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Forage intake and digestibility of Angus, Hereford, and Hereford-Angus first-calving beef females grazing fescue-legume and fescue pastures

Edward Eugene Beaver

To the Graduate Council:

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J. W. Holloway, Major Professor

We have read this thesis and recommend its acceptance:

W. T. Butts Jr., W. R. Backus

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

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The Graduate Council:

FORAGE INTAKE AND DIGESTIBILITY OF ANGUS, HEREFORD, AND HEREFORD-ANGUS FIRST-CALVING BEEF FEMALES GRAZING FESCUE-LEGUME AND FESCUE PASTURES

A Thesis
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Edward Eugene Beaver

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ABSTRACT

Forage intake and digestibility were measured from March 10 to September 15 for 80 lactating Angus, Hereford, and Hereford-Angus first-calf females. Females were fed Cr_2O_3 twice per day during this period, and an AM and PM fecal sample was collected for each female each week, and samples were composited. Fecal samples were analyzed for calcium, chromium, dry matter (DM), and crude fiber, and these components were used in a fecal index to calculate DM intake, DM digestibility, and digestible DM intake for each female each sampling time.

Females grazing fescue-legume and fescue pastures had similar DM digestibility as an average ($P > .1$). However, females on fescue-legume had significantly higher ($P < .0001$) DM intakes and digestible DM intakes over the grazing season than did females on fescue pastures. The advantage for females on fescue-legume was primarily due to higher DM and digestible DM intakes during late spring and summer. However, females on the two pasture types consumed similar amounts of forage during the fall and early spring. A breed X pasture type interaction was detected for average DM digestibility for Hereford-Angus females. As an average of the season, Hereford-Angus on fescue-legume had higher DM digestibility, DM and digestible DM intake over Angus and Hereford on same pasture type, while Angus and Hereford females on fescue-legume had similar DM digestibilities, and DM and digestible DM intakes. Angus and Hereford females on fescue had similar digestibilities, DM, and digestible DM intake, while Hereford-Angus had higher DM and digestible

DM intakes, however Hereford-Angus on fescue had the lowest digestibility of any breed on fescue. Over time, Hereford-Angus on fescue-legume had higher peaks during the late spring and stayed higher during late spring and summer for DM digestibility than Angus and Herefords on fescue-legume. However, Angus, Hereford, and Hereford-Angus on fescue-legume had similar patterns for DM and digestible DM intakes. Hereford-Angus on fescue had lower levels of digestibility during spring and summer than Angus and Herefords on fescue, but Hereford-Angus on fescue showed an increase for DM and digestible DM intake during the late summer and fall over Angus and Hereford females on fescue.

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CHAPTER I

INTRODUCTION

The animal-pasture system is very complex and dynamic involving the following relationships: 1) competition among plant species for available nutrients, 2) selective patterns of grazing, and 3) digestibility, DM, and digestible DM intakes of grazing animals. The understanding of these complex relationships involved in grazing situations have not been effectively explored. This is due to complications unique to grazing situation, such as difficulty in conducting pasture nutrition studies without confining animals to stalls, which may bias results. Other techniques for measuring intake and selection include following the animal as it grazes and harnessing collection bags from the animal in the field. These techniques may provide useful information but interfere with the animal's normal grazing behavior.

Use of the fecal index for prediction of forage intake and digestibility of forage consumed will allow the animal-pasture complex to be studied in much more depth. The purpose of this study was to compare utilization of forage by Angus, Hereford, and Hereford-Angus first-calving beef females grazing fescue-legume and fescue pastures throughout the grazing season. DM intake, DM digestibility, and digestible DM intake estimated by use of a fecal index for each breed on each pasture type were used to compare Angus, Hereford, and Hereford-Angus grazing fescue-legume and fescue pasture.

CHAPTER II

REVIEW OF LITERATURE

Selective Grazing

Selective grazing is an important factor in influencing the intake and digestibility of consumed forage. It can be defined as the difference between forage available and that consumed (Weir et al., 1958 and Hardison et al., 1954). Coleman et al. (1971) stated that selective grazing will occur if there is sufficient forage available, then animals will show a preference for one species of plant over another, or even one part of the plant may be preferred over another part.

This section has been divided into the following subtopics: diets selected by the animal, factors that influence this selection, forage characteristics that cause selection, comparison of selection between sheep and cattle, influence of senses on selection, and the effect of grazing pressure on selective grazing.

Diets Selectively Grazed

Animals have been reported to select forage that is higher in crude protein and digestibility and lower in acid detergent fiber and soluble carbohydrates than were found in samples collected from the same forage. Hardison et al. (1954) found that steers grazing a grass-legume mixture selected a forage more than 6% higher in digestibility than steers hand fed whole forage. Blazer et al. (1960) reported animals that selective graze increase quality of forage consumed over forage available. Alder and Minson (1963) stated that animals grazing lucerne and cocksfoot selected the more digestible portions of the plants.

Factors that Influence Selective Grazing

Hercus (1960) agreed with Cowlishaw and Alder in that composition of diet is due to 1) appetite of the animal (as hunger increased, the quality of diet decreases), 2) previous forage experience of the animal (if animal is allowed, it will select a higher quality diet than forage available), but added that 3) season of the year would affect selective grazing (during the dry part of the grazing season, quality of forage is decreased and quality of diet selected by animal decreases).

Cowlishaw and Alder (1959) described 7 factors influencing selective grazing, 1) the physiological state of the animal, 2) the animal's previous eating history, 3) the environment of the forage, 4) the palatability of the forage available, 5) dung contamination, 6) fungal attack on forage, and 7) the density and toughness of the forage. The physiological state of the animal was important in that their preference in forage depends on physiological status, degree of fatness, and degree of hunger (Heady, 1963). Herus (1960) agreed with Cowlishaw and Alder in that the composition of the diet is due to appetite of the animal, previous forage experience of the animal, and type of forage available, but added that season of the year was another factor that would affect selective grazing. Reppert (1958) found that seasonal changes altered animal preferences in range forage due to change of chemical composition of forage by seasonal differences.

Hardison et al. (1954) observed that twins select forage to a similar degree. He concluded that there are certain genetic preferences for different forages.

Arnold (1959) determined that the major factors influencing selective grazing were quality and quantity of pasture available.

As the quality and the quantity of forage increase, the more selective in grazing the animal will be.

