SUMMER PERFORMANCE AND FORAGE INTAKE OF STOCKERS GRAZED ON BERMUDAGRASS

By

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SUMMER PERFORMANCE AND FORAGE

INTAKE OF STOCKERS GRAZED

ON BERMUDAGRASS

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CHAPTER I

INTRODUCTION

A major criticism of bermudagrass is that it will not support profitable weight gains of stocker cattle throughout the bermudagrass growing season. Bermudagrass is considered an excellent forage for cow-calf enterprises, and has the ability to withstand heavy stocking rates without reducing production. Steer gains on bermudagrass are commonly .5 to 1 kg per day during the first 60 to 75 days of the bermudagrass growing season (Oliver, 1972), but decrease markedly and are sometimes negative (McMurphy and Tucker, 1974) during the latter part of the growing season. The reduction in stocker gains is most often attributed to reduced dry matter intakes as a result of reduced forage quality or to the concept that bulk-fill limits intake of this forage.

The objectives of this study were to measure, at monthly intervals, (1) stocker weight gains and forage intakes; (2) _in vitro_ dry matter and organic matter digestibility and chemical indices of forage quality of bermudagrass samples collected by hand-clipping or use of an esophageal-cannulated steer, and (3) to determine which indices of forage quality accounted for the greatest proportion of variation in stocker weight gains and forage intakes.

CHAPTER II

REVIEW OF LITERATURE

Forage Intake

The interactions between plant and animal under varying conditions make illustrating the precise relationship between intake and satiety very difficult (Forbes, 1971). In the studies to date a great deal of valuable information relating to voluntary intake has been established. Data and reviews on intake control have been presented by Arnold (1970), Baumgart (1970), Campling (1970), Baile and Forbes (1974), Journet and Remond (1976) and many others. This, then will be an overview and readers should consult the citations given for a more in-depth study of intake controls.

Intake regulation by grazing animals comes under the control of many factors. Baile and Forbes (1974) discussed many of these factors that affect voluntary intake. Control of voluntary intake is usually discussed as either physiological or physical regulation. Physiological refers to blood metabolites, lipids, amino acids, or some other chemical factor, while physical refers to the actual volume or capacity of the digestive tract, mainly the rumen.

Baumgart (1970) presented evidence for regulation of energy intake by ruminants that centered on digestibility, density, energy content, and energy demand. Similar conclusions were drawn by Baile and Forbes (1974).

Energy content has been shown to be a major factor in intake

control. Baumgart (1970) presented data on non-lactating ruminants fed a ration which varied in energy content, that showed that regulation of digestible energy (DE) intake could be maintained when the energy content exceeded 2.5 Kcal DE/g. Other data presented showed that a ration above 2.7 Kcal DE/g would sustain energy balance of lactating dairy cows.

However, problems arise between experiments regarding the measurements of energy intake. Montgomery and Baumgart (1965) proposed that a measure of density (g/ml) times the energy content (Kcal/g) would yield a better relationship (Kcal/ml) to intake than energy as Kcal/g. It was found that the measure of energy could also effect the interpretation of energy intake. Baumgart (1970) reported energy intake of rations **varying** in energy content and found DE intakes of 45.0, 43.6, and 41.9, ME intakes of 38.8, 38.7, and 37.7, and NE intakes of 19.3, 19.4, and 19.5 Mcal/day.

End products of digestion such as volatile fatty acids, sugars, and lipids have been studied by Baile and Forbes (1974) as other physiological intake regulators. Some may serve to attenuate control of intake by acting as signals but this is not well defined. Amos and Evans (1976) inhibited protein degradation in the rumen, to increase protein bypass, and increased the supply of amino acids to the lower tract but failed to show an animal response.

Physical regulation of intake by grazing ruminants, called bulk-fill, refers to the bulky, fibrous nature of diets of low digestiblity and energy content, to limit voluntary intake to the capacity of the reticulorumen and to the rate of removal of ingesta from this organ (Balch and Campling, 1962). Regulation of voluntary intake by limited

rumen capacity becomes most apparent when employing forage feeding systems for ruminants with high energy demands, i.e., lactating cows or rapid gaining stockers (Baile and Forbes, 1974).

