3-1982

# Prediction of postweaning subcutaneous fat deposition in feedlot steers

Kevin E. Jeske

To the Graduate Council:

I am submitting herewith a thesis written by Kevin E. Jeske entitled "Prediction of postweaning subcutaneous fat deposition in feedlot steers." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

W.T. Butts Jr, Major Professor

We have read this thesis and recommend its acceptance:

J.W. Holloway, H.A. Lasater

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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H. Alan Lasater

Accepted for the Council:

L. Evans Roth

Vice Chancellor
Graduate Studies and Research

X

# PREDICTION OF POSTWEANING SUBCUTANEOUS FAT DEPOSITION IN FEEDLOT STEERS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Kevin E. Jeske

March 1982

ACKNOWLEDGEMENTS

The author wishes to express his most sincere appreciation to those who served in providing him with guidance and instruction during his course of study. Persons to whom he is especially grateful include:

Dr. W.T. Butts, Jr., major professor, for his ability to recognize an original research problem and his ability to stimulate interest and thought toward seeking the solution. Also, for his friendship, guidance and support.

Dr. J.W. Holloway, committee member, for serving on his committee; but more importantly, for helping the author to appreciate the planning and exercise of original research.

Dr. H.A. Lasater, committee member, for serving on his committee, but more importantly, for his advice and instruction in statistical principles.

Dr. M.C. Crider, for his consciencious efforts in obtaining accurately, the data used in this study. Also, for his steady friendship, guidance and support throughout his course of study.

Dr. J.R. McCurley, for his assistance in overcoming the many programing obstacles encountered early in the analyses. Also, for his steady friendship, guidance and support throughout his course of study.

Cathy Livingston, for her diligence in the typing of this manuscript from the first draft to the final copy. More importantly, however, for her kindness and thoughtful consideration throughout his course of study.

Kathy, his loving wife, for standing by him in times of discouragement and for giving to him the added confidence necessary to fulfull his own objectives.

## ABSTRACT

Linear measurements of height, length, width and depth were obtained from 66 weanling feedlot steers of Angus, Hereford, Angus x Hereford and Hereford x Angus dams bred to Angus or Hereford sires. Ultrasonic fat estimates were obtained on a biweekly basis thereafter until the animals were slaughtered. Asymptotic curves were fitted through biweekly fat estimates up to 12 mm and extrapolated to predict levels of fat through 450 days postweaning. These curves were compared to curves that were fitted through all biweekly fat estimates. Deviations of the 12 mm curve from the lifetime curve were used in regression analysis. Weaning age was important ($P<.05$) in predicting deviations between the curves up to 20 mm. Fat estimates at weaning were related ($P<.05$) to deviations in postweaning days necessary to reach subsequent levels of fat on respective curves. Postweaning days necessary to reach 12 mm on the 12 mm curve was highly related ($P<.001$) to differences in the parameter estimates of the equations corresponding to the curves. Width at weaning was also highly related ($P<.001$) to these differences. Depth at weaning was related to a lesser extent ($P<.01$). $R^2$ for models predicting differences in parameter estimates ranged from 48 to 70%.

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# CHAPTER I

## INTRODUCTION

Beef producers are well acquainted with the relationship that exists between live-animal estimates of subcutaneous fat thickness and subsequent performance of the animal in terms of carcass traits such as yield and quality grade. Progress could be made in the industry if a mathematical model could be designed that would enable one to predict fat deposition in individual calves based on objective measurements on weanling animals.

Fitzhugh (1976) states that each component of an organism whether cell, tissue, organ or whole body, follows an inherent growth pattern that is influenced by the environment in which the pattern is expressed. Biological interpretability of parameters is dependent on understanding the interrelationships of genetics and environment. Therefore, when attempts are made to describe a growth curve for a particular trait it must be remembered that that growth curve represents a composite of several growth curves, one for each of the many components that contribute to that trait.

The objective of this study was to develop a technique that would utilize a minimal range of early postweaning subcutaneous fat estimates combined with weaning body measurements to predict fat thicknesses at ages beyond that range.

## CHAPTER II

## REVIEW OF THE IMPLICATIONS OF FAT IN CATTLE

### A. Biological Function of Fat

The biological function or role of fat in beef and dairy animals has been discussed by many researchers. Berg and Butterfield (1976) described fat as serving as an energy store providing animals with useable energy during periods of low food availability such as in drought situations or during the winter. Others have suggested that the outermost layer of fat is more important as an insulating layer against the cold, as suggested by Young and Dietz (1971). The findings of Pitts and Bullard (1968) lend support to this idea as the results of their study showed one particularly significant difference between arctic and tropic zone mammals. Total fat in the arctic mammals was comprised of a larger percentage of subcutaneous fat. However, Berg and Butterfield (1976) disputed the importance of fat as insulation and suggested that most native species in Northern climates obtain their insulation primarily from a thick hair coat rather than a fluctuating fat depot. Ledger (1959), after studying the differences in fat deposition between the Shorthorns of England and the Boran of East Africa, suggested that the degree of thermal tolerance of an animal was associated with its ability to deposit fat in areas other than in the subcutaneous depot. Explaining the inability of many Bos taurus cattle to achieve what are considered to be acceptable levels of fat for slaughter in the tropics, he proposed that animals in warmer environments will grow steadily until their fat levels begin to cause them "thermal embarassment." At that point, they decrease their grazing activity and consequently never reach desired levels of fat.

## B. Four Major Fat Depots

The four major fat depots are defined by Kempster et al. (1976) and Minish and Fox (1979). Subcutaneous fat is the most peripheral layer of fat located beneath the skin and adjacent to the connective tissue sheaths that cover the most peripheral muscle layer. Intermuscular fat is located between adjacent muscles in the carcass and includes the thin connective tissue sheaths that cover the muscles. Intramuscular fat, more commonly referred to as marbling, consists of the small flecks of fat that are located within muscle groups. Finally, KPH is a collective term for all fat in the pelvic area and that which surrounds the kidney and heart.

## C. Growth Rates and Relative Proportions Among Depots

Callow (1948) and Callow (1962) demonstrated that as cattle grow, the four major fat depots increase at different rates with subcutaneous fat having the highest growth impetus, causing it to increase at a slower rate. Johnson et al. (1972) studied fat deposition in 23 cattle representing three breeds. Subcutaneous and intermuscular fats increased to high proportions of total fat, but did so at different rates. Intermuscular fat rose quickly to 45-50% of total fat in 56 days while subcutaneous fat rose more slowly to about 29% in 270 days. Kempster et al. (1976) reported similar results in a study that examined 643 steer carcasses of 15 breed-type x feeding system groups. Intermuscular fat accounted for 50% of total fat in those carcasses followed by subcutaneous fat which accounted for about 30%. Similar findings were reported by Berg and Butterfield (1976) and Truscott et al. (1976).

Breed differences are noted in the research, especially between dairy and beef-type breed groups. Dairy-type breeds tended to deposit a higher proportion of their fat internally and a lower proportion subcutaneously than did beef-type breeds (Callow, 1961; Berg and Butterfield, 1976; Kempster et al., 1976; Truscott et al., 1976; Berg et al., 1978). At constant total fat weights, Kempster et al. (1976) observed that carcasses from Ayrshire and Ayrshire crosses tended to contain less subcutaneous fat and more intermuscular plus KPH fat than those from Friesian and beef-breed x Friesian crosses. Callow (1961) made comparisons between Friesians, dual-purpose Milking Shorthorns and Herefords. Results showed that Herefords had the highest proportion of subcutaneous fat, followed by the Shorthorns, with the Friesians having the least. Friesians and Angus were compared by Truscott et al. (1976). The proportion of intermuscular fat was the same in both breeds. Angus, however, were found to have a greater proportion of subcutaneous fat than Friesian. These findings were supported by Kempster et al. (1976) and Berg and Butterfield (1976), who observed the Angus breed to have markedly higher proportions of subcutaneous fats than other breeds. Moran and Holmes (1978), comparing three beef breeds, observed that at the mean weight of each breed, Charolais bulls had a significantly lower proportion of subcutaneous fat than either Angus or Hereford bulls.

Intermuscular and KPH fat have been found to achieve their maximum proportions earlier than subcutaneous fat (Callow, 1962; Johnson et al., 1972; Berg and Butterfield, 1976; Kempster et al., 1976). Kempster et al. (1976) noted, however, that growth coefficients for KPH fat were highly variable both within breed and between breed-type groups. KPH was reported to be the most variable depot followed by cod fat and subcutaneous fat, while intermuscular fat was the least variable. An inverse relationship was reported to exist between the rate of KPH deposition and the rate of intermuscular fat deposition.

