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Date May 30, 1986

SELECTION OF REPLACEMENT BEEF HEIFERS
BASED ON POSTWEANING FEED INTAKE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Louis Alfred Caldwell

June 1986

ACKNOWLEDGMENTS

The author wishes to express his appreciation to the many individuals who have contributed to the successful completion of this course of study and of this manuscript:

To Dr. J. C. Waller for serving as major professor and for reviewing this manuscript.

To Dr. J. B. McLaren for his advise concerning the analyses of the data and for serving on the graduate committee.

To Dr. R. O. O'Brian for his concern and advise in the author's efforts to obtain a minor in statistics and for serving on the graduate committee.

To R. A. Reynolds for his help in the collection of the data used in this study and for his friendship during the attainment of this advanced degree.

To fellow graduate students for their friendship and advise.

To the University of Tennessee Computing Center for use of their facilities in obtaining the results of this study.

To his parents, Mike and Katha Caldwell, for providing encouragement and financial assistance for the author to pursue an advanced degree.

To his wife, Susan, for her love, encouragement and sacrifices which helped to make this advanced degree possible.

ABSTRACT

Increasing cow herd productivity is a major concern of the cow-calf producer. Research has indicated that 25-30% of the beef cows placed in breeding pastures fail to concieve and wean a calf the following year. This decrease in weaning percentage equates to a 20% increase in the cost of producing a live calf at weaning. This increase in production costs justifies research with the purpose of evaluating possible alternative selection criteria for replacement animals.

Past selection of replacement animals has been based on such traits as hip height, weaning weight or yearling weight yeilding a heavier product at weaning. This method of increasing production has been associated with increased birth weight,frequency of dystocia and decreased rebreeding efficiency, thus reducing the overall herd proformance.

This study was designed to determine the effect of using voluntary feed intake, measured during a 60-day postweaning period, as a criterion for replacement heifer selection. One hundred sixty-eight Angus, Hereford and reciprocal cross heifers were utilized in this study. During each of the six years, 30 heifers were grouped and fed by sire. Their diet consisted of ad libitum corn silage, supplemental protein provided by .454 kg. cottonseed meal/head/day, and a free-choice mineral mix. Total feed intake of each pen was partitiioned into intake of individual heifers using both the ratio of mean heifer weight to mean pen weight and the net energy system. Feed required for maintenance and gain was estimated from mean empty body weight and empty body gain during the feeding trial. An

equation estimating daily feed intake of yearling heifers was also employed. Equations were adjusted so that the sum of estimated feed intake for individual heifers within each pen would total actual feed intake for the pen. Daily feed intake of beef cattle is extremely variable and influenced by numerous factors. Rumen capacity, low digestibility, and rate of passage limit the amount of forage consumed. Forage availability, use of supplements, climatic conditions, animal size, reproductive status, and genetic potential also affect daily feed intake. Upon completion of the feed intake trial, heifers were returned to the herd where production data were obtained.

Heifers ranged in initial weight from 170 kg. to 310 kg. and in final weight from 225 kg. to 364 kg. Average daily gain of the heifers ranged from .22 kg./day to 1.40 kg./day. Daily feed intake (DFI) ranged from 4.5 kg. to 7.0 kg. Selection of the top 25% of the replacement hiefers based on DFI produced positive secondary selection differentials for most probable producing ability when contrasted with the remainder of the replacement population ($p<.05$) and when contrasted with the bottom 25% ($p<.05$). Positive secondary selection differentials were also observed for mean weaning weight ratio when the top 25% were contrasted with the remainder of the replacement population ($p<.05$) and when contrasted with the bottom 25% ($p<.05$).

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CHAPTER I

INTRODUCTION

Increased productivity is economically important to the cow calf producer. Emphasis may be placed on improving herd calving percentage, increasing lifetime calf production, maintaining a 12 month calving interval, increasing weaning weights of calves or on the total amount of beef produced per cow. Recent data indicates that 25-30% of the beef cows in the United States fail to wean a calf. Eliminating poor producers and restocking with replacement heifers enhances the genetic potential for production.

Replacement heifer selection has been based on single traits such as hip height, weaning weight and yearling weight and has resulted in the production of larger animals. Problems resulting from such selection practices have been increased birth weight, frequency of dystocia and decreased rebreeding efficiency. To overcome these associated problems, Dickerson et al., (1974), Fitzhugh, (1975), Smith and Cundiff, (1976) and Smith et al., (1976) have suggested selecting for both increased or unchanged final weight and decreased birth weight by utilizing a measure of relative growth. Heifer selection based on preweaning relative growth rate (RGR) produced positive influences in both postweaning RGR and a reduction in cow lifetime average progeny weaning weight (Etienne and Martin, 1979).

A postweaning criterion must be chosen to identify superior producing females within the replacement group. The criterion should be easily measured and applicable to all heifers during the prebreeding period.

This study was initiated as a result of observations made by farm managers of the definite differences in dry matter intake within the herd. The objectives of this research were to estimate the individual daily feed intake of heifers grouped by sires for a 60-day postweaning period and to determine if selecting replacement heifers based on estimated daily feed intake would result in differences in productivity.

CHAPTER II

REVIEW OF LITERATURE

INTRODUCTION

Many researchers have studied the maternal influence on the pre-weaning performance of the beef calf. In addition, the relationship between the dam's pre- and post-weaning performance and the subsequent performance of her calves are of major concern since replacement heifers are selected based on these performance records. It has been observed that cows tend to repeat previous growth performances of their calves enabling the estimation of the most probable producing ability (MPPA) for weaning traits and repeatibiltiies for these traits.

This literature review will be organized in two major sections. Section one contains reviews of factors which contribute to the voluntary feed intake and prediction equations used to estimate daily feed intake of beef cattle. Section two contains the maternal influence of the cow as measured by progeny performance.

FACTORS INFLUENCING VOLUNTARY FEED INTAKE

Numerous factors are involved in the uptake of feed by ruminants. Those that will be discussed in this literature reviev fall into two broad catregories: physical and physiological restriction or activation of feed intake. Physical factors include body weight, body measurements, the condition of the animal, and the growth potential of the animal. All of these factors are a result of the genetic potential the animal possesses. Physiological factors include level of supplementation, caloric density of the diet, the pH content and the production of volitile fatty acids (VFA) within the rumen, rumen distention, environmental effects and the animals thermostatic regulation of body temperature. Most of the physiological factors affecting feed intake are uncontrollable by the animal but by alternative mechananisms define either hunger or satiety in regards in feed intake.

Body Weight

Animal research has demonstrated that body has a positive influence on feed consumption. Trowbridge et al. (1915) reported that heavier animals have a greater expenditure of energy for maintenance than smaller animals. Since feed required for body maintainance accounts for a large proportion of the total feed consumed by an animal it can be readily accepted that larger cattle have both a greater capacity and a greater need for feed. The National Research Council (N.R.C., 1984) currently recommends that feed requirements for maintenance of beef cattle be based on body weight in kilograms to the 0.75 power. These recommendations were based on the work of Garrett et al. (1959), Lofgreen and Garrett (1968) and Garrett (1980). From a metabolic standpoint energy for maintenance is the fasting heat production of the animal. Kleiber (1947), Blaxter (1972) and Thonney (1976) stated that body weight$^{0.75}$ is an appropiate estimator of fasting heat production of animals when comparing energy metabolism data of animals varying in body size. Preston (1972) calculated the relationship of dry matter intake to metabolic weight ($w^{0.75}$). Regression analysis indicated an average requirement of 95 grams of dry matter intake for each unit of metabolic weight maintained. Using a similiar approach, Garrett (1974) observed that the fasting heat production of nonpregnant beef cows should be calculated as 82 * $W^{0.75}$kg., which was not significantly different from the value recommended for steers and heifers (77 * $W^{0.75}$kg.).

In a study with identical twin calves, Winchester and Hendricks (1953) reported that maintainance requirements varied with body weight to the 0.66 power. Other researchers have suggested that feed requirements of beef cattle were linearly related to body weight.

