between 'breeding value' in the different environments?"

"Is there an interaction between genotype and environment?"

The concept of genotype by environment interaction may be expressed as a correlation if only two environments are considered (Falconer, 1952). The response of a measured trait in two different environments may be considered to be a single trait which has a defined genetic correlation. This concept would allow one to determine

whether or not a trait should be selected in the environment in which the animal will be utilized or in the environment which would more fully allow the expression of the trait in question.

An expansion on this theory was presented by Robertson (1959). He reported that the expression of a genetic correlation for a trait in multiple environments could be assessed through the use of mean squares from a factorial analysis of variance. The interaction of a genotype by environment may be assessed from the variance of the genotype between each environment from the variable ranking of genotypes within each environment. Thus a genetic correlation of 1.00 would indicate no interaction.

It was shown by Falconer and Latyszewski (1952) that if selection was more effective in a favorable environment, that environment must be able to reduce the random environmental variation which normally lowers the correlation between genotype and phenotype. This would mean that the heritability of the trait would be higher in a favorable environment as opposed to a less favorable environment.

Classification of Interactions. The classification of interactions was alluded to by Haldane (1946). He demonstrated that with two genotypes and two environments there would be six different combinations of responses to the two environments by the two genotypes. He further showed that with M genotypes and N environments there would be a possible  $\frac{(M N)1}{M1 N1}$  different types of interactions.

McBride (1958) pursued the question of genotype by environment interaction in a somewhat different manner. His classifications of genotypes and environments dealt with 'inter' and 'intra' populations or genotypes and 'micro' and 'macro' environments. McBride's theory would yield four classifications of interactions. These classification of interactions would be based upon differing responses of 'intra'-populations within 'micro' and/or 'macro'-environments and 'inter'-populations within 'micro' and/or 'macro'-environments.

McBride's classification of 'macro' environments would include climatic differences as well as major differences between management practices. 'Micro' environments would be a classification including minor environmental differences such as changes in a population's behavior or sub-clinical infections within the population for a particular macro-environment. Population differences would be those between (inter) or within (intra) breeds, lines or strains of individuals. These types of interactions could individually incorporate any or all of the classifications outlined by Haldane (1946).

Evidence has shown that such "intangibles" as social behavior ("peck order") in domestic fowl or certain behavioral patterns in swine can lead to interactions between micro-environments and intra-population genotypes without the presence of an interaction between macro-environments and the same intra-population genotypes.

Interactions have a definite relation to animal selection within breeds or lines of a specific specie. The existence of this interaction may necessitate the practice of selection within the environment for which the animal is to respond. Many workers have observed or studied this type of interaction and will be reviewed in following sections. The presence of this type of interaction was felt by McBride (1958) to be a very important source of variation in large animal selection.

An interaction involving inter-population genotypes and micro-environments is not generally thought to be important in the field of applied genetics. However, the ideas on heterosis suggest that heterozygous genotypes are capable of handling a wider range of micro-environments than homozygous genotypes. Micro-environmental fluctuations may cause some populations (purebred) to vary while there is no variation exhibited by other populations (hybrids). The contributions of a strain to the genotype environment interaction may be due to the differences in variation between the strains.

The interaction of inter-population genotypes with macro-environments will influence important decisions in animal breeding. Before an animal breeder can select the breed or strain for his environmental situation he must first test for the presence of this interaction. He must then determine whether or not the conditions under which he is to perform his selection are important, that is,

whether or not an intra-population by macro-environment interaction exists. "The existence of highly adapted local races of many organisms suggests that this interaction may be extremely prevalent". McBride (1946).

Dunlop (1962) classified genotype-environment interactions by categorizing the differences in genotype and environments as being "large" or "small". Large genetic differences would be those associated with between breed or strains and small differences as being within breed or strains. The environmental differences would include within region or management practices (small) or across regions or management practices (large). These classifications are essentially the same as those described by McBride (1958).

Dunlop (1962) maintained that the important genotype by environment interactions would be the ones involving a "large" genotype classification.

Pani and Lasley (1972) summarized many of the above principles into a classification system that most adequately exemplifies the genotype by environment interaction. Utilizing the statistical significance of differences in magnitude of change as well as ranking of genotypes within an environment they were able to more accurately determine the impact of a genotype-environment interaction. Figure 1 contains the four possible classifications of these interactions.