Conrad et al. (1964) used diets ranging from 52 to 80 percent digestibility (100% roughage to 100% concentrate) with dairy cows producing 20 kg of milk per day, to study voluntary intake. Intake of rations between 52 and 66 percent digestibility were dependent on body size, rate of passage, and digestibility. While intake of rations between 67 and 80 percent digestibility decreased with increasing digestibility and were dependent on metabolic body size and level of production. Montgomery and Baumgart (1965) found similar results, with Holstein heifers fed alfalfa:corn rations, but showed the point at which energy balance was reached to be 56% digestibility. Montgomery and Baumgart (1965b) suggested that the difference between their work and that of Conrad et al. (1964) might be due to physical form of the rations, theirs being ground and pelleted while the rations of Conrad et al. (1964) were fed whole.

Similar results with steers and wethers indicate the energy intake of highly digestible diets is in balance with energy demand. Blaxter et al. (1961) showed increased intake by sheep to be very rapid when ration digestibility was increased from 38 to 70 percent, and intake increased more slowly when digestibility increased from 70 to 79 percent. Furthermore, studies where energy demand was modified by stimulating growth rate or metabolic rate, steers altered intake to try to compensate for the change in demand (Baile and Forbes, 1974).

The slow process of digestion of fibrous feed components principally limits intake (Journet and Remond, 1976). Campling et al. (1961)

presented evidence that the capacity of the rumen directly regulates food intake. In an experiment with rations of different digestibility fed ad libitum to fistulated cows, intake varied by 35 percent while rumen contents (at meal end) were very close.

Rumen capacity is correlated with body weight. Conrad et al. (1964) found a highly significant correlation (r = .369) when log feed intake was regressed on log body weight. However, the fractional power of body weight to which intake is best correlated with body weight has been variable between experiments. Conrad et al. (1964) reported that body weight to the .37 power best fit the regression of intake on body weight, while Blaxter et al. (1961) found that body weight to the .734 power for sheep and a similar relationship for steers (Blaxter and Wilson, 1962) best fit the regression.

Work by Campling and Balch (1961) showed that intake can be manipulated by rumen distension. They found that when the ingesta was removed from the rumen of fistulated cows the cows consumed 177% of a normal meal. The opposite effect was found when ingesta was placed in the rumen. This would indicate strongly that stretch receptors in the rumen act on the central nervous system to regulate feed intake (Campling, 1970). Baile and Forbes (1974) also support this, citing that slight internal pressure in the rumen can stimulate motility while gross distension inhibits motility. Rumen distension alone cannot account for the termination of food intake. Paloheimo (1944) showed (as cited by Balch and Campling, 1962) that the rumen will expand appreciably with only slight increases of internal pressure, indicating that the abdomen as a whole must respond to fill.

Abdominal characteristics which would be most likely to be factors

in the regulation of food intake would be lower gut fill (Campling et al., 1961), abdominal organs and fat deposits (Forbes, 1968 and Arnold, 1970) and the fetus of pregnant ruminants (Forbes, 1970). This is evidenced by decreasing intakes as animals grow to maturity and in the latter stage of pregnancy. However, these abdominal factors as well as the rumen may be adaptable to some extent. Mowatt (1963) found (as cited by Baile and Forbes, 1974) that the rumen could adapt to artificial bulk placed in the rumen. However, adaptation of the rumen is not rapid. Blaxter and Wilson (1962) reported that steers may require 30 days or more to adapt to a poorly digestible diet.

Foremost in the studies of intake regulation has been the pronounced effect of increased dry matter intake with **supplemental protein** added to low-protein, high-fiber diets. Huber and Thomas (1971) reported a significant increase in total intake when the ration contained 12.5 versus 8.5 percent crude protein. Amos et al. (1976) also reported increased intake of bermudagrass hay, ground and pelleted, with increased protein. The increase in intake has been attributed to increased cellulose digestion (Egan, 1965) and increased dry matter digestion (Huber and Thomas, 1971; Amos et al., 1976). The resulting increased digestiblities would facilitate removal of dry matter from the rumen.

Other physical factors may also effect voluntary intake. Generally chopping, mastication or grinding increase intake. But with finely ground forage, Campling et al. (1963) and Campling and Freer (1966) found intake lower than for forage not ground. It was assumed that rapid removal of small particles from the rumen caused fill at some point further down the digestive tract.

With highly digestible diets (> 67%) it is unlikely that bulk-fill limits intake (Campling, 1970). Bulk-fill would seem to be most limiting to young ruminants, ruminants on diets of low digestibility, or ruminants with high energy demands, but other factors also aid intake regulation. Factors other than those already discussed and less easily defined may have a significant effect on intake, such as mineral balance, preference, vitamin supply, and environmental or sociological factors. This has been shown by Mowatt (1963) where cows were fed a forage diet to apparent capacity then offered a highly digestible ration. The cows resumed intake, indicating palatability or some other form of acceptability was responsible for the iniatiation of re-feeding.

