CONSUMPTION AND UTILIZATION OF TDN BY VARIOUS TWO-BREED CROSS COWS THROUGH A PRODUCTION CYCLE

By

DONALD MONROE MARSHALL

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Thesis Approved:

Richard R Frahm
Thesis Adviser

Gerald W. Horn

Keith Lusby

Norman N. Durham
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Due to increasing production costs and interest rates, many cattlemen are faced with the task of discovering new methods of increasing production efficiency of their cow herds. Research studies have shown that crossbreeding can result in significant increases in herd productivity. In a review of crossbreeding studies, Cundiff (1970) found that systematic crossbreeding utilizing British beef breeds resulted in increased production per cow exposed by 20 to 25 percent. Since heterosis is maximized as genetic divergence between breeds increases, even greater increases in productivity may result when crossing British breeds with some of the more recently imported exotic breeds. There has also been interest in increasing milk production in beef herds by crossing beef breeds with dairy breeds. Since feed costs constitute a considerable portion of expenses in a commercial cow-calf operation, production must be increased relative to nutritional requirements which will likely increase with cows of larger size and/or higher milk production.

Research studies are underway in the United States and other countries to identify specific breed combinations that are most productive and efficient under given mating systems and particular environmental conditions. This study is a portion of an extensive research project in progress at the Oklahoma Agricultural Experiment Station designed to evaluate lifetime productivity of various two-breed cross cows when mated to sires of a third breed. To adequately measure efficiency of such a beef production system, it is necessary to consider nutrient requirements of the breeding herd. Thus, the primary objectives of this study were to evaluate and compare TDN requirements and efficiency of TDN conversion to calf weaning weight of various two-breed cross cows and their calves through a production cycle.

CHAPTER II

REVIEW OF LITERATURE

Effects of Cow Size and Breed Type on Nutrient Requirements of Beef Cows

Maintenance Requirements

Efficient production of weaned calves is critical to the profitability of a commercial beef cow herd. It is important to identify and study factors which influence calf weaning weight and the amount of feed required to produce a weaned calf. However, published information concerning feed consumption of the beef cow and how this is influenced by biological type is limited.

Nutrient requirements which must be accounted for in producing a weaned calf include maintenance of the cow, growth of the fetus during pregnancy, milk production from birth to weaning, creep feed and other consumption by the calf, along with restoration of the dam's depleted body stores. Maintenance requirements have classically been regarded as dependent on cow weight. The National Research Council (N.R.C., 1976) has based energy needs for maintenance of cattle on the following relationship:

$$\text{Mcal Net Energy for Maintenance} = .077\ (\text{Kg Body Weight}^{.75})$$

This equation directly accounts for variation in body size only and assumes no differences in maintenance requirements due to such factors as breed type or sex of the animal.

Brody (1935) reported a general feeding standard applicable to all warm-blooded animals for maintenance of:

$$\text{Pounds of Daily Digestible Nutrients for Maintenance} = .053\ (\text{lb Body Weight}^{.73})$$

The exponents of .73 and .75 applied to body weight were derived by Brody and Proctor (1932) and Kleiber (1932), respectively, from data based on the fasting heat production of mature animals from species varying widely in body size from mouse to elephant.

Data from 18 lots of large, intermediate and compress Hereford females, ranging from nine to 15 per lot, were studied by Stonaker et al. (1952). They reported feed consumption of cattle of the same age was directly proportional to body weight, indicating that the same total weight of similar-aged breeding females could be maintained on a given area of land independent of individual cow size.

Klosterman et al. (1968) reported results from 62 non-gravid, non-lactating Hereford and Charolais cows and concluded there was little genetic difference among cows in maintenance requirements. However, their study did indicate that a measure of condition should be included with body weight to accurately estimated maintenance needs. Fatter cows tended to gain weight while the reverse was true for cows with less finish when the amount of feed given was based on metabolic weight. Based on data from 20 Angus X Hereford, 20 Angus X Holstein and 85 Angus cows, Thompson et al. (1981) similarly found that fatter cows had lower winter energy requirements than thin cows when cows of both groups were of the same lean body mass.

Turner et al. (1974) reported information from 58 Charolais and 39 Hereford cows mated to Hereford and Charolais bulls, respectively. Their trials indicated maintenance needs increased in proportion to body size and estimated the requirement to be .036 kg TDN per kg body weight to the .75 power. However, Thomas and Moore (1960) reported higher maintenance requirements for Jersey cows than Holsteins at any given weight.

Worstell and Brody (1953) suggested the possibility of lower fasting metabolism in Brahmans than in Holstein or Jersey cattle, although it was not demonstrated. In a study involving nine Africander and nine Hereford X Angus crossbred bulls and steers, Vercoe (1970) indicated that Brahmans had a lower fasting metabolism than the other two breeds.

Intake and Utilization of Nutrients

Due to high maintenance overhead, feed costs comprise a major portion of expenses in a beef cow-calf enterprise. Thus, it is important to consider nutrient requirements of the breeding herd and the efficiency with which those nutrients are converted to calf weaning weight. Cartwright (1970) noted that efficiency of the breeding herd is more important than that of sale calves since approximately two cattle must be maintained for each sale calf produced.

There has been interest in increasing weaning weights of calves by introducing larger "exotic" breeds of cattle and by increasing milk production potential via infusion of dairy breeding into commercial beef herds. Several research studies have indicated that heavier cows tend to produce faster growing, heavier calves although the magnitude of the relationship varied considerably (Brinks et al., 1962; Voccaro and

Dillard, 1966; Jeffery et al., 1971; Urick et al., 1971; Jeffery and Berg, 1972; Miguel et al., 1972; Benyshek and Marlowe, 1973; Klosterman et al., 1974). A positive relationship between milk production and calf weight or growth rate has been reported by various researchers (Knapp and Black, 1941; Neville, 1962; Velasco, 1962; Totusek et al., 1973; Franke et al., 1975; Belcher and Frahm, 1979; Chenette and Frahm, 1981). It is logical to assume nutrient requirements to be higher for cows of larger mature size and higher milk-producing ability. It is important that calf weaning weights are increased by sufficient magnitude to offset increased feed costs.

Melton et al. (1967) reported data from 30 Hereford and 15 Charolais, individually-fed cows. Charolais cows were larger, consumed more feed and produced more milk than Herefords. However, there appeared to be little difference between the two breeds in amount of TDN required to produce a pound of calf weight.

Kress et al. (1969) studied individual feed consumption data from 56 fraternal and identical twin Hereford cows producing 135 lactation records. They reported efficiency estimates were negatively related to cow weight at calving and to the ratio of weight to height at the withers. The relationship between efficiency and cow height at withers was generally positive, but seldom significant. Therefore, they hypothesized that fatter cows are less efficient producers of calf weight and that cows of varying skeletal size are approximately equal in efficiency. Kress et al. (1969) compared economics of a group of small cows with a group of large cows. Assuming the two groups are equally efficient, the amounts of feed consumed and product produced would be the same for each group, although there would be a greater number of animals in the group of small cows. If fixed costs per cow are the only costs varying between the two groups, then total fixed costs would be less for the herd of large cows.

Data from 30 Hereford and 15 Charolais cows and their calves were reported by Carpenter et al. (1972). Cows were fed individually in a drylot to maintain comparable fatness in all cows. Charolais cows were significantly more efficient than Herefords based on the ratio of calf weaning weight to feed intake of cow and calf. Efficiency was positively associated with milk yield and calf performance, but negatively related to feed consumption and cow weight change during lactation. Mature cow size did not significantly affect production efficiency, although there was a trend for smaller cows to be more efficient.

Kropp et al. (1973) reported data from 42 Hereford, 42 Hereford X Holstein (crossbred) and 50 Holstein two-year-old females mated to Angus bulls. Cows were assigned to a range or drylot management regime, with the drylot cows fed in such a manner to simulate changes in energy intake of the range cows. Holstein and Crossbred cows weaned significantly heavier calves ($P<.01$), but consumed 43% and 14% more roughage, respectively, in drylot than Herefords. Similar results were reported for cows of these breeds as three-year-olds (Holloway et al., 1975a) and as four- and five-year-olds (Wyatt et al., 1977). Cows were mated to Charolais bulls in the latter two reports.

Lusby et al. (1976) measured forage intake on 49 four-year-old Hereford, Hereford X Holstein and Holstein cows on range during a summer and winter phase. Holsteins weighed about 80 kg more and consumed more forage ($P<.05$) than the other groups in both phases. Crossbreds consumed significantly more forage ($P<.05$) in winter than Herefords, but only slightly more in summer. Weights were similar for Crossbreds and Herefords, but crossbreds produced more milk (Lusby, 1974), apparently accounting for their higher feed intake.

Production efficiency of two- and three-year-old Hereford, Hereford X Charolais and Charolais cows in drylot was reported by Holloway et al. (1975b). An inverse relationship was found between the conversion of digestible energy intake to milk gross energy by cows and the conversion of milk energy to weaning weight by calves. Holstein cows were most efficient ($P<.01$) in converting digestible energy intake to milk gross energy, followed by Crossbreds and Herefords. However, Herefords were most efficient in converting milk digestible energy to weaning weight. Although breed differences were small for conversion of total feed energy intake of cow and calf to weaned weight, Herefords and Crossbreds were more efficient ($P<.10$) than Holsteins in converting total cow and calf energy intake to retail cuts.

Klosterman et al. (1974) reported data from 133 individually-fed cow-calf pairs. Hereford, Hereford X Angus, Hereford X Charolais and Charolais cows of varying sizes were mated to either Hereford or Charolais bulls. They reported that 13% of the metabolizable energy fed to the cow and calf resulted as net energy in the calf at slaughter. Thus, 87% was required for maintenance and other "nonproductive functions" based on 100% calf crop slaughtered. The authors noted that the proportion of energy intake required for herd maintenance would be even higher if cows not producing a calf were included and if calves were sold at weaning. Efficiency based on TDN consumption of cow and calf per unit of edible portion produced tended to be similar for cows of all sizes and breeds.

Onks et al. (1975) reported data from individually-fed Angus cow-calf pairs. Data were obtained from 63 individual cows and 118 cow-years over a five-year period. Cow weight had a significant ($P<.01$) influence on annual TDN intake of the cow and calf, but not on the amount of cow and calf TDN intake per unit of calf weaned.

Data from 73 individually-fed two-, three- and four-year-old Angus, Charolais and reciprocal cross cows and their progeny were reported by Marshall et al. (1976). Calves were sired by Polled Hereford bulls. Data included 122 weaning records and were collected over a three-year period. Breed of dam effects were significant ($P<.01$) for total TDN intake of the cow and calf but not for the efficiency of TDN requirement to produce a unit of weaning weight. Effects of cow weight on intake and efficiency were similar to breed effects, as the heavier weaning weights of calves produced by heavier cows tended to offset their higher feed requirements.