Growth coefficients for fat have been shown to vary based on anatomical location in the live animal body. They are lowest in the distal limbs, increase centripetally on the limbs and increase toward the loin and rib area (Berg et al., 1978). Berg and Butterfield (1976) suggested that fat distribution may be related to local pressures that develop as growth occurs. In young animals the internal and intermuscular depots show little resistance toward growth. As these depots become filled there is increased resistance toward continued growth causing more of the surplus energy to be stored under the skin as subcutaneous fat. Their research indicated that there was an almost complete lack of subcutaneous fat in foetal calves. As they grew, it increased to a level of about 30% of total fat by the time the calves entered the early stages of fattening. They also noted that there was no substantial rise in intramuscular fat with advanced fattening. In studies where cattle were fed to extremely high levels of fat, Kempster et al. (1976) reported that subcutaneous fat actually exceeded intermuscular fat in total amount.

## D. Relationship Between Lean, Fat and Bone

Guenther et al. (1965), comparing the deposition of lean, fat and bone in 36 Hereford feeder steers, found that fat accumulation was most rapid during the latter half of the feeding period and noted that the sharpest increase in fat accumulation occurred after the lean production had begun to subside. Steers at that point had an average weight of 355 kg and were about 11 months old.

Of the three major tissues, bone is considered to have the first demand on all available nutrients (Berg and Butterfield, 1968). It is the earliest tissue to develop followed by muscle and finally fat. "Early developing" refers to the fact that bone represents a higher proportion of the carcass at birth than at later stages. Analysis of tissue percentages throughout growth confirmed Guenther's (1965) observations that muscle percentage first increases and then, as the fattening phase begins decreases. Fat tissue as a percentage of all tissue increases continuously while bone percentage decreases (Berg and Butterfield, 1968).

Plane of nutrition has been shown to have an effect on the proportion of fat relative to the other tissues (Guenther et al., 1965; Berg and Butterfield, 1968; Nour et al., 1981). The latter study compared corn and corn silage diets, concluding that at a given rib weight class, the higher the level of nutrition the greater the percentage of fat accumulation relative to bone.

Berg and Butterfield (1966) observed that the relative growth of bone, muscle and fat under a high plane of nutrition was reversed under conditions of semi-starvation. Tissues which were the last to be formed were the earliest to be depleted. Fat and muscle were depleted first and there was a markedly lesser effect on bone. Compensation led to the recovery of normal proportions in most cases. These observations were consistent with those of Yeates (1964), Hight (1966) and Everitt and Jury (1977). The latter study involved twenty-one sets of identical twin Jersey and Friesian x Jersey cross bull calves ranging from 5 to 11 days of age. The results of their study showed that cattle are most susceptible to permanent stunting through short periods of underfeeding in late prenatal and early postnatal life. Their work was even more specific in showing that the critical period of nutritional restriction may be as short as four weeks after birth with an effect of increasing magnitude if the period of underfeeding was extended. Jury et al. (1980) indicated that steers and heifers can not be relied upon to exhibit compensatory growth after weaning at 3-4 months of age if they are reared under poor environmental conditions prior to weaning.

E. Relationship Between Fat Thickness and Live Weight

Carcass weight has been reported to exhibit a sigmoid curve with its point of inflection approximating the stage of increased fat deposition between 12 and 18 months of age (Berg and Butterfield, 1968). Truscott et al. (1980) showed that fat depth variation in any one animal was highly related to live weight and the weight-adjusted common logarithm of fat depth at any point; thus, allowing an assessment of an individual's future fat depth status. They also found that correlations between fat depth and age were generally lower than those between fat depth and weight.

Brown et al. (1980) observed seasonal changes in weight and fatness in mature Angus cows pastured over a 3-year period. Both weight and fatness were observed to decrease during the spring and increase in the fall. However, Truscott et al. (1980), in a similar study involving Hereford bulls, steers and heifers, observed fat depth to increase during the spring and decrease in the late fall and winter.

Moran and Holmes (1978) reported that Angus had the greatest rate of increase in fat thickness with increased live-weight. When compared at the mean live-weight for each breed, Charolais bulls had significantly lower fat measurements than either Angus or Hereford bulls.

## F. Economic Aspects of Fat

Accepted levels of subcutaneous and intermuscular fat vary between marketing areas (Kempster et al., 1976). This variablity is caused by the amounts of each type thought to be necessary to insure good eating quality, but it is possible that desirable fat levels may be established to suit the breed-type or kind of animal that is best adapted to survive in the environment where that market exists (Kempster et al., 1976). Feeder cattle today are traded largely upon the basis of weight, breed-type and subjective evaluations of form; all of which serve as indicators of what is to be expected of the cattle in terms of subsequent performance (Butts et al., 1980). Fowler (1965) listed several of the factors that determine the economic worth of a slaughter animal. They include: 1) live-weight of the animal, 2) dressing yield (percent), 3) cutability, 4) current value of meat and meat by-products.

Since 1965, the USDA has provided yield grading standards which serve as an additional marketing tool for those who buy or sell beef carcasses (Minish and Fox, 1979). Quantitative considerations in grading are based on the percentage of boneless, closely-trimmed retail cuts from the round, rib and chuck. Yield grades are determined by using the following four factors: 1) fat thickness (subcutaneous), 2) rib-eye area, 3) percent KPH and 4) carcass weight. Quality grades are based on two factors: 1) degree of marbling and 2) maturity of the carcass (Minish and Fox, 1979; Abraham et al., 1980).

Extensive research has been done examining the association between fat thickness and yield grade (Davis et al. 1964; Crouse and Dikeman, 1976; Butts et al., 1977; McLemore and Butts, 1979; Minish and Fox, 1979; Butts et al., 1980). According to Abraham et al. (1980), a measure of external fat thickness is the most important single factor affecting the yield of retail cuts from beef carcasses.

Berry et al. (1973) selected 100 steer carcasses which exhibited wide variation in carcass length. Correlation coefficients between carcass fat thickness and percent boneless retail cuts ranged from -.52 to -.76. Cross et al. (1973) studied 82 carcasses including purebred Angus, Hereford, Charolais and Brahman x British crosses. The correlation coefficients between a single carcass fat measure and percent retail cuts was -.73. Breed differences were not examined with respect to this relationship. Kauffman et al. (1975) examined 22 market weight cattle including Angus, Charolais, Hereford and Brown Swiss. Fat thickness was adjusted according to the standards set forth by the USDA (1965). Fat-standardized muscle was defined as muscle standardized to contain 10% fat. The correlation between adjusted fat thickness and percent fat-standardized muscle was -.57. Crouse and Dikeman (1976), in an extensive research project, studied the carcasses of 1,121 steers that were the progeny of Hereford or Angus dams mated to Hereford, Angus, Charolais, Simmental, Limousin, South Devon or Jersey sires. Correlation coefficients for fat thickness and adjusted fat thickness related to percent retail product were -.68 and -.79, respectively. Similar coefficients of -.79 and -.82, respectively, were reported by Abraham et al. (1980) studying 280 beef carcasses from steers, heifers and cows.

G. Subjective and Objective Estimation

Fowler (1965) described some visual characteristics of external fat distribution. It was evidenced by the fulness and apparent thickness of fat covering the back loin, rump, ribs and round. Steers with excessive fat had full pendulous briskets; thick and soft fat in the foreflank, crops and over the shoulder; deep and soft hindflanks; and had heavy deposits of fat at the tongueroot, in the twist and in the cod. These excesses of fat were most apparent when the animals walked. While these indicators were helpful in evaluating condition, objective estimation was more desirable for increased accuracy.

Price et al. (1958) described the use of the Sperry Reflectoscope, an ultrasonic instrument used to estimate the depth of subcutaneous fat and also the depth of lean muscles along the top of the back of live hogs and cattle. He reported that such instrumentation had been successful in estimating fat thickness in hogs and that lesser success had been achieved in beef cattle.