Wheeler (1963) considered the height and density of the pasture to be two of the more important qualities in determination of preference. Animals were found to have a greater ease of selection in a tall, rank, growing forage compared to a lower growing denser forage (Lofgreen et al., 1957). However, Heady and Torell (1959) reported height playing a factor in selective grazing only if forage is scarce and plants were tall.

Heady (1963) stated that stems have a higher level of lignin, cellulose, and crude fiber and were lower in ether extract and crude protein than leaves. Arnold (1960) discussed a strong preference for leaf as opposed to stem by grazing animals. Also, parts of the plant were chosen for highest available nitrogen content and selective grazing became more pronounced as forage increased in age and maturity. Alder and Minson (1963) found that there was a decline in digestibility of the stem from the top to the bottom.

Sheep vs. Cattle

The major similarity in selective grazing of sheep and cattle was that they selected the leaves and fruits over stem parts (Heady, 1963). Sheep however have been found to select the more digestible plant parts than steers (Lofgreen et al., 1957 and Meyer et al., 1957). One of the reasons sheep are more selective than cattle although they eat a wider range of plant species is they graze a higher leaf to stem ratio (Cowlishaw and Alder, 1959). Sheep are more selective than cattle in their grazing due to a couple of factors: sheep obtain less in their bite than do cattle which enables them to selectively graze; and sheep have lips more mobile than cattle which allows sheep to eat less fibrous herbage (Arnold and Dudzinski, 1963). Cattle were found to show more definite periods of grazing and spent more time ruminating than sheep (Lofgreen et al., 1957). As a result of these differences, Meyers et al. (1957) stated there is doubt that the use of data from one species can be used to predict the response of another species on grazing pasture or rangeland due to selective grazing.

Influence of Senses

Sight, taste, and smell are used by cattle in their selection of forage (Hardison et al., 1954), and the impairment of these senses influences preference of certain forage species but did not influence animal productively through the year (Arnold, 1966).

Sight. Arnold (1966) found that blinkered sheep lost more weight than controls on tall dry pastures, but gained more weight than controls on short pastures. Blinkered sheep were found to graze a half hour less each day than control sheep. It was also found that on grass-clover mixtures pastures, control sheep took in more clover than grass, while the blinkered sheep were found to do the reverse. Sight it seems played an important part in selective grazing of tall forage, as it is used to recognize plant material. Arnold (1966) believed that the sense of sight is used by the animal to orientate itself in the pasture space. Tribe and Gordon (1949) have indicated that color is not a factor influencing grazing behavior as sheep were found to be color blind.

Smell. Tribe (1949) concluded that although smell seems to be an important sense in stimulation of appetite, it has no real importance in selecting certain grass and clover species. Arnold (1966), however, found that young sheep without olfactory lobes were less sensitive for stale or feces-contaminated forage to fresh-cut forage than were the control sheep, and the impairment of smell was shown to reduce the intake of certain forage species.

Taste. Krueger et al. (1974) considered taste as the most influential sense in direct preference and reported that sheep selected for sour and sweet plants and rejected bitter plants. On the other hand, Arnold (1966) found that impairment of taste increased intake in some instances and decreased it in other instances.

Touch. Arnold (1966) and Krueger et al. (1974) showed that the role of touch in selective grazing was not as influential as the other senses. Heady (1964) summed it up best in that, a composition of sight, touch, taste as well as instinct and experience all bear influence on preference of the animal.

Effects of Grazing Pressure

Grazing pressure has been reported by Arnold et al. (1966) to have a negative influence on selective grazing of animals, in that sheep grazing at a high stocking rate had less green material to eat and therefore consumed a higher proportion of mature dead forage. Increasing stock rate caused an increase intake of less preferred plant species (Pieper et al., 1959). Heady (1964) showed that too intensive grazing caused a preferred plant by the animal to disappear from the pasture due to being less resistant to grazing than other species of forage. Pieper et al. (1959) showed that as stocking rate increased, dry matter intake, protein, gross energy, ether extract, and phosphorous content of forage were all decreased, whereas lignin content increased.

These factors resulted in decreased performance as stocking rate increased (Hennessy and Robinson, 1979). Blazer et al. (1960) summed it up with the statement that high selective grazing on a low stocking rate will result in a high output per animal, but low output per acre, while a high stocking rate causes low selective grazing and a lower output per animal at an increase in output per acre.

Methods of Measuring Forage Intake and Digestibility on Pasture

Direct determination of forage quality cannot be derived from grazing studies of an extensive nature. Therefore, several methods have been suggested to measure intake and digestibility of forage. Some of these use a natural constituent of the diet to serve as an internal indicator for the prediction of digestibility. This section will discuss three internal indicators, lignin, fecal nitrogen, and chromogen.

Lignin

Lignin is a naturally occurring constituent, but not a chemical entity, and composition of lignin varies with plant species and stage of maturity. Streeter (1969) stated that lignin is found in the plants' cell wall and is a substance that is insoluble in 72% H_2SO_4 and thought to be completely undigestible by ruminant animals. Ellis et al. (1946) defined lignin as the undigested residue of sample subjected to 72% H_2SO_4 for two hours at 20°C.

Lignin is used extensively as a means of predicting forage digestibility by the lignin-ratio technique (Kane et al., 1950). McCullough (1959) found three large errors in the use of lignin as a digestibility indicator. First, lignin is not a specific chemical substance and therefore the methods used to determine lignin are subject to error. Second, lignin can be digested to various degrees, and third, lignin which is a part of the structure of the plant may itself be a source of interference in digestibility of the forage. Brission (1960) agreed that there is an error in the use of lignin in a feed to feces ratio, as lignin gives a larger prediction error compared to chromogen or nitrogen.

Fecal Nitrogen

The basis for fecal N is that the major contributors of N (epithelial cells, bacteria, mucus, bile, and digestive juice residues) to feces include dietary sources as well as endogenous and bacterial sources. This N is thought to be excreted at a fairly constant rate and composes the largest amount of total fecal N (Brission, 1960).

Brission (1960) considered fecal nitrogen a more accurate predictor of feed/feces ratio than fecal chromogen. N has been reported to be excreted in near proportional amounts to the dry matter intake of the animal (Greenhalgh and Corbett, 1960). Greenhalgh and Corbett (1960) also found fecal N of the animals was related to species of grass animals consumed. McCullough (1959) and Lamboune and Readon (1962) stated that relationships of fecal N to intake and digestibility were as good as other indicators such as lignin ratio and chromogen technique. Also, N determination is faster and more reproducible than the other methods.