Parkins et al. (1977) reported estimates of energy requirements of both cow and calf to produce a weaned calf. Requirements were based on equations derived from revisions of the Metabolizable Energy System (ARC, 1965) and the Net Energy System (Lofgreen and Garrett, 1968). Results indicated that it is more efficient to creep feed the calf than to give additional feed to the cow to convert to milk. The amount of cow and calf net energy required to produce a unit of calf gain decreased as calf growth rate increased. When comparing biological efficiency of cows varying both in size and milk yield, larger cows producing smaller amounts of milk were generally more efficient in producing calf weight than smaller cows yielding higher amounts of milk. At a given level of milk yield, efficiency of calf production increased as cow size increased.

Results were based on milk yields of 5, 10 or 15 kg per day and cows' weights of 400, 500 or 600 kg.

Bowden (1977) reported feed utilization data of four types of F_1 heifers varying in potential mature size. Individual feed intake was measured from about eight weeks after weaning until first calving on 29 Simmental X Angus (SA), 28 Charolais X Angus (CA), 25 Hereford X Angus and Angus X Hereford (HA) and 25 Jersey X Angus (JA) crossbred heifers. Heifers were assigned to either of two levels of feeding - one sufficient to allow "normal" growth and the other 10% higher energy intake. Average intakes of digestible energy were greater ($P<.05$) for SA and CA heifers than for HA and JA heifers during pregestation (129-day feeding period) and gestation. When adjusted to constant metabolic body weight, digestible energy intakes of HA heifers were lower ($P<.05$) than those of the other F_1 groups during the pregestation period, but there were no significant differences between groups during the gestation period. Feed utilization data of these same F_1 females as two-year-olds was reported by Bowden (1980). SA and CA cows consumed significantly ($P<.05$) more digestible energy during lactation (200 days) than HA or JA cows. Calves from CA and HA cows consumed more creep feed than did calves from SA or JA cows to compensate for their dams' lower milk yield. Conversion of cow and calf digestible energy intake into calf weaning weight did not differ significantly among dam breed groups.

Lemenager et al. (1980) reported on the influence of cow size and breed type on energy requirements based on data from straightbred Hereford, and crossbred Angus X Hereford, Charolais X Hereford and Brown Swiss X Hereford cows. Intake was measured by breed group during the last trimester of gestation and during lactation for each of two trials.

A total of 178 and 154 cows were involved in trial one and trial two, respectively. Consumption during both the gestation and lactation phases of each trial was highest for Brown Swiss X Hereford cows, intermediate for Angus X Hereford and Charolais X Hereford cows, and lowest for Herefords. Using Hereford cows as a base for comparison, TDN intake ratios were calculated for each breed group from both actual intake and NRC (1970) requirements. Since ratios calculated from their study were higher than those based on NRC requirements, the authors suggested that weight alone cannot accurately predict energy requirements of the larger breeds or breeds varying in levels of milk production potential.

The topic of beef cattle size has been debated for many years (Klosterman, 1972). In a review of body size influence on the biological efficiency of cows, Morris and Wilton (1976) reported negative phenotypic and genetic correlations between cow size and dairy efficiency (milk yield per unit of feed intake) of -.18 and -.37, respectively. However, they found no consistent relationship between cow size and efficiency of beef production when considering feed requirements of cows, replacement heifers and feedlot cattle, and when sales of feedlot cattle were considered at constant finish. Reviewing cow size effects on economic efficiency, Morris and Wilton (1977) noted that the small differences in biological efficiency indicated by various studies do not consistently favor any particular size of cow in economic terms.

Dickerson (1978) discussed concepts of animal size relative to other biological variables, relating these concepts to efficiency of animal production. He concluded that body size *per se* is of minor importance in relation to reproduction, growth or "functional output per unit of body size" (p. 377).

Cartwright (1970) encouraged increased selection emphasis of beef cattle on a herd output per unit input basis. He further discussed possible advantages from using specialized dam and sire lines or breeds, utilizing heterosis and complementarity.

In a review article on beef cattle size and efficiency, Klosterman (1972) suggested that a need for cows varying in size will probably exist because of possible size genotype X environmental interactions and development of small cow lines mated to sires with larger, leaner carcasses. He noted that reproductive performance is more important to the cow-calf producer than cow size.

Fitzhugh (1978) elaborated on the relationship between animal size and efficiency noting that breeding females and their replacements comprise 40 to 70 percent of the production unit. He suggested that natural selection appears to favor small mature size both within and between species under harsh environmental conditions (lack of feed resources), but that the better-adapted individuals within native breed types generally carry heavier weight and more condition.

Additional information is needed to determine how cow size and breed type interact with different biological and economical variables in affecting beef production efficiency. Studies utilizing computer systems analysis techniques have suggested potential interactions involving cow size with breeding system, beef prices relative to other food prices and management and labor regimes (Long et al., 1975; Fitzhugh et al., 1975; Cartwright et al., 1975; Morris and Wilton, 1976).

Summary of Literature Review

Research pertaining to the influence of beef cow size and breed type on nutrient requirements and efficiency of nutrient utilization has not been conclusive. Studies have generally indicated that maintenance requirements are proportional to body size although some work has suggested possible genetic differences in fasting metabolism of cattle. Because of favorable relationships of mature cow size and level of milk production with calf performance, there has been interest in introducing larger "exotic" and dairy breeds into commercial beef herds. It is important to determine the extent to which nutrient requirements are increased relative to increased weaned calf production. Research results generally indicate that cows of varying mature sizes and breed types tend to be about equally efficient in terms of the amount of feed consumed by cow and calf per unit of calf weight or gain. Reproductive performance appears to be more important than cow size *per se* in determining both biological and economical efficiency of commercial beef production. Possible development of specialized sire and dam lines and potentially important genotype X environmental interactions dictate the probable need for variation in mature cow size both within and between breeds. Computer simulation of beef production will likely continue to be important in determining which specific cow type-management combinations are most productive and efficient under given environmental circumstances.

CHAPTER III

MATERIALS AND METHODS

Experimental Design

Data used in this study were collected from 1976 through 1980 as part of an extensive experiment (Project 1502) in progress at the Oklahoma Agricultural Experiment Station to evaluate lifetime productivity of various two-breed cross cows. The crossbred cows involved in this study were produced in 1973, 1974 and 1975 by Angus and Hereford cows mated to Angus, Hereford, Simmental, Brown Swiss and Jersey bulls. All heifer calves produced by these matings were introduced into the herd for subsequent evaluation as cows. The cow herd had been described in detail by Belcher and Frahm (1979). Cows were maintained on native and bermudagrass pasture at the Lake Carl Blackwell Research Range west of Stillwater. Five pregnant cows of each of seven breed groups (Hereford X Angus reciprocal crosses, HA; Simmental X Angus, SA; Simmental X Hereford, SH; Brown Swiss X Angus, BA; Brown Swiss X Hereford, BH; Jersey X Angus, JA; and Jersey X Hereford, JH) were transported to a drylot at the Southwestern Livestock and Forage Research Station near El Reno in the fall of 1976, 1977 and 1979. Thus, a total of 105 cows were involved in the drylot study (Table I). Cows entering the drylot in the fall of 1976, 1977 and 1979 were four-, five- and six-years-old, respectively, at calving time in the spring. Cows entering the drylot in 1976

TABLE I

NUMBER OF COWS INVOLVED IN DRYLOT STUDY

Crossbred Cow Group	Year of Study			Crossbred Group Total
	1976-77[1]	1977-78[2]	1979-80[3]	
Hereford X Angus	5	5	5	15
Simmental X Angus	5	5	5	15
Simmental X Hereford	5	5	5	15
Brown Swiss X Angus	5	5	5	15
Brown Swiss X Hereford	5	5	5	15
Jersey X Angus	5	5	5	15
Jersey X Hereford	5	5	5	15
Yearly Totals	35	35	35	105

[1]Cows were four years of age in spring of 1977.
[2]Cows were five years of age in spring of 1978.
[3]Cows were six years of age in spring of 1980.

were mated to Charolais bulls, whereas those entering the drylot in 1977 and 1979 were mated to either Charolais or Limousin bulls (Table II). All cows had weaned a calf just prior to entering the drylot.

Management and Data Collection

Thirty-five pregnant cows (five of each crossbred group) were placed in a drylot in October of 1976, 1977 or 1979 to measure individual feed intake for one production cycle. No cows were placed in drylot in 1978 due to a lack of available corn silage, the primary feedstuff utilized by drylot cows. Cow year-groups will be designated as Year One, Year Two and Year Three for cows in drylot during the respective one-year periods of 1976-77, 1977-78 and 1979-80. Management of the three year-groups of cows was as similar as possible except as noted otherwise.

Feed intake was measured daily for each cow for approximately one year. If a cow or her calf died in drylot, a replacement cow (or cow-calf pair) of the same age, breed group and production status was moved into drylot from the cow herd on range.

Analyses of feedstuffs utilized by drylot cows and calves are presented in Table III. Weekly silage samples were analyzed for content of dry matter and crude protein at the station research lab. In vitro dry matter digestibility (IVDMD) was estimated each month on weekly composite silage samples according to procedures of Tilley and Terry (1963). The total digestible nutrients (TDN) content of silage was estimated by the relationship: TDN = 16.7 + .074 (IVDMD) developed by Oh et al. (1966). Dry matter, TDN and crude protein content of protein supplement, supplemental grain and calf creep feed were estimated from tabular

TABLE II

NUMBER OF BULLS MATED TO DRYLOT COWS

Sire Breed	Year of Study			Sire Breed Totals
	1976-77	1977-78	1979-80	
Charolais	6	8	8	22
Limousin	-	7	7	14
Yearly Totals	6	15	15	36

TABLE III

DRYLOT FEEDSTUFFS ANALYSES

	Ingredient	Dry Matter (%)	Dry Matter Basis: TDN (%)	Dry Matter Basis: Crude Protein (%)
	Corn silage	34.3	61.1	8.0
Year	Protein supplement	89.4	67.0	56.7
One	Whole shell corn	89.0	91.0	10.0
	Calf creep feed	89.5	81.1	15.4
Year	Corn silage	37.2	58.5	9.2
Two	Protein supplement	89.4	67.0	56.7
	Calf creep feed	89.5	81.1	15.4
	Corn silage	39.1	61.1	9.4
Year	Protein supplement	89.4	67.0	56.7
Three	Ground milo	89.0	80.0	12.4
	Calf creep feed	89.5	81.1	15.4

values (NRC, 1976). Composition of protein supplement and calf creep feed are presented in Table IV and Table V, respectively.

