A SIMULATION MODEL OF WEIGHT GAINS OF ANGUS AND HEREFORD CALVES FROM BIRTH TO WEANING IN OKLAHOMA

By

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CHAPTER I

INTRODUCTION

The most profitable management of land and animal resources has been the goal of ranchers for many years. In Oklahoma, farmers and ranchers have made progress toward this goal by proper management and fertilization of pasture and range land, improved nutrition, and management of farm animals and utilization of superior genetics. However, with recent increases in seed, fuel, and fertilizer practices, are the pounds of beef gained worth the energy used to produce them? With computer technology we can simulate different management techniques and see the predicted results in terms of pounds of beef.

The purpose of this thesis is to contribute to a larger study, which, when complete, should help answer some of the questions ranchers have in terms of land and animal management. This thesis deals with calf production from birth to weaning simulated under varying animal and land management techniques.

CHAPTER II

REVIEW OF LITERATURE

Major factors influencing the weaning weights of calves on range or pasture are: milk production of their dams, forage intake by the calves, and genetic and environmental factors. Consequently, this literature review is divided into sections that deal with: 1) estimates of milk production of Angus and Hereford cows, 2) estimates of forage intake of Angus and Hereford calves, 3) genetic and environmental factors that influence calves' weaning weight, and 4) energy requirements of preweaning calves.

Estimates of Milk Production of Angus and Hereford Cows

A number of studies have reported information about milk production of beef cows, and in some (Drewry et al., 1959; Neville, 1962; Rutledge et al., 1979; and Keller, 1980), milk production accounted for more than 60% of the variation in weaning weight. However, estimating the amount of milk an average Angus or Hereford cow will produce is difficult because so many factors influence a cow's milk yield. Techniques used to determine milk yield vary in scientific literature, and factors such as age of dam, birth weight and sex of calf, breed (genetic ability), stage of lactation, and forage availability and digestibility affect the amount of milk a range cow will produce.

Methods of Estimating Milk Yield

Methods of estimating the milk yields of beef cows vary; however, the most commonly used methods are difference in calf weight before and after nursing, and hand or machine milkout preceded by an injection of oxytocin. Correlations between alternative methods have been determined (Holland, 1961; Totusek and Arnett, 1965; Chow et al., 1967; Belcher et al., 1980; and Sommerville and Lowman, 1980). Correlations (usually above .7) range from .58 (Gleddie and Berg, 1968) to .96 (Serwanja et al., 1969), with conflicting results as to which technique gives higher yields. The calf nursing technique gave higher estimates than machine milkout (Wilton, 1973) and hand milkout (Holland, 1961; Arnett, 1962; Totusek and Arnett, 1965; and Neidhardt et al., 1979). Other studies (Wistrand and Riggs, 1968; Serwanja et al., 1969; and Le Du et al., 1979b) found no significant difference between the calf nursing and machine milkout techniques, while still others (Gleddie and Berg, 1968; Belcher et al., 1978; and Belcher et al., 1980) found machine milkout gave higher estimates than calf nursing. Calf capacity, especially at very early ages, may limit a cow's milk yield estimate (Gifford, 1953; Chow et al., 1967; Wistrand and Riggs, 1968; Petit et al., 1978; Le Du et al., 1979b; and Neidhardt et al., 1979). This could cause milk consumption to be overestimated when the machine milkout technique is used, or cause milk yield to be underestimated when the calf nursing technique is used.

Separation interval (before milkout) also has a pronounced effect on milk production estimates (Peterson and Rigor, 1932; Hendrix, 1971; Belcher et al., 1979b; and Williams et al., 1979a), with shorter separation intervals giving higher estimates of 24-hour milk production. These factors need to be kept in mind when reviewing estimates of milk yield of beef cows and milk consumption by beef calves.

Age of Dam

Age of dam has a pronounced effect on milk production (Nelms et al., 1979; Reynolds et al., 1978; Butson et al., 1979; Williams et al, 1979a and 1979b; and Keller, 1980); however, there are conflicting results as to when maximum production is reached and at what age milk production begins to decline. Type of climate (arid vs. temperate) may influence at what age milk production begins to decline (Wyatt, 1976). In some studies, milk production peaked at 5 to 6-1/2 years of age (Gifford, 1953; Heyns, 1960; and Jonmundsson et al., 1978), while other studies show milk production increases until a cow is about eight years old (Minyard and Dinkel, 1960 and Rutledge et al., 1971). Several other researchers, in studies involving young cows, have found that milk production increases by 1.8 to 3.3 pounds per year from age two until a cow is four or five years old (Pope et al., 1963; Melton et al., 1967; Notter et al., 1978; Gaskins et al., 1979; and Gaskins and Anderson, 1980). One set of multiplicative correction factors suggests adjusting daily milk yield upward by 1.33, 1.2, and 1.09 for three, four, and five year old cows, respectively (Neville et al., 1974). Studies that also determine the age at which milk production begins to decline (Robison et al., 1978 and Boggs et al., 1980) showed milk production to peak at five or six years of age, remain constant through eight years of age, then gradually decline, with cows above age nine having a daily milk yield similar to three and four year old cows. The age of maximum milk production appears to be in the range of six to nine years, with an increase in milk production each year from age two until age five or six.

Sex of Calf

The data for effects of sex of calf on milk yield are contradictory. No significant relationship was found between sex of calf and the milk yield of their dam (Melton et al., 1967; Gleddie and Berg, 1968; Omar, 1974; Notter et al., 1978; Reynolds et al., 1978; Robison et al., 1978; Terada et al., 1979; Williams et al., 1979a; and Keller, 1980); however, this conflicts with other studies showing that cows nursing bull calves produce more milk than cows nursing heifers (Pope et al., 1963 and Richardson et al., 1979) or steers (Knapp and Black, 1941). In two studies, dams of bull calves gave more milk some years but less milk than dams of heifer calves in other years (Hughes, 1971 and Jeffrey et al., 1971a). Rutledge et al. (1971) found that cows with heifer calves produce more milk than cows with bull calves. These variable results indicate that differences thought to be due to sex may instead be influenced by some other factors such as calf weight (Robison et al., 1978).

Birth Weight

If calf capacity limits a cow's milk yield, then birth weight of a calf should influence its dam's milk production, with larger calves being able to consume more milk than smaller calves. In many studies, birth weight of a calf does seem to have a positive influence on its dam's milk yield (Drewry et al., 1959; Robison et al., 1978; and Richardson et al., 1979). During very early lactation there is residual milk in the udder after calves nurse (Schwulst et al., 1966 and Neidhardt et al., 1979). The influence of birth weight on milk production was positive, but was not a major factor affecting milk production after other factors were considered (Rutledge et al., 1971). In contrast, some Hereford calves were able to consume 18 to 22 pounds of milk early in lactation (Neville, 1962), indicating that calf capacity should not be a limiting factor for a beef cow's milk production. This is in agreement with research (Christian et al., 1965 and Keller, 1980) that found no significant correlation between a calf's birth weight and its dam's milk yield. If a calf's birth weight does affect its capacity, which in turn influences its dam's milk production, the effects should not be a major influence on the dam's milk production, since birth weight within European breeds is usually within a relatively narrow (55-90 pounds) range.

Breed of Cow

Studies measuring the milk production of Angus and Hereford cows under the same management conditions show Angus to have a definite advantage, ranging from .09 to 7.1 pounds per day (Table I). Actual pounds of milk produced varies among different levels of nutrition, age, and management; however, these studies show that with similar treatment for Angus and Hereford cows, the Angus usually produce more milk.

TABLE I

MILK PRODUCTION OF ANGUS VS. HEREFORD COWS

Adapted from:	Angus, lbs./day	Hereford, lbs./day
Gifford, 1953	8.4	6.2
Klett et al., 1961	8.6	6.4
Melton et al., 1967	8.36	7.32
Gleddie and Berg, 1968	18.52	11.47
Dickey, 1970	9.74	9.65
Omar et al., 1977	14.93	9.88
Cobb et al., 1978	12.35	11.25
Notter et al., 1978	11.91	11.03

Stage of Lactation

Stage of lactation has a marked influence on daily milk yield, with yields being highest in early lactation. However, reports vary as to when maximum yield is reached and at what rate milk yields decline. Season of birth seems to influence which month in lactation maximum daily milk yield in range cows is reached and season of birth also seems to influence persistence of lactation (Kartchner et al., 1969). This shows a response to forage digestibility and availability. In one of the first studies of milk production of beef cows (Gifford, 1953), maximum production was reached during the first month and declined gradually until weaning.

A study with four and five year old Hereford cows (Kress and Anderson, 1974) resulted in the following milk production equation:

$$M = 9.9225 + (-.0913 \text{ lb/day})(\text{day} - 104.5 \text{ days}) + (-.0002007 \text{ lb/day})(\text{day} - 104.5 \text{ days})^2 \text{ for days 20 to 195 in lactation.}$$

Maximum daily milk production occurred during the first month. In a Canadian study (Gleddie and Berg, 1968) involving several beef breeds and different ages of cows, the decline in milk yield was linear, with the decrease equal to .044 pound per day. This study was with spring calving cows. In another Canadian study with cows that were (average) 86% Hereford, 14% bison, milk yield declined at a rate of .04 pound per day from June to October (Keller, 1980). The average calf age in June was 50 days. Very early lactation yield (first 30 days) was not measured.

In a study with Angus and Hereford crossbred cows that were two, three, and four years old, the average decline from day 28 to day 196 was .06 pound per day, with an average yield over the total lactation of 12.31 pounds per day (Gaskins et al., 1979).

In a study with Hereford heifers (Abadia and Brinks, 1971), the linear decrease was .06 pound per day, with peak milk production occurring at 35 to 40 days. This agrees with a study (Kress, 1969) reached during the second month of lactation.

In the study with spring calving, Polled Hereford cows age four years and older, showed a decline in milk yields from 14.31 pounds per day in April (first month in lactation) to 7.41 pounds per day in September. Three year old cows' milk yields were constant through the second month of lactation (12.33 pounds) and then declined (Boggs et al., 1980).

Studies with fall and winter calving cows usually do not show the steady linear decline in milk production as lactation progresses, due to the availability of spring grass at the time when milk yield normally declines (Velasco, 1961; Holloway et al., 1973; Kropp, 1972; and Peart et al., 1978). In a six year study in Oklahoma with the average calf birth date in March, Angus and Hereford cows' milk production tended to increase until the third month in lactation (June) and declined thereafter. Another Oklahoma study with late winter-early spring calving, two year old Angus heifers showed that heifers calving in early February increased their milk production slightly through the sixth week of lactation (middle of March), at which time daily milk yield began to decrease, only to increase again in late April and May (third month in lactation). Heifers calving in March showed increases in milk production until the end of May (second month in lactation), at which time milk production decreased for both groups. The milk production curves appeared to parallel the feed conditons on the range for these heifers (Deutscher and Whiteman, 1971). An Oklahoma study with fall-calving cows of various ages with varying levels of nutrition (Furr and Nelson, 1964) showed milk production to generally decrease during the winter, reaching a low point in March or April. A marked recovery in milk production occurred with the availability of spring grass in May (sixth or seventh month of lactation) and then declined until weaning in July.

The shape of the milk production curve for range beef cows appears to be influenced by several factors, important factors being season of birth and age of dam. It seems there is usually a linear decrease in milk production from the first month of lactation until weaning if a mature cow calves in spring or summer. A spring or summer calving heifers' milk production tends to increase during the second month of lactation before it begins to decline. In Oklahoma, cows calving in the fall, winter or very early spring tend to exhibit a decrease in milk yield until late spring, at which time the availability of high quality forage tends to increase their milk production (Pope et al., 1963).

Cow Size

Since there is a general belief in the dairy industry that larger cows exhibit increased milk production, several researchers have tested this hypothesis with beef cows. In a study measuring the relationship between milk production and wither height, hip height, weight in relation to wither height, or weight in relation to hip height (Williams et al., 1979b), the correlations between physical measurements and milk yield were small and nonsignificant.

A study defining cow body size as the product of length (shoulder point to pins), width of hooks and depth at withers (Gillooly et al., 1967) showed that body size did not significantly affect milk production and cow height was not significantly correlated with milk production in a study with Hereford cows (Kress and Anderson, 1974). An Oklahoma study with four year old range cows (Pope et al., 1963) using wither height, wither height X width at hooks, and metabolic weight (weight$^{.73}$) as measures of cow body size determined that body size of the beef cow had little or no relationship with milk production.

Milk Production Estimates

Estimates of the milk production of Angus and Hereford range cows (Table II) show age of dam and stage of lactation to be major factors influencing a cow's milk production.

Estimates of Forage Intakes by Angus and Hereford Calves

Major factors influencing forage intake of nursing range calves appear to be milk production of their dams, forage digestibility, and calf age and size (Lusby et al., 1974; Holloway et al., 1975; Kartchner et al., 1976; Holloway et al., 1978; Kartchner et al., 1979; and Le Du and Baker, 1979a). There appears to be negative correlation between milk intake and forage intake by nursing calves (Lusby et al., 1974; Holloway et al., 1975; Wyatt et al., 1976; Le Du and Baker, 1979a; and Boggs et al., 1980); however, Barnes et al. (1978) found no significant relationship between the two factors. Increasing forage digestibility results in an increase in forage consumption by nursing calves (Hodgson, 1968 and Horn et al., 1979), and it seems that physical capacity is a very important factor controlling the forage intake of nursing calves (Hodgson, 1968).

Lusby et al. (1976b) determined that calves whose average weight was 373 pounds consumed 2.87 pounds of forage dry matter per day

TABLE II

MILK YIELDS OF ANGUS AND HEREFORD CALVES IN OKLAHOMA AND ADJOINING STATES

Adapted from	Calving Date (average)	Breed	1st	2nd	3rd	4th	5th	6th	7th	8th
			Month in lactation (lbs. per day)							
2 yr. olds										
Pope et al., 1963	Spring	British breed		9.8	9.7	8.3	7.5	6.5		
Furr and Nelson, 1964	November	Hereford		7.59	5.87	6.25	5.32	4.61	7.08	6.19
Deutscher, 1970	February	Angus	10.3	10.25	9.55	11.65	8.73	6.53	8.04	6.26
Hendrix, 1971	March	Angus X Hereford		12.45	10.25	11.95	10.65	9.15	9.45	
Kropp, 1972	January	Hereford	14.3	13.4	13.2	11.7	12.3	12.3	10.8	
Belcher, 1978	February	Hereford X Angus	7.6	11.62	10.67	11.32	8.63	7.76		
3 yr. olds										
Pope et al., 1963	Spring	British breed		11.7	11.7	10.4	8.5	7.1		
Boggs et al., 1980	March	Polled Hereford	12.3	12.3	10.3	10.8	5.1	6.97		
4 yr. olds										
Pope et al., 1963	Spring	British breed		11.6	12.2	10.7	9.1	7.8		
Furr and Nelson, 1964	November	Hereford			6.42	4.1	6.17		7.65	6.57
Lusby, 1973	January	Hereford	17.01	16.03	15.63	14.06	13.31	11.41	10.14	7.12
Boggs et al., 1980	March	Polled Hereford	14.41	13.99	9.7	8.8	6.8	5.11		
All Ages										
Gifford, 1953	Yr.-around	Angus	9.53	10.08	9.41	9.01	7.85	7.59	7.97	6.83
Gifford, 1953	Yr.-around	Hereford	8.52	7.67	7.26	6.07	5.25	4.79	4.8	4.14
Drewry et al., 1959	March	Angus	14.1		16.00			9.00		
Melton et al., 1967	December	Angus		11.13	9.5	8.93	8.07	7.11	5.59	
Melton,et al., 1967	December	Hereford		9.79	8.29	7.88	7.3	5.81	4.8	
Hughes, 1971	March	Hereford			13.85	16.43	14.80	14.11	11.59	10.62
Omar, 1974	Spring	Angus	15.43	17.1	17.45	14.58	14.19	11.1		
Omar, 1974	Spring	Hereford	11.57	10.67	10.95	9.44	8.35	7.60		
5 to 8 yrs.										
Velasco, 1962	March	Hereford	8.67	9.74	11.2	9.1	8.88	6.29	4.1	2.35
Wyatt, 1975	January	Hereford	17.8	13.17	11.65	9.91	10.63	8.71	7.36	6.63
Boggs et al., 1980	March	Polled Hereford	14.5	13.51	11.31	10.89	7.59	8.6		
>9 yrs.										
Boggs et al., 1980	March	Polled Hereford	13.9	11.0	9.59	9.7	8.49	7.19		

(D.M. % = 45) on range, and .008 pound dry matter per pound of body weight.

