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Relationships of preweaning cow-calf characteristics to calf characteristics at selected postweaning points of evaluation

W. L. Bryson

To the Graduate Council:

I am submitting herewith a thesis written by W. L. Bryson entitled "Relationships of preweaning cow-calf characteristics to calf characteristics at selected postweaning points of evaluation." 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.

Will T. Butts Jr., Major Professor

We have read this thesis and recommend its acceptance:

J. W. Holloway, R. A. McLean

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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Accepted for the Council:

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The Graduate School

RELATIONSHIPS OF PREWEANING COW-CALF CHARACTERISTICS TO CALF CHARACTERISTICS AT SELECTED POSTWEANING POINTS OF EVALUATION

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

W. L. Bryson

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ABSTRACT

One hundred thirteen Angus cow-calf pairs (62 mature cows and 25 sires) were individually fed *ad libitum* over a five year period. Variation in cow size and production potential was comparable to that of Tennessee Agricultural Experiment Station herds. Postweaning, calves were individually fed a complete growing and finishing ration. Unit efficiency (UNEFF) was defined as the ratio of cow TDN consumption to calf weight. Prediction equations ($Y = b_0 + b_1 (AGE) + b_2 (AGE)^2$) for weight, fat, postweaning gain, postweaning TDN intake and unit efficiency was determined from biweekly weight, fat and feed consumption records.

Instantaneous efficiency (INEFF) was the ratio of the rate of TDN intake to the rate of gain at a given point (ratio of slopes of tangent lines to each respective equation). The most efficient point (MEP) was determined as the minimum of the equation for UNEFF.

Factor analysis was performed to aid in the description of animals. Regression analysis was performed to determine relationships of preweaning cow-calf characteristics to characteristics at selected postweaning endpoints. Preweaning cow-calf characteristics explained appreciable variation in UNEFF, weight, and age, above that explained by year and sex, at MEP, 400 kg weight (WT400), 14 mm fat (FAT14), 207 days postweaning (207DAYS) or at an INEFF of nine kg TDN/kg gain (INEFF9).

Cow weight at the previous weaning was negatively related ($P < .05$) to UNEFF at INEFF9 and to postweaning gain at WT400. Cow weight change from previous to current weaning was positively ($P < .05$) related to age, postweaning TDN and INEFF at MEP. Cow fat positively affected age, fat and postweaning days at MEP ($P < .05$). Calf weight and postweaning gain, when evaluated at FAT14, were negatively affected ($P < .05$) by cow fat at previous weaning. Age at all endpoints was positively affected by weaning age ($P < .001$). Also younger calves at weaning gained more to WT400 ($P < .001$). Thinner calves at weaning were higher in INEFF at FAT14, but were lower in INEFF at MEP ($P < .05$).

UNEFF at all endpoints was positively related to weaning efficiency ($P < .001$). Weaning efficiency also had a positive effect on gain at WT400 ($P < .001$) and INEFF at MEP ($P < .05$). Weaning efficiency showed a negative effect ($P < .05$) on instantaneous rate of gain (INGAIN) when evaluated at MEP, WT400 or 207DAYS. The variables not affected by sex were TDN intake at 207DAYS; INEFF and postweaning gain at WT400; INEFF and INGAIN at FAT14; age, postweaning TDN intake and days postweaning at MEP; and INGAIN, fat, age and postweaning days at INEFF9.

Calf weaning weight had a positive effect on UNEFF, weight, postweaning TDN, instantaneous intake and INEFF at MEP ($P < .05$). Calf weaning weight also had a positive effect on UNEFF, weight, postweaning TDN and instantaneous intake at FAT14 ($P < .05$). Weaning age was a positive effect ($P < .001$) upon UNEFF, weight, postweaning

TDN, fat and instantaneous rate of intake at 207DAYS. AT INEFF9, weaning weight was positively correlated with UNEFF, weight, instantaneous TDN intake and INGAIN and was negatively correlated with postweaning days ($P < .05$). At WT400, calf weaning weight had a negative ($P < .05$) effect on age, postweaning days, postweaning TDN, fat and INEFF and had positive effects on weight, instantaneous rate of intake and INGAIN.

Preweaning cow-calf characteristics were relatively unimportant in explaining variation in all calf characteristics studied unless evaluated at 400 kg weight. This is interpreted to be attributed to relationship of these preweaning characteristics to physiological age.

Preweaning characteristics of cow-calf pairs were importantly related across all endpoints only to calf age, weight and unit efficiency. These relationships were thought to reflect the part-whole aspects of these variables from weaning to postweaning.

These results suggest that little biological antagonism exists between pre- and postweaning factors related to feed efficiency. Increased unit efficiency at weaning is favorably associated with unit efficiency at all endpoints studied and is either favorably associated with calf instantaneous efficiency evaluated at the most efficient point or is independent of that measure of efficiency at other endpoints. Preweaning pair characteristics were related to slaughter age and weight at all endpoints but were largely independent of level of calf fatness. Variation in preweaning characteristics and relationships between pre- and postweaning characteristics reported in this study provide producers an opportunity to select particular kinds of animals to achieve specific goals in specific production and economic situations.

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CHAPTER I

INTRODUCTION

Level of per capita consumption of meat and animal products has reached a plateau in recent years (Koch and Algeo, 1983). Furthermore, Breidenstein and Carpenter (1983) state consumer preference for meat has been toward a leaner product of acceptable quality. This change has been a result of several factors. There has been considerable public concern about the association of excessive fat to cholesterol and cholesterol related diseases. Additionally, consumers have become more fitness-aware and price-conscious of fat.

The value of slaughter animals is influenced by weight, quality grade and yield grade. At present, choice quality grade and yield grade three are the standards for evaluating beef carcasses, with a penalty for quality grade less than choice or yield grade greater than three.

In relation to this pricing structure one should consider the relationship of weight, quality grade and yield grade as well as other characteristics of the production process. For an individual animal, as weight increases, quality grade becomes more acceptable; however, yield grade becomes less acceptable. Other aspects of beef production to be considered are differences among animals. It has been shown that postweaning feed efficiencies are similar for cattle differing in mature size and maturing patterns if compared at similar levels of fatness.

The profitability of production of different types of animals may shift from one type to another depending upon their characteristics at time of slaughter, type of management and economic considerations (McLemore and Butts, 1982).

Variation among pairs in conversion of cow and calf intake into calf weight is small when evaluated at the point of maximum efficiency of the pair (Joandet and Cartwright, 1969; Onks, 1976; Crider, 1981). There is, however, considerable variation in weight, fat, and age at the point of maximum efficiency of the pair.

As a result of consumer trends, pricing structures, characteristics of growth and profitability of production, determining relationships of calf preweaning characteristics to characteristics at time of slaughter is of great concern. Therefore, the objective of this study is to determine relationships which may exist between definable cow-calf preweaning characteristics and calf characteristics at time of slaughter.

CHAPTER II

REVIEW OF LITERATURE

I. Heritabilities and Correlations

Correlations of birth weight to weaning weight of .41 to .69 have been reported (Brinks *et al.*, 1962; Christian *et al.*, 1965; Smith and Cundiff, 1976; and Nelson and Kress, 1979). Smith and Cundiff (1976) reported a correlation of .60 for 365-day weight with birth weight. Brinks *et al.* (1964) also reported a positive correlation of .35 for birth weight with mature weight of the dam. Gregory *et al.* (1950), Swiger (1961), Brinks *et al.* (1962), Smith *et al.* (1976) and Nelson and Kress (1979) reported heritability estimates for birth weight ranging from .22 to .68. These positive correlations suggest that an increase in birth weight would indicate an increase in weight at all stages of growth.

Negative correlations were reported by Smith and Cundiff (1976) between birth weight and relative growth rate at preweaning, post-weaning and postnatal stages of growth.

Hohenboken *et al.* (1973) reported correlation between birth weight and creep feed total digestable nutrients during lactation of .39. Cundiff *et al.* (1981) reported correlations of .40 and .71 between birth weight and postweaning feed efficiency to a small amount of marbling and feed efficiency to 18.9% fat composition, the heavier calf being more efficient. The positive correlations between birth weight and measures of size and measures of feed intake suggest a positive relationship between size and feed intake.

Heritability estimates of weaning weight range from .25 to .57 (Gregory et al., 1950; Pahnish et al., 1961; Swiger, 1961; Brinks et al., 1962; Smith and Cundiff, 1976). Christian et al. (1965), Hohenboken et al. (1973) and Marshall et al. (1976) reported correlations of weaning weight with milk production or milk consumption of .48, .33 and .44 respectively. Weaning weight was also reported to be positively correlated with feed intake of the cow, calf and cow and calf during lactation (Christian et al., 1965; Hohenboken et al., 1973; Marshall et al., 1976). Tanner et al. (1965) and Marshall et al. (1976) reported correlations of .34 and .32 between weaning weight and cow weight. In a review, Morris and Wilton (1976) reported average correlation between weaning weight and cow weight of .23. Smith and Cundiff (1976) reported a positive correlation between weaning weight and relative growth rate of the calf during lactation of .40. However, the correlation between weaning weight and postwean relative growth rate was -.48 in the same study. The positive correlations of weaning weight with preweaning characteristics in relation to the negative correlation to relative growth rate postweaning suggests the possibility of antagonistic views of the cow-calf segment as opposed to the feedlot segment of the industry in selection goals for calves at weaning.

Morris and Wilton (1976) reported that values of heritability estimates of feedlot gain range from .4 to .5. Jeremiah et al.

(1970) analyzed data from 1,710 steers at eight junior livestock shows from 1963 to 1968. They reported correlations of .20 to .44 between final weight and marbling, .28 to .42 between fat thickness and marbling, .85 to .90 between quality grade and marbling, -.33 to -.35 between cutability and marbling and .36 to .52 between weight and fat thickness. Kauffman et al. (1968), Hedrick et al. (1969) and Cross et al. (1973) reported correlations within these ranges. Adams et al. (1973) reported correlation of .43 between quality grade and fat thickness. Black et al. (1938), using weight constant slaughter points ($\overline{X}$ = 900 lbs.), reported correlation between final height at withers and average daily gain, quality grade and efficiency of gain of -.19, -.83 and -.37 respectively. Blackmore et al. (1958) reported similar values for quality grade and average daily gain using time constant slaughter points.