The feeding facility was all on concrete with a portion of the pen as well as the individual feeding stalls under a pole barn open to the south. Each year the seven cow groups were randomly allotted to seven pens. Each pen was 36 X 47 feet with 21 feet of pen length under the shed. The five cows of the same crossbred group were kept in the same pen. Cows were moved into individual feeding stalls each morning about 8:00 a.m. and were allowed ad libitum consumption of corn silage plus a specific amount of protein and grain supplement (Appendix Table XIX shows the average amount of each feedstuff consumed per cow per year). Calves did not have access to their dams during this period.

In a review of forage consumption by grazing livestock, Cordova (1978) noted that quantitative intake data is limited with regard to grazing livestock. Much of the published data concerning beef cow intake has been done with cows fed in drylot. The extent to which comparisons of intake made under drylot conditions can be extrapolated to cows maintained on range is not well defined. In this study, the corn silage-based drylot ration was supplemented to meet protein needs and to parallel weight change patterns between drylot cows and range cows. Drylot cows were weighed monthly for the entire production cycle. Range cows were weighed monthly from October through February, with an additional weight taken following calving in the spring. Calves were born during February, March and early April.

Year One drylot cows were fed corn silage daily for the entire drylot period. One pound of pelleted protein supplement was fed to each cow daily from approximately three months pre-calving until parturition

TABLE IV

COMPOSITION OF PROTEIN SUPPLEMENT FED TO DRYLOT COWS

Ingredient	Percentage of Supplement (as-fed basis)
Soybean oil meal	68
Ground alfalfa hay	19
Urea	6
Dicalcium phosphate	4
Sugarcane molasses	3
Trace mineral salt	.4
Vitamin A (17,706 I.U. per lb of suppl.)	.13

TABLE V

COMPOSITION OF DRYLOT CALF CREEP FEED

Ingredient*	Percentage of Ration (as-fed basis)
Corn, ground or rolled	63.75
Ground alfalfa hay	15.00
Sugarcane molasses	3.00
Soybean oil meal	10.00
Cottonseed hulls	5.00
Wheat midds	3.00
Salt	.25

*Added to Total: Trace mineral premix (1 lb/ton); Vitamin A premix (6810 I.U./lb).

and was increased to two pounds for the remainder of the drylot period. In addition, each cow received three to five pounds of whole shell corn per day during the peak of lactation.

Drylot cows in Year Two also received corn silage for the entire feeding period. Protein supplement was fed to cows from a few days after calving through the end of the drylot period. No grain was fed in Year Two.

Drylot cows received corn silage for all but six weeks of the drylot period in Year Three, during which time (due to a shortage of corn silage) a mixture of ½ corn silage and ½ wheat silage was fed. One to three pounds per cow of protein supplement was fed daily from two to three months prior to calving through the remainder of the drylot period. Each cow also received about six pounds of ground milo per day for approximately the last two-thirds of lactation.

Protein supplement and grain were fed to cows individually by adding them on top of the silage in each individual feeding stall, except for alten-week period in Year Three when ground milo was dumped into the silage wagon and augered into feed stalls along with the silage. For that ten-week period, milo consumption for each cow was estimated by calculating each cow's portion of total silage fed in a day to all cows and multiplying that portion by the total amount of milo fed that day.

To help calves maintain normal growth patterns and to assist drylot cows in maintaining adequate condition, creep feed was made available to calves by breed group during the latter portion of lactation. The length of the creep feeding period was 16, 9 and 19 weeks for Year One, Year Two and Year Three, respectively. For data analysis purposes, each calf within a crossbred group was credited with consuming an equal share of the total amount of creep feed consumed by that pen.

In Year One and Year Two, milk yield was estimated for each drylot cow monthly from April through September by calf nursing method. After being separated from their dams for twelve hours, Year One calves were weighed, allowed to suckle and then weighed again. Calves were separated from their dams for another 12 hours, followed by another weigh-suckle-weigh procedure. The two 12-hour estimates were added together to estimate 24-hour milk yield. Year Two milk production methods were similar to those in Year One, but involved a six-hour separation interval. The two six-hour estimates were added and the sum multiplied by two to estimate 24-hour milk yield.

Three-breed cross calves were born in drylot from February through early April. Birth weights were obtained within 24 hours of birth. All calves remained with their dams until weaning at an average age of 214 days in Year One and Year Two and 190 days in Year Three. Weaning weights were linearly adjusted to 205 days of age by multiplying preweaning average daily gain by 205 and adding birth weight. Preweaning average daily gain was calculated by dividing the difference between actual weaning weight and birth weight by calf age at weaning. Within any year, all drylot cows were the same age, so weaning weights were adjusted for age of dam only to compare weaning weights of drylot calves to calves on range whose dams were born in three different years. Weaning weights were adjusted for age of dam by multiplying the 205-day weight by 1.15, 1.10 and 1.05 for calves from two-, three- and four-year old cows, respectively.

Milk yield of Year Three drylot cows was estimated by machine milk-out procedures, utilizing five monthly estimates from May through

September. Crossbred cow groups were randomly separated into two milking groups to keep the actual cow-calf separation time close to the intended 12-hour separation period. The two milking groups consisted of three and four crossbred cow groups. Cows were injected with 10 to 20 mg of the tranquilizer acepromazine approximately 15 minutes before milking. Milk letdown was induced by injecting 1.5 mg of syntocin, a synthetic oxytocin, into the jugular vein. Milking time averaged about 10 minutes per cow, and each cow's udder was stripped out by hand to insure a complete milkout. Twelve-hour milk yield was multiplied by two to estimate 24-hour milk yield.

TDN intake was calculated separately for non-lactating and lactating periods. Lactating intake includes calf creep feed consumption. To account for variation among cows with regard to calving date, TDN intake was adjusted to 160 and 205 days for non-lactating and lactating periods, respectively. Average calving date ranged from March 2 for Jersey X Hereford cows to March 14 for Brown Swiss X Hereford cows. The 205-day lactating period corresponds to the average lactation length of the entire herd (drylot and range cows). Non-lactating TDN intake was calculated by multiplying average daily TDN intake prior to calving by 160. Lactating TDN intake was calculated by multiplying average daily TDN intake from calving to weaning by 205 and adding the actual creep feed TDN consumption of the calf. Annual TDN intake was calculated by adding the 160-day non-lactating and 205-day lactating intakes. TDN intake per unit cow weight and metabolic cow weight (cow weight$^{.75}$) was also calculated.

Average cow weights and milk yield estimates of drylot cows were utilized to determine NRC (1976) requirements for TDN for these groups of cows. Calf TDN consumption via creep feed was added to the dam's requirement for TDN during lactation to account for forage the calf would have consumed on pasture. Procedures used to estimate requirements from NRC are presented in Appendix Table XX.

Several measures of weaning efficiency were calculated. These include the ratios of calf 205-day weaning weight to average cow weight and average cow metabolic weight, and the ratio of cow and calf annual TDN intake to 205-day calf weaning weight.

Statistical Analysis

Because of disproportionate subclass numbers, data were analyzed by general linear models procedures available in the Statistical Analysis System (Helwig and Council, 1979). This generalized computer program was developed by Barr and Goodnight (1972) and revised by Barr et al. (1976).

Average cow weight, spring and fall condition scores of cow, milk yield, calf birth weight, calf 205-day weaning weight, calf 205-day weaning weight adjusted for age of dam, calf preweaning average daily gain and weaning efficiency traits were analyzed using the following model:

$$Y_{ijkl} = u + S_i + C_j + Yr_k + X_l + SC_{ij} + SX_{il} + CYr_{jk} + CX_{jl} + YrX_{kl} + e_{ijkl}$$

where: Y_{ijkl} = the observation trait of the ijklth observation; u = population mean; S_i = fixed effect of the ith sirebreed of the calf, i = 1, 2; C_j = fixed effect of the jth crossbred cow group, j = 1, 2, 3, 4, 5, 6, 7; Yr_k = fixed effect of the kth year, k = 1, 2, 3; X_l = fixed effect of the l^{th} sex of the calf, $l = 1, 2$; SC_{ij} = interaction of the i^{th} sirebreed of the calf and j^{th} crossbred dam group; SX_{il} = interaction of the i^{th} sirebreed of the calf and l^{th} sex of the calf; CYr_{jk} = interaction of the j^{th} crossbred dam group and k^{th} year; CX_{jl} = interaction of the j^{th} crossbred dam group and l^{th} sex of the calf; YrX_{kl} = interaction of the k^{th} year and l^{th} sex of the calf; e_{ijkl} = random error associated with the $ijkl^{th}$ observation.

Sirebreed of the calf and its interactions with other main effects were eliminated from analyses of TDN intake traits, as preliminary analyses showed they were not important sources of variation for intake traits. The following model was utilized for analysis of TDN intake traits:

$$Y_{ijk} = u + C_i + Yr_j + X_k + CYr_{ij} + CX_{jk} + YrX_{jk} + e_{ijk}$$

where: Y_{ijk} = the observed trait of the ijk^{th} observation; u = population mean; C_i = fixed effect of the i^{th} crossbred dam group, i = 1, 2, 3, 4, 5, 6, 7; Yr_j = fixed effect of the j^{th} year, j = 1, 2, 3; X_k = fixed effect of the k^{th} sex of the calf, k = 1, 2; CYr_{ij} = interaction of the i^{th} crossbred dam group and j^{th} year; CX_{il} = interaction of the i^{th} crossbred dam group and k^{th} sex of the calf; YrX_{jk} = interaction of the j^{th} year and k^{th} sex of the calf; and e_{ijk} = random error associated with the ijk^{th} observation.

Significant sources of variation were determined from analysis of each trait using the full models. Non-significant sources of variation were eliminated and least squares means were calculated based on reduced models (Tables VI, VII, and VIII). Non-significant main effects were included in reduced models if they interacted significantly with

TABLE VI

SOURCES OF VARIATION INCLUDED IN REDUCED MODEL FOR DRYLOT CALF TRAITS

Source	Birth Weight	Preweaning ADG	205-day Weaning Weight	Age of Dam Adjusted 205-day Weaning Weight
Sirebreed of calf (S)	X	X	X	X
Crossbreed Dam Group (C)	X	X	X	X
Year (Y)		X	X	X
Sex	X	X	X	X
S X C		X	X	X
S X Sex		X	X	X
C X Y		X	X	X
C X Sex		X	X	X
Y X Sex		X	X	X

X = Source of variation was included in reduced model.