Hodgson (1968) determined that the forage organic matter intake of steers three to six months old increased in a linear manner as digestibility increased from 68% to 82%, with 92% of the variation in organic matter intake due to digestibility. The predicted forage intake was:

$$Y = 1.36(\pm .104)X - 64.85$$

Y = forage organic matter intake (g/lb $LW^{.73}$)

X = forage organic matter digestibility (as grazed)

Kartchner et al. (1976) reported that 54% of the variation in the forage intake of spring born calves was due to dam's milk yield and forage digestibility, with the following forage intake prediction:

$$F.I. = 1.7632 + .00020 \ MC(lb) \times FQ - .00321 \ BW \times FQ$$

F.I. = forage intake (lb)

MC = milk consumption (lb)

FQ = forage % dry matter digestibility

BW = body weight (lb)

For fall born calves, 48% of the variation in forage intake was attributed to body weight, and the predicted forage intake was:

$$F.I. = 52.7983 + .000272109(BW)^2 + .016317 \ (FQ)^2 - .00452MC \times FQ - 1.8057186 \ FQ$$

Le Du and Baker (1979a) reported that forage intake decreased by 1.24 grams per gram milk organic matter per unit live weight and presented an intake equation of:

$$\text{F.I. g (organic matter)/lb/day} = -1.24 \pm (.086)\ \text{MC g (organic matter)/lb/day} + 9.12\ (\pm .18)$$

Horn et al. (1979) determined the average intake of 60 Angus X Angus-Hereford calves in July on Midland Bermudagrass (DMD% = 51.7) to equal 19.18 grams per pound metabolic weight.

Boggs et al. (1980) reported that calves two, three, four, five, and six months old consumed .62, 1.46, 1.51, 1.75, and 2.2% of their body weight in forage (forage dry matter digestibility ranged from 44-54%).

Genetic and Environmental Factors That Influence Calves' Weaning Weights

Genetic Effects

A calf's genetic ability to grow is determined by the genes it inherits from its sire and dam. Birth weight, which is influenced by both genetic and environmental factors, is one of the first measurements we can make on a newborn calf and it is positively correlated with weaning weight within a breed (Gregory et al., 1950; Drewry et al., 1959; Christian et al., 1965; Burfening et al., 1978; and Richardson et al., 1979). Genetic factors influencing birth weight are breed, sex of calf and calf's sire, and dam within a breed. Hereford calves or calves from Hereford dams are, on the average, heavier at birth than Angus calves or calves from Angus dams (Burris and Blum, 1952; Gifford, 1953; Marlowe, 1962; Gregory et al., 1978; Notter et al., 1978; and Gregory et al., 1979).

Sex of calf influences birth weight (Table III). The American Angus Association's breed standard (based on field data) is 70 pounds for bull calves and 65 pounds for heifers. The American Hereford Association uses 75 pounds as a standard birth weight for bull calves if the actual birth weight is not recorded, and 70 pounds for heifers.

Sex of calf also influences weaning weight (Table IV). The Angus Association adjusts heifer calves' weaning weights upward by 7% and bull calves' weaning weights downward by 3%, to a common steer basis when calculating ratios (American Angus Association, 1979). Hereford steer calves' weaning weights are adjusted upward by 5%, to a bull basis. The Hereford Association does not ratio heifers with male calves (American Hereford Association, 1973).

Even though Hereford calves are heavier at birth, it seems that Angus and Hereford calves, on the average, weigh about the same at weaning. Several studies (Gleddie and Berg, 1968; Brown et al., 1970; Omar et al., 1977; Crocket et al., 1978; and Gregory et al., 1979) showed Angus calves (or calves from Angus dams) to gain more from birth to weaning and to be heavier at weaning than Hereford calves or calves from Hereford dams. In contrast, Notter et al. (1978) found calves from three year old Hereford dams to be slightly heavier than those from Angus dams, and Melton et al. (1967) reported average gains per calf to weaning of 271.2 pounds and 280 pounds for Angus and Hereford calves, respectively. Pell and Thayne (1978)

TABLE III

BIRTH WEIGHT DIFFERENCES BETWEEN MALE AND FEMALE CALVES

Adapted from:	Difference Male - Female	
Gregory et al., 1950	5.0 lbs.	(6.8%)
Koch et al., 1959	5.2 lbs.	(8.0%)
Taylor et al., 1960	4.1 lbs.[a]	
Brinks et al., 1961	5.3 lbs.	(7.0%)
Fitzhugh, 1965	4.58 lbs.[a]	
Petty, 1966	4.21 lbs.[a]	
Vesely et al., 1971	3.97 lbs.[a]	
Nelsen, 1976	4.74 lbs.[a]	
Holland et al., 1977	3.23 lbs.[a]	
Burfening et al., 1978	6.6 lbs.	(7.5%)
Gregory et al., 1978	6.6 lbs.	(7.4%)
Notter et al., 1978	4.6 lbs.	(5.5%)
Gregory et al., 1979	8.8 lbs.	(10.0%)
Holroyd et al., 1979	4.8 lbs.	(6.9%)
Chenette and Frahm, 1981		(6%)

[a]Taken from Woldehawariat et al., 1977.

TABLE IV

WEANING WEIGHT DIFFERENCES BETWEEN MALE AND FEMALE CALVES

Adapted from:	Difference Male > Female
Gregory et al., 1950	2.4%
Minyard and Dinkel, 1960	8.3%
Brinks et al., 1961	7.0%[b]
Brinks et al., 1961	6.0%[a,b]
Lasley et al., 1961	8.0%[b]
Neville, 1962	3.0%[a]
Swiger et al., 1962	6.0%[a,b]
Brown et al., 1970	4.0%[a,b]
Sellers et al., 1970	10.5%[b,c]
Rutledge et al., 1971	4.6%
Nelsen, 1976	11.5%[b,c]
Anderson and Wilham, 1978	10.0%
Anderson and Wilham, 1978	7.0%[a]
Burgening et al., 1978	8.2%[a]
Gregory et al., 1978	5.4%[a]
Notter et al., 1978	5.0%[a]
Pell and Thayne, 1978	9.9%
Pell and Thayne, 1978	4.8%[a]
Gregory et al., 1979	7.9%
Holroyd et al., 1979	7.4%
Chenette and Frahm, 1981	6.5%[c]
Leighton et al., 1982	10.0%
Leighton et al., 1982	7.0%[a]

[a]Steers instead of bulls.

[b]Taken from Woldhawariat et al., 1977.

[c]Average of Angus and Hereford calves.

showed Angus cows to wean slightly heavier calves up to 48 months of age, but after the age of 48 months, Hereford cows weaned heavier calves. These results seem to indicate that, although Herefords are heavier at birth, Angus calves grow faster from birth to weaning, probably due to the superior milk production of their dams, which causes the weaning weights of calves of these two breeds to be fairly equal.

Another genetic factor influencing purebred calves' weaning weights is the level of inbreeding. If a calf's parents are related, the calf will be inbred, and this usually results in a decrease in weaning weight (Table V).

Environmental Effects

Some environmental factors thought to influence calves' weaning weights include age of dam, year and season of birth, general health, and management system. Some of these environmental factors, such as age of dam (Table VI) and year and season of birth, are probably due mainly to differences in milk and forage intake by the calves (Marlowe and Gaines, 1958; Brown, 1961; Neville, 1962; Cundiff et al., 1966; and Rutledge et al., 1971), although effects of year and season of birth could also be influenced by environmental stress due to the weather. A few researchers have reported that adjusting for milk quantity does not reduce all of the difference in average daily gains of calves from mature cows compared with calves from young cows (Jeffery et al., 1971a and Nelms et al., 1978). Since birth weight is positively associated with weaning weight (Table VII), it may be an additional factor affecting weaning weights of calves from mature vs. young cows (Table VIII). Birth weight (in addition to milk and forage consumption and the weather) may also affect weaning weight differences attributed to season of birth, since cows under favorable pasture conditions during the last part of gestation usually give birth to heavier calves (Koch and Clark, 1955; Ellis et al., 1965; and Turvey, 1967).

TABLE V

EFFECT OF INBREEDING ON CALF WEANING WEIGHT

Adapted from:	Decrease (lbs.) per % inbreeding
Koch, 1951	-.48
Burgess et al., 1954	-1.76
McCleery and Blackwell, 1954	-1.19[a]
Swiger et al., 1961 (two herds)	-1.42[a]
	-.05[a]
Swiger et al., 1962	-.70[a]
Brinks et al., 1963	-2.11[a,b]
	-.59[a,c]
Nelms and Stratton, 1964	-1.38[a]
Nelms and Stratton, 1967	-.465[a]
Dinkel et al., 1968	-.80[a,b]
	-1.35[a,c]

[a]Taken from Brinks and Knapp (1975)

[b]Females

[c]Males

TABLE VI

AGE OF DAM EFFECTS ON WEANING WEIGHT (lbs.)

Adapted from:	Age of Dam (Years) 2	3	4	5	6-9	10	11+
American Angus Assoc.	-27	-18	-7	0	0	0	-9
Petty and Cartwright (1966)	-29	-19	-10	-3			
Sellers (1968)[a]	-27	-20	-10	-10	0	0	-11
Sellers (1968)[a,c]	-22	-20	-10	-10	0	0	-9
Sellers (1968)[a,d]	-32	-20	-9	-9	0	0	-13
Sellers (1968)[b]	-17	-13	-5	-5	0	0	-3
Sellers (1968)[b,c]	-15	-14	-5	-5	0	0	-3
Sellers (1968)[b,c]	-19	-12	-3	-3	0	0	-2
Woldehawariat et al. (1977)[e]	-25.78	-16.2	-8.28	-2.77	+.28	-1.32	
Anderson and Wilham (1978)[c]	-18	-9	4	-1	0	-4	-4
Anderson and Wilham (1978)[a,c]	-20	-10	-4	-1	0	-4	-4
Anderson and Wilham (1978)[b,c]	-17	-8	-3	-1	0	-4	-4
Chenette and Frahm (1981)[a,c]	-32	-18	-9				
Chenette and Frahm (1981)[b,c]	-25	-15	-5				
Chenette and Frahm (1981)[a,d]	-45	-22	-5				
Chenette and Frahm (1981)[b,d]	-32	-15	-5				

[a]Angus

[b]Hereford

[c]Males

[d]Females

[e]Average of 26 studies reported

TABLE VII

CORRELATION ESTIMATES BETWEEN BIRTH WEIGHT AND WEANING WEIGHT

Adapted from:	Correlation
Koch et al., 1955	.39
Brinks et al., 1962	.3
Fitzhugh, 1965	.41
Petty, 1966	.38
Nelsen, 1967	.46
Vesely et al., 1971	.42
Burfening et al., 1978	.34
Nelson and Kress, 1979	.39

Some other environmental factors affecting weaning weights include parasite control and health care, presence or absence of creep feeding, and quality and amount of creep if calves are creep fed.

Energy Requirements of Preweaning Calves

The amount of energy required for maintenance per unit of body weight is higher for calves than for mature cattle. Age, body size, diet, and other factors affect the amount of energy a calf requires for maintenance and gain. Roy et al. (1957) reported that maintenance requirements peaked at about three days of age, then decreased rapidly until eight days of age, declining more slowly for the next three

TABLE VIII

AGE OF DAM EFFECTS ON BIRTH WEIGHT (lbs.)

Adapted from:	Age of Dam (years)								
	2	3	4	5	6	7	8	9	10+
Angus									
Swiger et al., 1962	-4.69	-2.49	0	.31	.79	1.61	1.61	2.2	.59
Nelsen, 1976	-4.14	-1.50	-.4	.26	1.58	.70	.70	.48	.70
Chenette and Frahm, 1981	-8.00	-3.00	-2.0						
B.I.F. (all breeds)	-8.00	-5.00	-2.0						
Hereford									
Swiger et al., 1965	-4.69	-1.89	-.51	1.61	1.89	1.39	3.78	2.2	-1.3
Petty, 1966	-8.38	-3.98	.31	3.89	3.70	1.89	2.29	2.09	1.1
Nelsen, 1976	-6.16	-1.54	1.10	1.76	1.98	.88	.22	2.2	-3.52
Chenette and Frahm, 1981	-11.00	-4.00	-1.00						

weeks, at which time the study ended. They suggested that the changes in the maintenance requirements during the first few days of life may be due to the calf's effort to adjust to its new environment.

A review article (Jacobson, 1969) reported estimates of 18.6 to 23.6 kilocalories of digestible energy per pound of body weight for maintenance and from 1.22 to 1.733 megacalories digestible energy per pound of gain for nonruminating calves (Table IX), with greater energy requirements for ruminating calves (Table X).

Roy (1980) reports the maintenance requirement of a pre-ruminant calf as 49 kilocalories of metabolizable energy per pound of metabolic weight, the requirements for gain for a pre-ruminant calf as 1.41 megacalories of metabolizable energy per pound of gain for gains of .55 to 1.1 pounds per day for a 66 pound calf, increasing to 2.38 megacalories of metabolizable energy per pound of gain for a 350 pound calf gaining 2.2 pounds to 313 pounds per day. The maintenance requirement for ruminant calves is derived from the equation:

$$ME(mcal) = 1.9837 + .00986\ Wt(lb)$$

where: ME = metabolizable energy
Wt = weight

In a review article (Agricultural Research Council, 1981) that reported experiments dealing with the metabolizable energy requirements of calves being fed liquid diets, the maintenance requirements ranged from .043 to .073 megacalories of metabolizable energy per pound of metabolic weight per day (Table XI).

The Agricultural Research Council developed the following formula to estimate the metabolizable energy requirements for maintenance (ME_m)

TABLE IX

ESTIMATES OF DIGESTIBLE ENERGY REQUIREMENTS OF A 110 POUND NONRUMINATING CALF[a]

Adapted from:	Maintenance (kcal/day)	Plus Daily Gain of: 1.1 pounds	Plus Daily Gain of: 2.2 pounds
Blaxter and Wood (1951)	2620	4155	5690
Brisson et al. (1957)	2235	3575	4915
Bryant et al. (1967)	2410	4260	6130
McGilliard et al. (1969)	2065	3975	5885
Average	2332	3991	5665

[a]Taken from Jacobson (1969).