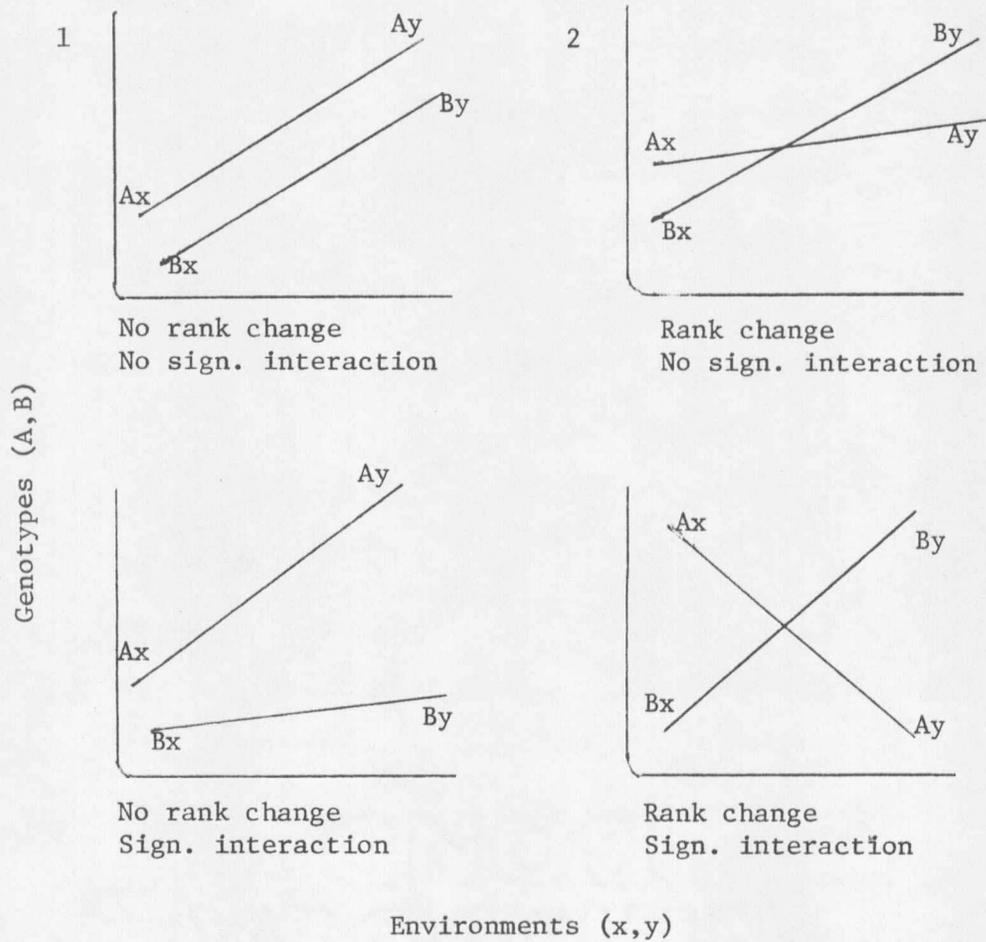


Figure 1. Four different types of genetic by environment interactions. (Pani and Lasley, 1972)

A significant interaction could result in either a change in ranking of genotype (Type 4) or a change in magnitude of genotype response (Type 3).

#### Sources of Environmental Variation (Beef Cattle)

Throughout the literature the primary sources of environmental variation which were examined were: sex of calf, age of dam and year of birth or season within year. Also examined were the effects of herd and nutrition. One other environmental sources is whether or not calves are creep fed during the preweaning period.

All of these sources as well as others have been found to have varied and/or predictable influences on the traits, birth weight, preweaning average daily gain (ADG) and weaning weight. In the following sections the effects of these sources of variation will be reviewed for an understanding of their importance and contribution to genotype by environment interactions.

Sex of Calf. Traditionally sex of the calf has been recognized as one of the prime sources of environmental variation in the birth weight, average daily gain and weaning weight of beef calves. It has been consistently reported throughout the literature that male calves were heavier than female calves at birth. This was found by Woodward and Clark (1950), Koch et al. (1959), Marlowe et al. (1965), Brinks et al. (1971), Kress and Webb (1972), Nelsen (1976) and many others within the Hereford and Angus breeds of cattle. The difference in birth weights generally falls within a range of 1.5 to 2.5 kg with

males being heavier. Taylor et al. (1960) reported a difference of 2.0 kg (29.1 vs. 27.1 kg, males vs. females, respectively) in Angus calves and a difference of 2.3 kg (31.8 vs. 29.5 kg, males vs. females, respectively) in Hereford calves. In a study involving 5,067 Angus birth weights and 4,778 Hereford birth weights, Marlowe (1962) found a difference of 2.0 kg and 1.8 kg within the two breeds, respectively, with male calves being heavier ( $P < .01$ ) than female calves.