TABLE VII

SOURCES OF VARIATION INCLUDED IN REDUCED MODELS FOR COW WEIGHT, CONDITION, MILK YIELD AND EFFICIENCY TRAITS

Source	Cow Weight	Spring Condition Score	Fall Condition Score	24-Hour Milk Yield	Annual TDN Intake / 205-day Calf Weight	Calf 205-Day Weight / Cow Weight	Calf 205-Day Weight / Cow Metabolic Weight
Sirebreed of Calf (S)	X	X			X	X	X
Crossbred Dam Group (C)	X	X	X	X	X	X	X
Year (Y)	X	X	X	X	X	X	X
Sex (S)	X		X	X	X	X	X
S X C	X	X				X	X
S X Sex						X	X
C X Y							
C X Sex							
Y X Sex			X		X	X	X

X = Source of variation was included in reduced model.

TABLE VIII

SOURCES OF VARIATION INCLUDED IN REDUCED MODELS FOR TDN INTAKE TRAITS

Source	TDN Intake (lb)			Daily TDN Intake Per 100 lb Cow Weight (lb/day)		
	160-Day Non-lactating Period	205-Day Lactation Period	365-Day Total	160-Day Non-lactating Period	205-Day Lactating Period	365-Day Total
Crossbred Dam Group (C)	X	X	X	X	X	X
Year (Y)	X	X	X	X	X	X
Sex	X	X	X		X	
C X Y	X				X	X
C X Sex	X					
Y X Sex		X			X	

X = Source of variation was included in reduced model.

other main effects. Least squares means were tested for significant differences by the Least Significant Difference (LSD) technique (Snedecor and Cochran, 1967). Partial correlation coefficients between traits (Snedecor and Cochran, 1967) were calculated by SAS (1979) procedures using a model containing sirebreed of the calf, crossbred dam group, sex of the calf and year, along with all two-factor interactions.

CHAPTER IV

RESULTS AND DISCUSSION

Comparisons among these crossbred groups have been reported for cow productivity (Belcher and Frahm, 1979; Frahm et al., 1981; Marshall et al., 1981) and for milk production (Belcher and Frahm, 1979; Chenette and Frahm, 1981). The primary traits of interest in this study are those related to intake and efficiency of utilization of TDN by the various two-breed cross groups. Calf performance, cow weight, condition and milk yield are summarized for the drylot cows only to help characterize the level of production attained by the set of cows on which individual feed consumption was measured.

Sources of Variation

Effects of year and sirebreed of calf are partially confounded since calves were sired by only Charolais bulls in Year One and by Charolais and Limousin bulls in Years Two and Three. Cows were four-, five- and six-years-old at calving in Years One, Two and Three, respectively, thus confounding year with age of dam.

Mean squares from analyses of variance for drylot calf traits are presented in Table IX. Crossbred dam group and sex of calf were significant sources of variation for birth weight. Of the effects included in the analysis, only crossbred dam group did not significantly affect preweaning average daily gain (P>.10). Calf weaning weight was

TABLE IX

MEAN SQUARES FOR DRYLOT CALF TRAITS

Source	df	Birth Weight (lb)	Preweaning Average Daily Gain (lb/day)	205-Day Weaning Weight (lb)	Age of Dam Adjusted 205-Day Weaning Weight (lb)
Sirebreed of Calf (S)	1	320.18	.37**	18558.46**	18176.57**
Crossbred Dam Group (C)	6	671.15**	.06	5428.66**	5519.95**
Year (Y)	2	189.65	.21**	10435.40**	23774.92**
Sex	1	804.06*	.17*	13018.65**	13986.80**
S X C	6	169.08	.08*	3347.10^{+}	3325.10^{+}
S X Sex	1	184.17	.16*	6198.56^{+}	6281.42^{+}
C X Y	12	170.79	.08*	3284.71*	3223.06*
C X Sex	6	91.10	.07^{+}	3617.64*	3906.42*
Y X Sex	2	9.80	.19**	9468.15**	8812.43**
Error	67	146.91	.03	1617.82	1674.95

$^{+}$P<.10, *P<.05, **P<.01.

significantly affected by all main effects ($P<.01$) and by all two-factor interactions ($P<.10$).

Table X presents mean squares from analyses of variance for cow weight, condition scores, 24-hour milk yield and efficiency traits. Year was a significant source of variation for all traits ($P<.05$). The effect of year was confounded by method of milk yield estimate for 24-hour milk yield. Crossbred dam group significantly affected ($P<.01$) all traits except 24-hour milk yield and the ratio of annual TDN intake (cow and calf) to 205-day calf weight. Sirebreed of calf was a significant source of variation for the ratio of annual TDN intake to 205-day calf weight ($P<.05$) and the ratio of 205-day calf weight to cow metabolic weight ($P<.10$). The effect of calf sex was significant ($P<.05$) for cow weight. With some exceptions, interactions were generally not important sources of variation for these traits.

Mean squares from analyses of variance for TDN intake traits are presented in Table XI. Crossbred dam group and year were significant sources of variation ($P<.01$) for all intake traits. Variation in intake among cow groups would be expected because of differences in mature size of the various crosses. Sex of calf was a significant source of variation ($P \leq 10$) for TDN intake during the 205-day lactating and 365-day total periods. The interaction between crossbred dam group and year was a significant source of variation for TDN intake during the 160-day non-lactating period ($P<.10$) and for daily intake per 100 lb cow weight for the 205-day lactating period ($P<.05$) and 365-day total ($P<.10$).

TABLE X

MEAN SQUARES FOR COW WEIGHT, CONDITION, MILK YIELD AND EFFICIENCY TRAITS

Source	df	Cow Weight (lb)[1]	Spring Condition Score[2]	Fall Condition Score[2]	24-Hour Milk Yield (lb)	Annual TDN Intake / 205-Day Calf Weight	205-Day Calf Weight / Cow Weight	205-Day Calf Weight / Cow Metabolic Weight
Sirebreed of Calf (S)	1	7,701.5	.222	.082	5.73	7.38*	.0062	.2915+
Crossbred Dam Group (C)	6	105,758.1**	6.353**	4.499**	4.97	2.20	.0172**	.2413**
Year (Y)	2	177,673.4**	21.647**	7.406**	552.27**	24.77*	.0561**	1.0535**
Sex	1	23,798.1*	.577	.925	9.91	1.94	.0031	.1563
S X C	6	14,937.2*	1.615*	.312	4.34	1.21	.0059+	.1398+
S X Sex	1	16,672.5	.961	1.604	.05	3.29	.0177*	.4534*
C X Y	12	5,518.3	.616	.953	7.41	1.38	.0041	.1030
C X Sex	6	4,317.8	.254	.641	7.56	1.70	.0017	.0631
Y X Sex	2	6,826.5	.310	3.180*	1.51	9.93**	.0210**	.5542**
Error	67	5.646.3	.532	.752	5.30	1.28	.0031	.0735

[1]Based on average of eight monthly (March - October) weights.
[2]Based on a scale of 1 through 9 where 5 = average condition.
+P<.10, *P<.05, **P<.01.

TABLE XI

MEAN SQUARES FOR TDN INTAKE TRAITS

Source	df	TDN Intake (lb) 160-Day Non-lactating Period	TDN Intake (lb) 205-Day Lactating Period	TDN Intake (lb) 365-Day Total	Daily Intake Per 100 lb Cow Weight (lb/day) 160-Day Non-lactating Period	Daily Intake Per 100 lb Cow Weight (lb/day) 205-Day Lactating Period	Daily Intake Per 100 lb Cow Weight (lb/day) 365-Day Total
Crossbred Dam Group (C)	6	143,488**	471,351**	1,118,483**	.0638**	.1284**	.0962**
Year (Y)	2	1,522,504**	3,322,363**	7,758,384**	.0926**	.5921**	.1611**
Sex	1	43,472	121,469+	310,276+	.0001	.0001	.0001
C X Y	12	34,955+	67,740	153,749	.0149	.0350*	.0192+
C X Sex	6	36,146+	45,098	130,005	.0066	.0155	.0074
Y X Sex	2	13,788	171,390*	132,225	.0022	.0521+	.0117
Error	75	18,659	44,708	98,232	.0100	.0172	.0113

+P<.10
*P<.05
**P<.01

Least Squares Means of Traits and Crossbred Cow Group Comparisons

Least squares means for drylot calf traits are presented in Table XII. Birth weights ranged from 94.5 lb for calves produced by BH and SA cows to 74.9 lb for calves from Jersey crosses. Birth weights of calves from SH, BA, and HA cows were intermediate, averaging 84.5 lb. Marshall et al. (1981) reported somewhat lower birth weights for calves produced by the same crossbred cow groups (range and drylot cows) in 1978 and 1979, although breed group rankings were similar.

Calves produced by Simmental crosses, Brown Swiss crosses and JH cows gained weight most rapidly from birth to weaning (averaged 1.79 lb/day), followed by calves from HA cows (1.73 lb/day) and JA cows (1.60 lb/day). Drylot calves produced by JA cows were 50 lb lighter (P .05) at 205 days than calves of the other crossbred cow groups. This surprisingly low weaning weight is atypical for this breed group based on weaning weights obtained from calves produced by cows on pasture, and reflects the low birth weights and cow weights of the JA group. Although the means varied from 436 to 464 lb among other breed groups, the differences were not significant.

Yearly comparisons of weaning weights of drylot calves vs the entire calf crop (drylot and range calves) are presented in Appendix Table XVIII. Range cows generally produced calves that were heavier at weaning than calves produced in drylot, especially in Years Two and Three. Crossbred group rankings were similar for drylot calves and the entire calf crop, with the exception of calves produced by JA cows.

Least squares means for average cow weight, condition scores and

TABLE XII

LEAST SQUARES MEANS FOR DRYLOT CALF TRAITS BY CROSSBRED COW GROUP

Crossbred Cow Group[1]	No. Calves	Birth Weight (lb)	Preweaning Average Daily Gain (lb/day)	205-Day Weaning Weight (lb)
HA	15	82.2 ± 3.1^{cd}	$1.73 \pm .05^{ab}$	436 ± 11^{a}
SA	15	92.2 ± 3.1^{ab}	$1.81 \pm .05^{a}$	464 ± 11^{a}
SH	15	86.0 ± 3.2^{bc}	$1.77 \pm .07^{ab}$	445 ± 15^{a}
BA	15	85.2 ± 3.1^{bc}	$1.78 \pm .05^{a}$	448 ± 11^{a}
BH	15	96.8 ± 3.1^{a}	$1.80 \pm .05^{a}$	464 ± 11^{a}
JA	15	73.3 ± 3.1^{e}	$1.60 \pm .06^{b}$	401 ± 12^{b}
JH	15	76.4 ± 3.2^{de}	$1.78 \pm .07^{a}$	447 ± 16^{a}
Total or Average	105	85.6	1.75	444

[1]H = Hereford, A = Angus, S = Simmental, B = Brown Swiss, J = Jersey.