TABLE X

ESTIMATES OF DIGESTIBLE ENERGY REQUIREMENTS OF A 110 POUND RUMINANT CALF[a]

Adapted from:	Maintenance (kcal/day)	Plus Daily Gain of: 1.1 pounds	Plus Daily Gain of: 2.2 pounds
Roy et al. (1963)	2427	4489	6551
Roy (1964)	3339	5790	8242
Average	2883	5139	7396

[a]Taken from Jacobson (1969).

of calves on liquid diets:

$$M.E.m = .046392\ mcal./wt^{.75}(lb)/day$$

M.E.m = metabolizable energy required for maintenance

where: mcal = megacalories

$Wt.^{.75}$ = metabolic weight

TABLE XI

METABOLIZABLE ENERGY REQUIREMENTS FOR MAINTENANCE OF CALVES ON LIQUID DIETS

Adapted from:	mcal/lb metabolic weight
Blaxter and Wood (1952)	.049
Gonzalez-Jimenez and Blaxter (1962)	.051
van Es et al. (1969)	.048
Vermorel et al. (1974)	.044
Holmes et al. (1975)	.044
Holmes and Davey (1976)	.043
Webster et al. (1976)	.073
Kirshgessner et al. (1976)	.047

The Agricultural Research Council (1965) reported average values for fasting metabolism of different ages (Table XII) which show the difference in maintenance requirements between very young and mature cattle.

TABLE XII

AVERAGE VALUES FOR THE FASTING HEAT PRODUCTION OF CATTLE

Months	Kcal per lb $wt^{.73}$
1	63.5
3	61.2
6	56.7
12	49.9
18	45.4
24	43.1
36	40.8
48	38.5
>48	36.3

Although developed for feedlot cattle, the California Net Energy System (Lofgreen and Garrett, 1968) may be useful in predicting the maintenance and gain requirements of older, ruminating calves. The net energy required for maintenance under this system is .043 megacalories per pound metabolic weight, and gain is equal to:

$$\text{(steers)} \quad \frac{.0001748 + (.003112)(NEAG)/wt^{.75} - .01322}{.001556}$$

and

$$\text{(heifers)} \quad \frac{.0001974 + (.005756)(NEAG)/wt^{.75} - .01405}{.002878}$$

where:

NEAG = Net energy available for gain (mcal/day).

CHAPTER III

MODEL DESCRIPTION

This study is designed to attempt to estimate the pounds of beef a rancher will have at weaning time, given a specified land and animal management scheme. Variable inputs include cows' milk production, type of pasture, month of calving, sex of calf, and calf birthweight. Stocking rate is not adjusted for in this model, since only the calves are considered. Forage intake of cows is not included. Calves are grown from their milk and forage intake. Calves' weights at birth are assumed to be those used by the Angus and Hereford Associations adjusted for age of dam by the Beef Improvement Federation's recommendations, unless a birth weight is specified. Calves may be weaned at anytime up to 240 days of age.

Simulation of Milk Production

Generally, the milk production of beef cows on grass declines from the first month of lactation until weaning (Table II). However, if forage quality and quantity increases as lactation progresses, the decline may not be as large as expected or an increase may be observed (Furr and Nelson, 1964; Kropp, 1972). The expected average milk production over the lactation period may be varied by the user. Age of dam is adjusted for by subtracting 15%, 9%, 4%, and 7% (Table II) from the average for two, three, four, and older than 10 year old cows, respectively. The equation to predict the decline in milk production, developed from averages of data in Table II (R^2 = .95), is:

$$DC = -18.6323 + 3.8213 \times MBAR - .1855 \times MBAR^2 \qquad (1)$$

where DC is the decrease in milk production per month and MBAR is the average milk production for the lactation. DC has upper and lower limits of .95 and .4, respectively. Milk production is simulated for a maximum of eight months by the equation:

$$M(1) = MBAR + DC \times 3.5 \qquad (2)$$

and

$$m(I) = M(1) - DC \times (I-1) \qquad (3)$$

where M(1) = milk production in the first months and I = one to eight, for each of the eight months in lactation. The TDN values were available for bermudagrass, native tall grass, native short grass, weeping lovegrass, and fescue pastures (Brorsen, 1980). The TDN value of a particular pasture for a certain month is used to further adjust milk production, depending on whether the pasture has a TDN value higher or lower than an average TDN value which is calculated across all pastures over all months. Milk yield is increased or decreased for a cow on a certain pasture in a particular month, depending on whether the TDN for that pasture in that month is above or below the average TDN value. The increase or decrease is equal to:

$$D = [(TDN(pasture) \div average\ TDN) - 1] \times 4 \qquad (4)$$

where: D = pounds of milk added to the milk production for that pasture in a specified month.

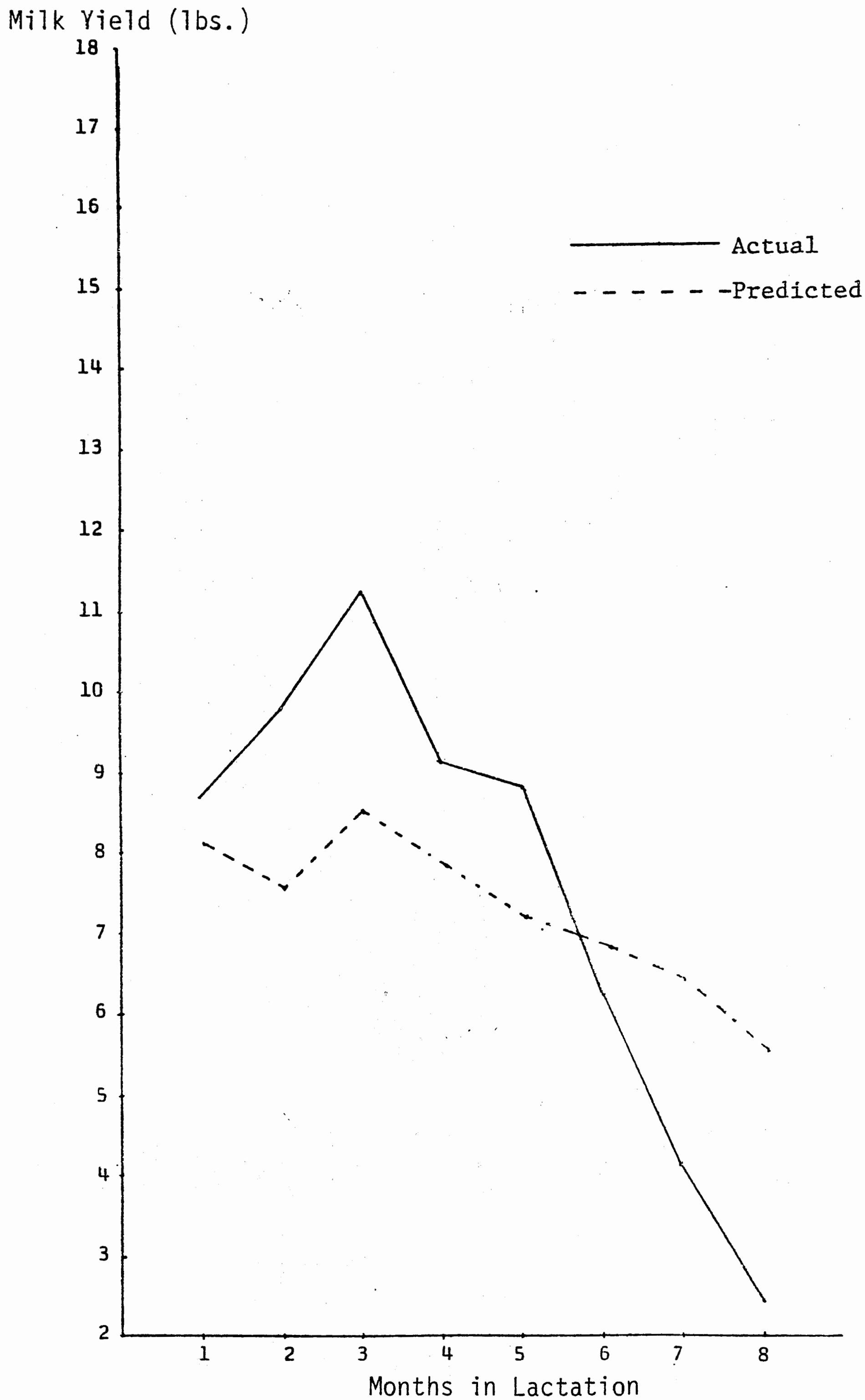
The maximum increase for a succeeding month's milk production increase over the preceding month is four pounds. If a pasture is not producing forage in a specified month (e.g., fescue in late summer), the TDN value is, by default, equal to 1/4 of that particular pasture's average TDN value.

When compared with actual experiments conducted in Oklahoma (Figures 1-7), the equation does a fairly good job in adjusting for changes in milk production due to forage quality. Discrepancies may be due to the fact that certain years had an early or late spring, mild winter, higher summer rainfall than average, etc. Differences between actual and predicted milk yields were not significantly different from zero (t test, $P > .1$).

Usually, milk production increases in the spring. The studies by Pope et al. (1963), Velasco (1962), Deutscher (1970), and Omar (1974) all reported the highest milk yields in May and June. Studies by Kropp (1972), Lusby (1973), and Wyatt (1975) report the peak milk yield as being at the beginning of lactation, which was during the winter. A possible explanation is that the cows in these studies were on a higher plane of nutrition in December, January, and February than the average range cow and, consequently, the usual increase in milk production that occurs on the range in spring due to the improvement in forage quality did not occur.

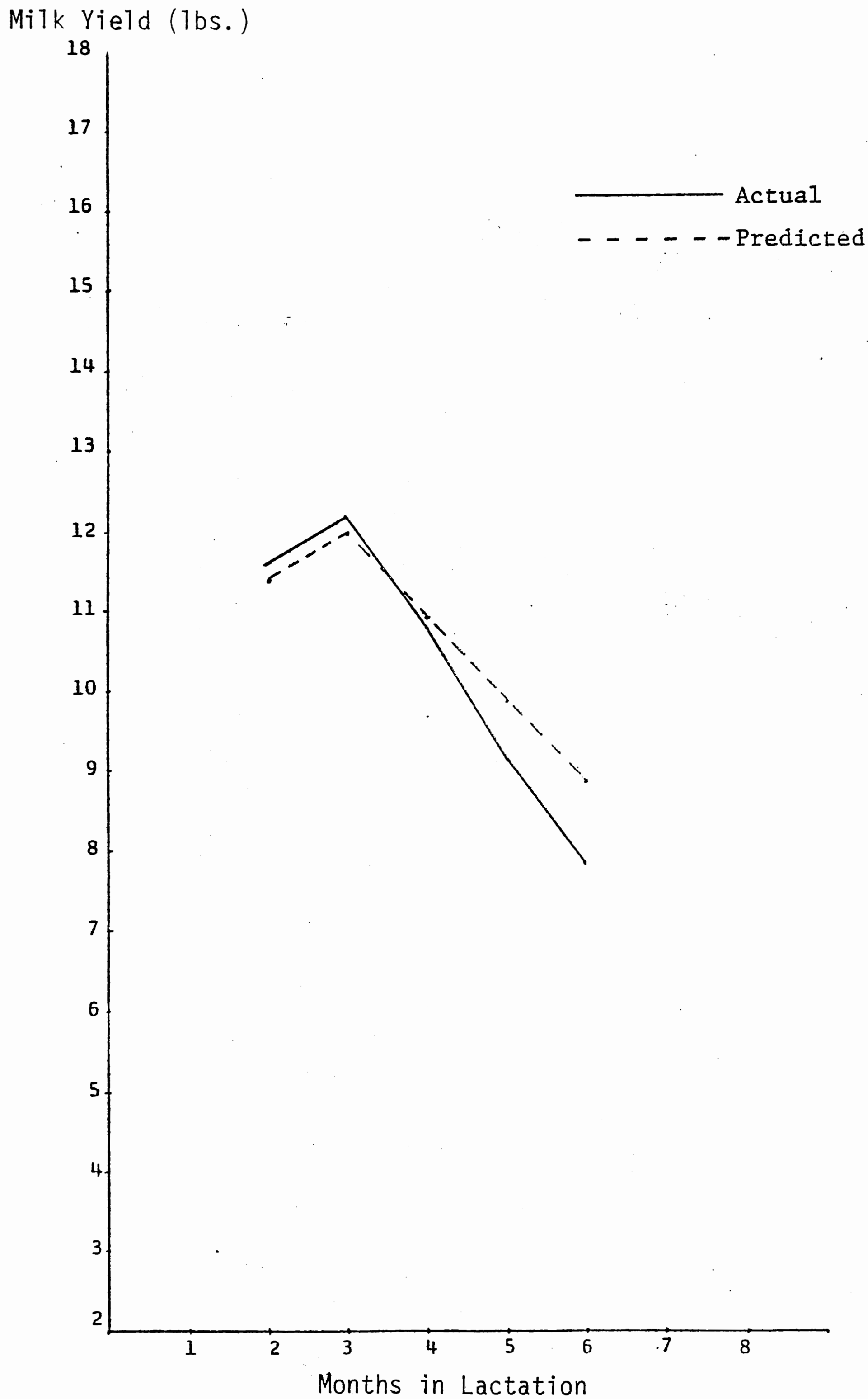
Simulation of Forage Intake

An equation to predict forage intake was developed from raw data for calves nursing straightbred Hereford cows summarized by Lusby (1976a, 1976b), Wyatt (1977a, 1977b), and Barnes et al. (1978). R^2 values were determined for models utilizing combinations of two to



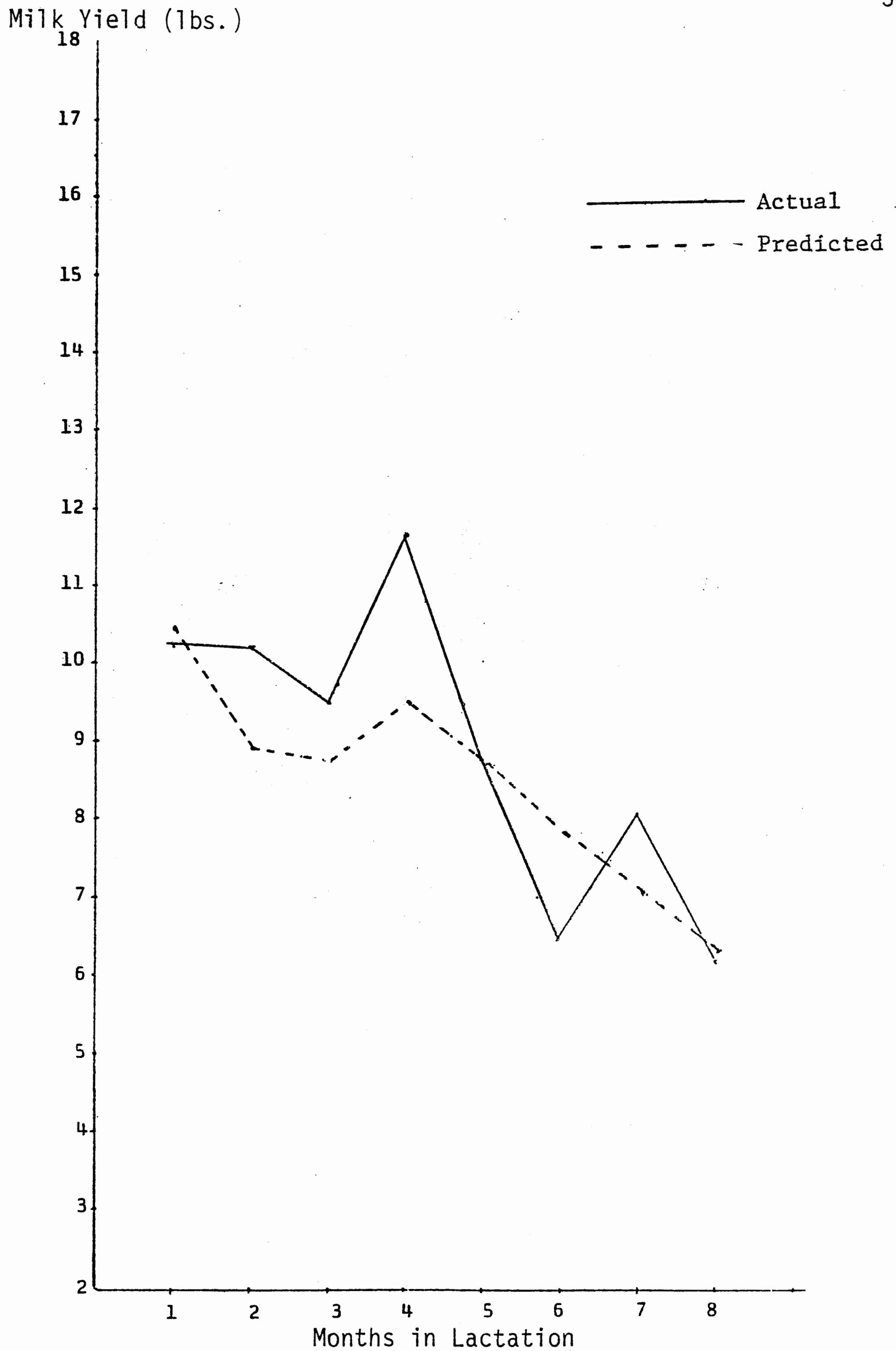
Source: M. Velasco, "Level of winter feeding of range beef cows" (M.S. thesis, Oklahoma State University, 1962).