Using a Branson Sonoray Model 5, Meyer et al. (1961) estimated the area of the rib-eye muscle and fat thickness of 202 live cattle. Measurements were taken on both sides of the midline at the 12th - 13th rib. Correlation coefficients between live animal estimates and subsequent carcass measurements were generally higher for rib-eye area than for fat thickness with ranges of .58 to .89 and .11 to .63, respectively. Davis et al. (1964) used the Model 4 in their study involving 60 Hereford feedlot steers. Ultrasonic estimates of the loin-eye area and fat thickness were highly correlated with the corresponding carcass measurement. The correlation coefficients were .87 and .90, respectively. Both were also significantly correlated with carcass grade. Brown et al. (1964) conducted similar research using a Branson Model 52 to estimate the rib-eye area and fat thickness of 92 young Hereford and Angus bulls. Correlation coefficients between live animal and carcass measurements were .78 for rib-eye area and .46 for fat thickness. Correlations between ultrasonic measurements and performance traits were generally low and inconsistent. Davis et al. (1966) reported even greater success using the Model 52 to measure the same characteristics on 17 heifers and 10 bulls. Highly significant correlations between live animal estimates and carcass measurements for rib-eye area and fat thickness were observed ranging from .86 to .91 and from .64 to .85, respectively.

A total of 120 cattle were scanned by Watkins et al. (1967), using a Branson Model 510. In their study, Methylene blue was hypodermically injected under the hide of 35 cattle along the pathway of the transducer to make possible the post-mortem identification of the exact path traveled by the transducer. Correlation coefficients between ultrasonic estimates and carcass measurements were .56 and .90 for loin-eye area and fat thickness, respectively. Both were considered to be highly significant.

Twelve groups of cattle of various breeds totaling 785 head were used in a study conducted by McReynolds and Arthaud (1970) to determine the best location from which to obtain ultrasonic estimates. All estimates were made at the 12th - 13th rib, but were taken at positions 5, 9 or 13 cm from the midline. Correlations between estimated fat and actual fat were .14, .38 and .55 at positions of 5, 9 and 13 cm from the midline, respectively, suggesting that the 13 cm position was superior.

## H. Errors Associated With Ultrasonic Estimation

Ultrasonic estimation has been tested for repeatability by several researchers. Brown et al. (1964) obtained correlation coefficients of .91 and .94 between independent interpretations of the ultrasonic scan for rib-eye area and fat thickness, respectively. McReynolds and Arthaud (1970) reported correlation coefficients of .82 and .86 for repeated fat estimates at the 9 and 13 cm positions, respectively. Both studies suggested that greater correlations might be expected when estimates have been repeated due to greater refinement in technique gained through increased experience.

With repeatability so high for ultrasonic measurement, it was natural to wonder why correlations between live-animal estimates and carcass measurements varied among different studies. Temple et al. (1965) observed that very firm or fat animals were difficult to sonoray. Watkins et al. (1976) found fat thickness to be overestimated in cattle with less than 20 mm and underestimated in cattle with greater than 20 mm. However, they stated that fat thickness was more accurately estimated ($r = .84$; $P<.01$) in fatter animals than in those with less than 20 mm ($r = .55$; $P<.01$). McReynolds and Arthaud (1970) made the same observations with respect to over- and underestimation when working with extremely fat or thin cattle.

Davis et al. (1964) observed that muscle and fat configurations with respect to each other differed greatly between the live animal and on-rail carcass. With the rail hook at the hock joint, the weight of the carcass caused a pivoting of the carcass at the femur head. The foreshank had a tendency to drop forward, pivoting to a large extent at the shoulders. The combined effect of these two motions was the compression at both ends of the *longissimus dorsi* muscle, resulting in a shorter more compact muscle that tended to be expanded in cross-sectional area near the 10th - 13th rib section. Temple et al. (1965) reported that the location that was scanned on the live-animal may have shifted as much as 5 cm in relation to the skeleton when the carcass was hung on the rail.

Fat removed with the hide in skinning was reported to have produced differences of up to 5 mm between estimated and actual fat thickness (Temple et al., 1965). These differences were also observed in separate studies conducted by Brackelsberg et al. (1967) and McReynolds and Arthaud (1970).

Interpretation errors have arisen from failure to identify hide, fascial tissue, fat and muscle boundaries. Temple et al. (1965) reported correlations between interpreters varying from .61 to .94 for fat thickness and from .61 to .91 for rib-eye area. McReynolds and Arthaud (1970) reported that it was often impossible to determine which signal should be read and the operator was forced to make a decision based on his own judgement. Davis et al. (1966) reported similar observations, finding highly significant differences between operators.

Changes in line voltage to the unit have caused variation in the calibration ratios and even when a constant voltage regulator was used calibration ratios varied during operation time (Temple et al., 1965).

### I. The Logistic Equation

The logistic curve is perhaps the most widely used mathematical curve in biological investigations of growth of populations and of organic growth in plants and animals (Nair, 1954). Stoodley et al. (1980) described the behavior of the curve in relation to growth. Initially, growth is slow, then it increases exponentially until it reaches a point where the nearly linear growth is followed by a "slackening off," after which it reaches a maximum. The logistic curve may be written

$$Y_t = \frac{k}{1 + be^{-at}} ,$$

where a, b and k are constants or parameters to be estimated from the observed data ($t_i$, $y_i$) for i = 1, 2...N and t is a time scale beginning at zero. An equation of this type has uppper and lower asymptotes, is sigmoid in shape and has a point of inflection located midway between the two asymptotes (Nair, 1954).

There are many variations of the basic model described by Nair (1954) and these were discussed in greater depth by Nelder (1961) and Fitzhugh (1976). Some of the more commonly encountered variations include the Gompertz Curve, the Bertalanffy Equation, Brody's Curve and Richards Curve.

One version of the logistic equation is described by Daniel and Wood (1971) and is of the form

$$Y_t = \frac{1}{\beta_1 + \beta_2 e^{-\beta_3 t}} ,$$

where $\beta_1$, $\beta_2$ and $\beta_3$ are constants, or parameters to be estimated from the observed data ($t_i$, $y_i$) for i = 1, 2...N.

The curve for this modified form still has upper and lower asymptotes, but has a special relationship between $\beta_1$ and the upper asymptote ($Y_m$). The relationship is inverse such that:

$$Y_m = \frac{1}{\beta_1} .$$

In other words, the maximum value of $Y_t$ for this equation fit through any set of data points is equal to the reciprocal of the value of $\beta_1$. The point of inflection is still located midway between the two asymptotes, but the relationship between $Y_m$ and $\beta_1$ introduces a certain amount of control to curve-fitting (Daniel and Wood, 1971).

# CHAPTER III

# PREDICTION OF POSTWEANING SUBCUTANEOUS FAT DEPOSITION IN FEEDLOT STEERS: TECHNIQUE DEVELOPMENT

## A. Introduction

The material presented in this chapter describes the approach that was used in searching for and developing a technique that would adequately predict postweaning fat deposition in feedlot steers using a minimum of early postweaning subcutaneous fat estimates, combined with weaning body measurements.

The analysis is subdivided into six phases of development, the first being the most preliminary and the sixth being the final result. The results of each phase are discussed separately, for it was the results of each individual phase which determined the approach in subsequent phases.

## B. Materials and Methods

Source of data. Postweaning data were collected from 48 steer calves in a study conducted over two years (1978-1979). The mating system used to produce the calves consisted of breeding straightbred Angus or Hereford sires to mature (4 to 13 years of age) Angus or Hereford dams. Therefore, the calves were straightbred Angus (AA), straightbred Hereford (HH) or one of the two reciprocal crosses (AH or HA). All sires and dams used were considered to be typical of those maintained in the herds of the Tennessee Agricultural Experiment Station.

Calving occurred on pasture in the spring each year (January - March).

About six weeks later 24 cow-calf pairs with male calves were selected at random. Following selection, the pairs were randomly assigned to individual paved lots that were designed to allow the calves access to the cow's feed and also to their own creep feed.

The pairs were confined to their assigned pens during the day. At night, the cows and calves were transferred to dirt exercise lots. Three weeks subsequent to being assigned to specific pens, all calves were castrated. The calves remained with their dams until weaning, which occured around 281 days of age. The data from six calves were deleted from the analyses due to the death or serious illness incurred by either the calf or its dam. This left a total of 42 calves to be studied.

Calves consumed alfalfa pellets (alfalfa, aerial pt, dehy, grnd, pelleted, mn 17 prot, IRN 1-00-023) as a creep feed from about 80 days of age until they were weaned. After weaning, calves were provided corn silage _ad libitum_ (IRN 3-08-154) and 2.73 kg of a concentrate mixture on a daily basis. The concentrate mixture consisted of 86% corn (IRN 4-02-914) and 14% cottonseed meal (IRN 5-01-621). This diet was fed for about 160 days. Calves were subsequently offered a high energy diet _ad libitum_ consisting of 59% corn (IRN 4-02-915), 10% cottonseed meal (IRN 5-01-621), 20% cottonseed hulls (IRN 1-01-599), 5% molasses (IRN 6-02-632), 2% animal fat (IRN 4-00-409), 0.5% ground limestone and 0.5% salt.