Laster et al. (1973) reported that male calves from Angus dams were 3.2 kg heavier than female calves and male calves from Hereford dams were 2.9 kg heavier than female calves. Smith et al. (1976) reported that males were 2.7 kg heavier at birth than females (36.3 vs. 33.6 kg, respectively) in a study involving 2,368 calves from Hereford and Angus dams sired by Hereford, Angus, Jersey, South Devon, Limousin, Charolais and Simmental bulls.

Anderson and O'Mary (1974) reported that Simmental sired bull calves from Angus dams were 5 kg ( $P < .01$ ) heavier than contemporary heifer calves (42.8 vs. 37.8 kg, respectively). Simmental bull calves were found to be 3.6 kg heavier ( $P < .01$ ) than heifer calves (42.2 vs. 38.6 kg, respectively) in a study of 20,949 calves conducted by Burfening et al. (1977). Laster et al. (1973) examined the differences between male and female birth weights of calves sired by Simmental bulls. The difference between birth weights of male and female calves from Angus dams and Simmental sires was 5.5 kg (37.8+.6 vs. 32.3+.6 kg,

respectively). This difference was the largest single difference within the seven breeds of sire analyzed. Calves from Hereford dams and Simmental sires followed this same trend with males being 3.2 kg heavier than females.

Much of the reported differences in birth weights between male and female calves is thought to be associated with the fact that gestation length is generally longer in males than in females. This difference does not always explain the variation sufficiently, however. Gestation length for males was found to be 1.7 days longer (285.7 vs. 284.0 days, respectively) as reported by Smith et al. (1976) and was similar to the 1.9 days reported by Bellows et al. (1971) and the 1.2 days reported by Cundiff et al. (1974). Even though gestation length was a significant source of variation for birth weight the differences in birth weights between males and females remained significant when this effect was statistically removed (Smith et al. 1976).

Sex of the calf is also a significant contributor to differences in preweaning average daily gain between male (bull and steer) and female calves. Marlowe et al. (1965), Kress and Webb (1972). Schaeffer and Wilton (1974a) and others have all reported significant effects of sex on ADG. Work with Hereford and Angus calves by Tanner et al. (1970), Brinks et al. (1972) and Brinks and Knapp (1975) revealed that bull calves gained between .04 and .06 kg per day more

than heifer calves. Nelms and Bogart (1956) reported that sex was not a significant source of variation on ADG in Angus male and female calves. Their findings indicated that the adjustment of sex for birth weight was enough to remove the effect of sex on ADG. Woodward and Clark (1950) also reported that sex of the calf was not a significant source of variation for ADG. Burfening et al. (1977) reported that sex was an important ( $P < .01$ ) source of variation for ADG in Simmental sired calves. The bull calves gained .08 kg per day more than the heifer calves.

The effect of sex of the calf is generally significant for weaning weight, and in all cases the bull or steer calves are heavier than their heifer contemporaries. These differences as reported in the literature are usually within the range of 10 to 25 kg for bulls vs. heifers and 5 to 20 kg for steers vs. heifers. Brinks et al. (1961), Pahnish et al. (1961), Linton et al. (1968), Tanner et al. (1970), Kress and Webb (1972) and Nelson (1976) all reported these trends with Hereford and Angus calves. Cundiff et al. (1966) reported that steers were 5.1 kg ( $P < .01$ ) heavier than heifers at weaning and that bulls were 25.3 kg ( $P < .01$ ) heavier than heifers at weaning. Differences between bulls and steers may be in part due to the stresses of castration as well as confounding of selection pressures with superior males being retained as bulls with the remaining males being castrated.

Woodward and Clark (1950) reported that sex of the calf was not significant for weaning weight even though it was significant for birth weight of the same individuals. They did report that the calves with the larger birth weights were also larger at weaning.

A study conducted on 11,740 three-quarter Simmental cross calves found that bull calves were 19 kg ( $P < .01$ ) (260 vs. 249 kg) heavier than heifer calves, (Friedrich et al. 1975). Burfening et al. (1977) studied 9,301 one-half and 11,648 three-quarter Simmental cross calves and found a difference of 19 kg ( $P < .01$ ) (221 vs. 240 kg) in favor of the bull calves.