[abcde]Means in the same column not sharing at least one superscript are significantly different ($P<.05$).

24-hour milk yield are presented in Table XIII. Based on an average of eight monthly weights (March through October), cow weights ranged from 1048 lb for SA cows to 762 lb for JA cows. Weights were intermediate for HA cows (1002 lb), SH cows and Brown Swiss crosses (averaged 959 lb) and JH cows (827 lb). Relative to other crossbred cow groups, weights of HA cows in drylot were heavier than the average of HA cows in the entire herd (Frahm et al., 1981), while the reverse situation occurred for JA cows.

Drylot cows were supplemented so that weight change patterns of drylot cows were similar to those of range cows. Twelve and six weights were obtained during the year for drylot and range cows, respectively. In Year One, range cows were initially heavier than drylot cows, although fluctuations in weight tended to be parallel for the two groups over the period during which weights were available for both groups (Figure 2). The two groups were similar in weight at the end of the drylot period. In Years Two and Three, weights were similar for drylot and range cows initially and at the end of the drylot period (Figures 3 and 4). Weight changes of drylot cows closely paralleled those of range cows in both years. Figure 1 illustrates monthly weights of drylot cows by crossbred cow group when averaged over years. Relative fluctuations in weight were generally similar among the various crossbred cow groups.

Cow condition scores were higher in fall than spring for all crossbred cow groups. Spring condition scores varied from 5.2 for HA cows to 3.0 for JA cows (5 = average condition), whereas fall scores ranged from 5.9 for SH cows down to 4.1 for JA cows.

Twenty-four hour milk yield averaged 14.2 lb/day over all crossbred cow groups. Milk yields were 1.8 and 2.1 lb/day higher ($P<.05$) for BA

TABLE XIII

LEAST SQUARES MEANS FOR COW WEIGHT, CONDITION AND MILK YIELD

Crossbred Cow Group[1]	No. Calves	Cow Weight (lb)	Spring Condition Score[2]	Fall Condition Score[2]	24-Hour Milk Yield (lb)
HA	15	1002 ± 20^{ab}	$5.2 \pm .2^{a}$	$5.7 \pm .2^{a}$	$13.8 \pm .6^{b}$
SA	15	1048 ± 20^{a}	$4.9 \pm .2^{ab}$	$5.6 \pm .2^{a}$	$14.0 \pm .6^{ab}$
SH	15	961 ± 24^{b}	$4.5 \pm .2^{b}$	$5.9 \pm .2^{a}$	$13.5 \pm .6^{b}$
BA	15	958 ± 20^{b}	$4.4 \pm .2^{bc}$	$4.8 \pm .2^{bc}$	$15.6 \pm .6^{a}$
BH	15	958 ± 20^{b}	$3.8 \pm .2^{d}$	$5.4 \pm .2^{ab}$	$14.1 \pm .6^{ab}$
JA	15	762 ± 20^{d}	$3.0 \pm .2^{e}$	$4.1 \pm .2^{d}$	$14.2 \pm .6^{ab}$
JH	15	827 ± 21^{c}	$3.9 \pm .2^{cd}$	$4.6 \pm .2^{cd}$	$14.2 \pm .6^{ab}$
Total or Average	105	931	4.2	5.2	14.2

[1]H = Hereford, A = Angus, S = Simmental, B = Brown Swiss, J = Jersey.
[2]Based on a scale of 1 through 9 where 5 = average condition.
[abcde]Means in the same column not sharing at least one superscript significantly differ ($P<.05$).

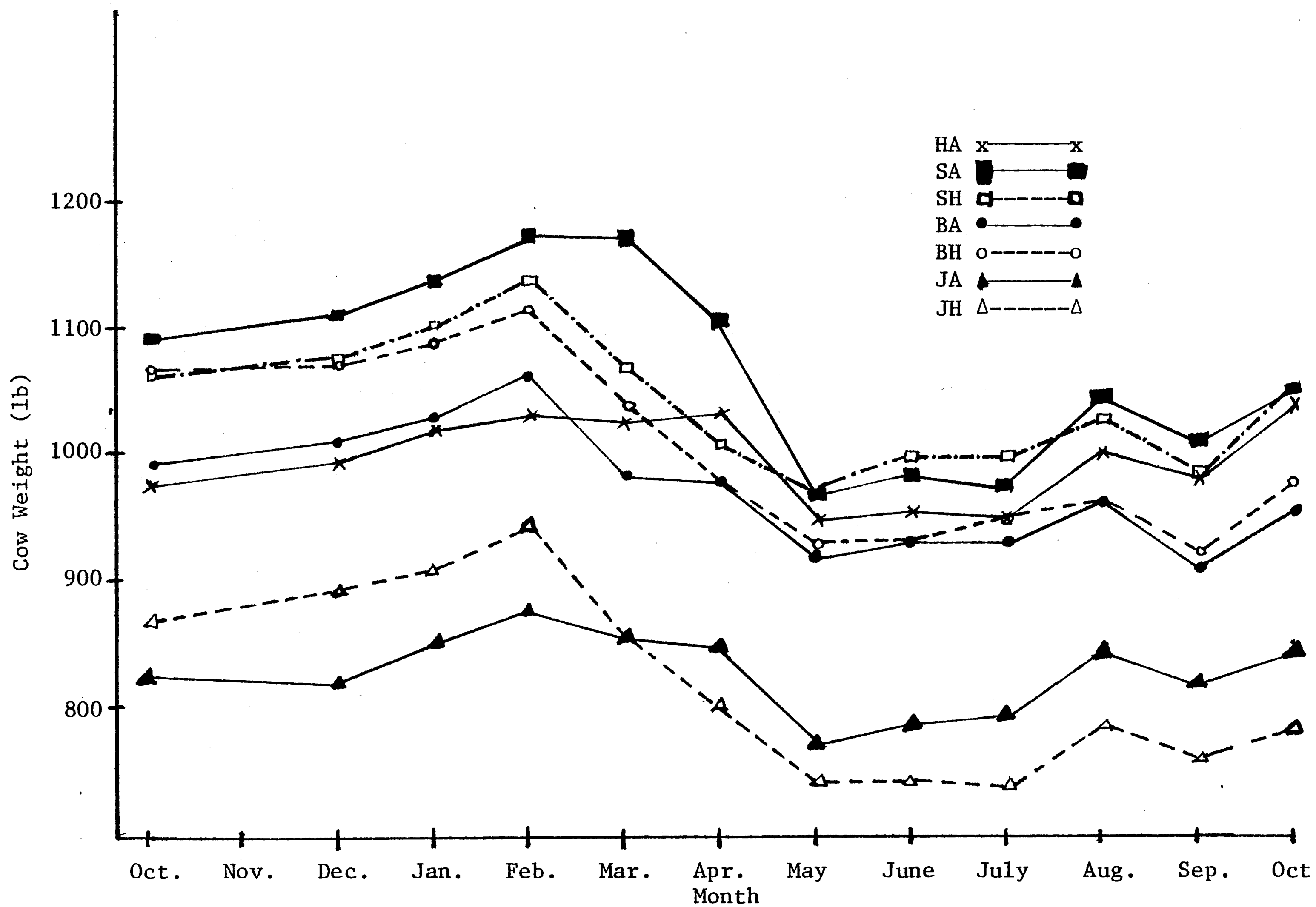

Figure 1. Monthly Drylot Cow Weights by Crossbred Cow Group (Averaged Over Years)