II. Feed Requirements

Relative amounts of feed required for maintenance and gain are important factors of efficiency. Neville and McCullough (1969) reported requirements of total digestable nutrients (TDN) per kilogram of weight for maintenance, gain and milk production, respectively, for lactating cows to be .0108 kg TDN/day, 2.3 kg TDN/kg gain and .3041 kg TDN/kg milk.

Rebhan and Donker (1960) using monozygotic twins and triplets determined that as weight and fat increase so does maintenance requirements; further, at the same weights but different conditions the fatter animal requires more TDN per unit maintenance. Lemenager et al. (1980) analyzed data within breed groups which were fed to maintain similar weight change patterns during the last trimester of gestation and first 96 days of lactation and reported that as milk production potential increased so did TDN required; however, as cow condition during gestation increased TDN required during lactation decreased. Brown et al. (1980) reported that cows grazing low quality pasture and giving more milk maintained less weight and fatness during lactation, also, that taller cows when allowed increased energy during lactation increased in fatness more rapidly than did small cows.

Klosterman et al. (1974) reported that, when fed based on metabolic weight, cows with high condition increased in weight while cows with low condition decreased in weight.

III. Cow and Calf Characteristics as Related to Production

Considerable research has been directed toward relating cow-calf characteristics to weaning efficiency. Of these characteristics, cow size has been of great interest. Klosterman (1972) suggested that size is not very highly related to efficiency of production and that all sizes have tradeoffs. He also suggested medium is the size to produce, as medium is the middle of small and large. Melton et al. (1967) and Carpenter et al. (1972) reported smaller cows to be more efficient at weaning when considered within breeds. Kress et al. (1969) reported no difference of efficiency of skeletally large or small cows. Crider et al. (1982) and Butts et al. (1983) reported that cow size (expressed as weight) did not influence weaning efficiency per se, however, when calf weaning weight was considered jointly with cow weight, then cow weight negatively affected weaning efficiency (smaller cows were more efficient). Long and Fitzhugh (1970), Long et al. (1971), and Fitzhugh et al. (1975), using simulated crossbreeding data, indicated that smaller cows were more efficient when bred to larger bulls. Klosterman et al. (1974) and Cartwright (1979) found that smaller crossbreeds were more efficient at weaning. Notter et al. (1979) concurred with these conclusions if calving difficulty of two year olds bred to large sires could be avoided. It should be noted that Klosterman et al. (1974) found no size effect on weaning efficiency when the same cows were grouped into three weight classes.

Carpenter et al. (1972) reported cows heavier at maturity were older at first calving, weaned heavier calves, had longer calving intervals and produced fewer calves relative to age than lighter cows at maturity. Carpenter et al. (1972) also reported that earlier maturing cows were younger at first calving, had shorter calving intervals and produced more calves relative to age than later maturing cows. Cartwright (1979) found that effects of size depends on environmental conditions; furthermore, he concluded that cow size and milk production are inter-dependent.

Cartwright (1979) and Notter _et al_. (1979) concluded that optimal milk production increases with size of the cows. This conclusion that there is an optimal milk production within a cow size may be indicated by the differences of the effects of milk production on weaning efficiency reported by other researchers. Kress _et al_. (1969) and Marshall _et al_. (1976) showed significant effects of milk production on weaning efficiency while Parker _et al_. (1974) indicated that milk production was not directly related to weaning efficiency but that higher milk production hastened the rate of maturity which affected weaning efficiency negatively. Through extrapolution, this finding is supported with data of Melton _et al_. (1967) where calves from large cows within a breed gained less weight to weaning than calves from small cows. Marshall _et al_. (1976) and Butts (1983) found significant effects on weaning efficiency due to calf age and sex.

As was the case with cow-calf weaning efficiency, relationships of cow-calf characteristics to cow-calf efficiency during postweaning have been questions of interest. Research attempting to explain the relationship between cow-calf characteristics and postweaning cow-calf efficiency have differed as to the point of evaluation postweaning. Constant body condition (Klosterman _et al_., 1974), constant age (Melton _et al_., 1967; Boyd and Koger, 1974; Ellison _et al_., 1974) and maximal unit nutritional efficiency (Joandet and Cartwright, 1969; Fox, 1973; Onks _et al_., 1975; Crider _et al_., 1982) have been points at which nutritional efficiency was determined.

Joandet and Cartwright (1969) defined maximal nutritional efficiency when they stated, "there is a point in the life of a slaughter animal at which cumulative TDN required to produce a unit of live weight is minimal" and called this "optimum slaughter weight."

Klosterman _et al_. (1974) found no significant effect of cow size on postweaning unit efficiency. Kress _et al_. (1969) reported, however, that large cows produced the more profitable unit. Crider _et al_. (1982) reported that smaller cows had calves that were more efficient postweaning. Using modeling techniques and considering all inputs and outputs, Long _et al_. (1975) demonstrated that on a _per annum_ basis small cows were more profitable in the pasture regime while larger cows were more profitable under drylot conditions. Onks _et al_. (1975) and Crider _et al_. (1982) both found that heavier calves at weaning had improved unit efficiency at their most efficient point. Crider _et al_. (1982) also found that pairs more efficient at weaning were less efficient postweaning at MEP. Bowden (1981) examined the ratio of weaning weight to weight of the dam and determined that this measure may be useful as an indicator of cow-calf efficiency of energy conversion within breeds but not for comparisons among breeds.

IV. Optimal Slaughter Points

Kleiber (1936), Knox and Koger (1946), Washburn _et al_. (1948), Stonaker _et al_. (1952), Knox (1957), and Brungardt (1972) have shown evidence that postweaning efficiencies are similar among animals if considered at constant fatness irrespective of their mature size or maturing patterns. Zeller and Hetzer (1944) reported the same relationship with Poland China barrows. Other researchers have shown that, over constant time periods, larger animals are more efficient (Woodward et al., 1942; Guilbert and Gregory, 1944).

Knox (1957) indicated that larger type cattle reach required weights earlier and are leaner while small type cattle reach required fat earlier at lighter weights. Zinn et al. (1970) reported that as weight and fat increases so does marbling and carcass quality grade.

Harrison et al. (1978) suggests that retail cuts from cattle fed a high quality ration for certain period of time will be of acceptable palatability regardless of marbling level or quality grade. Smith (1979) states "market requirements for slaughter weight and composition are the primary determinants of optimal size." McLemore and Butts (1979) indicate that profitability of production may shift from one type to another depending upon economical considerations of inputs, types of management and characteristics of animals at time of slaughter.

CHAPTER III

MATERIALS AND METHODS

This experiment was conducted over a five-year period. Experimental units consisted of 113 Angus cow-calf pairs (62 mature cows and 25 sires were represented) selected from Tennessee Agricultural Experiment Station herds to represent variation in cow size and maternal ability within the herds. Cows before entering the experiment had been bred to bulls selected for yearling weight. After entering the experiment cows were assigned to one of three breeding groups based on cow weight so that each breeding group could be exposed to a bull of comparable size.

Cows were bred to calve in March, April and May. Open cows were replaced each year with cows of similar size and maternal ability. Cows were calved on pasture and after calves were approximately three weeks of age, the pair was confined to individual pens during the day. At night pairs were turned out into one of three dirt exercise lots, dependent upon their respective breeding group. Since these groups were based on initial cow weight, cross-nursing of calves was restricted within weight groups.

Cows were fed grass silage _ad libitum_. Silage was homogeneous within year but species composition and maturity varied across years due to environment and forage availability. Silages fed consisted of orchard grass (IFN 3-03-454), timothy (IFN 3-04-916) and red clover (IFN 3-01-436). During the first year, sudan grass

(IFN 3-04-499) was fed during lactation and the following dry period as the perennial grass silage was not available. When needed, dehydrated alfalfa pellets (IFN 1-00-023) were supplemented to maintain cow weight changes and calf performance comparable with similar pairs on pasture. Calves were offered alfalfa pellets *ad libitum* during lactation as a creep.

Following weaning, calves were individually fed a complete growing and finishing ration of approximately 67% TDN *ad libitum* until slaughter; cows remained in individual pens until two weeks prior to calving. Biweekly weights, fats and feed consumptions were recorded during the postweaning phase.

Milk production was estimated monthly the first two years by the calf nursing method (Drewery *et al.*, 1959) and bi-monthly the last three years. Total milk production was the sum of two segments of the lactation curve. The first segment was a quadratic curve from calving to peak lactation (70 to 90 days). The second segment was a linear function from peak lactation to weaning (Cole and Johansen, 1933). A more detailed description of the estimation of milk production was given by Onks (1976).

NRC (1970) values were used to convert biweekly feed consumption to total digestable nutrients (TDN). These values were similar to those from an in vitro digestibility trial (method of Tilley and Terry, 1963) conducted during the first year and from apparent digestibility estimates determined by the lignin ratio technique by Gill *et al.* (1978) during the last year of the study.

Annual TDN was equal to the TDN consumption of the cow from one weaning date to the next plus the TDN consumption of the calf from creep feed. Unit efficiency was defined as the ratio of the sum of the cow TDN intake for 12 months plus the calf TDN intake to the weight of the calf. Weaning efficiency was unit efficiency at weaning. A more detailed description of the management of the experimental units are described by Neel (1973), Onks (1976) and Butts et al. (1983).

A quadratic equation was fitted through the biweekly unit efficiency from weaning until slaughter using age and age squared as the independent variables. The minimum of this equation was termed the most efficient point (MEP). Calves were not slaughtered until they were clearly past this point. There were four calves whose curves did not reach a minimum until an unreasonable age even though it was apparent that these calves had reached observed minimums when the data was plotted. The calves were subsequently assigned a value for MEP by adding one within year, sex standard deviation to the calf's oldest observed age.