Some of the problems with using fecal N are 1) fecal N varies with various forage species, 2) the error of measuring fecal N, and 3) the season of the year influence on fecal N. Langlands (1969) found fecal N not to be satisfactory in predicting digestibility of the diet selected by grazing sheep. He reported that two groups of sheep selected diets similar in digestibility, but their feces had different N concentrations. Arnold and Dudzinski (1963) delineated an error--the error of measuring fecal N due to an over or underestimation of residual feed nitrogen which is not endogenous. Streeter (1969) found regressions of fecal N on digestibility varied with the season of the year and with the range in fecal N.

Chromogen

Chromogens are naturally occurring plant pigments that are not digested and consist predominantly of chlorophyll residues and their degradation products (Reid et al., 1950). Chromogens produce a green color in organic solvents and can be quantified spectrophotometrically. The appropriate wavelength for measurement of chromogen concentration is questionable. Reid et al. (1950) proposed measuring chromogens at 406 nm while Brission et al. (1954) reported 406 nm correct for fecal chromogen in sheep but 404 nm for steer feces. Brission (1960) reported increased precision by using fecal nitrogen and chromogen in an index rather than using chromogen. Cook and Harris (1951) however found the chromogen method is not useful in measuring the digestibility of shrubs and browse. It seems that some oils in desert range plants carry chromogens through intestinal walls and are lost through the urine, which causes a negative digestibility. Weir et al. (1960) found chromogens not as consistent as lignin methods on mixed native range and therefore concluded that chromogens have limited use.

Fecal Index Multiple Equations

Individual internal and external indicators have been used to estimate digestibility and intake, but two or more put together in an index might give a more accurate estimate of feed to feces ratio. Multiple regression equations using combinations of crude protein, lignin, silica, ADF, and NDF as independent variables and in vitro digestibility as a dependent variable were used by Rao et al. (1973) and Holecheck (1980). Holloway et al. (1979) reported increased accuracy in prediction of DM intake (R^2 = .32 to .87), DM digestibility (R^2 = .45 to .79) and digestible DM intake (R^2 = .44 to .82) by using multivariable regression of various fecal components on these dependent variables. Estell (1979) demonstrated an increase in accuracy of multivariable indices over univariable equations.

CHAPTER III

MATERIALS AND METHODS

Animal Management

Eighty, 2-year-old, Angus, Angus-Hereford, and Hereford first calf heifers were studied over 2 growing seasons (40 females per year for 1981 and 1982) (Table 1). Females calved January through March of each year and were allotted to either fescue-legume or fescue pastures. Calves were weaned in mid-October of each year.

Females allotted to four 8.1-ha pastures with two pastures per treatment. Each fescue-legume pasture had 11 cow-calf pairs for a stocking rate of 1.23 cow-calf pairs per ha. Each fescue pasture had 9 cow-calf pairs for a stocking rate of 1.11 cow-calf pairs per ha. Animals were rotated between pastures within pasture type each week and were continuously grazed throughout the forage season.

Pasture Management

Fescue-legume pastures consisted of 60-70% Kentucky-31 tall fescue (Festuca arundinacea Schreb.) and 30-40% red clover (Trifolium pratense L.), Korean and Kobe lespedeza (Lespedeza stipulacea Maxim.) and white clover (Trifolium repens L.). In 1981, 78.6 kg of phosphate and 67.4 kg of potassium per ha were applied to fescue-legume pastures. No fertilizer was applied on fescue-legume pastures in 1982 but were seeded that year with 5.6 kg of Kobe lespedeza, 3.4 kg of Korean lespedeza, and 6.7 kg of red clover per ha.

Table 1. Allotment of cattle to experimental pastures[a]

	1981		1982	
Breed	Fescue-Legume	Fescue	Fescue-Legume	Fescue
Angus	8	10	11	8
Hereford	11	5	6	6
Hereford X Angus	3	3	5	4

[a]Number indicates number of cattle in each breed-pasture type subgroup.

Fescue pastures consisted of 90% tall fescue and 10% common bermudagrass (Cynandon dactylon L.). Each year 38.2 kg of nitrogen per ha were applied to the fescue pastures with no seeding performed either year.

Sample Management

A chromic oxide (Cr_2O_3) carrier feed was fed twice daily at 0800 and 1630 hours (Hopper, 1977). Females were fed approximately 346 grams of carrier feed per feeding and in 1981 were fed from February 24 to September 29, while in 1982 the females were fed from March 1 to September 15. One AM and one PM fecal grab sample was taken from each female each week and were refrigerated until composited. Approximately 35% of the fecal samples were collected off the ground, while the other 65% were collected by rectal stimulation. These samples were composited to provide 1 sample per cow per week. Each fecal sample was dried at 60°C and ground through a 1.0 millimeter screen. Dried fecal samples were analyzed for dry matter, calcium, crude fiber (AOAC, 1975), chromium (Williams et al., 1962). Fecal ash samples were prepared for mineral analysis by AOAC (1975) procedures and analyzed spectrophotometrically for Ca. These analyses were used in a fecal index equation for dry matter intake developed by Wehner (1981). DM intake (DMI) = -11.19 + (2.51 x fecal DM output) + (.95 x calcium) + (.41 x crude fiber) - (.1446 x fecal DM output) + (.08 x DM) + (.2302 x fecal DM output x DM) - (.0579 x calcium x DM). R^2 = .70, RSD = .98. In developing this equation, he made 86 determinations over a 2-year growing season (1980 and 1981) using 3-year-old spring calving Angus, Angus-Hereford, and Hereford cows using a wide array of forage species, including red clover (Trifolium pratense L.), orchardgrass (Dactylis glomerata L.), white clover (Trifolium repens L.), tall fescue (Festuca arundinacea Schreb.), lespedeza (Lespedeza stipulacea Maxium.), bluegrass (Poa pratensis L.), hairy vetch (Vicia villosa Roth.), and common bermudagrass (Cynodon dactylon L.) which were harvested over a range of maturities. Fecal DM output was estimated for each week of the experiment by CR_2O_3 dilution method.

$$\text{Fecal DM output} = CR_2O_c \text{ fed}/Cr_2O_3 \text{ in feces}$$

Dry matter digestibility (DMD) was calculated by the equation: DMD = (DMI - fecal DM output)/DMI. Also digestible dry matter intake (DDMI) was calculated by the equation: DDMI = DMI x DMD.