Age of Dam. The chronological age of a calf's dam is also considered to be one of the more important sources of environmental variation for birth weight, ADG and weaning weight of beef calves.

A dam's first calf is traditionally her smallest in terms of birth weight with subsequent calves being heavier until she reaches her mature size and age. As a dam nears the end of her productive lifetime, the birth weights of her calves may decrease slightly. This same trend generally applies to ADG and weaning weight of her calves.

Marlowe (1962) reported that birth weights of Hereford and Angus calves increase at a rate of .75 kg per year of age of the dam up to 6 or 7 years of age. At this time they start to decrease. Lasley et al. (1961), Koonce and Dillard (1967) and Kress and Burfening (1972)

reported that peak production in terms of birth weight was reached at 6, 8 to 11 and 5 years of age, respectively, in Hereford dams. Nelsen (1976) found that age of dam effects were maximized at 5 through 10 years of age in both Hereford and Angus dams. He reported that birth weights were 2.2, 1.0, 0.5 and 0.0 kg lighter in 2, 3, 4 and 11 year old dams of Angus breeding, respectively, when compared to 5 through 10 year old dam averages. In Herefords the differences were 3.2, 0.9, 0.0 and -0.9 kg for the 2, 3, 4 and 11 year old dams, respectively.

Burfening et al. (1977) reported differences of 6.9, 5.3, 4.2 and 1.4 kg ( $P < .01$ ) in birth weights of Simmental cross calves from 2, 3, 4 and 5 year old dams when compared to 6 through 8 year old dams, respectively. The mean birth weights were 35.9, 37.5, 38.6, 41.4 and 42.8 kg for the 2, 3, 4, 5 and 6 through 8 year old dams, respectively.

Laster et al. (1973) reported that age of dam had a significant effect on birth weights of calves born from Hereford and Angus dams. Birth weights of calves from 2 year old dams were 2.7 kg lighter than calves from 3 year old dams and 3.6 kg lighter than calves from 4 and 5 year old dams. The difference between birth weights of calves from Simmental sires were 3.1 kg for calves from 2 and 3 year old dams and 2.7 kg for calves from 2 and 4 or 5 year old dams.

The influence of the dam's age on birth weight as reported by Smith et al. (1976) was not consistent among breed crosses. The Simmental, Limousin and Charolais cross calves tended to have birth

weights which increased at a slower rate as the cows neared maturity than did the calves from Hereford, Angus, Jersey and South Devon crosses. The increase in birth weights of the calves from 2 to 3, 3 to 4 and 4 to 5 and older ages of dam averaged .4, 1.1 and 1.6 kg, respectively, for the Hereford, Angus, Jersey and South Devon dams and 2.0, 1.9 and .8 kg, respectively, for the Limousin, Simmental and Charolais dams.

The effect of age of dam was called "the most important source of variation" for the ADG of Angus and Hereford calves by Marlowe and Gaines (1958). Cunningham and Henderson (1965), Marlowe et al. (1965) and Kress and Webb (1972) all reported that age of dam was a significant source of variation on ADG in Hereford and Angus calves. Schaeffer and Wilton (1974a) examined records of 25,571 Angus and 68,053 Hereford calves and found highly significant age of dam effects on ADG. Nelms and Bogart (1956) and Tanner et al. (1970) both determined that the effect of age of dam on ADG only approached significance. Smith et al. (1976) reported that ADG was significantly affected by age of dam. The respective values for ADG of calves from 2, 3, 4 and 5 year or older dams were .69, .78, .85 and .87 kg per day, respectively. Also examined was the relative preweaning growth rate expressed as the percentage change in body weight per day of age. Age of dam also significantly affected this trait with mean values of .82, .86, .88 and .88 for 2, 3, 4 and 5 year old or older dams, respectively.

The age of dam effect on ADG in Simmental calves was found by Burfening et al. (1977) to be highly significant. The largest ADG was within the 4 year old dams with the "mature" cows being slightly lower, (.96 vs. .93 kg per day, respectively) probably due to some confounding of age of dam and percentage of Simmental breeding in the different age groups. The ADG of the calves from the 2 and 3 year old dams were .87 and .92 kg per day, respectively.

