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Effect of nitrogen fertilization on nutritive value of Midland bermudagrass pastures for yearling beef cattle

Larry Allen Carver

To the Graduate Council:

I am submitting herewith a dissertation written by Larry Allen Carver entitled "Effect of nitrogen fertilization on nutritive value of Midland bermudagrass pastures for yearling beef cattle." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Animal Science.

K. M. Barth, Major Professor

We have read this dissertation and recommend its acceptance:

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Accepted for the Council:

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and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

EFFECT OF NITROGEN FERTILIZATION ON NUTRITIVE VALUE OF MIDLAND BERMUDAGRASS PASTURES FOR YEARLING BEEF CATTLE

A Dissertation

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Larry Allen Carver

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ABSTRACT

Midland bermudagrass pastures not fertilized with N (MID-1) or fertilized, in three equal installments, with either 112 (MID-2), 224 (MID-3) or 448 (MID-4) kg N/ha/year were compared to common bermudagrass (CB) fertilized with 112 kg N/ha/year and orchardgrass-ladino clover (OG) pastures. Forage consumption was determined by the cage-and-strip method from the middle of April to the middle of September during three consecutive years. Angus yearling steers, initially weighing about 215 kg, were used in a modified put-and-take grazing system.

In vitro digestible dry matter (Tilley and Terry) and N (Auto-analyzer) were determined on all forage samples from the three years. During the last year, selected forage samples were analyzed for their amino acid content. In addition, jugular blood samples, obtained monthly from all tester animals, were analyzed for plasma urea nitrogen (PUN).

The forage composition and intake data from the three years were reduced to polynomial equations describing the regression of *in vitro* digestible dry matter (IVDDM) and crude protein (CP) content and the intake of estimated total digestible nutrients (ETDN) and CP on elapsed days of grazing (D). The results of these regression equations were used to generate predicted percentages of IVDDM, ETDN and CP and also of ETDN and CP intake per unit of metabolic weight and above maintenance for 20-day intervals until 140 elapsed days of grazing.

Nitrogen fertilization increased the IVDDM of Midland bermudagrass (45.6, 46.5, 47.4 and 48.5% for MID-1, MID-2, MID-3 and MID-4, respectively) but only MID-4 was significantly greater than MID-1. A

decrease (P<.05) in IVDDM from April to September was observed in all treatments (50.8 to 37.7, 54.2 to 33.7, 56.6 to 34.2, 57.1 to 34.9, 49.8 to 40.2 and 69.2 to 58.3% for MID-1, MID-2, MID-2, MID-4, CB and OG, respectively).

N fertilization increased (P<.05) the CP content of Midland pastures at all levels of fertilization (9.5, 10.7, 13.0 and 16.1% for MID-1, MID-2, MID-3 and MID-4, respectively). However, over the entire season, OG pastures contained more (P<.05) CP (17.7%) than all bermudagrass forages. All forages decreased (P<.05) in CP content from April to September (14.3 to 7.5, 17.6 to 7.8, 18.2 to 10.1, 23.2 to 12.6, 17.2 to 7.9 and 19.1 to 16.2% for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively).

OG contained more (P<.05) ETDN in the consumed forage (61.7%) than the mean of all bermudagrasses (51.2%). The %ETDN in consumed forage decreased (P<.05) during the season in all treatments (62.3 to 45.8, 59.8 to 42.3, 61.6 to 43.6, 65.8 to 49.9, 57.2 to 48.6 and 67.6 to 57.8% for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively).

The mean CP content of consumed OG forage during the entire season was 19% compared to 15% for all bermudagrasses (P<.05). CB contained less (P<.05) CP on the average (13.4%) than the mean of all Midland forages (15.4%). MID-1 contained less (P<.05) CP (11.4%) than fertilized (MID-N) Midland (16.7%) but Midland fertilized with 224 and 448 kg N/ha (MID-HN) contained more (P<.05) CP (17.8%) in consumed forage than did MID-2. MID-4 contained 21.1% CP in consumed forage compared to 14.5% in MID-3 (P<.05). The CP content of consumed forage in all treatments decreased (P<.05) during the season (17.0 to 11.5, 17.3 to 12.0, 19.2 to 12.6, 30.2 to 17.3, 19.4 to 8.1 and 20.2 to 16.5% for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively).

Multiple regression equations were developed for the prediction of ADG from forage composition and consumption. All equations gave a more reliable prediction of ADG for steers grazing MID-N and CB pastures than for steers grazing MID-1 and OG pastures.

Over the entire season, no significant difference was apparent between the mean PUN level of animals grazing OG (16.19 mg/100 ml) and that of animals grazing all bermudagrasses (14.41 mg/100 ml), nor did a significant difference exist between the PUN level of animals grazing CB (13.02 mg/100 ml) and that of animals grazing all Midland pastures (14.76 mg/100 ml). Animals grazing MID-1 had a lower ($P<.05$) PUN level (11.57 mg/100 ml) than did animals grazing MID-N (15.82 mg/100 ml). Animals consuming MID-2 had a lower ($P<.05$) PUN level (13.97 mg/100 ml) than did animals grazing MID-HN (16.76 mg/100 ml). Animals consuming MID-3 had a lower ($P<.05$) PUN (14.34 mg/100 ml) than did animals grazing MID-4 (19.18 mg/100 ml). Regression equations were developed to predict ADG, %CP in consumed forage, %DDM content of consumed forage and CP intake per unit of metabolic weight from PUN levels.

The general order of amino acid levels, from high to low, expressed as a percentage of forage CP was aspartic acid, alanine, glutamic acid, valine, phenylalanine, arginine, lysine, leucine, glycine, isoleucine, threonine, tryosine, serine, proline, histidine and methionine. The mean of MID-1 and MID-4 contained more ($P<.05$) serine, lysine, aspartic acid, glutamic acid and glycine than did OG. The latter contained more ($P<.05$) methionine than the mean of MID-1 and

MID-4. MID-1 contained significantly more arginine, threonine, serine, glycine and valine than did MID-4. The latter contained a higher percentage of methionine ($P<.05$) than did MID-1.

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CHAPTER I

INTRODUCTION

During the past 18 months, grain in the United States has become too expensive and too scarce to use as extensively in beef production as in the past. The surpluses of food stocks are gone. As a result, more grain is needed for people and less is available for livestock. Beef cattle are not good converters of grain to meat (9 to 1) but they have the capability to convert forages unusable by non-ruminants into food products. This ability to convert forages and a shortening of the normal grain-feeding period could result in a lifetime conversion of two units of grain to one unit of meat. In the near future, there may be a return to the growing of cattle on forages followed by a shorter grain-feeding period. Feedlots will contain yearling and two-year-olds instead of calves.

In 1973, 1,125,000 beef cows calved in Tennessee and most of the marketed calves were sold as feeder calves. Cows were bred to calve in the late winter and early spring and calves were sold as feeders in the fall. The majority was shipped out of the state and finished in the feedlots of the Midwest and Southwest. In the future, Tennessee can increase its income from beef cattle greatly by utilizing more forage, which can be economically produced in the state, to put low-cost gains on the cattle and to keep them longer to be sold to feeders as yearlings or two-year-olds.

Forages are important to the world's food resources as plant materials containing relatively high amounts of structural carbohydrates. Since most monogastric animals are limited in their capacity to digest fibrous carbohydrates, the usefulness of these forages lies in utilization by ruminant animals. Good pasture is the most economical source of nutritious forage. This is particularly true in the southeastern United States where adequate grazing is available throughout most of the year.

In Tennessee, a major part of this forage is provided by permanent pastures of "Kentucky 31" tall fescue (*Festuca arundinacea* Schreb), orchardgrass (*Dactylis glomerata* L.), ladino clover (*Trifolium repens* L.), red clover (*Trifolium pratense* L.) and lespedeza (*Lespedeza striata* Hook and Arn.). However, these cool-season grasses and legumes have a lush period during the spring, followed by low production during the summer months. To maximize beef production from forage, therefore, a year-round pasture program that produces the maximum amount of nutrients must be utilized. Warm-season grasses, such as bermudagrass (*Cynodon dactylon* [L.] Pers.) can be used to fill this gap in many forage programs. Although Coastal bermudagrass may be used in the more southern states, it is injured or killed by low winter temperatures in most of Tennessee and at more northerly locations. In such situations the cultivar Midland, which has been found to be well adapted and productive in Tennessee, can be used.

The success of any beef cattle grazing program depends largely upon the quality and amount of forage available to the cattle. As agricultural land area is reduced and more feed grains are needed for human consumption, ever-increasing levels of animal production per unit of feed are necessary. Therefore, the improvement of the nutritive value of pasture forages becomes more important.

Experiments reported here were conducted at Ames Plantation, Grand Junction, Tennessee, from 1971 through 1973 and were to evaluate the productivity and relative nutritive value of Midland bermudagrass pastures under various levels of nitrogen fertilization and of common bermudagrass and of orchardgrass-ladino clover pastures for beef production in Tennessee. The general categories discussed in this study are:

(1) Effect of treatment and elapsed days of grazing on composition of available and consumed forage.

(2) Effect of treatment and elapsed days of grazing on consumption of dry matter (DM), digestible dry matter (DDM), total digestible nutrients (TDN) and crude protein (CP) by yearling beef steers.

(3) Relationship of average daily weight gain (ADG) to the composition of available and consumed forage.

(4) Relationship of ADG with the amount of forage consumed.

(5) Prediction of ADG from forage composition and consumption.

(6) Effect of treatment and elapsed days of grazing on plasma urea nitrogen concentrations in yearling beef steers.

(7) Amino acid composition of selected forages.

CHAPTER II

REVIEW OF LITERATURE

Bermudagrass is widely distributed over tropical and subtropical areas of the world. It is not native to the United States although its presence here was recorded as early as 1807. Common bermudagrass is a major component of the ground cover of many acres in Tennessee, particularly in the western part of the state. At present, new seedings are recommended primarily for conservation use. Established stands are used for pasture, rather than hay, because the grass is difficult to mow and bale and is less productive than newer bermudagrass hybrids. Common bermuda produces many heads throughout the summer which makes the control of its spreading difficult (Fribourg, 1963). Coastal bermudagrass is recommended in Tennessee for hay and pasture where winter injury is not a factor. The Coastal cultivar is an F_1 hybrid between Tift bermudagrass and one introduced from Africa. It may suffer severe winter injury during some years on some sites in Tennessee.

Midland bermudagrass is an F_1 hybrid between Coastal bermudagrass and a winter-hardy common bermudagrass from Indiana. It is similar to Coastal in most of the good traits that characterize it. In Tennessee, it has yielded as much as Coastal in most instances when Coastal was not injured by winter temperatures; however, Midland has outproduced Coastal when the latter was winter-injured (Fribourg, 1963). Midland starts to grow two to three weeks earlier in the spring than common and three to five weeks earlier than Coastal. Results from 10 years of research in

Maryland have demonstrated the high yield potential of Midland (Decker, 1965).

Effect of Season on Digestibility and Crude Protein Content of Forage

There is a progressive decline in digestibility as plants change from a leafy vegetative to a morphologically stemmier growth with increasing maturity (Blaser, 1964; Cook and Harris, 1968). Coastal bermudagrass samples harvested at 28 day intervals from grazed areas exhibited a seasonal decrease in digestibility from 65.4% to 38.6% from May through September (Utley et al., 1974). Webster et al. (1965) also observed seasonal changes in in vitro digestible dry matter of Midland bermudagrass. Digestibility was highest in the spring (69% at 448 kg N/ha) and dropped to 60% by mid-summer. McCroskey (1972) found that Midland had a digestibility of over 75% in April but that it fell below 60% in June, declining throughout the remainder of the year to a low of 34% in March. Season had a highly significant effect upon rumen microbial utilization of common, Midland and Coastal bermudagrass forage (Hall et al., 1964). Cellulose digestibilities for cuttings made in May and July were: 62.8, 39.4; 56.0, 44.4; and 53.8, 42.0 percent for Coastal, Midland, and common, respectively.

A probable reason for the seasonal effect on forage digestibility is that photosynthesis occurs at lower temperatures than does growth, suggesting that soluble carbohydrates in forage increase during the spring when forage growth is slow. Thus, early maturing varieties are lower in dry matter digestibility on a given date in spring than late-maturing varieties (Blaser, 1964).

Effect of Nitrogen Fertilization on Digestibility of Forage

No increase was apparent in digestible dry matter of Midland bermudagrass fertilized with up to 1568 kg N/ha (Webster et al., 1965). Conversely, Wilkinson et al. (1969) reported that in vitro dry matter digestibility of Midland increased from 67% to 71% when the level of N applied was increased from 224 to 1120 kg/ha.

In Tennessee, Midland bermudagrass fertilized with 0, 133, 400 and 800 kg N/ha increased in average in vitro digestible dry matter from about 37% to 46% over the range of applied N. In general, digestibility of unfertilized Midland was between 35% and 43% and, at the highest N fertilization level, it was as high as 51% (Fribourg et al., 1971). Horn and Taliaferro (1974) reported significant increases in digestibility of four bermudagrass varieties when 56, 168 and 504 kg N/ha were applied (57.2%, 58.1% and 59.6%, respectively, $P<.001$).

The reason high nitrogen fertilization had little or no effect on the digestible energy value of grasses is that the increase in crude protein content concurrent with added N was associated with a decrease in soluble carbohydrates. The soluble carbohydrates of bermudagrass with high N fertilization were about one-half as high as those with low N fertilization. This drastic reduction in soluble carbohydrates with added N was attributed to increased respiration and utilization of soluble carbohydrates for synthesis of protein and structural materials with increased yields (Blaser, 1964).

Effect of Nitrogen Fertilization on Crude Protein Content of Forage

Many investigators have demonstrated that the crude protein (CP) content of Coastal and Midland bermudagrasses can be increased with increasing levels of nitrogen fertilization. Mathias et al. (1973) found that nitrogen content of Midland increased with increasing levels of N applied to the sward and the differences among rates of N were greater in the second harvest than in the first. Midland fertilized with 0 to 112 kg N/ha had a crude protein content of approximately 10% which increased to around 18% with 448 kg or more of N/ha. Overall CP levels for four bermudagrasses fertilized with 56, 168 and 504 kg N/ha were 11.5%, 12.3% and 14.0%, respectively (Horn and Taliaferro, 1974). Hart et al. (1965) concluded that more than 112 kg N/ha must be applied before the first cutting and that at least 112 kg N/ha are needed after each of the first two cuttings to maintain a 14% to 16% CP level in Coastal bermudagrass.

Forage Consumption

In the ruminant, rate of energy expenditure, environmental temperature, qualitative characteristics of the diet and physical effects of food in the gut are significant factors influencing both the level and the day-to-day changes in food consumption (Conrad, 1966). Dry matter intake increases with increasing concentrations of digestible nutrients up to approximately 66% dry matter digested. Conditions which limit forage intake above this digestibility are probably very similar to those limiting intake of mixed rations or all-concentrate rations (Conrad, 1966; Waldo, 1969). Forage consumption decreased rapidly as daytime temperatures approached 29°C (Carter et al., 1960).

At the same digestibility percentage, legumes usually are consumed in greater quantities than grasses. There is a greater change in intake per unit change in digestibility of grasses which contain more cell wall material than do legumes. However, a low correlation exists between rumen content of cell wall constituents and dry matter intake (Fontenot and Blaser, 1965). Davis et al. (1970) found dry matter intake of steers grazing fescue-lespedeza pastures to be higher than that of steers grazing orchardgrass-ladino clover pastures. However, the intake of digestible dry matter from orchardgrass-ladino was greater, as also was the average daily weight gain of the animals. Thus, digestible dry matter intake was a better index of animal weight gain than was dry matter intake alone.

Measuring Forage Consumption

The problem of measuring the amount of nutrients an animal obtains from pasture is a difficult one. Three indirect methods have been used successfully for obtaining forage samples representative of ingested material under pasture and range conditions. They are: (1) hand-plucking, (2) harvesting before-and-after grazing, and (3) the cage-and-strip method.

Hand-plucking method. Hand-plucking involves collecting material representative of the forage being consumed from each plant species. According to Cook (1964), the investigator observes the grazing animal and collects plants or portions of plants similar to those selected by the animal. The "selected" diet of the animal is compared to a random sample of the forage which represents available forage. The hand-plucking method may fail to give an accurate estimate of forage actually consumed by animals and, therefore, is subject to human bias (Harris et al., 1967).

Before-and-after method. A random set of strips is harvested before grazing and another set harvested after grazing. Differences in weight and chemical composition between the before and the after grazing samples are an estimate of the amount and chemical content of ingested material (Cook, 1964). This method assumes that forage consumption equals forage available before grazing minus residue or rejected forage after grazing (Carter et al., 1960; Cook and Harris, 1968). The before-and-after method tends to overestimate intake by 25% to 40% when compared to estimating intake by the chromic acid and chromogen indicator technique (Lofgreen et al., 1956; Peterson et al. 1956; Carter et al., 1960). This overestimation probably is due to the following reasons:

(1) Pre-grazing samples are obtained without essential loss of forage from leaf shatter or lodged stems.

(2) Post-grazing samples do not include the leaves that shattered during grazing.

(3) Stems that lodged during grazing may be clipped farther from the base than pre-grazed samples.

(4) Other errors may be attributed to fouling by droppings and to feed dropped from mouths of grazing animals.

Carter et al. (1960) gave the following prediction equation for correction of forage consumption from bromegrass pasture estimated by difference to what it would be if the indicator method were used:

$$y = 182 + .682x$$

where: x = grams of dry forage apparently consumed daily as estimated by the before-and-after method.

y = estimated forage consumption per day corrected to indicator-method estimate.

Alfalfa and sudangrass intakes estimated by before-and-after and indicator methods resulted in coefficients of correlation too low to calculate a regression equation.

Cage-and strip-method. A third method of measurement is to use protecting cages and to cut the protected areas at the end of each grazing period. The cages are placed at random within the pasture and are moved to new locations for each new period (Cook, 1964). The vegetation enclosed in the cage is considered to represent the before grazing samples even though harvest takes place at the end of a period. A comparable number and variety of uncaged strips are likewise harvested. The calculations for obtaining the chemical content of the ingested material are:

(1) Cage forage production minus strip forage production equals intake.

(2) Percentage composition of cage forage sample X cage forage production equals amount of nutrients from cage forage.

(3) Percentage composition of strip forage sample X strip forage production equals amount of nutrients from strip forage.

(4) Nutrients from cage forage minus nutrient from strip forage equals the amount of nutrient intake.

(5) Nutrient intake divided by DM consumption X 100 equals percentage of nutrient in ingested forage (Cook, 1964).

Linehan (1952) found that the simple difference between the amount of any nutrient present in cages at the end of grazing and that left uneaten in the strip at the end of grazing tended to give a high consumption value. When a grazing period was prolonged, the simple difference between the amount of nutrients present in vegetation at the beginning of grazing and that left uneaten at the end of grazing tended to give a low consumption value. For these reasons, Linehan proposed a system of interpolation to attempt to make allowance for differences in the growth of the cage forage which was permitted unrestricted development and the strip forage which was grazed and subjected to defoliation by the animals. Assuming that the rate of consumption of grass by livestock and the rate of forage growth at any time during the grazing period are each proportional to the quantity of grass remaining uneaten at that time,

$$\text{amount of any grass nutrient consumed} = \frac{(c-f)\ (\log d - \log f)}{(\log c - \log f)},$$

where

c = quantity of any grass nutrient present at the start of grazing (strip sample of period k-1 when k = present period).

d = quantity of any grass nutrient present in cages at the end of grazing.

f = quantity of any grass nutrient left uneaten in the strip at the end of grazing (strip samples of period k).

This procedure gave excellent agreement with animal weight gain measured over a four-year period. However, the percentage standard error attached to the consumption figure obtained from each sample observation was in the order of 50%.

Measuring the Protein Adequacy of Farm Animals by Blood Urea Nitrogen

Protein adequacy of the diet in meat animals is generally assessed using one or more production factors, such as average daily gain (ADG). However, when results from several experiments were reviewed (Nelson et al., 1954; Preston, 1966; Kay et al., 1968; Klosterman et al., 1968; Jordan and Hanke, 1970), these estimates were not precise. Therefore, criteria based on specific nitrogen components in the blood may be a more accurate measure of dietary protein adequacy.

There are several factors that influence nutritive value of a protein for the ruminant: digestibility, amino acid composition, solubility, degree of denaturation, particle size, previous diet of the animal, presence of other nitrogenous compounds and carbohydrate materials, as well as the level of protein in the diet. The effect of most of these factors is related to the degree of ammonia production in the rumen. Blood urea nitrogen (BUN) has been suggested to be a simple and realistic predictor of both nitrogen utilization and nitrogen intake. Blood urea levels of individual animals have been shown to be dependent upon the diet, but for any given diet are relatively constant and are not affected significantly by the age of the animal or the time of sampling (Lewis, 1957; Preston et al., 1965; Nolan et al., 1970; Carver and Pfander, 1974; Torell et al., 1974).

Lewis (1957) found that the BUN concentration was closely related to changes in rumen ammonia concentration without the marked diurnal variations found in rumen fluid ammonia. The major factor controlling the BUN level was ammonia formation in the rumen and not overall nitrogen intake. A value of 45 mg urea nitrogen per 100 ml of plasma was reported for Welsh Mountain ewes under normal grazing conditions. The quality of the pasture tended to be reflected in the mean BUN levels (Torell et al., 1974). Blood urea levels for animals consuming early, green annual pasture, partly green native pasture + dry subterranean clover and dry native pasture were 24.2, 18.8 and 13.7 mg/100 ml, respectively.

Increasing the protein concentration in the ration markedly increased BUN levels (Preston et al., 1965; Torell et al., 1974). Preston et al. (1965) stated that this blood constituent could be quantified with protein intake per unit weight$^{.75}$ ($W^{.75}_{kg}$) and gave the regression equation of:

$$y = 16.46 - 4.907X + .5032X^2 - .01126X^3$$

where

y = estimated BUN level.

X = crude protein intake, g per $W^{.75}_{kg}$.

A BUN level in excess of 10 mg/100 ml would indicate adequate protein intake with the type of ration used. Torell et al. (1974) reported simple coefficients of correlation of .99, .95 and .95 between supplemental N intake and BUN, between BUN and weight gain and between supplemental N intake and weight gain, respectively.

Amino Acid Composition of Forage

The amounts of the essential amino acids in the forage are important particularly when considering rations for nonruminant animals. The amounts of amino acids required by chickens and pigs for growth and production have been determined. However, relationships between the amounts of individual amino acids in forages and N metabolism of ruminants are not well defined. Information on the amounts of the various amino acids in the forage might help to ascertain the value of forage protein in ruminant rations.

Effect of Stage of Growth

Glutamic acid appeared to be the most abundant amino acid in grasses and both glutamic and aspartic acid increased in concentration as grass plants mature. Other amino acids, particularly lysine, arginine and leucine were shown to decrease with advancing maturity of grasses (Smith and Agiza, 1951; Reber and MacVicar, 1953). Similar changes in amino acid composition of alfalfa, as it matured, led Smith and Agiza (1951) to conclude that such changes may be partially responsible for the higher feed value of spring hay over autumn hay. However, results from studies with grasses and legumes by Tristam (1939) and by Waite et al. (1953) indicated that changes in amino acid concentration with maturation were insufficient to cause observed differences in nutritive value of forages.

Results from a study of alfalfa harvested at four successive stages of growth (Loper et al., 1963) generally showed that the concentrations of amino acids from high to low percentage of total forage dry matter were: aspartic acid, glutamic acid, leucine, valine, alanine, glycine, arginine, phenylalanine, lysine, serine, isoleucine, proline, threonine, tyrosine, histidine and methionine. In contrast, Smith and Agiza (1951) reported aspartic and glutamic acid to be lower in full-bloom alfalfa than in alfalfa at pre-bud stage. The two reports agree that the remaining 14 amino acids decreased with increase in plant maturity when expressed as a percentage of the forage dry matter.

Comparison of the amino acid composition of alfalfa, red clover, ladino clover and birdsfoot trefoil showed that amino acid concentrations fell into three distinct groups (high, medium and low) within each legume species (Loper _et al_., 1963). The amino acids present in highest amounts were aspartic acid, glutamic acid and leucine. The amino acids in low concentrations were tyrosine, histidine and methionine. Methionine was always present in the lowest amount. Ladino clover was markedly higher than the other legumes in its percentage content of amino acids.

The concentrations of all amino acids in ryegrass were highest before floral emergence and gradually decreased with advancing maturity. However, when expressed as a percentage of total protein nitrogen, all amino acids showed very little change in concentration with changes in stage of growth, even though the total protein contents varied considerably (Wilson and Tilley, 1965; Goswami and Willcox, 1969).

Effect of Nitrogen Fertilization

When nitrogen deficient plants were supplied with nitrogen fertilizer, the basic amino acid content increased (Smith and Agiza, 1951; Waite _et al_., 1953). MacGregor _et al_. (1961) reported a gradual decrease in lysine, methionine and tryptophan content of proteins when the protein content was increased by nitrogen fertilization. Keser (1955) reported a decrease in the concentrations of sulfur-containing amino acids under N deficient conditions. When the amino acid concentrations of ryegrass were expressed as a percentage of the forage dry matter, the lowest values were found in the forage not receiving N and a gradual increase was observed as the level of nitrogen application was increased. When expressed as a percentage of total protein, the amino acid composition of the protein fraction changed very little with increased levels of nitrogen application (Goswami and Willcox, 1969).

Lugg (1949), in his review of the literature on plant proteins, stated that the percentage of amino acids seemed to be remarkably constant except for the low percentages of sulfur-containing amino acids in legumes.

CHAPTER III

EXPERIMENTAL PROCEDURE

Experimental Pastures

Eight 1.2-hectare (ha) Midland bermudagrass pastures, two 1.2-ha common bermudagrass pastures and two 1.2-ha orchardgrass-ladino clover pastures were established in 1969 on Memphis silt loam soil at Ames Plantation, Grand Junction, Tennessee. The data reported here were collected during 1971, 1972 and 1973. The experimental design was a randomized complete block with two replications. The Midland forages either were not fertilized or they were fertilized with 112, 224 or 448 kg N/ha/year. Common bermudagrass was fertilized with 112 kg N/ha/year. The orchardgrass-ladino clover pastures were not fertilized with N. These treatments will be referred to as MID-1, MID-2, MID-3, MID-4, CB and OG, respectively.

Shortly before or at the time grazing started each year (March 15 to April 1), 112 kg/ha of P_2O_5 and 224 kg of K_2O were applied to MID-2, MID-3, MID-4 and CB together with the first N application. Phosphorus and K were applied to MID-1 and OG according to soil test. Nitrogen was applied as ammonium nitrate in three equal installments each year between (1) March 20 to April 1 (as soon as dormancy was visibly broken), (2) May 20 to June 1, and (3) July 1 to July 15.