Forage Quality

Intake of forage, though under many systems of control, has been related to some measure of forage quality, such as protein content (Huber and Thomas, 1971; Amos and Evans, 1976) energy content (Baumgart, 1970) and digestibility (Blaxter and Wilson, 1962; Campling and Freer, 1966; Conrad et al., 1964; Campling, 1970; Baile and Forbes, 1974).

The best measure of forage quality is animal production. But animal production is measured after the forage has been consumed and quality may change continuously. This emphasizes the need for estimates of forage quality by which animal performance can be predicted.

Maturity of forages has consistently been shown to adversely effect quality of forage by decreasing digestibility (Akin et al., 1977). Burton et al. (1964) studying young and old (30 days older) leaves from the same sorghum plant, found in vitro digestibility was reduced from 75.3% to 61.4% respectively. Utley et al. (1971) harvested and pelleted Pensacola Bahiagrass, Coastal bermudagrass and Coast-Cross-1

bermudagrass at 4 and 8 weeks of age and found that dry matter digestibility (digestion trial) was decreased 4.6, 10.6, and 7.3%, respectively, for the three grasses. In addition, daily intake (kg) of steers in stalls, decreased as maturity increased from 4 to 8 weeks, from 7.99 to 7.49 for Pensacola Bahiagrass, 7.87 to 7.44 for Coastal and from 8.73 to 8.25 for Coast-Cross-1 bermudagrass.

The chemical indices of forage quality most commonly related to animal performance are protein, fiber, and lignin (Lathapipate, 1969). Of these lignin has probably received the most attention because of its property to lower digestibility of other forage components (Sullivan, (1962).

Decreases in digestibility of forages with increasing lignification may be due to cell encrustation (Kamstra, et al., 1958) or lignin-carbohydrate complexing (Morrison, 1974). Akin et al. (1977) studied lignification in coastal bermudagrass as maturity advanced by using the upper, middle and lower plant parts, and observed that lignification could partially explain decreased digestion. Utley et al. (1971) found digestibility and forage intake decreased with increased lignification and maturity.

Hart et al. (1976) reported a marked decrease in intake and performance of steers following an increase in percent lignin in a green chop bermudagrass ration. Hopson (1971) found a highly significant negative correlation ($r = -.93$) between dry matter intake of steers grazing bermudagrass and percent lignin in the diet with esophageal-collected bermudagrass samples. This was supported by Smith (1973) who also found that lignin (% of dry matter of esophageally-collected bermudagrass forage samples) was negatively correlated to dry matter intake ($r = -.98$ to $-.52$). Barton et al. (1976) reported that lignin

was negatively correlated with *in vitro* dry matter digestibility, r = -.72 and -.67 for tropical and temperate grasses, respectively.

Maturity and lignification may radically affect protein content and/or protein availability. Utley *et al*. (1971) found a 4.3% decrease in crude protein level between 4 and 8 weeks old coastal bermudagrass. Decreases in percent crude protein with increases in age have also been reported by Prine and Burton (1956), Danley and Vetter (1973), Burton *et al*. (1963) and many others. Digestibility of crude protein may be lowered by increased lignification as it inhibits microbial digestion of the cell wall or sheaths and stems (Akins *et al*., 1977).

Another possibility which may decrease protein availability is binding to other chemical components. Goering *et al*. (1972) found increased acid-detergent insoluble nitrogen and pepsin-insoluble nitrogen in alfalfa samples that were heated or ensiled which contributed to reduced protein availability. Protein is also bound by plant tannins which limit microbial digestion. (McLeod, 1974)

The relationship of crude protein to dry matter intake has been variable. Smith (1973) using stockers on bermudagrass reported values of r = .81 to r = -.64 between dry matter intake and crude protein across 4 months. Prates *et al*. (1975) reported correlations of .84 between crude protein and digestible organic matter intake of steers grazing Pensacola Bahiagrass.

Tropical grasses, such as bermudagrass, are commonly referred to as having high fiber content and this is often used to explain their low quality (Moore and Mott, 1973). Neutral-detergent fiber often is above 70% (Telford *et al*., 1975) while temperate grasses seldom exceed 70% (Moore and Mott, 1973). Hopson (1971) reported correlations of .39 and -.95 between neutral-detergent fiber and intake (dry matter) and *in*

in vitro dry matter digestibility, respectively, for hand-clipped forage samples. Smith (1973) also reported negative correlations as low as -.52 between dry matter intake and neutral-detergent fiber and -.86 between average daily gain and neutral-detergent fiber.