Statistical Analysis

The data consisted of 2440 estimates of DM intake and DMD of 80 females during the grazing season. Analysis of variance procedure utilized to study influence of pasture types and breed on DM1, DMD, and DDMI. The model was: $\hat{Y}$ = year, pasture type, breed, and pasture type-breed interaction, where $\hat{Y}$ was an average of the season for DMI, DMD, and DDMI. The models in Table 2 were used to predict patterns of DMI, DMD, and DDMI for Angus, Hereford, and Hereford-Angus over the grazing season.

Table 2. Regression coefficients for models explaining seasonal trends in DM intake and digestibility of Angus, Hereford-Angus cows grazing fescue-legume and fescue pastures

Item	DM Intake: Fescue-Legume	DM Intake: Fescue	P[a]	DM Digestibility: Fescue-Legume	DM Digestibility: Fescue	P[a]	Digestible DM Intake: Fescue-Legume	Digestible DM Intake: Fescue	P[a]
Year	-13.09	-13.09	.0001	-4.60	-4.60	.0001	-64.60	-64.60	.0001
Pasture type	.82	0.0	.1480	3.85	0.0	.0001	56.25	0.0	.0001
Breed Angus	8.39	8.39	.0667	2.35	2.35	.0001	44.13	44.13	.0116
Hereford	-1.45	-1.45		.41	.41		19.50	19.50	
Hereford-Angus	0.0	0.0		0.0	0.0		0.0	0.0	
Pasture type x breed Angus	1.23	0.0	.7588	-4.67	0.0	.5810	-60.70	0.0	.2448
Hereford	9.10	0.0		-1.51	0.0		-34.43	0.0	
Hereford-Angus	0.0	0.0		0.0	0.0		0.0	0.0	
Time	.98	.98	.0001	.18	.18	.0001	2.52	2.52	.0001
$Time^2$	-1.3×10^{-2}	-1.3×10^{-2}	.0001	-2.4×10^{-3}	-2.4×10^{-3}	.0044	-3.2×10^{-2}	-3.2×10^{-2}	.4312
$Time^3$	7.5×10^{-5}	7.5×10^{-5}	.0001	1.46×10^{-5}	1.46×10^{-5}	.1612	2.0×10^{-4}	2.0×10^{-4}	.0001
$Time^4$	-1.8×10^{-7}	-1.8×10^{-7}	.0001	-4.3×10^{-8}	-4.3×10^{-8}	.0001	-5.7×10^{-7}	-5.7×10^{-7}	.0001
$Time^5$	1.5×10^{-10}	1.5×10^{-10}	.0001	4.9×10^{-11}	4.9×10^{-11}	.0358	6.1×10^{-10}	6.1×10^{-10}	.0002
Pasture type x time	.03	0.0	.3382	-.14	0.0	.3694	-2.14	0.0	.0111
Pasture type x $time^2$	6.6×10^{-4}	0.0	.0001	2.0×10^{-3}	0.0	.0001	2.9×10^{-2}	0.0	.0001
Pasture type x $time^3$	2.3×10^{-6}	0.0	.0129	-1.3×10^{-5}	0.0	.0001	-1.9×10^{-4}	0.0	.0001
Pasture type x $time^4$	-1.6×10^{-8}	0.0	.0449	3.8×10^{-8}	0.0	.0091	5.4×10^{-7}	0.0	.0298
Pasture type x $time^5$	5.7×10^{-11}	0.0		-4.3×10^{-11}	0.0	.8968	-6.0×10^{-10}	0.0	
Breed x time Angus	-.30	-.30	.1767	-.08	-.08	.3650	-1.5	-1.5	.0985
Hereford	-.08	-.08		-.01	-.01		-.73	-.73	
Hereford-Angus	0.0	0.0		0.0	0.0		0.0	0.0	
Pasture type x breed x time Angus	-.14	0.0	.983k	.17	0.0	.2523	2.11	0.0	.7487
Hereford	-.14	0.0		.06	0.0		1.33	0.0	
Hereford-Angus	0.0	0.0		0.0	0.0		0.0	0.0	
Pasture type x breed x $time^2$ Angus	3.1×10^{-3}	0.0	.0359	-2.2×10^{-3}	0.0		-.03	0.0	.1922
Hereford	5.8×10^{-4}	0.0		-7.6×10^{-4}	0.0	.0148	-.02	0.0	
Hereford-Angus	0.0	0.0		0.0	0.0		0.0	0.0	
Pasture type x breed x $time^3$ Angus	-2.7×10^{-5}	0.0	.5826	1.4×10^{-5}	0.0	.0458	1.6×10^{-4}	0.0	
Hereford	-4.4×10^{-7}	0.0		4.7×10^{-6}	0.0		1.1×10^{-4}	0.0	
Hereford-Angus	0.0	0.0		0.0	0.0		0.0	0.0	
Pasture type x breed x $time^4$ Angus	1.0×10^{-7}	0.0	.1676	-4.2×10^{-8}	1.8×10^{-8}	.8649	-4.9×10^{-7}	0.0	
Hereford	2.9×10^{-9}	0.0		-1.3×10^{-8}	-3.7×10^{-7}		-3.3×10^{-7}	0.0	
Hereford-Angus	0.0	0.0		0.0	0.0		0.0	0.0	
Pasture type x breed x $time^5$ Angus	1.4×10^{-10}	0.0	.0153	4.8×10^{-11}	0.0	.9160	5.5×10^{-10}	0.0	
Hereford	1.3×10^{-11}	0.0		1.5×10^{-11}	0.0		3.7×10^{-10}	0.0	
Hereford-Angus	0.0	0.0		0.0	0.0		0.0	0.0	
R^2[b]	.174			.297			.178		
RSD[c]	2.163			8.855			1.672		

[a]Probability of a larger F ratio of partial mean squares.

[b]Coefficient of determination.

[c]Residual standard deviation.