Sample Collection

Forage growth and consumption were determined by the cage-and-strip method. Six random cage and six strip samples were harvested from each experimental pasture at approximately 14 day intervals. A rotary mower with collecting basket was used to harvest the samples at a stubble height of 4-5 cm (1.5-2.0 inches) above ground for the bermudagrass and at a stubble height of 7-8 cm (3 inches) in the orchardgrass-clover pastures. A 50 cm (20 inches) swath was cut all around the caged area, 25 cm (10 inches) outside and 25 cm inside the caged area. The remaining area, 71 cm (28 inches) X 71 cm, was harvested as the sample. The mower strips were 50 cm (20 inches) X 6.1 m (20 ft). Each sample was placed in a cotton bag, identified, oven dried at 65°C for 72 hours and weighed. After each sampling period, the cages and strips were assigned randomly to new locations using the fence posts as coordinates.

Grazing Management

The experimental (tester) animals were placed on the respective bermudagrass (both common and Midland) pastures when the grass started to break dormancy (about April 1). Extra steers (put-and-take animals) were added to the pastures when growth on an individual pasture reached an average height of 7 to 10 cm (3 to 4 inches). These extra steers were removed when the individual pastures had been grazed to a minimum average height of 4 cm (1.5 inches). The tester animals remained on their respective pastures throughout the grazing season. However, if after August 1 bermudagrass pastures were grazed lower than 1.2 cm (.5 inches), grazing of this particular pasture was terminated for the year.

The tester animals were placed on the orchardgrass-ladino clover pastures approximately April 1 when the spring growth reached 7 to 10 cm (3 to 4 inches). The extra animals were added when the individual pasture growth averaged 13 to 15 cm (5 to 6 inches) and removed when the growth had been grazed to an average height of 8 cm (3 inches). The tester animals were removed approximately September 15 or when the pastures were grazed to an average height of 5 cm (2 inches).

Experimental Animals

The animals used in this investigation were yearling beef steers weighing 205-225 kg and grading Medium or Good. The grazing method used was a modified put-and-take system. The number of tester animals for each treatment is listed in table 1. In addition, 72 put-and-take animals were kept on a holding pasture of the same species as that on which they would be used as "putters."

Generally, an average of body weights taken on two consecutive days was used as initial and final weights for the grazing period. Individual weights of the tester animals were taken at 14-day intervals when possible.

At no time did the animals receive supplemental feed while on pasture. The animals had access to salt, minerals, water and artificial shade at all times. Shades were increased in size to accommodate the number of animals in each pasture, and the area under the shade was filled with sand or soil to prevent accumulation of water under the shades. Animals were wormed with phenolthiazine at the time of purchase and again two weeks prior to the start of grazing.

TABLE 1. EXPERIMENTAL SETUP

Treatment	Nitrogen Applied (kg/ha)	Number of tester animals in each replication
1. Midland bermudagrass	0	3
2. Midland bermudagrass	112	3
3. Midland bermudagrass	224	5
4. Midland bermudagrass	448	8
5. Common bermudagrass	112	3
6. Orchardgrass-ladino clover	0	3

Digestibility and Chemical Analyses

After air equilibration, the cage-and-strip samples were ground in a Wiley mill to pass a 20-mesh screen and stored in glass jars for subsequent chemical analysis and _in vitro_ digestibility determinations.

In Vitro Digestibility of Forage

Feeding of a grass-legume hay to the rumen fistulated steer was begun two weeks prior to collecting the first rumen liquor and the steer was maintained on this hay throughout the digestibility studies. When the steer was not being used for digestibility determinations, he was maintained on a bermudagrass and orchardgrass-ladino clover pasture.

In vitro dry matter digestibility (IVDDM) was determined using the artificial rumen technique of Tilley and Terry (1963). A series of three separate analyses were made using rumen fluid obtained on different days. All forage samples (not replicated) were included in each of the three analyses.

Nitrogen Content of Forage

The samples were analyzed for total N by personnel of the University of Tennessee Department of Plant and Soil Science, using an Autoanalyzer with a modification of the procedure of Thomas _et al_. (1967). Percent nitrogen was converted to crude protein (CP) by multiplying by 6.25.

Amino Acid Composition of Forage

Forage samples, collected in 1973, from unfertilized Midland, Midland fertilized with 448 kg N/ha and orchardgrass-clover pastures were analyzed for amino acid content. A .1 to .2 g sample was hydrolyzed with 10 ml of 6N HCl for 24 hours at 110 C in a sealed pyrex tube. The HCl was evaporated and the sample diluted with 10 ml of hydrolysate buffer (Perkin-Elmer, 1971). This diluted sample was applied to the column of the Perkin-Elmer Model KL-3B amino acid analyzer. The amino acid concentration was determined by comparing the area under the curve, obtained by integration, with that obtained from a standard of known concentration.

Urea Nitrogen Content of Plasma

In 1973, blood samples were obtained approximately every 28 days from all tester animals by jugular puncture with a needle and syringe. The samples were heparinized, centrifuged and the plasma frozen until analyzed. Plasma urea nitrogen was determined on all plasma samples by a modification of the procedure described by Fawcett and Scott (1960) and Chancey (1961). This procedure was based on the hydrolysis of urea by urease and the reaction of ammonia with sodium phenate and hypochlorite which results in a blue color. Optical densities were determined and compared to the optical densities of standards of known urea nitrogen concentrations.

Forage Consumption and Composition of Consumed Forage

A 1 to 2-g aliquot of each air-equilibrated (moisture content in balance with air) cage-and-strip cut was dried at 100 C for seven hours to remove the residual moisture and the total dry matter (%DM) content was calculated. Total dry matter consumption was determined by the following equation:

Total DM consumption (I, J, K) = (yield from cage [I, J, K] X %DM) - (yield from strip [I, J, K] X %DM).

where

I = treatment

J = replication

K = period

The intake per animal of IVDDM, TDN and CP was calculated by the following steps:

(1) IVDDM consumed per period, kg = (DM yield from cage, kg X %IVDDM) - (DM yield from strip, kg X %IVDDM)

(2) $\%\text{IVDDM in consumed forage} = \frac{\text{value from step 1}}{\text{total DM consumed per period, kg}} \times 100.$

(3) $\text{IVDDM consumed per animal per day, kg} = \frac{\text{value from step 1}}{\text{animal days}}.$

(a) animal days = number of elapsed days per period X number of animals grazing during the period.

(b) number of animals = tester animals + put-and-take animals.

(4) $\text{IVDDM consumed per unit of metabolic weight, g per day} = \frac{\text{value from step 3}}{\text{metabolic weight, } W^{.75}_{kg}}.$

(5) IVDDM percentage of each cage and strip cut was converted to TDN percentage by the equation: TDN, % = 5.81 + .869 (IVDDM, %) (Heaney and Pigden, 1963).

(6) Steps 1 through 4 were repeated to calculate TDN consumption and composition of consumed forage. In addition, TDN intake above maintenance was determined by the following calculation:

TDN intake above maintenance, kg/day = TDN intake per animal per day, kg - maintenance requirement/day, kg

$\text{TDN maintenance requirement, kg/day} = \frac{.036\ W^{.75}_{lb.}}{2.205}$ (Garrett *et al.*, 1959).

(7) Steps 1 through 4 were repeated to calculate CP consumption and composition of consumed forage. In addition, CP intake above maintenance was determined by the following equation:

CP intake above maintenance = (CP intake per animal per day, kg) - (maintenance requirement per day, kg).

$$\text{maintenance requirement, kg/day} = \frac{5.86\ W_{kg}^{.75}}{1000} \quad \text{(Preston, 1966).}$$

Statistical Analysis

In analyzing forage production, consumption, chemical composition and digestibility data collected during the period of more than one year, a number of factors prevented combining of raw data: (1) rainfall, (2) temperature, (3) severity of winter, (4) start of growth in the spring, (5) cessation of growth in the summer and/or fall, and (6) time intervals between sample harvests within and among years.

Non-linear regression models of weight on age have been used to predict the weight of animals at any age (Brody, 1945; Brown _et al._, 1972). It was decided to use this technique to describe the changes in IVDDM and CP content and consumption due to elapsed days of grazing and level of N fertilization. Such a model simplifies the management of data and provides the user an opportunity to predict the digestibility and CP content and consumption of forage at any time during the grazing season. Fifty-two observations were used originally in fitting each treatment curve. After the development of the regression equations, only four values (constant, b_1, b_2 and b_3) were obtained with only a small loss of information.

Forage Composition and Consumption

Data collected from individual pastures during each year were reduced to polynomials describing the effect of elapsed time (D) within the grazing season (D_1 = April 12) on IVDDM and CP content and TDN and CP intake. The IVDDM content and TDN intake were best described by a second degree polynomial and CP content and intake were best described by a third degree polynomial. In preliminary analysis, a stepwise procedure was used to add D, D^2 and D^3 to the various models. In the final analysis, only those elements which explained a significant amount of variation in the respective dependent variables were used to construct response curves.

Analysis of variance of the regression (b) values was performed using the following model:

$$y_{ijk} = u + y_1 + t_j + b_k + (y \times t)_{ik} + (t \times b)_{jk} + e_{ijk}$$

where

u = theoretical population mean.

y_{ijk} = IVDDM, TDN or CP content, TDN or CP intake.

y_i = year, i = 1971, 1972 or 1973.

t_j = treatment, j = 1, . . . 6.

b_k = replication, k = 1, 2.

e_{ijk} = random error.

Predicted Composition and Intake of DDM, TDN and CP

Prediction equations derived from data for each replication were used to generate estimated IVDDM, TDN and CP content of forage in each pasture on the 20, 40, 60, 80, 100, 120, 140 and 160 elapsed day of the grazing season and TDN and CP intake on the 20, 40, 60, 80, 100, 120 and 140 elapsed day. Analysis of variance of the estimated values was performed according to the procedure described for the b values. The significance level used throughout the results and discussion was P<.05.

/Orthogonal contrasts were used for mean separation when significant (P<.05) F ratios were observed (table 2). Contrast 1 allowed a comparison of orchardgrass-ladino clover (OG) pastures with mean data from all bermudagrass pastures (BER). Contrast 2 tested the difference between common bermudagrass (CB) and the mean of the Midland bermudagrass treatments (MID). Contrast 3 compared the difference between Midland bermudagrass not fertilized with N (MID-1) and Midland fertilized with N (MID-N). Contrast 4 tested the difference between a low level of N fertilization (MID-2) on Midland and the mean of two higher levels of N fertilization (MID-HN). Contrast 5 tested the difference between Midland fertilized with 224 kg N/ha (MID-3) and Midland fertilized with 448 kg N/ha (MID-4). The level of significance throughout the results and discussion was P<.05.

Relation of Average Daily Weight Gain to Forage Composition and Consumption

Coefficients of simple correlation of ADG with TDN and with CP were determined on the basis of: (1) percentage composition of ingested forage, (2) intake, kg/day, (3) intake above maintenance, kg/day, (4) intake, kg/day/100 kg body weight, (5) intake, g/day/unit of metabolic weight, and (6) percent compositon of strip forage (available forage) samples. The level of significance used was P<.05.

Coefficients of simple correlation of ADG with DM and with IVDDM were determined on the basis of: (1) percentage composition of ingested forage, (2) intake, kg/day, (3) intake, g/day/unit of metabolic weight, and (4) percent composition of strip forage sample.

TABLE 2. ORTHOGONAL CONTRAST[a]

	Orchardgr-ladino clover	Common bermuda 112 kg N/ha	Midland bermudagrass, kg N per ha			
			0	112	224	448
Comparison 1	5	-1	-1	-1	-1	-1
Comparison 2	0	4	-1	-1	-1	-1
Comparison 3	0	0	3	-1	-1	-1
Comparison 4	0	0	0	2	-1	-1
Comparison 5	0	0	0	0	1	-1

[a]Comparisons: (1) orchardgrass-clover (OG) compared to the mean of all bermudagrasses (BER); (2) common bermudagrass (CB) compared to the mean of all Midland bermudagrass (MID) pastures; (3) unfertilized Midland (MID-1) compared to fertilized Midland (MID-N); (4) Midland fertilized with 112 kg N/ha (MID-2) compared to the mean of Midland fertilized with 224 and 448 kg N/ha (MID-HN); and (5) Midland fertilized with 224 kg N/ha (MID-3) compared to Midland fertilized with 448 kg N/ha (MID-4).

Using as independent variables combinations of measures of nutrient composition and consumption, a stepwise regression analysis was employed to develop a series of multiple regression equations for the prediction of ADG of steers grazing pastures of Midland bermudagrass at various levels of N fertilization, common bermudagrass and orchardgrass-ladino clover. The level of significance used was $P<.05$.

Amino Acid Composition of Forage and Urea Nitrogen Content of Blood Plasma

A least-squares regression procedure was used to evaluate differences between treatments and days within grazing season. Orthogonal contrasts were used for mean separation when significant F ratios were obtained. The level of significance used was $P<.05$.

CHAPTER IV

RESULTS AND DISCUSSION

Composition of Available Forage

In Vitro Digestible Dry Matter

The data from each pasture were reduced to equations describing the regression of percent *in vitro* digestible dry matter (IVDDM) in available forage on elapsed days of grazing (D). The fit of the original data to the regression line for IVDDM of unfertilized Midland bermudagrass (MID-1) is shown in figure 1. In April, IVDDM was greater than 50% but, by September, it had decreased to less than 40%. The digestibility of Midland bermudagrass fertilized with 448 kg N/ha (MID-4) compared to that of orchardgrass-ladino clover (OG) is shown in figure 2. Although N was added to the Midland pastures three times a year, the forage decreased in digestibility from the beginning to the end of the grazing season. Thus, by the end of the season, the digestibility of MID-4 was less than that of MID-1 (33.0% compared to 38.0%, respectively). Webster *et al*. (1965) and McCroskey (1972) also found that IVDDM of Midland bermudagrass was highest in the spring and declined throughout the remainder of the year. The digestibility of OG was greater than that of Midland throughout the season and the decrease in IVDDM during the season was less than the decrease observed in Midland forage.

The effect of level of N fertilization on IVDDM of Midland bermudagrass forage is presented in figure 3. Initially, MID-1 was significantly less digestible than Midland fertilized with 224 (MID-3)

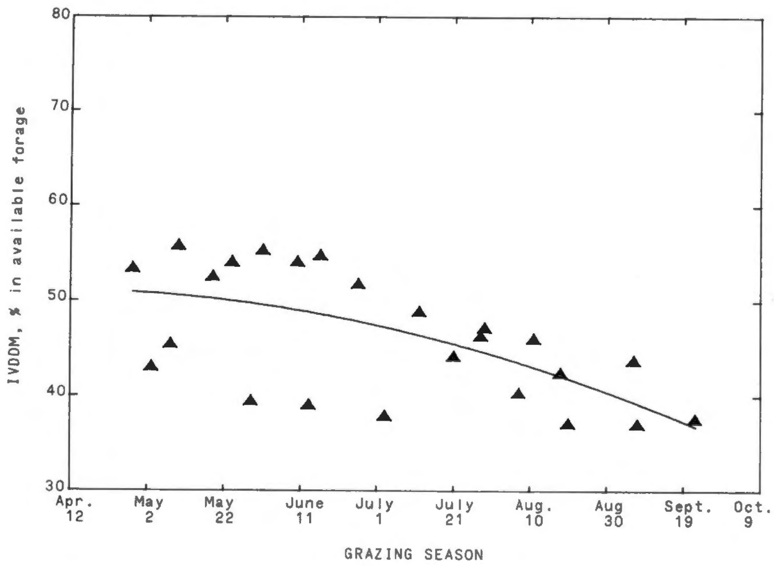

Figure 1. Change during the grazing season in IVDDM content of available forage from unfertilized Midland bermudagrass pastures.

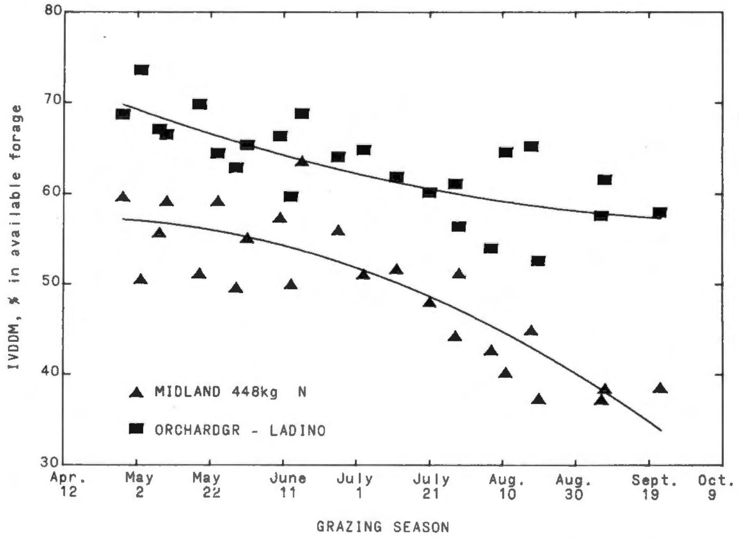

Figure 2. Change during the grazing season in IVDDM content of available forage from Midland bermudagrass fertilized with 448 kg N/ha and orchardgrass-ladino clover pastures.

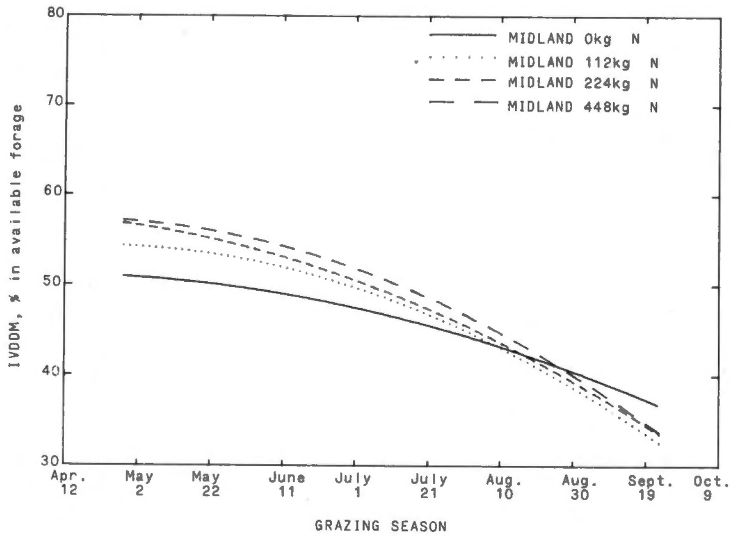

Figure 3. Change during the grazing season in IVDDM content of available forage from Midland bermudagrass pastures fertilized with four rates of nitrogen.

and 448 kg N/ha (MID-4) but did not differ significantly from forage of the 112 kg N/ha (MID-2) fertilization level. As the season progressed, however, digestibilities became more similar and the differences were not significant. Meredith (1963) concluded that less than a 1% increase in digestibility was due to higher N rates, and Webster et al. (1965) found no increase in IVDDM with fertilization up to 1568 kg N/ha. However, Fribourg et al. (1971) found that digestibility of unfertilized Midland was between 35% and 43%, and that digestibility increased to a high of 51% after the application of 800 kg N/ha. Initially, IVDDM of MID-2 was 5% higher than that of common bermudagrass (CB) fertilized with 112 kg N/ha (figure 4) but decreased continuously during the growing season. By early July, the IVDDM of MID-2 became less digestible than CB. IVDDM of CB remained essentially constant (50%) until the end of July, decreasing thereafter to about 40%. Common bermudagrass is later maturing than Midland and thus would tend to be less digestible on a given date in the early spring than would Midland (Fribourg, 1963).

The coefficients of the equations just described are contained in table 3. An analysis of the coefficients of regression (b values) showed no significant year effect but a significant year*treatment interaction existed in the b_1 and b_2 mean squares. Since the b_o (constant) was not significantly affected by year or year*treatment interaction and because single-year pasture observations are less meaningful, the data for the three years were combined. The combined data gave a significant difference in the constant, b_1 and b_2 due to treatment differences but were not significantly affected by replication.

The small positive b_1 for MID-2 indicates that digestibility

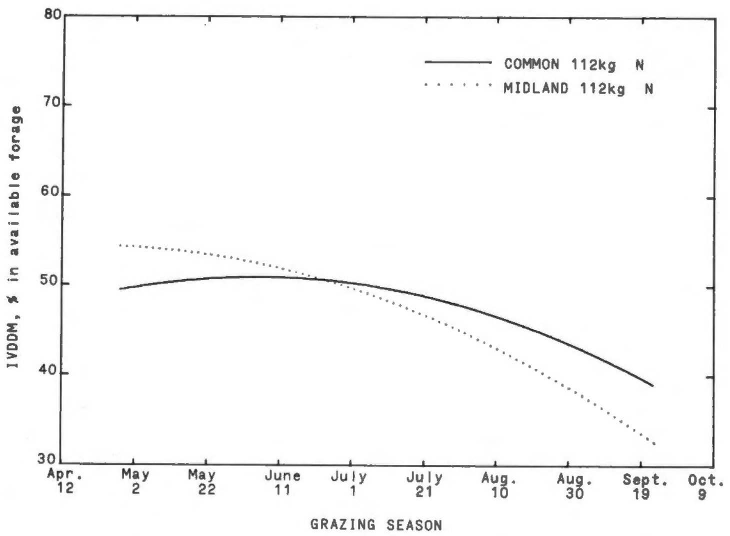

Figure 4. Change during the grazing season in IVDDM content of available forage from common and Midland bermudagrass pastures fertilized with 112 kg N/ha.

TABLE 3. EQUATIONS DESCRIBING REGRESSION OF PERCENTAGE OF IN VITRO DIGESTIBLE DRY MATTER OF AVAILABLE FORAGE ON ELAPSED DAYS OF GRAZING (D)[a]

Treatment	Constant	Coefficients of: D	Coefficients of: D^2	R^2
Midland, No N	51.157[bc]	-.0064	-.0005[f]	.331[g]
Midland, 112 kg N/ha	54.325[cd]	+.0140	-.0009[e]	.637[g]
Midland, 224 kg N/ha	57.503[d]	-.0315	-.0007[ef]	.675[g]
Midland, 448 kg N/ha	57.360[d]	-.0028	-.0009[e]	.674[g]
Common, 112 kg N/ha	48.028[b]	+.1081	-.0010[e]	.313[g]
Orchardgr-clover	72.202	-.1564	+.0004	.488[g]

[a]%IVDDM = constant + b_1D_i + $b_2D_i^2$, where D_i = ith elapsed day of the grazing season and D_1 = April 12.

[b-f]Values with the same superscript are not significantly different (P<.05).

[g]Coefficients of regression are significantly different (P<.05) from zero.

increased over a period of approximately the first 15 days and then decreased throughout the rest of the season. In contrast, the large positive b_1 for CB indicates that the digestibility increased over a period of approximately 100 days before starting to decrease. The positive b_2 of OG indicates that the decrease in digestibility leveled off as the days became shorter, whereas the digestibility of bermudagrass continued to decrease. Utley et al. (1974) showed Coastal bermudagrass to decrease in digestibility from 65% to 39% from May through September.

The R^2 values (table 3) indicate that more of the decrease in IVDDM of N-fertilized Midland forage was attributable to elapsed days of grazing than was attributable to this effect on the other treatments. This difference probably was due to the increased growth resulting from N fertilization (Doss et al., 1966; Fribourg et al., 1971) and the inability to maintain a stocking rate high enough to keep the forage grazed as closely as that of MID-2 or CB. In Tennessee, the latter forage is known to give less growth response to N fertilization than does Midland (Fribourg, 1963).

Predicted forage digestibilities within each treatment were calculated for 20, 40, 60, 80, 100, 120, 140 and 160 elapsed days of grazing (table 4). The mean overall digestibilities for the season--45.6^{b}, 46.5^{bc}, 47.4^{bc}, 48.5^{c}, 47.6^{bc} and 62.6^{d}% for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively--show that N fertilization increased the dry matter digestibility of Midland bermudagrass. Only MID-4 was significantly greater in digestibility than MID-1; however, the increase was small and probably would not be physiologically important to the

TABLE 4. PREDICTED IN VITRO DIGESTIBLE DRY MATTER CONTENT OF AVAILABLE PASTURE FORAGE[a]

Date	Elapsed days of grazing	Midland bermudagrass, kg N/ha				Common bermuda 112 kg N/ha	Orchardgr-ladino clover
		0	112	224	448		
		Percent					
May 2	20	50.8^{b}	54.3^{b}	56.6^{c}	57.1^{c}	49.8^{b}	69.2^{d}
May 22	40	50.1^{b}	53.5^{b}	55.1^{b}	56.0^{b}	50.8^{b}	66.6^{c}
June 11	60	49.0^{b}	52.0^{b}	53.1^{b}	54.3^{b}	50.9^{b}	64.4^{c}
July 1	80	47.6^{b}	49.8^{b}	50.4^{b}	51.9^{b}	50.3^{b}	62.5^{c}
July 21	100	45.7^{b}	46.8^{b}	47.2^{b}	48.7^{b}	48.9^{b}	60.9^{c}
August 10	120	43.4^{b}	43.2^{b}	43.5^{b}	44.9^{b}	46.7^{b}	59.7^{c}
August 30	140	40.8^{b}	38.8^{b}	39.2^{b}	40.3^{b}	43.6^{b}	58.8^{c}
September 19	160	37.7^{bc}	33.7^{b}	34.2^{b}	34.9^{b}	40.2^{c}	58.3^{d}
Overall Mean		45.6^{b}	46.5^{bc}	47.4^{bc}	48.5^{c}	47.6^{bc}	62.6^{d}

[a] %IVDDM = Constant + b_1Di + b_2Di^2 where Di = ith elapsed day in the grazing season and D_1 = April 12.

[b-d] Values of the same date with the same superscript are not significantly different ($P>.05$).

animal. A significant decrease in digestibility was reflected in all treatments from April to September. The greatest decrease was in the treatments of MID-3 and MID-4. The estimated IVDDM of Midland bermudagrass observed throughout the season was greater than that reported by Fribourg <u>et al</u>. (1971) but less than that observed by McCroskey (1972). One explanation for the absence of a greater effect of N fertilization on IVDDM of Midland bermudagrass forage may be due to the increased growth and CP content which is accompanied by a decrease in soluble carbohydrate content (Blaser, 1964).

The estimated IVDDM values were converted to estimated total digestible nutrients (ETDN) using the Heaney and Pigden (1963) equation: %ETDN = 5.81 + .869 (%IVDDM). The results indicated that treatment and seasonal trends were similar to those for IVDDM (table 5). The TDN requirement of a 300-kg steer fed to gain at least .5 kg/day is 57% of the ration (NRC, 1970). Strip samples taken from Midland and common bermudagrass contained less than the required TDN throughout the season, while OG was adequate in TDN throughout the grazing season.