Moore and Mott (1973) have stated that none of the chemical constituents can be used alone for reliable prediction of either digestibility or intake of tropical grasses and that chemical analysis should be combined with an *in vitro* fermentation procedure.

In vitro dry matter digestibility is highly correlated with *in vivo* dry matter digestibilities (Tilley and Terry, 1963; McLeod and Minson, 1969) and differences in average daily intake have been related to differences in dry matter digestibility. However, the relationship is very dependent on the level of digestibility. Baumgart (1970) reported a correlation of r = .85 between intake and dry matter digestibility, of Holstein heifers fed a pelleted alfalfa:corn ration, when the digestibility was below 56%, while r - .18 for rations above 56% digestibility. Thus, multiple regression equations using *in vitro* digestibilities and chemical analyses may not be consistently accurate predictors of *in vivo* dry matter digestibility or dry matter intakes (Butterworth and Diaz, 1970; Golding *et al.*, 1976).

Stocker Performance on Bermudagrass

Research has generally shown that average daily gains of stockers on bermudagrass have been less than desirable, particularly in the latter part of the grazing season (Oliver, 1972). This reduction in gain is the major criticism of bermudagrass.

The decreased performance of stockers in the latter part of the bermudagrass growing season has been shown by many researchers (Utley

et al., 1974; Brown et al., 1961; Hart et al., 1976; McMurphy and Tucker, 1974). The causes of the depressed gains have been attributed to several factors. Increased maturity of bermudagrass has been reported to decrease intake, digestibility of forage protein, and stocker weight gain (Utley et al., 1971) of stockers fed pelleted diets of 4 and 8 weeks old Pensacola Bahiagrass, Coastal bermudagrass and Coast-Cross-1 bermudagrass. Research by Burton et al. (1963) has shown that the decrease in in vitro dry matter digestibility of bermudagrass was more rapid after six weeks of accumulated growth. This might be interpreted that management to keep accumulated growth below six weeks of age or less would be beneficial.

That beef gains can be increased by fertilization has been well demonstrated. Suman et al. (1962) showed a significant increase in beef production (kg/ha) as nitrogen fertilization increased from 112 to 450 kg/ha. However, in most studies the increase in beef gains resulted from increased forage production which allowed increased stocking rates and increased stocking rates have been shown to adversely affect stocker average daily gain (Knox, 1978). Knox (1978) reported stocker weight gains, of Hereford steers grazing Coastal bermudagrass (rotation grazing) with stocking rates of .4, .8, and 1.2 steers/ha, over four years. The average daily gains were .59, .37, and .35 kg, while total beef produced was 41, 51, and 67 kg/ha, for the .4, .8, and 1.2 steers/ha respectively.

However, Oliver (1972) stated that less than desirable weight gains of stockers on bermudagrass might be the result of less than desirable management of the forage. In a study of six management systems for stockers (three grazing and three harvesting and feeding),

Hart et al. (1976) showed that average daily gains of steers fed a hay (.7 kg) or pelleted (.8 kg) bermudagrass diet were superior to grazing (continuous, .6 kg; rotational, .5; or strip grazing, .4 kg).

One possibility for increased gains with harvested bermudagrass fed to steers and for decreased gains of steers grazing continuously might be that fecal contamination of the pasture would reduce the available forage that steers would readily consume (Brown et al., 1961).

Increased utilization of bermudagrass forage by rotation grazing (3 days on, 10 days off) versus continuous grazing produced larger animal gains over several years (Oliver, 1972).

CHAPTER III

SUMMER PERFORMANCE AND FORAGE INTAKE OF STOCKERS GRAZED ON BERMUDAGRASS

Summary

A randomized block design was employed to measure stocker weight gains and forage intakes, at monthly intervals of stocker steers grazed on a Midland bermudagrass pasture during the summers of 1976 and 1977. In vitro dry matter and organic matter digestibilities and chemical indices of forage quality of bermudagrass samples, collected by hand-clipping or use of an esophageal-cannulated steer were measured during each intake trial. Chemical indices of forage quality which were measured were: crude protein, acid-detergent and pepsin-insoluble nitrogen, neutral-detergent fiber and acid-detergent fiber and lignin (1976). In addition gross energy, density, and tannin concentrations were measured in 1977. Ruminal ammonia and plasma urea concentrations of steers were determined during each intake trial (1977).