_Data collection._ Birth and weaning weights were recorded for all calves included in the study and weights from that point were collected on a biweekly basis. Each time weights were recorded, an ultrasonic estimate of the subcutaneous fat thickness was made using a Branson Model 12 Sonoray.

Estimates were made over the *longissimus dorsi* muscle between the 12th and 13th ribs, about three-fourths of the distance between the dorsal midline and the distal edge of the *longissimus* muscle. At weaning, linear body measurements were obtained for each calf. These measurements included height (WNHT), width (WNWID), length (WNLEN) and depth (WNDEP). Calves were slaughtered at an average age of 611 days, ranging from 555 to 669 days and an average estimated fat thickness of 21 mm, ranging from 16 to 35 mm.

*Analysis of data: phase I.* Preliminary analysis was begun by plotting the observed fat estimates over the age at which each estimate was obtained. Two separate second order polynomials were fitted through the observed points for each calf. The models included linear and quadratic age (AGE and AGESQ) and linear and quadratic weight (CAWT and CAWTSQ), respectively. Additionally, a second data set was created that contained only those observed fat estimates obtained after the calves were put on the high energy diet. The same models were fitted through the limited range of observations. $R^2$ values were examined to detect any differences in fit caused by the two different feeding regimes.

*Analysis of data: phase II.* The lack of control and limited ability of second order polynomials to predict reasonable estimates of fat beyond the range of the data was reason to consider the modified logistic equation described by Daniel and Wood (1971):

$$Y = \frac{1}{\beta_1 + \beta_2 e^{-\beta_3(t)}} ,$$

where Y represented fat thickness, t represented calf age and $\beta_1$, $\beta_2$ and $\beta_3$ represented parameters to be estimated. For use in this equation it was necessary to convert calf age (AGE) to postweaning age (PWAGE) so that the time scale began with zero days. PWAGE was calculated by subtracting WNAGE from all values of AGE. In early experimentation with this model it was found desirable to fix $\beta_1$ at a constant value. A value of 0.02 was arbitrarily selected and because of the nature of the equation, that value resulted in forcing all curves to level off at 50 mm of fat. The rate and postweaning age at which the maximum occurred was determined by the estimates obtained for $\beta_2$ and $\beta_3$ .

Initial estimates for $\beta_2$ and $\beta_3$ were required in order to begin the nonlinear iteration procedures for obtaining best estimates. The Method of Selected Points, outlined by Nair (1954) was used. It involved selecting three points that covered the entire range of the data and were equidistant on a time scale with an initial value of zero. With these initial estimates, the nonlinear iteration procedures available in SAS (1979) were utilized in solving for the best estimates of $\beta_2$ and $\beta_3$ . Using these generated estimates, regression lines were plotted through the observed data points. Specific calves were selected from the data set to demonstrate the effects of varying the magnitude of specific beta values, while holding all others constant. This was done in order to learn more about the relationship between beta values and the curves that they generated.

Analysis of data: phase III. All observations in the data set that contained ultrasonic estimates that were greater than 12 mm were deleted. The logistic function, with $\beta_1$ fixed at 0.02 was fitted through those observations that remained utilizing the same nonlinear iteration procedures described in phase II. Using these generated estimates, regression lines were plotted through the observed points up to 12 mm and were then extrapolated to predict fats beyond that range. These lines were overlayed and compared to the regression lines that had been obtained using the full range of data. Plots for each calf were then evaluated on the basis of how closely the limited-range curve estimated the full-range curve.

Analysis of data: phase IV. Twelve new variables were created for each calf based on the observed differences in the two curves. Equations corresponding to the limited-range curves were solved algebraically to determine at what age each calf was predicted to reach levels of 12, 15, 20 and 30 mm fat. Those ages were then substituted into the equations corresponding to the full-range curves to determine the corresponding levels of fat on those curves at those ages. Four new variables were created that expressed the difference in fat between the two curves when fat was 12, 15, 20 and 30 mm on the limited-range curve. These variables were: FATDIF12, FATDIF15, FATDIF20 and FATDIF30, respectively. Next, the first derivative was taken at each of these points to determine the slope of the curve at those points. Difference in slope between the two curves at corresponding ages were then calculated and called DERDIF12, DERDIF15, DERDIF20 and DERDIF30. The final four variables to be examined were created by calculating the differences in postweaning days necessary to reach fat levels of 12, 15, 20 and 30 mm between respective curves. These variables were: AGEDIF12, AGEDIF15, AGEDIF20 and AGEDIF30.

Each of the twelve newly created variables were regressed over the linear body measurements obtained for each calf at weaning. Linear, quadratic and interaction terms were included in prediction models for the twelve newly created variables. Predicted differences at each level of fat (12, 15, 20, 30) were then added to appropriate expressions in the logistic equation for the limited-range curve to yield adjusted fats (AJFATxx). First, the fats were adjusted using only FATDIFxx:

$$\text{AJFAT} = \frac{1}{.02 + \beta_2' e^{-\beta_3' \text{ (PWAGE)}}} + \text{FATDIFxx} \quad ,$$

where $\beta_2'$ and $\beta_3'$ were beta values generated for the limited range curve.

Secondly, the fats were adjusted using only DERDIFxx:

$$\text{AJFATxx} = \frac{1}{.02 + \beta_2' e^{-(\beta_3' + \text{DERDIFxx}) \text{ (PWAGE)}}}$$

Thirdly, the fats were adjusted using only AGEDIFxx:

$$\text{AJFATxx} = \frac{1}{.02 + \beta_2' e^{-\beta_3' \text{(PWAGE + AGEDIFxx)}}}$$

Adjusted fats for each calf using each of the three adjustment techniques were overlayed with both; the full-range and limited-range curves.

Adjusted fats were also obtained by using various combinations of these adjustment techniques. These results were plotted as well to examine the benefit of multiple adjustment.

Analysis of data: phase V. In an attempt to simplify the adjustment process, a method for adjusting the beta values in the limited-range curve was investigated. $\beta_1$ in both equations (full and limited) remained constant at 0.02, but the deviations between $\beta_2$ and $\beta_3$ between respective curves were determined and used as new variables ($\beta$2DEV and $\beta$3DEV). Models were then developed to predict these deviations based on measured calf traits at weaning and the predicted postweaning days at which a fat thickness of 12 mm was obtained on the limited-range curve (PWDAYS12). Adjusted equations were of the form

$$\text{AJFATxx} = \frac{1}{.02 + (\beta_2' + \text{P}\beta\text{2DEV})e^{-(\beta_3' + \text{P}\beta\text{3DEV})(\text{PWAGE})}} ,$$

or more simply,

$$\text{AJFATxx} = \frac{1}{.02 + \text{AJUST}\beta\text{2}e^{-\text{AJUST}\beta\text{3 (PWAGE)}}} ,$$

where AJUST$\beta$2 was equal to the sum of $\beta_2'$ (limited-range curve) and predicted $\beta$2DEV, and AJUST$\beta$3 was equal to the sum of $\beta_3'$ (limited-range curve) and predicted $\beta$3DEV.

The effectiveness of the adjusted equation was evaluated by plotting the continuous adjusted curve overlayed on the full- and limited-range curves.

Analysis of data: phase VI. The entire data set was re-examined once again, lifting the imposed restriction on $\beta_1$. All three parameters ($\beta_1$, $\beta_2$, $\beta_3$) were allowed to iterate as new estimates were obtained. The mean estimate for $\beta_1$ was calculated and used as a replacement for the value of 0.02 that had been arbitrarily selected for use in all previous analyses. Using the new value for $\beta_1$ nonlinear regression techniques were utilized once again to generate estimates of $\beta_2$ and $\beta_3$ for the full-range equation and the limited-range equation. New values were calculated for $\beta$2DEV and $\beta$3DEV and analysis from that point on was the same as described in section V.

## C. Results and Discussion

Phase I. Plots of the observed fat estimates over calf age indicate that a curvilinear model should be used in regression analysis. The selected models which included AGE, AGESQ, CAWT and CAWTSQ explained 91.8 and 92.6% of the variation, respectively over the entire postweaning period. They explained 88.3 and 91.0%, respectively over the observations obtained during the high energy diet period alone. Finding no justification for separating the two feeding periods in terms of goodness of fit, the entire postweaning period was included for all subsequent analyses.