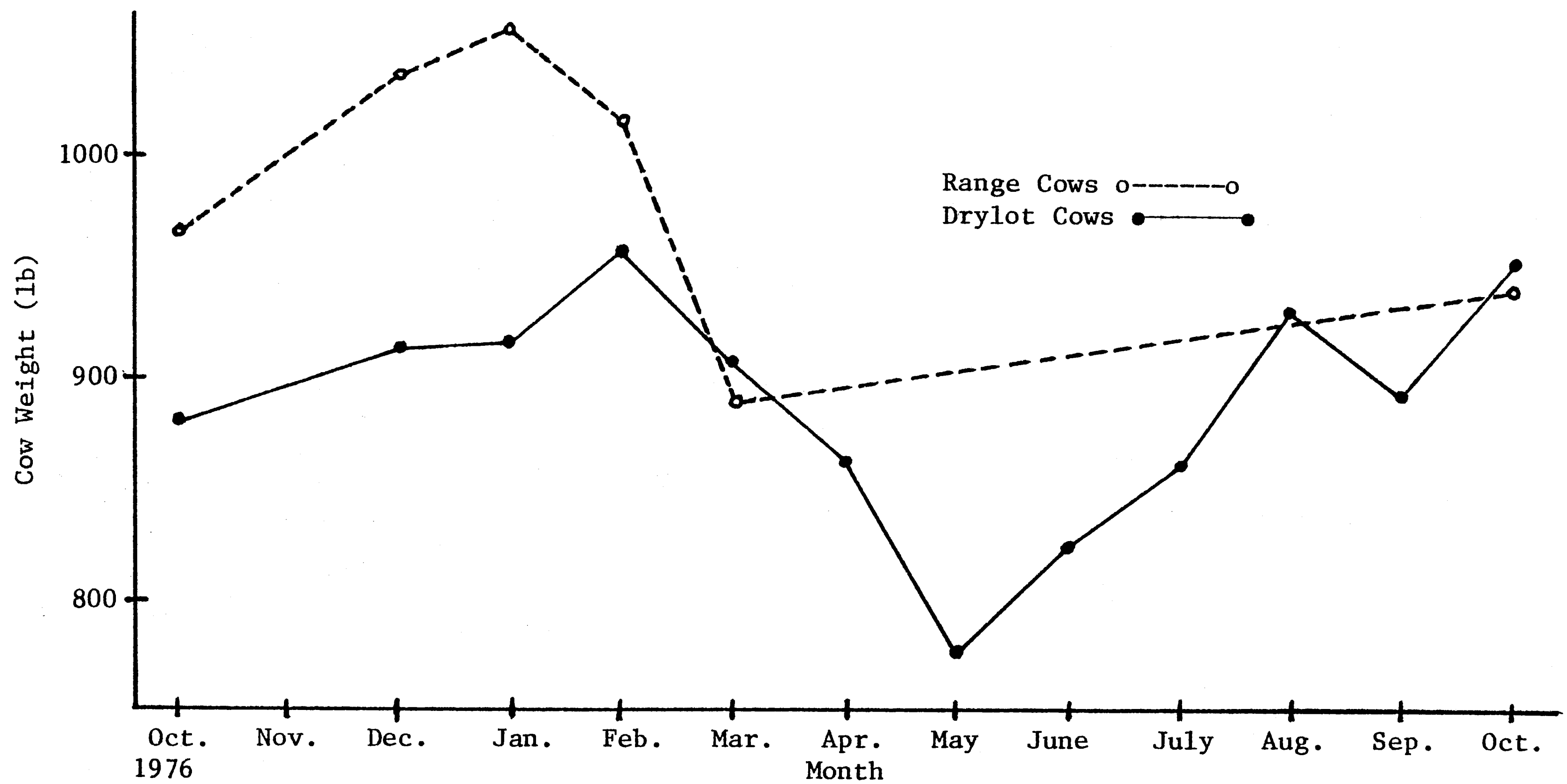

Figure 2. Comparison of Range vs Drylot Cow Weights for Year One

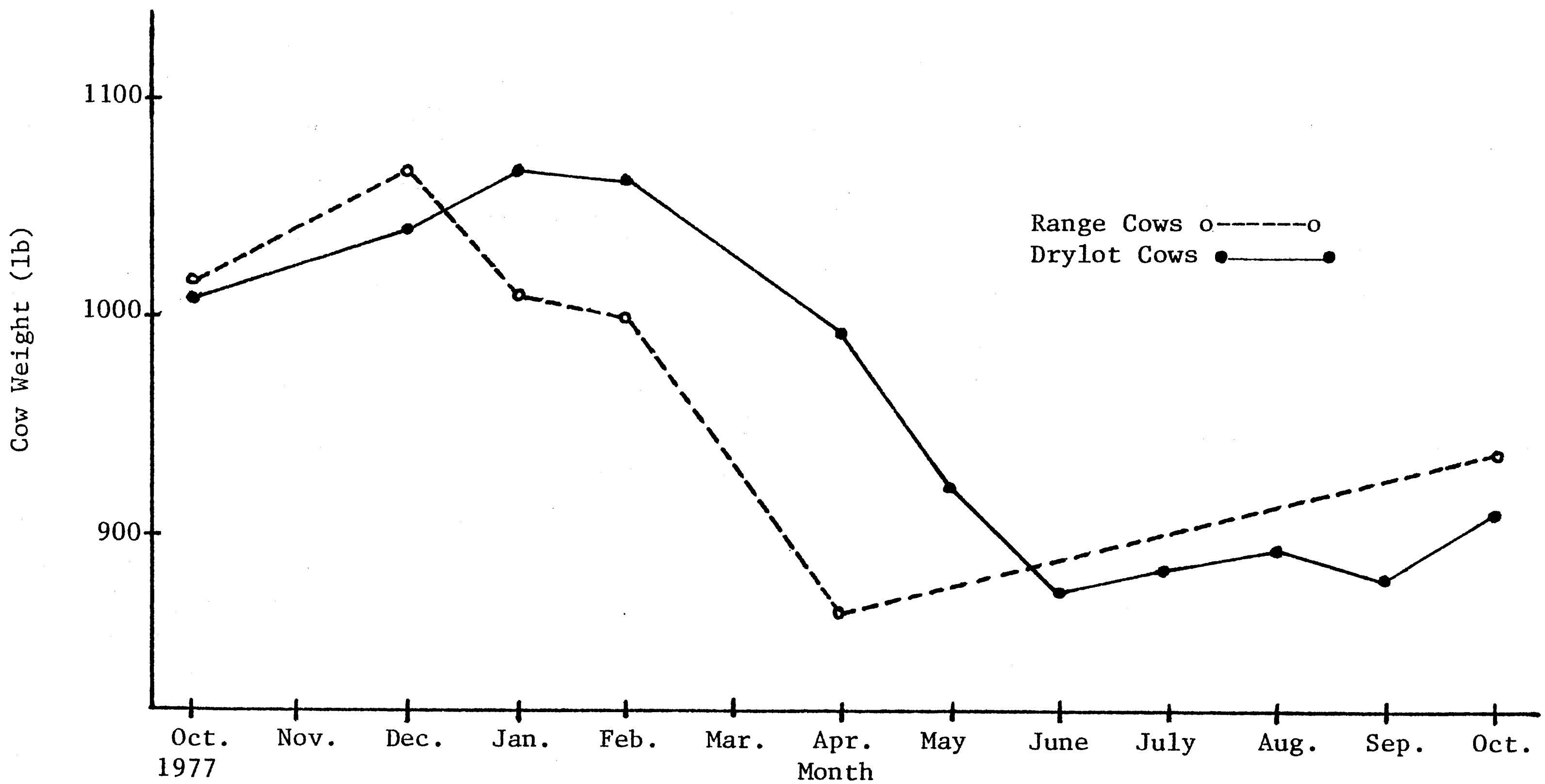

Figure 3. Comparison of Range vs Drylot Cow Weights for Year Two

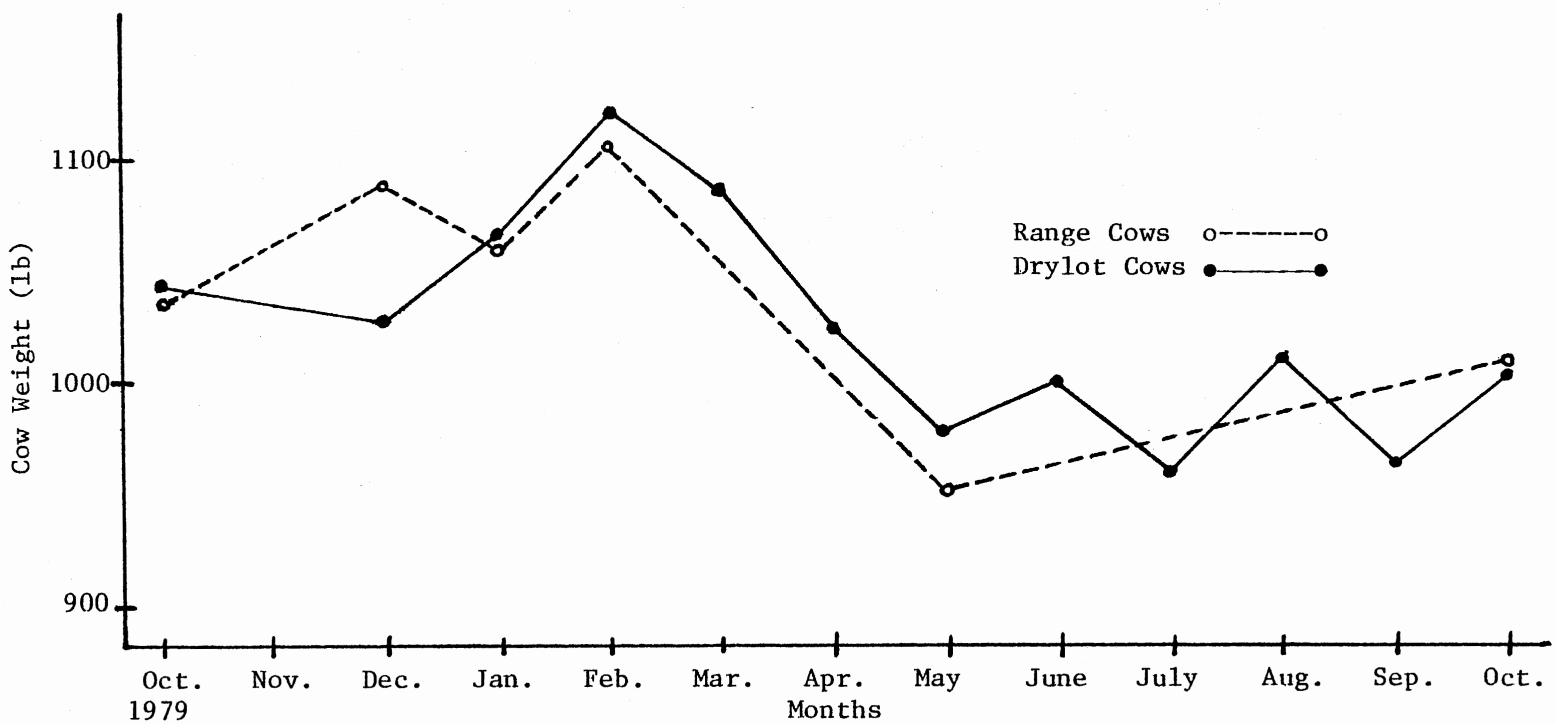

Figure 4. Comparison of Range vs Drylot Cow Weights for Year Three

cows than for HA and SH cows, respectively. No other differences between breed groups were significant. Using machine milkout methods, Belcher and Frahm (1979) and Chenette and Frahm (1981) obtained milk yield estimates from two- and four-year-old range cows, respectively. Cows were sampled from the same herd from which the drylot cows were selected. The two-year-old cows produced 14.2 lb/day, overall, which is about 2 lb/day less than the amount produced by the four-year-olds. Ranking of crossbred cow groups in the present study was similar to rankings found in those studies.

Least squares means for TDN intake traits are presented in Table XIV. Overall, cows consumed an average of 1590, 2981 and 4576 lb TDN for the 160-day non-lactating, 205-day lactating and 365-day total periods, respectively. Relative differences in intake among crossbred cow groups were similar for the three periods. SA cows consumed significantly more ($P<.05$) TDN than all other crossbred cow groups. For the 365-day total, HA, SH, and Brown Swiss cross cows consumed an average of 503 lb (11%) less TDN than SA cows, while Jersey crosses consumed 702 lb (18.5%) less TDN than SA cows. Although heavier cows tended to consume more TDN than cows of lighter weights, the smaller Jersey crosses consumed the most TDN per unit of body weight. Daily TDN intake per 100 lb cow weight averaged 1.48 lb/day for Jersey crosses, 1.34 lb/day for SA and BA cows, 1.28 lb/day for HA and BH cows and 1.24 lb/day for SH cows during the 365-day total period. Averaged over all crossbred cow groups, cows consumed 47% more daily TDN per 100 lb body weight during lactation than during non-lactation. Excluding the HA group, Angus crosses consumed 6.11, 4.80 and 5.75% more daily TDN per 100 lb cow weight than Hereford crosses for the dry, lactating and 365-day total periods,

TABLE XIV

LEAST SQUARES MEANS FOR TDN INTAKE TRAITS BY CROSSBRED COW GROUP

		TDN Intake (lb)			Daily TDN Intake Per 100 lb Cow Weight (lb/day)		
Crossbred Cow Group[1]	No. Cows	160-Day Non-lactating Period	205-Day Lactating Period	365-Day Total	160-Day Non-Lactating Period	205-Day Lactating Period	365-Day Total
HA	15	1578 ± 35^{bc}	2997 ± 59^{b}	4576 ± 89^{bc}	$.998 \pm .03^{d}$	$1.487 \pm .03^{bc}$	$1.274 \pm .03^{bc}$
SA	15	1775 ± 35^{a}	3311 ± 59^{a}	5091 ± 89^{a}	$1.056 \pm .03^{bcd}$	$1.552 \pm .03^{b}$	$1.336 \pm .03^{b}$
SH	15	1598 ± 35^{bc}	3011 ± 60^{b}	4575 ± 89^{bc}	$.989 \pm .03^{d}$	$1.449 \pm .03^{c}$	$1.239 \pm .03^{c}$
BA	15	1651 ± 36^{b}	3000 ± 59^{b}	4672 ± 89^{b}	$1.083 \pm .03^{bc}$	$1.540 \pm .03^{bc}$	$1.345 \pm .03^{b}$
BH	15	1584 ± 35^{bc}	2953 ± 59^{bc}	4530 ± 89^{bc}	$1.031 \pm .03^{cd}$	$1.496 \pm .03^{bc}$	$1.289 \pm .03^{bc}$
JA	15	1449 ± 38^{d}	2770 ± 60^{d}	4248 ± 89^{d}	$1.198 \pm .03^{a}$	$1.754 \pm .03^{a}$	$1.514 \pm .03^{a}$
JH	15	1497 ± 45^{cd}	2722 ± 61^{cd}	4342 ± 91^{cd}	$1.124 \pm .03^{ab}$	$1.677 \pm .04^{a}$	$1.439 \pm .03^{a}$
Total or Average	105	1590	2981	4576	1.068	1.565	1.348

[1]H = Hereford, A = Angus, S = Simmental, B = Brown Swiss, J = Jersey.