The R-SQUARE procedure of the Statistical Analysis System (SAS) was employed to calculate all possible regressions of stocker weight gain and forage intakes (dry matter, digestible dry matter, organic matter and digestible organic matter, in kg/head/day and kg/100 kg steer body wt) on: in vitro and chemical indices of forage quality, and to regress stocker weight gains on: forage intakes of dry matter, digestible dry matter, organic matter and digestible organic matter (kg/

head/day and kg/100 kg steer body wt), crude protein, digestible protein (apparent and true) and soluble protein (acid-detergent and pepsin) (g/head/day).

Mean stocker weight gains were .59 and .35 kg per day from May through September in 1976 and 1977, respectively. However, average daily gains decreased ($P<.01$) to .16 and -.60 during the July to August period, of 1976 and 1977. Dry matter intakes increased from 4.95 to 6.75 kg/head/day from May to September in 1976, and from 5.39 and 6.53 to 9.59 and 10.15 in 1977, for intakes calculated from the digestibilities of hand-clipped and esophageal-collected forage samples respectively. Stocker intakes (g/head/day) of crude protein, digestible protein (apparent and true) and soluble protein (acid-detergent and pepsin) accounted for a greater proportion of the variation in stocker weight gains than did dry matter, digestible dry matter, organic matter, or digestible organic matter intakes (kg/head/day and kg/100 kg steer body wt). Indices of forage quality measured on forage samples collected by use of an esophageal-cannulated steer did not increase the proportion of variation in stocker weight gains or forage intakes accounted for by those of hand-clipped forage samples. The maximum amount of variation in stocker weight gains and forage intakes were accounted for by regression were 74 and 85%, respectively. Rumen ammonia and plasma urea concentration accounted for only 15% of the variation in forage intakes (dry matter and organic matter) calculated from the indigestibilities of hand-clipped forage samples.

Introduction

A major criticism of bermudagrass is that it will not support profitable weight gains of stocker cattle throughout the bermudagrass

growing season. Bermudagrass is considered an excellent forage for cow-calf enterprises, and has the ability to withstand heavy stocking rates without reducing production. Steer gains on bermudagrass are commonly .5 to 1 kg per day during the first 60 to 75 days of the bermudagrass growing season, but decrease markedly (Oliver, 1972) and are sometimes negative (McMurphy and Tucker, 1974) during the latter part of the growing season. The reduction in stocker gains is most often attributed to reduced dry matter intakes as a result of reduced forage quality or to the concept that bulk-fill limits intake of this forage.

The objectives of this study were to measure, at monthly intervals, (1) stocker weight gains and forage intakes; (2) in vitro dry matter and organic matter digestibility and chemical indices of forage quality of bermudagrass samples collected by hand-clipping or use of an esophageal-cannulated steer, and (3) to determine which indices of forage quality accounted for the greatest proportion of variation in stocker weight gains and forage intakes.

Experimental Procedure

Two stocker weight gain and forage intake studies were conducted on Midland Bermudagrass (Cynodon dactylon (L) Pers) during the bermudagrass growing season (May through September) of 1976 (Experiment I) and 1977 (Experiment II). The studies were conducted at the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma.

Experiment I

Forage intakes and stocker weight gains were measured on 8 yearling steers (285± 8.1 kg mean initial weight) of Hereford (4), Angus (2) and Hereford x Angus (2) breeding. The steers were wormed and dusted for

parasites when placed on pasture (May 12) and subsequently dusted for fly control as needed. Shade was available to the steers throughout the experiment, and salt was available on an ad libitum basis.

A 2.2 ha pasture of Midland bermudagrass was employed for this study. One application of .56 kg 2-4-D/ha was made for weed control on May 21 and 67 kg actual N/ha as ammonium nitrate was applied on May 24. The pasture was mowed to a height of about 8 cm to remove cool season annual grasses and excess forage on June 6 and July 29, respectively. The pasture was grazed continously for the five month study and was immediately adjacent to the handling facilities.