Individual quadratic equations were used to predict weight, fat, calf postweaning TDN consumption and calf postweaning weight gain of each calf. Instantaneous efficiency (kg TDN/kg gain at a given point, INSTEFF) was calculated as the ratio of the first derivative of the equation for calf postweaning TDN intake to the first derivative of the equation for calf postweaning gain. Instantaneous rate of gain (kg/day at a given point, INGAIN) was calculated as the first derivative of the equation for calf postweaning gain. Instantaneous rate of intake (kg TDN/day at a given point, INTDN) was calculated as the first derivative of the equation for calf postweaning TDN intake.

Calves were evaluated for age, weight, fat thickness, unit efficiency, instantaneous efficiency, instantaneous gain, instantaneous TDN intake, calf postweaning TDN intake, calf postweaning gain and number of postweaning days at five postweaning points: (1) MEP, (2) instantaneous efficiency of nine kg TDN/kg gain, (3) 14 mm of backfat (ultrasonic estimate), (4) 400 kg of live weight and (5) 207 days postweaning. Values chosen for points of evaluation were near the mean values of the variables at MEP. These points of evaluation were considered to represent values within the range of typical industry practice. Calves with traits which did not achieve the value chosen for a particular point of evaluation were deleted from that analysis. Five calves were deleted from the evaluation at constant instantaneous efficiency. Seven calves were deleted from evaluation at 400 kg of liveweight. All calves achieved 14 mm of fat and 207 days postweaning.

At each postweaning point of evaluation, traits were subjected to factor analysis by image analysis (Harmon 1976) to describe the data and to detect redundancies in variables. Factor analysis was also performed on preweaning characteristics to determine traits of interest.

Multivariable regression was then utilized to relate preweaning characteristics to characteristics at the postweaning points of evaluation. Least-Squares solutions of the models (Barr _et al_. 1976) were used to obtain estimates of parameters. Models presented contained terms for year, sex and linear regressions on initial cow weight and fat, calf age, weight and fat at weaning and unit efficiency at weaning.

CHAPTER IV

RESULTS

I. Description of Preweaning Cow-Calf Characteristics

Table 1 contains means, standard deviations and residual standard deviations of cow-calf characteristics at weaning. Preweaning characteristics were within ranges of published literature as discussed in more detail by Onks (1976) and Butts et al. (1983).

Factor analysis was performed on several preweaning characteristics after adjusting for year and sex of the calf and may be seen in Table 2. From a total of 29 variables, seven factors were extracted using the image method. The seven factors explained 72% of the total variation present with 11, 8, 12, 8, 5, 14 and 15% explained by each respective factor. Factor one clearly represents calf consumption during lactation, while factor two may be termed an efficiency factor. A high score on factor two would be associated with heavier calves that were more efficient at weaning. Factor three represents pair consumption. Milk production is clearly factor four. Factor five is cow weight change from the previous weaning to the current weaning. Factor six represents calving date, while factor seven represents cow size. Results of this image analysis suggest that, within this data, measures of calf consumption, measures of pair consumption and efficiency, measures of milk production, cow weight changes from weaning to weaning, cow size measures and calf

TABLE 1. MEANS, STANDARD DEVIATIONS AND RESIDUAL STANDARD DEVIATIONS OF ANGUS COW AND CALF WEANING TRAITS

	Steers		Heifers		
Trait	Mean	SD	Mean	SD	RSD[a]
Number	63		50		113
Cow weight at weaning (kg)	452	54	446	54	43
Cow weight at weaning the previous year (kg)	458	52	459	54	46
Cow fat at weaning (mm)	5.9	3.7	6.7	3.9	2.5
Cow fat at weaning the previous year (mm)	7.8	4.6	6.8	3.4	3.7
Cow weight change from previous to current weaning (kg)	- 6	53	- 13	54	31
Calf age at weaning (days)	253	36	253	36	28
Calf weight at weaning (kg)	220	41	200	37	31
Calf fat at weaning (mm)	2.2	0.9	2.4	1.2	1.0
Total milk during lactation (kg)	1637	321	1640	337	287
Unit efficiency at weaning[b]	11.1	2.4	12.1	2.4	1.5
Calf total digestable nutrient intake during lactation (kg)	141	48	131	40	39
Cow and calf total digestable nutrient intake through weaning (kg)	2387	377	2367	393	241

[a]Residual standard deviations from the model $\hat{Y}$ = year sex.

[b]Ratio of cow and calf total digestable nutrient intake through weaning to calf weaning weight.

TABLE 2. ROTATED FACTOR PATTERN OF ANGUS COW AND CALF PREWEANING CHARACTERISTICS

Variables[b]	Rotated Factor Pattern[a]						
	1	2	3	4	5	6	7
Cow age	.00	-.20	.01	.03	.08	.00	.03
Most probable producing ability	.05	.02	.07	.08	-.08	.27	.21
Calf date of birth	-.26	-.10	-.19	.04	-.15	-.91	-.07
Calf birth weight	.00	.12	.12	-.02	-.05	.03	.40
Calf age at weaning	.25	.04	.13	.02	.08	.92	.03
Calf weight at weaning	.28	.54	.37	.11	.20	.63	.15
Calf average daily gain to weaning	.25	.78	.39	.25	.21	.07	.10
Calf gain from birth to weaning	.29	.54	.37	.12	.21	.63	.10
Calf fat at weaning	.25	.08	.09	.14	.06	.34	-.02
Calf pellet intake during lactation	.93	.12	.16	.04	.04	.28	.13
Calf dry matter intake during lactation	.93	.12	.16	.03	.04	.28	.13
Calf TDN[c] intake during lactation	.89	.10	.16	.03	.03	.28	.15
Cow weight the fall prior to entering experiment	.17	-.03	.10	.01	.18	.00	.85
Cow fat the fall prior to entering experiment	.22	-.14	.02	.09	.09	-.06	.42
Cow weight at previous weaning	.11	.02	.18	-.01	.33	.18	.83
Cow fat at weaning	-.02	-.25	.10	.02	-.12	.00	.40
Cow and calf total dry matter intake to weaning	.13	.03	.83	.06	-.06	.21	.17
Cow and calf TDN intake to weaning	.20	-.02	.92	.06	-.06	.16	.27
Unit efficiency at weaning	-.19	-.66	.34	-.07	-.29	-.55	.10
Adjusted cow and calf TDN intake to weaning	.20	-.02	.88	.08	.27	.16	.25
Adjusted unit efficiency at weaning	-.17	-.70	.41	-.06	.03	-.54	.10
Cow depth of body	.00	-.09	.22	.04	-.09	-.06	.77
Cow length of body	.03	.09	.03	.00	.07	.28	.57
Cow height at withers	-.01	.02	.10	-.09	-.12	-.04	.66
Estimated milk intake to 180 days	.01	.03	.03	.84	-.04	.01	.00
Total milk intake during lactation	.16	.04	.13	.79	.11	.56	.04
Average daily milk intake during lactation	.02	.02	.04	.99	.04	.00	.02
Cow fat at previous weaning	.13	-.07	-.17	.10	.26	.10	.50
Cow weight change from previous to current weaning	-.06	.00	-.08	-.01	-.89	-.20	-.08
Cumulative portion	11	19	31	39	44	58	72

[a]Image method, varimax rotation.

[b]Variables are residuals from the model $\hat{Y}$ = year sex.

[c]Total digestable nutrients

size measures explain a large percentage of variation present in preweaning characteristics. Therefore, measures of these variables appear most likely to explain variation in postweaning characteristics.

II. Description of Postweaning Calf Characteristics

Prediction Equations

A graphical representation of the polynomial used to predict unit efficiency for each individual calf may be seen in Figure 1. The most efficient point is also designated on Figure 1. This second-order polynomial ($\hat{Y} = b_2 + b_1 \text{ (AGE)} + b_2 \text{ (AGE)}^2$) appeared adequate as only six calves had a coefficient of determination below 60% with 65% of the calves having a coefficient of determination above 90%. The minimum coefficient of determination of the prediction equations for weight, fat, postweaning TDN intake and postweaning gain for the function $\hat{Y} = b_0 + b_1 \text{ (AGE)} + b_2 \text{ (AGE)}^2$ was 90, 70, 90 and 90% respectively.

Means and Standard Deviations

Means, standard deviations and residual standard deviations from the model Y = year + sex are presented in tables 3-7 to provide a general description of the calves at different points postweaning. Steers tended to be younger when evaluated at the most efficient point and at 400 kg weight, but were older at 14 mm fat and at the common instantaneous efficiency of nine kg TDN/kg gain. Steers tended to be heavier and trimmer at all postweaning points of