Although the $R^2$ values were very high for these models, it was observed that the models had a major weakness in that if the curves were extended to predict fat levels beyond the range of the data, they would yield inaccurate and unreasonable estimates. It was hypothesized that fat deposition would increase at an increasing rate to a point where it would begin to increase at a decreasing rate and eventually level off. Thus, fat would not be expected to increase to an infinate level as a second order polynomial suggests. Under this hypothesis, the modified logistic function described by Daniel and Wood (1972) seemed to have potential application.

Phase II. Fixing $\beta_1$ in the generalized equation at a value of 0.02 modified the form of the equation to

$$Y = \frac{1}{.02 + \beta_2 e^{-\beta_3 (x)}}$$

with $\beta_2$ and $\beta_3$ the only two parameters to be estimated. Convergence criterion were met using any of the three nonlinear iteration methods available to SAS (1979). $R^2$ using the logistic model was increased to 97.4%. Mean parameter estimates for $\beta_2$ and $\beta_3$ are presented in Table 1.

Manipulation of $\beta_2$ and $\beta_3$ for selected calves demonstrated the influence of each on the resultant curve. It was confirmed that $\beta_1$ was responsible for determining the leveling point and that there was a reciprocal relationship between the two (i.e., $\beta_1 = \frac{1}{Y_m}$ ). $\beta_2$ was determined to exert most of its influence on the lateral displacement of the curve with respect to observed data points. Larger values of $\beta_2$ had the effect of shifting the curve to the right without affecting the slope. $\beta_3$ was determined to exert most of its influence on the slope of the curve with larger values of $\beta_3$ resulting in greater slope. The next analysis was conducted to determine how well curves fitted only through data points up to 12 mm would approximate those fitted through the entire range of the data.

There were three major reasons for selecting the 12 mm level as the termination point. First of all, it seemed most practical to attempt to minimize that point as much as possible. In applications, it would be most efficient to obtain the least amount of data necessary to adequately describe the curve. Secondly, the observed ultrasonic fat estimates in this study ranged from 1 - 35 mm. Selecting a termination point at 12 mm allowed most calves to have at least six data points beyond that point, providing enough points with which to make comparisons. Finally, the third reason for selecting this point was the availability of data in a related study that involved large numbers of feeder cattle for which ultrasonic fat estimates were obtained up to 12 mm. Application of the results obtained from this study to that data set would enhance the usefulness of the latter data in modeling the consequences of varying slaughter points.

Phase III. $R^2$ for the logistic curve fit through the limited range of

TABLE 1

DESCRIPTIVE STATISTICS OF PARAMETER ESTIMATES IN THE FULL-RANGE AND LIMITED-RANGE CURVES: 1978-1979 [$\beta_1$, $\beta_1' = 0.02$]

| Parameter | N | Minimum | Maximum | Mean |
|---|---|---|---|---|
| $\beta_2$ | 42 | 0.45696160 | 3.98567435 | 1.18177769 |
| $\beta_2'$ | 42 | 0.29928953 | 2.63668695 | 0.75050718 |
| β2DEV[a] | 42 | -0.94810077 | 3.40156170 | 0.43127051 |
| | | | | |
| $\beta_3$ | 42 | 0.00819655 | 0.01577123 | 0.001170748 |
| $\beta_3'$ | 42 | 0.00481197 | 0.01619599 | 0.00298979 |
| β3DEV[b] | 42 | -0.00218772 | 0.00972572 | 0.00298979 |

[a]β2DEV = $\beta_2 - \beta_2'$.
[b]β3DEV = $\beta_3 - \beta_3'$.

data averaged 95.8. When the curve was extrapolated beyond 12 mm, however, the agreement between the full-range curve and limited-range (12 mm) curve was variable. Mean parameter estimates for the limited-range curve ($\beta_2'$ and $\beta_3'$ ) are shown in Table 1. For some calves the observed differences between the curves were small, but for others they were large. Greater refinement was necessary. Increasing the termination point to a level greater than 12 mm would have improved the agreement between the curves, but doing so would have compromised our goal of minimizing the amount of data needed to predict fat deposition. Also, the number of data points beyond the termination point would have been reduced, reducing the effectiveness of comparisons. Instead, several new variables were created based on the observed differences between respective curves generated for each calf. These variables were FATDIF, DERDIF and AGEDIF, described in phase IV.

Phase IV. Descriptive statistics of the linear body measurements obtained at weaning are shown in Table 2. These traits were regressed over FATDIF, DERDIF and AGEDIF. For FATDIF, analysis including year and breed effects indicated that year was nonsignificant ($P<.05$), and breed was significant ($P<.05$) only for FATDIF30. WNAGE was important ($P<.05$) in models predicting FATDIF12, 15, 20. Removing year and breed caused WNAGE to become significant ($P<.05$) for all four levels of fat. The effect of WNDEP increased from the lower levels of fat upward, but achieved statistical significance only for FATDIF30.

Including quadratic terms and interactions with or without year and breed effects, did not improve the predictability of FATDIF at any level. Overall $R^2$ for models containing only WNAGE and WNDEP to predict FATDIF12, 15, 20,

TABLE 2

DESCRIPTIVE STATISTICS OF CALF VARIABLES: 1978-1979

| Variable | N | Minimum | Maximum | Mean | SD | Variance | CV |
|---|---|---|---|---|---|---|---|
| WNWT (lbs) | 42 | 282 | 622 | 478.8 | 63.3 | 4005.6 | 13.2 |
| WNDEP (cm) | 42 | 29.5 | 45.1 | 38.16 | 4.22 | 17.82 | 11.06 |
| WNWID (cm) | 42 | 20.7 | 38.6 | 30.98 | 4.14 | 17.12 | 13.35 |
| PWDAYS12 (days) | 42 | 203 | 361 | 269.3 | 39.4 | 1551.9 | 14.6 |
| WNAGE (days) | 42 | 243 | 308 | 280.7 | 16.2 | 260.8 | 5.8 |
| WNFAT (mm) | 42 | 1 | 3 | 2.1 | 0.7 | 0.5 | 33.3 |
| WNHT (cm) | 42 | 75.2 | 99.3 | 89.46 | 5.40 | 29.17 | 6.04 |
| WNLEN (cm) | 42 | 80 | 124 | 97.6 | 7.0 | 48.5 | 7.1 |

30 were 23, 30, 36 and 41%, respectively.

Analysis of variance of DERDIF showed year to be nonsignificant (P>.05) and breed to be significant (P<.05) only for DERDIF30. No other individual components of variance were statistically significant in these models. Removing year and breed increased the importance of WNAGE and WNDEP, but neither were significant (P>.05).

Models were not improved by including quadratic terms and interactions, with or without year and breed effects. Overall $R^2$ for models containing only WNAGE and WNDEP to predict DERDIF12, 15, 20, 30 were 24, 32, 33 and 31%, respectively.

For AGEDIF, analysis of variance including year and breed effects showed year to be nonsignificant (P>.05) and breed significant (P<.05) for all levels of fat. WNFAT was related (P<.05) to AGEDIF30. Removing year and breed increased the importance of WNAGE and WNDEP. WNAGE became significant (P<.05) for all levels of fat, while WNDEP was significant (P<.05) only at AGEDIF30.

Models were not improved by including quadratic terms and interactions, with or without year and breed effects. Overall $R^2$ for models containing only WNAGE and WNDEP to predict AGEDIF12, 15, 20, 30 were 29, 35, 40 and 43%, respectively.

Adjusting the logistic equation for the limited-range curve using differences in the curve as related to calf traits at weaning improved the predictability of that curve. Adjustments on the basis of predicted AGEDIF or predicted FATDIF alone were generally more effective than adjustments on the basis of predicted DERDIF. However, predicted AGEDIF was generally more effective than either of the other two.

Adjusted fats (AJFAT) obtained using predicted AGEDIF were generally within 4 mm of those on the full-range curve. Using combinations of two or more adjustments were unsuccessful. Gross error in adjusted fats resulted, caused by overadjustment.

Overall, the results obtained in this analysis were encouraging, but the cumbersome method of adjusting fat at specific points needed improvement. There was a need to develop an adjustment technique that could be used in as general a way as possible. A single adjustment for $\beta_2'$ and $\beta_3'$ , based on calf traits at weaning, seemed to be a plausable alternative.