Crude Protein Content

The data were reduced to regression equations of percent CP in available forage on elapsed days of grazing. The regression line for MID-4 and the plot of the individual data is depicted in figure 5. The decrease in CP was very rapid at the beginning of the grazing season but decreased to a lower rate after about 60 days. The regression line and observed data points for the OG forage is presented in figure 6. In contrast to the other treatments, the CP content of this forage

TABLE 5. ESTIMATED TOTAL DIGESTIBLE NUTRIENT CONTENT OF AVAILABLE PASTURE FORAGE[a]

Date	Elapsed days of grazing	Midland bermudagrass, kg N/ha				Common bermuda 112 kg N/ha	Orchardgr-ladino clover
		0	112	224	448		
		Percent					
May 2	20	50.0^{b}	53.0^{bc}	55.0^{c}	55.4^{c}	49.1^{b}	66.0^{d}
May 22	40	49.4^{b}	52.3^{b}	53.7^{b}	54.5^{b}	49.9^{b}	63.7^{c}
June 11	60	48.4^{b}	51.0^{b}	51.9^{b}	53.0^{b}	50.1^{b}	61.8^{c}
July 1	80	47.1^{b}	49.0^{b}	49.6^{b}	50.9^{b}	49.5^{b}	60.1^{c}
July 21	100	45.5^{b}	46.5^{b}	46.9^{b}	48.2^{b}	48.3^{b}	58.7^{c}
August 10	120	43.5^{b}	43.3^{b}	43.6^{b}	44.8^{b}	46.4^{b}	57.7^{c}
August 30	140	41.2^{b}	39.5^{b}	39.8^{b}	40.8^{b}	43.7^{b}	56.9^{c}
September 19	160	38.6^{bc}	35.1^{b}	35.5^{b}	36.1^{b}	40.7^{c}	56.5^{d}
Overall Mean		45.2^{b}	46.2^{bc}	47.0^{bc}	48.0^{c}	47.2^{bc}	60.2^{d}

[a]%ETDN = Constant + b_1Di + b_2Di^2, where Di = ith elapsed day in the grazing season and D_1 = April 12.

[b-d]Values of the same date with the same superscript are not significantly different (P>.05).

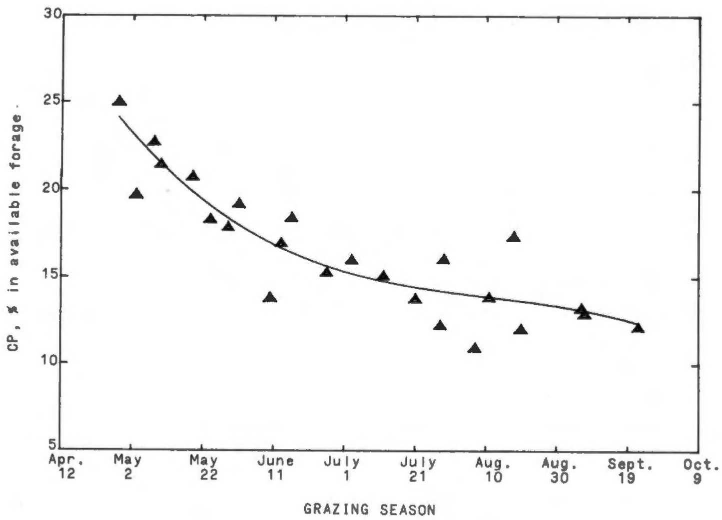

Figure 5. Change during the grazing season in CP content of available forage from Midland bermudagrass pastures fertilized with 448 kg N/ha.

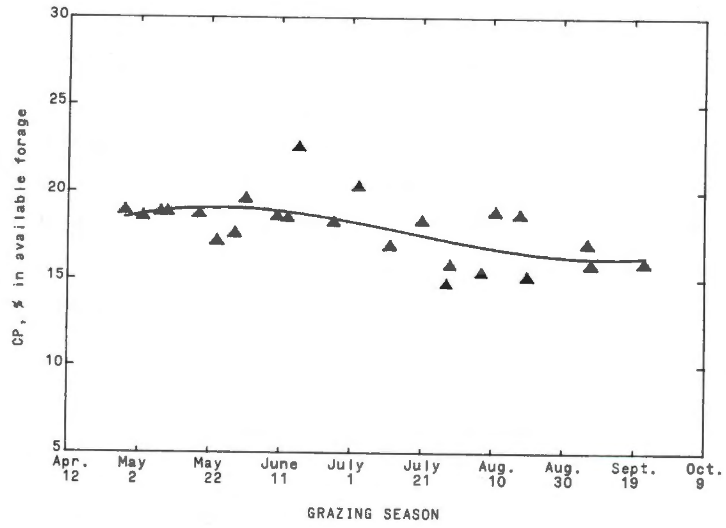

Figure 6. Change during the grazing season in CP content of available forage from orchardgrass-ladino clover pastures.

increased during the first 50 days and then started to decrease. Even then, the decrease was only slight compared to that in bermudagrass. Davis (1969) and Barth et al. (1972) also found that %CP of orchardgrass increased during the first part of the season.

Nitrogen fertilization resulted in an increase in CP content of Midland bermudagrass forage throughout the grazing season (figure 7). This agrees with the observations of Horn and Taliaferro (1974). Mathias et al. (1973) found that the CP content of Midland forage increased with increasing levels of N fertilization and that the differences among rates of N fertilization were greater in the second harvest following application than in the first. The changes in CP content in Midland and common bermudagrasses fertilized with 112 kg N/ha were essentially the same (figure 8).

The coefficients of the equations describing the regression of CP content of available forage on elapsed days of grazing are shown in table 6. There was a significant year effect on the constants and b_1's. All b values showed a significant year*treatment interaction effect. The three years of data were combined because the CP content of forage in an individual year is of little value in trying to predict the CP content of forage in a different grazing season. This criterion led to the theory that the combined data would be more valuable in making a prediction than would any single year. When the data were combined, the constant, b_1 and b_2 mean squares for treatment effects were significant.

The results of the combined data indicate that the b_1's for all bermudagrass forages were negative, whereas b_1 was positive for OG.

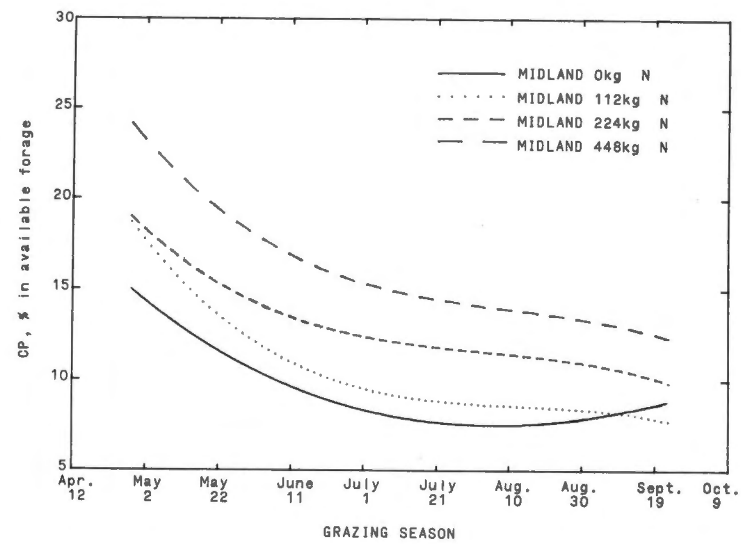

Figure 7. Change during the grazing season in CP content of available forage from Midland bermudagrass pastures fertilized with four rates of nitrogen.

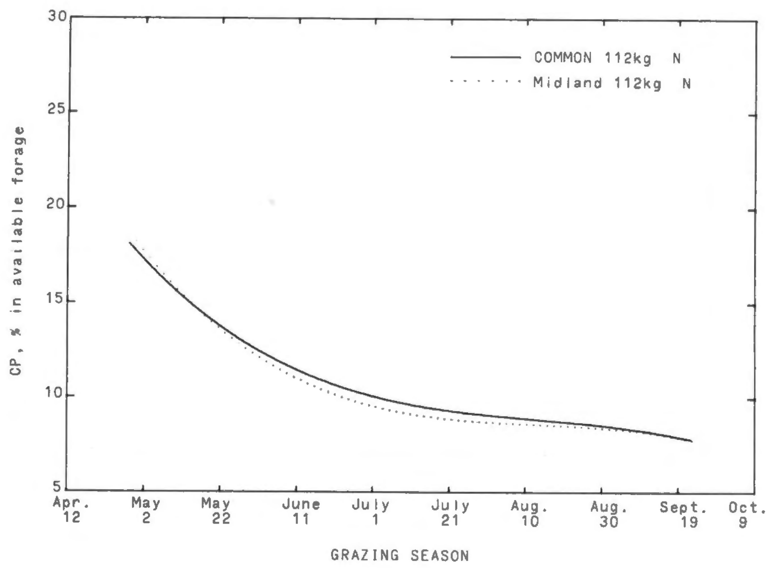

Figure 8. Change during the grazing season in CP content of available forage from common and Midland bermudagrass pastures fertilized with 112 kg N/ha.

TABLE 6. EQUATIONS DESCRIBING REGRESSION OF CRUDE PROTEIN CONTENT OF AVAILABLE FORAGE ON ELAPSED DAYS OF GRAZING (D)[a]

Treatment	Constant	Coefficients of: D	D^2	D^3 (X 10^{-5})	R^2
Midland, No N	17.909[b]	-.200227[e]	+.001123[f]	-.145[i]	.640[j]
Midland, 112 kg N/ha	23.581[c]	-.348387[d]	+.002756[g]	-.744[h]	.756[j]
Midland, 224 kg N/ha	22.524[c]	-.253474[de]	+.002074[fg]	-.609[hi]	.566[j]
Midland, 448 kg N/ha	28.619	-.316772[de]	+.002415[fg]	-.644[hi]	.764[j]
Common, 112 kg N/ha	22.232[c]	-.293092[de]	+.002242[fg]	-.606[hi]	.744[j]
Orchardgr-clover	17.486[b]	+.084660	-.001286	+.433	.236

[a]%CP = constant + $b_1D_i + b_2D_i^2 + b_3D_i^3$, where D_i = ith elapsed day of the grazing season and D_1 = April 12.

[b-i]Values with the same superscript are not significantly different (P>.05).

This suggests that an increase in CP content of OG occurred during the first part of the season, followed by a decrease during the latter part. The positive b_2 for all bermudagrasses indicated a reduction in the rate of decrease in CP content of available forage. Later in the season the more rapid decrease of CP content of all bermudagrass treatments is indicated by the negative b_3, whereas the b_3 of OG was positive.

The small R^2 (table 6) for the OG (.236) indicated that the time during the grazing season had little effect on the CP content of this forage. However, the number of days after growth started in the spring greatly affected the CP of all bermudagrasses even though N fertilization was applied three times a year.

The regression equations described above were used to calculate predicted CP values for 20, 40, 60, 80, 100, 120, 140 and 160 elapsed days of grazing (table 7). The overall means--9.5, 10.7^b, 13.0, 16.1, 10.9^b and 17.7% for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively (values with the same superscript are not significantly different)--showed that increasing levels of N fertilization significantly increased the CP content of Midland bermudagrass forage. However, over the entire grazing season, OG pastures had a significantly higher %CP than all bermudagrass treatments. A significant decrease was found in CP content in all treatments from April to September. These results with Midland agree with those of Hart _et al_. (1965) who stated that more than 112 kg N/ha must be applied before the first cutting and that at least 112 kg N/ha were needed after each of the first two cuttings to maintain a 14% to 16% CP level in Coastal bermudagrass.

The CP requirement of a 300-kg steer, fed to gain at least

TABLE 7. PREDICTED CRUDE PROTEIN CONTENT OF AVAILABLE PASTURE FORAGE

Date	Elapsed days of grazing	Midland bermudagrass, kg N/ha				Common bermuda 112 kg N/ha	Orchardgr-ladino clover
		0	112	224	448		
		- - - - - - - -	- - - - - - - -	- - - - - - - -	Percent	- - - - - - - -	- - - - - - - -
May 2	20	14.34^{c}	17.65^{b}	18.24^{b}	23.20^{b}	17.22^{b}	18.70^{b}
May 22	40	11.60^{b}	13.58^{bc}	15.32^{c}	19.38^{d}	13.70^{bc}	19.10^{d}
June 11	60	9.62^{b}	10.98^{bc}	13.46^{c}	16.88^{d}	11.40^{bc}	18.89^{d}
July 1	80	8.34^{b}	9.52^{b}	12.40^{c}	15.34^{d}	10.03^{b}	18.30^{e}
July 21	100	7.66^{b}	8.84^{b}	11.82^{c}	14.45^{d}	9.28^{b}	17.52^{e}
August 10	120	7.54^{b}	8.58^{b}	11.44^{c}	13.90^{d}	8.87^{b}	16.78^{e}
August 30	140	7.90^{b}	8.38^{bc}	10.97^{c}	13.38^{d}	8.51^{bc}	16.29^{e}
September 19	160	8.66^{b}	7.78^{b}	10.11^{b}	12.55^{c}	7.90^{b}	16.25^{d}
Overall Mean		9.46^{c}	10.66^{b}	12.97^{d}	16.14^{e}	10.86^{b}	17.73^{f}

[a] $\%CP = \text{Constant} + b_1Di + b_2Di^2 + b_3Di^3$, where Di = ith elapsed day of the grazing season and D_1 = April 12.

[b-f] Values of the same date with the same superscript are not significantly different ($P>.05$).

.5 kg/day, is 10% of the ration (NRC, 1970). Thus, although N fertilization of bermudagrass increased the CP content of strip samples (which agrees with Decker, 1965; Hart et al., 1965; Mathias et al., 1973), when the N fertilization level of 112 kg N/ha was reached, the forage was deficient in CP during the last 80 days of the season. The fact that the overall mean was greater than the 10% required was due to a high protein content in the early part of the season. MID-1 was adequate in CP for only the first 50 days of the grazing season.

From the standpoint of CP content of bermudagrass forage, it appears that N fertilization was not required in the early spring and, possibly, that it would be better to make three applications of approximately 56 kg N/ha (over a span of time running from about May 1 through the middle of July) to maintain a more nearly constant and desirable protein level. Hart et al. (1965) recommended three applications of 112 kg N/ha per year to Coastal bermudagrass to maintain a CP content of 14% to 16%. Such a CP level would be in excess of a steer's requirement and thus would not be of any benefit to the animal.

Composition of Consumed Forage

Total Digestible Nutrient Content

The IVDDM values were converted to ETDN values using the Heaney and Pigden (1963) equation: %ETDN = 5.81 + .869 (%IVDDM). The data then were reduced to equations describing the regression of ETDN percentage in consumed forage on elapsed days of grazing.

Consumed OG and MID-4 forage contained the same amount of ETDN (68%) at the start of the season (figure 9). However, MID-4 decreased

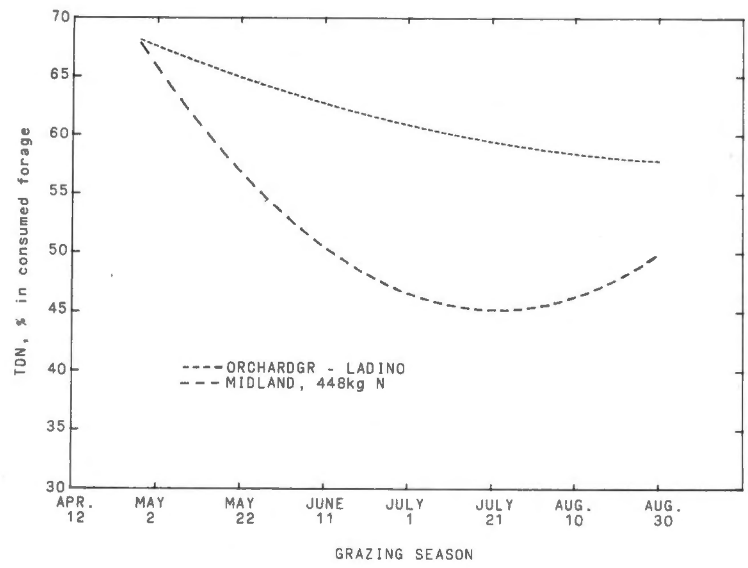

Figure 9. Change during the grazing season in ETDN content of consumed forage from Midland bermudagrass fertilized with 448 kg N/ha and orchardgrass-ladino clover pastures.

rapidly to approximately 45% around the first part of July. These results agree with those of McCroskey (1972) who found that the digestibility of Midland bermudagrass was over 75% in April, fell to 60% in June and declined throughout the remainder of the year to a low of 34%. While the ETDN content of OG decreased, the rate of decrease was much slower and the ETDN content still was above 60% on August 30. The higher digestibility of OG probably was a result of its higher soluble carbohydrate content (Davis, 1969). The ETDN contents of consumed CB and MID-2 forages were similar throughout the season (figure 10), with MID-2 being slightly higher in TDN during the first part of the season and CB higher in TDN after July 1. Common bermudagrass starts to grow later in the spring, thus would have a lower level of ETDN in the early spring and, from the present results, appears not to accumulate as much structural carbohydrate material as does Midland bermudagrass. The effect of N fertilization of Midland bermudagrass pastures on the ETDN content of consumed forage is shown in figure 11. As was shown previously with the TDN content of available forage, N fertilization had little if any beneficial effect on the TDN content of consumed forage.

The coefficients of the equations just described are listed in table 8. When the data were combined across years, no significant differences were apparent among treatments or replications and the treatment*replication interaction was not significant in the regression sources (constant, b_1 and b_2). Elapsed days of grazing accounted for approximately 50% of the variation in ETDN content of consumed forage in in MID-3 and OG; for approximately 40% in MID-1 and MID-2; but for less than 30% for MID-4 and CB.

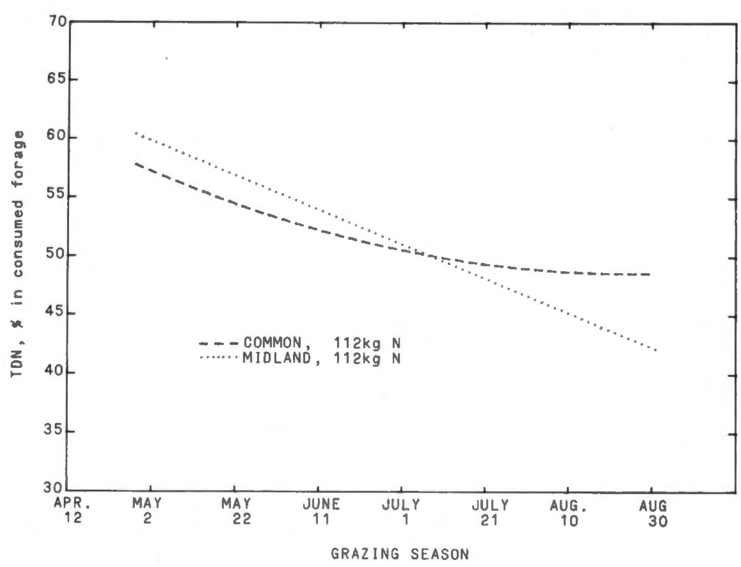

Figure 10. Change during the grazing season in ETDN content of consumed forage from common and Midland bermudagrass pastures fertilized with 112 kg N/ha.

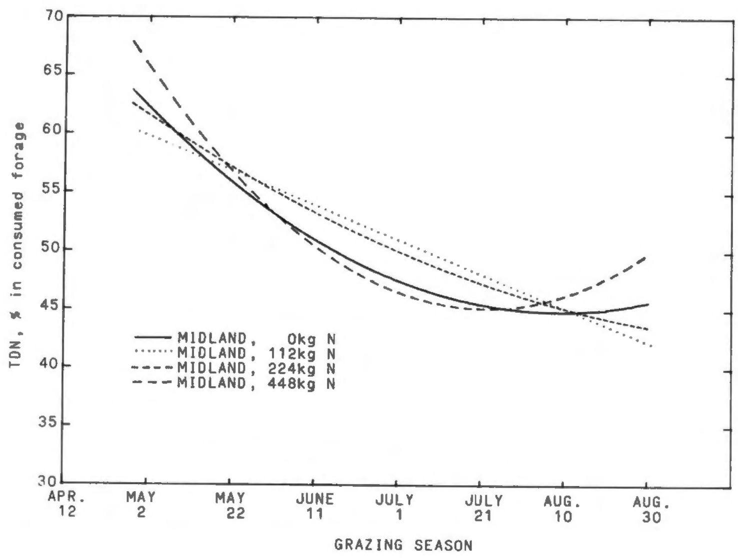

Figure 11. Change during the grazing season in ETDN content of consumed forage from Midland bermudagrass pastures fertilized with four rates of nitrogen.

TABLE 8. EQUATIONS DESCRIBING THE REGRESSION OF PERCENTAGE ETDN IN CONSUMED FORAGE ON ELAPSED DAYS OF GRAZING (D)[a]

Treatment	Constant	Coefficients of: D	Coefficients of: D^2	R^2
Midland, No N	70.032171	-.424912	.001797	.42[c]
Midland, 112 kg N/ha	62.759647	-.146361	.000003	.40[c]
Midland, 224 kg N/ha	66.613212	-.263362	.000709	.47[c]
Midland, 448 kg N/ha	77.144024	-.631078	.003118	.27[c]
Common, 112 kg N/ha	60.473640	-.176725	.000657	.20[b]
Orchardgr-clover	70.577274	-.161119	.000498	.48[c]

[a]%ETDN = constant + b_1D_i + $b_2D_i^2$, where D_i = ith elapsed day of grazing and D_1 = April 12.

[b]Coefficients of regression are significantly different ($P<.05$) from zero.

[c]Coefficients of regression are significantly different ($P<.01$) from zero.

With the regression equations, the ETDN content of consumed forage was calculated for 20, 40, 60, 80, 100, 120 and 140 elapsed days of grazing. An analysis of variance showed that a significant difference existed among treatments and elapsed days of grazing, significantly affecting the ETDN content of consumed forage. Except on day 20 (table 9), ETDN of OG was significantly higher than the mean of all bermudagrass pastures. No significant difference was apparent between ETDN content of CB and MID-2. In addition, no significant difference was apparent between MID-1 and MID-4 pastures. N fertilization increased the DM yield, resulting in a greater yield of ETDN from a given area. However, the concentration of ETDN per unit of forage was not significantly affected by N fertilization. At the end of the season (140 days), the mean ETDN content of MID-3 and MID-4 (46.8%) was significantly greater than that of MID-2 (42.3%). On day 140, MID-4 contained significantly more ETDN than did MID-3 (49.9% vs 43.6%). An advantage of higher N fertilization might be that the ETDN content of the forage is maintained at a higher level during the latter part of the season. Over the entire season, the only significant difference was that between mean ETDN content of OG and that of all bermudagrass pastures (61.7% vs 51.2%, respectively).

The percentage ETDN in consumed forage of OG decreased throughout the season, but the decrease was not significant after 60 days. The decrease in ETDN of CB was not significant after day 20 and, in MID-1, the decrease was not significant after day 40. MID-2 and MID-3 decreased significantly in ETDN content during the season until day 100. MID-4 did not decrease significantly in ETDN after 60 days. Davis (1969)

TABLE 9. ESTIMATED ETDN CONTENT OF CONSUMED FORAGE[a]

Elapsed days of grazing	Comparison[b] 1		2		3		4		5	
	OG	BER	CB	MID	MID-1	MID-N	MID-2	MID-HN	MID-3	MID-4
	Percent									
20	67.6[c]	61.3[c]	57.2[d]	62.4[d]	62.3[e]	62.4[e]	59.8[f]	63.7[f]	61.6[g]	65.8[g]
40	64.9	56.3	54.5[d]	56.7[d]	55.9[e]	57.0[e]	56.9[f]	57.1[f]	57.2[g]	56.9[g]
60	62.7	52.2	52.2[d]	52.2[d]	51.0[e]	52.6[e]	54.0[f]	51.9[f]	53.4[g]	50.5[g]
80	60.9	49.2	50.5[d]	48.8[d]	47.5[e]	49.3[e]	51.1[f]	48.4[f]	50.1[g]	46.6[g]
100	59.4	47.1	49.4[d]	46.6[d]	45.5[e]	46.9[e]	48.2[f]	46.3[f]	47.4[g]	45.2[g]
120	58.4	46.1	48.7[d]	45.4[d]	44.9[e]	45.6[e]	45.2[f]	45.8[f]	45.2[g]	46.3[g]
140	57.8	46.0	48.6[d]	45.4[d]	45.8[e]	45.3[e]	42.3	46.8	43.6	49.9
Mean	61.7	51.2	51.6[d]	51.1[d]	50.4[e]	51.3[e]	51.1[f]	51.4[f]	51.2[g]	51.6[g]

[a] $\%ETDN = constant + b_1 D_i + b_2 D_i^2$, where D_i = ith elapsed day of the grazing season and D_1 = April 12.

[b] Comparisons: (1) orchardgrass-clover (OG) compared to the mean of all bermudagrass (BER) pastures; (2) common bermudagrass (CB) compared to the mean of all Midland bermudagrass (MID) pastures; (3) unfertilized Midland (MID-1) compared to fertilized Midland (MID-N); (4) Midland fertilized with 112 kg N/ha (MID-2) compared to the mean of Midland fertilized with 224 and 448 kg N/ha (MID-HN); and (5) Midland fertilized with 224 kg N/ha (MID-3) compared to Midland fertilized with 448 kg N/ha (MID-4)

[c-g] Values with the same superscript for the same elapsed days of grazing are not significantly different ($P>.05$).

found that the higher nutritional value of clover, as compared to that of grasses, was due to the ability of clover to maintain its soluble carbohydrate level throughout the season. In contrast, the level of soluble carbohydrate in grasses decreased throughout the season.

The TDN requirement of a 300-kg steer gaining at least .5 kg/day is 57% (NRC, 1970) of the ration. Therefore, the consumed forage from CB and MID-1 met the TDN requirements only during the first 40 days of the season. Midland forages, fertilized with various levels of N, satisfied TDN requirements only during the first 60 days while OG forage met TDN requirements throughout the season.

Crude Protein Content

The data were reduced to quadrinomial equations describing the regression of %CP in consumed forage on elapsed days of grazing. A comparison of the %CP in forage consumed from OG and MID-4 is presented in figure 12. The CP content of MID-4 forage decreased from the start of the season until the first part of June, leveled off and then began to decrease again about the first part of August. In contrast, the CP content of forage consumed from OG increased until the middle of May and then decreased to the first part of August, an occurrence probably related to the greater amount of ladino clover in the pasture. The %CP in forage consumed from CB and MID-2 was about the same until the middle of July when the CP content of MID-2 started to increase while the CP content of CB decreased (figure 13). Why these rate changes occur is not known. The effect of N fertilization of Midland bermudagrass on the CP content of consumed forage is shown in figure 14.