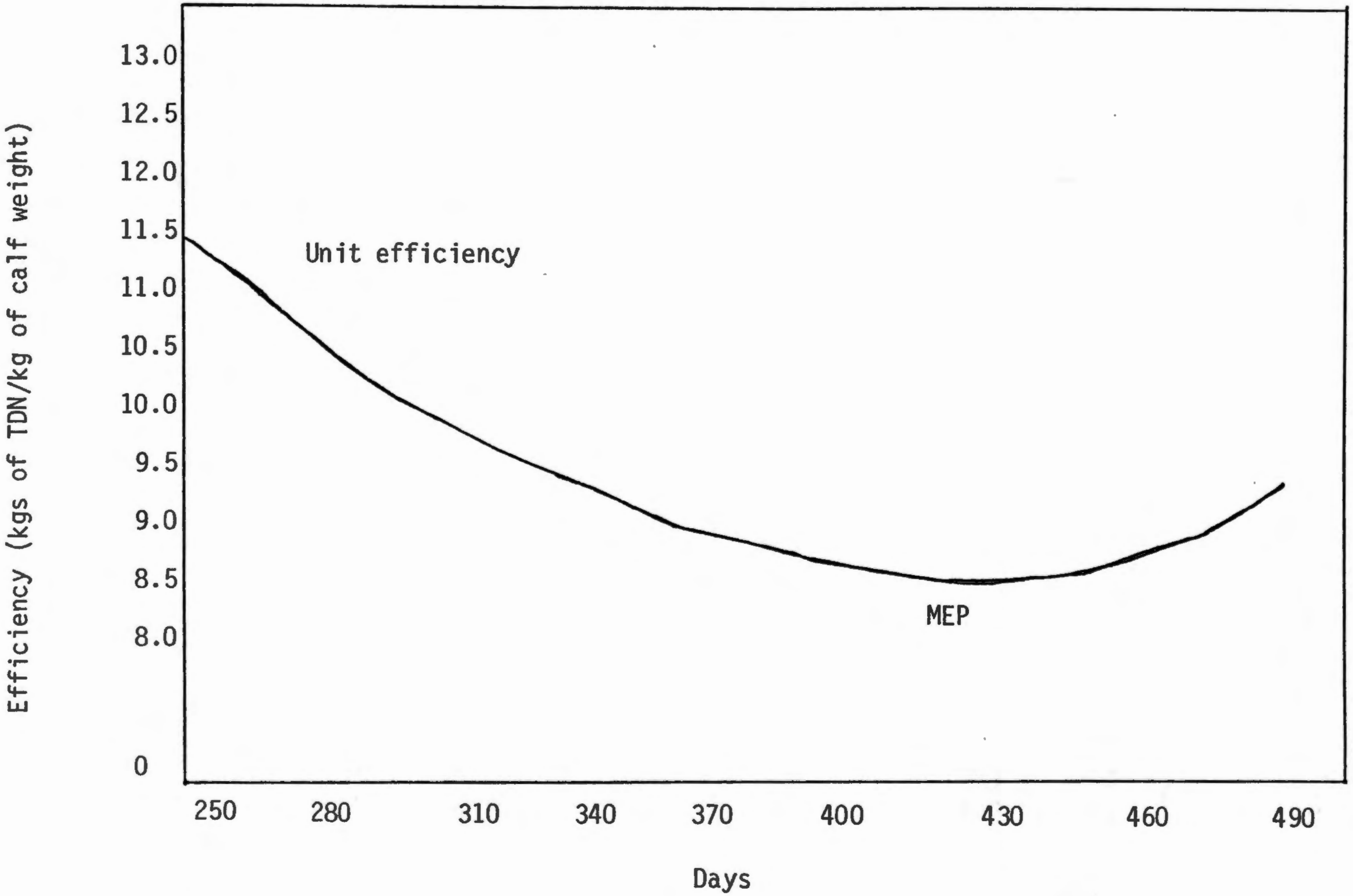

Figure 1. Graphical representation of the polynomial predicting unit efficiency, $\hat{Y} = b_0 + b_1 (AGE) + b_2 (AGE)^2$)

TABLE 3. MEANS, STANDARD DEVIATIONS AND RESIDUAL STANDARD DEVIATIONS OF ANGUS COW AND CALF CHARACTERISTICS AT THE MOST EFFICIENT POINT (MEP)

	Steers		Heifers		
Trait	Mean	SD	Mean	SD	RSD[a]
Number	63		50		113
Age (days)	439	50	448	45	37
Weight (kg)	417	48	386	56	41
Fat (mm)	12.8	6.3	15.4	7.4	4.4
Instantaneous rate of gain (kg/day)	0.82	0.16	0.66	0.15	0.13
Instantaneous rate of TDN[b] intake (kg/day)	6.9	1.1	6.2	0.8	0.8
Postwean gain (kg)	298	42	185	44	28
Postwean TDN (kg)	1223	264	1228	311	190
Days post weaning	186	46	195	43	32
Calf instantaneous efficiency	8.6	1.4	9.6	2.6	1.7
Pair efficiency[c]	8.6	1.1	9.3	1.0	0.8

[a]Residual standard deviations from the model $\hat{Y}$ = year sex.

[b]Total digestable nutrients.

[c]Ratio of cow and calf TDN intake to calf weight.

TABLE 4. MEANS, STANDARD DEVIATIONS AND RESIDUAL STANDARD DEVIATIONS OF ANGUS CALF CHARACTERISTICS AT AN INSTANTANEOUS POSTWEANING EFFICIENCY OF NINE KG TDN/KG GAIN

	Steers		Heifers		
Trait	Mean	SD	Mean	SD	RSD[a]
Number	61		47		108
Age (days)	453	59	445	53	48
Weight (kg)	433	60	380	53	48
Fat (mm)	13.9	6.8	14.8	7.7	5.7
Instantaneous rate of gain (kg/day)	.78	.13	.70	.09	.09
Instantaneous rate of TDN[b] intake (kg/day)	6.9	1.1	6.3	.7	.8
Postwean gain (kg)	212	51	182	47	35
Postwean TDN (kg)	1327	331	1189	326	251
Days post weaning	199	53	190	54	41
Pair efficiency[c]	8.6	1.0	9.4	1.0	.8

[a]Residual standard deviations from the model $\hat{Y}$ = year sex.

[b]Total digestable nutrients.

[c]Ratio of cow and calf TDN intake to calf weight.

TABLE 5. MEANS, STANDARD DEVIATIONS AND RESIDUAL STANDARD DEVIATIONS OF ANGUS CALF CHARACTERISTICS AT 400 KG WEIGHT

	Steers		Heifers		
Trait	Mean	SD	Mean	SD	RSD[a]
Number	63		43		106
Age (days)	426	53	472	48	49
Fat (mm)	12.0	7.1	18.4	8.7	7.0
Instantaneous rate of gain (kg/day)	0.89	0.29	0.70	0.29	0.27
Instantaneous rate of TDN[b] intake (kg/day)	7.2	1.1	6.6	0.8	0.8
Postwean gain (kg)	180	42	198	38	30
Postwean TDN (kg)	1135	348	1404	362	307
Days post weaning	173	64	218	66	57
Calf instantaneous efficiency	8.7	4.1	10.8	5.5	4.3
Pair efficiency[c]	8.8	1.2	9.6	1.3	0.9

[a]Residual standard deviations from the model $\hat{Y}$ = year sex.

[b]Total digestable nutrients.

[c]Ratio of cow and calf TDN intake to calf weight.

TABLE 6. MEANS, STANDARD DEVIATIONS AND RESIDUAL STANDARD DEVIATIONS OF ANGUS CALF CHARACTERISTICS AT 14 MM FAT

Trait	Steers Mean	Steers SD	Heifers Mean	Heifers SD	RSD[a]
Number	63		50		113
Age (days)	466	48	452	39	31
Weight (kg)	438	60	383	35	44
Instantaneous rate of gain (kg/day)	0.70	0.19	0.68	0.24	0.16
Instantaneous rate of TDN[b] intake (kg/day)	7.1	1.3	6.5	0.7	0.8
Postwean gain (kg)	218	44	184	26	28
Postwean TDN (kg)	1456	336	1273	214	190
Days post weaning	213	42	199	37	22
Calf instantaneous efficiency	11.2	5.5	12.0	8.0	5.2
Pair efficiency[c]	8.9	1.1	9.5	1.0	0.8

[a]Residual standard deviations from the model $\hat{Y}$ = year sex.

[b]Total digestable nutrients.

[c]Ratio of cow and calf TDN intake to calf weight.

TABLE 7. MEANS, STANDARD DEVIATIONS AND RESIDUAL STANDARD DEVIATIONS OF ANGUS CALF CHARACTERISTICS AT 207 DAYS POST WEANING

	Steers		Heifers		
Trait	Mean	SD	Mean	SD	RSD[a]
Number	63		50		113
Age (days)	460	36	460	36	28
Weight (kg)	434	51	392	47	44
Fat (mm)	14.2	4.2	16.1	5.5	2.3
Instantaneous rate of gain (kg/day)	0.72	0.14	0.60	0.19	0.14
Instantaneous rate of TDN[b] intake (kg/day)	7.0	1.1	6.3	0.7	0.7
Postwean gain (kg)	215	29	191	25	25
Postwean TDN[b] (kg)	1407	153	1320	124	137
Calf instantaneous efficiency	10.7	3.9	12.4	6.1	4.2
Pair efficiency[c]	8.7	1.1	9.4	1.0	0.8

[a]Residual standard deviations from the model $\hat{Y}$ = year sex.

[b]Total digestable nutrients.

[c]Ratio of cow and calf TDN intake to calf weight.

evaluation. Steers also tended to have higher instantaneous rates of gain when evaluated across all points of evaluation; however, when evaluated at 14 mm fat or at an instantaneous efficiency of nine kg TDN/kg gain, the difference between heifers and steers was small. Although the difference is small, steers were more efficient across all points of evaluation than were heifers. Heifers had lower instantaneous rates of intake. Steers gained more postweaning than did heifers. Heifers required fewer days postweaning to reach 14 mm fat or to reach an instantaneous efficiency of nine kg TDN/kg gain; whereas, steers required fewer days postweaning to reach most efficient point or 400 kg weight.

Examination of the residual standard deviations (tables 3-7) reveals that both unit efficiency and instantaneous rate of TDN intake do not differ in variation across endpoints of evaluation. Although weight at each endpoint does not differ in variation, the amount of variation is larger than variation present at weaning (41-48 kg vs 31 kg). The largest variation in instantaneous gain after adjustment for year and sex occurs when evaluation is at a constant weight (400 kg). This could indicate that calves were at different points in their growth patterns or that their growth patterns differed when evaluated at a weight of 400 kg than when they were evaluated at the other endpoints. Variation in instantaneous efficiency appears less pronounced when evaluated at the most efficient point as opposed to evaluation at other postweaning points. Residual standard deviations of postweaning consumption, age, fat and number of postweaning days indicate that variation differs for each variable across all points of evaluation postweaning.

Factor Analysis

A rotated factor pattern of calf characteristics at MEP is presented in Table 8. Extraction of four factors represents 87% of the correlation structure of which factors one, two, three and four represent 35, 23, 14 and 15% respectively. High scores on factor one represent older, heavier, fatter calves that were on feed longer with heavier gains and larger TDN intakes. High scores on factor two would be indicative of younger, trimmer calves that were on feed fewer days with higher instantaneous rates of gain and higher instantaneous rates of intake. High instantaneous rates of gain and low instantaneous efficiency would indicate a low score on factor three. Calves having high scores on factor four would be heavier calves with more desirable pair efficiencies.