Figure 1. Actual and Predicted Milk Yields



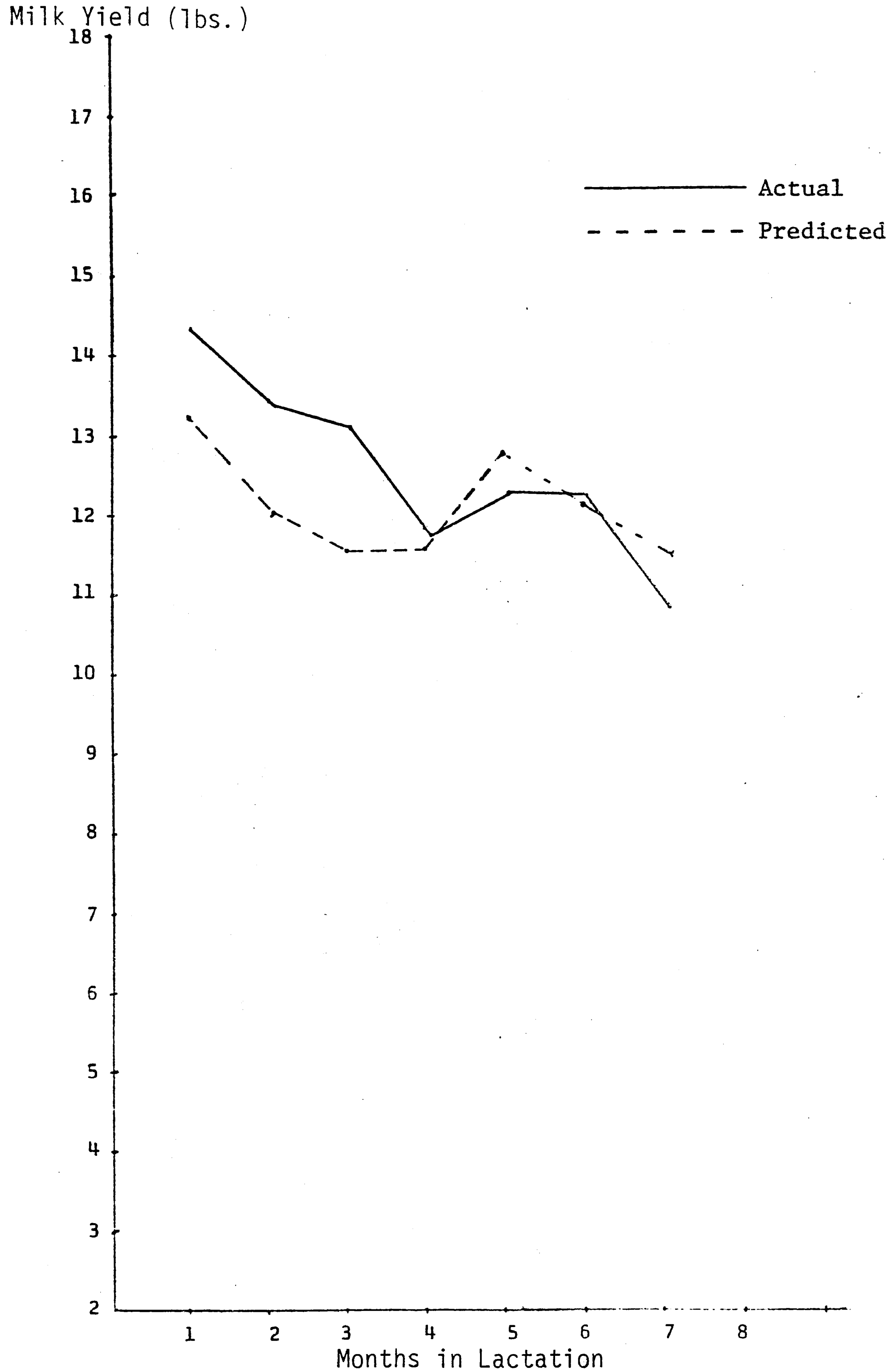
Source: L. S. Pope et al., "Factors affecting Milk production of range beef cows," Okla. Agr. Exp. Sta. Misc. Pub. (1963).

Figure 2. Actual and Predicted Milk Yields



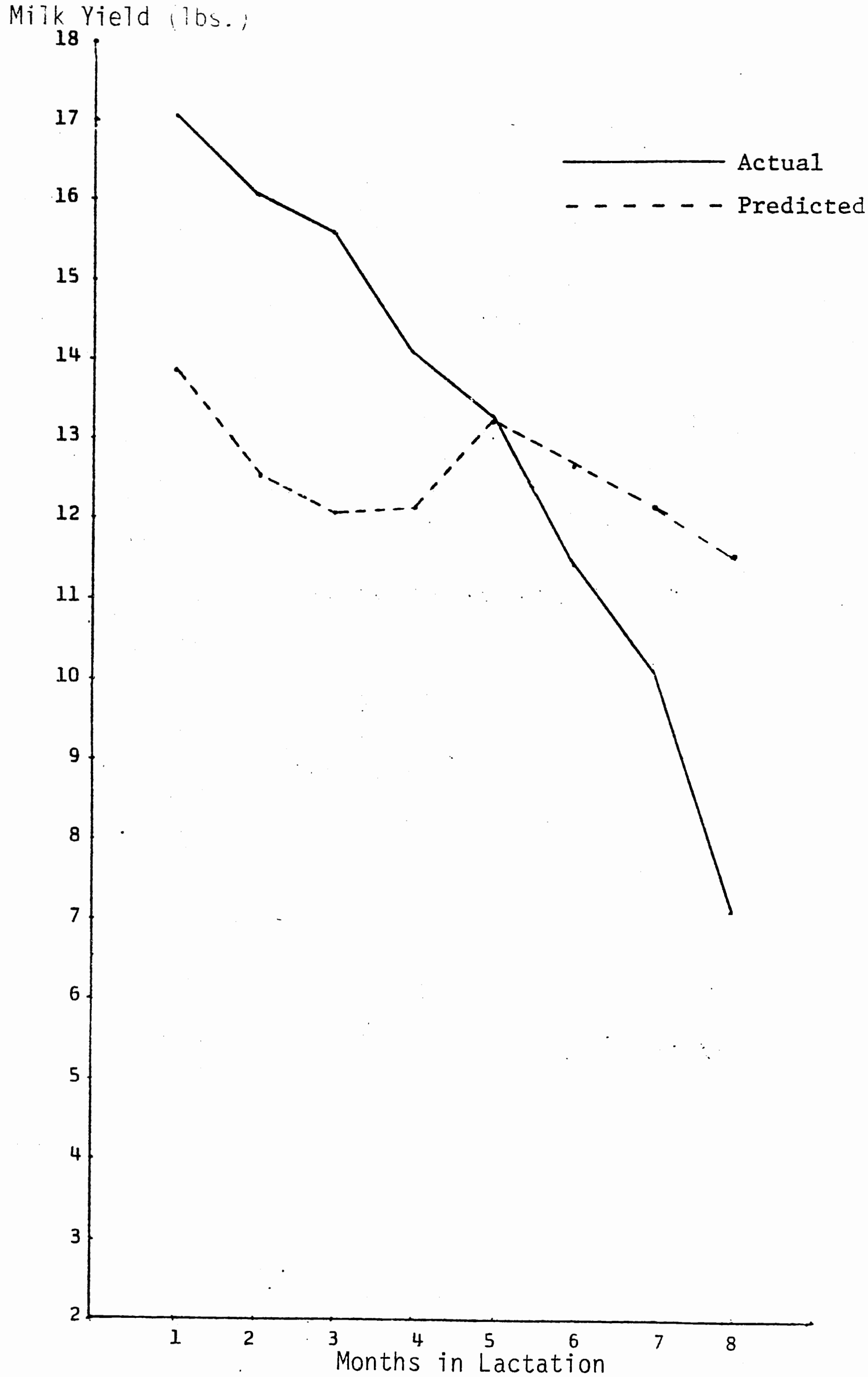
Source: G. H. Deutscher, "Productivity of Angus-Holstein crossbreds vs. Angus heifers under tallgrass range conditions" (M.S. thesis, Oklahoma State University, 1970).

Figure 3. Actual and Predicted Milk Yields



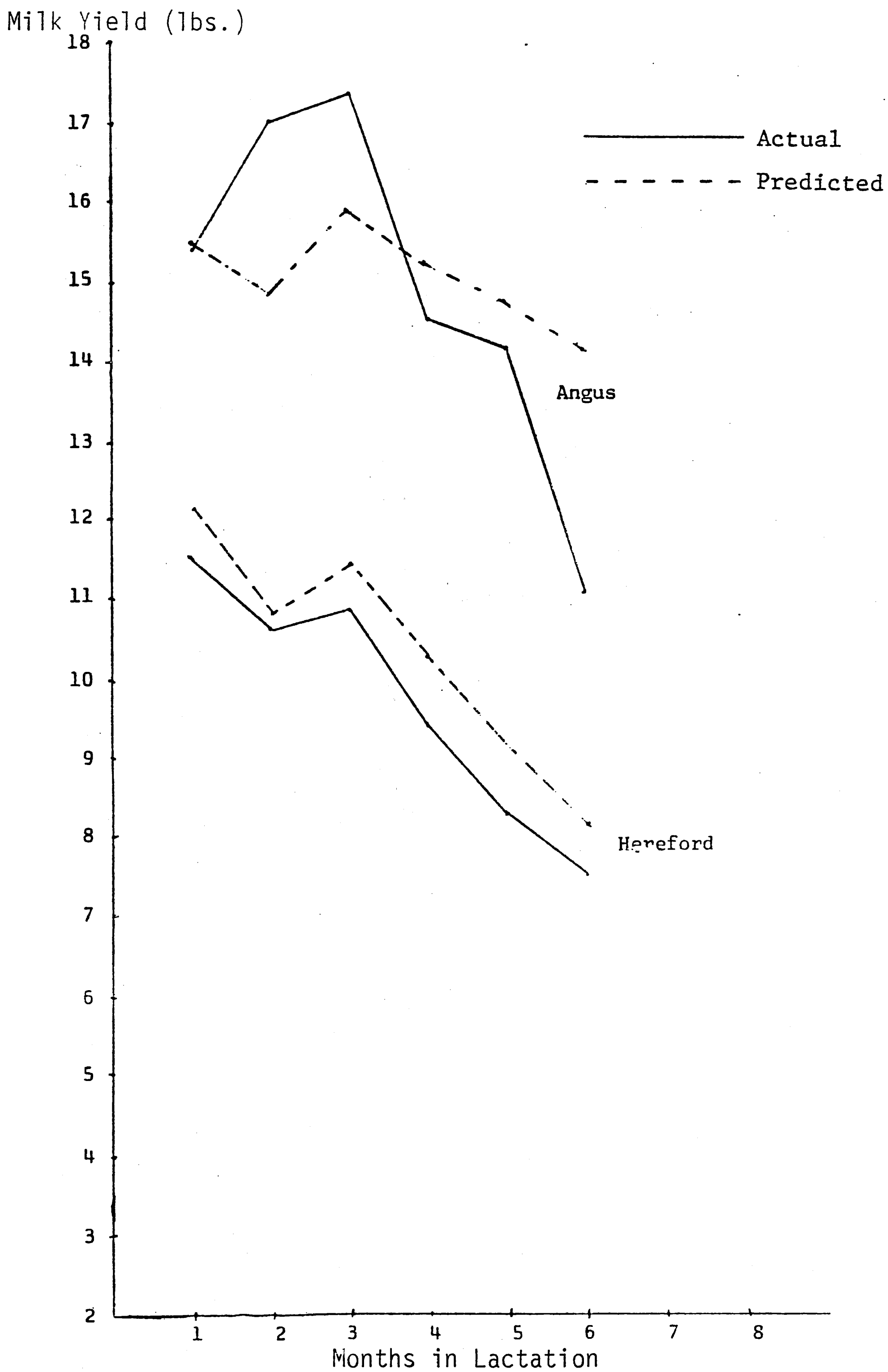
Source: J. R. Kropp, "The performance on range and in drylot of two-year-old Hereford, Holstein, and Hereford x Holstein females as influenced by level of winter supplementation" (M.S. thesis, Oklahoma State University, 1972).