Knox (1957), in a study with "large" and "comprest" cattle, measured feed intake by the amount of lignin voided in the feces and observed that feed intake by cattle of the two types was directly proportional to body weight. In contrast, Stonaker et al. (1952) reported that within a given age group, total feed consumption and gains increased with size but there were no significant differences in the amount of feed consumed per 454.5 kg. of body weight maintained between Hereford females of large, intermediate and comprest (small) sizes.

Body weight of cattle has a definite impact on the amount of feed the animal requires for maintenance. Body weight and/or size also limits the amount of feed that can be consumed during any given period of time due to the physical capacity of the animal. Since changes in the composition of gain occur as an animal increases in weight and degree of maturity, the amount and composition of the feed consumed must change to meet the energy requirements of the animal.

Body Measurements

Body measurements of beef cows have been shown to account for more of the total variation in daily feed requirements when added to regression equations that contain only body weight. Melton et al. (1967) found positive relationships between feed intake and body measurements of chest depth, width at the hooks and body length. These data indicate that including body measurements in a regression equation would improve the prediction of feed requirements for cattle. Smithson (1968) reported that weight alone accounted for 27.7 percent of the variation in daily feed requirements. The addition of body length and heart girth separately to the regression equation containing weight accounted for 44.8 and 42.9 percent of the daily feed requirements, respectively. When the variables of weight, heart girth and body length were considered together the regression equation explained 55.2 percent of the variation in daily feed requirements.

Condition

Research has indicated that weight alone cannot be used to accurately determine the energy requirements of beef cattle (Klosterman and Parker, 1976). Lemenger et al. (1980) reported that visual body condition score combined with weight, appeared to predict energy requirements of cows more accurately than weight alone.

Conflicting results have been reported in studies determining the relationship between condition of the animal and feed intake. McCandlish and Gaessler (1920) observed that "fleshy" cows required 7.39 lb. of TDN per day to maintain 1000 lb. of live weight while "thin" cows required only 5.43 lb. of TDN per day. Eckles et al. (1927) reported similiar results in that dairy calves in a very high condition required 6.79 therms per day per 1000 lb. for maintenance. Using these same animals in a later feeding trial when the condition of the calves had been adjusted to a normal state they observed energy requirements of only 5.37 therms per 1000 lb. of body weight maintained. Rebhan and Donker (1960), in a study to determine the effect of condition on energy requirements for maintenance in three sets of monozygous dairy bulls, found a positive relationship between condition of the animal and feed intake. Armsby and Fries (1917) maintained a steer in a respiration calorimeter for three months and reported a live weight gain of 300 lb. Maintenance requirements were increased by 36%, an increase that was proportionally greater than the increase in live weight. Thus, as the animal progresses to a heavier weight and increases in the degree of maturity, condition of the animal increases accompanied with an increase in energy required for maintenance.

Trowbridge et al. (1915) determined that condition of the animal had little influence on energy requirements for maintenance. Klosterman et al. (1968) reported that cows with a high degree of condition, indicated by a weight to height ratio, tended to gain weight while cows in a thin condition lost weight when the ration fed was adjusted for their metabolic weight. The researchers further proposed an equation to adjust for the condition of the animal:

$$\text{Kcal DEm} = 130 * W^{0.75}\text{kg.} -(W/H - 4.0) * 1716 ,$$

where W/H, the weight to height ratio, defines the condition of the animal. Kress et.al. (1970) stated that the weight to height ratio is an acceptable indicator of body condition with fatter animals having a greater weight per unit height. Reports of Anderson et al. (1983) support the findings of Klosterman et al. (1968) in that smaller cows would receive less than optimum energy for maintenance and larger cows would receive more than optimum energy for maintenance. Klosterman and Parker (1976), in a study with Hereford and Charolais cows, concluded that fat cows have a lower maintenance energy requirement per unit of weight than thin cows.

Thompson et al. (1983) reported estimates of maintenance energy requirements of fat and thin cows. Fat Angus-Hereford cows had a 6.1% lower energy requirement than thinner cows of the same breeding while fat Angus-Holstein cows had a 2.7% higher maintenance requirements for energy than their thinner counterparts. The observed differences in maintenance energy requirements between the two crosses were postulated to be the result of Holstein cattle having less subcutaneous fat than cattle of beef breeds and in effect having less insulation to regulate heat loss to the environment.

Lamborne and Reardon (1963) and Graham (1967) in studies with sheep, reported that maintenance requirements were negatively related to condition. Lighter sheep were observed to lose weight while heavier sheep maintained their body weight when the amount of feed fed was based on their metabolic weight. Sheep with less condition were found to have higher maintenance requirements per unit of weight than sheep with more condition.

Conditon or the amount of insulation provided by an animal's condition appears to regulate heat loss to the enviroment and reduce the feed required to maintain body temperature. Conflicting results reported of the influence of body condition on maintenance energy requirements leads to the conclusion that condition of the animal might serve to regulate feed requirements by some other means. Condition of the animal may be involved in abdominal distention.

Rate of Maturity

The rate of maturity has been reported to influence the energy requirements of beef cows. Early maturing cows have a lower than average breed mature weight while later maturing cows have a higher than average mature weight. Brown and Brown (1971) in a study of simulated data reported that earlier maturing cows cost more to maintain at all ages up to five years than later maturing cows of the same mature weight. However, the cost to reach a given weight was greater for the later maturing cows at all weights. Further comparing an early maturing cow of a low mature weight with a later maturing cow of a high mature weight the authors noted a greater cumulative cost of development at all ages up to 5 years for the early maturing cow. At all weights, the later maturing cow had a greater cumulative cost. At maturity the heavier cows cost 30 percent more to maintain, but their increased weight at slaughter was believed to offset the additional costs. Klosterman and Parker (1976) observed that early maturing cattle consumed more feed per unit of body weight than later maturing types. Song and Dinkel (1978) studied the effect of degree of maturity on energy intakes in beef heifers and found a linear relationship between maximum metabolizable energy intake per unit of metabolic weight and the degree of maturity. As beef heifers reach mature weight the amount of feed consumed increases due to increased maintenance requirements and increased gastrointestinal volume. Manipulation of maintenance requirements of developing beef heifers should result in more efficient utilization of injested feed. This is supported by the work of Clanton et al. (1983). in a study of developing replacement

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(1) Miller A.A.,
1967 Cow Size as related
to efficiency of beef production.
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Rpt PR 2485.

S 117
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(2) Klosterman E.W.
Effect of size, breed, sex upon
feed efficiency of beef cattle,
Ohio Agr. Res. & Dev. Center
Res. Bull. 1088 July 76

S 101
E22

(3) Garrett 1959 The net energy req. for
sheep + cattle for maint. + gain
J.A.S. 18:528.

energy per kg. of weight gain than a lighter animal of the same frame size as this gain would be higher in the proportion of fat being stored.

Level of Supplementation

The addition of supplements to diets consisting mainly of roughages is primarily to increase the protein and energy content of the ration fed to ruminants. Depending upon the quality of the forage consumed, the amount of supplement required to balance the ration may displace the intake of roughages. Crabtree and Williams (1971) included a commercial lamb pellet to a diet of chopped hay or straw at 0, 100, 200 and 400 g/day and observed intakes in 6-month-old ewe lambs. The straw intake remained constant until the concentrate level approached 38% of the total ration. Hay intake was noted to decrease as the level of concentrate increased but total dry matter intake increased. Crude protein contents (6.7 and 3.9%, respectively) may have had an effect on intake at low concentrate levels. They further observed hay intakes to be similiar when nonpregnant nonlactating cows were fed ad libitum hay plus 0 or 2.5 kg. concentrate per day. The addition of 5.0 or 7.5 kg. concentrate resulted in a decrease in hay intake but again total dry matter intake increased with increasing amounts of concentrate. The rate of disappearance of dry matter from the reticulorumen increased during the meal as the amount of concentrate fed increased. The reduced rate of disappearance of hay was thought to be due to a decrease in digestibility of crude fiber in the ration. Weston (1966) suggested that grinding or pelleting of feeds could increase the rate of disappearance of dry matter from the rumen and increase feed intake.