Factor analysis of characteristics adjusted for year and sex at an instantaneous efficiency of nine kg TDN/kg gain is presented in Table 9. The four factors explain 90% of the total variation. Factors 1, 2, 3 and 4 each represent 44, 23, 19 and 4%, respectively, of total variation. Factor one is positively correlated with postweaning gain, postweaning TDN consumption, fat and number of days postweaning. Secondary loadings consist of age and weight. Calves having high scores on factor two would have high instantaneous rates of gain and high instantaneous rates of intake. Furthermore,

TABLE 8. ROTATED FACTOR PATTERN OF ANGUS CALF CHARACTERISTICS AT THE MOST EFFICIENT POINT

Variables[b]	Rotated factor pattern[a] 1	2	3	4
Age (days)	.59	-.56	.03	.32
Weight (kg)	.58	.10	.14	.76
Fat (mm)	.73	-.36	-.03	-.04
Instantaneous rate of gain (kg/day)	-.09	.73	-.61	.27
Instantaneous rate of TDN[c] intake (kg/day)	-.10	.96	.02	.15
Postwean gain (kg)	.85	.10	.00	.22
Postwean TDN (kg)	.97	-.08	-.09	.00
Days post weaning	.79	-.53	-.02	-.26
Calf instantaneous efficiency	.00	-.01	.97	-.08
Pair efficiency[d]	.12	-.14	.26	-.80
Cumulative portion	35	58	72	87

[a]Image method, varimax rotation.

[b]Variables are residuals from the model $\hat{Y}$ = year sex.

[c]Total digestable nutrient.

[d]Ratio of cow and calf total digestable nutrient intake to calf weight.

TABLE 9. ROTATED FACTOR PATTERN FOR CALF CHARACTERISTICS AT AN INSTANTANEOUS POSTWEANING EFFICIENCY OF NINE KG TDN/KG GAIN

Variable[b]	Rotated factor pattern[a]			
	1	2	3	4
Age (days)	.69	-.27	.41	.50
Weight (kg)	.50	.08	.83	.15
Fat (mm)	.86	-.22	.02	.16
Instantaneous rate of gain (kg/day)	-.19	.96	.12	-.06
Instantaneous rate of TDN[c] intake (kg/day)	-.13	.97	.11	-.02
Postwean gain (kg)	.83	.03	.46	-.26
Postwean TDN (kg)	.92	-.04	.33	.01
Days post weaning	.93	-.31	.06	.11
Pair efficiency[d]	-.05	-.15	-.73	.01
Cumulative portion	44	67	86	90

[a]Image method, varimax rotation.

[b]Variables are residuals from the model $\hat{Y}$ = year sex.

[c]Total digestable nutrient.

[d]Ratio of cow and calf total digestable nutrient intake to calf weight.

these two variables load similarly across all four factors and, therefore, may be considered redundant when evaluation is made at an instantaneous efficiency of nine kg TDN/kg gain. Calves with high scores on factor three would be older, heavier calves that gained more postweaning and had more desirable pair efficiency at this point. Factor four is essentially unimportant as it explains only an additional 4% of the variance.

Rotated factor pattern of calf characteristics adjusted for year and sex at 400 kg weight are shown in Table 10. The four factors explained 89% of the total variation present. Each factor accounted for 23, 16, 19 and 31% of the total variation. Factor one contains negative loading for instantaneous rate of gain and positive loadings for measures of efficiency; therefore, high scores on factor one would belong to calves with low instantaneous rates of gain and undesirable measures of efficiency. Factor two consists primarily of a positive loading for a single variable, instantaneous rate of intake. A high score on factor three would indicate a calf that gained more postweaning on more TDN over a longer period of time, and was fatter with a lower instantaneous rate of gain to 400 kg weight.

Table 11 contains rotated factor loadings of characteristics adjusted for year and sex at 14 mm fat. Four factors accounted for 87% of the variation present with each factor contributing approximately equal amounts of variation. High scores on factor one would indicate calves that were heavier, had gained and consumed more

TABLE 10. ROTATED FACTOR PATTERN FOR CALF CHARACTERISTICS AT 400 KG WEIGHT

Variable[b]	Rotated factor pattern[a] 1	2	3	4
Age (days)	.30	-.38	.21	.75
Fat (mm)	.25	-.23	.33	.78
Instantaneous rate of gain (kg/day)	-.71	.44	-.37	-.39
Instantaneous rate of TDN[c] intake (kg/day)	.04	.94	-.14	-.20
Postwean gain (kg)	.18	-.17	.92	.23
Postwean TDN (kg)	.48	-.04	.58	.64
Days post weaning	.23	-.30	.45	.63
Calf instantaneous efficiency	.90	.12	.19	.33
Pair efficiency[d]	.54	.00	.07	.70
Cumulative portion	23	39	58	89

[a]Image method, varimax rotation.

[b]Variables are residuals from the model $\hat{Y}$ = year sex.

[c]Total digestable nutrient.

[d]Ratio of cow and calf total digestable nutrient intake to calf weight.

TABLE 11. ROTATED FACTOR PATTERN FOR CALF CHARACTERISTICS AT 14 MM FAT

Variable[b]	Rotated factor pattern[a] 1	2	3	4
Age (days)	.01	.18	.47	.73
Weight (kg)	.60	-.06	.00	.78
Instantaneous rate of gain (kg/day)	.19	-.91	-.28	.03
Instantaneous rate of TDN[c] intake (kg/day)	.87	-.07	-.15	.01
Postwean gain (kg)	.70	-.22	.42	.35
Postwean TDN (kg)	.80	.24	.46	.21
Days post weaning	.10	.24	.95	.02
Calf instantaneous efficiency	.11	.90	.04	-.08
Pair efficiency[d]	-.10	.44	.18	-.68
Cumulative portion	26	48	67	87

[a]Image method, varimax rotation.

[b]Variables are residuals from the model $\hat{Y}$ = year sex.

[c]Total digestable nutrient.

[d]Ratio of cow and calf total digestable nutrient intake to calf weight.

postweaning and had higher instantaneous intakes at 14 mm fat. Factor two contains positive loadings of efficiency and a negative loading for instantaneous gain. Older calves that gained more weight and consumed more TDN postweaning over a longer period of time would have high factor three scores. High scores on factor four would indicate a calf that was older and heavier at 14 mm fat and had gained more postweaning. This calf would also have a more desirable unit efficiency at 14 mm fat.

Table 12 contains rotated factor loadings of calf characteristics adjusted for year and sex at 207 days postweaning. Eighty-one percent of the total variation was explained by four factors. Factors one, two, three and four each accounted for 26, 21, 15 and 19% of the total variation respectively. Calves that were heavier and gained more postweaning and consumed more TDN and at a higher rate of intake at 207 days would have high scores on factor one. High scores on factor two would indicate calves with high postweaning efficiency and low instantaneous rate of gain at 207 days. Age is the unique loading in factor three. High scores on factor four would be indicative of calves with heavy weights, large postweaning gains and more desirable pair efficiency at 207 days.

Several variables tend to load together on a common factor across all postweaning points of evaluation. Weight and unit efficiency are two variables that tend to load together. A possible cause is the relationship between weight and unit efficiency as unit efficiency is a ratio of which weight is the denominator. Another

TABLE 12. ROTATED FACTOR PATTERN FOR CALF CHARACTERISTICS AT 207 DAYS POST WEANING

Variable[b]	Rotated factor pattern[a]			
	1	2	3	4
Age (days)	.05	.09	.92	.11
Weight (kg)	.58	.01	.58	.54
Fat (mm)	.24	.06	.19	.12
Instantaneous rate of gain (kg/day)	.19	-.92	-.13	.18
Instantaneous rate of TDN[c] intake (kg/day)	.84	-.09	-.12	.14
Postwean gain (kg)	.59	-.19	-.03	.73
Postwean TDN (kg)	.91	.05	.32	.09
Calf instantaneous efficiency	.15	.94	.01	-.10
Pair efficiency[d]	-.07	.20	-.24	-.85
Cumulative portion	26	47	62	81

[a]Image method, varimax rotation.

[b]Variables are residuals from the model $\hat{Y}$ = year sex.

[c]Total digestable nutrient.

[d]Ratio of cow and calf total digestable nutrient intake to calf weight.

set of variables that tend to load together are fat, postweaning consumption and number of days postweaning. Instantaneous rate of gain and instantaneous rate of intake tend to load together across most points of evaluation. Calf postweaning efficiency and instantaneous rate of gain also tend to load in common factors across all points of evaluation.

III. Relationships of Cow-Calf Preweaning Characteristics to Calf Characteristics at Various Postweaning Endpoints

Multiple regression procedures were used to relate preweaning cow-calf characteristics to calf characteristics at various postweaning endpoints. Calf characteristics included calf age, weight, fat thickness, instantaneous rate of gain, instantaneous rate of TDN intake, postweaning gain, postweaning TDN intake, number of postweaning days, postweaning instantaneous efficiency and unit efficiency. These calf characteristics were regressed on year, sex, cow weight at previous weaning, cow fat at previous weaning, cow weight change from previous to current weaning, calf age at weaning, calf weight at weaning, calf fat at weaning and weaning efficiency. Results may be seen in Tables 13-22.