Figure 4. Actual and Predicted Milk Yields



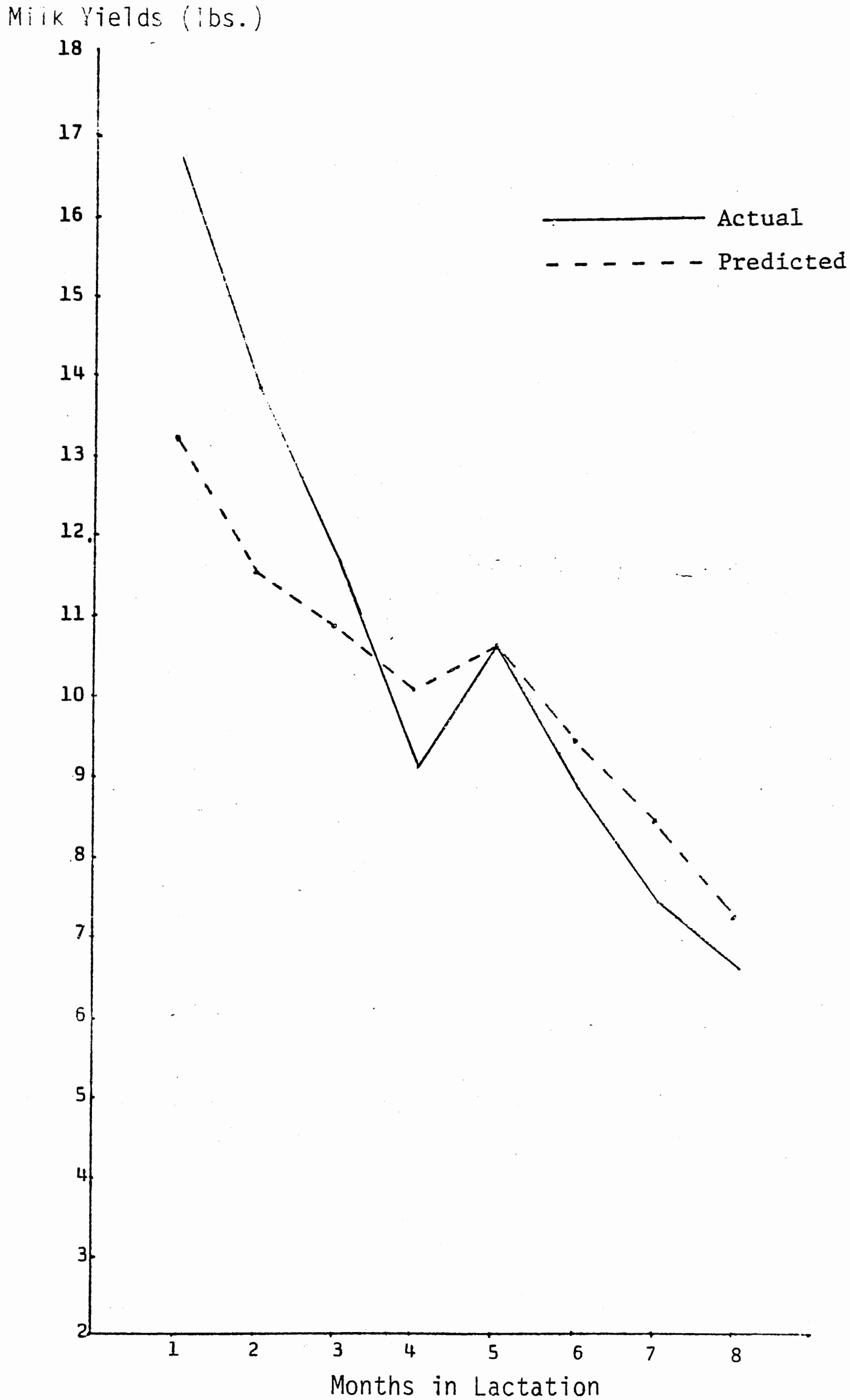
Source: K. S. Lusby et al., "Performance of four year old Hereford, Hereford x Holstein, and Holstein females as influenced by level of winter supplementation under range conditions," (Res. Rep. MP 92, Ok. Agr. Exp. Sta. and USDA, 1974).

Figure 5. Actual and Predicted Milk Yields



Source: M. A. Omar, "Estimate of daily milk yield of Hereford and Angus dams" (M.S. thesis, Oklahoma State University, 1974).

Figure 6. Actual and Predicted Milk Yields



Source: R. E. Wyatt et al., "Performance of four and five year old Hereford, Hereford x Holstein, and Holstein cows on range and in dry lot, J. Anim. Sci. (1976b, 45:1120).

Figure 7. Actual and Predicted Milk Yields

six of the following variables: weight, milk consumption, forage dry matter digestibility, milk consumption ÷ forage dry matter digestibility, weight ÷ forage dry matter digestibility, and weight, milk, and forage dry matter digestibility squared and cubed. Using models with four or more variables did not substantially increase the R^2 values over .95. The two equations with lowest sum of squared differences between actual and predicted forage intake were:

$$F.I. = .01449121WTD - 1.07357191MCD \qquad (5)$$

$$R^2 = .952$$

$$S.E. = .08$$

where: F.I. = forage intake

WTD = weight ÷ forage dry matter digestibility

MCD = milk consumption ÷ forage dry matter digestibility

and

$$F.I. = .02497435Wt + 1.32815529\ DMD - 2.7885397\ MC \qquad (6)$$

$$R^2 = .956$$

$$S.E. = .08$$

where: Wt = weight

DMD = forage dry matter digestibility

MC = milk consumption

The sum of the squared differences between actual and predicted forage intake was lower for equation 5, as was the difference between the actual and predicted overall average forage intake, so it was used in the model. However, in biological terms, equation 6 is easier to explain, since both weight and forage dry matter digestibility have a positive linear effect on forage intake and milk consumption exerts a negative influence on forage intake.

With equation 5, it is possible for the forage intake of very young calves to be less than zero. If the predicted forage intake is less than zero, the forage intake is programmed to equal zero. Predictions from the model's formula were compared with the results of actual experiments (Table XIII) to test the equation's validity.

TABLE XIII

COMPARISON OF PREDICTED FORAGE INTAKE WITH RESULTS OF ACTUAL EXPERIMENTS[a]

	Number Records	Predicted Forage Intake (lbs.)	Actual Forage Intake (lbs.)
Kartchner (1975)	10	6.08 ± 1.04	5.36 ± .97
Le Du and Baker (1979a)	30	3.52 ± .60	3.31 ± .56
Weighted Average		4.16 ± .52	3.82 ± .49
Lusby et al. (1976a,b)	12	5.08 ± .95	2.88 ± .89
Wyatt et al. (1977a,b)	23	6.30 ± .68	7.02 ± .64
Barnes et al. (1978)	73	8.11 ± .38	8.52 ± .36
Weighted Average of all five studies	148	6.52 ± .27	6.56 ± .25

[a]Dry matter

The model predicted the average forage dry matter intake of three studies not used in developing the equation to within .33 pound. The predicted average intake of all five studies is only .04 pound lower than the actual forage dry matter intake--the largest deviation (2.2

lbs.) being on the data collected by Lusby et al. (1976b). A t-test was run on the predicted values for the five studies and the overall difference was not significantly different from zero (P > .5). The difference between predicted and actual forage intake of the studies by Le Du and Baker (1979a) and Kartchner (1975)--studies not used in developing the equations--were not significantly different from zero, either (t-test, P > .1). The equation predicted a forage dry matter intake of .5%, 1.08%, 1.37%, 1.63%, 1.81%, 1.89%, and 2.01% of body weight at two through eight months of age. This is in contrast to a report by Lusby et al. (1976b), who reported that at 373 pounds calves consumed .77% of their body weight in forage dry matter. However, the calves in the study by Lusby were receiving an unusually high level of milk, which would decrease their forage intake. The models' results agree fairly closely with a report by Boggs et al. (1980), who found intakes of .62%, 1.46%, 1.51%, 1.75%, and 2.2% of body weight at three, four, five, six, and seven months of age, respectively.

Simulation of Calf Growth

Calf growth is simulated by the California Net Energy System, developed by Lofgreen and Garrett (1968). Modifications of the equations are necessary to simulate the growth of very young calves. Raw data collected by Holloway et al. (1973), Kropp et al. (1973), Lusby et al. (1976a, 1976b), Wyatt et al. (1977a, 1977b), and Barnes et al. (1978) were used to develop the modifications. Since animals' maintenance and gain requirements vary for different ages and sexes, the adjustments used in the model were divided into five classes for each sex.

Maintenance Adjustments

It is generally accepted that males have a higher maintenance requirement per unit of body weight than females, and that bulls have a higher maintenance requirement than steers (McDonald et al., 1973; Agricultural Research Council, 1981). Also, the maintenance requirement of young calves per unit of metabolic weight is greater than that of mature cattle (McDonald et al., 1973; Roy, 1980; Agricultural Research Council, 1981). During the first few weeks of life a calf has a much higher maintenance requirement than when it is older; consequently, the standard of .035 megacalories per pound (.077 mcal./ $kg.wt.^{.75}$) of metabolic weight is adjusted upward by 50% the first month. The Agricultural Research Council (1965) reported that at one month of age the fasting metabolism of steer calves was 52% higher per unit of metabolic weight than that of three and four year old steers, and McDonald et al. (1973) reported that the fasting metabolism of young calves is 50% higher per unit of metabolic weight than that of mature cows. The 50% increase is lower than the estimate preferred by the Agricultural Research Council (1965) of a 60% increase in fasting metabolism at one month of age and higher than the 40% increase in the maintenance requirement at one month of age for heifers in the Texas A & M simulation model (Sanders and Cartwright, 1979). Roy (1980) stated that increasing weight produced a more pronounced decline in fasting metabolism than did increasing age after the first few weeks of life; therefore, the adjustments used in this model are based on weight rather than age--excluding the first month. Weight classes were determined by grouping calves with similar energy requirements for maintenance together (Table XIV). Although females usually have a lower maintenance requirement than males per unit of body weight, largely due to a higher fat content (Agricultural Research Council, 1965), the fat content of very young heifers evidently is not high enough to overcome the increased maintenance requirement attributed to their age and the species' standard of .035 megacalories per pound has to be increased to correctly simulate the gain of the heifers used in the Oklahoma State University studies. As heifers get older and heavier, their maintenance requirement decreases due to their sex, i.e., increased fat content. Since data for bull calves were not available, their maintenance requirement was simulated to be 15% higher than steer calves after the first month (Agricultural Research Council, 1981).

TABLE XIV

ADJUSTMENTS ON THE MAINTENANCE REQUIREMENTS OF YOUNG CALVES

Class	Steers	Heifers	Other Studies
≤ 31 days	1.5	1.5	1.4 Sanders and Cartwright (1979)
Under 200 lbs.	1.1	1.08	1.08 Roy (1980)
Under 310 lbs.	1.065	1.053	
Under 440 lbs.	1.065	.94	1.03 Roy (1980)
Over 440 lbs.	1.02	.94	1.02 Roy (1980)

After the first month, steer calves under 200 pounds have an 11% increase above the species mean. This is in fairly close agreement with Roy (1981), who stated that at 200 pounds, calves' maintenance requirements per pound of metabolic weight are 8% higher than animals that weigh 550 to 900 pounds. However, the 8% increase is lower than reports by the Agricultural Research Council (1965) that gave an increase of 40% for the fasting metabolism of two month old heifers at 207 pounds. The adjustment for heifers in the 200 pound and under weight class is an 8% increase. The upper limit on the third class is 310 pounds. For the third class, the steers' maintenance was increased by 6.5%, and heifer maintenance is increased by 5.3%. This is higher than an increase of 3% for 331 pound calves (Roy, 1980), but a 28% increase in the fasting metabolism of 440 pound calves is listed (Agricultural Research Council, 1981). For the fourth weight class (upper limit of 440 pounds) and the fifth weight class (calves heavier than 440 pounds), the steer calves' maintenance requirements were increased by 6.5% and 2% above the species average, respectively. Roy (1980) reports that at 331 pounds and 400 pounds, calf maintenance requirements per unit of metabolic weight are 3% and 2% higher, respectively, than animals weighing 550 to 900 pounds. For heifers in the fourth and fifth weight class, the maintenance requirement per unit of metabolic weight was decreased to equal 94% of the species mean. Lowering the maintenance was necessary in order to correctly simulate the gain of heifers in the Oklahoma State University studies. Heifers in the fourth weight class weigh over 440 pounds, so it is possible that at these weights the heifers have accumulated enough body fat to lower their maintenance requirement. It is usually accepted that females have lower maintenance requirements than males (McDonald et al., 1974; Agricultural Research Council, 1981).

Gain Adjustments

In the adult, energy retained as fat can equal 85% to 95% of total energy retention, while in young animals, fat retention can be as low as 50% of the retained energy (Agricultural Research Council, 1981). Also, male gains usually have a lower energy content than female gains. The amount of energy required for growth at a certain weight can vary by as much as 30%, due to sex and mature size (Agricultural Research Council, 1981). McDonald et al. (1974) states that protein synthesis is probably a slightly more efficient process than fat synthesis, so the efficiency of utilization of metabolizable energy should be larger for young "growing" animals than older "fattening" stock. They report that about 35% of the energy retained is stored as protein in calves, while in older cattle that figure is about 15%. The Agricultural Research Council (1965) reported that at 660 pounds, the utilization of metabolizable energy is equal for fattening and growth in heifers, but below 660 pounds, utilization is higher for growth. Since the California Net Energy equations for gain were developed for older, fatter feedlot cattle, adjustments have to be made to simulate the more efficient gain of younger, leaner calves. The California Net Energy system uses different equations to predict steer and heifer gains, so the adjustments must be considered separately.

The adjustments on the steer calves' gain equation are increases of 12% for the first class, 9.6% for the second weight class, 3% for the third weight class, and no increase in the gain of steers for the fourth and fifth weight class. Apparently, steer gains in the heavier weight classes have a high enough energy content to be predicted fairly well by the California Net Energy System equations. Bull gain was programmed to be 15% more efficient than steers' gain (Agricultural Research Council, 1981).

The gains of heifer calves are increased by 10% for the first two weight classes, 8% for the third and fourth weight classes, and 4.2% for the fifth weight class. If any calves reach a weight of 660 pounds, the California Net Energy System equations are used with no adjustment.

Milk Utilization

It appears that utilization of the energy from milk varies due to the percentage of milk in the diet. Sucking can cause the esophageal groove to form a channel and allow milk to bypass the rumen, even in adult cattle (McDonald et al., 1974), so in animals consuming forage, milk is utilized more efficiently than food that passes into the rumen. In the Texas A & M systems model (Sanders and Cartwright, 1979), the model's developers doubled the TDN content of the milk. They stated that this was necessary to correctly simulate the gain of nursing calves. They attributed that partly to the fact that milk contained many important nutrients besides energy and partly due to rumen bypass. In the A & M model, calves consumed all the milk their dams produced. To accurately simulate the gain of calves in the Oklahoma studies, the utilization of milk was varied for the five classes. The average of the five adjustments is 150%, lower than the 200% adjustment used in the Texas A & M model.

Intake Limit

The dry matter intake as a percentage of body weight was calculated for calves in the Oklahoma studies. The maximum dry matter intake of calves in the Oklahoma studies was 3.9% of body weight; consequently, a 4% limit was used in the model. Roy (1980) stated that the maximum dry matter intake for 110 pound calves was 2.2% of their weight; however, data from the Oklahoma studies showed several calves consumed over 3% of their body weight in dry matter at 110 pounds.

Results of the model's predictions compared with the results of actual experiments (Table XV) were tested and found not to be significantly different ($P > .5$). Another t-test was run on the studies not used to develop the gain adjustments and the difference between observed and predicted gain again was not significantly different from zero ($P > .5$). In an additional effort to check the model's gain prediction, data collected for the studies in Table XV were averaged to show the pattern of calf average daily gain. Predictions using the same weight of calf, milk intake, and forage intake were plotted against actual gain (Figures 8-12) to see if the model's gain predictions follow the same pattern as the actual gain. In these graphs, actual forage dry matter digestibility was used if available and the model's forage values were used if actual dry matter digestibility was not available. If the trend of predicted gain for a certain month of age is ahead or behind (higher or lower) than actual gain, it could be due to the fact that actual gain was measured in a year that had an early or late spring or unusually wet summer, etc., causing the model's predicted forage digestibility values (pasture management and data base described in Brorsen, 1980) to be higher or lower than they were the year or years the actual results were collected. The largest difference (Figure 9) between predicted and actual gain is about one pound. This difference is due mainly to discrepancies between actual and predicted gain at three months of age for data collected by Wyatt et al. (1977b).