[abcd]Means in the same column not sharing at least one superscript significantly differ ($P<.05$)

respectively.

Cow intake data from this study generally agree with results of other studies. In a study involving 12-year-old Charolais and Hereford cows partitioned into two weight classes, Turner et al. (1974) reported total TDN requirements of cow and calf for an entire year were 5388 and 5692 lb for small and large cows, respectively. Marshall et al. (1976) reported yearly cow and calf TDN intakes of 5388, 5692, and 5598 lb for Angus, Charolais and reciprocal crosses, respectively. Differences in intake reflected differences in cow weights. Bowden (1980) reported significantly higher ($P<.05$) intakes of digestible energy for SA cows than for HA and JA cows during a 200-day lactation period. Daily dry matter intakes of JA cows were greater ($P<.05$) than those of SA, and HA cows when expressed as a percentage of average body weight.

Lemenager et al. (1980) reported higher TDN intakes for BH cows than for AH or Charolais X Hereford cows, followed by straightbred Herefords. In another study conducted at the Oklahoma Agricultural Experiment Station, higher forage intakes were measured for Holstein cows than Hereford X Holstein or Hereford cows in drylot (Kropp et al., 1973; Holloway et al., 1975a; Wyatt et al., 1977) and on range (Lusby et al., 1976). Crossbreds generally consumed more forage than Herefords.

Efficient production of weaned calves is critical to maximize profit in a commercial cow herd. Weaning efficiency was calculated by three methods in this study (Table XV). Based on the ratio of calf 205-day weight to cow weight, Jersey crosses were most efficient, weaning 53% of their body weight. HA cows weaned the smallest percentage of their weight (44%), but were not significantly different from SA, SH, and BA cows (averaged 46%). BH cows were intermediate, weaning 49% of

TABLE XV

LEAST SQUARES MEANS FOR EFFICIENCY TRAITS
BY CROSSBRED COW GROUP

Crossbred Cow Group[1]	No. Cows	Annual TDN Intake (lb) / 205-Day Calf Weight (lb)	205-Day Calf Weight (lb) / Cow Weight (lb)	205-Day Calf Weight (lb) / Cow Metabolic Weight (lb)
HA	15	$10.5 \pm .3^{abc}$	$.440 \pm .016^{c}$	$2.47 \pm .08^{c}$
SA	15	$11.0 \pm .3^{a}$	$.446 \pm .016^{bc}$	$2.53 \pm .08^{bc}$
SH	15	$10.1 \pm .3^{bc}$	$.465 \pm .019^{bc}$	$2.58 \pm .10^{abc}$
BA	15	$10.5 \pm .3^{abc}$	$.475 \pm .015^{bc}$	$2.63 \pm .07^{abc}$
BH	15	$10.0 \pm .3^{bc}$	$.488 \pm .016^{ab}$	$2.70 \pm .08^{ab}$
JA	15	$10.8 \pm .3^{ab}$	$.527 \pm .016^{a}$	$2.76 \pm .08^{a}$
JH	15	$9.9 \pm .3^{c}$	$.529 \pm .017^{a}$	$2.83 \pm .08^{a}$
Total or Average	105	10.4	.481	2.64

[1]H = Hereford, A = Angus, S = Simmental, B = Brown Swiss, J = Jersey.
[abc]Means in the same columns not sharing at least one superscript significantly differ (P<.05).

their body weight. Ranking of crossbred cow groups did not change when the ratio of calf 205-day weight to cow metabolic weight was calculated. Belcher and Frahm (1979) reported slightly higher estimates for both ratios than were found in this study, but relative differences between crossbred cow groups were similar. Bowden (1980) also reported higher ratios for JA cows than for HA or SA cows, based on calf weaning weight as a percentage of dam's weight postcalving and at weaning.

Dinkel and Brown (1978) questioned the usefulness of the ratio of calf weight to cow weight as an estimate of efficiency, especially considering increased availability of cow feed consumption data. The ratio of cow and calf annual TDN intake to calf weaning weight, a more direct estimate of cow efficiency, was calculated in this study. Pounds of TDN required to produce a lb of 205-day calf weight ranged from 9.9 for JH cows to 11.0 for SA cows. The most efficient groups were JH, BH and SH (averaged 10.0 lb/lb) followed by HA and BA (averaged 10.5 lb/lb). The least efficient groups were JA and SA (averaged 10.9 lb/lb). The Hereford crosses were consistently more efficient than the Angus crosses (10.0 vs 10.8 lb/lb excluding the HA group). The unusually low weaning weights of calves produced by JA cows may have caused the ratio of TDN intake to calf weaning weight to be higher than it might have been with a different sample of JA cows.

Other studies have generally shown no significant differences in efficiency of conversion of cow and calf feed intake to calf weight by cattle differing in mature size and/or breed type (Melton et al., 1967; Holloway et al., 1975b; and Marshall et al., 1976). Bowden (1980) reported no significant differences among SA, HA, JA or Charolais X Angus cows as two-year-olds for the ratio of Mcal digestible energy intake of dam and calf to kg calf weaning weight. However, in a study involving 30 Hereford and 15 Charolais cows and their calves, Carpenter et al. (1972) reported that Charolais cows were significantly more efficient than Herefords based on the ratio of calf weaning weight to feed intake of cow and calf.

The relative importance of reproductive traits should be considered when evaluating net efficiency of weaned calf production. Reproductive performance of the crossbred groups evaluated in this study has been reported by Belcher and Frahm (1979) and Marshall et al. (1981).

Table XVI presents TDN intake estimates calculated from NRC (1976) requirements. Estimates are based on an average of 12-monthly weights of drylot cows. Relative to the lactating period, intakes may be somewhat underestimated for the 160-day non-lactating period since actual cow weights during this period averaged somewhat higher than during the 205-day lactating period (Figure 1). Conversely, intakes based on NRC (1976) requirements during lactation may be overestimated relative to non-lactating intakes. Intakes estimated from actual intake data are higher than those estimated from NRC (1976) requirements. Intakes obtained from TDN consumption data were 15, 10 and 12% higher than estimated intakes based on NRC (1976), for the 160-day non-lactating, 205-day lactating and 365-day total periods, respectively. The difference between the 15 and 10% increase of actual vs estimated intake for the non-lactating and lactating periods, respectively, reflects the underestimate for the non-lactating phase and the overestimate for the lactating phase due to using average cow weight in making predictions. The total for 365 days is not affected by this bias.

TABLE XVI

A COMPARISON OF ESTIMATED TDN INTAKE BASED ON NRC REQUIREMENTS AND ACTUAL TDN INTAKE

Crossbred Cow Group[2]	Estimated TDN Intake (lb)[1] 160-Day Non-lactating Period	Estimated TDN Intake (lb)[1] 205-Day Lactating Period	Estimated TDN Intake (lb)[1] 365-Day Total	Actual TDN Intake (lb) 365-Day Total
HA	1401	2764	4165	4576
SA	1468	2875	4344	5091
SH	1441	2798	4238	4575
BA	1378	2780	4157	4672
BH	1410	2759	4169	4530
JA	1306	2493	3696	4248
JH	1253	2563	3816	4342
Overall Average	1380	2719	4084	4576

[1]Based on average of monthly drylot cow weights and milk production estimates and includes actual calf creep consumption. Intake estimates are averaged over years.

[2]H = Hereford, A = Angus, S = Simmental, B = Brown Swiss, J = Jersey.

Relationships Among Certain Traits

The primary analysis of data in this study was designed to compare TDN intake of crossbred cow groups. To assist in characterizing the cattle involved and reflect the level of productivity attained, various other traits were measured and analyzed. Partial correlation coefficients (Table XVII) were calculated to look at relationships between various traits independent of cow breed type. Variables are adjusted for all effects included in the initial full model analysis.

Annual TDN intake of cow and calf was positively associated with cow weight (r = .59), but lowly associated with calf 205-day weight (r = .02). Marshall et al. (1976) reported correlations of .66 and .48 between cow-calf yearly TDN intake and cow weight and weaning weight, respectively. Intake was unfavorably related to measures of efficiency with partial correlation coefficients of .63, -.42 and -.35, respectively, for the ratios of annual TDN intake to calf weaning weight, and calf weaning weight to cow weight and cow metabolic weight. These results agree with a correlation of -.43 reported by Carpenter et al. (1972) between cow 205-day lactation feed consumption and weaning weight produced per unit of feed intake. Marshall et al. (1976) reported a smaller undesirable correlation of .08 between yearly cow TDN and weaning efficiency, and a small (but of opposite sign) correlation of -.03 between cow-calf yearly TDN intake and weaning efficiency.

There was a moderate, unfavorable association between cow weight and the ratio of annual TDN intake to 205-day calf weight (r = .31) and a stronger, unfavorable association between the ratios of calf 205-day weight to cow weight (r = -.65) or cow metabolic weight (r = -.51).