Calf Age

Table 13 contains effects of preweaning characteristics on calf age at various endpoints. Year differences were important in explaining variation in calf age at all postweaning points except at

TABLE 13. PARTIAL AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF PREWEANING COW-CALF CHARACTERISTICS AS RELATED TO CALF AGE AT SELECTED POSTWEANING ENDPOINTS

	ENDPOINTS							
	Most efficient point		Instantaneous efficiency of nine kg TDN/kg gain		400 kg weight		14 mm fat	
Cow-calf preweaning characteristics	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial
Error degrees freedom	100		95		93		100	
Cow weight at prev. weaning (kg)	.04	.04	.04	.04	.04	.04	.05	.06
Cow fat at prev. weaning (mm)	2.25*	.20	.14	.01	1.60	.12	- .86	- .08
Cow wt. change from prev. to current weaning (kg)	.22*	.25	- .11	- .10	- .12	- .12	.06	.07
Calf age at weaning (days)	.92***	.70	1.15***	.74	1.18***	.78	.99***	.80
Calf weight at weaning (kg)	.01	.01	- .52^{+}	- .38	- 1.48***	- 1.10	- .23^{+}	- .21
Calf fat at weaning (mm)	- 1.74	- .04	- 3.58	- .06	- .61	- .01	- 1.19	- .03
Weaning efficiency	5.21^{+}	.27	- 5.79	- .25	3.66	.16	- 1.65	- .09
Residual standard deviation (days)	30		42		37		21	
Year[a] R^2	.39***		.26***		.06		.52***	
Sex[b] R^2	.00		.01^{+}		.17*		.01***	
Additional R^2 above year and sex	.24		.24		.37		.26	

[a]Coefficient of determination of the model $\hat{Y}$ = year.

[b]Additional coefficient of determination accounted for by sex after year differences were removed.

$^{+}P < .1$, $*P < .05$, $**P < .01$, $***P < .001$.

400 kg weight. Sex was an important source of variation of calf age when evaluation was made at a constant weight or fat, but not when evaluated at a constant instantaneous efficiency or at the most efficient point. Increases in coefficients of determination above that accounted for by year and sex, were observed across all postweaning points. Older calves at weaning were older at all postweaning endpoints ($P<.001$) when all other variables were held constant. This is in agreement with Crider (1981) who evaluated calves at the most efficient point and at 12 mm fat. Calf weaning weight varied in its importance upon age at each endpoint. When evaluated at a constant weight (400 kg), calf weaning weight negatively affected age ($P<.001$). Calf weaning weight tended toward a significant effect ($P<.1$) upon age at 14 mm fat and of an instantaneous efficiency of nine kg TDN/kg gain. When considered partial to other preweaning characteristics, older calves ($P<.05$) at weaning from cows that were thinner the previous weaning ($P<.05$) and lost less weight from the previous weaning to the current weaning ($P<.05$) and calves that had less desirable weaning efficiencies ($P<.1$) were older at the most efficient point. Crider (1981) reported a negative relationship of calf weaning weight to age at the most efficient point and a positive relationship of weaning efficiency with age at 12 mm fat. In these data these variables did not show the same relationships, perhaps as a result of being considered partial to more preweaning characteristics.

Calf Weight

Partial coefficients from regression of calf weight on preweaning characteristics are contained in Table 14. Year and sex both were significant sources of variation in calf weight at all postweaning endpoints. The additional variation explained by the models above that explained by year and sex were significant. Calf weaning weight, when adjusted for year, sex, characteristics of the cow, calf weaning age, calf weaning fat and weaning efficiency, was positively related ($P < .05$) to weight at each postweaning evaluation point. Crider (1981) also reported positive significant effects of calf weaning weight on weight at either the most efficient point or at 12 mm fat. Cow fat at the previous weaning showed a negative effect upon weight across all evaluation points, but was significant only when evaluation was at 14 mm fat ($P < .05$) or at 207 days postweaning ($P < .1$). The only evaluation endpoint that cow weight change from previous to current weaning tended toward significant ($P < .1$) was at the most efficient point. Calves from cows that lost more weight were lighter at the most efficient point.

Calf Fat

Table 15 contains partial regression coefficients of calf fat on preweaning characteristics at various endpoints. Variations due to year are larger than variations accounted for by other sources of variation in the model, except when evaluation is at 400 kg weight. Sex effects were significant ($P < .01$) at each endpoint except when

TABLE 14. PARTIAL AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF PREWEANING COW-CALF CHARACTERISTICS AS RELATED TO CALF WEIGHT AT SELECTED POSTWEANING ENDPOINTS

	ENDPOINTS							
	Most efficient point		Instantaneous efficiency of nine kg TDN/kg gain		14 mm fat		207 days	
Cow-calf preweaning characteristics	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial
Error degrees freedom	100		95		100		100	
Cow weight at prev. weaning (kg)	.10	.10	.11	.09	.08	.07	.06	.06
Cow fat at prev. weaning (mm)	- .38	- .03	- .82	- .05	- 1.97*	- .14	- 1.48†	- .11
Cow wt. change from prev. to current weaning (kg)	.20†	.20	- .02	- .02	.02	.02	.03	.03
Calf age at weaning (days)	- .16	- .11	.01	.00	- .06	- .04	- .09	- .06
Calf weight at weaning (kg)	1.08***	.82	.70*	.46	.98***	.69	1.14***	.86
Calf fat at weaning (mm)	.58	.01	- 2.32	- .04	- .57	- .01	- .02	.00
Weaning efficiency	1.34	.06	- 6.44	.25	- 3.35	- .14	- 2.06	- .09
Residual standard deviation (kg)	29		38		29		26	
Year[a] R^2	.31***		.25***		.22**		.19**	
Sex[b] R^2	.10**		.18***		.20***		.14***	
Additional R^2 above year and sex	.32		.24		.36		.46	

[a]Coefficient of determination of the model $\hat{Y}$ = year.

[b]Additional coefficient of determination accounted for by sex after year differences were removed.

†P < .1, *P < .05, **P < .01, ***P < .001.

TABLE 15. PARTIAL AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF PREWEANING COW-CALF CHARACTERISTICS AS RELATED TO CALF FAT AT SELECTED POSTWEANING ENDPOINTS

	ENDPOINTS							
	Most efficient point		Instantaneous efficiency of nine kg TDN/kg gain		400 kg weight		207 days	
Cow-calf preweaning characteristics	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial
Error degrees freedom	100		95		93		100	
Cow weight at prev. weaning (kg)	-.02	-.12	.00	.00	.00	.00	-.01	-.11
Cow fat at prev. weaning (mm)	.39*	.24	-.02	-.01	.26	.13	.04	.03
Cow wt. change from prev. to current weaning (kg)	.02	.14	-.03	-.22	-.03	-.19	.00	.00
Calf age at weaning (days)	-.04†	.20	.01	.05	-.02	-.09	-.01	-.07
Calf weight at weaning (kg)	.05†	.29	-.04	-.23	-.12**	-.59	.03*	.25
Calf fat at weaning (mm)	.08	.01	-.39	-.05	.52	.06	.31	.06
Weaning efficiency	.54	.19	-.51	-.17	.42	.12	.16	.08
Residual standard deviation (mm)	4.3		5.9		5.8		2.3	
Year[a] R^2	.58***		.37***		.20**		.75***	
Sex[b] R^2	.02**		.00		.10**		.03***	
Additional R^2 above year and sex	.04		.03		.27		.02	

[a]Coefficient of determination of the model $\hat{Y}$ = year.

[b]Additional coefficient of determination accounted for by sex after year differences were removed.

†P < .1, *P < .05, **P < .01, ***P < .001.

evaluation was at an instantaneous efficiency of nine kg TDN/kg gain. Heavier calves at weaning were fatter ($P < .05$) at the most efficient point and at 207 days postweaning, but were trimmer ($P < .05$) at 400 kg weight when all other variables were held constant. Effects of calf weaning weight on fat at an instantaneous efficiency of nine kg TDN/kg gain were negative but not significant. Calves from cows that were fatter at the previous weaning were fatter at the most efficient point ($P < .05$).

Instantaneous Rate of Gain

Instantaneous rate of gain was significantly affected by year across all postweaning endpoints (Table 16). Sex was not an important source of variation in instantaneous gain when evaluated at a constant instantaneous efficiency or a constant fat; however, when evaluated at the other postweaning points, sex was an important source of variation ($P < .05$). Weaning efficiency showed a consistent negative effect on instantaneous rate of gain, but was significant ($P < .05$) only when evaluated at the most efficient point, 400 kg weight or 207 days postweaning. Calf fat at weaning tended toward a significant effect ($P < .1$) on instantaneous rate of gain when evaluated at a constant fat and a constant instantaneous efficiency. Calf weight positively affected ($P < .05$) instantaneous rate of gain at 400 kg weight and instantaneous efficiency of nine kg TDN/kg gain. Cow weight change was the only other variable of importance in predicting instantaneous rate of gain. Cow weight change approached

TABLE 16. PARTIAL AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF PREWEANING COW-CALF CHARACTERISTICS AS RELATED TO CALF INSTANTANEOUS RATE OF GAIN AT SELECTED POSTWEANING ENDPOINTS

	ENDPOINTS									
	Most efficient point		Instantaneous efficiency of nine kg TDN/kg gain		400 kg weight		14 mm fat		207 days	
Cow-calf preweaning characteristics	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial
Error degrees freedom	100		95		93		100		100	
Cow weight at prev. weaning (kg)	.0000	.00	.0000	.00	.002	.03	.0002	.05	.0000	.00
Cow fat at prev. weaning (mm)	- .0031	- .07	.0010	.03	- .0091	- .13	.0022	.04	.0020	.05
Cow wt. change from prev. to current weaning (kg)	- .0008†	- .25	.0005	.23	.0008	.14	- .0001	.02	- .0002	- .06
Calf age at weaning (days)	- .0004	- .08	- .0005	- .16	- .0004	- .05	.0004	.07	- .0006	- .12
Calf weight at weaning (kg)	- .0003	- .07	.0012*	.42	.0048**	.66	- .0002	- .04	- .0012	- .28
Calf fat at weaning (mm)	.0043	.02	- .0180†	- .15	- .0262	- .09	- .0312†	.15	- .0027	- .02
Weaning efficiency	- .0314*	- .44	- .0003	- .01	- .0436*	- .36	- .0222	.25	- .0279*	- .40
Residual standard deviation (kg/day)	.13		.09		.21		.17		.14	
Year[a] R^2	.27***		.33***		.09**		.40***		.22*	
Sex[b] R^2	.17***		.08†		.10*		.01		.16***	
Additional R^2 above year and sex	.08		.05		.38		.04		.04	

[a]Coefficient of determination of the model $\hat{Y}$ = year.

[b]Additional coefficient of determination accounted for by sex after year differences were removed.