Crabtree and Williams (1971), in a second experiment, varied the composition of the ration and the level of concentrate supplementation to determine the effect on voluntary hay intake of 6-month-old ewe lambs. Increased dietary nitrogen content increased hay intake and was suggested to be due to changes in rate and extent of digestion, rate of passage and nitrogen status of the animal. Increasing the proportion of dietary concentrate, while maintaining the nitrogen content constant, resulted in reduced hay intake. Further, increasing the crude protein content of the concentrate at a constant level of dietary concentrate reduced hay intake. The authors concluded that the voluntary intake of hay in mixed diets is a function of hay quality, proportion of concentrate and that energy intake was not regulated by energy demands.

Caloric Density

Bull et al. (1976) studied the influence of caloric density on energy intake in dairy cows. Five diets with caloric densities of 0.58, 0.63, 0.68, 0.84, and 1.17 were used. Physical fill was noted to be the factor limiting intake for the two most dilute diets. The diet with a caloric density of 0.68 represented the level above which physiological regulation limited feed intake. The authors reported a curvilinear relationship between bulk caloric density and dry matter intake. Baumgardt et al. (1976) combined the data of Bull et al. (1976) and DePeters (1975) and observed that neutral-detergent fiber (NDF) and bulk density of the diet were both highly correlated with dry matter intake ($r = -0.91$ and $r = 0.93$, respectively). They also observed a curvilinear relationship between NDF and dry matter intake and between bulk density and dry matter intake. The authors suggested that an equation estimating daily feed intake should include a measure of digestibility, density and neutral-detergent fiber of the ration as variables.

Rumen pH and VFA Production

Variations in rumen pH may be important in the physiological regulation of feed intake. An increase in the rumen pH is associated with a decrease in volitile fatty acid (VFA) uptake by the vascular system. Within the rumen, VFA are produced in the forestomach and absorbed through the rumen epithelium before passage into the abomasum. Bhattacharya and Warner (1968) increased the rumen pH of cattle and sheep by alkali treatment and observed an accompanying increase in feed consumption. Total concentration of rumen VFA was elevated while total blood VFA concentration was reduced. It was concluded that the increase in pH reduced the rate of VFA absorption to a point where blood VFA were unable to act as a satiety signal. Intake levels were increased until other satiety signals were activated.

The VFA are considered part of the feedback system affecting feed intake. Intraruminal injections of VFA have been observed to decrease feed consumption by ruminants. Theurer and Hale (1968) infused acetate or propionate intravenously into steers fed an 80% concentrate diet. Acetate caused a 9% reduction in dry matter intake while consumption during propionate infusion was only 66% as much as during a saline infusion. Baile and Mayer (1968) observed that intraruminal injections of acetate into goats caused a much greater reduction in feed intake than intraveneous injections. They suggested that receptors for acetate regulation of feed intake are probably located on the luminal side of the reticulorumen than in either the hypothalamus or ruminal or portal venous system. Baile and Pfander (1966) noted that lactate affected feed intake to a greater degree than acetate. Lactic acid injected into the rumen of sheep caused a 75% decrease in feed intake while intake was only depressed 60% when acetate was injected. It was suggested that ruminants can apparently monitor the concentration of these acids in the rumen and reduce feed intake as a result of increased sensitivity of receptors in the rumen epithelium during increased absorption of lactate.

Rumen Distention

The capacity of the rumen has been observed to be a factor limiting the amount of feed consumed during a period of time (Campling, 1970). The rumen of cattle fed for approximately 6 hr./day were reported to increase in the total weight of digesta by 48% and increase in weight of dry matter by 96% over prefeeding values. These results support the concept that cattle consuming roughages tend to eat until a certain level of rumen distention is achieved. This level of distention is considered variable and may act to prevent distress from overeating. Campling and Balch (1961) noted that when ground roughages were fed, eating stopped before the critical level of rumen fill with unground roughages had been reached. The authors postulated that the increased passage of fine feed particles from the rumen was filling a more distal end of the digestive tract before the rumen became full. Campling and Balch (1961) reported that ruminants in which the boli were removed continued to eat for longer periods of time and consumed more feed than during normal feeding. Thus, the amount of feed consumed was not regulated by prehension, mastication or swallowing. Weston (1966) and Welton and Baumgardt (1970) observed that the addition of sawdust to the rumen of sheep depressed feed intake while the addition of polyvinylchloride or polypropylene fibers (1000g/day) had little effect on feed intake. This would support the hypothesis that movement of feed to the distal end of the digestive tract results in lower feed intake due to total gastrointestinal tract distention.

Other researchers have used water in an attempt to displace the rumen capacity. Balch and Campling (1961) infused 45 kg. of water directly into the rumen during the first 30 minutes of a 3 to 4 hour feeding period of cows fed a hay diet. This rate of infusion exceeded the probable rate of absorption from the rumen, yet there was no reported effect on feed intake. Similiar results have been obtained by Thomas et al. (1961) studying the intake of heifers fed silage rations and by Davies (1962) studying the intake of sheep fed rations of high fluid content. Holmes and Lang (1963) found no significant correlation between herbage water content and dry-matter intake of grazing cattle.

A decrease in feed intake has been observed in pregnant and fat ruminants. This phenomenon has been ascribed to the compression of the rumen by the uterus and/or abdominal fat (Forbes, 1968 and Forbes, 1969). Thus it is suggested that abdominal rather than rumen distention may be a factor limiting roughage intake. Jordan et al. (1973) observed the voluntary intake of roughages by nonpregnant and pregnant beef cows. Results of their experiment indicated that beef cows during the last half of pregnancy tended to consume less dry matter than nonpregnant cows and a further decrease in intake occured about 2 weeks before calving.

Environment and Thermostatic Regulation

Numerous observations on the effects of changes in environment on feed intake have shown that at high temperatures feed intake decreases (Ragsdale et al., 1950 and Reik et al., 1950). Conversely, at low temperatures feed intake increases (Moose et al., 1969 and Ragsdale et al., 1950). Continuous high temperatures depress intake to an extent that zero energy balance is no longer maintained and above 40 C ruminants of temperate climates do not eat at all (Appleman and DeLouche, 1958 and Ragsdale et al., 1950). This effect has been observed to reverse by means of increased heat loss during exposure to cooler temperatures.

The layer of insulation provided by an animal's covering of hair or wool reduces the changes in rate of heat loss to the environment. Armstrong et al. (1959) and Wodzicka-Tomaszewska (1963) observed that when sheep are shorn, heat loss increases under some environmental conditions and an increase in metabolic rate and feed intake occurs in order to maintain body temperature and energy balance. The greater the heat loss to the environment, the greater the increase in feed intake after shearing (Wodzicka-Tomaszewska, 1965).

Other researchers have shown the influence of heat balance on feed intake by directly heating or cooling internal organs. Gengler et al. (1970) increased the temperature of the rumen content of cattle from the normal 38.0 C to 41.3 C with heating coils placed directly in the rumen and observed a decrease in feed intake of 15%. Bhattacharya and Warner

(1968) decreased the temperature of the rumen by adding cold water (5 C) and reported a lower body temperature and increased feed intake by 24%, although adding warm water (49 C) did not decrease intake. Similarly, Ittner et al. (1951) and Thompson et al. (1949) noted that heat stressed cattle consumed more feed when given cold water to drink prior to feeding. Coppock and West (1986) in a study of possible nutritional adjustments that may reduce heat stress in lactating dairy cows, reported that when chilled drinking water was offered a transient reduction in body temperature and respiration rate occured. Increased dry matter intake was reported and a yeild response was noted to be sufficient to pay for the cost of chilling the water from 28 to 10 C.

Brobeck (1960) suggested that there are receptors in the hypothalamus that activate feed intake when a certain heat load minimum or depression of temperature is reached. Della-Fera and Baile (1984) studied the various central nervous system factors controlling feed intake intergrating in the hypothalamus. They reported that two families of neuropeptides are responsibe for the control of feed intake in sheep: the cholecystokinin (CCK) peptides, of which CCK-8 is the primary brain form supressing feed intake by acting as a satiety signal, and the opioid peptides, such as metenkephalins, B-endorphin, and dynorphrin A peptides, stimulating feed intake by the initiation of hunger or feeding.