Forage intake by the steers was measured at approximately 4-week intervals. During each forage intake trial (Table I) of 8 consecutive days (5-day preliminary period, and 3-day fecal collection period), the steers were administered 8 g chromic oxide, in gelatin capsules, in split dosages of 4 g at 8:00 am and 4:00 pm each day. Fecal grab samples were taken at 8:00 am and 4:00 pm of each day of the collection period, and were stored in plastic bags and frozen until the end of each intake trial. After each trial fecal samples were transferred while frozen to aluminum pans and dried to constant weights in a forced draft oven at 55° C. Dry fecal samples were ground through a 2 mm screen in a Wiley mill. Composite fecal samples were made across collection times (e.g., 8:00 am and 4:00 pm) within days of the fecal collection period on an equal dry weight (8 g) basis. One gram of each daily fecal composite for each steer was prepared by the method of Williams et al. (1962) and analyzed for chromium content by atomic absorbtion spectroscopy. For calculation of fecal output the daily fecal chromium values were averaged across days. Fecal dry matter output was determined by dividing daily chromium intake (5.47 g) by fecal chromium

TABLE I

SCHEDULE OF FORAGE INTAKE TRIALS
FOR 1976 AND 1977

	Year	
Trial	1976	1977
1	5/19 - 5/26	5/26 - 6/2
2	6/16 - 6/23	6/22 - 6/29
3	7/14 - 7/21	7/20 - 7/27
4	8/11 - 8/18	8/17 - 8/24
5	9/8 - 9/15	9/14 - 9/21

content (grams chromium/gram dry matter). Fecal composites were made across days, by steer, within intake trials for analysis of dry matter, ash, crude protein, acid-detergent fiber and lignin. Daily fecal dry matter output is listed in Appendix Tables XXVI and XXVII.

The steers were weighed during each intake trial. Steers were weighed full on the first and second morning of each fecal collection period and averaged across days. Average daily gains were calculated for each 28-day period (i.e., May to June, June to July, July to August and August to September).

On the first day of each fecal collection period six hand-clipped (HC) forage samples were collected from the pasture for analysis. The forage samples consisted of multiple random clippings of forage within a 15 m radius, around each of the six predetermined reference points.

The HC forage samples were placed in tared, cloth bags and weighed as soon as possible, then placed in a forced draft oven at 55^{o} C and dried to constant weight. After drying the HC forage samples were ground through a Wiley mill equipped with a 2 mm screen and stored for further analysis in plastic bags. No attempt was made to mimic animal selection, however, inedible materials (i.e., feces, dried grass, and roots) were removed from the clippings.

Chemical analysis performed on the bermudagrass forage samples are shown in Table II. Dry matter and ash were determined by weighing a 2 g air dry sample and drying in a 100^{o} C forced air oven overnight. The samples were then placed in a muffle furnace at 500^{o} C for a minimum of 4 hours and reweighed to determine residual ash. Total nitrogen was determined by the macro-kjeldahl method of the A.O.A.C. (1960). Neutral-detergent fiber, acid-detergent fiber, acid-detergent lignin, acid-detergent insoluble nitrogen and pepsin insoluble nitrogen were

TABLE II

ANALYSES PERFORMED ON BERMUDAGRASS FORAGE SAMPLES

Item	1976 Hand-Clipped	1977 Hand-Clipped	1977 Esophageal
IVDMD[ab]	X	X	X
IVOMD[c]	X	X	X
Dry Matter, %	X	X	X
Crude Protein[b]	X	X	X
ADIN[bd]	X	X	X
PIN[be]	X	X	X
Neutral-Detergent Fiber[b]	X	X	X
Acid-Detergent Fiber[b]	X	X	X
Acid-Detergent Lignin	X	X	X
Ash[b]	X	X	X
Gross Energy, Kcal/g		X	X
Density, g/ml		X	X
Tannin[b]			X

[a] *In vitro* dry matter digestibility.

[b] Expressed as % of dry matter.

[c] *In vitro* organic matter digestibility.

[d] Acid-detergent insoluble nitrogen.

[e] Pepsin insoluble nitrogen.

determined by the procedures of Goering and Van Soest (1970).

In vitro digestibility of forage dry and organic matter were determined by a modification of the procedure of Tilley and Terry (1963). Thirty ml of a 1:1 solution of strained rumen fluid and buffer (McDougal, 1948), which contained 1.26 g urea/liter of buffer, was added to approximately .5 g of forage for a 48-hour fermentation period. At the end of the fermentation period 7 ml of 1N HCL and 2 ml of 5% pepsin[1], in water, were added for a 24-hour pepsin digestion period. Digested residue was filtered through gooch crucibles.[2] The gooch crucibles were prepared with a hy-flo supercel mat and ashed and tared prior to filtration. Samples were filtered with a light vacuum and washed repeatedly with approximately 300 ml of hot water, prior to being dried for 24 hours at 100° C. After dry residue was determined, the crucibles were ashed in a muffle furnace at 500° C for a minimum of 4-hours and the ash residue determined. Quadruplicate blank tubes and bermudagrass standards were included in each run to determine contribution of rumen fluid and validity, respectively. Calculation of forage dry matter (DM) and organic matter (OM) digestibilities were calculated as follows:

$$DM = \frac{\text{Initial DM} - (\text{Residual DM} - \text{Blank DM})}{\text{Initial DM}} \times 100$$

$$OM = \frac{\text{Initial OM} - (\text{Residual OM} - \text{Blank OM})}{\text{Initial OM}} \times 100$$

Forage dry matter intake (DMI) was calculated from fecal output (from chromium analysis) and in vitro dry matter digestibility (IVDMD) by the

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[1]Pepsin (1:10,000) Sigma Chemical Co., St. Louis, MO.