<u>Phase V</u>. Mean parameter estimates and beta-value deviations (β2DEV, β3DEV) between respective curves are presented in Table 1, and were found to be related to certain calf traits as well. Analysis of variance of β2DEV including year and breed effects indicated that year and breed were both nonsignificant ($P>.05$). PWDAYS12 was highly significant ($P<.001$), but no other variables were statistically significant ($P>.05$). Quadratic terms and interactions did not improve $R^2$. WNWID was significant ($P<.05$) in a model for predicting β2DEV that included WNAGE, WNFAT, WNHT, WNWID and PWDAYS12. PWDAYS12 was highly significant ($P<.001$) and the overall $R^2$ was 43%.

Analysis of variance of β3DEV including year and breed effects indicated that year and breed were both nonsignificant ($P>.05$). PWDAYS12 was highly significant ($P<.001$) and WNWID was important ($P<.02$). Models containing quadratic terms and interactions showed no improvement. In a model containing WNAGE, WNDEP, WNHT, WNWID and PWDAYS12 to predict β3DEV both PWDAYS12 and WNDEP were highly significant ($P<.001$), and the overall $R^2$ was 64%.

Plots were generated using the beta adjustments predicted from the best five-variable model for each beta deviation. The adjusted curves generally approximated the full-range curves, with adjusted fat levels being generally within 4 or 5 mm of the full-range curves. Larger deviations were observed, however, for some calves at greater postweaning ages.

The final analysis was carried out in the same manner as the present analysis except that a new value for $\beta_1$ , i.e., the mean value of $\beta_1$'s estimated from the complete curves, was used as described in phase VI of the Materials and Methods section.

Phase VI. When all three parameters in the logistic equation ($\beta_1$, $\beta_2$, $\beta_3$) were allowed to vary and nonlinear regression was performed over the entire range of the data for each calf, the mean $\beta_1$value that was estimated was 0.0072978. The mean $R^2$ for the model was 98%. Holding $\beta_1$ fixed at 0.0072978 meant that all curves would level off at 137 mm (about 5.4 inches). This was not considered to be totally unreasonable. It was certainly better, in theory, than suggesting an infinate level.

Substituting the new value for $\beta_1$ into the equations over the full- and limited-range, corresponding $R^2$ of 98 and 96% resulted. Mean values for $\beta_2$, $\beta_2'$, $\beta_3$ and $\beta_3'$ resulting from this substitution are presented in Table 3.

Analysis of variance showed PWDAYS12 to be highly significantly ($P<.001$) related to β2DEV and β3DEV. WNWID was related to β2DEV and β3DEV as well, ($P<.01$ and $P<.001$, respectively). Models were selected to predict β2DEV and β3DEV by deleting all variables which were not significant at the .10 level, and are shown in Table 4. The variables in the model for β2DEV were PWDAYS12 ($P<.001$) and WNWID ($P<.01$). Those included in the model for β3DEV were PWDAYS12 ($P<.001$), WNWID ($P<.001$) and WNDEP ($P<.10$). $R^2$ for these models

TABLE 3

DESCRIPTIVE STATISTICS OF PARAMETER ESTIMATES IN THE FULL-RANGE AND LIMITED-RANGE CURVES: 1978-1979 [$\beta_1$, $\beta_1'$ = 0.0072978]

| Parameter | N | Minimum | Maximum | Mean | SD | CV |
|---|---|---|---|---|---|---|
| $\beta_2$ | 42 | 0.41053862 | 1.90716341 | 0.82358994 | 0.33928124 | 41.195 |
| $\beta_2'$ | 42 | 0.30876760 | 2.34309183 | 0.72171297 | 0.44305857 | 61.390 |
| β2DEV[a] | 42 | -1.20675218 | 1.32564032 | 0.10187697 | 0.39031473 | 383.124 |
| $\beta_3$ | 42 | 0.00692342 | 0.1214474 | 0.00945702 | 0.00107770 | 11.396 |
| $\beta_3'$ | 42 | 0.00451988 | 0.1505986 | 0.00809250 | 0.00220799 | 27.284 |
| β3DEV[b] | 42 | -0.00365891 | 0.00672843 | 0.00136452 | 0.00204180 | 149.635 |

[a] β2DEV = $\beta_2 - \beta_2'$.
[b] β3DEV = $\beta_3 - \beta_3'$.

TABLE 4

ANALYSIS OF VARIANCE OF BETA DEVIATIONS: 1978-1979

| | β2DEV[a] | | | β3DEV[b] | | |
|---|---|---|---|---|---|---|
| Source | df | Type I MS | Type III MS | df | Type I MS | Type III MS |
| WNWID | 1 | 0.0145* | 0.9385** | 1 | 0.00000239 | 0.00002958*** |
| PWDAYS12 | 1 | 2.9532*** | 2.9532*** | 1 | 0.00004340*** | 0.00004340*** |
| WNDEP | | | | 1 | 0.00007325*** | 0.00000507† |
| Residual | 39 | | 3.2784 | 38 | | 0.00005189 |
| Total | 41 | | 6.2462 | 41 | | 0.00017093 |

[a] β2DEV = $\beta_2 - \beta_2'$ .
[b] β3DEV = $\beta_3 - \beta_3'$ .
†P<.10.
*P<.05.
**P<.01.
***P<.001.

were 48 and 70%, respectively. Coefficients of partial regression are shown in Table 5.

Adjusting both $\beta_2'$ and $\beta_3'$ was effective in producing curves which resembled those plotted through the entire range of the data. Comparisons were made between the mean fats of each curve, (full-range, limited-range and limited-range adjusted) at 45-day intervals (Table 6). These mean fats were then plotted on one graph (Figure 1) for visual illustration.

Using the full-range curve (solid line) as the standard for comparison, the mean fats on the limited-range curve (dotted line) deviated from +.32 to -11.86 mm during the first 450 days postweaning. The limited-range adjusted curve (broken line), however, deviated only from +.13 to +1.30 mm over the same time interval. The limited-range curve had slightly over-estimated fats at earlier ages, improved to a point somewhere between 135 and 180 days, and then began to underestimate by increasing amounts thereafter. Overestimation was consistent for the limited-range adjusted curve, but the magnitude of overestimation was not nearly as great as that observed for the unadjusted limited-range curve.

TABLE 5

COEFFICIENTS OF PARTIAL REGRESSION AND LEAST-SQUARES MEANS: 1978-1979

| Source | β2DEV[a] | β2DEV[b] |
|---|---|---|
| Intercept | -3.67591874*** | -0.02329341*** |
| WNWID | 0.04654895** | 0.00027468*** |
| PWDAYS12 | 0.00867317*** | $4.4009850 \times 10^{-5}$*** |
| WNDEP | | 0.00011258† |
| $R^2$ | 0.48 | 0.70 |

[a]$\beta2DEV = \beta_2 - \beta_2'$.

[b]$\beta3DEV = \beta_3 - \beta_3'$.

†P<.10.

**P<.01.

***P<.001.

TABLE 6

SUBCUTANEOUS FAT THICKNESS AT 45-DAY INTERVALS: 1978-1979

| Postweaning age (days) | Mean fat (mm) [N = 42] | | | Difference relative to full-range curve[a] (mm) | |
|---|---|---|---|---|---|
| | Full-range curve | Limited-range curve | Adjusted curve | Limited-range curve | Adjusted curve |
| 0 | 1.37 | 1.69 | 1.50 | + 0.32 | + 0.13 |
| 45 | 2.07 | 2.36 | 2.24 | + 0.29 | + 0.17 |
| 90 | 3.11 | 3.30 | 3.34 | + 0.19 | + 0.23 |
| 135 | 4.68 | 4.64 | 4.98 | + 0.04 | + 0.30 |
| 180 | 6.99 | 6.55 | 7.41 | - 0.44 | + 0.42 |
| 225 | 10.39 | 9.26 | 10.95 | - 1.13 | + 0.56 |
| 270 | 15.25 | 13.06 | 16.00 | - 2.19 | + 0.75 |
| 315 | 22.00 | 18.27 | 22.98 | - 3.73 | + 0.98 |
| 360 | 30.98 | 25.10 | 32.18 | - 5.88 | + 1.20 |
| 405 | 42.22 | 33.60 | 43.56 | - 8.62 | + 1.34 |
| 450 | 55.32 | 43.46 | 56.62 | - 11.86 | + 1.30 |

[a]Positive values indicate overestimation; negative values indicate underestimation.