TABLE XV

COMPARISON OF PREDICTED CALF AVERAGE DAILY GAIN WITH RESULTS OF ACTUAL EXPERIMENTS

Adapted From:	n	Predicted ADG (lbs.)	Actual ADG (lbs.)
Kropp et al.[a] (1973)	58	1.84 ± .09	1.35 ± .05
Holloway et al.[a] (1973)	51	1.52 ± .09	1.68 ± .05
Kartchner (1975)	10	1.66 ± .21	2.00 ± .12
Lusby et al.[a] (1976a)	63	1.80 ± .09	1.77 ± .05
Lusby et al. (1976b)	12	1.68 ± .19	2.03 ± .11
Wyatt et al. (1976)	23	1.81 ± .14	2.34 ± .08
Wyatt et al.[a] (1977)	38	1.32 ± .11	1.85 ± .06
Barnes et al. (1978)	73	2.18 ± .08	1.96 ± .05
Le Du and Baker (1979a)	30		1.74 ± .07
Weighted Average	358	1.781 ± .04	1.786 ± .02

[a]Calves two months old and younger--no forage records.

Data from the Oklahoma State University studies was then plotted against completely simulated predictions (variable inputs included age

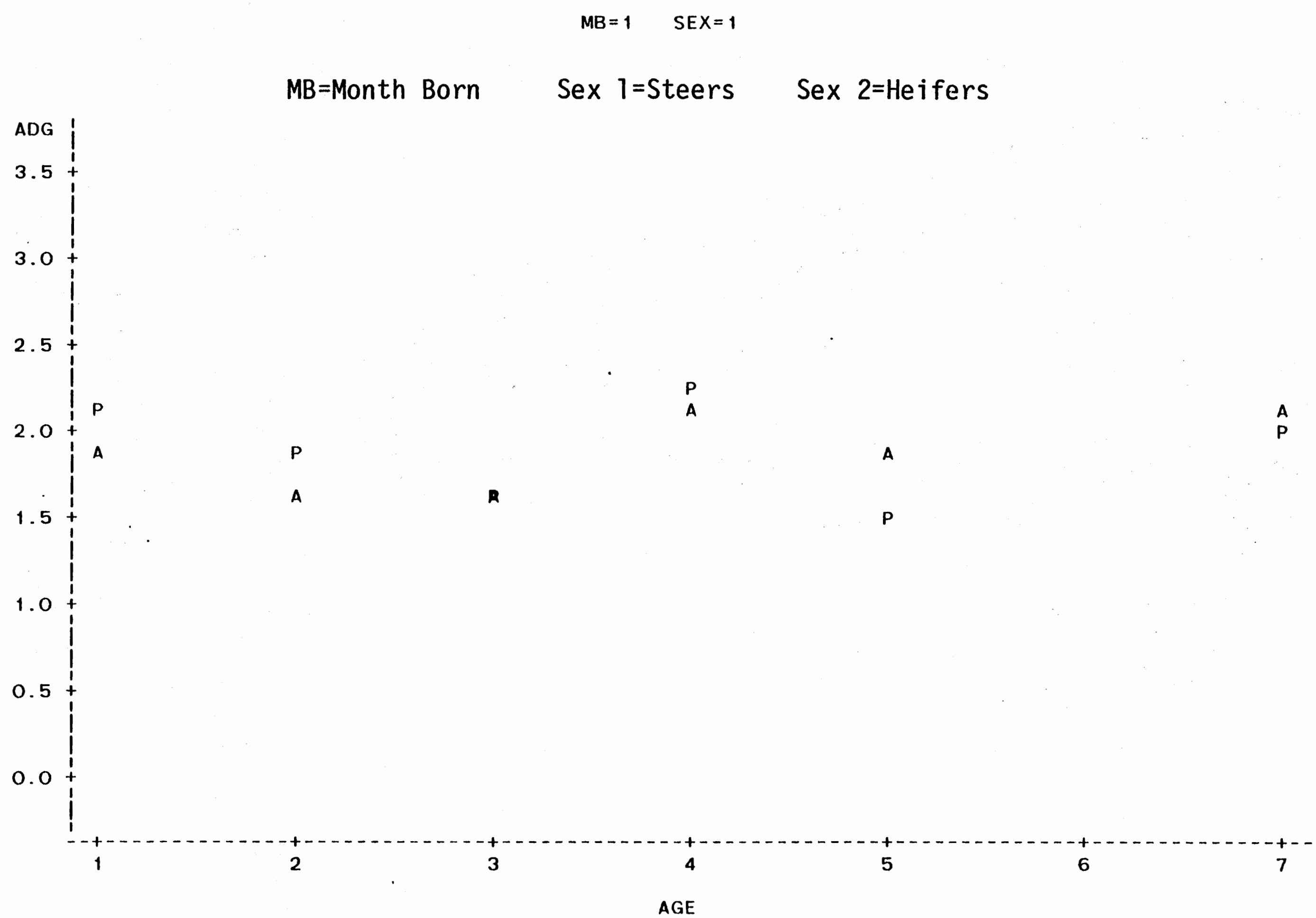


Figure 8. Predicted and Actual ADG by Months of Age

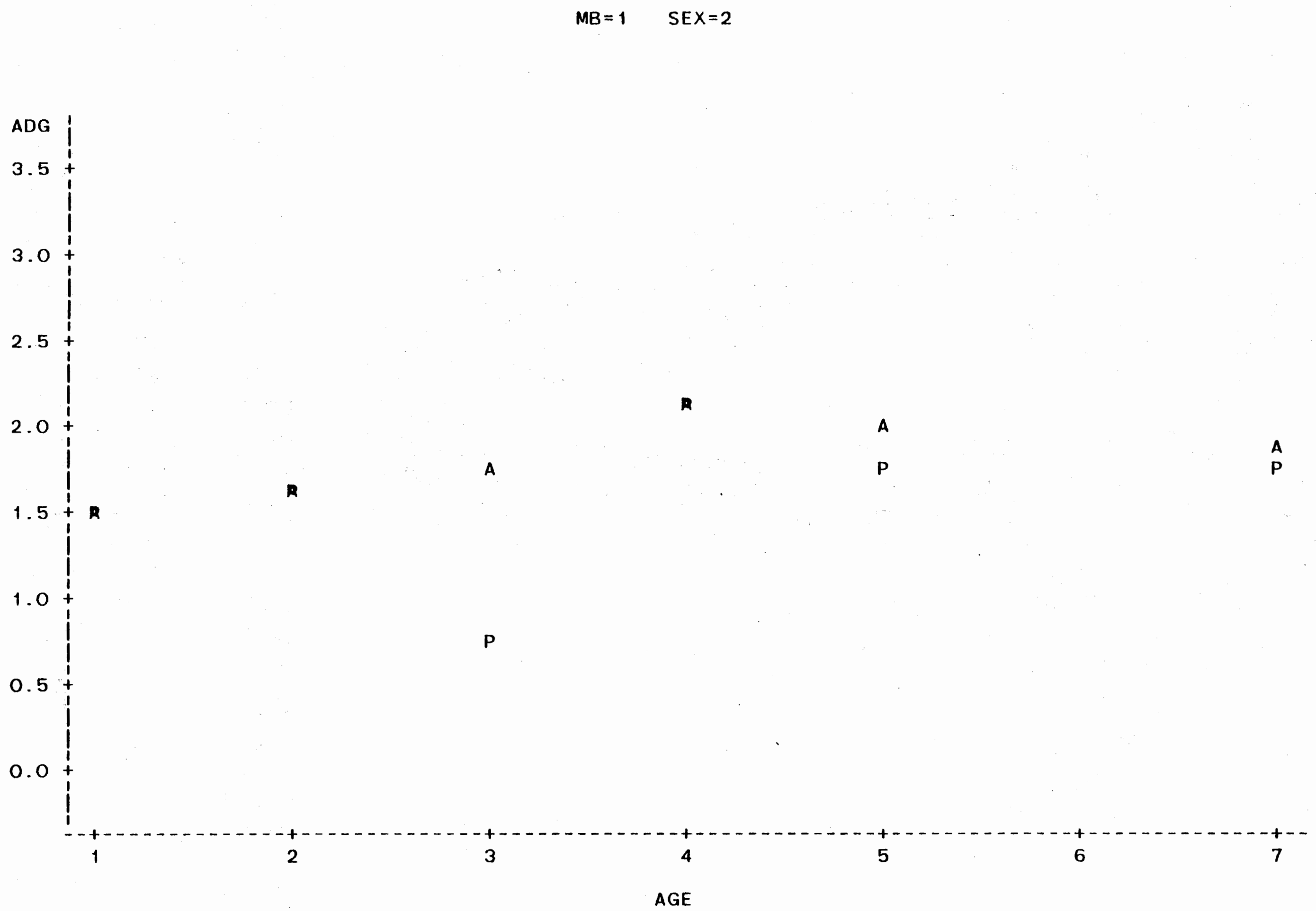


Figure 9. Predicted and Actual ADG by Months of Age

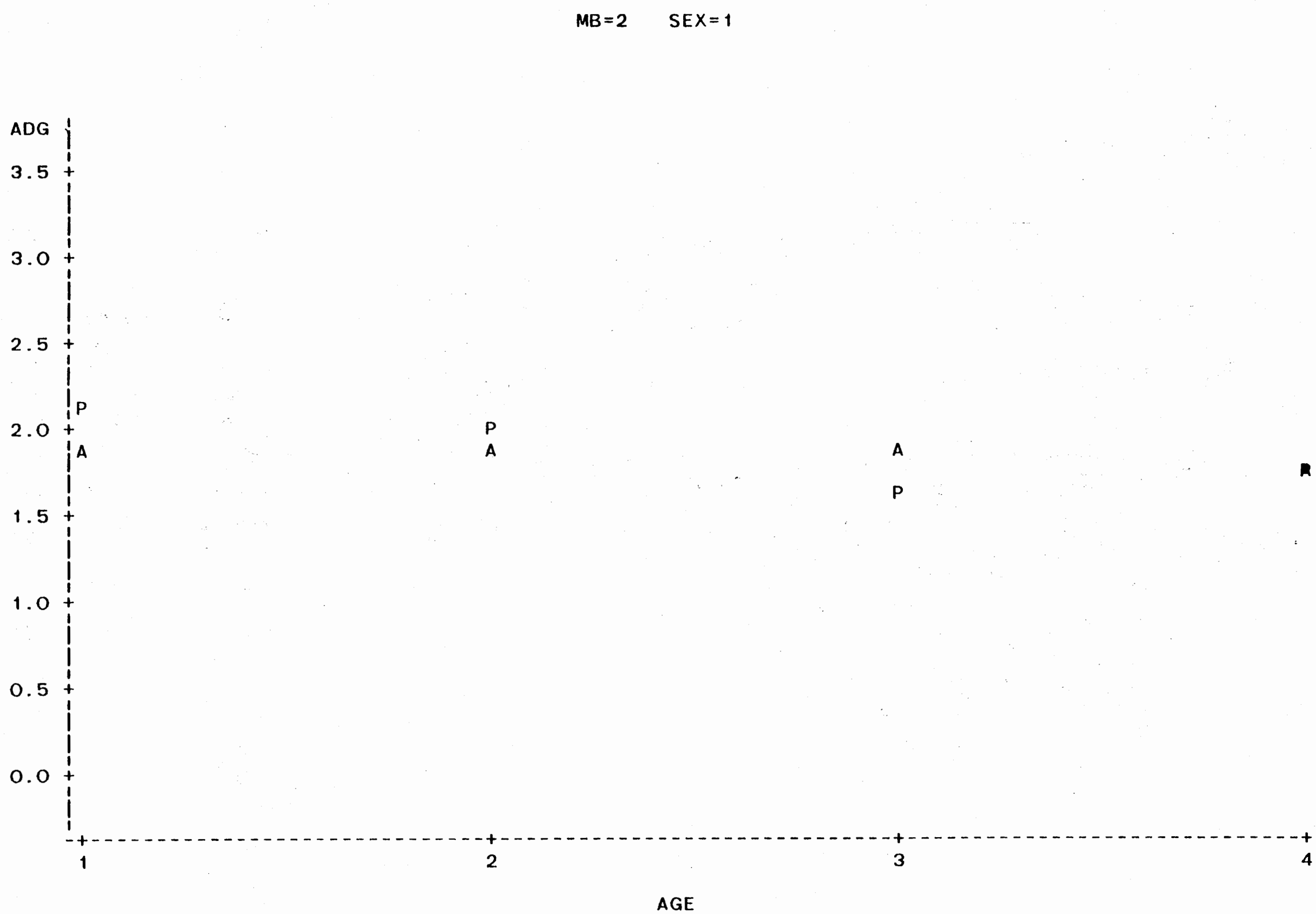


Figure 10. Predicted and Actual ADG by Months of Age

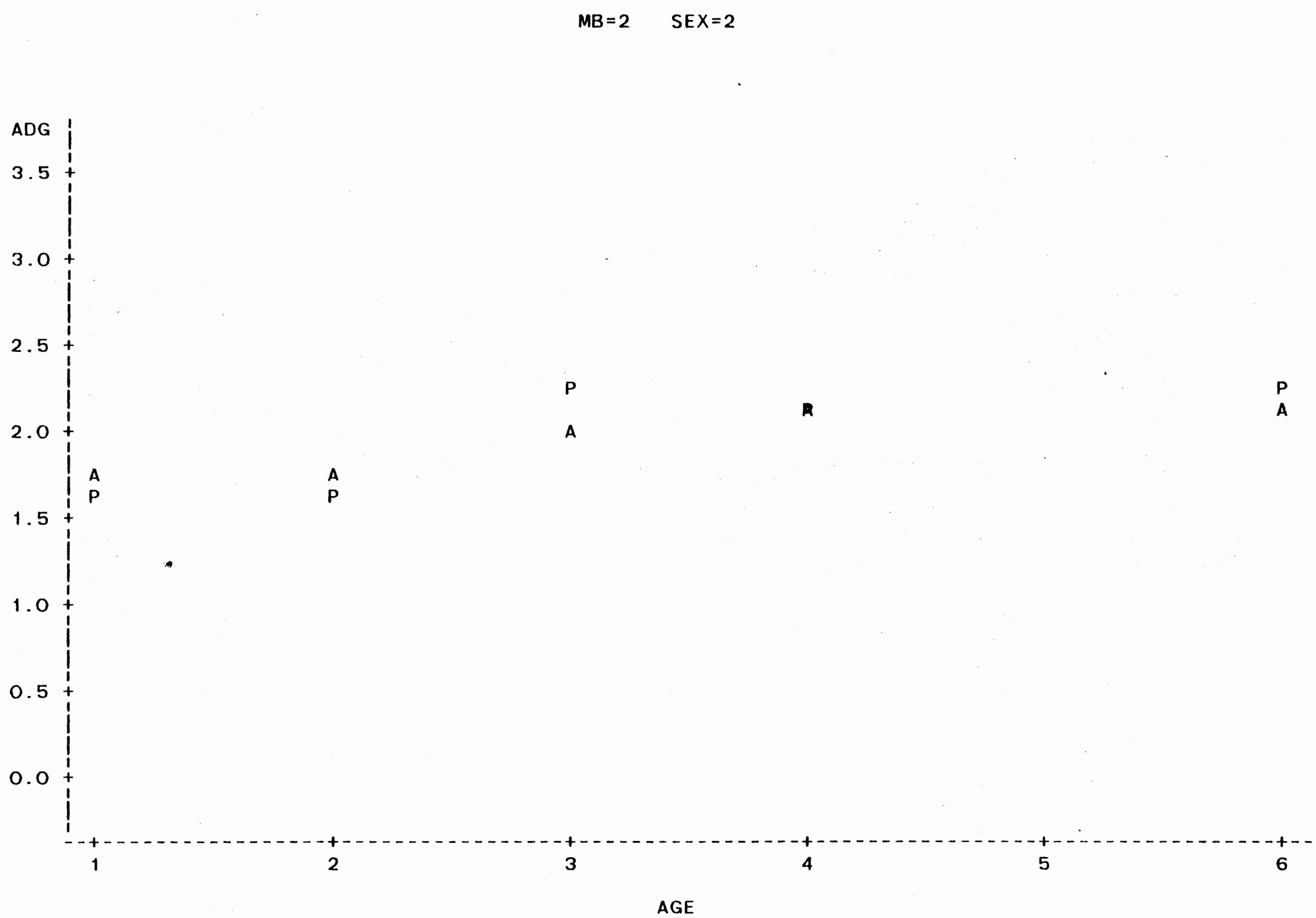


Figure 11. Predicted and Actual ADG by Months of Age

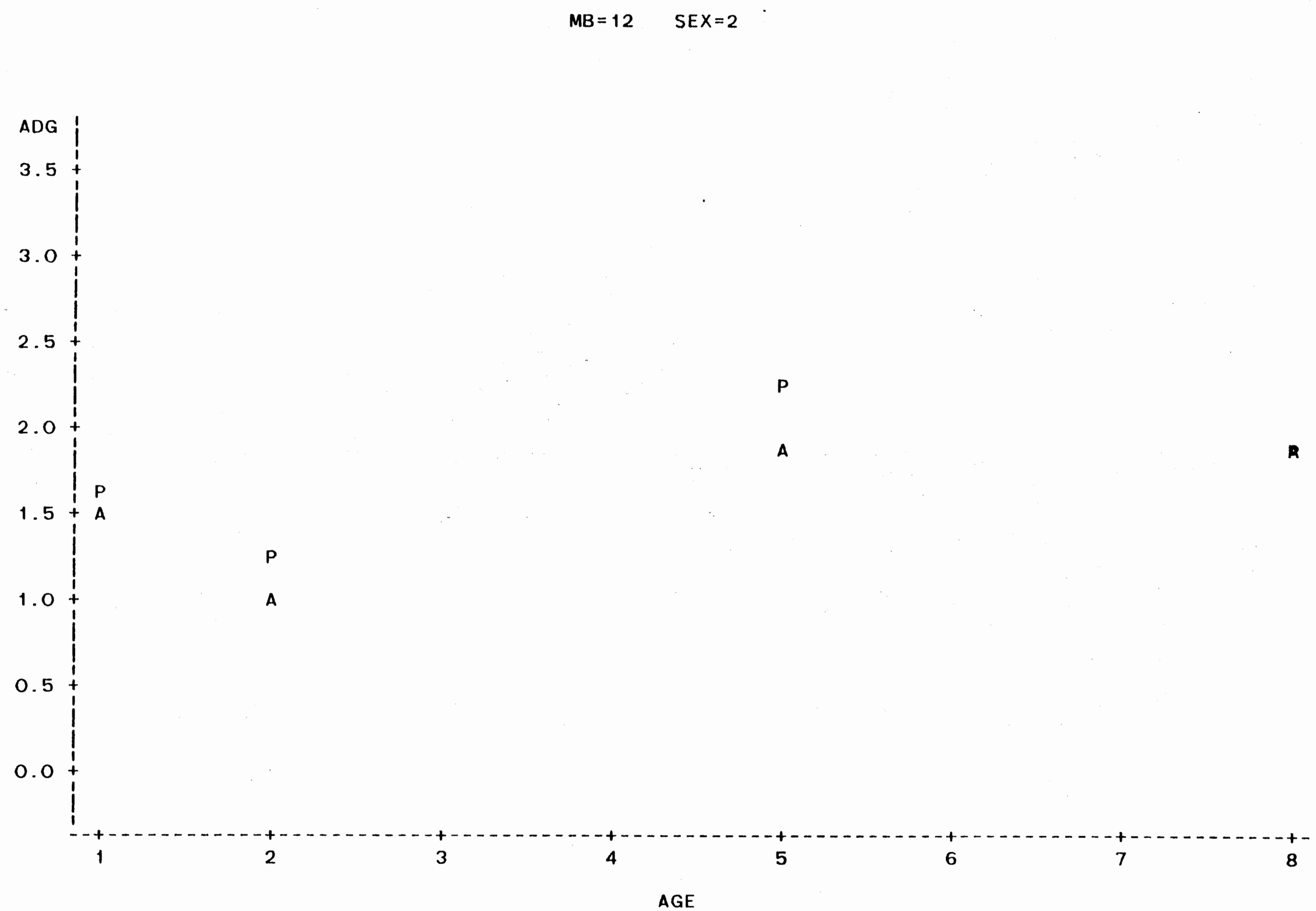


Figure 12. Predicted and Actual ADG by Months of Age

of cow, month of birth, sex of calf, level of milk production, and type of pasture) to see if the model could accurately simulate calf growth using predicted milk and forage intake instead of actual milk and forage intake (Figures 13-16).

Records from simulations of 686 calves (with varying months of birth and types of pastures) were averaged to see if differences between sexes and ages of dams seemed reasonable. At 210 days of age, Angus steer calves averaged 5.03% heavier than heifer calves and Hereford steer calves were 4.9% heavier than heifer calves. The adjustments for bull calves' maintenance and gain were taken from the literature, since no records were available, and evidently underestimated gains for bull calves, since at 210 days, bull calves were only about 1% heavier than steer calves, increasing to 1.4% at 240 days. Weaning weights were 14% less for two year old cows, 8% less for three year olds, 4% less for four year olds, and 5% less for cows 11 years old or older. These figures are fairly close to industry-wide accepted differences of 15%, 10%, 5%, and 5% for two, three, four, and older than 10 year old cows, respectively.