†$P < .1$, *$P < .05$, **$P < .01$, ***$P < .001$.

significance ($P < .1$) in predicting instantaneous rate of gain at the most efficient point.

Instantaneous Rate of TDN Intake

Year differences were significant contributors to variation of instantaneous rate of TDN intake at all postweaning endpoints (Table 17). Sex was significant only at the most efficient point or at 207 days postweaning. Very little additional variation in instantaneous rate of intake was explained above that accounted for by year and sex. Calf weight at weaning showed a positive effect on instantaneous rate of intake across all endpoints. An additional factor of importance in predicting instantaneous rate of intake at 400 kg weight was cow fat at previous weaning ($P < .05$). This characteristic approached significance in predicting instantaneous rate of intake at the most efficient point. At 207 days postweaning, calf weaning age also approached significant levels.

Postweaning Gain

Table 18 contains the results of multiple regression of post-weaning gain on cow-calf preweaning characteristics. Very little variation in postweaning gain was explained above that accounted for by year and sex except when evaluation was at 400 kg weight. Younger calves with less desirable efficiency at weaning from lighter, fatter cows the previous weaning required more postweaning gain to reach 400 kg weight. Cow fat at the previous weaning

TABLE 17. PARTIAL AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF PREWEANING COW-CALF CHARACTERISTICS AS RELATED TO CALF INSTANTANEOUS RATE OF TDN INTAKE AT SELECTED POSTWEANING ENDPOINTS

	ENDPOINTS									
	Most efficient point		Instantaneous efficiency of nine kg TDN/kg gain		400 kg weight		14 mm fat		207 days	
Cow-calf preweaning characteristics	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial
Error degrees freedom	100		95		93		100		100	
Cow weight at prev. weaning (kg)	.000	.00	.000	.00	-.001	-.05	.000	.00	.000	.00
Cow fat at prev. weaning (mm)	-.041†	-.16	.012	.04	-.063*	-.25	-.024	-.09	-.005	-.02
Cow wt. change from prev. to current weaning (kg)	-.001	.00	.002	.10	.001	.05	.001	.05	.000	.00
Calf age at weaning (days)	-.005	-.25	-.006	-.21	-.001	-.03	-.005	-.16	-.007†	-.24
Calf weight at weaning (kg)	.010*	.34	.011*	.45	.008†	.31	.011*	.40	.009*	.36
Calf fat at weaning (mm)	-.025	-.02	.099	.10	.024	.02	-.051	-.04	-.020	-.02
Weaning efficiency	.016	.04	-.010	-.02	-.056	.13	-.012	-.03	-.020	-.05
Residual standard deviation (kg/day)	.82		.76		.82		.84		.69	
Year[a] R^2	.32***		.39***		.33***		.43***		.48***	
Sex[b] R^2	.08**		.06		.02		.03		.08**	
Additional R^2 above year and sex	.06		.06		.13		.05		.04	

[a]Coefficient of determination of the model $\hat{Y}$ = year.

[b]Additional coefficient of determination accounted for by sex after year differences were removed.

†P < .1, *P < .05, **P < .01, ***P < .001.

TABLE 18. PARTIAL AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF PREWEANING COW-CALF CHARACTERISTICS AS RELATED TO CALF GAIN AT SELECTED POSTWEANING ENDPOINTS

	ENDPOINTS									
	Most efficient point		Instantaneous efficiency of nine kg TDN/kg gain		400 kg weight		14 mm fat		207 days	
Cow-calf preweaning characteristics	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial
Error degrees freedom	100		95		94		100		100	
Cow weight at prev. weaning (kg)	.11	.13	.12	.12	- .20***	- .25	.08	.10	.06	.11
Cow fat at prev. weaning (mm)	- .38	- .04	- .88	- .07	.96[†]	.10	- 1.90*	- .20	- 1.36[†]	- .19
Cow wt. change from prev. to current weaning (kg)	.19[†]	.24	- .01	- .01	.02	.03	.02	.03	.02	.04
Calf age at weaning (days)	- .14	- .12	.03	.02	- .45***	- .40	- .05	- .04	- .08	- .10
Calf weight at weaning (kg)	.05	.05	- .30	- .24			- .02	- .02	.12	.16
Calf fat at weaning (mm)	1.10	.02	2.40	.05	- 1.19	- .03	- .68	- .02	.50	.02
Weaning efficiency	1.50	.08	- 6.35	- .31	8.63***	.52	- 3.39	- .20	- 1.95	- .16
Residual standard deviation (kg)	28		37		18		29		26	
Year[a] R^2	.52***		.40***		.43*		.32**		.09**	
Sex[b] R^2	.06**		.12***		.02		.19***		.19***	
Additional R^2 above year and sex	.03		.01		.38		.04		.06	

[a]Coefficient of determination of the model $\hat{Y}$ = year.

[b]Additional coefficient of determination accounted for by sex after year differences were removed.

[†]$P < .1$, $*P < .05$, $**P < .01$, $***P < .001$.

was also negatively associated with gain when evaluation was at 14 mm fat ($P < .05$) or at 207 days postweaning ($P < .1$). Cow weight change from the previous weaning to the current weaning approached significance ($P < .1$) when evaluation was made at the most efficient point.

Postweaning TDN Consumption

Effects of preweaning characteristics on postweaning TDN consumption may be seen in Table 19. Year effects were significant ($P < .001$) sources of variation when evaluated at the most efficient point, a constant instantaneous efficiency and at 14 mm fat. Sex effects were significant ($P < .05$) when evaluation was made at a constant instantaneous efficiency, a constant weight and at a constant fat. Cow weight change from previous to current weaning ($P < .05$), calf weight at weaning ($P < .05$) and weaning efficiency ($P < .1$) were positively associated with postweaning TDN intake to the most efficient point. Therefore, heavier calves with less desirable weaning efficiency from cows that lost less weight from the previous weaning to the current weaning consumed more TDN postweaning when evaluated at the most efficient point. Calf weaning weight showed significant effects on postweaning TDN consumption to 400 kg weight ($P < .001$), 14 mm fat ($P < .05$) and 207 days postweaning ($P < .001$). Heavier calves at weaning consumed less TDN to 400 kg weight and more TDN to 14 mm fat and 207 days postweaning than lighter calves at weaning partial to all other preweaning characteristics.

TABLE 19. PARTIAL AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF PREWEANING COW-CALF CHARACTERISTICS AS RELATED TO CALF POSTWEANING TDN AT SELECTED POSTWEANING ENDPOINTS

	ENDPOINTS									
	Most efficient point		Instantaneous efficiency of nine kg TDN/kg gain		400 kg weight		14 mm fat		207 days	
Cow-calf preweaning characteristics	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial
Error degrees freedom	100		95		93		100		100	
Cow weight at prev. weaning (kg)	.08	.01	.05	.01	- .26	- .04	- .03	.00	- .35	- .12
Cow fat at prev. weaning (mm)	7.04	.10	.48	.00	4.40	.05	- 6.70	.09	1.18	.03
Cow wt. change from prev. to current weaning (kg)	1.39*	.26	- .56	- .09	- .50	- .07	.34	.06	.01	.00
Calf age at weaning (days)	- 1.49	- .19	.03	.00	- .06	.00	- 1.63	- .20	- 1.12†	- .27
Calf weight at weaning (kg)	2.51*	.36	- .67	- .08	- 7.28***	- .80	2.52*	.34	3.72***	1.03
Calf fat at weaning (mm)	6.32	.02	- 12.84	- .04	23.42	.06	2.98	.01	8.20	.06
Weaning efficiency	33.50†	.29	- 35.34	- .26	20.25	.13	- 1.41	- .01	10.58	.18
Residual standard deviation (kg)	189		261		201		191		114	
Year[a] R^2	.55***		.37***		.24		.52***		.06	
Sex[b] R^2	.01		.06*		.10**		.08**		.08	
Additional R^2 above year and sex	.04		.03		.40		.03		.32	

[a]Coefficient of determination of the model $\hat{Y}$ = year.

[b]Additional coefficient of determination accounted for by sex after year differences were removed.

†P < .1, *P < .05, **P < .01, ***P < .001.

Number of Postweaning Days

Sex effects were only significant on the number of days postweaning when evaluation was made at 400 kg weight of 14 mm fat (Table 20). At the most efficient point cow fat at the previous weaning ($P < .05$) and weaning efficiency ($P < .1$) had significant effects on number of postweaning days. Calves more efficient at weaning from cows that were thinner at the previous weaning took fewer days to reach the most efficient point. Heavier calves at weaning required fewer postweaning days to reach an instantaneous efficiency of nine kg TDN/kg gain ($P < .05$), a weight of 400 kg ($P < .001$) or a fat thickness of 14 mm when considered partial to all other preweaning effects. Christian et al. (1963) found that heavier calves at weaning reach a constant grade (choice) in fewer days than lighter calves at weaning.

Calf Instantaneous Efficiency

Year effects were important sources of variation in instantaneous efficiency ($P < .05$ to $P < .001$) across all endpoints except when evaluated at the most efficient point (Table 21). Sex effects were significant only if instantaneous efficiency was evaluated at the most efficient point ($P < .01$) or at 207 days postweaning ($P < .05$). Heavier calves at weaning were more efficient at 400 kg weight than were lighter calves; however, heavier calves at weaning tended ($P < .1$) to be less efficient than lighter calves at weaning when evaluated at 207 days. Fatter calves at weaning were less

TABLE 20. PARTIAL AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF PREWEANING COW-CALF CHARACTERISTICS AS RELATED TO CALF DAYS POSTWEANING AT SELECTED POSTWEANING ENDPOINTS.