PREDICTION OF FEED INTAKE

There are many reported nutritional and physiological experiments on the feeding behavior of ruminants. With this vast source of information it still remains difficult to predict the feed intake by a group of animals of any one diet. Numerous researchers have developed equations predicting intake. Most consider only one or two qualities of the feed and one or two charisteristics of the animal being fed. More aspects of the mechanisms controlling feed intake will be required before the amount of feed consumed by ruminants can be predicted with greater accuracy.

The accurate prediction of dry matter intake in cattle is important for the day-to-day management of grazing cattle, planning of feedlot rations, and the harvesting and storing of feed resources. In research with grazing animals, where feed intake cannot be directly measured, the interpretation of the results depends largely on the accuracy of the intake estimates provided by prediction equations.

Equations Predicting Feed Intake

Conrad et al. (1964), analyzing 114 trials with lactating cows, grouped their data by low (52.1% to 66.7%) and high (66.7% to 80.0%) digestibility of the feed. They suggested that in the low-digestibility group, feed intake is controlled by the rate of passage from and the amount of undigested material in the digestive tract (physical limit) and is positively related to digestibility. At high digestibility, dry matter intake is regulated by the level of energy requirement (physiological limit), their findings were condensed to two equations (Conrad, 1966). For the physical-limiting phase (low digestibility):

$$I = (0.0107 * W) / (1 - DIG)$$

where:

I = dry matter intake (kg/cow/day),

W = live weight (kg), and

DIG = dry matter digestibility (fraction).

For the physiological limiting phase (high digestibility):

$$DDM = 0.526 + 0.333 * FCM + 0.056 * W^{0.73} + 3.08 * dW$$

where:

DDM = digestible dry matter intake (kg/day),

FCM = fat corrected milk (kg/day), and

dW = live weight change (kg/day).

Dinius and Baumgardt (1970) observed that feed intake of sheep increased as the caloric density increased up to 2.5 kcal./g., after which intake started to decrease. They regressed dry matter intake on digestible energy and as digestible energy increased to 2.47 kcal./g., dry matter intake increased by the equation:

$$DMI = 31.74 * DE + 4.57 \quad (r = 0.61)$$

where:

DMI = dry matter intake (kg dry matter); and

DE = digestible energy (kcal/g. diet).

As digestible energy increased above 2.47 kcal/g., dry matter intake decreased by the equation:

$$DMI = -26.13 * DE + 147.5 \quad (r = 0.76)$$

Garrett (1973) proposed the following regression equation to predict daily feed intake:

$$DMI = 4.67 + 0.0144 * W + 0.077 * R$$

where:

DMI = dry matter intake (lb.);

W = body weight (lb.); and

r = % roughage in diet.

Nino and Hughes (1976) formulated equations predicting feed intake that may be described by a single curve. The two curves as denoted by the equations of Dinius and Baumgardt (1970) were preceived to be too exact in predicting feed intake. These two curves were observed by Nino and Hughes to overpredict feed intake. They therefore formulated an equation predicting feed intake that may be described by a single curve. The curvilinear relationship between daily feed intake and caloric density was:

$$DMI = 0.10 * W^{0.75} * (-0.388 + 1.11 * Q - 0.222 * Q^2)$$

where:

DMI = dry matter intake (kg.);

W = body weight (kg.); and

Q = caloric density (kcal./g. diet).

Fox and Black (1977) have developed correction factors to adjust equations predicting feed intake of cattle of various breeds and different weights as follows:

$$DMI = 1.22\ K * M * W^{0.75}$$

where:

DMI = dry matter intake (lb.);

k = 0.10 for cattle < 800 lbs.;

= 0.095 for cattle 800 to 1060 lb.;

= 0.090 for cattle > 1060 lb.

M = 1.0 for calves;

= 1.1 for yearlings;

= 1.17 for Holsteins;

= 1.09 for Holstein crosses;

= 1.0 for other breeds;

= 0.91 with monensin; and

W = equivalent weight in lb.

This equation with correction factors indicates that Holstein cattle consume 17% more feed than cattle of typical breeding. The "equivalent weight" adjustment of this equation projects intake of large-framed cattle to be 6-13% greater than for medium-framed cattle.

Gill (1979) proposed the following equation to predict dry matter intake:

$$DMI = 0.90 \; [\; K * W^{0.75}/2.2 - (\; (W - 500)/500)^2 \;]$$

where:

DMI = dry matter intake (lb.);

K = 0.18 + (0.077 * feeder grade) + (0.0001 * initial weight (lb.)); and

W = actual body weight (lb).

The Agricultural Research Council of Great Britian (A.R.C., 1980) uses the following regression equation to estimate daily feed intake:

$$DFI = 0.142 - (0.0129 * ME) * W^{0.75}$$

where:

DFI = daily feed intake (lb.);

ME = metabolizable energy (Mcal/kg.); and

W = weight of the animal (lb.).

Meiske et al. (1982) utilized data on 7040 steers fed in 347 pens to formulate regression equations prediction dry matter intake. The equation that best fits the data is:

$$DMI = 1.54 + 0.1025 * W^{0.75} - 0.7143 * ME$$

where:

DMI = dry matter intake (kg.);

W = weight (kg.); and

ME = metabolizable energy (Mcal/ kg. dry matter).

They reported a correlation between predicted and actual dry matter intake of 0.833 (R^2 = 0.694). Thus 69.4% of the observed variation in dry matter intake was accounted for by the equation. The equation that best fits the data for dry matter intake expressed in pounds is:

$$DMI = 3.40 + 0.125 * W^{0.75} - 3.46 * ME$$

where:

DMI = dry matter intake (lb.);

W = actual body weight (lb.); and

ME = metabolizable energy (Mcal/lb. dry matter).

For yearling or large framed steers the authors recommended the following equation:

$$DMI = 3.47 + 0.1375 * W^{0.75} - 3.806 * ME$$

where:

DMI = dry matter intake (lb.);

W = actual body weight (lb.); and

ME = metabolizable energy (Mcal/lb. dry matter).

The National Research Council (N.R.C.,1984) recommends the following equation estimating daily feed intake of growing and finishing cattle:

$$DFI = W^{0.75} * (0.1493 * NE_m - 0.046 * NEm^2 - 0.0196)$$

where:

DFI = daily feed intake (kg. dry matter);

W = weight of the animal (kg.); and

NE_m = net energy for maintenance (Mcal/kg. diet).

They offered the following adjustments for frame size of the calf;

None: medium-frame steers and bulls, large-frame heifers.

+10%: Large-frame steers, medium-frame yearling steers.

+5%: Large-frame bulls.

-10%: medium-frame heifers.

This equation was used to estimate daily feed intake in the present study with no adjustments made for frame size although the equation was adjusted to equal total feed intake for the pen of heifers.

MATERNAL INFLUENCE ON PROGENY PERFORMANCE

Research is lacking to define the total maternal environment provided by the cow and the relation of this environment to the response in weight gain or loss observed in the calf. Studies involving identical twin heifer calves have been conducted to determine the effect of varying the management regimes on cow productivity measured by milk production of the cow and weight gains of the calf. Swanson (1957, 1960) fattened one heifer of identical twin dairy calves at 4 to 6 months of age with a grain ration while maintaining the other heifer of the pair on a roughage ration to 1 year of age. The fattened heifers lost an average of 125 lb. the first month after calving, then regained 88 lb. in 8 months. The heifers on the roughage diet lost only 50 lb. during the first month following calving and regained 176 lb. in the subsequent 8 months. The heifers on the roughage diet produced 4,362 lb. of milk during the first lactation compared to 3,669 lb. for the heifers on the grain diet.