MB=1

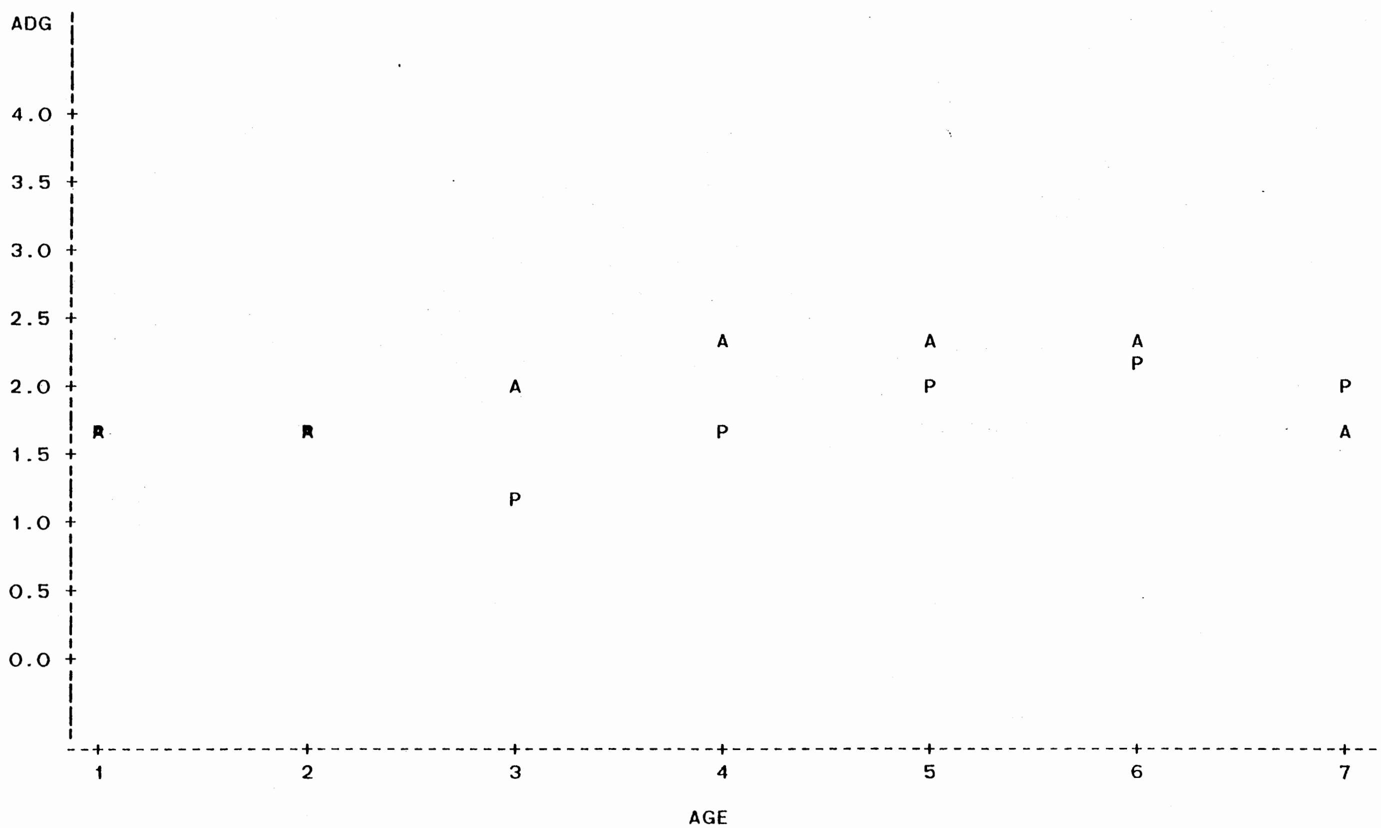


Figure 13. Predicted and Actual ADG by Months of Age

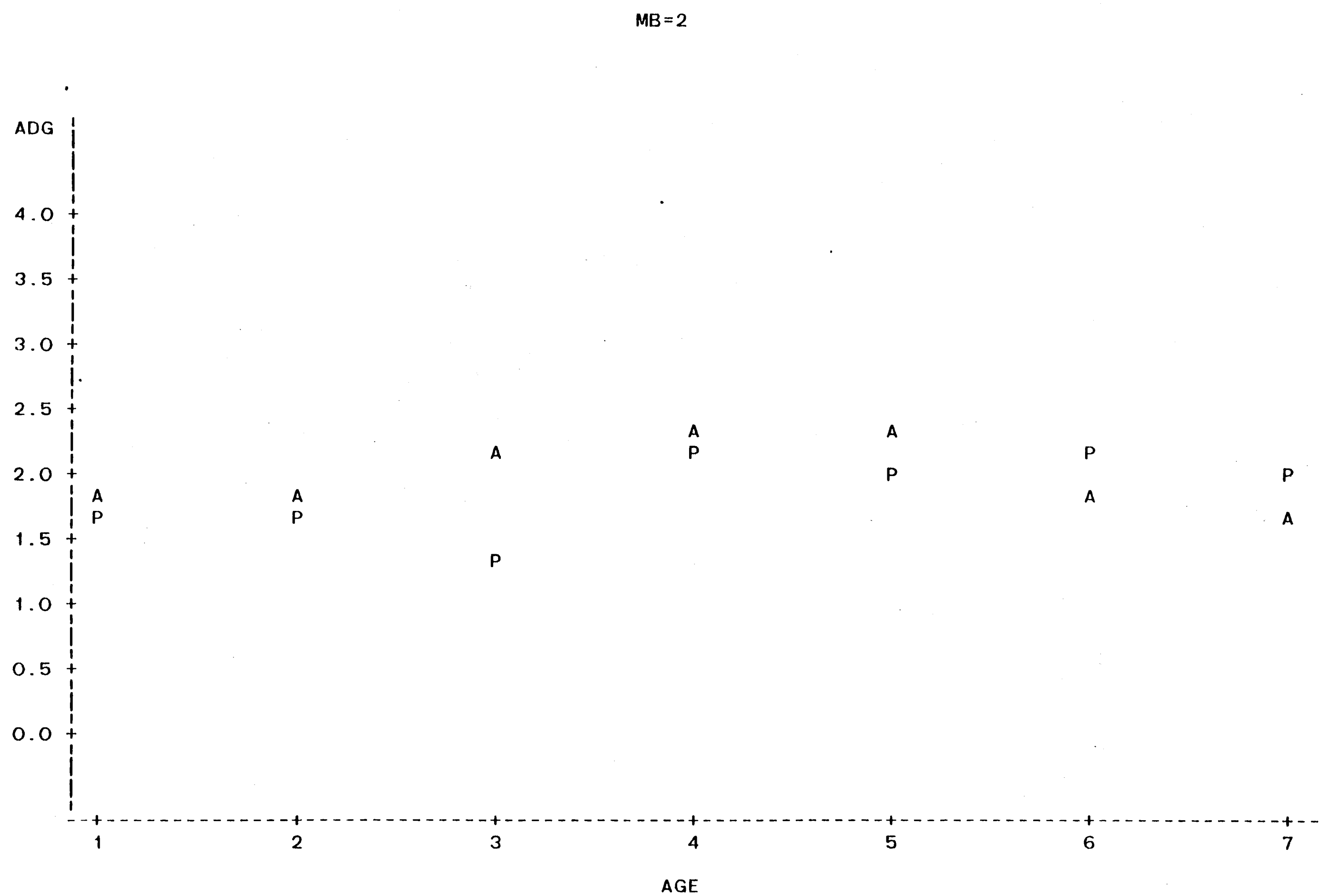


Figure 14. Predicted and Actual ADG by Months of Age

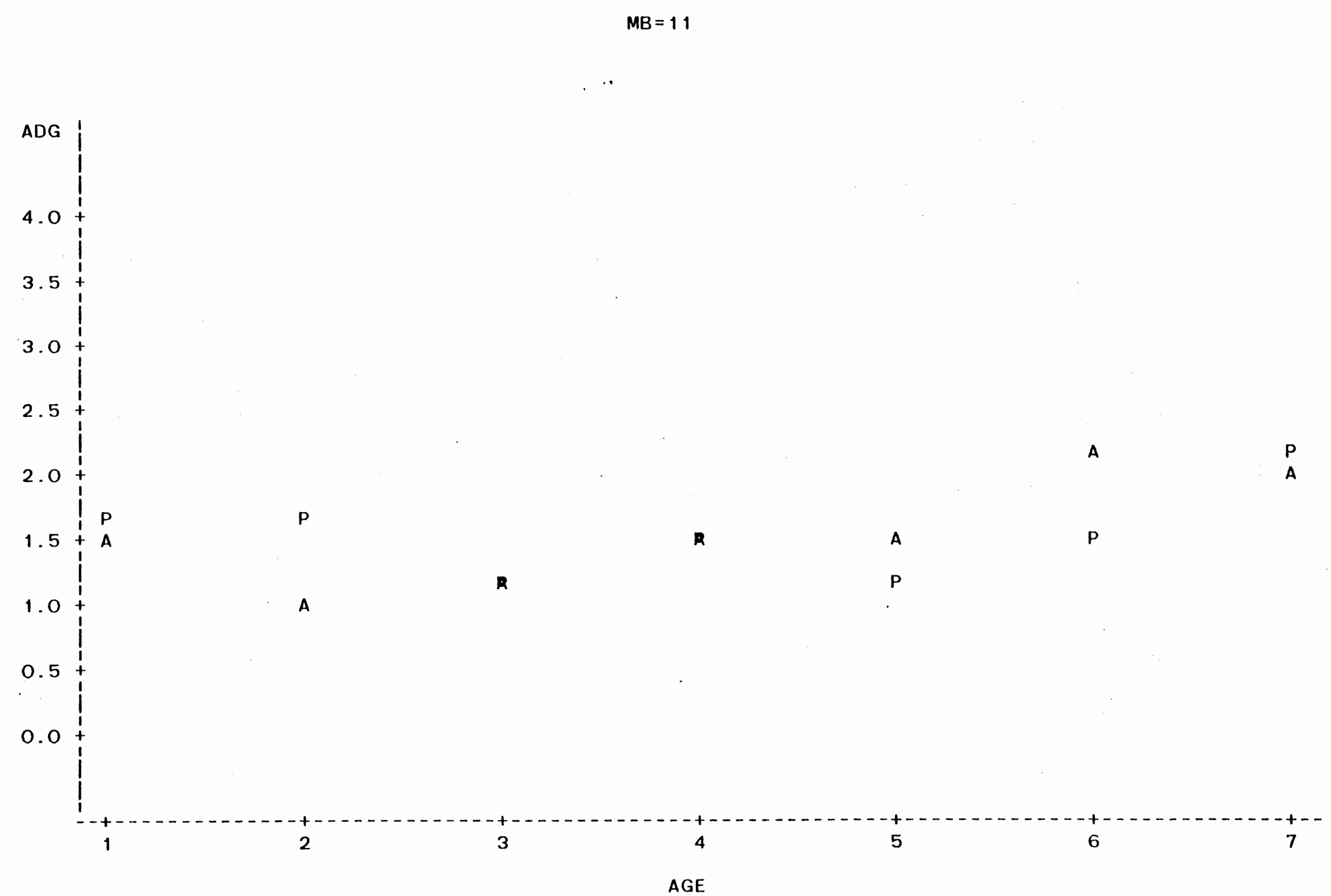


Figure 15. Predicted and Actual ADG by Months of Age

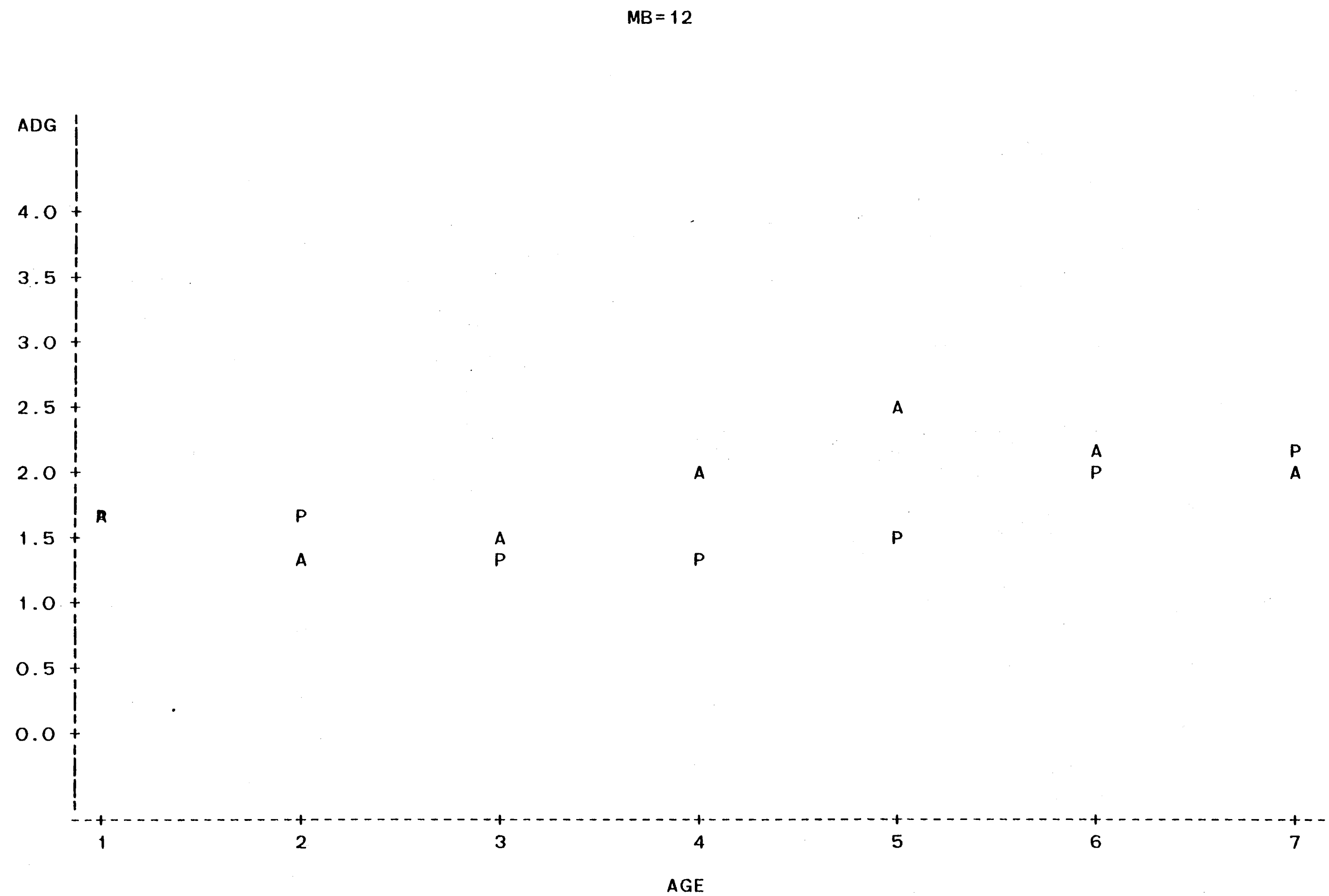


Figure 16. Predicted and Actual ADG by Months of Age

CHAPTER IV

COMPARISONS OF DIFFERENT MANAGEMENT PLANS USING MODEL PREDICTIONS

The purpose of this study is to simulate beef cow herd management systems and to predict the pounds of calf available for sale. Prices are not supplied in the model, since fertilizer, fuel, and livestock prices fluctuate frequently. After simulating the pounds of calf available for sale, a rancher can apply current prices to seed, fuel, fertilizer, labor, and calves and utilize what seems to be the most profitable alternative. Some of the frequently encountered production alternatives include: spring versus fall calving, percentage (if any) replacement heifers kept, type of pasture utilized, and the presence or absence of creep pasture for calves. Unless otherwise stated, calves are simulated to be out of mature cows, 50% steers, and 50% heifers, and to receive no creep pasture.

Results of the simulation of spring versus fall calving (Table XVI) show a rancher with native grass will have more pounds of calf to sell if cows calve in the spring. The difference in weaning weight between spring and fall calves is due both to the decreased milk production caused by low forage TDN content and limited forage intake by the calves. It should be remembered that in most native pastures some cool season forage is available, so predicted weights for fall born calves may be lower than expected.

TABLE XVI

WEANING WEIGHT (lbs.) OF SPRING VS.
FALL BORN CALVES

Month Born	Age Weaned (Months)		
	6	7	8
February	344	393	440 (Oct.)
March	359	408 (Oct.)	449
April	397 (Oct.)	423	449
September	318	344	378 (May)
October	296	328 (May)	383
November	284 (May)	333	384

If fall born calves are allowed unlimited access to wheat pasture by the use of creep gates, their weaning weights are much higher (Table XVII), despite the fact that cows' milk production is not increased.

Chessmore (1979) listed the results of two studies in which calves with access to small grains were about 100 pounds heavier at weaning time than calves not creep grazed. The average difference between creep grazed and not creep grazed in Table XVII is 91 pounds. This is lower than two of the studies reported by Chessmore, but higher than an expected average increase of 50 to 60 pounds, when compared to calves without access to green forage (Chessmore, 1979). If green pasture was available to non-creep grazed calves, their weaning weights would have been closer to the weights of creep-grazed calves. Calves born in the fall on fescue pastures have weaning weights (Table XVIII) similar to calves on native grass with access to small grain creep. Although fescue is not as palatable as wheat pasture, the cows have the benefit of the increased TDN value which, in turn, increases milk production. Bell et al. (1973) reports increased weaning weights of 100 pounds when cows and calves had access to fescue and clover grazing, when compared with cows and calves on bermudagrass only.

TABLE XVII

WEANING WEIGHT (lbs.) OF FALL BORN CREEP GRAZED CALVES

Cow Age (yrs.)	No Creep	Creep Grazed
Two	284	376
Three	305	396
Four	320	411
Five-Ten	333	424
Eleven Plus	313	405

[a]Average calving date, November 1, weaned at seven months.

Sudangrass is sometimes utilized for creep grazing in the summer. Comparisons of the weaning weights of spring born calves on bermudagrass, native tallgrass, and lovegrass (Table XIX) show that sudangrass creep pasture should increase gains by about 15 pounds. This figure is fairly close to reports by McCroskey et al. (1971) and Ray et al. (1972).

TABLE XVIII

WEANING WEIGHT (lbs.) OF FALL BORN CALVES ON FESCUE VS. NATIVE GRASS WITH SMALL GRAIN CREEP PASTURE[a]

Cow Age (yrs.)	Fescue	Native Grass With Creep
Two	399	398
Three	416	421
Four	436	435
Five-Ten	444	449
Eleven Plus	424	426

[a]Average calving date, October 1, weaned at seven months.

A short calving interval with an early, short calving season can have a dramatic effect on weaning weights at a given date. Differences in weaning weights at a given month (Table XX) show a substantial difference between calves born early in the calving season when compared with calves born late in the calving season. If calves are weaned in May, a calf born in September on bermudagrass pasture is simulated to weigh 71 pounds more than a calf born in November. Likewise, a calf born in February on native grass is simulated to weigh 62 pounds more than a calf born in April, if weaning time is in October. At 65¢ per pound, the per head price difference between calves born early and late in the calving season is $46.15 and $40.30 for fall and spring born calves, respectively, in this simulation. Differences in whole herd average weaning weights (Table XXI) for three different distributions of the calving season show how important it is to get calves on the ground early in the calving season.

TABLE XIX

WEANING WEIGHT (lbs.) OF CALVES ON VARIOUS SUMMER PASTURES WITH AND WITHOUT SUDAN-GRASS CREEP GRAZING[a]