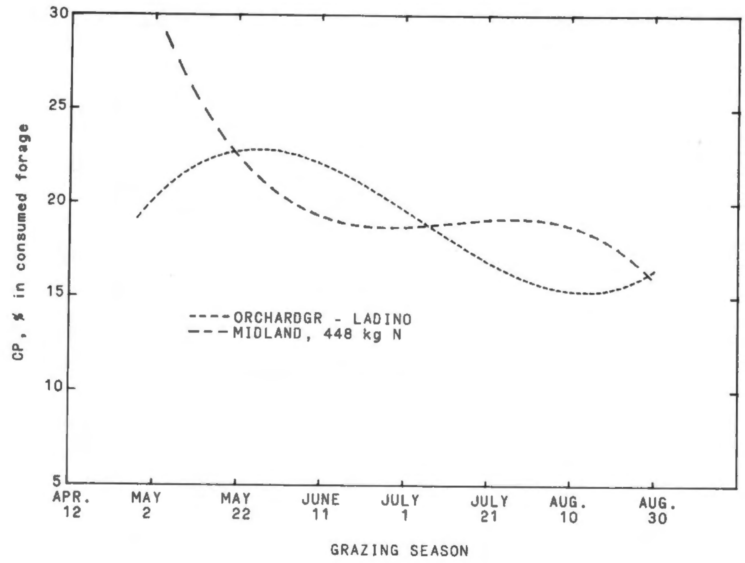

Figure 12. Change during the grazing season in CP content of consumed forage from Midland bermudagrass fertilized with 448 kg N/ha and orchardgrass-ladino clover pastures.

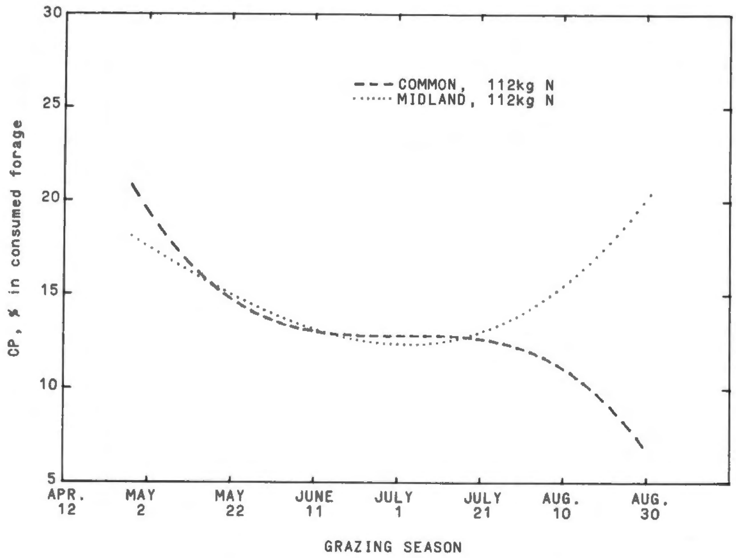

Figure 13. Change during the grazing season in CP content of consumed forage from common and Midland bermudagrass pastures fertilized with 112 kg N/ha.

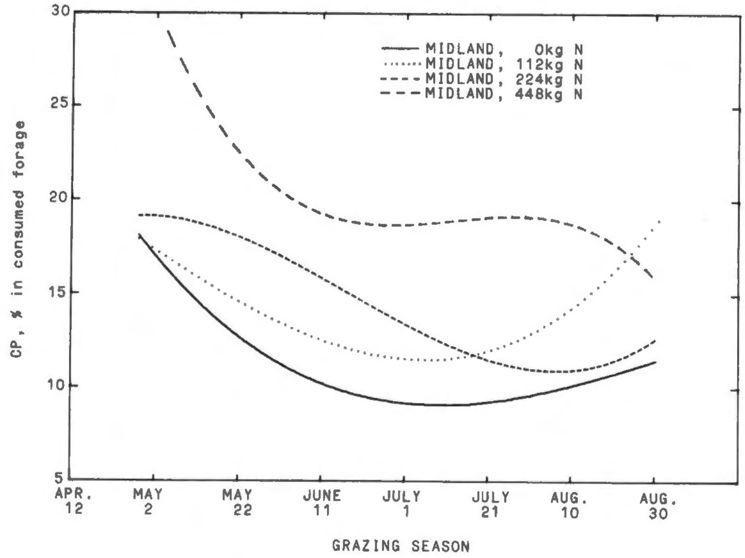

Figure 14. Change during the grazing season in CP content of consumed forage from Midland bermudagrass pastures fertilized with four rates of nitrogen.

N fertilization increased the CP content of Midland forage throughout the season.

The equations describing the regression of %CP in consumed forage on elapsed days of grazing are presented in table 10. When the data were combined across years, a significant difference was apparent in the constant, b_1, b_2 and b_3 due to treatment. The CP content of MID-4 and OG was not affected as much by elapsed days of grazing (R^2 = .21 and .28, respectively) as was that of MID-1, MID-3 and CB. This probably was because the added N and clover N maintained the forage in a more physiologically immature stage than was the case with the lower levels of fertilization.

These regression equations were used to calculate the predicted CP content of consumed forage at 20, 40, 60, 80, 100, 120 and 140 days of grazing. OG contained significantly more CP (table 11) in the consumed forage than did the bermudagrasses. Generally, no difference was seen in this value for CB and the mean CP content of the consumed forage from Midland bermudagrasses. Each increase in rate of N fertilization resulted in higher CP content of the consumed forage throughout the grazing season. Over the entire season, consumed OG forage contained 19.0% CP. The mean of all consumed bermudagrasses was 15.0% CP ($P<.05$). CB contained less CP on the average (13.4%) than the mean of all Midland pastures (15.4%) but this difference was not significant. MID-1 contained less ($P<.05$) CP (11.4%) than MID-N (16.7%). MID-3 and MID-4 contained more ($P<.05$) CP (17.8%) than MID-2. MID-4 contained 21.1% CP compared to 14.5% CP for MID-3 ($P<.05$).

The CP content of consumed CB forage decreased significantly

TABLE 10. EQUATIONS DESCRIBING THE REGRESSION OF PERCENT CP IN CONSUMED FORAGE ON ELAPSED DAYS OF GRAZING (D)[a]

Treatment	Constant	Coefficients of:			R^2
		D	D^2	D^3	
Midland, No N	23.463474	-.381023	.003091	-.000007	.40[c]
Midland, 112 kg N/ha	20.366190	-.151795	-.000118	.000008	.25[b]
Midland, 224 kg N/ha	18.352600	.100876	-.003392	.000017	.47[c]
Midland, 448 kg N/ha	43.990202	-.872419	.009839	-.000036	.21[b]
Common, 112 kg N/ha	28.460992	-.585508	.007273	-.000030	.45[c]
Orchardgr-clover	12.857017	.510506	-.007803	.000031	.28[b]

[a]$\%CP = constant + b_1D_i + b_2D_i^2 + b_3D_i^3$, where D_i = ith elapsed day of the grazing season and D_1 = April 12.

[b]Coefficients of regression are significantly different (P<.05) from zero.

[c]Coefficients of regression are significantly different (P<.01) from zero.

TABLE 11. PREDICTED CRUDE PROTEIN CONTENT OF CONSUMED FORAGE[a]

Elapsed days of grazing	Comparison[b]									
	1		2		3		4		5	
	OG	BER	CB	MID	MID-1	MID-N	MID-2	MID-HN	MID-3	MID-4
	- - - - - - - - -	- - - -	- - - -	- - - -	- - -	Percent - - -	- - - -	- - - -	- - - -	- - - -
20	20.2[c]	20.6[c]	19.4[d]	20.9[d]	17.0	22.2	17.3	24.7	19.2	30.2
40	22.8	16.5	14.8	17.0	12.7	18.4	14.6	20.3	18.0	22.6
60	22.1	14.2	13.1[d]	14.5[d]	10.2	15.9	12.6	17.6	15.9	19.4
80	19.6	13.2	13.1[d]	13.3[d]	9.2	14.7	11.6	16.2	13.4	19.0
100	16.9	13.1	13.1[d]	13.1[d]	9.3	14.4	12.0	15.6	11.5	19.6
120	15.3[c]	13.4[c]	12.0[d]	13.8[d]	10.2	15.0	14.3[f]	15.3[f]	11.0	19.6
140	16.5[c]	13.7[c]	8.1	15.0	11.5	16.2	18.8[f]	15.0[f]	12.6	17.3
Mean	19.0	15.0	13.4[d]	15.4[d]	11.4	16.7	14.4	17.8	14.5	21.1

[a]%CP = constant + $b_1D_i + b_2D_i^2 + b_3D_i^3$, where D_i = ith elapsed day of the grazing season and D_1 = April 12.

[b]Comparisons: (1) orchardgrass-clover (OG) compared to the mean of all bermudagrass (BER) pastures; (2) common bermudagrass (CB) compared to the mean of all Midland bermudagrass (MID) pastures; (3) unfertilized Midland (MID-1) compared to fertilized Midland (MID-N); (4) Midland fertilized with 112 kg N/ha (MID-2) compared to the mean of Midland fertilized with 224 and 448 kg N/ha (MID-HN); and (5) Midland fertilized with 224 kg N/ha (MID-3) compared to Midland fertilized with 448 kg N/ha (MID-4).

[c-f]Values with the same superscript for the same elapsed days of grazing are not significantly different (P>.05).

throughout the season. However, the %CP of MID-2 did not decrease significantly during the entire grazing season. The CP content of forage consumed from MID-1 and from MID-3 and MID-4 did not change significantly after 40, 60 and 20 elasped days, respectively.

The %CP required for a 200-kg steer to gain at least .5 kg/day is 11.1% and for 300-kg steers to have the same ADG the %CP is at least 10% of the ration. Therefore, %CP of the consumed forages was adequate from all treatments throughout the grazing season except for CB forage after 120 days and for MID-1 forage between 60 and 120 days.

Amount of Intake

Dry Matter

The intake per unit of metabolic weight ($W^{.75}_{kg}$) was reduced to equations describing the regression of intake on elapsed days of grazing. When the data were combined across the years, no significant difference was apparent in the regression sources due to treatment or replication. The regression coefficients (R^2) from all treatments were small (.06 to .17) and, therefore, were not significant.

The regression equations were used to calculate the estimated amount of (g) DM intake per unit metabolic weight. Seasonal means were: MID-1, 110.5; MID-2, 105.1; MID-3, 114.7; MID-4, 72.3; CB, 99.0; and OG, 108.0. Animals grazing MID-3 consumed significantly more DM (114.7 g) than did animals grazing MID-4 (72.3 g).

Estimated Total Digestible Nutrients

The data were reduced to equations describing the regression of ETDN intake above maintenance and ETDN intake per unit of metabolic weight on elapsed days of grazing. Animals grazing OG increased their ETDN intake above maintenance (figure 15) until about the end of June, then decreased their ETDN intake thereafter. At the beginning of the grazing season, animals grazing MID-4 consumed about the same amount of ETDN above maintenance as did those grazing OG pastures. Thereafter, consumption decreased steadily and, finally, leveled off around the beginning of July. Animals grazing CB (figure 16) increased their ETDN intake above maintenance until the middle of July, then decreased their ETDN intake for the remainder of the season. The ETDN intake of animals grazing MID-2 decreased throughout the season, but their intake remained higher than the intake of animals grazing CB. Animals grazing MID-2 consumed more ETDN above maintenance than did animals grazing MID-3 and the latter consumed more ETDN than did animals grazing MID-4 (figure 17).

Between 60 and 120 elapsed days (table 12), animals grazing OG consumed significantly more ETDN above maintenance than did animals grazing all bermudagrass pastures. Between 100 and 140 days, animals grazing MID-2 consumed more ETDN above maintenance than the mean con-consumption of animals grazing MID-3 and MID-4. Overall, animals grazing OG consumed 2.54 kg/day ETDN above maintenance compared to the mean 1.57 kg/day consumption of the animals grazing all bermudagrass pastures, a significant difference. No significant difference was apparent between the ETDN consumption above maintenance of animals grazing CB (1.79 kg/day) and that of animals grazing all Midland bermudagrasses (1.51 kg/day). No significant difference was apparent between the mean consumption above maintenance of animals grazing MID-N (1.41 kg/day) and

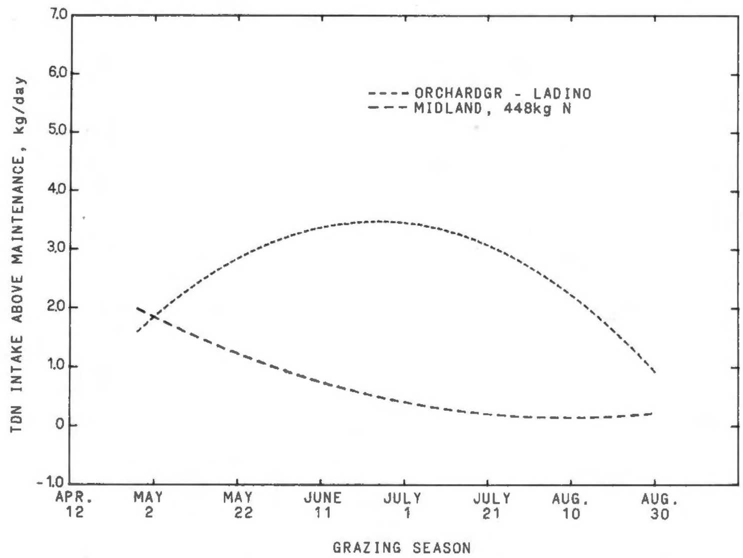

Figure 15. Change during the grazing season in ETDN intake above maintenance from Midland bermudagrass fertilized with 448 kg N/ha and orchardgrass-ladino clover pastures.

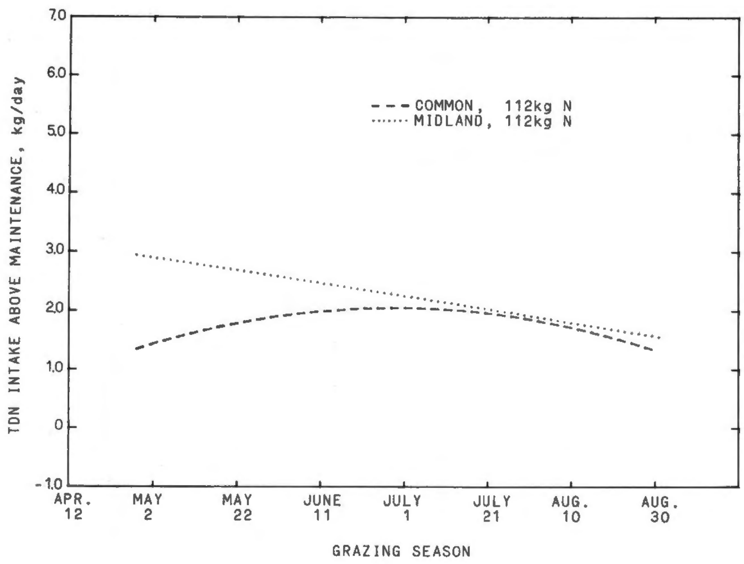

Figure 16. Change during the grazing season in ETDN intake above maintenance from common and Midland bermudagrass pastures fertilized with 112 kg N/ha.

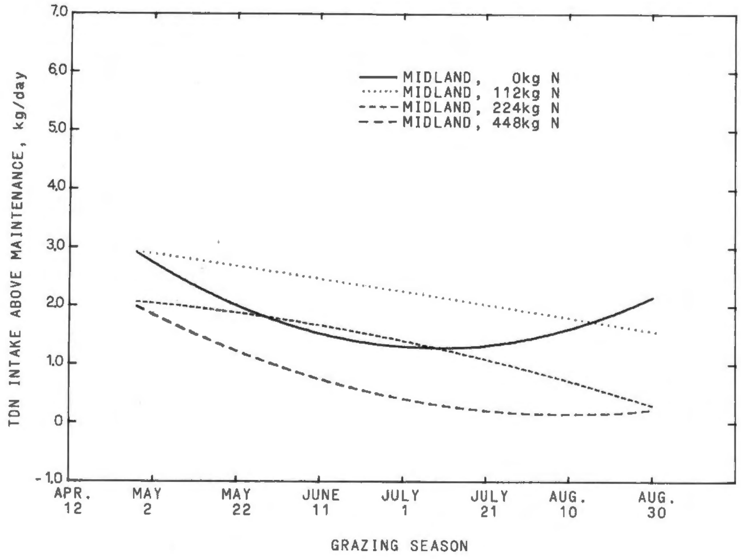

Figure 17. Change during the grazing season in ETDN intake above maintenance from Midland bermudagrass pastures fertilized with four rates of nitrogen.

TABLE 12. ESTIMATED TOTAL DIGESTIBLE NUTRIENT INTAKE ABOVE MAINTENANCE (kg/day)[a]

Elapsed days of grazing	Comparison[b] 1		2		3		4		5	
	OG	BER	CB	MID	MID-1	MID-N	MID-2	MID-HN	MID-3	MID-4
20	1.85[c]	2.19[c]	1.44[d]	2.38[d]	2.74[e]	2.26[e]	2.90[f]	1.95[f]	2.05[g]	1.85[g]
40	2.85[c]	1.92[c]	1.80[d]	1.95[d]	2.01[e]	1.93[e]	2.69[f]	1.56[f]	1.89[g]	1.23[g]
60	3.38	1.69	2.01[d]	1.61[d]	1.53[e]	1.63[e]	2.47[f]	1.21[f]	1.67[g]	.75[g]
80	3.46	1.49	2.08[d]	1.34[d]	1.31[e]	1.36[e]	2.26[f]	.91[f]	1.41[g]	.41[g]
100	3.07	1.33	2.01[d]	1.17[d]	1.34[e]	1.11[e]	2.03	.65	1.09[g]	.21[g]
120	2.23	1.22	1.79[d]	1.07[d]	1.62[e]	.89[e]	1.80	.43	.72[g]	.14[g]
140	.93[c]	1.14[c]	1.42[d]	1.06[d]	2.16	.70	1.57	.26	.30[g]	.22[g]
Mean	2.54	1.57	1.79[d]	1.51[d]	1.81[e]	1.41[e]	2.24	1.00	1.30	.69

[a]ETDN, kg/day = constant + b_1D_i + $b_2D_i^2$, where D_i = ith elapsed day of the grazing season and D_1 = April 12.

[b]Comparisons: (1) orchardgrass-ladino clover (OG) compared to the mean of all bermudagrass (BER) pastures; (2) common bermudagrass (CB) compared to the mean of all Midland bermudagrass (MID) pastures; (3) unfertilized Midland (MID-1) compared to fertilized Midland (MID-N); (4) Midland fertilized with 112 kg N/ha (MID-2) compared to the mean of Midland fertilized with 224 and 448 kg N/ha (MID-HN); and (5) Midland fertilized with 224 kg N/ha (MID-3) compared to Midland fertilized with 448 kg N/ha (MID-4).

[c-g]Values with the same superscript for the same elapsed days of grazing are not significantly different (P>.05).

that of animals grazing MID-1 (1.81 kg/day). Animals grazing MID-2 consumed significantly more ETDN (2.24 kg/day) than the mean consumption above maintenance by animals grazing MID-HN (1.00 kg/day). Animals on MID-3 consumed more ETDN ($P<.05$) than did animals grazing MID-4 (.69 kg/day).

Animals grazing OG pastures consumed significantly more ETDN above maintenance on day 80 (appendix) than the mean consumption during the rest of the season (3.46 and 2.08 kg/day, respectively) and they consumed significantly more on day 120 (2.23 kg) than on day 140 (.93 kg). Animals grazing MID-4 consumed more ETDN on day 20 (1.85 kg) than the mean consumption during the rest of the season (.49 kg) and they consumed more on day 40 (1.23 kg) than the mean consumption during the period 60 through 140 days (.35 kg).

Using the equation developed by Garrett et al. (1959), the maintenance requirement of a 300-kg steer would be 1.6 kg TDN/day. In addition, steers of this weight would need 2.0 kg TDN/day to support daily weight gains of .5 kg (Garret et al., 1959). Based on the regression equations, animals consuming OG forage were consuming enough ETDN at all periods during the season (appendix) except prior to 20 elapsed days and after 120 elapsed days of grazing. Animals consuming CB were receiving adequate ETDN above maintenance between 60 and 120 elapsed days but were below the requirement to support an ADG of .5 kg during the rest of the season. Animals grazing MID-1 appeared to receive enough ETDN prior to 60 elapsed days and after 120 elapsed days. MID-2 provided enough ETDN above maintenance until after 100 elapsed days. At the two highest levels of N fertilization, the animals were not consuming enough ETDN above maintenance at anytime during the season.

The predicted ETDN intake per unit of metabolic weight is shown in table 13. The significant differences were similar to those just discussed with respect to ETDN intake above maintenance. ETDN intake per unit of metabolic weight, within treatment, was not significantly affected by elapsed days of grazing except that animals grazing OG pastures consumed more ETDN on day 80 (72.4 g) than the mean daily consumption during the rest of the season (54.3 g) and they consumed more on day 100 (67.1 g) than the mean of 120 and 140 days (48.0 g). Animals grazing MID-4 consumed more ETDN on day 20 (52.2 g) than the mean for the rest of the season (37.0 g) and they consumed more on day 40 (45.2 g) than the mean of the period 60 through 140 days (35.4 g).

The TDN requirement per unit of metabolic weight for a 300-kg steer to gain at least .5 kg/day is 49.5 g/day (Garrett et al., 1959). Animals grazing OG did not consume enough ETDN after 120 days. Animals grazing MID-3 and MID-4 did not consume adequate ETDN per unit of metabolic weight after 80 and 40 days, respectively. Animals grazing either CB, MID-1 or MID-2 consumed enough ETDN per unit of metabolic weight to meet their requirements throughout the grazing season.

The percentage of ETDN in consumed forage can be predicted better from elapsed days of grazing (R^2 = .42, .40, .47, .27, .20 and .48 for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively) than can either ETDN intake above maintenance (R^2 = .04, .04, .06, .08, .02 and .10 for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively) or ETDN intake per unit of metabolic weight (R^2 = .04, .05, .07, .07, .02 and .11, respectively). Therefore, under the conditions of this study, elapsed

TABLE 13. ESTIMATED INTAKE OF TOTAL DIGESTIBLE NUTRIENTS PER UNIT OF METABOLIC WEIGHT ($W_{kg}^{.75}$)[a]

Elapsed days of grazing	Comparison[b] 1		2		3		4		5	
	OG	BER	CB	MID	MID-1	MID-N	MID-2	MID-HN	MID-3	MID-4
	g/day/$W_{kg}^{.75}$									
20	54.7[c]	58.2[c]	49.0[d]	60.5[d]	66.0[e]	58.7[e]	66.4[f]	54.9[f]	57.6[g]	52.2[g]
40	66.2[c]	55.5[c]	52.8[d]	56.2[d]	56.5[e]	56.1[e]	68.4	49.9	54.7[g]	45.2[g]
60	72.1	52.9	54.8[d]	52.4[d]	50.2[e]	53.1[e]	68.1	45.6	51.4[g]	39.8[g]
80	72.4	50.3	55.2[d]	49.1[d]	47.2[e]	49.7[e]	65.6	41.8	47.6[g]	35.9[g]
100	67.1	47.9	53.8[d]	46.4[d]	47.4[e]	46.1[e]	61.0	38.6	43.4[g]	33.7[g]
120	56.2	45.5	50.8[d]	44.2[d]	50.8[e]	42.0[e]	54.2	36.0	38.7[g]	33.2[g]
140	39.7[c]	43.3[c]	46.0[d]	42.6[d]	57.4	37.6	45.2	33.9	33.6[g]	34.2[g]
Mean	61.2	50.5	51.8[d]	50.2[d]	53.6[e]	49.1[e]	61.3	42.9	46.7	39.2

[a]ETDN = constant + $b_1D_i + b_2D_i^2$, where D_i = ith elapsed day of the grazing season and D_1 = April 12.

[b]Comparisons: (1) orchardgrass-ladino clover (OG) compared to the mean of all bermudagrass (BER) pastures; (2) common bermudagrass (CB) compared to the mean of all Midland bermudagrass (MID) pastures; (3) unfertilized Midland (MID-1) compared to fertilized Midland (MID-N); (4) Midland fertilized with 112 kg N/ha (MID-2) compared to the mean of Midland fertilized with 224 and 448 kg N/ha (MID-HN); and (5) Midland fertilized with 224 kg N/ha (MID-3) compared to Midland fertilized with 448 kg N/ha (MID-4).

[c-g]Values with the same superscript for the same elapsed days of grazing are not significantly different ($P>.05$).

days of grazing did not significantly affect ETDN intake since none of the R^2's in the latter two sets was significant.

Crude Protein

The CP intake data were reduced to equations describing the regression of CP intake above maintenance and CP intake per unit of metabolic weight on elapsed days of grazing. The effect of elapsed days of grazing on CP intake above mainentance is shown in figures 18, 19 and 20. Animals grazing OG increased their consumption during the first part of the season and their consumption became greater about May 7 than did that of animals grazing MID-4. Animals grazing MID-2 and CB consumed approximately the same amount of CP above maintenance throughout the season. Animals grazing MID-1 consumed less CP above maintenance than animals grazing MID-N. Except for the beginning of the growing season, little difference was noted between CP intake above maintenance of animals grazing Midland pastures fertilized with different levels of N.

The regression equations just described are listed in table 14. When the data were combined across years, no significant difference was apparent among treatments or replications for either measure of intake. The predicted CP intake above maintenance for steers during the entire grazing season, calculated by using the regression equations, is shown in table 15. After day 20, animals grazing OG consumed significantly more CP than did animals consuming any of the bermudagrass forages. Generally, no significant difference was noted between the consumption of animals grazing CB and that of animals grazing Midland bermudagrass. After day 20, animals grazing MID-N consumed significantly more CP than

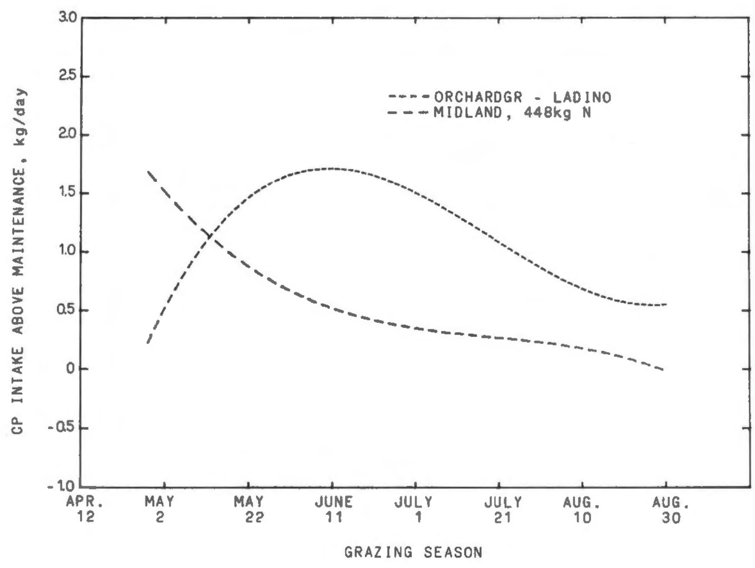

Figure 18. Change during the grazing season in CP intake above maintenance from Midland bermudagrass fertilized with 448 kg N/ha and orchardgrass-ladino clover pastures.