	ENDPOINTS							
	Most efficient point		Instantaneous efficiency of nine kg TDN/kg gain		400 kg weight		14 mm fat	
Cow-calf preweaning characteristics	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial
Error degrees freedom	100		95		93		100	
Cow weight at prev. weaning (kg)	.04	.05	.04	.04	.04	.03	.05	.06
Cow fat at prev. weaning (mm)	2.25*	.21	.14	.01	1.60	.10	- .86	- .09
Cow wt. change from prev. to current weaning (kg)	.23	.27	- .11	- .11	- .12	- .10	.06	.08
Calf age at weaning (days)	- .08	- .06	.15	.10	.18	.10	- .01	- .01
Calf weight at weaning (kg)	.01	.01	- .52*	- .40	- 1.48***	- .90	- .23[+]	- .23
Calf fat at weaning (mm)	1.74	.04	- 3.58	- .07	- .61	- .01	- 1.19	- .03
Weaning efficiency	5.21[+]	.28	- 5.79	- .27	3.66	.13	- 1.65	- .10
Residual standard deviation (days)	30		42		37		22	
Year[a] R^2	.49***		.40***		.22		.69***	
Sex[b] R^2	.00		.02[+]		.08*		.03***	
Additional R^2 above year and sex	.10		.03		.43		.03	

[a]Coefficient of determination of the model $\hat{Y}$ = year.

[b]Additional coefficient of determination accounted for by sex after year differences were removed.

$^+P < .1$, $*P < .05$, $**P < .01$, $***P < .001$.

TABLE 21. PARTIAL AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF PREWEANING COW-CALF CHARACTERISTICS AS RELATED TO CALF INSTANTANEOUS EFFICIENCY AT SELECTED POSTWEANING ENDPOINTS

	ENDPOINTS							
	Most efficient point		400 kg weight		14 mm fat		207 days	
Cow-calf preweaning characteristics	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial
Error degrees freedom	100		93		100		100	
Cow weight at prev. weaning (kg)	.00	.00	.00	.00	.00	.00	.00	.00
Cow fat at prev. weaning (mm)	- .05	- .10	- .12	- .10	- .18	- .11	- .12	- .10
Cow wt. change from prev. to current weaning (kg)	.01*	.26	- .02	- .23	.03	.24	.01	.11
Calf age at weaning (days)	.00	.00	.02	.15	- .04	- .22	.00	.00
Calf weight at weaning (kg)	.02*	.40	- .06*	- .52	.02	.12	.04†	.33
Calf fat at weaning (mm)	- .41*	- .20	.39	- .08	1.18*	.18	.39	.08
Weaning efficiency	.44*	.53	.64	.33	.20	.07	.42	.20
Residual standard deviation (kg TDN/kg gain)	1.61		4.02		5.15		4.23	
Year[a] R^2	.24		.13**		.39***		.25*	
Sex[b] R^2	.05**		.06		.02		.06*	
Additional R^2 above year and sex	.15		.19		.06		.05	

[a]Coefficient of determination of the model $\hat{Y}$ = year.

[b]Additional coefficient of determination accounted for by sex after year differences were removed.

†$P < .1$, *$P < .05$, **$P < .01$, ***$P < .001$.

efficient calves at 14 mm fat ($P < .05$). Lighter, fatter calves at weaning that were more efficient at weaning and from cows that lost more weight from previous weaning to current weaning were more desirable in instantaneous efficiency when evaluated at the most efficient point ($P < .05$).

Unit Efficiency

Table 22 contains results of multiple regression of unit efficiency on preweaning characteristics. Year variation contributes significantly to the variation present in unit efficiency across all postweaning points. Sex also is a significant contributor in explaining the variation present at all endpoints. Weaning efficiency has a positive relationship on unit efficiency at all postweaning points. The more desirable the weaning efficiency is, the more desirable the unit efficiency will be at postweaning points. The heavier calf at weaning possessed ($P < .05$) the less desirable unit efficiency at all points of evaluation except at 400 kg weight.

Lighter calves at weaning ($P < .01$, $P < .05$) that had more desirable weaning efficiencies ($P < .001$, $P < .001$) and were from cows that were heavier at the previous weaning ($P < .1$, $P < .05$) were more desirable in unit efficiency at both 14 mm fat and at an instantaneous efficiency of nine kg TDN/kg gain, respectively.

TABLE 22. PARTIAL AND STANDARD PARTIAL REGRESSION COEFFICIENTS OF PREWEANING COW-CALF CHARACTERISTICS AS RELATED TO PAIR UNIT EFFICIENCY AT SELECTED POSTWEANING ENDPOINTS

	ENDPOINTS									
	Most efficient point		Instantaneous efficiency of nine kg TDN/kg gain		400 kg weight		14 mm fat		207 days	
Cow-calf preweaning characteristics	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial	Partial	Stand. partial
Error degrees freedom	100		95		93		100		100	
Cow weight at prev. weaning (kg)	-.002	-.09	-.003*	-.14	.000	.00	-.002†	-.10	-.002	-.09
Cow fat at prev. weaning (mm)	.021	.08	.006	.02	-.004	-.01	.018	.07	.030*	.11
Cow wt. change from prev. to current weaning (kg)	-.001	-.05	-.002	-.10	-.003	-.12	.00	.00	-.001	-.05
Calf age at weaning (days)	-.002	-.06	.000	.00	.001	.03	-.004	-.13	-.002	-.06
Calf weight at weaning (kg)	.009**	.32	.008*	.30	.002	.06	.010**	.37	.010**	.36
Calf fat at weaning (mm)	.032	.03	.029	.02	.055	.04	.022	.02	.030	.03
Weaning efficiency	.531***	1.15	.527***	1.15	.519***	.97	.525***	1.16	.526***	1.14
Residual standard deviation (kg TDN/kg wt)	.47		.45		.71		.49		.50	
Year[a] R^2	.47**		.45**		.43*		.40***		.45***	
Sex[b] R^2	.08***		.09***		.07**		.08***		.08***	
Additional R^2 above year and sex	.29		.32		.25		.34		.30	

[a]Coefficient of determination of the model $\hat{Y}$ = year.

[b]Additional coefficient of determination accounted for by sex after year differences were removed.

†P <.1, *P <.05, **P <.01, ***P <.001.

CHAPTER V

CONCLUSIONS

Results indicate that preweaning cow-calf characteristics were importantly related to all postweaning calf characteristics studied only if evaluation was at 400 kg weight (Table 23). Variation in postweaning calf characteristics, above that explained by year and sex, accounted for by cow-calf preweaning characteristics (R^2 values) ranged from .13 for instantaneous rate of TDN intake to .43 for postweaning days. Conversely, preweaning characteristics of cow-calf pairs were importantly related consistently across all endpoints only to calf age, calf weight and pair unit efficiency (R^2 values, above that attributable to year and sex, ranged from .24 to .37). These latter relationships were interpreted to reflect the part-whole aspects of these variables between weaning characteristics and postweaning characteristics.

Of the postweaning points evaluated, it was hypothesized that evaluations at the most efficient point, at an instantaneous efficiency of nine kg TDN/kg gain and at 14 mm fat were those of most direct application to the industry. Characteristics of the calves at these evaluation points appear consistent with slaughter weights and levels of fat observed in the industry. Intuitively, pair unit efficiency and calf instantaneous efficiency at slaughter provide the basis of decisions which determine overall production systems and quality and quantity of product produced. That these

TABLE 23. COEFFICIENTS OF DETERMINATION ATTRIBUTED TO COW-CALF PREWEANING CHARACTERISTICS[a]

	ENDPOINTS				
Calf Characteristics	Most Efficient Point	Instantaneous efficiency of nine kg TDN/kg gain	400 kg weight	14 mm fat	207 days
Age (days)	.24	.24	.37	.26	
Weight (kg)	.32	.24		.36	.46
Fat (mm)	.04	.03	.27		.02
Instantaneous rate of gain (kg/day)	.08	.05	.38	.04	.04
Instantaneous rate of TDN[b] intake (kg/day)	.06	.06	.13	.05	.04
Postwean gain (kg)	.03	.01	.38	.04	.06
Postwean TDN (kg)	.04	.03	.40	.03	.32
Days postweaning	.10	.03	.43	.03	
Calf instantaneous efficiency	.15		.19	.06	.05
Pair efficiency[c]	.29	.32	.25	.34	.30

[a]Additional variation explained above that accounted for by year and sex.

[b]Total digestable nutrients.

[c]Ratio of cow and calf TDN intake to calf weight.

decisions, and the resulting systems and product, vary with changes in economic conditions is recognized. Pair unit efficiency probably is the major overall influence in production systems which integrate pre- and postweaning phases of production. However, in the United States, the two phases usually are segmented. In this case, calf instantaneous efficiency probably is the major basis for determination of slaughter time. Maximum net revenue from feeding an individual group of animals is associated with that point in time when marginal net revenue is equal to zero. Whereas, in continuous feeding operations where the goal is to maximize returns from feeding space and investment, slaughter generally occurs when marginal net revenue of the slaughter animals is equal to that of replacement feeders (McLemore and Butts, 1979). In all cases, level of fatness is an important indirect criterion of proper slaughter time.

These results suggest that little biological antagonism exists between pre- and postweaning factors related to feed efficiency. Increased unit efficiency at weaning is favorably associated with unit efficiency at all endpoints studied and is either favorably associated with calf instantaneous efficiency evaluated at the most efficient point or is independent of that measure of efficiency at other endpoints. Preweaning pair characteristics were related to slaughter age and weight at all endpoints but were largely independent of level of calf fatness. Variation in preweaning character- and relationships between pre- and postweaning characteristics reported in this study provide producers an opportunity to select particular kinds of animals to achieve specific goals in specific production and economic situations.

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VITA

William Lawrence Bryson, born January 24, 1952, is the son of Marion Lawrence and Clara Jane Matheson Bryson. He is a native of Somerville, Tennessee where he attended Fayette County High School, graduating in 1970. He began his college education at the University of Tennessee, Knoxville in the Fall, 1970. In June, 1975 Lawrence moved to Orlando, Oklahoma to become Herdsman for a Hereford breeder. After similar positions in Rogersville, Tennessee and West Terre Haute, Indiana, he returned to Knoxville to complete his Bachelor of Science Degree in Animal Science in June, 1981. He is a member of the National Block and Bridle Club and the Gamma Sigma Delta Honor Society. In 1974 Lawrence married Pamela Marie Karnowski of Alcoa, Tennessee. They have two sons, Robert Matheson Bryson, age 7, and Gilbert Lawrence Bryson, age 5.