Studies involving Hereford and/or Angus calves by Kress and Webb (1972) and Kress and Burfening (1972) showed that age of dam was a significant source of variation for weaning weights. These researchers reported that peak production for this trait was reached at 5 to 10 years of age. A study involving 19,907 Hereford and Angus records conducted by Sellers et al. (1970) also revealed that the age of dam affected ( $P < .01$ ) weaning weights of the progeny. The maximum production in the study was between 6 through 12 years of age with a decrease in the weaning weights of calves whose dams were over 12 years of age.

Progeny from 2 and 3 year old one-half Simmental dams were used in a study by Friedrich et al. (1975). Calves from 2 year old dams were 9 kg lighter than calves from 3 year old dams (254 vs. 263 kg, respectively). Burfening et al. (1977) also examined records of Simmental sired calves. Their study also reported peak weaning weights of calves from dams 5 through 8 years of age. The study did not contain any dams older than 8 years however. The differences

between the 2, 3 and 4 year old dams with the 5 through 8 year old dams were -21, -8 and 0 kg, respectively ( $P < .01$ ).

Year Effects. The effects of year and/or month or season of birth on birth weight, ADG and weaning weight have been reported in the literature as being varied and to a certain degree controversial. It is generally thought that such traits as ADG and weaning weight would increase over years due to selection for these traits. Not all researchers are able to show this trend, however. Primarily the time effects fluxuate from time period to time period with only limited predictability.

Season and month of birth were reported to have a significant effect on birth weight by Lasley et al. (1961) and Wilson et al. (1972). Koonce and Dillard (1967), Kress and Webb (1972) and Burfening and Kress (1973) all reported that year of birth was a significant source of variation for birth weight in Hereford calves. Sagebiel et al. (1973) reported that there were differences in birth weights from year to year but there was no indication of any trend for increased weights over the years involved. Conversely, Burris and Blunn (1952) reported that year was not a major source of variation for birth weight on a within sex and breed basis. Their findings were that management practices from year to year were able to effectively remove the variation of yearly environmental fluxuations. The study conducted by Nelsen (1976) on field records involving Angus and Hereford cattle

revealed that year did in fact significantly affect birth weight and that a linear relationship did exist. He reported that from 1958 to 1971 there was an average increase in birth weight of -29 kg per year over all herds in the study.

Preweaning average daily gains are also affected by year (Cunningham and Henderson, 1965; Kress and Webb, 1972 and Nelsen, 1976). Studies by Marlowe et al. (1965) on 17,294 Angus and 11,663 Hereford calves over 6 years and by Schaeffer and Wilton (1974b) on 16,524 Angus and 47,293 Hereford calves over 2 years both showed significant year effects on ADG. The study of Marlowe and coworkers did not indicate that there was a trend for increased ADG over years. The variation was one of fluxuation rather than uniformity.

Cundiff et al. (1966), Linton et al. (1968), Sellers et al. (1970) and others have reported that season of birth or month of birth has a significant effect on weaning weights of beef calves. Sellers et al. (1970) reported that weaning weights of calves born during December through May were over 7 kg heavier than calves born from June through August and 5 kg heavier than those born from September through November. Cundiff (1966) also reported increased weaning weights of calves born during the winter and early spring months as opposed to those born during the summer and fall. The study conducted by Friedrich et al. (1975) on Simmental calves followed the afore mentioned trends. Calves

weaned in January through March were 27 kg lighter than calves weaned in July through September (243 vs. 270 kg, respectively).

Year effects on weaning weights have also been widely reported to be significant throughout the literature. Cundiff et al. (1966), Busch and Dinkel (1967), Linton et al. (1968), Tanner et al. (1970) Kress and Webb (1972) and Burfening and Kress (1973) all reported that year was a significant source of variation on weaning weight in Hereford and Angus calves. Bailey et al. (1977) reported that year was a significant but variable source of variation for weaning weight in Hereford cattle. The difference between maximum and minimum annual weaning weights were 22.4 kg for the unadjusted weaning weight and 15.2 kg for the weaning weights adjusted for age of calf and metabolic size of the dam. The majority of the reported studies do not reveal any general trends toward increased weaning weight over years. Nelsen (1976), however reported that weaning weight increased significantly during the time span of this study (1.62 and 2.29 kg per year ( $P < .01$ ) for Hereford and Angus calves, respectively).

Management Practices (Creep feeding vs. no creep feeding). One source of environmental variation which may be directly associated with management practices is creep feeding of calves (supplying additional nutrition to preweaning calves above that supplied by the dam).

Several studies have been conducted by Nelson (1952, 1954, 1955)



































































































































































































































































































