Forage	Without Sudangrass	With Sudangrass
Bermudagrass	408	420
Native Tallgrass	408	422
Weeping Lovegrass	404	429

[a]Average calving date, March 1, weaned in October.

Another variable input in the model is percentage replacement heifers (cow age) kept. Results of simulations of four different herds differing only by cow age (Table XXII) show the effect young cows have on average herd weaning weights. However, the model does not adjust for any performance improvement due to selection of heifers.

TABLE XX

WEANING WEIGHT (lbs.) FOR A SPECIFIED WEANING DATE, GIVEN A CERTAIN MONTH OF BIRTH

Month Born	Month Weaned
	May[a]
September	377
November	306
	October[b]
February	440
April	378

[a]On bermudagrass

[b]On native tallgrass

Simulations of several different fall and spring calving management systems are shown in Table XXIII. Variable inputs influencing these simulations can include cow age, month born, and level of milk production.

TABLE XXI

WEANING WEIGHT (lbs.) BY SPECIFIED WEANING DATE WITH THREE HERD CLASSES[a,b,c]

	Born in Spring, Weaned in October
Herd A	425
Herd B	419
Herd C	413

[a]60% five to ten year old cows, 15% two year olds, 12% three year olds, 10% four year olds, and 3% older than ten years.

[b]Herd A: 67% of Herd A calves the first month of the calving season, and 33% calve the second month.

Herd B: 60% of Herd B calves the first month of the calving season, 30% the second month, and 10% calve the third month.

Herd C: 50% calve the first month, 30% calve the second month, and 20% calve the third month of the calving season.

[c]On native tallgrass.

TABLE XXII

SIMULATION OF WEANING WEIGHT (lbs.) WITH VARYING REPLACEMENT RATES

Herd Age[b]	Average Weaning Weight
A	415
B	422
C	425
D	411

[a]Born in spring on native tallgrass pasture and weaned in October.

[b]Herd age A: 15% two year olds, 12% three year olds, 10% four year olds, 60% five to ten year olds, 3% eleven year olds or older.

Herd age B: 12% three year olds, 10% four year olds, 67% mature cows, and 11% old cows.

Herd age C: 20% four year olds, 70% mature cows, 10% old cows.

Herd age D: 20% two year olds, 18% three year olds, 15% four year olds, and 47% mature cows.

TABLE XXIII

SIMULATION OF SEVERAL MANAGEMENT SYSTEMS[a]

Management System	Weaning Weight
Spring calving season	
Native tallgrass	408
Native tallgrass w/sudangrass creep	422
Bermudagrass	408
Bermudagrass w/sudangrass creep	420
Weeping lovegrass	404
Weeping lovegrass w/sudangrass creep	429
Fall calving season	
Native tallgrass	328
Native tallgrass w/wheat pasture creep	449
Native shortgrass w/wheat pasture creep	452
Bermudagrass	377
Fescue	444

[a]Spring born calves' average birth date is March 1, fall born calves' average birth date is October 1, calves are out of mature cows and weaned at 210 days.

CHAPTER V

SUMMARY AND IMPLICATIONS FOR FURTHER STUDY

Summary

The model is designed to simulate calf growth in Oklahoma. The purpose of this study is to contribute to a larger study which, when complete, should be able to simulate a complete cow/calf program in Oklahoma and help ranchers in predicting the outcome of management alternatives.

The equations are based on data from Oklahoma State University studies. Milk production depends on the total digestible nutrient content of the forage a range cow is on and on her genetic milking ability, called "milk class" in the model. A cow's "milk class" is assumed to be average for the breed (averages are based on data in Table II), unless specified otherwise. Age of cow adjustments for milk production are also based on data from Table II. Forage intake of young calves is based on the total digestible nutrient content of the forage, calf weight, and on the amount of milk the calf is receiving. Total digestible nutrient content and calf body weight have positive effects on forage intake, but higher milk intakes decrease forage intake. The California Net Energy Systems equations were modified to predict the growth of young calves. Adjustments are made for each sex on both maintenance and gain equations. The utilization of energy from milk is also adjusted, a reflection of the more efficient utilization of energy from milk than from forage, since milk does not pass into the rumen.

Data compiled by Brorsen (1980) for eight typical Oklahoma forages were used to simulate forage energy values. Calves may be born in any month and weaned at any time up to 240 days of age. Birth weights are assumed to be average for the breed unless otherwise specified. Birth weight is adjusted for age of dam by the Beef Improvement Federation's recommendations. Besides month of birth, birth weight, age of dam, type of pasture, and month weaned, user inputs can include level of milk production, percentage of steer or heifer calves, and the availability and type of creep pasture.

Areas for Further Study

The utilization of the energy in a calf's diet varies in relation to the amount of energy the calf is receiving. This model does not distinguish between the utilization of energy for a calf receiving 15 pounds of milk as opposed to a calf receiving only 8 or 10 pounds of milk. Further study into this relationship to determine adjustments for the varying efficiency of energy utilization would make the model more accurate.

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VITA 2

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