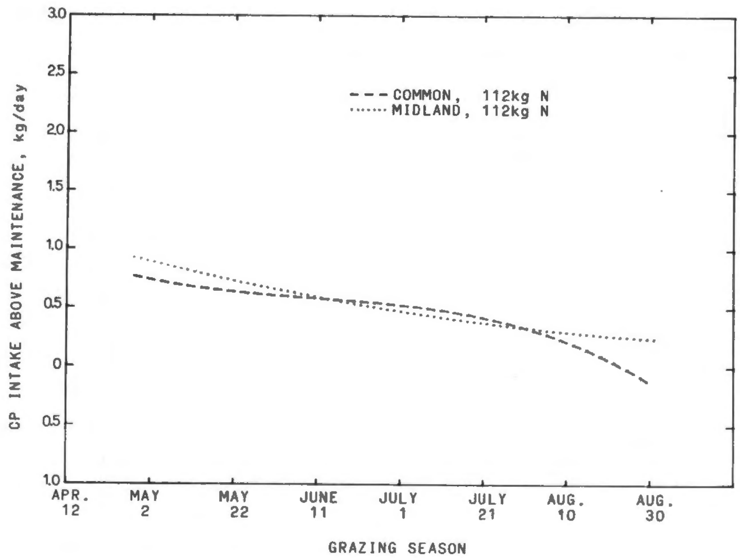

Figure 19. Change during the grazing season in CP intake above maintenance from common and Midland bermudagrass pastures fertilized with 112 kg N/ha.

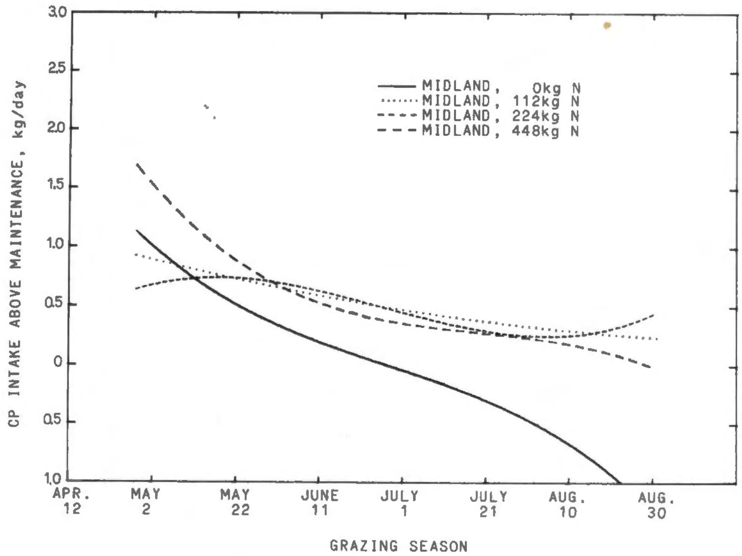

Figure 20. Change during the grazing season in CP intake above maintenance from Midland bermudagrass pastures fertilized with four rates of nitrogen.

TABLE 14. EQUATIONS DESCRIBING THE REGRESSION OF CP INTAKE ABOVE MAINTENANCE AND CP INTAKE PER UNIT OF METABOLIC WEIGHT ON ELAPSED DAYS OF GRAZING (D)[a]

Treatment	Constant	Coefficients of: D	D^2	D^3	R^2
		- -Intake above maintenance- -			
Midland, No N	1.762285	-.046423	.000458	-.000002	.13
Midland, 112 kg N/ha	1.071305	-.009565	.000026	.000000	.14
Midland, 224 kg N/ha	1.362182	.024100	-.000448	.000002	.15
Midland, 448 kg N/ha	2.533380	-.061697	.000591	-.000002	.30[b]
Common, 112 kg N/ha	.935006	-.013064	.000179	-.000001	.04
Orchardgr-clover	-1.353637	.121323	-.001469	.000005	.21[b]
		- - - Intake per unit of metabolic weight - - -			
Midland, No N	29.633100	-.822996	.009440	-.000032	.20
Midland, 112 kg N/ha	20.667172	-.147467	.000466	.000001	.18
Midland, 224 kg N/ha	12.808285	.251022	-.004147	.000016	.11
Midland, 448 kg N/ha	26.104228	-.224619	.000558	.000002	.24[b]
Common, 112 kg N/ha	.764432	.703041	-.009480	.000035	.15
Orchardgr-clover	-10.450133	1.538260	-.019098	.000066	.22[b]

[a] $\hat{y}$ = constant + $b_1D_i + b_2D_i^2 + b_3D_i^3$, where D_i = ith elapsed day of the grazing season and D_1 = April 12 and $\hat{y}$ = intake above maintenance (kg/day) and intake per unit of metabolic weight (g/day).

[b] Coefficients of regression are significantly different (P<.05) from zero.

TABLE 15. ESTIMATED INTAKE OF CRUDE PROTEIN ABOVE MAINTENANCE (kg/day)[a]

Elapsed days of grazing	Comparison[b] 1		2		3		4		5	
	OG	BER	CB	MID	MID-1	MID-N	MID-2	MID-HN	MID-3	MID-4
20	.52	.97	.74[c]	1.02[c]	1.00[d]	1.03[d]	.89[e]	1.10[e]	.68	1.52
40	1.47	.70	.63[c]	.72[c]	.51	.78	.73[e]	.81[e]	.74[f]	.88[f]
60	1.72	.50	.58[c]	.48[c]	.19	.58	.59[e]	.58[e]	.63[f]	.53[f]
80	1.51	.35	.52	.31	-.04	.43	.48[e]	.40[e]	.45[f]	.36[f]
100	1.09	.21	.42	.16	-.30	.31	.38[e]	.28[e]	.29[f]	.27[f]
120	.69	.06	.22[c]	.02[c]	-.67	.25	.30[e]	.22[e]	.26[f]	.18[f]
140	.56	-.14	-.13[c]	-.14[c]	-1.25	.23	.25[e]	.22[e]	.44	-.01
Mean	1.08	.38	.42[c]	.37[c]	-.08	.52	.52[e]	.52[e]	.50[f]	.53[f]

[a]CP, kg/day = constant + $b_1D_i + b_2D_i^2 + b_3D_i^3$, where D_i = ith elapsed day of the grazing season and D_1 = April 12.

[b]Comparisons: (1) orchardgrass-ladino clover (OG) compared to the mean of all bermudagrass (BER) pastures; (2) common bermudagrass (CB) compared to the mean of all Midland bermudagrass (MID) pastures; (3) unfertilized Midland (MID-1) compared to fertilized Midland (MID-N); (4) Midland fertilized with 112 kg N/ha (MID-2) compared to the mean of Midland fertilized with 224 and 448 kg N/ha (MID-HN); and (5) Midland fertilized with 224 kg N/ha (MID-3) compared to Midland fertilized with 448 kg N/ha (MID-4).

[c-f]Values with the same superscript for the same elapsed days of grazing are not significantly different ($P>.05$).

did animals grazing MID-1 throughout the season. Differences in CP consumption above maintenance among animals grazing MID-2 and the mean consumption of animals grazing MID-3 and MID-4 were not significant. Animals grazing OG consumed an average of 1.08 kg/day of CP above maintenance (.45 kg/day) which was significantly greater than the mean consumption of animals grazing all bermudagrass pastures (.38 kg/day). No significant difference was apparent in the consumption of CP above maintenance between animals grazing CB (.42 kg/day) and those grazing all Midland bermuda (.37 kg/day) pastures. Animals grazing MID-N consumed significantly more CP above maintenance (.52 kg/day) than animals grazing MID-1 (-.08 kg/day). Differences in the consumption above maintenance between animals grazing MID-2 (.52 kg/day) and those grazing MID-HN (.52 kg/day) were not significant. Nor was a significant difference noted in the consumption of CP between animals grazing MID-3 and MID-4 (.50 and .53 kg/day, respectively).

The amount of CP consumed above maintenance by animals grazing MID-1 decreased significantly throughout the season (appendix). Differences in consumption among the other treatments, except on day 60 with OG and day 20 with MID-4, were not significant.

According to the equation of Preston (1966), the CP requirement of a 300-kg steer is .31 kg/day for maintenance and a total of .45 kg/day for a gain of at least .5 kg/day. On this basis, animals grazing CB were not consuming enough CP above maintenance after 120 days to gain at least .5 kg/day (table 15). In fact, not even their maintenance requirements were met at that time. Animals grazing MID-1 did not consume enough CP for an ADG of .5 kg after 60 days and were below their CP maintenance requirements after that time. Animals grazing MID-N pastures consumed adequate CP above maintenance at all times during the season.

When CP intake was based on metabolic weight (table 16), the trends were similar to those just described for CP intake above maintenance. CP intake of animals grazing OG pastures differed significantly during the season when grazing periods were compared (appendix). Animals grazing MID-1 and MID-2 consumed more CP per unit of metabolic weight on day 20 than during the remainder of the growing season (16.7 vs. a mean of 9.6 g and 17.9 vs. a mean of 12.2 g, respectively). The CP requirement per unit of metabolic weight for a 300-kg steer gaining .5 kg/day is 8.5 g/day. Results in table 16 show, therefore, that animals grazing OG, MID-2, MID-3 and MID-4 and CB were consuming adequate amounts of protein throughout the season to attain an ADG of at least .5 kg. On the other hand, animals grazing MID-1 were deficient in CP intake per unit of metabolic weight betwen 40 and 100 days.

Relationship Between ADG and Forage Composition

Coefficients of simple correlation of ADG with elapsed days of grazing and the percentages of DDM, ETDN and CP in the strip samples (available forage) for each treatment and for all treatments combined are presented in table 17. This analysis indicated that a highly significant, negative correlation existed between ADG and elapsed days of grazing on all treatments. This negative correlation was due to the decrease in ETDN, DDM and CP content of the forage as the season progressed. Highly significant positive correlations of ADG with %ETDN

TABLE 16. ESTIMATED INTAKE OF CRUDE PROTEIN PER UNIT OF METABOLIC WEIGHT $(W^{.75}_{kg})^{a}$

Elapsed days of grazing	Comparison[b] 1		2		3		4		5	
	OG	BER	CB	MID	MID-2	MID-N	MID-2	MID-HN	MID-3	MID-4
	$g/day/W^{.75}_{kg}$									
20	13.2[c]	16.8[c]	11.3[d]	18.2[d]	16.7[e]	18.7[e]	17.9[f]	19.1[f]	16.3[g]	21.8[g]
40	24.8	15.3	16.0[d]	15.2[d]	9.8	17.0	15.6[f]	17.6[f]	17.2[g]	18.1[g]
60	27.4	13.7	16.4[d]	13.0[d]	7.3	15.0	13.6[f]	15.6[f]	16.3[g]	15.0[g]
80	24.2	12.2	14.3[d]	11.7[d]	7.8[e]	13.0[e]	12.1[f]	13.4[f]	14.3[g]	12.5[g]
100	18.4	10.9	11.3[d]	10.9[d]	9.7[e]	11.2[e]	11.1[f]	11.3[f]	11.9[g]	10.7[g]
120	13.2[c]	10.2[c]	9.1[d]	10.5[d]	11.5[e]	10.1[e]	10.6[f]	9.9[f]	10.0[g]	9.8[g]
140	11.7[c]	10.1[c]	9.4[d]	10.3[d]	11.6[e]	9.8[e]	10.5[f]	9.5[f]	9.2[g]	9.7[g]
Mean	19.0	12.8	12.5[d]	12.8[d]	10.6	13.5	13.0[f]	13.8[f]	13.6[g]	13.9[g]

[a]CP, $g/W^{.75} = \text{constant} + b_1D_i + b_2D_i^2 + b_3D_i^3$, where D_i = ith elapsed day of the grazing season and D_1 = April 12.

[b]Comparisons: (1) orchardgrass-ladino clover (OG) compared to the mean of all bermudagrass (BER) pastures; (2) common bermudagrass (CB) compared to the mean of all Midland bermudagrass (MID) pastures; (3) unfertilized Midland (MID-1) compared to fertilized Midland (MID-N); (4) Midland fertilized with 112 kg N/ha (MID-2) compared to the mean of Midland fertilized with 224 and 448 kg N/ha MID-HN); and (5) Midland fertilized with 224 kg N/ha (MID-3) compared to Midland fertilized with 448 kg N/ha (MID-4).

[c-g]Values with the same superscript for the same elapsed days of grazing are not significantly different (P>.05).

TABLE 17. SIMPLE COEFFICIENTS OF CORRELATION OF AVERAGE DAILY GAIN WITH ELAPSED DAYS OF GRAZING AND PERCENTAGES OF DDM, ETDN AND CP IN AVAILABLE FORAGE

Variable	Midland bermudagrass, kg N/ha				Common bermuda 112 kg N/ha	Orchardgr-ladino clover	Overall
	0	112	224	448			
Elapsed days of grazing	-.40[b]	-.62[b]	-.69[b]	-.63[b]	-.62[b]	-.43[b]	-.53[b]
Digestible dry matter, %	.01	.56[b]	.54[b]	.44[b]	.12	.28	.07
Total digestible nutrients, %	.26	.56[b]	.54[b]	.44[b]	.12	.27	.41[b]
Crude protein, %	.31[a]	.63[b]	.48[b]	.63[b]	.47[b]	.02	.44[b]

[a]Coefficients greater than ± .29 are significant ($P<.05$) for individual treatments and coefficients greater than ± .12 are significant ($P<.05$) when treatments were combined (overall).

[b]Coefficients greater than ± .37 are significant ($P<.01$) for individual treatments and coefficients greater than ± .15 are significant ($P<.01$) when treatments were combined (overall).

and %DDM were apparent in the three Midland treatments with N fertilization. However, these variables did not correlate significantly when treatments on MID-1, CB or OG are measured. In bermudagrass forages containing 12% CP and higher, the factor limiting growth would be the energy content. The fact that CP was more deficient than ETDN in MID-1 and that only ETDN was limiting in MID-N could explain why the ETDN content of MID-N correlated significantly with ADG while that of MID-1 did not.

Crude protein content of the strip samples had a highly significant positive correlation with ADG measured from all but OG pastures. ETDN and CP content in OG did not fluctuate very much during the season and thus would tend to give a low correlation with ADG. Overall treatments, elapsed days of grazing, ETDN and CP were significantly correlated with ADG. Thus, the indication is that these variables may be useful in predicting animal performance. Nevertheless, the same degree of predictability did not exist in regard to all pasture treatments studied nor does it apply to the same species with different levels of N fertilization. Indeed, Davis (1969) found that some of the highest coefficients of simple correlation with ADG were those of CP and DDM.

Relationship Between ADG and Composition of Consumed Forage

Elapsed days of grazing (table 18) were negatively correlated ($P<.05$) with ADG in all treatments. More than twice as much of the variation in ADG can be explained by the number of elapsed days of

TABLE 18. SIMPLE COEFFICIENTS OF CORRELATION OF AVERAGE DAILY GAIN WITH PERCENTAGES OF DDM, ETDN AND CP OF CONSUMED FORAGE

Variable	Midland bermudagrass, kg N/ha				Common bermuda 112 kg N/ha	Orchardgr-ladino clover	Overall
	0	112	224	448			
Elapsed days of grazing	-.40[b]	-.62[b]	-.69[b]	-.63[b]	-.62[b]	-.43[b]	-.53[b]
Digestible dry matter, %	.19	.48[b]	.26	.12	-.13	.47[b]	.18[b]
Total digestible nutrients, %	.12	.48[b]	.55[b]	.38[b]	.25	.44[b]	.40[b]
Crude protein, %	.24	-.01	.18	.07	.28	.27	.16[b]

[a]Coefficients greater than ± .29 are significant (P<.05) for individual treatments and coefficients greater than ± .12 are significant (P<.05) when treatments were combined (overall).

[b]Coefficients greater than ± .37 are significant (P<.01) for individual treatments and coefficients greater than ± .15 are significant (P<.01) when treatments were combined (overall).

grazing with all fertilized bermudagrasses as compared to MID-1 and OG. Percent ETDN was significantly correlated with ADG on MID-N treatments and on OG. Animal gains theoretically should be related more closely to the nutritive value of consumed forage than to that of available forage. Therefore, it is logical that ETDN content of consumed OG forage was correlated significantly with ADG and, conversely, was not correlated with ETDN content of available OG forage. The %CP in consumed forage was not correlated significantly with ADG, while %CP in available forage was.

When the data were combined across treatments, a significant correlation of ADG with elapsed days of grazing, DDM, ETDN and CP percentage in consumed forage was apparent.

Relationship Between ADG and Amount of Consumed Forage

Total forage intake was estimated by the cage-and-strip method (Cook, 1964). The amount of ETDN and of CP consumed was calculated (table 19) on the basis of: (1) intake, kg/day, (2) intake above maintenance, kg/day, and (3) intake, g/day per unit of metabolic weight. For DDM, these measures were: (1) intake, kg/day, and (2) intake, g/day per unit of metabolic weight.

Generally, low and non-significant correlations existed between ADG and the amount of forage nutrients consumed. The highest correlations were found with MID-1. The overall very low correlations indicate that the simple difference between the cage and the strip samples was not an accurate measure of the intake by the animals. Linehan (1952)

TABLE 19. SIMPLE COEFFICIENTS OF CORRELATION OF AVERAGE DAILY GAIN WITH CONSUMPTION OF DDM, ETDN AND CP

Variable	Midland bermudagrass, kg N/ha 0	112	224	448	Common bermuda 112 kg N/ha	Orchardgr-ladino clover	Overall
Elapsed days of grazing	$-.40^{b}$	$-.62^{b}$	$-.69^{b}$	$-.63^{b}$	$-.62^{b}$	$-.43^{b}$	$-.53^{b}$
DDM intake, kg/day	.28	.15	.18	.20	-.12	-.13	.10
DDM intake, $gm/W^{.75}$	$.32^{a}$	.16	.24	.23	-.09	-.09	$.13^{a}$
TDN intake, kg/day	.26	.10	.19	.18	-.13	-.14	.08
TDN intake above maintenance, kg/day	$.29^{a}$	.12	.21	.21	-.10	-.12	.10
TDN intake, $gm/W^{.75}$	$.30^{a}$	.20	.22	.17	-.10	-.10	.11
CP intake, kg/day	.27	.17	.14	.28	-.08	-.11	$.14^{a}$
CP intake above maintenance, kg/day	.28	.19	.15	.17	-.07	-.10	$.13^{a}$
CP intake, $gm/W^{.75}$	.24	.22	.17	$.32^{a}$	-.05	-.06	$.13^{a}$

[a]Coefficients greater than ± .29 are significant ($P<.05$) within individual treatments and coefficients greater than ± .12 are significant ($P<.05$) when all treatments were combined (overall).

[b]Coefficients greater than ± .37 are significant ($P<.01$) within individual treatments and coefficients greater than ± .15 are significant ($P<.01$) when all treatments were combined (overall).

recommended an interpolation method to compensate for the difference in forage growth which permitted unrestricted development inside the cage and the growth which was being grazed by animals during the same period of time. This interpolation procedure gave excellent agreement with animal performance over long periods of time. However, the percentage standard error attached to the consumption figure obtained from each observation was in the vicinity of 50%. The negative correlations of ADG with intake of forage nutrients from CB and OG cannot be explained.

Prediction of ADG From Forage Composition and Consumption

Multiple regression equations using various combinations of independent variables were compared for the purpose of evaluating their accuracy in predicting ADG of grazing steers. Dry matter intake was not included in the equations because of its low correlation with ADG. Not all combinations of the independent variables were used; instead, only combinations of two to five meaningful and easily measured variables were employed.

Twelve of the equations that best fit the above definition are presented in table 20. All equations resulted in significant R^2 values with the exception of equation 2 in the case of MID-1. The ability of these equations to predict ADG (as measured by the magnitude of R^2) of steers grazing bermudagrass was in the general range reported by Davis (1969) who used CP, DDM, acid insoluble lignin, cellulose, lignin-fiber ratio and soluble carbohydrates to predict ADG of steers grazing tall fescue. However, Davis reported R^2 values in the range of .60 for the

TABLE 20. MULTIPLE REGRESSION EQUATIONS FOR THE ESTIMATION OF ADG OF YEARLING STEERS GRAZING MIDLAND AND COMMON BERMUDAGRASS AND ORCHARDGRASS-LADINO CLOVER PASTURES

	Midland bermudagrass, kg N/ha				Common bermuda	Orchardgr-ladino
Equation component	0	112	224	448	112 kg N/ha	clover
Equation number 1						
Constant	.5145	.4834	.8454	.9284	1.6512	-.4509
Elapsed days of grazing	-.0042	-.0078	-.0096	-.0078	-.0122	-.0036
ETDN, % in consumed forage	-.0020	.0119	.0079	.0067	.0031	.0245
ETDN intake, $gm/W^{.75}$	.0036	.0001	.0082	-.0054	.0034	-.0010
CP, % in consumed forage	.0069	.0033	-.0074	-.0077	-.0085	.0067
CP intake, $gm/W^{.75}$	.0005	-.0008	-.0227	.0173	-.0256	-.0042
R^2	.247[a]	.403[b]	.515[b]	.440[b]	.428[b]	.264[a]
Equation number 2						
Constant	.1874	-1.0964	1.5100	1.3776	3.7891	1.1473
Elapsed days of grazing	-.0033	-.0024	-.0109	-.0083	-.0144	-.0053
ETDN, % in strip	.0058	.0195	-.0058	-.0207	-.0398	.0141
CP, % in strip	.0163	.0731	.0055	.0476	-.0157	-.0427
R^2	.171	.461[b]	.475[b]	.460[b]	.439[b]	.213[a]

[a]Coefficients of regression are significantly different ($P<.05$) from zero.

[b]Coefficients of regression are significantly different ($P<.01$) from zero.

prediction of ADG of steers grazing orchardgrass pastures while in this study an R^2 of .25 for predicting the ADG of steers grazing OG was found.

All equations predicted ADG of steers grazing MID-N and CB better than for OG and MID-1. The reason for this finding is not clear, although it is possible that important variables affecting animal growth in these two treatments were not considered in this study. In addition, the measures of intake used by this investigator might have been less accurate because of the shorter forage. With the OG pastures, the lower R^2's may have resulted from inaccuracies in measuring the forage consumption by the cage-and-strip method due to the growing habits of the species involved.

Highly significant R^2's were obtained (.34 and .35 for equations 1 and 2, respectively) using the same equations across treatments (not shown). However, a significantly better estimate of ADG was obtained using different equations for the different species and for the same species with different levels of N fertilization. Davis (1969) improved the predictability of ADG by using separate regression equations for tall fescue and orchardgrass pastures.

Plasma Urea Nitrogen of Grazing Steers

During the third year of the experiment, blood samples were collected from the jugular vein of steers approximately every 28 days and the plasma was analyzed for urea nitrogen (PUN). As expected, PUN levels (table 21) at the beginning of the grazing season did not differ significantly. Hence, the differences observed as the season progressed were due to variation in the animals' diet. From 48 through 112 days,

TABLE 21. EFFECT OF TREATMENT ON PLASMA UREA NITROGEN LEVELS (mg/100 ml) OF YEARLING BEEF STEERS

Elapsed days of grazing	Comparison[a] 1		2		3		4		5	
	OG	BER	CB	MID	MID-1	MID-N	MID-2	MID-HN	MID-3	MID-4
0	17.96[b]	23.17[b]	21.31[c]	23.63[c]	25.69[d]	24.94[d]	24.92[e]	21.96[e]	19.74[f]	24.17[f]
48	23.51	19.73	19.55[c]	19.78[c]	14.71	21.46	18.34	23.02	20.19	25.86
75	19.64	12.53	10.38	13.07	6.99	15.10	11.06	17.12	13.59	20.64
112	15.30	9.39	6.82	10.03	5.19	11.65	8.48	13.23	11.02	15.44
133	8.13[b]	7.16[b]	7.14[c]	7.16[c]	5.29	7.79	6.88	8.24	6.33	10.15
Mean	16.19[b]	14.41[b]	13.02[c]	14.76[c]	11.57	15.82	13.94	16.76	14.34	19.18

[a]Comparisons: (1) orchardgrass-ladino clover (OG) compared to the mean of all bermudagrass (BER) pastures; (2) common bermudagrass (CB) compared to the mean of all Midland bermudagrass (MID) pastures; (3) unfertilized Midland (MID-1) compared to the mean of fertilized Midland (MID-N); (4) Midland fertilized with 112 kg N/ha (MID-2) compared to the mean of Midland fertilized with 224 and 448 kg N/ha (MID-HN); and (5) Midland fertilized with 224 kg N/ha (MID-3) compared to Midland fertilized with 448 kg N/ha (MID-4).

[b-f]Values with the same superscript for the same elapsed days of grazing are not significantly different ($P > .05$).

all contrasts were significant except contrast 2 on day 48. Animals grazing OG had a higher mean PUN concentration than did animals grazing all bermudagrasses. Animals grazing CB had a lower PUN level than did animals grazing MID. Animals grazing MID-1 had a lower PUN level than did animals grazing MID-2, MID-3 and MID-4. Animals grazing MID-2 were lower significantly in PUN content than were animals grazing MID-HN, and animals on MID-4 were higher significantly in PUN levels than were animals grazing MID-3.

Over the entire season, no significant difference was found between mean PUN level of animals grazing OG and mean PUN level of animals on all bermudagrass pastures (16.19 vs 14.41 mg/100 ml) nor was there any significant difference in the PUN levels of animals grazing CB (13.02 mg/100 ml) and those of animals grazing all MID pastures (14.76 mg/100 ml). Animals grazing MID-1 had a significantly lower PUN level (11.57 mg/100 ml) than did animals grazing MID-N (15.82 mg/100 ml). Animals consuming MID-2 forage had a significantly lower PUN level (13.94 mg/100 ml) than did animals grazing MID-HN (16.76 mg/100 ml). Animals consuming MID-3 were significantly lower in PUN (14.34 mg/100 ml) than were animals grazing MID-4 (19.18 mg/100 ml). The change in PUN level follow those with respect to CP content of the forage and, thus, the urea nitrogen content of the plasma was related to the CP content of the diet. Preston _et al_. (1965) and Torell _et al_. (1974) also found that the level of urea nitrogen in blood was related to CP intakes.

Effect of Elapsed Days of Grazing

To ascertain the effect of elapsed days of grazing on PUN levels, orthogonal contrasts of PUN levels of elapsed days of grazing within treatment were calculated (table 22). Animals grazing all bermudagrasses were significantly higher in PUN concentrations initially than the mean level for the remainder of the grazing season (contrast 1). Animals on all treatments were significantly higher in PUN prior to day 48 than the mean concentration observed from 75 through 133 days (contrast 2). Animals grazing OG, MID-3 and MID-4 were higher in PUN after 75 days than the mean level observed for the rest of the season (contrast 3) and, in addition, were significantly higher in levels also on day 112 than on day 133 (contrast 4). No significant differences in the PUN levels were apparent in animals grazing CB, MID-1 or MID-2 during the same periods (contrasts 3 and 4).

The results outlined above agree with those concerning the effect of elapsed days of grazing on CP content of the available and consumed forage. As the protein content of the forage decreased, the PUN level decreased. This decrease was not significant in the MID-1 pastures nor in those fertilized at the low level as the season progressed, indicating the elimination of the excess protein the animals had been consuming earlier in the season.