Christian et al. (1965), in a similar experiment with identical twin beef heifers, raised both members of the twins and their progeny in a drylot. One member of the pair was creep fed while the other member received a diet consisting of roughages starting at 60 days of age. A significant negative correlation was found between weaning weight of the dam and her butterfat production during the first 60 days of lactation. These results are in agreement with observations made by Deese and Koger (1967) and Koch (1969, 1972). These results suggest that there exists a negative correlation between preweaning performance of the dam and the maternal environment she provides for her calves. Koch (1972) suggested that this negative correlation between maternal ability of the dam and the subesequent productivity of her heifer calves may lead to alternative rearing systems for replacement heifers calves.

Hill et al. (1966) stated that the calf's genotype for growth and the dam's genotype for maternal ability has about equal influence on the variance of 180-day calf weights. However, they reported a negative genetic correlation between the genotypes for growth and maternal ability. Koch (1972), further investigated the relationships between maternal effects and other genetic and enviromental factors affecting growth. The author reported that the genetic and permanent environmental components of maternal ability and the covariance of individual and maternal effects accounted for 35 to 45% of the variation in daily gain from birth to weaning of the calf. However, the genetic correlation between maternal and individual effects on gain from birth to weaning was negative.

Repeatability

Gregory et al. (1950) studied the effect of using weaning traits as criteria for selection in beef cattle. They observed that cows tend to repeat their previous performance with respect to preweaning rate of gain of their calves. They also postulated that repeatability of mothering ability, which is largely measured by milk flow, is probably quite high in beef cows.

Koch (1951) estimated the repeatibility for weaning weight to be 0.52. Botkin and Whatley (1953) determined the repeatibility of weaning weight by the same procedure described by Koch (1951) and by the regression of subsequent calf records on earlier records of calves by the same cow. Repeatibility of weaning weight calculated by the first method was 0.43 and by the second method was 0.49.

These estimates of repeatibility for weaning weight are in close agreement with those reported by Lueker et al. (1963) and by Minyard and Dinkel (1965) estimating repeatibility of weaning weight for Hereford, Angus and the two breeds combined to be 0.42, 0.52 and 0.42, respectively.

CHAPTER III

MATERIALS AND METHODS

FEED INTAKE TRIAL

Data for this segment of the study were from 168 Angus, Hereford and recriprocal cross females born January through March over a 6-year period (1975 and 1977 to 1981). Heifers were sired by bulls varing in the growth patterns of weaning weight, condition and mature size expressed by their progeny. Twenty-four Angus heifers were fed in individual stalls the first year of the study. Heifers in subsequent years were grouped by sire five per pen. Following a 30-day adjustment period beginning in November of each year, heifers were fed for a 60-day postweaning period. During these feeding periods,heifers ranged from 10 to 12 months of age. The ration fed consisted of corn silage fed ad libitum (IFN 3-28-245), 0.454 kg. cotton seed meal (CSM) per head per day (IFN 5-01-621) and a free choice salt and mineral mix.

Data collected during this period included initial and final weights, individual feed intake for the first year of the study, and daily pen feed intake in subsequent years. Performance traits were calculated for each heifer. Individual daily feed intake (kg. dry matter) of group-fed heifers was estimated by the following three methods.

Method One: Individual Feed Intake (INDFE)

The first procedure partitioned pen feed intake to individual feed intake (INDFE) by multiplying pen feed intake (PFI) by the ratio of the individual heifer's mean weight (MWT) to the sum of the mean weights of all heifers in the pen (PMWT). In equation form this procedure would be:

$$INDFE= (MWT/PMWT) * FPI$$

Method Two: Total Feed Fed (TFED)

The second procedure to determime individual feed intake utilized equations from N.R.C.(1984) for estimating the net energy required for maintenance (NE_m) and the net energy required for gain (NE_g). The equation used to determine NE_m was:

$$NE_m = 0.077 * EBW^{0.75}kg.,$$

where:

EBW = empty body weight of the heifer (kg.)

(calculated as live mean wt. * 0.891, N.R.C., 1984).

Since cottonseed meal was a daily allowance of 0.454 kg. per head, the NE_m contributed by cottonseed meal was subtracted from the animals calculated daily requirement for NE_m prior to determining the amount of corn silage needed to supply energy for maintenance. The equation for determining NE_g for yearling heifers was:

$$NE_g = 0.0608 * EBW^{0.75} * ADG^{1.119} ,$$

where:

EBW = empty body weight of the heifer (kg.)

(calculated as live mean wt. * 0.891), and

ADG = empty body average daily gain

(calculated as ((FWT - IWT)/days) * 0.918, N.R.C.,1984).

The NE_g of 0.454 kg. cottonseed meal was subtracted from the animals calculated requirement for NE_g proir to determining the amount of corn silage needed to supply energy required for the amount of weight gain observed in each animal. Individual feed intake (TFED) was then the sum of corn silage required for maintenance, corn silage required for gain, and 0.454 kg. of cottonseed meal.

Method Three: Daily Feed Intake (DFI)

The third procedure utilized another equation from N.R.C. (1984) estimating daily feed intake (DFI) of growing and finishing cattle:

$$DFI(kg.\ dm) = EBW^{0.75} * (0.1493 * NE_m - 0.0460 * NEm^2 - 0.0196$$

where:

EBW = empty body weight of the heifer (kg.) caluclated as mean body wt. * 0.891, N.R.C., 1984); and

NE_m= net energy for maintenance of the ration consisting of corn silage and 0.454 kg. cottonseed meal.

Feed efficiencies were also calculated for each heifer as ADG/DFI.

COW PRODUCTIVITY

At the conclusion of each feeding trial heifers were returned to the Tennessee experiment station herd at Alcoa. The heifers received no special consideration and were handled under normal management practices for the Alcoa herd. Heifers were bred to calve at 2 years of age and females failing to calve by the second calving season were removed from the herd. All calves were raised solely on their dam with the exception of bull calves born in the fall that were creep fed a commercial ration. This herd supported an annual production sale accounting for 28 cows being sold from the study as either open cows or as cow-calf pairs. All crossbred cows (N = 15) were removed from the herd in 1982 creating inadequate records for this group of females.

Data collected during the production phase of this experiment included sire of calf (CSIRE), calves date of birth (BDAY), birth weight (BWT) and weaning weight (WWT). Adjusted 205 day weight (ADJ205) was calculated for each calf by the equation:

$$ADJ205 = BWT + ADJADG * 205 ,$$

where ADJADG = average daily gain adjusted for age of dam and sex of calf.

Calving interval (CI), weaning weight ratio (WWR), number of progeny weaned (P) and most probable producing ability (MPPA) was calculated for each cow. CI was calculated by the equation:

$$CI = (DATEl - DATEf)/ (C-1) ,$$

where DATEl = the date at last calving;

DATEf = date at first calving; and

C = number of calvings.

WWR was determined by the equation:

$$WWR = (SUM(ADJ205/HERD))/P *100,$$

where HERD = herd average for that particular year, sex and breed of calf; and

P = number of progeny weaned by the cow.

Moat probable producing ability (MPPA) was calculated for weaning weight by the equation:

$$MPPA = H +(NR/(1 + (P-1)R) * (C-H) ,$$

where H = herd average weaning weight ratio of 100;

N = number of calves included in the cow's average;

R = repeatability factor for weaning weight ratio (0.4); and

C = average weaning weight ratio for all calves the cow has produced.

STATISTICAL ANALYSIS

Stastical analysis was performed on cows possessing complete records of herd performance data (P, CI, MWWR, MPPA). When cows with incomplete calving data were eliminated, the total was reduced to 104 cows raising a total of 365 progeny. Correlations were calculated from the error line sum of squares for all variables of the cow collected during the feed intake trials and during the production phase of the experiment using SAS, 1982 edition.

Cows were classified as either first, second, third or fourth quartile using each of the three measures of feed intake as possible selection criteria. Quartile one contained 26 cows with the highest feed intake estimates of the total 104 cows. Thus, equal subclass numbers were obtained for analysis by sorting cows to the perspective quartile. Dependent variables for all analysis were DFI, INDFE, TFED, IWT, FWT, ADG, EFF, P, CI, MWWR, and MPPA. All eleven variabes were available for each of the 104 females in the analysis.