CHAPTER IV

RESULTS AND DISCUSSION

Dry Matter Digestibility

Pasture Type

As an average of the season, females on fescue-legume selected a diet similar ($P > .1$) in DM digestibility to that of females grazing fescue, 50.18 vs. 50.13% respectively (Table 3). These results appear to be at variance with data reported in Figure 1 which indicates a difference between pasture types over time. This apparent disagreement is due to the fact Figure 1 runs from March 10 to September 15, and the average was taken for the grazing season of February 24 to September 29. The average differed from those reported by Holloway and Butts (1983), in that cows grazing fescue-legume were found to select forage 4.6 percentage units more ($P < .01$) digestible than cows grazing fescue. Also reported by these authors were average digestibilities over 5 grazing seasons of 63.9% on fescue-legume and 59.3% on fescue pastures which were higher than found in these results. However, these digestibilities were estimated by use of the lignin ratio method on mature Angus females.

Although the average for the two pasture types was similar ($P > .1$), there were differences in pattern of digestibility (Figure 1 and Table 3). In the early spring (March 10 to May 1, Figure 1), females grazing fescue-legume and fescue pastures had similar DM digestibilities, but those grazing fescue-legume had experienced an increase in DM

Table 3. Least-square means for DM digestibility, DM intake, and digestible DM intake for females grazing fescue-legume and fescue pastures[a]

	Pasture Type		
Item	Fescue-Legume	Fescue	RSD[b]
Digestibility %	50.18c	50.13c	10.00
Dry Matter Intake kg/day	11.87c	11.08d	2.58
Digestible Dry Matter Intake kg/day	6.18c	5.67d	2.00

[a]Least-squares means from model: $\hat{Y}$ = year, pasture type, breed, breed X pasture type.

[b]Residual standard deviation from the model.

[c,d]Means on the same line under the same classification with different superscripts differ ($P < .05$, t-test).

Figure 1. Breed and pasture effects on forage digestibility.

Angus-F = Angus on fescue = $(-.73702 + .0347 \times day - .00033 \times day^2 + 1.29727 \times 10^{-6} \times day^3 - 1.81737 \times 10^{-9} \times day^4$.

Crossbred-F = Hereford-Angus on fescue = $.97656 + .041341 \times day - .00039 \times day^2 + 1.56948 \times 10^{-6} \times day^3 - 2.23641 \times 10^{-9} \times day^4$.

Hereford-F = Hereford on fescue = $-1.24736 + .048827 \times day - .00047 \times day^2 + 1.8733 \times 10^{-6} \times day^3 - 2.6550 \times 10^{-9} \times day^4$.

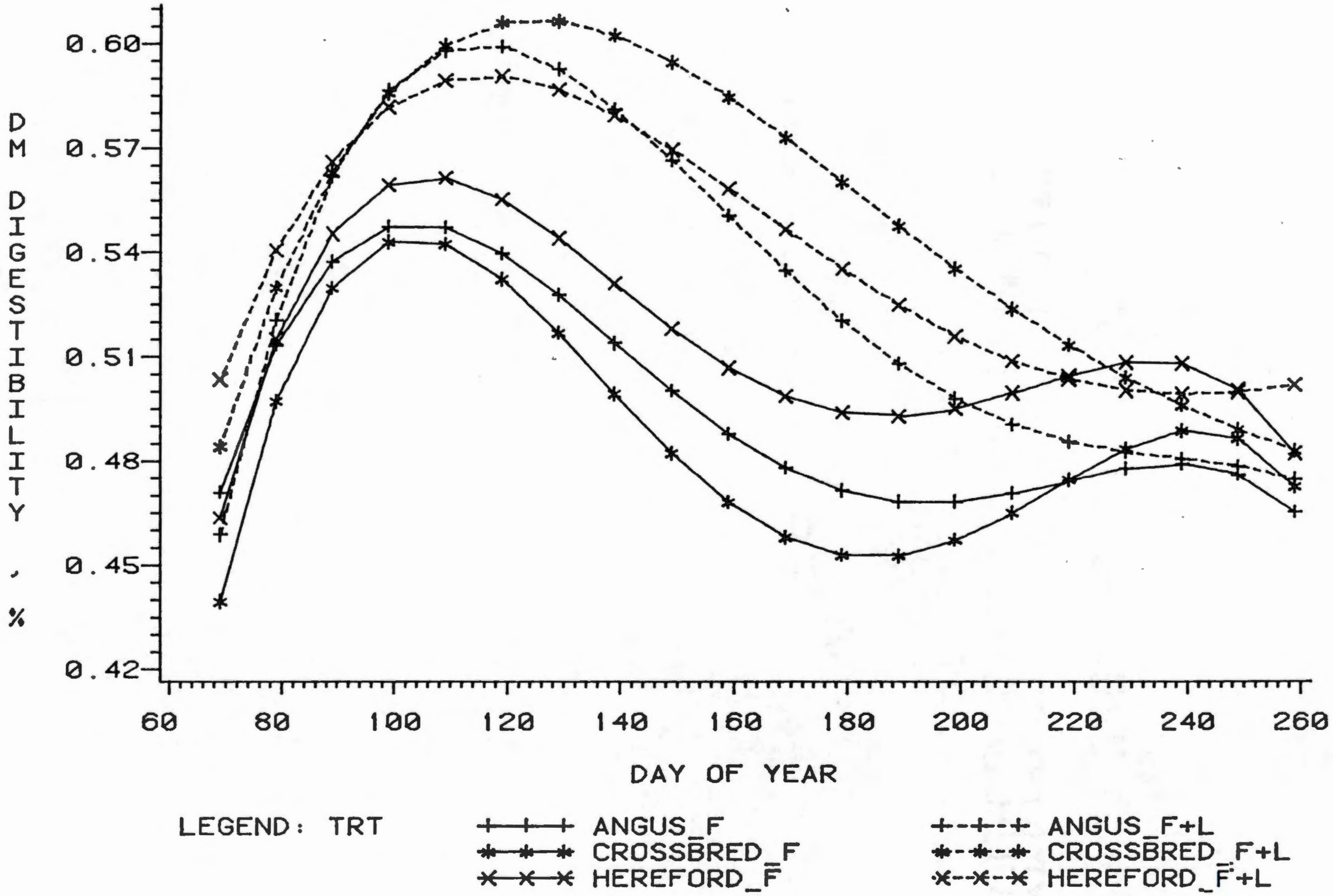
Angus-F+L = Angus on fescue-legume = $(.88709 + .035889 \times day - .00030 \times day^2 + 1.07029 \times 10^{-6} \times day^3 - 1.35032 \times 10^{-9} \times day^4$.