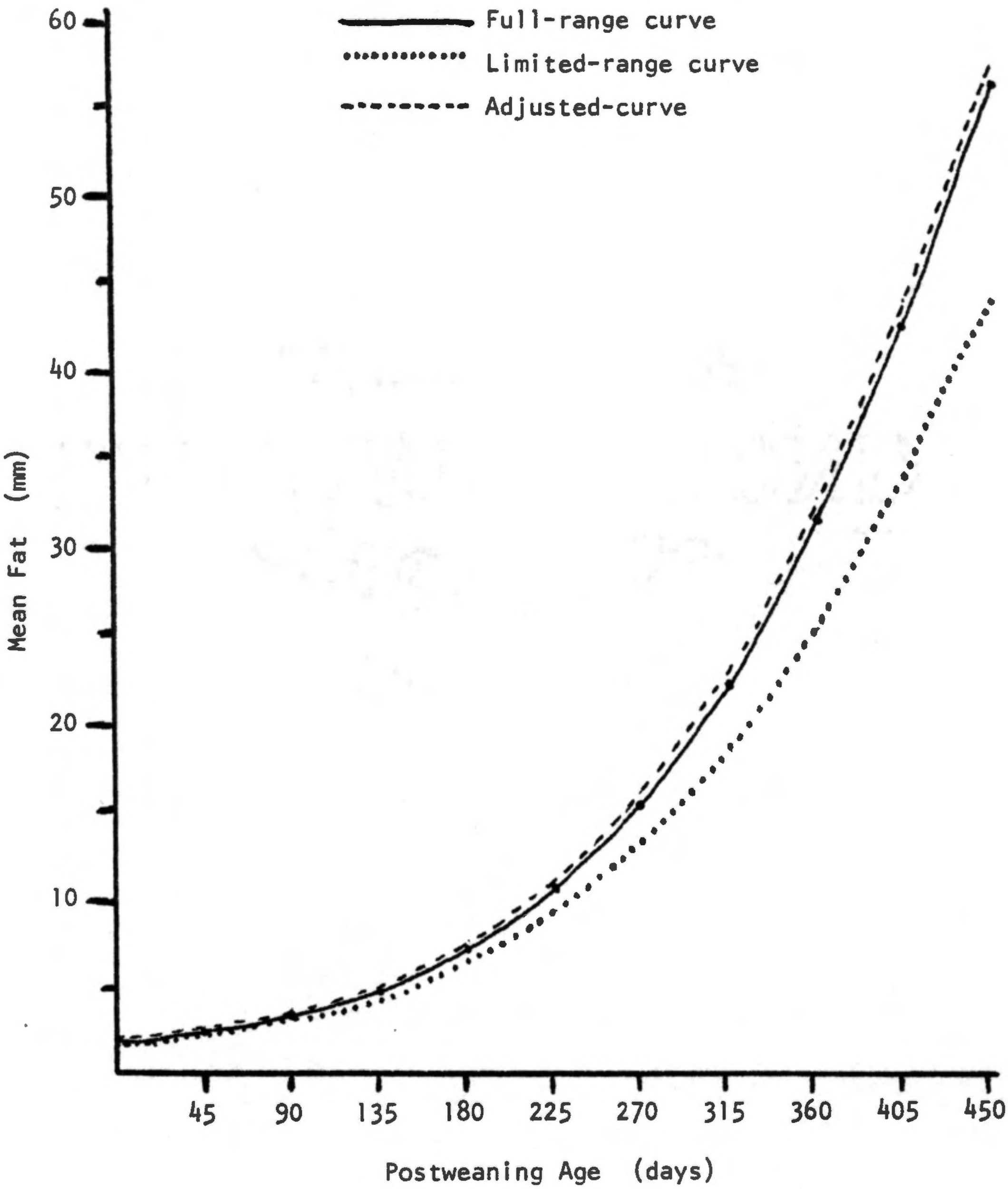


Figure 1. Mean subcutaneous fat at 45-day intervals: 1978-1979 [N=42].

## CHAPTER IV

## PREDICTION OF POSTWEANING SUBCUTANEOUS FAT DEPOSITION IN FEEDLOT STEERS: TECHNIQUE APPLICATION

### A. Introduction

While the results obtained in the final analysis in Chapter II demonstrated that for those calves sonoray measurements up to 12 mm could be combined with initial calf traits to predict fat deposition beyond 12 mm, the best test of the results was considered to be application of the technique on an entirely different data set.

In this chapter, the coefficients of partial regression determined from the prediction models for β2DEV and β3DEV from data from calves finished in 1978-1979 were used as coefficients in the prediction of beta deviations for similar calves fed in 1980. Beta values developed over a 12 mm range from the 1980 data were then adjusted by adding appropriate predicted deviations. Plots were generated as before and comparisons made.

### B. Materials and Methods

<u>Source of the data</u>. Postweaning data were collected from 24 steer calves in 1980 in a continuation of the study described in Chapter III.

<u>Data Collection</u>. Calf management and data collection was the same as described in Chapter III; the only notable difference being that they were weaned about 56 days earlier (Table 7).

TABLE 7

DESCRIPTIVE STATISTICS OF CALF VARIABLES: 1980

| Variable | N | Minimum | Maximum | Mean | SD | Variance | CV |
|---|---|---|---|---|---|---|---|
| WNWT (lbs) | 24 | 302 | 545 | 444.5 | 56.0 | 3132.5 | 12.6 |
| WNDEP (cm) | 24 | 24.4 | 34.3 | 29.1 | 2.61 | 6.81 | 8.93 |
| WNWID (cm) | 24 | 37.4 | 45.8 | 42.24 | 2.16 | 4.67 | 5.12 |
| PWDAYS12 (days) | 24 | 217 | 327 | 257.5 | 30.0 | 899.2 | 11.6 |
| WNAGE (days) | 24 | 177 | 249 | 224.3 | 19.6 | 384.2 | 8.7 |
| WNFAT (mm) | 24 | 1 | 3 | 2.2 | 0.8 | 0.6 | 35.1 |
| WNHT (cm) | 24 | 75.0 | 88.7 | 82.51 | 3.29 | 10.83 | 3.9 |
| WNLEN (cm) | 24 | 91.0 | 116.0 | 110.38 | 5.56 | 30.94 | 5.04 |

Analysis of the data. A full-range curve was plotted from the data by regressing the logistic equation with $\beta_1$ fixed at 0.0072978 over all observations in the data set generating values for $\beta_2$ and $\beta_3$ to be used in plotting the curve for comparison purposes only, not for the purpose of calculating beta deviations. All observations in the data set that contained ultrasonic estimates that were greater than 12 mm were then deleted. The logistic function, with $\beta_1'$ fixed at 0.0072978 was then fitted to the fat estimates that remained and values for $\beta_2'$ and $\beta_3'$ were generated. These beta values were adjusted using the coefficients of partial regression for β2DEV and β3DEV developed from the 1978-1979 calves (Table 5):

$$\text{AJUST}\beta 2 = \beta_2' + -3.675918474 + 0.04654895\ (\text{WNWID}) + 0.00867317\ (\text{PWDAYS12})$$

$$\text{AJUST}\beta 3 = \beta_3' + -0.02329341 + 0.00027468\ (\text{WNWID}) + 4.4009850 \times 10^{-5}\ (\text{PWDAYS12}) + 0.00011258\ (\text{WNDEP})$$

An adjusted equation of the form

$$\text{AJFAT} = \frac{1}{0.0072798 + \text{AJUST}\beta 2 e^{-\text{AJUST}\beta 3\ (\text{PWAGE})}}$$

was used to plot limited-range adjusted curves overlayed on the full-range curves.

## C. Results and Discussion

In field applications a full-range curve would not have been possible to generate if data had been collected only up to 12 mm. For testing the technique developed in Chapter III, however, the full-range curve was necessary. None of the data collected beyond 12 mm was used in any portion of the adjustment process. Such data were used only for plotting the full-range curve used as a standard for comparison.

There appeared to be greater fluctuation in the fat estimates obtained for the calves in 1980 than for calves in 1978-1979. The plotted points suggested that calves in 1980 had a greater rate of increase in fat deposition when placed on the high energy diet than those in 1978-1979. Average weaning age differed in 1980 compared to 1978-1979. The oldest calf at weaning in 1980 was about the same age as the youngest calf in 1978-1979. The actual difference in the mean WNAGE for both studies was about 56 days. Descriptive statistics of the calf variables for each study are presented in Tables 2 and 7. Calves in 1980 tended to weigh less at weaning ($P<.01$), had less depth ($P<.001$), greater width ($P<.001$) were not as tall ($P<.001$) and had greater body length ($P<.001$). PWAGE12 was about 12 days less for the 1980 calves, but this was not a significant difference ($P>.05$).