Contrasts of quartile means and their standard errors were calculated as follows:

1. First quartile versus the other three quartiles providing an estimate of one generation of one-way selection differential associated with selecting the top 25% of the heifers for that measure of feed intake and the correlated secondary selection differentials for the other two measures of feed intake and the four measures of cow productivity.

2. First quartile versus fourth quartile providing an estimate of one generation of two-way selection differential associated with selecting the top 25% of the heifers for that measure of feed intake and the correlated secondary selection differentials for the other two measures of feed intake and the four cow productivity traits.

3. First and second quartile versus third and fourth quartile providing an estimate of one generation of one-way selection differential associated with selecting the top 50% of the heifers for that measure of feed intake and the correlated secondary selection differentials for the other two measures of feed intake and the four cow productivity traits.

CHAPTER IV

RESULTS AND DISCUSSION

MEANS AND STANDARD DEVIATIONS OF HEIFER INTAKE STUDY TRAITS AND COW PRODUCTIVITY TRAITS

Means and standard deviations of traits of the heifers during the feed intake study and subsequent productivity traits are shown in Table 1. The variables DFI and INDFE possessed similiar means (5.77 and 5.79, respectively). The variable DFI, estimating daily feed intake of yearling heifers, was adjusted by adding a correction factor to the prediction equation so that the sum DFI for all heifers in a pen would equal the total feed intake measured for the pen. INDFE partitioned total feed intake to individual heifer intake by multiplying total pen feed intake by the ratio of heifer mean weight to pen mean weight. In both cases, individual feed intake summed to the measured total pen feed intake. DFI had a lower associated standard deviation than INDFE (0.54 and 0.67, respectively) and thus more narrowly predicted individual feed intake. This is not to suggest that DFI predicts feed intake more accurately that INDFE, but that there was less variation across all heifers when feed intake was determined by the DFI equation.

The variable TFED, estimating daily feed intake by the net energy system, tended to underestimate individual heifer feed intake (4.98 kg. versus 5.78 kg.). Variations in the energy values of the feedstuffs used in the equations may have resulted in the observed decrease in predicted daily feed intake by this procedure.

TABLE 1. MEANS AND STANDARD DEVIATIONS OF HEIFER INTAKE STUDY TRAITS AND COW PRODUCTIVITY TRAITS.

TRAIT	MEAN	STD. DEV.
HEIFER INTAKE STUDY TRAITS		
DFI (kg)[a]	5.77	0.54
INDFE (kg)[a]	5.79	0.67
TFED (kg)[a]	4.98	0.89
IWT (kg)	245.80	26.54
FWT (kg)	297.26	30.13
ADG (kg/day)	0.62	0.16
EFF (kg dm/kg gain)	0.108	0.028
COW PRODUCTIVITY TRAITS		
P	3.13	1.52
CI	386.15	69.78
MWWR	97.61	13.09
MPPA	98.92	7.69

[a] Values are on dry matter basis

(see text for calculation of feed intake estimates).

The cows weaned an average of 3.13 calves. Twenty-two productive cows remained in the herd during the analysis of this study. This resulted in a decrease in the number of lifetime production records available to be analyzed.

PHENOTYPIC CORRELATIONS AMONG HEIFER TRAITS AND FEED INTAKE ESTIMATES USED AS POSSIBLE CRITERIA FOR SELECTION

Phenotypic correlations among heifer traits and feed intake estimates considered as possible selection criteria are shown in Table 2. The correlations conform in sign and generally in magnitude with results reported by other researchers (Koch et. al., 1974; Smith and Cundiff, 1976; Smith et. al.,1976). The three estimates of daily feed intake were highly positively correlated with each other (r = 0.50 to r = 0.96) and moderately to highly postiively to IWT and FWT (r = 0.57 to r = 0.62 and r = 0.63 to r = 0.83, respectively). Increased feed intake was attributed to heavier initial and final weights.

Two measures of daily feed intake (DFI and INDFE) were moderately positively correlated with ADG (r = 0.29 and r = 0.33, respectively) and lowly correlated with efficiency of gain (r = -0.07 and r = -0.01, respectively). Feed intake estimated by these two methods was attributed to increased ADG but was not affected by the efficiency with which this gain was acquired.

The third measure of feed intake (TFED) was highly positively correlated with ADG (r = 0.88) and with efficiency of gain (r = 0.73). Increased feed intake by this estimate was associated with increased ADG and with the efficiency with which this gain was acquired.

TABLE 2. PHENOTYPIC CORRELATIONS AMONG HEIFER TRAITS AND FEED INTAKE ESTIMATES USED AS POSSIBLE CRITERIA FOR SELECTION.

TRAIT	INDFE	TFED	IWT	FWT	ADG	EFF
DFI	0.96**	0.50**	0.59**	0.63**	0.29*	-0.07
INDFE	....	0.54**	0.62**	0.67**	0.33**	-0.01
TFED	....	....	0.57**	0.83**	0.88**	0.73**
IWT	....	....	....	0.93**	0.12	-0.09
FWT	....	....	....	....	0.48**	0.27*
ADG	....	....	....	....	....	0.93**

* ($p < 0.01$).

** ($p < 0.001$).

The correlations suggest that heifers with higher initial and final weights will have an associated increase in daily feed intake. Increased daily gains of the heifers increased the amount of feed consumed while the efficiency of gain had no effect on feed intake. Koch et al. (1973) reported that increase feed consumption would be postively related to average daily gain while there would be no improvement in feed efficiency other than that attributable to a smaller portion of the intake being used for body maintenance.

PHENOTYPIC CORRELATIONS OF HEIFER TRAITS AND FEED INTAKE ESTIMATES USED AS POSSIBLE CRITERIA FOR SELECTION WITH COW PRODUCTIVITY TRAITS

The reproductive traits were generally lowly positively correlated with all of the heifer traits and feed intake estimates (Table 3), except for the correlations between the number of progeny weaned (P) and TFED ($r = -0.13$), IWT ($r = -0.08$), FWT ($r = -0.11$) and ADG ($r = -0.11$) which were all lowly negatively correlated and nonsignificant. All reproductive traits were lowly negatively correlated with efficiency of gain ($r = -0.14$ to $r = -0.02$). The negative signs could be explained if it were found that increased heifer performance (IWT, FWT, ADG, EFF) indicated a high degree of body fat or increased daily gains. Slower growing and/or leaner heifers have been reported to have superior productivity as cows.

TABLE 3. PHENOTYPIC CORRELATIONS OF HEIFER TRAITS AND FEED INTAKE ESTIMATES USED AS POSSIBLE CRITERIA FOR SELECTION WITH COW PRODUCTIVITY TRAITS.

HEIFER TRAIT	COW PRODUCTIVITY TRAITS			
	P	CI	MWWR	MPPA
DFI	0.07	0.04	0.21*	0.18
INDFE	0.03	0.05	0.22*	0.18
TFED	-0.13	0.05	0.04	0.02
IWT	-0.08	0.08	0.06	0.05
FWT	-0.11	0.07	0.06	0.05
ADG	-0.11	0.01	0.03	0.01
EFF	-0.14	-0.02	-0.06	-0.07

* ($P < 0.05$).

SELECTION DIFFERENTIALS WHEN SELECTION WAS BASED ON ESTIMATED DAILY FEED INTAKE (METHOD 1, INDFE)

Quartile means and standard errors (Table 4) were derived using INDFE as the quartile classification for analysis. A contrast of quartile 1 with the other 3 quartiles produced an estimate of the selection differential for INDFE (based on selecting the top 25% over the remainder of the replacement heifer population) and of the correlated secondary selection differentials in all other traits. Results of the contrast (Table 5) indicate that selection for INDFE will produce significant secondary selection differentials for DFI, TFED, IWT, FWT, MPPA and MWWR.

A contrast of quartile 1 with quartile 4 produced an estimate of the selection differential for INDFE (based on selecting the top 25% over the bottom 25% of the replacement heifers) and of the correlated secondary selection differentials in all other traits. Results of the contrast (Table 5) indicate that selection for INDFE will produce significant secondary selection differentials for DFI, TFED, IWT, FWT, ADG, and MWWR.