Relationship of PUN with Other Variables

As shown in table 23, PUN of animals in all treatments were highly significantly correlated with elapsed days of grazing, ADG, %CP in consumed forage and %DDM in consumed forage. PUN was significantly correalted with intake of CP and DDM per unit of metabolic weight except in animals grazing MID-1 and CB. The CP of these forages would contain a higher proportion of true protein than that of the highly

TABLE 22. EFFECT OF ELAPSED DAYS OF GRAZING ON PLASMA UREA NITROGEN LEVELS (mg/100 ml) OF YEARLING BEEF STEERS

	Comparison[a]							
	1		2		3		4	
Treatment	INT	MN-2	V-2	MN-2	V-3	MN-3	V-4	V-5
Midland, No N	25.69	8.04	14.71	5.82	6.99[d]	5.24[d]	5.19[e]	5.29[e]
Midland, 112 kg N/ha	24.92	11.19	18.34	8.81	11.06[d]	7.68[d]	8.48[e]	6.88[e]
Midland, 224 kg N/ha	19.74	12.78	20.19	10.31	13.59	8.68	11.02	6.33
Midland, 448 kg N/ha	24.17	18.02	25.86	15.41	20.64	12.80	15.44	10.15
Common, 112 kg N/ha	21.31	10.97	19.55	8.11	10.38[d]	6.98[d]	6.82[e]	7.14[e]
Orchardgr-clover	17.96[b]	16.64[b]	23.51	14.36	19.64	11.72	15.30	8.13

[a]Comparisons: (1) initial value (INT) compared to the mean of values observed after 48, 75, 112 and 133 elapsed days (MN-1); (2) day 48 (V-2) compared to the mean of values observed after 75, 112 and 133 days (MN-2); (3) day 75 (V-3) compared to the mean values observed after 112 and 133 days (MN-3); and (4) day 112 (V-4) compared to day 133 (V-5).

[b-e]Values with the same superscript in the same treatment are not significantly different ($P > .05$).

TABLE 23. SIMPLE COEFFICIENTS OF CORRELATION OF PLASMA UREA NITROGEN WITH ELAPSED DAYS OF GRAZING, ADG, DDM AND CP CONTENT OF CONSUMED FORAGE AND DDM AND CP INTAKE PER UNIT OF METABOLIC WEIGHT

Variables	Midland bermudagrass, kg N/ha				Common bermuda 112 kg N/ha	Orchardgr-ladino clover
	0	112	224	448		
Elapsed days of grazing	-.80[b]	-.86[b]	-.80[b]	-.74[b]	-.71[b]	-.64[b]
Average daily gain	.49[b]	.80[b]	.68[b]	.45[b]	.68[b]	.44[b]
DDM, % in consumed forage	.45[b]	.66[b]	.58[b]	.30[b]	.53[b]	.56[b]
DDM intake, $gm/W^{.75}$	-.15	.46[b]	.34[a]	.11	-.11	.62[b]
CP, % in consumed forage	.66[b]	.62[b]	.63[b]	.79[b]	.50[b]	.74[b]
CP intake, $gm/W^{.75}$	-.20	.71[b]	.39[b]	.38[b]	.17	.73[b]

[a]Coefficients of correlation are significantly different ($P<.05$) from zero.

[b]Coefficients of correlation are significantly different ($P<.01$) from zero.

fertilized forages. Thus, as Lewis (1957) found, the urea level of whole blood is not related necessarily to the total CP intake but is related to the ammonia-producing ability of the CP.

When the data from all treatments were combined, PUN was significantly correlated with elapsed days of grazing, %CP in consumed forage, CP intake per unit of metabolic weight, %DDM in consumed forage and ADG (r = .70, .69, .19, .47 and .53, respectively). The relationship with ADG was most interesting particularly because a low PUN level would indicate that animal performance was limited by the CP level of the diet.

Prediction of Composition and Consumption of Forage and ADG from PUN Levels

It has been shown that PUN was highly significant when correlated with ADG, %CP in consumed forage, CP intake per unit of metabolic weight and %DDM in consumed forage. If PUN could be used to estimate these variables, it would be of practical value for estimating nutritional value of pastures in terms of CP adequacy.

Regression equations (tables 24 and 25) for using PUN to predict %CP and DDM in consumed forage and CP intake per unit of metabolic weight and ADG, respectively. For the prediction of ADG and %CP in consumed forage, R^2's were significant in all treatments. The prediction of CP intake per unit of metabolic weight was significant in all treatments except MID-1. R^2 for the estimation of %CP in consumed forage was significantly greater than the R^2 for the estimation of CP intake per unit of metabolic weight except in the OG treatment. These comparisons indicate that the amount of ammonia formation in the rumen was related

TABLE 24. EQUATIONS DESCRIBING THE REGRESSION OF CP AND DDM CONTENT ($\hat{y}$) OF CONSUMED FORAGE PLASMA UREA NITROGEN (PUN)[a]

Treatment	Constant	Coefficients of: PUN	PUN^2	PUN^3	R^2
		- -%CP in consumed forage- -			
Midland, No N	5.4526	1.0937	-.0402	.0005	.55[c]
Midland, 112 kg N/ha	-12.7870	4.4538	-.2025	.0028	.80[c]
Midland, 224 kg N/ha	5.8795	.5622	.0209	-.0007	.49[c]
Midland, 448 kg N/ha	-2.7202	1.2853	.0171	-.0008	.72[c]
Common, 112 kg N/ha	9.9298	.3730	.0080	-.0003	.28[b]
Orchardgr-clover	25.9549	-3.9036	.3351	-.0069	.57[c]
		- -%DDM in consumed forage- -			
Midland, No N	44.6497	.6203	-.0116	.0002	.20
Midland, 112 kg N/ha	60.1460	-2.8823	.1971	-.0031	.47[c]
Midland, 224 kg N/ha	35.5736	.2075	.1004	-.0023	.39[c]
Midland, 448 kg N/ha	73.2656	-4.1486	.2386	-.0036	.12
Common, 112 kg N/ha	64.6954	-4.3354	.3087	-.0054	.44[c]
Orchardgr-clover	55.4800	-.5382	.0965	-.0022	.32[c]

[a] $\hat{y}$ = constant + $b_1PUN + b_2PUN^2 + b_3PUN^3$, where PUN = plasma urea nitrogen, mg/100 ml.

[b] Coefficients of regression are significantly different (P<.05) from zero.

[c] Coefficients of regression are significantly different (P<.01) from zero.

TABLE 25. EQUATIONS DESCRIBING THE REGRESSION OF CP INTAKE PER UNIT OF METABOLIC WEIGHT AND ADG ($\hat{y}$) ON PLASMA UREA NITROGEN (PUN)[a]

		Coefficients of:			
Treatment	Constant	PUN	PUN^2	PUN^3	R^2
		- - CP intake, g per unit metabolic weight - -			
Midland, No N	17.0510	.0317	-.0254	.005	.04
Midland, 112 kg N/ha	18.8680	-2.7480	.1869	-.0031	.56[c]
Midland, 224 kg N/ha	.1741	1.6273	-.0775	.0015	.17[b]
Midland, 448 kg N/ha	-13.5170	2.3430	-.0709	.0007	.21[b]
Common, 112 kg N/ha	3.9919	1.2739	-.0307	---	.20[b]
Orchardgr-clover	43.4366	-10.0110	.7837	-.0161	.56[c]
		- - - - - ADG, kg/day - - - -			
Midland, No N	.8126	-.0971	.0064	-.00009	.30[b]
Midland, 112 kg N/ha	.3013	-.0422	.0094	-.00018	.67[c]
Midland, 224 kg N/ha	.3635	-.1460	.0150	-.0003	.52[c]
Midland, 448 kg N/ha	1.8868	-.2844	.0144	-.0002	.25[c]
Common, 112 kg N/ha	1.031	-.2286	.0194	-.0003	.56[c]
Orchardgr-clover	-.3161	.1122	-.0019	---	.21[b]

[a] $\hat{y}$ = constant + b_1PUN + b_2PUN^2 + b_3PUN^3, where PUN = plasma urea nitrogen, mg/100 ml.

[b] Coefficients of regression are significantly different (P<.05) from zero.

[c] Coefficients of regression are significantly different (P<.01) from zero.

to the %CP which, in turn, was related to the amount of non-protein nitrogen in fertilized bermudagrass forages. In animals grazing OG, PUN was equally good in estimating CP intake per unit of metabolic weight and %CP in consumed forage.

If PUN levels of 8, 19, 15, 20 and 25 mg/100 ml are incorporated into regression equations, the estimated percentage of CP in consumed forage and CP intake per unit of metabolic weight ($W^{.75}_{kg}$) would be as shown in table 26. The protein requirement of a 300-kg steer gaining .5 kg/day is 10% of the ration (NRC, 1970) or 8.5 g per $W^{.75}_{kg}$ (Preston, 1966). Thus, a PUN content of 10 mg/100 ml would indicate that animals were consuming adequate protein on a percentage basis. Similar results were obtained by Preston _et al._ (1965). However, on the basis of intake per $W^{.75}_{kg}$, MID-1, MID-3 and CB appeared to meet the CP requirement when the PUN level was 10 mg/100 ml. At a PUN level of 15 mg/100 ml, MID-2 and OG became adequate and at a PUN level of 20 mg/100 ml, MID-4 pastures would provide at least 8.5 g of utilizable CP per $W^{.75}_{kg}$, indicating again that ammonia formation in the rumen was more a function of the CP percentage in fertilized grasses than it was a function of the amount of CP actually consumed and that the level of non-protein nitrogen in the forage was a function of fertilization level.

Amino Acid Composition of Some Forages

Amino Acid Composition

When the amino acid (AA) content was expressed as a percentage of the forage dry matter, OG forage contained significantly more methionine and leucine (table 27) than the mean of MID-1 and MID-4 (.119 _vs._ .059%

TABLE 26. ESTIMATED CP CONTENT OF CONSUMED FORAGE AND CP INTAKE PER UNIT OF METABOLIC WEIGHT AT VARIOUS PLASMA UREA NITROGEN LEVELS

Plasma urea nitrogen mg/100 ml	Midland bermuda No N		Midland bermuda 112 kg N		Midland bermuda 224 kg N		Midland bermuda 448 kg N		Common bermuda 112 kg N		Orchardgr-ladino clover	
	%[a]	W$^{.75}$[b]	%[a]	W$^{.75}$[b]	%[a]	W$^{.75}$[b]	%[a]	W$^{.75}$[b]	%[a]	W$^{.75}$[b]	%[a]	W$^{.75}$[b]
8	11.89	15.9	11.32	7.3	11.36	9.0	8.25	1.0	13.27	12.6	12.64	5.3
10	12.87	15.3	14.30	6.9	12.89	10.2	11.04	3.5	14.16	14.4	13.53	5.6
15	14.50	13.5	17.91	9.2	16.65	12.2	17.71	8.0	16.31	16.7	19.51	15.3
20	15.25	11.5	17.69	13.9	19.88	13.7	23.43	10.6	18.19	16.6	26.72	27.9
25	15.48	9.8	15.75	18.5	22.06	15.9	27.60	11.7	19.57	15.0	29.99	31.4

[a]Percent CP in consumed forage.

[b]CP intake, gm per unit of metabolic weight.

TABLE 27. AMINO ACID PERCENTAGE OF DM OF MIDLAND BERMUDAGRASS AND ORCHARDGRASS-LADINO CLOVER FORAGE

	Comparison[a]			
	1		2	
Amino Acid	OG	MID	MID-1	MID-4
	- - - - - - - - - - Percent of DM - - - - - - - - -			
Tyrosine	.307	.236	.189[b]	.283[b]
Phenylalanine	.487	.405	.324	.486
Lysine	.377	.399	.337	.461
Histidine	.160	.125	.092	.157
Arginine	.471	.409	.333[b]	.484[b]
Aspartic acid	.599	.677	.484[b]	.870[b]
Glutamic acid	.547	.602	.533	.671
Threonine	.354	.309	.270	.347
Proline	.201	.250	.203	.297
Serine	.246	.272	.256	.289
Alanine	.696	.576	.438[b]	.713[b]
Glycine	.349	.345	.306	.384
Valine	.528	.448	.366	.531
Methionine	.119[b]	.060[b]	.005[b]	.114[b]
Isoleucine	.424	.298	.219	.376
Leucine	.519[b]	.299[b]	.158[b]	.441[b]

[a]Comparisons: (1) orchardgrass-ladino clover (OG) compared to the mean of unfertilized Midland bermudagrass and Midland fertilized with 448 kg N/ha (MID); and (2) unfertilized Midland (MID-1) compared to Midland fertilized with 448 kg N/ha (MID-4).

[b]Values for the same amino acid in the same comparison are significantly different ($P<.05$).

and .519 vs. .299%, respectively). OG also had a higher tyrosine and isoleucine content (P>.05).

MID-4 contained a higher percentage of all AA's than did MID-1 (contrast 2). The difference was significant with respect to methionine, tyrosine, arginine, aspartic acid, alanine and leucine but was not significant with respect to phenylalanine, histidine, lysine, valine and isoleucine. This increase in AA content, when expressed as a percentage of the forage dry matter, was due to the increase in CP content with N fertilization. Smith and Agiza (1951), Waite et al. (1953) and Goswami and Willcox (1969) observed an increase in levels of all AA's as the level of N application was increased. Keser (1955), when studying sulfur-containing AA's only, reported a decrease in these AA's under N-deficient conditions.

When AA composition was expressed as a percentage of the CP (table 28), Midland bermudagrass contained significantly more serine, lysine, aspartic acid, glutamic acid and glycine than did OG. The latter contained significantly more methionine. MID-1 contained significantly more arginine, threonine, serine, glycine, valine, phenylalanine, lysine, glutamic acid and alanine than did MID-4. The latter contained a significantly higher percentage of methionine than did MID-1. If the concentration had been expressed as the percent of true protein, there might not have been any significant differences. Goswami and Willcox (1969) found that N fertilization had little effect on AA levels when AA composition of the protein fraction was expressed as a percentage of total protein.

The general order of AA's (mean of the three treatments, not

TABLE 28. AMINO ACID PERCENTAGE OF CP OF MIDLAND BERMUDAGRASS AND ORCHARDGRASS-LADINO CLOVER FORAGE

	Comparison[a]			
	1		2	
Amino Acid	OG	MID	MID-1	MID-4
	-Percent of CP-			
Tyrosine	1.723	1.699	1.891	1.506
Phenylalanine	2.603	2.799	3.180[b]	2.418[b]
Lysine	2.084[b]	2.874[b]	3.435[b]	2.312[b]
Histidine	.884	.888	.925	.851
Arginine	2.519	2.838	3.269[b]	2.407[b]
Aspartic acid	3.172[b]	4.378[b]	4.659	4.097
Glutamic acid	2.911	4.066	4.980[b]	3.152[b]
Threonine	1.883	2.156	2.582[b]	1.730[b]
Serine	1.323	1.948	2.453[b]	1.444[b]
Proline	.986	1.515	1.801	1.228
Alanine	3.656	3.789	4.160[b]	3.418[b]
Glycine	1.806	2.318	2.817[b]	1.819[b]
Valine	2.768	2.981	3.381[b]	2.581[b]
Methionine	.707[b]	.312	.055[b]	.568[b]
Isoleucine	2.247	2.090	2.286	1.893
Leucine	2.772	2.080	1.878	2.282

[a]Comparisons: (1) orchardgrass-ladino clover (OG) compared to the mean of unfertilized Midland and Midland bermudagrass fertilized with 448 kg N/ha (MID); and (2) unfertilized Midland (MID-1) compared to Midland fertilized with 448 kg N/ha (MID-4).

[b]Values for the same amino acid in the same comparison are significantly different ($P<.05$).

shown) from high to low percentage of CP was: aspartic acid (4.0), alanine (3.7), glutamic acid (3.6), valine (2.9), phenylalanine (2.7), arginine (2.7), lysine (2.6), leucine (2.3), glycine (2.1), isoleucine (2.1), threonine (2.0), tyrosine (1.7), serine (1.7), proline (1.3), histidine (.9) and methionine (.5). Loper et al (1963), using alfalfa at four stages of growth, reported that, generally, the order from high to low percentage was aspartic acid, glutamic acid, leucine, valine, alanine, glycine, arginine, phehylalanine, lysine, serine, isoleucine, proline, threonine, tyrosine, histidine and methionine. Results of the present study were remarkably similar to those of Loper et al. (1963).

Effect of Elapsed Days of Grazing on Amino Acid Composition of Forage

When the AA composition was expressed as a percentage of the forage dry matter, most AA's decreased during the season but methioine stayed at about the same level and leucine increased in MID-1 forage. Isoleucine and histidine percentages increased in MID-4 and tyrosine and methionine increased in OG as the season progressed.

When expressed as a percentage of the CP, tyrosine, phenylalanine, lysine, histidine, arginine, threonine, serine, methionine and leucine increased in concentration in all treatments as the season progressed. In addition, aspartic acid, alanine and isoleucine percentage increased in MID-1, isoleucine percentage increased in MID-4 and glutamic acid percentage increased in OG. Proline, glycine and valine percentages decreased during the season in all three forages. In addition, glutamic acid level decreased in MID-1; aspartic acid, glutamic acid and alanine levels decreased in MID-4; and aspartic acid, alanine and isoleucine levels decreased in OG. Smith and Agiza (1951), working with grasses, found increases in glutamic and aspartic acid levels with increasing maturity and decreases in lysine, arginine and leucine levels. Loper et al. (1963) mentioned that, in alfalfa, aspartic and glutamic acid levels were lower at the full bloom stage than at the pre-bud stage.

Correlation of Amino Acid Levels with Crude Protein Percentage

When expressed as a percentage of the forage dry matter (table 29), arginine, aspartic acid, glutamic acid, threonine, serine, alanine, glycine, valine, phenylalanine, tyrosine, lysine, histidine and isoleucine were correlated positively with percent CP in the forage of MID-1. Leucine and methionine levels were correlated negatively with percent forage CP.

In MID-4, lysine, methionine and leucine were correlated positively and histidine and isoleucine correlated negatively with forage CP. Smaller correlations of glutamic acid, threonine, serine and proline levels were found in OG but a higher correlation of the isoleucine level was found with forage CP percentage than with Midland bermudagrass. The mean composition of the three forages gave a significant positive correlation of levels of all AA's, except histidine, with forage CP percentage.

When the AA content was expressed as a percentage of the CP (table 30) and correlated with the %CP in the forage, the coefficients were primarily negative and were not significant. In MID-1, leucine and lysine were correlated significantly (r = -.86 and -.83, respectively) with CP percentage in the forage.

In heavily fertilized Midland, proline, tyrosine and histidine levels had significant correlations (r = .88, -.73 and -.71,

TABLE 29. SIMPLE COEFFICIENTS OF CORRELATION OF AMINO ACID PERCENTAGE OF FORAGE DM, WITH CRUDE PROTEIN CONTENT OF FORAGE

Amino Acid	Midland bermudagrass No N	Midland bermudagrass 448 kg N/ha	Orchardgrass-ladino clover	Overall
Tyrosine	.383	.206	-.030	.440[a]
Phenylalanine	.689	.713[a]	.646	.747[b]
Lysine	.342	.711[a]	.185	.512[b]
Histidine	.196	-.050	.122	.312
Arginine	.926[b]	.808[b]	.665	.806[b]
Aspartic acid	.840[b]	.762[a]	.718[a]	.717[b]
Glutamic acid	.770[a]	.696[a]	.440	.538[b]
Threonine	.963[b]	.757[a]	.504	.658[b]
Serine	.948[b]	.694[a]	.520	.544[b]
Proline	.697	.923[b]	.482	.610[b]
Alanine	.936[b]	.912[b]	.870[b]	.905[b]
Glycine	.938[b]	.818[b]	.716[a]	.694[b]
Valine	.930[b]	.827[b]	.864[b]	.840[b]
Methionine	-.001	.412	-.477	.441[a]
Isoleucine	.074	-.352	.809[b]	.550[b]
Leucine	-.672	.203	.439	.465[a]

[a]Coefficients of correlation are significantly different ($P<.05$) from zero.

[b]Coefficients of correlation are significantly different ($P<.01$) from zero.

TABLE 30. SIMPLE COEFFICIENTS OF CORRELATION OF AMINO ACID PERCENTAGE OF FORAGE CP, WITH CRUDE PROTEIN CONTENT OF FORAGE

Amino Acid	Midland bermudagrass No N	Midland bermudagrass 448 kg N/ha	Orchardgrass-ladino clover	Overall
Tyrosine	-.448	-.726[a]	-.652	-.563[b]
Phenylalanine	-.610	-.171	-.118	-.473[a]
Lysine	-.831[a]	-.280	-.430	-.652[b]
Histidine	-.273	-.707[a]	-.330	-.348
Arginine	-.717	-.182	-.149	-.561[b]
Aspartic acid	-.306	.448	.034	-.088
Glutamic acid	.095	.352	-.023	-.247
Threonine	-.594	-.193	-.020	-.502[b]
Serine	-.520	-.184	-.160	-.624[b]
Proline	.272	.880[b]	.336	.178
Alanine	-.221	.585	.311	-.111
Glycine	.367	.470	.337	-.192
Valine	.385	.239	.343	-.202
Methionine	-.140	-.083	-.659[a]	.181
Isoleucine	-.624	-.175	.028	-.290
Leucine	-.865[b]	-.440	-.076	-.137

[a]Coefficients of correlation are significantly different ($P<.05$) from zero.

[b]Coefficients of correlation are significantly different ($P<.01$) from zero.

respectively) with %CP of forage. Only methionine and tyrosine (r = -.66 and -.65, respectively) approached having a significant corresponding correlation in the case of OG forage. With respect to the mean composition of the three forages, all AA levels, except those of proline and methionine, were correlated negatively with the %CP in the forage. Tyrosine, lysine, arginine, threonine, serine and phenylalanine levels were correlated significantly with %CP of forage.

Thus when total CP content increased, most AA levels showed a decrease when expressed as a percentage of the CP. These same amino acids showed an increase when expressed as a percentage of forage DM. Such findings indicate that, with increasing CP levels, non-protein nitrogen increased at a faster rate than did true protein.

General Discussion

The CP content of unfertilized Midland bermudagrass was too low for growing beef steers and, with an N fertilization level of 112 kg/ha, the CP level was not adequate throughout the grazing season. An application of 224 kg N/ha/year provided CP in excess of the animals' needs; therefore, three applications of 56 kg N/ha (168 kg/ha/year) should maintain a more constant and desirable CP level. An N-fertilization level of 448 kg/ha was too high for a grazing program. The stocking rate to keep the forage grazed would be so great that overcrowding and fouling by urine and feces would decrease forage consumption and animal performance. Such a high level of fertilization might be better for hay production from Midland bermudagrass.

Midland bermudagrass was deficient in ETDN for growing beef cattle. This cannot be corrected by N fertilization; therefore, a Midland-legume combination might provide the additional ETDN level necessary to make Midland bermudagrass a high quality forage for growing beef steers.

Common and Midland bermudagrass fertilized with 112 kg N/ha/year were of equal nutritive value. Possibly greater use, particularly of established stands of common bermudagrass, could be made of such forage for beef production than is being done at the present.

Under the climatic conditions of this study, orchardgrass-ladino clover provided more ETDN and CP throughout the grazing season than did Midland and common bermudagrass at all levels of N fertilization.

Multiple regression equations, developed for the prediction of ADG from forage composition, had higher coefficients of regression than did equations developed for the prediction of ADG from forage consumption. Therefore, the simple difference between the cage and strip samples apparently was not an accurate measure of the amount of forage actually consumed by the animal.

Plasma urea nitrogen correlated significantly with elapsed days of grazing, ADG and %CP in consumed forage. The level of plasma urea nitrogen was not necessarily related to the total CP intake but was related to the ammonia-producing ability of the CP. Therefore, this blood constituent could be used for estimating the nutritional value of pastures in terms of CP adequacy.

CHAPTER V

SUMMARY

Midland bermudagrass pastures not fertilized with N or fertilized, in three equal installments, with either 112, 224 or 448 kg N/ha/year were compared to common bermudagrass fertilized with 112 kg N/ha/year and to orchardgrass-ladino clover pastures. Forage consumption was determined by the cage-and-strip method from the middle of April to the middle of September during three consecutive years. Angus yearling steers weighing about 215 kg were used in a modified put-and-take grazing system. Individual weights of all tester animals were taken at 14-day intervals. *In vitro* digestible dry matter (Tilley and Terry, 1963) and N (Autoanalyzer) were determined on all forage samples from the three years. During the last year, selected forage samples were analyzed for their amino acid content and jugular blood samples, obtained from all tester animals at monthly intervals, were analyzed for plasma urea nitrogen (PUN).

Forage compositon and intake data from the three years were reduced to polynomials describing the regression of *in vitro* digestible dry matter (IVDDM) and crude protein (CP) content and the intake of total digestible nutrients (TDN) and CP on elapsed days of grazing (D). The results of these regression equations were used to generate predicted percentages and ETDN and CP intake of IVDDM, TDN and CP for 20-day intervals for a period of 140 elapsed days of grazing. A least-squares regression procedure was used to evaluate the effect of treatments and

elapsed days of grazing on amino acid composition of forage and plasma urea nitrogen levels of yearling steers. Orthogonal contrasts were used for mean separation when significant F (P<.05) ratios were obtained.

Nitrogen fertilization increased the mean IVDDM content of Midland bermudagrass (45.6, 46.5, 47.4 and 48.5% for MID-1, MID-2, MID-3 and MID-4, respectively) but only MID-4 was significantly greater than MID-1. A decrease (P<.05) of IVDDM from April to September was observed in all treatments (50.8 to 37.7; 54.3 to 33.7; 56.6 to 34.2; 57.1 to 34.9; 49.8 to 40.2; and 69.2 to 58.3% for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively). When IVDDM was converted to ETDN and the results compared to the theoretical TDN requirements of a 300-kg steer gaining .5 kg/day (57%), available forage from all bermudagrass pastures were lower than this theoretical requirement throughout the grazing season. However, OG forage was adequate in TDN throughout the season.

N fertilization increased (P<.05) the CP content of Midland bermudagrass pastures at all levels of fertilization (9.5, 10.7, 13.0 and 16.1% for MID-1, MID-2, MID-3 and MID-4, respectively). However, over the entire season, OG pastures contained more (P<.05) CP (17.7%) than the mean of all bermudagrass forages. The CP content of all forages decreased (P<.05) from April to September (14.3 to 7.5; 17.6 to 7.8; 18.2 to 10.1; 23.2 to 12.6; 17.2 to 7.9; and 19.1 to 16.2% for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively). The CP requirement of a 300-kg steer gaining .5 kg/day is 10% of the ration. Thus, although the addition of N increased the CP content of bermudagrass, the available forage from MID-2 was deficient in CP from day 80 to the end of the season. MID-1 was adequate in CP for only the first 50 days of the grazing season. It appeared that N fertilization was not required to maintain the desired CP content of bermudagrass forage in the early spring. Possibly the fertilization program should include three applications of approximately 56 kg N/ha from May through the middle of July if a more constant and desirable protein level is to be maintained.