Comparing the full-range curve to the limited-range curve, deviations from +.45 to -12.66 mm were observed during the first 450 days as shown in Table 8. This behavior was not different from that observed in 1978-1979 where the deviations ranged from +.32 to -11.86 mm as shown in Table 6.

The adjusted limited-range curve deviated from -1.72 to -4.34 mm over the same period in 1980, compared to deviations from +.13 to +1.3 mm in 1978-1979. There was a trend in 1980 that was similar to that in 1978-1979 in that the limited-range curve slightly overestimated fats at earlier ages, improved slightly to a point between 135 and 180 days and then began to underestimate at an increasing rate thereafter. Adjusted limited-range curves in 1980 differed, however, from those observed in 1978-1979. Where there was consistent overestimation in 1978-1979, there was consistent un-

TABLE 8

SUBCUTANEOUS FAT THICKNESS AT 45-DAY INTERVALS: 1980

| Postweaning age (days) | Mean fat (mm) [N = 42] | | | Difference relative to full-range curve[a] (mm) | |
|---|---|---|---|---|---|
| | Full-range curve | Limited-range curve | Adjusted curve | Limited-range curve | Adjusted curve |
| 0 | 3.03 | 3.48 | 1.31 | + 0.45 | - 1.72 |
| 45 | 4.02 | 4.32 | 1.86 | + 0.30 | - 2.16 |
| 90 | 5.34 | 5.38 | 2.65 | + 0.40 | - 2.69 |
| 135 | 7.08 | 6.70 | 3.77 | + 0.38 | - 3.31 |
| 180 | 9.37 | 8.34 | 5.37 | - 1.03 | - 4.00 |
| 225 | 12.36 | 10.39 | 7.64 | - 1.97 | - 4.72 |
| 270 | 16.20 | 12.92 | 10.82 | - 3.28 | - 5.38 |
| 315 | 21.05 | 16.04 | 15.20 | - 5.01 | - 5.85 |
| 360 | 27.02 | 19.82 | 21.07 | - 7.20 | - 5.95 |
| 405 | 34.12 | 24.34 | 28.64 | - 9.78 | - 5.48 |
| 450 | 42.28 | 29.62 | 37.94 | - 12.66 | - 4.34 |

[a]Positive values indicate overestimation; negative values indicate underestimation.

derestimation in 1980, typically by about 4 or 5 mm. These differences are more graphically illustrated in Figures 1 and 2.

For certain calves in 1980 the agreement between the full-range curve and the limited-range adjusted curve was extremely good, but it was observed that these calves characteristically had the same relative rates of fat deposition as those in the 1978-1979 study.

No attempt should be made to argue that the technique developed herein has been perfected. It can be said that the adjusted curve without exception does a better job of describing the full-range curve, but that is not to say it always does an acceptable job. While the adjusted curves in 1978-1979 were generally very good in terms of agreeing with respective full-range curves, the accuracy and consistency was variable in 1980.

The models used were the best ones that could be used from the approach that was tried. The success of this study was not in the perfection of a technique for prediction of fat deposition in feedlot steers, but rather a step toward that end. The logistic equation demonstrated its potential as a basic equation to describe the phenomenon of fat deposition, but perhaps other forms of this equation should be explored to increase its application over a wider sample of animals.

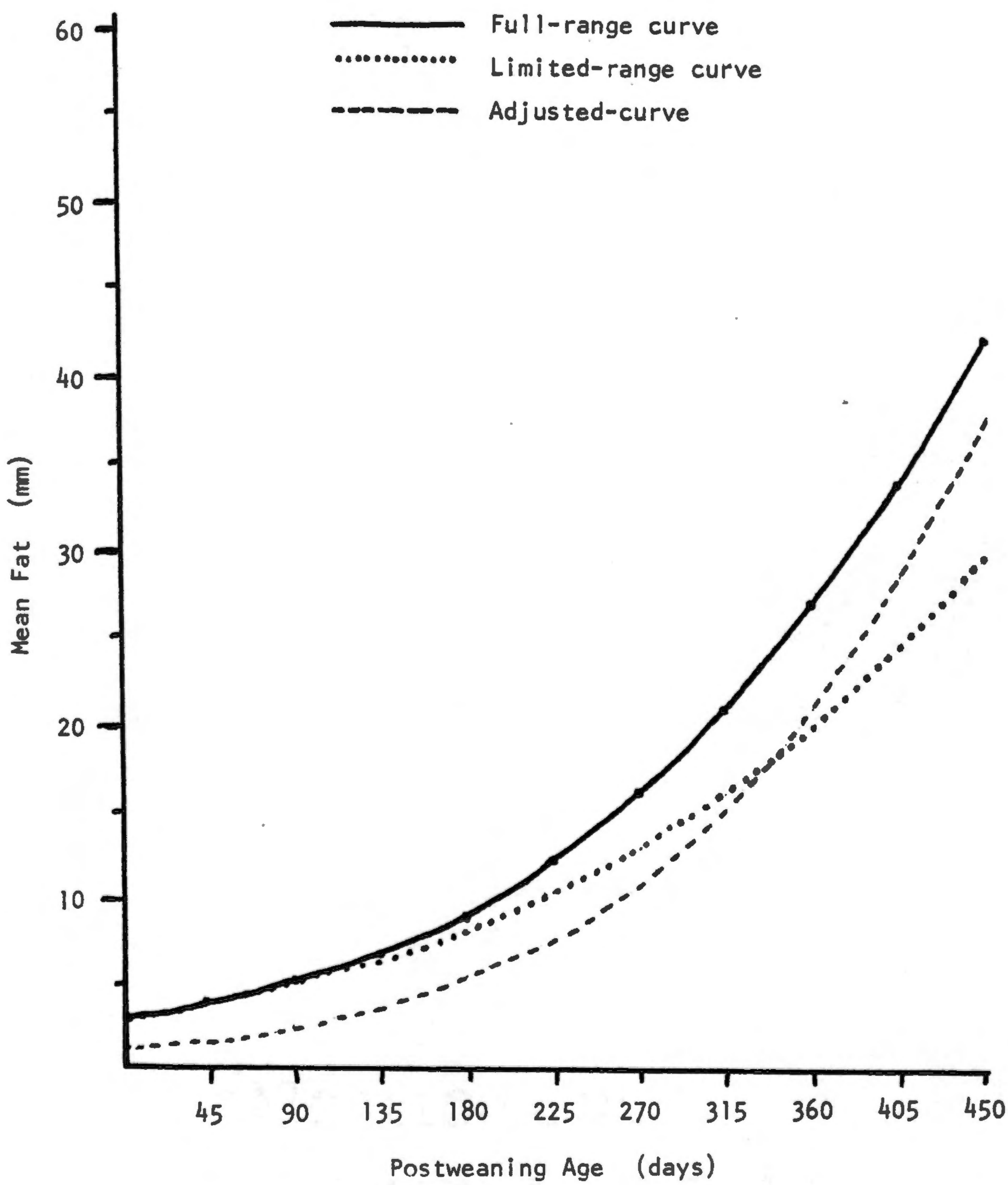


Figure 2. Mean subcutaneous fat at 45-day intervals: 1980 [N=24].

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# VITA

Kevin Ermin Jeske was born on November 3, 1957 in Hindsdale, Illinois. He moved to Gallatin, Tennessee in 1974 and graduated from Gallatin Senior High School in 1975.

Attending Volunteer State Community College from 1975-1977, he earned an Associate of Arts Degree in the field of Science and Mathematics.

In September of 1977 he was admitted to The University of Tennessee where he later received a Bachelor of Science Degree in Animal Science (December, 1979). He was accepted to the Graduate Program in the Department of Animal Science and began working toward a Master of Science Degree in the area of Animal Breeding and Genetics with emphasis on beef cattle. He received this degree in March, 1982.

While attending The University of Tennessee, he was a member of the Alpha Gamma Rho Fraternity, Gamma Beta Phi and Alpha Zeta. In August, 1981, he was married to Miss Kathy Lynn Martin from LaVergne, Tennessee.

Upon graduation from The University of Tennessee, Kevin and Kathy moved to Raleigh, North Carolina, where he was accepted to work toward earning a Ph.D. at North Carolina State University.