Crossbred-F+L = Hereford-Angus on fescue-legume = $-.33367 + .02037 \times day - .00015 \times day^2 + 4.7091 \times 10^{-7} \times day^3 - 5.20283 \times 10^{-10} \times day^4$.

Hereford-F = Hereford on fescue-legume = $-.25353 + .019623 \times day - .000157 \times day^2 + 5.1221 \times 10^{-7} \times day^3 - 5.8415 \times 10^{-10} \times day^4$.

$R^2 = .366$.

RSD = 14.856.



DM DIGESTIBILITY, %
0.60
0.57
0.54
0.51
0.48
0.45
0.42
60
80
100
120
140
160
180
200
220
240
260
DAY OF YEAR
LEGEND: TRT
ANGUS_F
CROSSBRED_F
HEREFORD_F
ANGUS_F+L
CROSSBRED_F+L
HEREFORD_F+L

Figure 1

digestibility to a greater extent during the summer than did females grazing fescue. However, by the latter end of summer or early fall (July 20 to September 15), the digestibility of females on fescue-legume had decreased to levels of DM digestibility similar to those on fescue. This decrease in DM digestibility over summer was similar to that found by Fribourg and Loveland (1980), in that vitro digestibility of fescue was highest in the spring (68-70%), lowest in the summer (56-58%), and intermediate in the fall (60-65%). These results were also similar to those found by Holloway et al. (1978) in which fescue pasture, although high in digestibility during spring, rapidly decreased in digestibility during summer, resulting in large advantages for fescue-legume pastures during the summer. This being due to the interaction of pasture type over time (Table 2).

Breed X Pasture Type

There was a failure of breed types to have similar grazing patterns on fescue-legume and fescue (Figure 1) due to interaction between breed and pasture type over time. As an average of the grazing season, Hereford females grazing fescue-legume tented ($P > .10$) to be 1.17 and 2.09 percentage units lower in DM digestibility than Angus and Hereford-Angus (Table 4). Hereford-Angus females grazing fescue, on the average, tended ($P > .10$) to be 1.86 and 2.32 percentage units lower in DM digestibility than Angus and Hereford females.

Hereford-Angus females on fescue-legume were found to have higher peaks during late spring (May 1) and stay higher during late spring and

Table 4. Least-square means for DM digestibility, DM intake, and digestible DM intake for Angus, Hereford, and Hereford-Angus Grazing Fescue-Legume and Fescue Pastures[a]

	Pasture Type						
	Fescue-Legume			Fescue			
Dam Breed	Angus	Hereford	Hereford-Angus	Angus	Hereford	Hereford-Angus	RSD[b]
Digestibility, %	50.27c	49.10d	51.18c	50.60c	51.06c	48.74d	9.996
Dry Matter Intake, kg/day	11.52c	11.81cd	12.29f	10.72e	10.91e	11.61cd	2.578
Digestible Dry Matter Intake, kg/day	6.07c	6.02c	6.45d	5.49ef	5.73ef	5.81c	1.995

[a]Least-square means from model: $\hat{Y}$ = year, pasture type, breed, breed x pasture type.

[b]Residual standard deviation from the model.

[c,d,e,f]Means on the same line with different superscripts differ ($P < .05$, t-test).

summer (May 1 to August 1) for DM digestibility than did Angus and Hereford females on fescue-legume which peaked earlier (April 10, Figure 1). Hereford-Angus females on fescue pastures had the lowest level of digestibility during spring and summer (March 10 to August 1, Figure 1) of any breed grazing fescue.

Dry Matter Intake

Pasture Type

Females grazing fescue-legume consumed .81 kg DM/day more forage DM than did cows on fescue (Table 3). Holloway and Butts (1983) found that mature Angus grazing fescue-legume consumed 1.69 kg DM/day more than females on fescue on the average, over five grazing seasons.

The advantage in DM intake for females grazing fescue-legume results largely from advantages during the summer. Females on fescue-legume consumed more DM throughout the grazing season, but the greatest difference between the two pasture types is seen during the summer (May 20 to July 1, Figure 2). These results were similar to Holloway et al. (1978); they reported that cows grazing fescue-legume consumed similar amounts of forage as cows grazing fescue during the spring, but consumed considerably more forage during the summer. This difference was probably due to the large amount of legume in the fescue-legume pastures during the hot part of summer when fescue was dormant.

Breed X Pasture Type

No breed and pasture type interaction over time was detected for DM intake as an average of the season. Hereford-Angus females on

Figure 2. Breed and pasture effects on forage intake.

Angus-F = Angus on fescue = 04.5906 + .58441 x day - .00707 x day^2 + 3.2983 x 10^{-5} x day^3 - 5.2301 x 10^{-8} x day^4.

Crossbred-F = Hereford-Angus on fescue = -16.1668 + .95845 x day - .011128 x day^2 + 5.1099 x 10^{-5} x day^3 - 8.05076 x 10^{-8} x day^4.

Hereford-F = Hereford on fescue = -19.8764 + .95137 x day - .01025 x day^2 + 4.4906 x 10^{-5} x day^3 - 6.87190 x 10^{-8} x day^4.