[2]50 ml. Pyrex glass with a coarse fritted filter disk, 40-60 microns pore diameter.

equation:

$$\text{Dry Matter Intake} = \frac{\text{Fecal Output (g DM)}}{\text{Forage Indigestibility} = (1-(\text{IVDMD}/100))}$$

Intake of forage components were calculated by multiplying dry matter intake by the percent of each component on a dry matter basis (e.g., crude protein intake equals dry matter intake times percent crude protein/100). Organic matter intake was calculated by multiplying dry matter intake by organic matter content (1- (percent ash/100)). Digestible dry and organic matter intakes were calculated by multiplying dry matter or organic matter intake by their respective digestibilities.

The available protein content of the forage was estimated by four procedures. Apparent digestible protein was calculated from the lignin and crude protein (CP) concentrations of forage and fecal samples by the lignin ratio procedure. Values for true protein digestibility were calculated from crude protein intake and fecal crude protein output, corrected for metabolic fecal nitrogen.[3] Two other indices of forage protein availability were calculated by subtracting (1) acid-detergent insoluble nitrogen and (2) pepsin insoluble nitrogen from crude protein, each on a dry matter basis.

These calculations were made as follows:

$$\text{Apparent digestible protein} = 100 - \left(100 \times \frac{\%\text{ lignin in forage}}{\%\text{ lignin in feces}} \times \frac{\%\text{ CP in feces}}{\%\text{CCP in forage}}\right)$$

$$\text{True digestible protein} = 100 \times \frac{\text{CP Intake} - (\text{Fecal CP output} - (18.75\text{g CP/kg DMI}))}{\text{CP Intake}}$$

$$\text{Acid-detergent soluble protein} = 100 \times \%\text{CP} - \%\text{Acid-detergent insoluble protein}$$

$$\text{Pepsin soluble protein} = \%\text{CP} - \%\text{Pepsin insoluble protein}$$

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[3]Metabolic fecal nitrogen correction factor (3 g N/kg DM intake) was an average of 1.92 (Burroughs et al., 1975) and 4.15g fecal nitrogen per kg DMI (Lofgreen and Kleiber, 1953).

Experiment II

In Experiment II (1977) 7 yearling, Hereford x Angus crossbred steers (322± 10.9 kg mean initial weight) were employed for a second forage intake and stocker weight gain study. In addition 11 put-and-take steers (224± 7.0 kg mean initial weight) and an esophageally-cannulated steer were stocked initially on May 18. The put-and-take steers were used according to subjective estimates of available forage. All steers were treated for parasites, and had access to shade and salt as in Experiment I.

The bermudagrass pasture used in Experiment II was a 3.6 ha pasture immediately adjacent to the pasture used in Experiment I and the working facilities. The pasture was not sprayed with 2-4-D, as was the pasture in Experiment I, but was mowed initially for weed control and to remove cool season annual grasses. The pasture was mowed to a forage height of about 8 cm, in two cuttings, where half the pasture was mowed at a time on June 7 and June 20, respectively. Ammonium nitrate was applied at the rate of 56 kg actual N/ha on June 22, August 3 and August 27.

The forage intake trials (Table I), fecal collection, and analyses were conducted as in Experiment I, but steer weights were taken differently. After the last fecal collection of each intake trial the steers were held overnight for a 16-hour shrink and weighed at 8:00 a.m. the next morning. Put-and-take steers were also weighed as they were removed or added to the pasture.

One hand-clipped forage sample was collected from each quarter of the pasture in the same manner samples were collected and prepared in Experiment I. Additionally forage samples were collected by use of an esophageally-cannulated steer (ES). Two ES forage samples were col-

lected between 8:30 and 11:00 am concurrent with HC sampling. The esophageally-cannulated steer was allowed to graze continuously with the experimental steers throughout the bermudagrass growing period and during sampling. Each ES forage sample was lyophilysed[4] and ground through a 2 mm screen in a Wiley mill and stored in a freezer at -18°C, until analyses were conducted.