TABLE XVII

PARTIAL CORRELATION COEFFICIENTS OF VARIOUS DEPENDENT VARIABLES[1]

	Annual TDN Intake	Cow Weight	205-Day Calf Weight	Annual TDN Intake / 205-Day Calf Wt.	205-Day Calf Wt. / Cow Wt.	205-Day Calf Wt. / Cow Metabolic Wt.	24-Hour Milk Yield	Spring Condition Score
Cow Weight	.59							
205-Day Calf Weight	.02	.11						
Annual TDN / 205-Day Calf Wt.	.63	.31	-.75					
205-Day Calf Wt. / Cow Wt.	-.42	-.65	.66	-.80				
205-Day Calf Wt. / Cow Met. Wt.	-.35	-.51	.78	-.84	.98			
24-Hour Milk Yield	.01	.12	.02	-.03	-.08	-.06		
Spring Condition Score	.22	.61	.07	.08	-.36	-.29	.03	
Fall Condition Score	.27	.36	-.06	.22	-.30	-.26	-.11	.49

[1]Correlations > |.24| significant at $P<.05$.

These results tend to support the conclusion of Dinkel and Brown (1978) that the latter two ratios are often biased in favor of the smaller cow. Marshall et al. (1976) found a small association between cow weight and conversion of cow and calf TDN to calf weaning weight (r = -.04). Calf weaning weight was the variable most strongly associated with efficiency traits, agreeing with the results of Marshall et al. (1976) and Dinkel and Brown (1978).

The correlation between milk yield and 205-day calf weight of .02 is smaller than most estimates found in the literature. Phenotypic correlations between calf 205-day weight and milk yield of .42 and .20 were reported by Belcher and Frahm (1979) and Chenette and Frahm (1981), respectively, from studies involving the same crossbred cow groups as the present study. The correlation between annual TDN intake and milk yield (r = .10) closely agrees with the correlation of .00 reported by Marshall et al. (1976). However, the correlation between milk yield and conversion of TDN to calf weaning weight (r = -.03) is lower than the correlation of -.52 reported by Marshall et al. (1976).

CHAPTER V

SUMMARY

Individual feed consumption data were collected on 105 two-breed cross cows in drylot over a three-year period (35 per year). Records from Hereford X Angus reciprocal crosses (HA), Simmental X Angus (SA), Simmental X Hereford (SH), Brown Swiss X Angus (BA), Brown Swiss X Hereford (BH), Jersey X Angus (JA) and Jersey X Hereford (JH) cows and their three-breed cross calves were included in the study. Cows were four, five and six years of age, respectively, for the three years involved and mated to Charolais or Limousin bulls. Pregnant cows were placed in drylot immediately following weaning of a calf and remained there until weaning of their next calf (approximately a one-year feeding period).

Cows were allowed ad libitum consumption of corn silage for about four hours each day supplemented with fixed amounts of protein and grain. Creep feed was made available to calves during the latter portion of lactation to assist cows in maintaining adequate condition.

Birth weights were heaviest for calves from BH and SA cows (94.5 lb) followed by calves from SH, BA and HA cows (84.5 lb). The lightest calves at birth were produced by Jersey crosses (74.9 lb).

Few significant differences were found among crossbred groups with regard to preweaning gain and 205-day calf weights, although drylot calves produced by JA cows attained 50 lb lighter 205-day weights than the average of the other crossbred cow groups. Drylot calves weighed less at weaning than calves produced and reared on range.

Fluctuations in cow weights over months were similar for the various crossbred cow groups in drylot and were also similar when comparing drylot versus range cows. Cow weights were heaviest for SA cows (1048 lb) followed by HA cows (1002 lb), Brown Swiss crosses and SH cows (averaged 959 lb), JH cows (827 lb) and JA cows (762 lb). Condition scores were highest for HA cows and Simmental crosses, intermediate for Brown Swiss crosses and lowest for Jersey crosses. Fall condition scores were higher than spring scores for all crossbred cow groups.

Twenty-four hour milk yield averaged 14.2 lb/day overall, with few significant differences between crossbred cow groups.

Consumption of TDN and related traits were of primary interest in this study. TDN intake (cow and calf) was adjusted to 160 and 205 days for non-lactating and lactating periods, respectively. Relative differences in TDN intake among crossbred groups were similar for the two periods. SA cows consumed significantly more TDN ($P<.05$) than all other crossbred groups. TDN intake for SA cows was 503 lb (11.0%) greater than for HA, SH and Brown Swiss cross cows, and 702 lb (18.5%) greater than for Jersey crosses for the 365-day total intake period. Jersey crosses consumed more TDN per 100 lb body weight than the other breed groups ($P<.05$) for the 365-day total. TDN intakes were 15, 10 and 12% higher than intakes estimated from NRC (1976) requirements for the non-lactating, lactating and total periods, respectively.

Three different ratios were calculated to estimate efficiency of weaned calf production. Based on the ratio of calf 205-day weight to cow weight, Jersey crosses were most efficient, weaning 53% of their body weight. BH cows weaned 49% of the weight, followed by SA, SH and

BA cows (averaged 46%) and HA cows (44%). Rankings were the same when calculating the ratio of calf 205-day weight to cow metabolic weight. A more direct measure of cow efficiency is the ratio of cow and calf yearly TDN intake to calf 205-day weight. In terms of pounds of TDN intake per pound of calf weaned, JH, BH and SH cows were most efficient (averaged 10.0 lb/lb) followed by HA and BA cows (averaged 10.5 lb/lb) and JA and SA cows (averaged 10.9 lb/lb). Hereford crosses were consistently more efficient than Angus crosses on this basis (10.0 vs 10.8 lb/lb excluding the HA group).

Partial correlation coefficients were calculated to determine relationships between various traits, independent of crossbred cow group and other effects included in the model. Cow weight was strongly associated with annual TDN intake of cow and calf (r = .59) and moderately (but unfavorably) associated with the conversion of TDN to calf 205-day weight (r - .31). Annual TDN intake was unfavorably related to weaning efficiency, while 205-day calf weight was favorably related to the ratio of TDN intake to 205-day calf weight (r = -.75). Twenty-four hour milk yield was not strongly related to annual TDN intake (r = .05), 205-day calf weight (r = .02) or the ratio of annual TDN intake to 205-day calf weight (r = -.03).

In conclusion, it is difficult to distinguish between effects of breed type and mature cow size in relation to energy requirements and conversion of energy to calf weaning weight. In this study, heavier cows tended to consume more TDN than cows of lighter weights, although the smaller Jersey crosses consumed more TDN per unit body weight than other crosses. In contrast to results of other studies, differences were found among cow breed groups concerning the amount of TDN required to produce a unit of calf weight. While these differences are important, reproductive performance must also be considered to evaluate net efficiency of weaned calf production.

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APPENDIX

TABLE XVIII

YEARLY COMPARISONS OF DRYLOT CALVES VERSUS ENTIRE CALF CROP WEANING WEIGHTS BY CROSSBRED COW GROUP[1]

	Drylot Calves						All Calves[2]					
	Year One		Year Two		Year Three		Year One		Year Two		Year Three	
Crossbred Cow Group[3]	No. Calves	Weaning Weight	No. Calves	Weaning Weight	No. Calves	Weaning Weight	No. Calves	Weaning Weight	No. Calves	Weaning Weight	No. Calves	Weaning Weight
HA	5	467	5	423	5	453	12	451	65	433	66	458
SA	5	481	5	442	5	493	8	486	39	464	36	513
SH	5	503	5	409	5	451	3	510	33	455	30	514
BA	5	463	5	436	5	469	7	506	33	478	28	523
BH	5	544	5	419	5	455	1	506	36	476	33	527
JA	5	476	5	379	5	369	7	482	40	460	44	477
JH	5	444	5	440	5	478	12	509	43	462	41	492
Total or Average	35	483	35	421	35	453	50	493	289	461	278	501

[1]All weaning weights are adjusted to 205 days and adjusted for age of dam.
[2]Entire calf crop includes drylot calves and range calves.
[3]H = Hereford, A = Angus, S = Simmental, B = Brown Swiss, J = Jersey.

TABLE XIX

TDN INTAKE OF FEEDSTUFFS BY CROSSBRED COW GROUP[1]

Crossbred Cow Group[2]	Corn Silage (lb TDN) 160-Day Non-Lactating Period	Corn Silage (lb TDN) 205-Day Lactating Period	Protein Supplement (lb TDN) 160-Day Non-Lactating Period	Protein Supplement (lb TDN) 205-Day Lactating Period	Grain (lb TDN)[3] 205-Day Lactating Period	Calf Creep Feed (lb TDN)
HA	1604	1905	40.5	198.7	462.9	340.7
SA	1745	2241	36.5	207.3	495.9	352.8
SH	1513	2018	33.8	207.9	469.4	340.0
BA	1665	1924	41.6	200.9	484.0	326.7
BH	1601	1883	38.9	199.1	473.8	309.5
JA	1439	1823	36.0	202.0	471.8	287.5
JH	1360	1920	30.7	210.3	473.7	325.7

[1]Based on raw means, averaged over years.
[2]H = Hereford, A = Angus, S = Simmental, B = Brown Swiss, J = Jersey.
[3]Includes whole corn or ground milo.

TABLE XX

PROCEDURE USED TO ESTIMATE TDN REQUIREMENTS WITH NRC

160-Day Non-Lactating Intake =

[Daily requirement for dry pregnant mature cows (middle third of pregnancy)] X 70 days

+

[Daily requirement for dry pregnant mature cows (last third of pregnancy)] X 90 days

205-Day Lactating Intake =

{ [Daily requirement for dry pregnant mature cows (middle third of pregnancy)]

+

[.28 X Milk Yield] } X 205 days

365-Day Intake = 160-Day Non-Lactating Intake + 205-Day Lactating Intake

1) Intake estimates based on an average of 12 monthly weights each year.

2) Intake estimates based on an average of 6 monthly milk yield estimates in Years One and Two and 5 monthly estimates in Year Three.

VITA

Donald Monroe Marshall

Candidate for the Degree of

Master of Science

Thesis: CONSUMPTION AND UTILIZATION OF TDN BY VARIOUS TWO-BREED CROSS COWS THROUGH A PRODUCTION CYCLE

Major Field: Animal Science

Biographical:

Personal Data: Born in Jefferson City, Missouri, January 18, 1957, the son of Chester L. and Goldie Marshall.

Education: Graduated from Jamestown High School, Jamestown, Missouri, May, 1975; received the Bachelor of Science in Agriculture degree from the University of Missouri, May, 1979, with a major in Animal Husbandry; completed requirements for the Master of Science degree at Oklahoma State University in December, 1981.

Experience: Raised and worked on livestock, poultry, and crop farming operation; worked part-time at commercial feed and farm supply business, 1972-1979; Graduate Assistant, Department of Animal Science, Oklahoma State University, 1979-1981.

Professional Organizations: American Society of Animal Science, Gamma Sigma Delta.