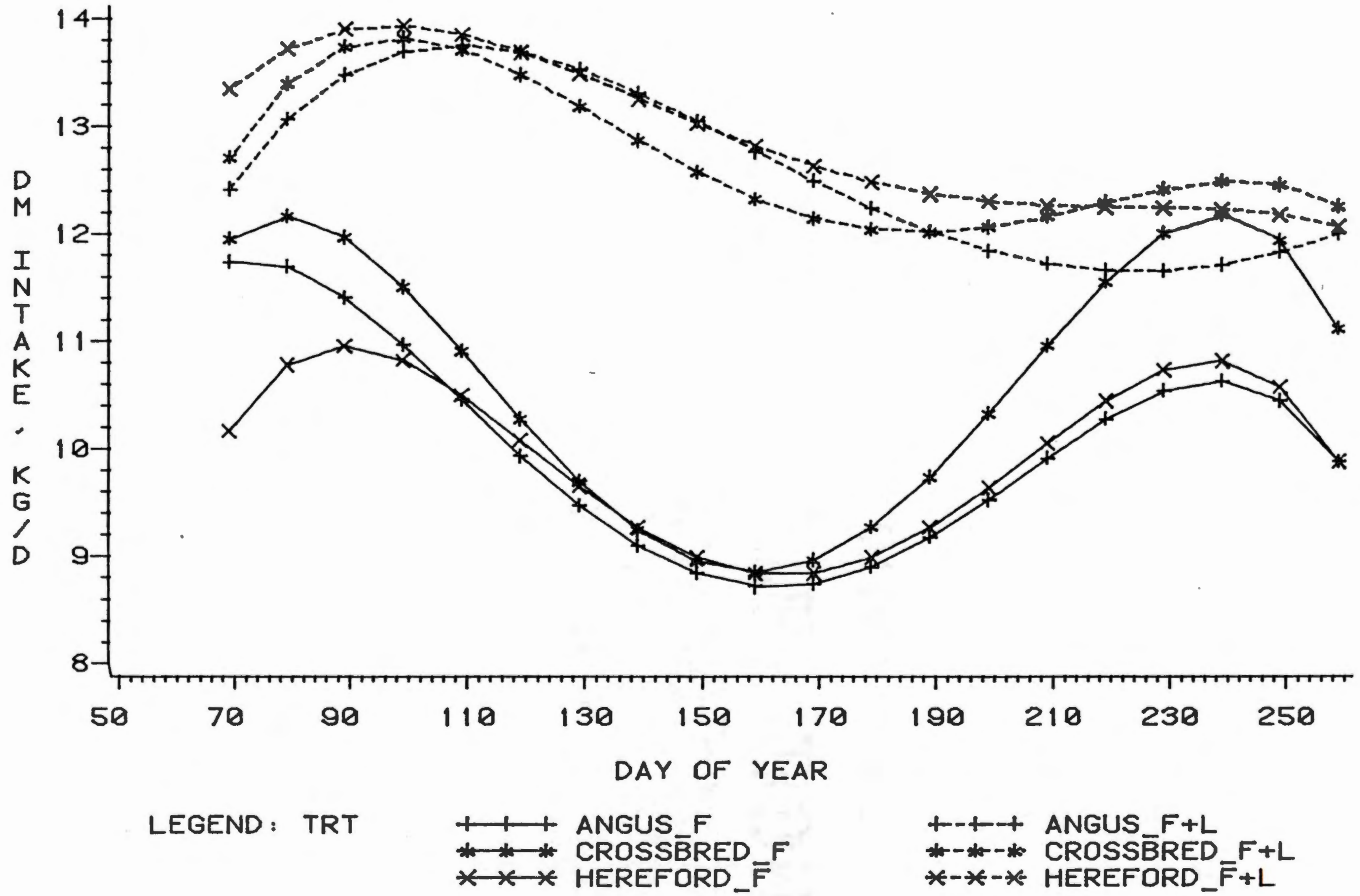
Angus-F+L = Angus on fescue-legume = -2.23295 + .389586 x day - .003248 x day^2 + 1.06459 x 10^{-5} x day^3 - 1.1945 x 10^{-8} x day^4.

Crossbred-F+L = Hereford-Angus on fescue-legume = -9.9890 + .67093 x day - .006617 x day^2 + 2.6664 x 10^{-5} x day^3 - 3.7989 x 10^{-8} x day^4.

Hereford-F+L = Hereford on fescue-legume = 1.09378 + .35815 x day - .003456 x day^2 + 1.3426 x 10^{-5} x day^3 - 1.8485 x 10^{-8} x day^4.

R^2 = .285.

RSD = 2.486.



DM INTAKE, KG/D
14
13
12
11
10
9
8
50
70
90
110
130
150
170
190
210
230
250
DAY OF YEAR
LEGEND: TRT
ANGUS_F
CROSSBRED_F
HEREFORD_F
ANGUS_F+L
CROSSBRED_F+L
HEREFORD_F+L

Figure 2

fescue-legume pastures consumed on the average ($P < .05$) .77 and .48 more kg DM/day than Angus and Hereford (Table 4). On fescue pastures, Hereford-Angus females consumed .89 and .70 more kg DM/day than Angus and Hereford females.

Hereford-Angus females grazing fescue-legume showed a similar pattern for DM intake as Angus and Hereford females while Hereford-Angus females grazing fescue, however, showed an increased DM intake during the later summer and fall (July 20 to September 15) over Angus and Hereford females (Figure 2). Figure 2 indicates that there were very little differences between breeds within pasture types for DM intake, but large differences between pasture types. Long (1980) reported that the effects of crossbreeding on forage intake are not yet clear.

Digestible DM Intake

Pasture Type

Females on fescue-legume consumed .51 kg/day more ($P < .001$) digestible DM as an average of the grazing season than females on fescue. Since there was no difference between pasture types in DM digestibility, the reason the advantage of females grazing fescue-legume in terms of DM intake ($P < .001$) of females on fescue-legume as to females on fescue. Holloway and Butts (1983) reported females on fescue-legume pastures consumed 1.4 kg/day more digestible DM than females on fescue; however, this work was again done on mature Angus females, and digestibility was determined by the lignin ratio technique.

Seasonal trends for digestible DM intake were similar to these observed for DM intake (Figures 2 and 3) in that cows on fescue-legume were higher in early spring (March 1), peaked later in season, and stayed higher than cows on fescue during the spring and summer. By the fall, the differences between pasture types were small. This difference in digestible DM intake between pasture types was seen by Holloway et al. (1978). He reported that females grazing fescue-legume consumed 1.46 kg/day more ($P < .01$) digestible DM than those grazing fescue.

Pasture Type X Breed

As an average of the grazing season, Hereford-Angus females grazing fescue-legume had ($P < .05$) .38 and .43 kg/day higher digestible DM intakes than Angus and Hereford respectively (Table 4). Hereford-Angus females on fescue tended to consume .32 and .08 kg/day higher digestible DM than Angus and Hereford (Table 4). No pasture type by breed interaction was seen on digestible DM intake.

Figure 3 shows patterns of digestible DM intake were similar to Figure 2 for DM intake. For females grazing fescue-legume, the only major difference between breeds was during summer and fall (July 1 to September 15); Angus females decreased in digestible DM intake at a faster rate and came to a lower point than did Hereford and Hereford-Angus females. The major difference between breeds on fescue pastures was Hereford-Angus females on fescue had a higher level of digestible DM intake from August 1 to September 15 than did Angus and Hereford females.

Figure 3. Breed and pasture effects on forage digestible DM intake.

Angus-F = Angus on fescue = $-9.5215 + .50943 \times day - .00566 \times day^2 + 2.4986 \times 10^{-5} \times day^3 - 3.8269 \times 10^{-8} \times day^4$.