OG contained more (P<.05) TDN in the consumed forage (61.7%) than the mean of all bermudagrasses (51.2%). No significant differences were noted in the percentages of ETDN in consumed forage in the bermudagrass treatments (50.4, 51.1, 51.2, 51.6 and 51.6% for MID-1, MID-2, MID-3, MID-4 and CB, respectively). The %ETDN in consumed forage decreased (P<.05) during the season in all treatments (62.3 to 45.8; 59.8 to 42.3; 61.6 to 43.6; 65.8 to 49.9; 57.2 to 48.6; and 67.6 to 57.8% for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively). The forage consumed from CB and MID-1 satisfied the theoretical TDN requirement only during the first 40 days of the season. Midland forages in the four N-fertilization treatments satisfied the TDN requirement only during the first 60 days. OG forage met the requirement throughout the season.

The mean CP content of consumed OG forage during the entire season was 19.0% compared to 15.0% for all bermudagrasses (P<.05). CB contained less (P<.05) CP on the average (13.4%) than the mean of all Midland forages (15.4%). MID-1 contained less (P<.05) CP (11.4%) than MID-N (16.7%) and MID-HN contained more (P<.05) CP (17.8%) in the consumed forage than did MID-2. MID-4 contained 21.1% CP in consumed forage compared to 14.5% in MID-3 (P<.05). The CP content of consumed forage in all treatments decreased ($P<.05$) during the season (17.0 to 11.5; 17.3 to 12.0; 19.2 to 12.6; 30.2 to 17.3; 19.4 to 8.1; and 20.2 to 16.5% for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively). The %CP required for 200-kg steers to gain at least .5 kg/day is 11.1% and the requirement for 300-kg steers is 10.0% of the ration. The CP content of the consumed forages was adequate in all treatments throughout the season, except for CB after 120 days and for MID-1 forage between day 60 and day 120.

The animals grazing OG consumed 2.54 kg/day ETDN above maintenance compared to 1.57 kg/day ($P<.05$) for animals grazing all bermudagrasses. No significant difference was apparent in ETDN consumption above maintenance of animals on CB 1.79 kg/day compared to consumption of animals grazing all Midland forages (1.51 kg/day). No significant difference was noted in consumption of animals grazing MID-N (1.41 kg/day) compared to that of animals grazing MID-1 (1.81 kg/day). Animals grazing MID-2 consumed more ($P<.05$) ETDN (2.24 kg/day) than did animals grazing MID-HN (1.00 kg/day). Animals grazing MID-3 consumed more ($P<.05$) ETDN above maintenance (1.30 kg/day) than did animals grazing MID-4 (.69 kg/day). The TDN requirement above maintenance for a 300-kg steer gaining .5 kg/day is 2.0 kg/day. Animals consuming OG forage were consuming enough ETDN during all periods except prior to 20 days and after 120 elapsed days. Animals consuming CB were receiving adequate TDN between day 60 and day 120 but were below the requirement to support an ADG of .5 kg during the rest of the season. Animals grazing MID-1 were deficient in ETDN intake between elapsed days 60 and 120. MID-2 provided enough ETDN above maintenance prior to 100 days. On MID-HN, the animals were not consuming enough ETDN above maintenance at anytime during the season.

The animals grazing OG consumed an average of 1.08 kg/day above maintenance which was greater (P<.05) than the mean consumption of animals grazing all bermudagrass pastures (.38 kg/day). No significant difference was noted in the consumption of CP above maintenance of animals on CB (.42 kg/day) compared to the consumption of animals on all Midland forages (.37 kg/day). Animals grazing MID-N consumed more (P<.05) CP above maintenance (.52 kg/day) than did animals grazing MID-1 (-.08 kg/day). No significant (P>.05) difference was apparent in the CP consumption above maintenance of animals grazing MID-2 (.52 kg/day) compared to that of animals grazing MID-HN (.52 kg/day). No significant difference was found in the CP consumption for animals on MID-3 and MID-4 (.50 and .53 kg/day, respectively). The CP requirement above maintenance for a 300-kg steer gaining .5 kg/day is .14 kg/day. Thus, animals grazing CB were not consuming enough CP above maintenance after 120 days to support an ADG of .5 kg. Animals grazing MID-1 did not consume enough CP for ADG after 60 elapsed days and were below their maintenance requirement at that time. Animals grazing MID-N pastures consumed adequate CP above maintenance at all times during the season.

Multiple regression equations were developed for the prediction of ADG from forage composition and consumption. All equations gave a more reliable prediction of ADG for steers grazing fertilized Midland and common bermudagrass pastures than for steers grazing unfertilized Midland and orchardgrass-ladino clover pastures.

Over the entire season, no significant difference was discerned between the mean PUN level of animals grazing OG (16.19 mg/100 ml) and that of animals on all bermudagrasses (14.41 mg/100 ml), nor did a significant difference exist between the PUN level of animals grazing CB (13.02 mg/100 ml) and that of animals on all Midland pastures (14.76 mg/100 ml). Animals grazing MID-1 had a lower ($P<.05$) PUN level (11.57 mg/100 ml) than did animals grazing MID-N (15.82 mg/100 ml). Animals consuming MID-2 had a lower ($P<.05$) PUN level (13.97 mg/100 ml) than did animals grazing MID-HN (16.76 mg/100 ml). Animals consuming MID-3 had a lower ($P<.05$) PUN (14.34 mg/100 ml) than did animals grazing MID-4 (19.18 mg/100 ml). Regression equations are presented to predict ADG, %CP in consumed forage, %DDM of consumed forage and CP intake per $W^{.75}_{kg}$ from PUN levels (.30, .67, .52, .25, .56, .21; .55, .80, .49, .72, .28, .57; .20, .47, .39, .12, .44, .32; and .04, .56, .17, .21, .20, .56 for MID-1, MID-2, MID-3, MID-4, CB and OG, respectively).

The general order of amino acid levels, from high to low, expressed as a percentage of forage CP was: aspartic acid, alanine, glutamic acid, valine, phenylalanine, arginine, lysine, leucine, glycine, isoleucine, threonine, tyrosine, serine, proline, histidine and methionine. Midland bermudagrass contained more ($P<.05$) serine, lysine, aspartic acid, glutamic acid and glycine than did OG. The latter contained more ($P<.05$) methionine than the mean content of MID-1 and MID-4. MID-1 contained significantly more arginine, threonine, serine, glycine and valine than did MID-4. MID-4 contained a higher ($P<.05$) percentage of methionine than did MID-1.

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APPENDIX

TABLE 31. UNADJUSTED MEANS OF AVERAGE DAILY WEIGHT GAIN AND COMPOSITION OF AVAILABLE AND CONSUMED FORAGE

Variable	Midland bermudagrass, kg N/ha				Common bermuda 112 kg N/ha	Orchardgr-ladino clover
	0	112	224	448		
Average daily gain, kg	.3495	.445	.419	.513	.537	.763
DM, % in consumed forage	93.85	94.25	94.01	94.61	93.87	93.16
DM, % in available forage	93.99	93.88	93.79	93.81	93.66	93.53
DDM, % in consumed forage	50.2	51.76	54.9	54.8	57.3	64.4
DDM, % in available forage	47.7	47.5	48.5	49.6	48.3	62.9
TDN, % in consumed forage	50.1	50.82	51.0	51.4	51.4	61.7
TDN, % in available forage	45.9	47.08	47.8	48.9	47.7	60.4
CP, % in consumed forage	11.01	14.34	15.6	20.48	13.25	19.57
CP, % in available forage	9.79	11.18	13.84	17.25	11.47	19.07

TABLE 32. UNADJUSTED MEANS OF DM, DDM, TDN, AND CP CONSUMPTION

Variable	Midland bermudagrass, kg N/ha 0	112	224	448	Common bermuda 112 kg N/ha	Orchardgr-ladino clover
DM intake, kg/day	9.57	9.01	7.10	5.77	8.18	7.97
DM intake, kg/100 kg BW	2.64	2.66	2.16	1.71	2.42	2.28
DM intake, $g/W^{.75}_{kg}$	110.2	108.8	99.9	73.4	103.8	106.7
DDM intake, kg/day	4.06	4.52	3.63	3.05	4.14	5.12
DDM intake, kg/100 kg BW	1.28	1.38	1.18	.91	1.23	1.46
DDM intake, $g/W^{.75}_{kg}$	53.8	58.9	47.1	39.0	52.6	63.4
TDN intake, kg/day	3.99	4.55	3.57	2.99	4.08	4.91
TDN intake above maintenance, kg/day	1.79	2.24	1.29	.68	1.76	2.5
TDN intake, kg/100 kg BW	1.26	1.34	1.09	.96	1.21	1.40
TDN intake, $g/W^{.75}_{kg}$	53.3	76.7	46.4	39.1	51.7	60.8
CP intake, kg/day	.94	1.01	1.06	1.08	1.03	1.58
CP intake above maintenance, kg/day	.50	.55	.60	.83	.57	1.10
CP intake, g/100 kg BW	296.1	301.4	324.7	322.9	308.8	428.6
CP intake, $g/W^{.75}_{kg}$	16.9	12.9	13.8	13.9	13.2	19.4

TABLE 33. LEAST-SQUARES MEANS OF AVERAGE ANIMAL WEIGHT, AVERAGE DAILY WEIGHT GAIN, AND COMPOSITION OF AVAILABLE AND CONSUMED FORAGE

Variable	Midland bermudagrass, kg N/ha				Common bermuda 112 kg N/ha	Orchardgr-ladino clover
	0	112	224	448		
Average weight, kg	315.3	332.5	327.8	333.6	334.7	351.1
Average daily gain, kg	.375	.470	.444	.538	.562	.774
DM, % in consumed forage	93.86	94.25	94.01	94.61	93.87	93.18
DM, % in available forage	93.95	93.84	93.75	93.77	93.62	93.49
DDM, % in consumed forage	50.88	52.44	55.60	55.52	57.96	64.77
DDM, % in available forage	47.82	47.60	48.58	49.68	48.36	62.94
TDN, % in consumed forage	50.77	51.50	51.69	52.10	52.05	62.13
TDN, % in available forage	45.95	47.14	47.87	48.96	47.79	60.37
CP, % in consumed forage	11.09	14.42	15.68	20.57	13.33	19.63
CP, % in available forage	10.02	11.40	14.07	17.47	11.69	19.19

TABLE 34. LEAST-SQUARES MEANS OF DM, DDM, TDN, AND CP CONSUMPTION

Variable	Midland bermudagrass, kg N/ha 0	112	224	448	Common bermuda 112 kg N/ha	Orchardgr-ladino clover
DM intake, kg/day	8.83	8.27	6.35	5.03	7.43	7.19
DM intake, kg/100 kg BW	2.43	2.45	1.96	1.51	2.22	2.05
DM intake, $g/W_{kg}^{.75}$	100.4	99.1	90.2	63.7	94.1	97.1
DDM intake, kg/day	3.79	4.24	3.36	2.78	3.87	4.80
DDM intake, kg/100 kg BW	1.20	1.30	1.11	.84	1.16	1.37
DDM intake, $g/W_{kg}^{.75}$	50.6	55.6	43.8	35.7	49.4	59.4
TDN intake, kg/day	3.70	4.26	3.28	2.71	3.79	4.58
TDN intake above maintenance, kg/day	1.51	1.96	1.01	.40	1.48	2.18
TDN intake, kg/100 kg BW	1.18	1.27	1.02	.89	1.14	1.31
TDN intake, $g/W_{kg}^{.75}$	52.8	76.2	46.0	38.7	51.3	57.1
CP intake, kg/day	.86	.92	.97	.99	.94	1.48
CP intake above maintenance, kg/day	.42	.47	.52	.75	.49	1.00
CP intake, g/100 kg BW	272.9	278.3	301.3	299.8	285.7	401.1
CP intake, $g/W_{kg}^{.75}$	16.0	11.9	12.8	13.0	12.2	18.2

TABLE 35. ANALYSIS OF VARIANCE FOR FORAGE COMPOSITION AND CONSUMPTION

Source of Variation	dF	Dry Matter		Total Digestible Nutrients			Crude Protein		
		% in consumed forage	intake, g/day/$W^{.75}_{kg}$	% in consumed forage	intake, kg/day above maintenance	intake, g/day/$W^{.75}_{kg}$	% in consumed forage	intake, kg/day above maintenance	intake, g/day/$W^{.75}_{kg}$
		- - -	- - -	- - -	- - -	mean squares	- - -	- - -	- - -
Treatment (TMT)	5	6.584^c	3272.7^c	259.5^c	6.158^c	1022.9^c	187.87^c	1.901^c	108.98^c
Replication (REP)	1	4.044^b	133.5	75.8^b	.116	50.6	.969	.082	23.99^a
Elapsed days of grazing (D)	6	2.664^c	1354.9^b	355.5^c	1.751^c	379.1^c	77.97^c	1.420^c	88.65^c
TMT*REP	5	3.631^c	2451.5^c	8.4	1.950^b	269.4^c	13.82	.274^a	13.73^a
TMT*D	30	1.140^c	762.9	10.2	.541^b	83.4^b	9.68	.216^b	22.45^b
REP*D	6	.561	788.2	12.4	.028	14.02	3.67	.006	12.36^a

$^a P < .05$

$^b P < .01$

$^c P < .001$

TABLE 36. EFFECT OF ELAPSED DAYS OF GRAZING ON DM CONTENT OF CONSUMED FORAGE

Contrast[a]	Midland Bermuda No N		Midland Bermuda 112 kg N/ha		Midland Bermuda 224 kg N/ha		Midland Bermuda 448 kg N/ha		Common Bermuda 112 kg N/ha		Orchardgrass Ladino Clover	
	Percent											
Comparison 1	95.1	92.6	95.0^{b}	94.3^{b}	94.6	93.9	94.5^{b}	94.6^{b}	94.1^{b}	93.9^{b}	93.0^{b}	93.1^{b}
Comparison 2	94.1^{c}	92.3^{c}	94.0^{c}	94.4^{c}	94.2^{c}	93.8^{c}	93.7^{c}	94.8^{c}	93.8^{c}	94.0^{c}	93.2^{c}	93.1^{c}
Comparison 3	93.7^{d}	92.0^{d}	93.8^{d}	94.5^{d}	94.1^{d}	93.7^{d}	94.1^{d}	95.0^{d}	93.9^{d}	94.0^{d}	93.3^{d}	93.0^{d}
Comparison 4	93.4^{e}	91.5^{e}	94.2^{e}	94.6^{e}	94.0^{e}	93.7^{e}	95.0^{e}	95.0^{e}	94.2^{e}	93.9^{e}	93.2^{e}	93.0^{e}
Comparison 5	92.9^{f}	90.8^{f}	94.7^{f}	94.6^{f}	93.9^{f}	93.5^{f}	95.7^{f}	94.6^{f}	94.4^{f}	93.7^{f}	93.1^{f}	92.9^{f}
Comparison 6	91.8^{g}	89.7^{g}	94.8^{g}	94.3^{g}	93.7^{g}	93.4^{g}	95.5^{g}	93.8^{g}	94.1^{g}	93.2^{g}	93.0^{g}	92.9^{g}

[a]Comparisons: (1) day 20 compared to the mean of days 40 through 140; (2) day 40 compared to the mean of days 60 through 140; (3) day 60 compared to the mean of days 80 through 140; (4) day 80 compared to the mean of days 100, 120, and 140; (5) day 100 compared to the mean of days 120 and 140; and (6) day 120 compared to day 140.

[b-g]Values with the same superscript in the same treatment are not significantly different (P>.05).

TABLE 37. EFFECT OF ELAPSED DAYS OF GRAZING ON DM INTAKE PER UNIT METABOLIC WEIGHT ($W^{.75}_{kg}$)

	Midland Bermuda No N		Midland Bermuda 112 kg N/ha		Midland Bermuda 224 kg N/ha		Midland Bermuda 448 kg N/ha		Common Bermuda 112 kg N/ha		Orchardgrass Ladino Clover	
	- - - - - - - - - - - - - - - - g/day/unit metabolic weight - - - - - - - - - - - - - - -											
Comparison 1	101.5[b]	112.0[b]	53.6	113.7	150.5[b]	108.7[b]	75.0[b]	71.9[b]	48.2	107.5	73.5[b]	113.8[b]
Comparison 2	100.2[c]	114.4[c]	113.9[c]	113.6[c]	112.1[c]	108.0[c]	83.5[c]	69.5[c]	110.2[c]	106.9[c]	104.5[c]	115.6[c]
Comparison 3	102.2[d]	117.5[d]	130.2[d]	109.5[d]	122.2[d]	104.5[d]	81.1[d]	66.6[d]	127.0[d]	101.9[d]	124.7[d]	113.3[d]
Comparison 4	106.7[e]	121.1[e]	120.5[e]	105.8[e]	124.0[e]	98.0[e]	73.2[e]	64.4[e]	116.8[e]	96.9[e]	133.3[e]	106.7[e]
Comparison 5	113.2[f]	125.0[f]	103.1[f]	107.1[f]	117.1[f]	88.5[f]	64.8[f]	64.3[f]	97.6[f]	96.6[f]	129.2[f]	95.4[f]
Comparison 6	120.9[g]	129.2[g]	96.2[g]	118.0[g]	101.2[g]	75.7[g]	61.2[g]	67.4[g]	87.8[g]	105.4[g]	111.5[g]	79.3[g]

[a]Comparisons: (1) day 20 compared to the mean of days 40 through 140; (2) day 40 compared to the mean of days 60 through 140; (3) day 60 compared to the mean of days 80 through 140; (4) day 80 compared to the mean of days 100, 120, and 140; (5) day 100 compared to the mean of days 120 and 140; and (6) day 120 compared to day 140.

[b-g]Values with the same superscript in the same treatment are not significantly different (P>.05).

TABLE 38. EFFECT OF ELAPSED DAYS OF GRAZING ON TDN CONTENT OF CONSUMED FORAGE

Contrast[a]	Midland Bermuda No N		Midland Bermuda 112 kg N/ha		Midland Bermuda 224 kg N/ha		Midland Bermuda 448 kg N/ha		Common Bermuda 112 kg N/ha		Orchardgrass Ladino Clover	
	Percent											
Comparison 1	62.3	48.4	59.8	49.6	61.6	49.5	65.8	49.2	57.2	50.7	67.6	60.7
Comparison 2	55.9	46.9	56.9	48.2	57.2	47.9	56.9	47.7	54.5^{c}	49.9^{c}	64.9	59.8
Comparison 3	51.0^{d}	45.9^{d}	54.0	46.7	53.4	46.6	50.5^{d}	47.0^{d}	52.2^{d}	49.3^{d}	62.7	59.1
Comparison 4	47.5^{e}	45.4^{e}	51.1	45.2	50.1	45.4	46.6^{e}	47.2^{e}	50.5^{e}	48.9^{e}	60.9^{e}	58.5^{e}
Comparison 5	45.5^{f}	45.3^{f}	48.2^{f}	43.8^{f}	47.4^{f}	44.4^{f}	45.2^{f}	48.1^{f}	49.4^{f}	48.7^{f}	59.4^{f}	58.1^{f}
Comparison 6	44.9^{g}	45.8^{g}	45.2^{g}	42.3^{g}	45.2^{g}	43.6^{g}	46.3^{g}	49.9^{g}	48.7^{g}	48.6^{g}	58.4^{g}	57.4^{g}

[a]Comparisons: (1) day 20 compared to the mean of days 40 through 140; (2) day 40 compared to the mean of days 60 through 140; (3) day 60 compared to the mean of days 80 through 140; (4) day 80 compared to the mean of days 100, 120, and 140; (5) day 100 compared to the mean of days 120 and 140; and (6) day 120 compared to day 140.

[b-g]Values with the same superscript in the same treatment are not significantly different ($P>.05$).

TABLE 39. EFFECT OF ELAPSED DAYS OF GRAZING ON TDN INTAKE ABOVE MAINTENANCE

	Midland Bermuda No N		Midland Bermuda 112 kg N/ha		Midland Bermuda 224 kg N/ha		Midland Bermuda 448 kg N/ha		Common Bermuda 112 kg N/ha		Orchardgrass Ladino Clover	
	- - - - - - - - - -	- - - -	- - - -	- - - -	- - - -	- - -	kg/day - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Comparison 1	2.74^{b}	1.66^{b}	2.90^{b}	2.14^{b}	2.05^{b}	1.18^{b}	1.85	.49	1.44^{b}	1.85^{b}	1.85^{b}	2.65^{b}
Comparison 2	2.01^{c}	1.59^{c}	2.69^{c}	2.03^{c}	1.89^{c}	1.04^{c}	1.23	.35	1.80^{c}	1.86^{c}	2.85^{c}	2.61^{c}
Comparison 3	1.53^{d}	1.60^{d}	2.47^{d}	1.92^{d}	1.67^{d}	$.88^{d}$	$.75^{d}$	$.24^{d}$	2.01^{d}	1.82^{d}	3.38^{d}	2.42^{d}
Comparison 4	1.31^{e}	1.70^{e}	2.26^{e}	1.80^{e}	1.41^{e}	$.71^{e}$	$.41^{e}$	$.19^{e}$	2.08^{e}	1.74^{e}	3.46	2.08
Comparison 5	1.34^{f}	1.89^{f}	2.03^{f}	1.69^{f}	1.09^{f}	$.51^{f}$	$.21^{f}$	$.18^{f}$	2.01^{f}	1.60^{f}	3.07^{f}	1.58^{f}
Comparison 6	1.62^{g}	2.16^{g}	1.80^{g}	1.57^{g}	$.72^{g}$	$.30^{g}$	$.14^{g}$	$.22^{g}$	1.79^{g}	1.42^{g}	2.23	.93

[a]Comparisons: (1) day 20 compared to the mean of days 40 through 140; (2) day 40 compared to the mean of days 60 through 140; (3) day 60 compared to the mean of days 80 through 140; (4) day 80 compared to the mean of days 100, 120, and 140; (5) day 100 compared to the mean of days 120 and 140; and (6) day 120 compared to day 140.

[b-g]Values with the same superscript in the same treatment are not significantly different ($P>.05$).

TABLE 40. EFFECT OF ELAPSED DAYS OF GRAZING ON TDN INTAKE PER UNIT OF METABOLIC WEIGHT ($W^{.75}_{kg}$)

Contrast[a]	Midland Bermuda No N		Midland Bermuda 112 kg N/ha		Midland Bermuda 224 kg N/ha		Midland Bermuda 448 kg N/ha		Common Bermuda 112 kg N/ha		Orchardgrass Ladino Clover	
	----------	----------	----------	----------	----------	g/day/$W^{.75}_{kg}$	----------	----------	----------	----------	----------	----------
Comparison 1	66.0^{b}	51.6^{b}	66.4^{b}	60.4^{b}	57.6^{b}	44.9^{b}	52.2	37.0	49.0^{b}	52.2^{b}	54.7^{b}	62.3^{b}
Comparison 2	56.5^{c}	50.6^{c}	68.4^{c}	58.8^{c}	54.7^{c}	43.0^{c}	45.2	35.4	52.8^{c}	52.1^{c}	66.2^{c}	61.5^{c}
Comparison 3	50.2^{d}	50.7^{d}	68.1^{d}	56.5^{d}	51.4^{d}	40.8^{d}	39.8^{d}	34.3^{d}	54.8^{d}	51.4^{d}	72.1^{d}	58.8^{d}
Comparison 4	47.2^{e}	51.9^{e}	65.6^{e}	53.4^{e}	47.6^{e}	38.6^{e}	35.9^{e}	33.7^{e}	55.2^{e}	50.2^{e}	72.4	54.3
Comparison 5	47.4^{f}	54.1^{f}	61.0^{f}	49.7^{f}	43.4^{f}	36.2^{f}	33.7^{f}	33.7^{f}	53.8^{f}	48.4^{f}	67.1	48.0
Comparison 6	50.8^{g}	57.4^{g}	54.2^{g}	45.2^{g}	38.7^{g}	33.6^{g}	33.2^{g}	34.2^{g}	50.8^{g}	46.0^{g}	56.2^{g}	39.7^{g}

[a]Comparisons: (1) day 20 compared to the mean of days 40 through 140; (2) day 40 compared to the mean of days 60 through 140; (3) day 60 compared to the mean of days 80 through 140; (4) day 80 compared to the mean of days 100, 120, and 140; (5) day 100 compared to the mean of days 120 and 140; and (6) day 120 compared to day 140.

[b-g]Values with the same superscript in the same treatment are not significantly different (P>.05).

TABLE 41. EFFECT OF ELAPSED DAYS OF GRAZING ON CP CONTENT OF CONSUMED FORAGE

Contrast[a]	Midland Bermuda No N		Midland Bermuda 112 kg N/ha		Midland Bermuda 224 kg N/ha		Midland Bermuda 448 kg N/ha		Common Bermuda 112 kg N/ha		Orchardgrass Ladino Clover	
	- - - - - - - - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - Percent	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -
Comparison 1	17.0	10.5	17.3[b]	14.0[b]	19.2	13.7	30.2	19.6	19.4	12.4	20.2[b]	18.9[b]
Comparison 2	12.7	10.1	14.6[c]	13.8[c]	18.0	12.9	22.6[c]	19.0[c]	14.8	11.9	22.8	18.1
Comparison 3	10.2[d]	10.0[d]	12.6[d]	14.2[d]	15.9	12.1	19.4[d]	18.9[d]	13.1	11.6	22.1	17.1
Comparison 4	9.2[e]	10.3[e]	11.6[e]	15.0[e]	13.4[e]	11.7[e]	19.0[e]	18.9[e]	13.1	11.1	19.6[e]	16.2[e]
Comparison 5	9.3[f]	10.8[f]	12.0[f]	16.5[f]	11.5[f]	11.8[f]	19.6[f]	18.5[f]	13.1	10.0	16.9[f]	15.9[f]
Comparison 6	10.2[g]	11.5[g]	14.3[g]	18.0[g]	11.0[g]	12.6[g]	19.6[g]	17.3[g]	12.0	8.1	15.3[g]	16.5[g]

[a]Comparisons: (1) day 20 compared to the mean of days 40 through 140; (2) day 40 compared to the mean of days 60 through 140; (3) day 60 compared to the mean of days 80 through 140; (4) day 80 compared to the mean of days 100, 120, and 140; (5) day 100 compared to the mean of days 120 and 140; and (6) day 120 compared to day 140.

[b-g]Values with the same superscript in the same treatment are not significantly different (P>.05).