A contrast of quartile 1 and quartile 2 with quartile 3 and quartile 4 produced an estimate of the selection differential for INDFE (comparing the top 50% with the bottom 50% of the replacement heifers) and the correlated secondary selection differentials in all other traits. Results of the contrast (Table 5) show that selection for INDFE will produce significant secondary selection differentials for DFI, TFED IWT, FWT and ADG, while producing no significant secondary selection differentials for any of the productivity traits.

TABLE 4. MEANS AND STANDARD ERRORS OF HEIFER INTAKE STUDY TRAITS AND COW PRODUCTIVITY TRAITS WHEN QUARTILES WERE BASED ON DAILY FEED INTAKE (METHOD 1, INDFE).

	QUARTILE MEANS				
TRAIT	1	2	3	4	STD. ERR.
DFI[a]	6.38	6.01	5.62	5.06	0.05
INDFE[a]	6.61	6.03	5.59	4.93	0.07
TFED[a]	5.54	5.31	4.82	4.23	0.09
IWT	269.97	249.11	239.71	224.39	2.60
FWT	324.34	301.84	288.64	268.87	2.95
ADG	0.67	0.68	0.61	0.53	0.02
EFF	0.105	0.113	0.109	0.105	0.003
P	3.19	2.92	3.26	3.12	0.15
CI	394.53	395.21	367.02	387.83	6.84
MWWR	102.56	95.82	97.47	94.59	1.28
MPPA	101.63	97.69	98.85	97.50	0.75

[a] Values are on dry matter basis

(see text for calculation of feed intake estimates).

TABLE 5. SELECTION DIFFERENTIALS WHEN SELECTION WAS BASED ON ESTIMATED DAILY FEED INTAKE (METHOD 1, INDFE).

	QUARTILE 1 VERSUS OTHER 3 QUARTILES		QUARTILE 1 VERSUS QUARTILE 4		QUARTILE 1 AND 2 VERSUS QUARTILE 3 AND 4	
TRAIT	CONTRAST	STD. ERR.	CONTRAST	STD. ERR.	CONTRAST	STD. ERR.
DFI	0.83***	0.05	1.32***	0.07	0.86***	0.04
INDFE	1.09***	0.06	1.67***	0.07	1.06***	0.05
TFED	0.76***	0.17	1.31***	0.21	0.90***	0.15
IWT	32.24***	4.76	45.58***	5.83	27.49***	4.12
FWT	36.75***	5.10	55.57***	6.24	35.06***	4.41
ADG	0.06	0.03	0.14**	0.04	0.11***	0.03
EFF	-0.004	0.006	0.001	0.008	0.003	0.006
P	0.09	0.35	0.08	0.43	-0.13	0.30
CI	11.18	15.82	6.69	19.37	17.44	13.70
MWWR	6.60*	2.93	7.97*	3.58	3.16	2.53
MPPA	3.62*	1.73	4.13*	2.11	1.48	1.49

* ($p < 0.05$).

** ($p < 0.01$).

*** ($p < 0.001$).

SELECTION DIFFERENTIALS WHEN SELECTION WAS BASED ON ESTIMATED DAILY FEED INTAKE (METHOD 2, TFED)

Quartile means and standard errors (Table 6) were derived using TFED as the quartile classification for analysis. A contrast of quartile 1 with the other 3 quartiles produced an estimate of the selection differential for TFED (based on selecting the top 25% over the remainder of the replacement heifer population) and of the correlated secondary selection differentials in all other traits. Results of the contrast (Table 7) indicate that selection for TFED will produce significant secondary selection differentials for DFI, INDFE, IWT, FWT, ADG, EFF, CI, MWWR, and MPPA.

A contrast of quartile 1 with quartile 4 produced an estimate of the selection differential for TFED (based on selecting the top 25% over the bottom 25% of the replacement heifers) and of the correlated secondary selection differentials in all other traits. Results of the contrast (Table 7) indicate that selection for TFED will produce significant secondary selection differentials for DFI, INDFE, IWT, FWT, ADG and EFF.

A contrast of quartile 1 and quartile 2 with quartile 3 and quartile 4 produced an estimate of the selection differential for TFED (comparing the top 50% with the bottom 50% of the replacement heifers) and the correlated secondary selection differentials in all other traits. Results of the contrast (Table 7) show that selection for TFED will produce significant secondary selection differentials for DFI, INDFE, IWT, FWT, ADG and EFF, while producing no significant secondary selection differentials for any of the productivity traits.

TABLE 6. MEANS AND STANDARD ERRORS OF HEIFER INTAKE STUDY TRAITS AND COW PRODUCTIVITY TRAITS WHEN QUARTILES WERE BASED ON DAILY FEED INTAKE (METHOD 2, TFED).

	QUARTILE MEANS				
TRAIT	1	2	3	4	STD. ERR.
DFI[a]	6.05	6.03	5.63	5.36	0.05
INDFE[a]	6.18	6.14	5.60	5.24	0.07
TFED[a]	6.10	5.24	4.60	3.95	0.09
IWT	267.95	252.51	236.99	225.75	2.60
FWT	331.14	306.98	285.24	265.67	2.95
ADG	0.79	0.67	0.58	0.46	0.02
EFF	0.132	0.111	0.103	0.086	0.003
P	2.81	3.12	3.08	3.50	0.15
CI	412.66	370.93	365.89	395.11	6.84
MWWR	101.98	97.31	93.45	97.70	1.28
MPPA	101.55	98.44	98.44	99.40	0.75

[a] Values are on dry matter basis

(see text for calculation of feed intake estimates).

TABLE 7. SELECTION DIFFERENTIALS WHEN SELECTION WAS BASED ON ESTIMATED DAILY FEED INTAKE (METHOD 2, TFED)

	QUARTILE 1 VERSUS OTHER 3 QUARTILES		QUARTILE 1 VERSUS QUARTILE 4		QUARTILE 1 AND 2 VERSUS QUARTILE 3 AND 4	
TRAIT	CONTRAST	STD. ERR.	CONTRAST	STD. ERR.	CONTRAST	STD. ERR.
DFI	0.38***	0.11	0.70***	0.13	0.55***	0.09
INDFE	0.52***	0.12	0.94***	0.15	0.74***	0.11
TFED	1.50***	0.09	2.15***	0.11	1.39***	0.08
IWT	29.54***	4.86	42.20***	5.96	28.86***	4.21
FWT	45.17***	4.02	65.46***	4.93	43.60***	3.48
ADG	0.22***	0.02	0.33***	0.03	0.21***	0.02
EFF	0.032***	0.005	0.047***	0.006	0.027***	0.004
P	-0.42	0.34	-0.69	0.42	-0.33	0.30
CI	35.35*	15.43	17.56	18.90	11.29	13.37
MWWR	5.82*	2.93	4.28	3.58	4.07	2.53
MPPA	3.51*	1.71	2.15	2.09	2.15	1.48

* ($p < 0.05$).

** ($p < 0.01$).

*** ($p < 0.001$).

SELECTION DIFFERENTIALS WHEN SELECTION WAS BASED ON ESTIMATED DAILY FEED INTAKE (METHOD 3, DFI)

Quartile means and standard errors (Table 8) were derived using DFI as the quartile classification for analysis. A contrast of quartile 1 with the other 3 quartiles produced an estimate of the selection differential for DFI (based on selecting the top 25% over the remainder of the replacement heifer population) and of the correlated secondary selection differentials in all other traits. Results of the contrast (Table 9) indicate that selection for DFI will produce significant secondary selection differentials for INDFE, TFED, IWT, FWT, ADG, MWWR and MPPA.

A contrast of quartile 1 with quartile 4 produced an estimate of the selection differential for DFI (based on selecting the top 25% over the bottom 25% of the replacement heifers) and of the correlated secondary selection differentials in all other traits. Results of the contrast (Table 9) indicate that selection for DFI will produce significant secondary selection differentials for INDFE, TFED, IWT, FWT, ADG, MWWR and MPPA.