Crossbred-F = Hereford-Angus on fescue = $-29.8807 + 1.0799 \times day - .01122 \times day^2 + 4.7668 \times 10^{-5} \times day^3 - 7.1132 \times 10^{-8} \times day^4$.

Hereford-F = Hereford on fescue = $-22.2404 + .81667 \times day - .008277 \times day^2 + 3.4619 \times 10^{-5} \times day^3 - 5.1297 \times 10^{-8} \times day^4$.

Angus-F+L = Angus on fescue-legume = $-11.2205 + .46459 \times day - .003837 \times day^2 + 1.2644 \times 10^{-5} \times day^3 - 1.45826 \times 10^{-8} \times day^4$.

Crossbred-F+L = Hereford-Angus on fescue-legume = $-12.2456 + .51743 \times day - .004613 \times day^2 + 1.69939 \times 10^{-5} \times day^3 - 2.2558 \times 10^{-8} \times day^4$.

Hereford-F+L = Hereford on fescue-legume = $-7.1373 + .38675 \times day - .003411 \times day^2 + 1.2211 \times 10^{-5} \times day^3 - 1.5602 \times 10^{-8} \times day^4$.

$R^2 = .171$.

RSD = 2.054.

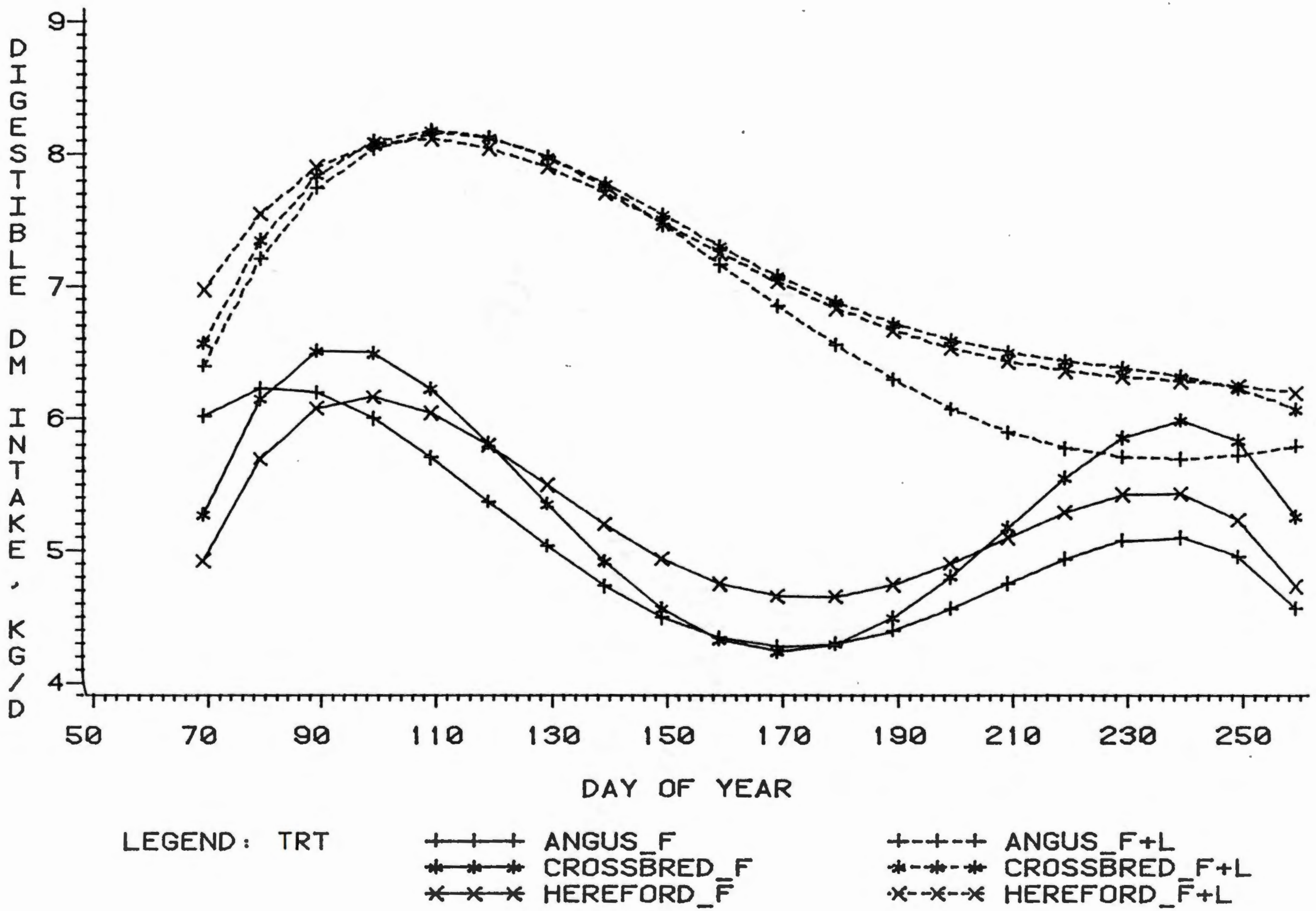

DIGESTIBLE DM INTAKE, KG/D
9
8
7
6
5
4
50
70
90
110
130
150
170
190
210
230
250
DAY OF YEAR
LEGEND: TRT
ANGUS_F
CROSSBRED_F
HEREFORD_F
ANGUS_F+L
CROSSBRED_F+L
HEREFORD_F+L

Figure 3

Conclusion

Females grazing fescue-legume and fescue pastures consumed forage similar ($P > .1$) in DM digestibility as an average. Females grazing fescue-legume had higher ($P < .0001$) DM intakes and digestible DM intakes than females on fescue pastures. This is due in part to the fact that females on fescue-legume consumed legumes during the summer when fescue was dormant. Patterns of intake over time show differences between fescue-legume and fescue pastures type. Females on fescue-legume began the trial in the spring with higher DM intake and digestible DM intake and remain at similar levels throughout the summer while females on fescue pastures became lower during the summer and increased during the fall.

Significant interactions of breeds, pasture type, and time were found for digestibility of Hereford-Angus females, and these interactions were seen on the average over the grazing season. Hereford-Angus grazing fescue-legume had the highest digestibility of any breed on fescue-legume, while Hereford-Angus females on fescue on the average had the lowest digestibility of the breeds on fescue.

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