TABLE 42. EFFECT OF ELAPSED DAYS OF GRAZING ON CP INTAKE ABOVE MAINTENANCE

Contrast[a]	Midland Bermuda No N		Midland Bermuda 112 kg N/ha		Midland Bermuda 224 kg N/ha		Midland Bermuda 448 kg N/ha		Common Bermuda 112 kg N/ha		Orchardgrass Ladino Clover	
	kg/day											
Comparison 1	1.00	-.26	.89[b]	.46[b]	.68[b]	.47[b]	1.52	.37	.74[b]	.37[b]	.52[b]	1.17[b]
Comparison 2	.51	-.41	.73[c]	.40[c]	.74[c]	.41[c]	.88[c]	.27[c]	.63[c]	.32[c]	1.47[c]	1.11[c]
Comparison 3	.19	-.57	.59[d]	.35[d]	.63[d]	.36[d]	.53[d]	.20[d]	.58[d]	.26[d]	1.72	.96
Comparison 4	-.04	-.74	.48[e]	.31[e]	.45[e]	.33[e]	.36[e]	.15[e]	.52[e]	.17[e]	1.51[e]	.78[e]
Comparison 5	-.30	-.96	.38[f]	.28[f]	.29[f]	.35[f]	.27[f]	.09[f]	.42[f]	.04[f]	1.09[f]	.63[f]
Comparison 6	-.67	-1.25	.30[g]	.25[g]	.26[g]	.44[g]	.18[g]	-.01[g]	.22[g]	-.13[g]	.69[g]	.56[g]

[a]Comparisons: (1) day 20 compared to the mean of days 40 through 140; (2) day 40 compared to the mean of days 60 through 140; (3) day 60 compared to the mean of days 80 through 140; (4) day 80 compared to the mean of days 100, 120, and 140; (5) day 100 compared to the mean of days 120 and 140; and (6) day 120 compared to day 140.

[b-g]Values with the same superscript in the same treatment are not significantly different ($P>.05$).

TABLE 43. EFFECT OF ELAPSED DAYS OF GRAZING ON CP INTAKE PER UNIT OF METABOLIC WEIGHT ($W^{.75}_{kg}$)

Contrast[a]	Midland Bermuda No N		Midland Bermuda 112 kg N/ha		Midland Bermuda 224 kg N/ha		Midland Bermuda 448 kg N/ha		Common Bermuda 112 kg N/ha		Orchardgrass Ladino Clover	
	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	g/day/$W^{.75}_{kg}$	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Comparison 1	16.7	9.6	17.9	12.2	16.3[b]	13.2[b]	21.8	12.6	11.3[b]	12.7[b]	13.2	19.9
Comparison 2	9.8	9.6	15.6[c]	11.6[c]	17.2[c]	12.3[c]	18.1	11.5	16.0[c]	12.1[c]	24.8	19.0
Comparison 3	7.3	10.2	13.6[d]	11.1[d]	16.3[d]	11.4[d]	15.0[d]	10.7[d]	16.4[d]	11.0[d]	27.4	16.9
Comparison 4	7.8	11.0	12.1[e]	10.7[e]	14.3[e]	10.4[e]	12.5[e]	10.1[e]	14.3[e]	9.9[e]	24.2	14.4
Comparison 5	9.7	11.6	11.1[f]	10.6[f]	11.9[f]	9.6[f]	10.7[f]	9.7[f]	11.3[f]	9.3[f]	18.4	12.4
Comparison 6	11.5	11.6	10.6[g]	10.5[g]	10.0[g]	9.2[g]	9.8[g]	9.7[g]	9.1[g]	9.4[g]	13.2[g]	11.7[g]

[a]Comparisons: (1) day 20 compared to the mean of days 40 through 140; (2) day 40 compared to the mean of days 60 through 140; (3) day 60 compared to the mean of days 80 through 140; (4) day 80 compared to the mean of days 100, 120, and 140; (5) day 100 compared to the mean of days 120 and 140; and (6) day 120 compared to day 140.

[b-g]Values with the same superscript in the same treatment are not significantly different ($P>.05$).

TABLE 44. EFFECT OF ELAPSED DAYS OF GRAZING ON AMINO ACID PERCENTAGE OF FORAGE DM FROM UNFERTILIZED MIDLAND BERMUDAGRASS PASTURES

Amino Acid	Comparison[a] 1		2		3		4		5		6	
	Percent[b]											
Tyrosine	.106	.203	.331	.177	.213	.167	.202	.156	.110	.179	.238	.120
Phenylalanine	.269	.333	.532	.293	.394	.268	.319	.251	.223	.264	.273	.256
Lysine	.213	.358	.450	.339	.429	.316	.389	.292	.301	.288	.257	.319
Histidine	.083	.094	.098	.093	.102	.091	.120	.081	.075	.084	.0	.169
Arginine	.402	.322	.454	.295	.345	.282	.342	.262	.199	.294	.304	.285
Aspartic acid	.572	.469	.665	.430	.668	.370	.479	.333	.429	.285	.244	.327
Glutamic acid	.842	.482	.521	.474	.701	.416	.759	.302	.390	.258	.217	.300
Threonine	.382	.251	.333	.235	.299	.218	.318	.185	.182	.187	.172	.202
Serine	.339	.242	.324	.225	.275	.212	.314	.178	.172	.182	.150	.214
Proline	.607	.409	.660	.359	.389	.351	.512	.298	.323	.285	.259	.312
Alanine	.448	.282	.412	.256	.364	.229	.396	.173	.191	.164	.109	.220
Glycine	.469	.349	.659	.286	.386	.261	.391	.218	.221	.216	.240	.193
Valine	.359	.177	.250	.163	.230	.145	.370	.070	.212	.0	.0	.0
Methionine	.0	.006	.0	.008	.028	.002	.0	.003	.009	.0	.0	.0
Isoleucine	.0	.256	.457	.216	.191	.221	.238	.216	.189	.230	.214	.246
Leucine	.0	.184	.0	.220	.284	.204	.164	.218	.137	.258	.278	.239

[a]Comparisons: (1) comparison of day 16 to the mean of days 28 through 130; (2) comparison of day 28 to the mean of days 47 through 130; (3) comparison of day 47 to the mean of days 62 through 130; (4) comparison of day 62 to the mean of days 82 through 130; (5) comparison of day 82 to the mean of days 100 through 130; and (6) comparison of day 100 to the mean of days 117 and 130.

[b]The values were based on only one sample per day; therefore, no statistical analysis was performed.

TABLE 45. EFFECT OF ELAPSED DAYS OF GRAZING ON AMINO ACID PERCENTAGE OF FORAGE DM FROM MIDLAND BERMUDAGRASS PASTURES FERTILIZED WITH 448 kg N/ha

	Comparison[a]													
Amino Acid	1		2		3		4		5		6		7	
	Percent													
Tyrosine	.252	.287	.411	.266	.381	.243	.258	.239	.153	.268	.222	.292	.316	.268
Phenylalanine	.504	.483	.775	.434	.790	.363	.425	.347	.380	.336	.287	.361	.385	.337
Lysine	.520	.452	.734	.405	.690	.348	.397	.336	.356	.330	.274	.358	.360	.356
Histidine	.0	.179	.253	.166	.238	.152	.161	.150	.121	.160	.148	.166	.166	.167
Arginine	.676	.456	.672	.420	.719	.360	.420	.346	.364	.339	.313	.353	.372	.334
Aspartic acid	1.039	.845	1.357	.760	1.969	.518	.566	.506	.610	.471	.445	.485	.524	.446
Glutamic acid	.779	.655	1.297	.540	1.513	.355	.225	.387	.461	.362	.276	.406	.319	.493
Threonine	.413	.337	.512	.308	.562	.258	.297	.248	.255	.246	.223	.257	.247	.268
Serine	.372	.277	.409	.255	.505	.205	.185	.210	.201	.213	.182	.229	.211	.247
Proline	.469	.271	.546	.226	.599	.151	.408	.087	.349	.0	.0	.0	.0	.0
Alanine	.845	.694	1.082	.630	1.141	.528	.750	.472	.670	.406	.480	.370	.385	.355
Glycine	.463	.372	.701	.317	.678	.245	.263	.241	.337	.209	.208	.209	.171	.248
Valine	.586	.523	.879	.464	.842	.388	.498	.360	.465	.326	.332	.323	.339	.307
Methionine	.090	.117	.206	.102	.160	.090	.087	.091	.070	.098	.161	.067	.0	.135
Isoleucine	.0	.430	.766	.374	.706	.307	.330	.301	.373	.277	.271	.281	.294	.268
Leucine	.0	.504	1.049	.413	.674	.361	.360	.361	.305	.380	.384	.378	.395	.361

[a]Comparisons: (1) comparison of day 16 to the mean of days 28 through 130; (2) comparison of day 28 to the mean of days 47 through 130; (3) comparison of day 47 to the mean of days 62 through 130; (4) comparison of day 62 to the mean of days 82 through 130; (5) comparison of day 82 to the mean of days 100 through 130; (6) comparison of day 100 to the mean of days 117 and 130; and (7) comparison of day 117 to day 130.

[b]The values were based on only one sample per day; therefore, no statistical analysis was performed.

TABLE 46. EFFECT OF ELAPSED DAYS OF GRAZING ON AMINO ACID PERCENTAGE OF FORAGE DM FROM ORCHARDGRASS-LADINO CLOVER PASTURES

Amino Acid	Comparison[a] 1		2		3		4		5		6		7	
	Percent[b]													
Tyrosine	.304	.308	.371	.297	.339	.289	.128	.329	.233	.361	.412	.336	.348	.325
Phenylalanine	.628	.467	.732	.422	.639	.379	.269	.407	.296	.444	.480	.426	.450	.403
Lysine	.150	.409	.670	.366	.450	.349	.181	.391	.300	.421	.427	.419	.450	.388
Histidine	.193	.155	.258	.138	.135	.138	.088	.151	.006	.199	.226	.186	.199	.174
Arginine	.574	.456	.678	.419	.633	.376	.294	.396	.260	.442	.494	.416	.428	.405
Aspartic acid	.730	.580	.849	.535	.951	.451	.291	.492	.486	.493	.503	.489	.556	.422
Glutamic acid	.618	.537	1.231	.421	.556	.394	.137	.458	.394	.480	.476	.482	.571	.394
Threonine	.622	.316	.541	.278	.411	.252	.125	.283	.269	.288	.310	.278	.320	.236
Serine	.215	.250	.415	.223	.366	.194	.085	.221	.184	.234	.236	.233	.267	.200
Proline	.467	.162	.0	.189	.525	.122	.208	.101	.405	.0	.0	.0	.0	.0
Alanine	.885	.669	1.039	.607	.909	.547	.577	.540	.679	.493	.616	.432	.433	.432
Glycine	.505	.327	.655	.272	.523	.222	.122	.247	.254	.244	.225	.254	.305	.203
Valine	.722	.499	.788	.451	.706	.400	.408	.399	.417	.393	.454	.362	.367	.358
Methionine	.119	.119	.086	.124	.094	.130	.0	.163	.058	.198	.254	.170	.149	.191
Isoleucine	.556	.405	.571	.377	.594	.333	.285	.346	.369	.338	.388	.313	.313	.313
Leucine	1.005	.449	.632	.419	.566	.390	.327	.405	.251	.457	.520	.425	.439	.412

[a]Comparisons: (1) comparison of day 16 to the mean of days 28 through 130; (2) comparison of day 28 to the mean of days 47 through 130; (3) comparison of day 47 to the mean of days 62 through 130; (4) comparison of day 62 to the mean of days 82 through 130; (5) comparison of day 82 to the mean of days 100 through 130; (6) comparison of day 100 to the mean of days 117 and 130; and (7) comparison of day 117 to day 130.

[b]The values were based on only one sample per day; therefore, no statistical analysis was performed.

TABLE 47. EFFECT OF ELAPSED DAYS OF GRAZING ON AMINO ACID PERCENTAGE OF FORAGE DM FROM UNFERTILIZED AND FERTILIZED MIDLAND BERMUDAGRASS AND ORCHARDGRASS-LADINO CLOVER PASTURES

Amino Acid	Comparison[a] 1		2		3		4		5		6		7	
	Percent													
Tyrosine	.221	.271	.371	.254	.311	.243	.196	.255	.165	.285	.317	.269	.300	.237
Phenylalanine	.467	.430	.680	.388	.608	.344	.338	.346	.300	.361	.383	.350	.369	.332
Lysine	.294	.406	.618	.370	.523	.340	.322	.344	.319	.353	.350	.355	.355	.354
Histidine	.092	.147	.203	.138	.158	.133	.123	.136	.067	.159	.187	.145	.121	.170
Arginine	.551	.415	.601	.384	.566	.348	.352	.346	.275	.370	.403	.354	.368	.341
Aspartic acid	.780	.631	.957	.577	1.196	.453	.446	.455	.508	.437	.474	.419	.441	.398
Glutamic acid	.746	.552	1.016	.475	.923	.386	.374	.388	.415	.380	.376	.382	.369	.395
Threonine	.472	.302	.462	.275	.424	.246	.246	.246	.236	.249	.266	.240	.246	.235
Serine	.308	.255	.383	.233	.382	.204	.195	.206	.186	.212	.209	.214	.209	.220
Proline	.432	.307	.265	.314	.451	.286	.328	.276	.322	.260	.300	.241	.257	.225
Alanine	.779	.597	.927	.542	.813	.488	.613	.457	.557	.424	.548	.362	.359	.366
Glycine	.472	.324	.589	.279	.522	.231	.261	.224	.261	.211	.216	.209	.195	.223
Valine	.592	.459	.775	.406	.645	.359	.432	.340	.368	.331	.393	.300	.315	.286
Methionine	.070	.090	.097	.089	.094	.088	.029	.103	.046	.121	.207	.079	.049	.108
Isoleucine	.185	.367	.598	.328	.497	.294	.284	.297	.311	.292	.329	.274	.273	.275
Leucine	.335	.391	.560	.363	.508	.335	.283	.347	.231	.386	.452	.354	.370	.337

[a]Comparisons: (1) comparison of day 16 to the mean of days 28 through 130; (2) comparison of day 28 to the mean of days 47 through 130; (3) comparison of day 47 to the mean of days 62 through 130; (4) comparison of day 62 to the mean of days 82 through 130; (5) comparison of day 82 to the mean of days 100 through 130; (6) comparison of day 100 to the mean of days 117 and 130; and (7) comparison of day 117 to day 130.

TABLE 48. EFFECT OF ELAPSED DAYS OF GRAZING ON AMINO ACID PERCENTAGE OF FORAGE CP FROM UNFERTILIZED MIDLAND BERMUDAGRASS PASTURES

Amino Acid	Comparison[a] 1		2		3		4		5		6	
	Percent[b]											
Tyrosine	.718	2.086	2.177	2.068	1.780	2.140	1.777	2.261	1.749	2.518	3.487	1.549
Phenylalanine	1.813	3.223	3.496	3.169	3.289	3.139	2.798	3.253	3.556	3.102	3.999	3.305
Lysine	1.436	3.768	2.954	3.931	3.579	4.019	3.410	4.222	4.784	3.941	3.765	4.118
Histidine	.557	1.166	.640	1.272	.855	1.376	1.052	1.484	1.191	1.631	1.080	2.182
Arginine	2.715	3.361	2.984	3.437	2.875	3.577	3.004	3.769	3.174	4.066	4.454	3.679
Aspartic acid	3.862	4.792	4.368	4.877	5.564	4.705	4.202	4.873	6.822	3.898	3.575	4.222
Glutamic acid	5.684	4.862	3.423	5.150	5.843	4.977	6.657	4.418	6.202	3.526	3.179	3.873
Threonine	2.576	2.583	2.190	2.662	2.491	2.705	2.789	2.677	2.903	2.564	2.520	2.608
Serine	2.287	2.480	2.130	2.550	2.295	2.614	2.758	2.566	2.740	2.480	2.197	2.763
Proline	2.425	2.347	1.639	2.488	1.920	2.631	3.244	2.426	3.378	1.951	2.101	1.801
Alanine	4.098	4.169	4.335	4.136	3.241	4.360	4.491	4.317	5.130	3.911	3.794	4.028
Glycine	3.023	2.783	2.709	2.797	3.040	2.737	3.475	2.491	3.037	2.218	1.597	2.840
Valine	3.163	3.417	4.327	3.235	3.217	3.240	3.432	3.176	3.520	3.004	3.516	2.492
Methionine	0.0	.064	0.0	.077	.240	.037	0.0	.049	.148	0.0	0.0	0.0
Isoleucine	2.668	2.667	3.003	2.600	1.592	2.852	2.086	3.108	3.013	3.155	3.135	3.176
Leucine	1.878	2.555	2.191	2.628	2.372	2.692	1.437	3.111	2.176	3.579	4.073	3.085

[a]Comparisons: (1) comparison of day 16 to the mean of days 28 through 130; (2) comparison of day 28 to the mean of days 47 through 130; (3) comparison of day 47 to the mean of days 62 through 130; (4) comparison of day 62 to the mean of days 82 through 130; (5) comparison of day 82 to the mean of days 100 through 130; and (6) comparison of day 100 to the mean of days 117 and 130.

[b]The values were based on only one sample per day; therefore, no statistical analysis was performed.

TABLE 49. EFFECT OF ELAPSED DAYS OF GRAZING ON AMINO ACID PERCENTAGE OF FORAGE CP FROM MIDLAND BERMUDAGRASS PASTURES FERTILIZED WITH 448 kg N/ha

	Comparison[a]													
Amino Acid	1		2		3		4		5		6		7	
	Percent[b]													
Tyrosine	.971	1.583	1.669	1.569	1.415	1.599	1.306	1.673	.664	2.009	1.259	2.385	2.576	2.194
Phenylalanine	1.942	2.485	3.141	2.376	2.934	2.265	2.155	2.292	1.646	2.508	1.627	2.948	3.139	2.751
Lysine	2.006	2.356	2.977	2.252	2.561	2.190	2.010	2.236	1.542	2.467	1.553	2.924	2.935	2.914
Histidine	.973	.972	1.028	.963	.883	.979	.816	1.020	.524	1.186	.839	1.360	1.353	1.367
Arginine	2.605	2.378	2.727	2.320	2.672	2.250	2.129	2.280	1.581	2.514	1.775	2.883	3.033	2.734
Aspartic acid	4.003	4.110	5.502	3.878	7.311	3.191	2.868	3.272	2.643	3.482	2.523	3.961	4.272	3.651
Glutamic acid	3.003	3.173	5.256	2.826	5.616	2.268	1.143	2.549	1.997	2.733	1.565	3.318	2.601	4.035
Threonine	1.591	1.749	2.076	1.695	2.087	1.616	1.503	1.645	1.108	1.824	1.264	2.104	2.014	2.194
Serine	1.434	1.445	1.658	1.410	1.875	1.317	.938	1.411	.873	1.591	1.032	1.871	1.720	2.022
Proline	1.808	1.755	2.214	1.679	2.225	1.570	2.067	1.445	1.513	1.423	1.638	1.316	1.404	1.228
Alanine	3.254	3.441	4.384	3.284	4.236	3.093	3.797	2.917	2.905	2.922	2.721	3.022	3.139	2.906
Glycine	1.784	1.822	2.843	1.652	2.519	1.479	1.334	1.515	1.460	1.534	1.179	1.712	1.394	2.030
Valine	2.258	2.626	3.565	2.470	3.126	2.339	2.520	2.294	2.018	2.386	1.882	2.638	2.764	2.513
Methionine	.350	.692	.835	.668	.596	.683	.444	.743	.305	.889	.913	.877	.650	1.105
Isoleucine	2.164	2.163	3.104	2.007	2.621	1.884	1.674	1.936	1.620	2.042	1.536	2.295	2.397	2.194
Leucine	2.608	2.607	4.251	2.333	2.502	2.300	1.823	2.419	1.325	2.784	2.177	3.087	3.220	2.955

[a]Comparisons: (1) comparison of day 16 to the mean of days 28 through 130; (2) comparison of day 28 to the mean of days 47 through 130; (3) comparison of day 47 to the mean of days 62 through 130; (4) comparison of day 62 to the mean of days 82 through 130; (5) comparison of day 82 to the mean of days 100 through 130; (6) comparison of day 100 to the mean of days 117 and 130; and (7) comparison of day 117 to day 130.

[b]The values were based on only one sample per day; therefore, no statistical analysis was performed.

TABLE 50. EFFECT OF ELAPSED DAYS OF GRAZING ON AMINO ACID PERCENTAGE OF FORAGE CP FROM ORCHARDGRASS-LADINO CLOVER PASTURES

	Comparison[a]													
Amino Acid	1		2		3		4		5		6		7	
	Percent[b]													
Tyrosine	1.472	1.758	1.549	1.793	1.328	1.886	.630	2.201	1.468	2.445	2.571	2.382	2.530	2.235
Phenylalanine	3.037	2.541	3.053	2.456	2.503	2.446	1.327	2.726	1.866	3.013	2.996	3.022	3.272	2.772
Lysine	.728	2.278	2.795	2.191	1.763	2.277	.891	2.624	1.891	2.868	2.665	2.970	3.272	2.669
Histidine	.936	.876	1.075	.843	.531	.906	.435	1.024	.043	1.351	1.410	1.322	1.447	1.197
Arginine	2.773	2.482	2.827	2.424	2.479	2.414	1.450	2.655	1.639	2.993	3.083	2.949	3.112	2.786
Aspartic acid	3.528	3.121	3.539	3.051	3.726	2.916	1.435	3.287	3.065	3.361	3.139	3.472	4.042	2.903
Glutamic acid	2.987	2.900	5.132	2.528	2.179	2.598	.677	3.078	2.481	3.277	2.971	3.430	4.151	2.710
Threonine	3.005	1.722	2.254	1.634	1.611	1.639	.615	1.895	1.696	1.961	1.935	1.974	2.326	1.623
Serine	1.040	1.363	1.732	1.301	1.436	1.274	.422	1.487	1.161	1.596	1.473	1.658	1.941	1.376
Proline	2.257	1.575	1.972	1.509	2.056	1.399	1.023	1.494	2.550	1.142	1.314	1.056	1.126	.986
Alanine	4.278	3.567	4.330	3.440	3.563	3.416	2.839	3.560	4.278	3.321	3.844	3.059	3.148	2.971
Glycine	2.443	1.715	2.729	1.546	2.051	1.445	.605	1.655	1.604	1.672	1.404	1.806	2.217	1.396
Valine	3.490	2.664	3.284	2.560	2.767	2.519	2.007	2.647	2.627	2.654	2.833	2.565	2.668	2.462
Methionine	.576	.841	.361	.921	.369	1.032	.808	1.088	.370	1.327	1.585	1.198	1.083	1.314
Isoleucine	2.689	2.184	2.379	2.152	2.328	2.116	1.405	2.294	2.328	2.283	2.422	2.214	2.276	2.153
Leucine	4.859	2.474	2.635	2.447	2.217	2.493	1.610	2.714	1.585	3.090	3.245	3.013	3.192	2.834

[a]Comparisons: (1) comparison of day 16 to the mean of days 28 through 130; (2) comparison of day 28 to the mean of days 47 through 130; (3) comparison of day 47 to the mean of days 62 through 130; (4) comparison of day 62 to the mean of days 82 through 130; (5) comparison of day 82 to the mean of days 100 through 130; (6) comparison of day 100 to the mean of days 117 and 130; and (7) comparison of day 117 to day 130.

[b]The values were based on only one sample per day; therefore, no statistical analysis was performed.

TABLE 51. EFFECT OF ELAPSED DAYS OF GRAZING ON AMINO ACID PERCENTAGE OF FORAGE CP FROM UNFERTILIZED AND FERTILIZED MIDLAND BERMUDAGRASS AND ORCHARDGRASS-LADINO CLOVER PASTURES

Amino Acid	Comparison[a] 1		2		3		4		5		6		7	
	- - -	- - -	- - -	- - -	- - -	- - -	Percent	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Tyrosine	1.054	1.801	1.798	1.801	1.508	1.860	1.238	2.016	1.293	2.257	1.915	2.428	2.864	1.993
Phenylalanine	2.264	2.759	3.230	2.680	2.909	2.635	2.093	2.770	2.356	2.908	2.311	3.207	3.470	2.945
Lysine	1.390	2.721	2.908	2.690	2.634	2.702	2.104	2.851	2.739	2.889	2.109	3.279	3.324	3.234
Histidine	.498	.952	.914	.958	.756	.998	.768	1.056	.586	1.213	1.125	1.257	.933	1.582
Arginine	2.698	2.696	2.846	2.671	2.675	2.670	2.194	2.789	2.131	3.009	2.429	3.299	3.533	3.066
Aspartic acid	3.798	3.914	4.470	3.822	5.534	3.479	2.835	3.640	4.177	3.462	2.831	3.777	3.963	3.592
Glutamic acid	3.891	3.521	4.604	3.341	4.546	3.100	2.826	3.169	3.560	3.039	2.268	3.424	3.310	3.539
Threonine	2.391	1.971	2.173	1.938	2.063	1.913	1.636	1.982	1.902	2.009	1.599	2.214	2.287	2.142
Serine	1.587	1.704	1.840	1.682	1.869	1.644	1.373	1.712	1.592	1.752	1.252	2.003	1.953	2.053
Proline	2.163	1.761	1.284	1.841	2.067	1.796	2.111	1.717	2.480	1.463	1.684	1.353	1.444	1.263
Alanine	3.877	3.684	4.350	3.573	3.680	3.551	3.709	3.512	4.104	3.315	3.282	3.331	3.360	3.302
Glycine	2.417	2.035	2.760	1.915	2.536	1.791	1.804	1.787	2.034	1.705	1.292	1.912	1.736	2.089
Valine	2.970	2.852	3.725	2.707	3.037	2.641	2.653	2.638	2.722	2.610	2.358	2.736	2.983	2.489
Methionine	.309	.519	.399	.540	.402	.567	.148	.672	.274	.805	1.249	.583	.361	.806
Isoleucine	.896	2.305	2.829	2.218	2.180	2.225	1.721	2.352	2.320	2.362	1.979	2.554	2.602	2.507
Leucine	1.620	2.448	2.295	2.474	2.364	2.496	1.624	2.714	1.695	3.054	2.711	3.226	3.495	2.958

[a]Comparisons: (1) comparison of day 16 to the mean of days 28 through 130; (2) comparison of day 28 to the mean of days 47 through 130; (3) comparison of day 47 to the mean of days 62 through 130; (4) comparison of day 62 to the mean of days 82 through 130; (5) comparison of day 82 to the mean of days 100 through 130; (6) comparison of day 100 to the mean of days 117 and 130; and (7) comparison of day 117 to day 130.

VITA

Larry A. Carver, son of Ray A. and Mildred (Reynolds) Carver, was born December 4, 1943, at Sarcoxie, Missouri. He was reared at Pierce City, Missouri, and there attended elementary and secondary schools. He entered the University of Missouri, Columbia, in September, 1961, and graduated with the B.S. degree in Animal Husbandry and a commission in the U. S. Army Field Artillery.

He began graduate studies at the University of Missouri, Columbia, in January, 1966, and was granted the M.S. degree in Animal Husbandry in August, 1971. During this period he served in the U. S. Army from March, 1968, to January, 1971, part of which time was spent as Battery Executive Officer and Battery Commander with the 7th Battalion, 8th Field Artillery, II Field Force Artillery, Bien Hoa, South Vietnam.

He resumed graduate studies in Animal Science at the University of Tennessee, Knoxville, in January, 1971, and received the Ph.D. degree in June, 1975.

He married the former Patricia A. Heidlage on June 12, 1965. Their first child, Lynette Kay, was born March 22, 1966, and their second child, Lee Allen, was born July 22, 1969.