A contrast of quartile 1 and quartile 2 with quartile 3 and quartile 4 produced an estimate of the selection differential for DFI (comparing the top 50% with the bottom 50% of the replacement heifers) and the correlated secondary selection differentials in all other traits. Results of the contrast (Table 9) show that selection for DFI will produce significant secondary selection differentials for INDFE, TFED IWT, FWT and ADG, while producing no significant secondary selection differentials for any of the productivity traits.

TABLE 8. MEANS AND STANDARD ERRORS OF HEIFER INTAKE STUDY TRAITS AND COW PRODUCTIVITY TRAITS WHEN QUARTILES WERE BASED ON DAILY FEED INTAKE (METHOD 3, DFI).

	QUARTILE MEANS				
TRAIT	1	2	3	4	STD. ERR.
DFI[a]	6.42	6.00	5.60	5.06	0.05
INDFE[a]	6.53	6.07	5.61	4.94	0.07
TFED[a]	5.46	5.30	4.80	4.35	0.09
IWT	265.82	249.84	240.99	226.55	2.60
FWT	320.37	305.05	290.87	272.74	2.95
ADG	0.66	0.68	0.60	0.55	0.02
EFF	0.103	0.113	0.108	0.108	0.003
P	3.35	2.69	3.19	3.27	0.15
CI	391.95	395.68	379.28	377.68	6.84
MWWR	102.70	96.39	96.76	94.59	1.28
MPPA	101.86	97.92	98.26	97.62	0.75

[a] Values are on dry matter basis

(see text for calculation of feed intake estimates).

TABLE 9. SELECTION DIFFERENTIALS WHEN SELECTION WAS BASED ON ESTIMATED DAILY FEED INTAKE (METHOD 3, DFI).

TRAIT	QUARTILE 1 VERSUS OTHER 3 QUARTILES		QUARTILE 1 VERSUS QUARTILE 4		QUARTILE 1 AND 2 VERSUS QUARTILE 3 AND 4	
	CONTRAST	STD. ERR.	CONTRAST	STD. ERR.	CONTRAST	STD. ERR.
DFI	0.87***	0.05	1.36***	0.06	0.88***	0.04
INDFE	0.99***	0.07	1.59***	0.09	1.02***	0.06
TFED	0.64***	0.18	1.11***	0.22	0.80***	0.15
IWT	26.69***	5.13	39.27***	6.29	24.06***	4.45
FWT	30.82***	5.61	47.64***	6.87	30.91***	4.86
ADG	0.05	0.04	0.12**	0.04	0.10**	0.03
EFF	-0.006	0.006	-0.005	0.008	-0.001	0.005
P	0.29	0.34	0.08	0.42	-0.21	0.30
CI	7.74	15.94	14.27	19.52	15.34	13.80
MWWR	6.79*	2.92	8.11*	3.58	3.87	2.53
MPPA	3.92*	1.72	4.24*	2.11	1.95	1.49

* ($p < 0.05$).

** ($p < 0.01$).

*** ($p < 0.001$).

CHAPTER V

SUMMARY AND CONCLUSIONS

Data for this study were from 168 Angus, Hereford and recriprocal cross females born January through March over a 6-year period (1975 and 1977-1981). Heifers were sired by bulls varing in the growth patterns of weaning weight, condition and mature size expressed by their progeny. Twenty-four Angus heifers were fed in individual stalls the first year of the study. Heifers in subsequent years were grouped by sire five per pen. All heifers were fed for a postweaning period of 60 days following a 30 day adjustment period beginning in November of each year. Daily feed intake was estimated for each heifer by three procedures. The first procedure partitioned pen feed intake to heifer feed intake (INDFE) by multiplying total pen feed intake by the ratio of heifer mean weight to pen mean weight, thus dipicting body weight as the main source of variation in the amount of feed consumed in replacement heifers. The second procedure utilized equations from N.R.C., 1984 estimating feed required for body maintenance and weight gain (TFED). Daily feed intake estimated by this procedure was then a function of the heifer's body weight and weight gain over the feeding period, and a function of the net energy for maintenance and gain of the feedstuffs. The third procedure utilized another equation from N.R.C., 1984 estimating daily feed intake of growing and finishing cattle (DFI). Daily feed intake as defined by this equation was then a function of body weight of the animal and net energy for maintenance supplied by the ration consumed.

Production parameters including number of progeny weaned (P), calving interval (CI), mean weaning weight ratio (MWWR) and most probable producing ability (MPPA) were available on 104 of the heifers. Heifers were partitioned into 4 quartiles with heifers having the highest intake for the feed estimate under selection in the first quartile. Selection differentials for the selected feed intake estimate and the associated secondary selection differentials for the heifer traits and the cow productivity traits were determined by linear contrasts using each of the three estimates of feed intake as possible criteria for replacement heifer selection. Selection of replacement heifers based on the feed intake estimate INDFE produced significant secondary selection differentials for DFI, TFED, IWT, FWT, and ADG in the contrast of quartile 1 with the other three quartiles, quartile 1 with quartile 4, and in the contrast of quartile 1 and quartile 2 with quartile 3 and quartile 4. The productivity trait MWWR possessed a significant secondary selection differential in the contrast of quartile 1 with quartile 4. The productivity traits MWWR and MPPA possessed significant secondary selection differentials in the contrast of quartile 1 with the other three quartiles.

Selection of replacement heifers based on the feed intake estimate TFED produced significant secondary selection differentials for INDFE, DFI, IWT, FWT, ADG and EFF in the contrast of quartile 1 with the other three quartiles, quartile 1 with quartile 4, and in the contrast of quartile 1 and quartile 2 with quartile 3 and quartile 4. The productivity traits MWWR and MPPA possessed significant secondary selection differentials in the contrast of quartile 1 with the other three quartiles.

Selection of replacement heifers based on the feed intake estimate DFI produced significant secondary selection differentials for INDFE, TFED, IWT, FWT, and ADG in the contrast of quartile 1 with the other three quartiles, quartile 1 with quartile 4, and in the contrast of quartile 1 and quartile 2 with quartile 3 and quartile 4. The productivity traits MWWR and MPPA possessed significant secondary selection differentials in the contrast of quartile 1 with the other three quartiles and in the contrast of quartile 1 with quartile 4.

Results of this research indicate that using estimated daily feed intake measured by these three procedures as criterion for replacement heifer selection would improve herd productivity as indicated by contrasting the top 25% of the replacement heifers for feed intake with the remainder of the replacement population and by the contrast of the top 25% with the bottom 25% of the replacement heifers selected for daily feed intake.

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APPENDIX

TABLE A-1. ANALYSIS OF VARIANCE FOR THE REGRESSION OF ESTIMATED DAILY FEED INTAKE (TFED) ON ACTUAL DAILY FEED INTAKE (DFEED) FOR THE FIRST YEAR OF THE STUDY (1975).

SOURCE	DF	MEAN SQUARE (DFEED)
TFED	1	3.686*
ERROR	13	0.109
TOTAL	14	

* $p < 0.001$

TABLE A-2. ANALYSIS OF VARIANCE FOR THE REGRESSION OF ESTIMATED DAILY FEED INTAKE (DFI) ON ACTUAL DAILY FEED INTAKE (DFEED) FOR THE FIRST YEAR OF THE STUDY (1975).

SOURCE	DF	MEAN SQUARE (DFEED)
DFI	1	4.509*
ERROR	13	0.106
TOTAL	14	

* $p < 0.001$

VITA

Louis Alfred Caldwell, Jr. was born in Paris, Tennessee on April 3, 1961, the son of Louis Alfred, Sr. and Katha Howard Caldwell. He attended schools in Paris, Tennessee and graduated from Henry County High School in 1979. He graduated from the University of Tennessee at Martin in 1983 receiving a Bachelor of Science degree in animal science. While attending the University of Tennessee at Martin he was initiated into Alpha Zeta, the National Honary Agriculture Fraternity. In the fall of 1983, he entered the graduate program at the University of Tennessee at Knoxville and received the Master of Science degree with a major in Animal Husbandry and a minor in Statistics in June, 1986.

Louis is married to the former Susan Elizabeth Hartz of McKenzie, Tennessee. They have one son, Brandon Louis, born on June 26,1984, and one daughter, Courtney Danielle, born on July 29,1985.