Blood and ruminal fluid samples were collected at 11:30 am of the first fecal collection day of each intake trial. Ruminal fluid samples were taken by use of a stomach tube and vacuum pump. Approximately 200 ml of rumen fluid was filtered through four layers of cheesecloth. The filtered samples were acidified by addition of 2 ml of 20% H_2SO_4/100 ml of ruminal fluid. Rumen ammonia analyses were conducted within nine hours of collection by the magnesium oxide method of Kjeldahl distillation (A.O.A.C., 1960). Blood samples were taken by jugular puncture, and were stored in heprinized syringes on ice during transport to the laboratory. The samples were then centrifuged at 12,062 x gravity for ten minutes. After centrifugation the plasma was frozen until analyzed for urea. Plasma urea was analyzed by diluting 1 ml of plasma to 50 ml with distilled water. Plasma urea was hydrolysed to ammonia by the procedure of Fawcett and Scott (1960) and ammonia concentration determined by the procedure of Chaney and Marbach (1962).

Chemical analyses of forage samples (HC and ES) were conducted as in Experiment I (Table II) and additional analysis for gross energy, density (HC and ES) and tannin content (ES only).

Gross energy was determined in a Parr oxygen bomb calorimeter(1960) and density by the water displacement procedure described by Sibbald

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[4]Thermovac, FD6 Freeze Dryer, Copiague, NY.

et al. (1960). Tannin concentrations were analysed by the Vanillian-HCL method described by Burns (1963). Tannin concentrations were determined on ES forage samples only, because the hand-clipped samples were heat dried and this might attribute to polymerization of tannins and errors in determination (J.C. Burns, Personal communication). Forage tannin concentrations are expressed as a percent of dry matter, based on catechin[5] equivalents.

Rainfall and ambient temperature measurements were obtained from a continuous weather recording station located approximately 1.6 km from the pastures used in these studies. In addition, to the ambient temperatures obtained from the weather recording station, black-bulb (Roman-Ponce et al., 1977) and air temperature (measured with celsius thermometers, at 2 to 3-hr intervals) was measured to estimate the radient heat load in Experiment II (Table XXVIII, Appendix).

Statistical Analysis

All data were analysed by analysis of variance using a random block design. Differences between means were tested for significance by the least significant difference (LSD) procedure, protected by a preliminary F test (Steel and Torrie, 1960). The standard errors of the means (S.E.) listed in the tables, were calculated from the error mean squares (EMS) of the analysis of variance as $\sqrt{\frac{EMS}{n}}$.

Coefficients of determination were calculated using the All Possible Regressions Program (R-SQUARE) of the Statistical Analysis System (SAS). The highest coefficients of determination (R^2 values) for each regression model are listed in the tables. The print out of the R-

[5](+)-Catechin, Sigma Chemical Co., St. Louis, MO.

SQUARE procedure was limited to K number of regression models where K equaled the number of independent variables. In some instances the R^2 values of the multiple regression models which utilized the largest number of independent variables shown in the tables were very similar. Where this was the case, the lowest R^2 values are indicated as parenthetical numbers immediately to the right of the R^2 values listed in the tables.

To determine the significance of the R^2 values, they were compared to the squared values of Table A.13 of Steel and Torrie (1960).

Results and Discussion

Experiment I

Forage digestibility and chemical composition of hand-clipped bermudagrass samples are shown in Table III. In vitro digestibility of both dry matter and organic matter was higher in May ($P<.01$) than any other time. Similar values for in vitro dry matter digestibility of Midland bermudagrass have been reported (Fribourg et al., 1971).

In vitro organic matter digestibilities (IVOMD) were about 2 percentage units lower than their respective in vitro dry matter digestibilities (IVDMD). Crude, digestible and soluble protein values follow a similar pattern of change, except for apparent digestible protein. Protein values were higher in May ($P<.01$) then decreased through August and remained about the same through the September intake trial. This is in agreement with other work which has characterized the protein content of bermudagrass at different times throughout the growing season (Smith, 1973; Hopson, 1971; and McCroskey, et al., 1968). Neutral-detergent fiber, acid-detergent fiber, and lignin were lowest in May (81, 33.2, and 4.2%, respectively) then increased ($P<.01$) in the

TABLE III

DIGESTIBILITY AND CHEMICAL COMPOSITION OF HAND-CLIPPED BERMUDAGRASS FORAGE SAMPLES (1976)

Item[a]	May	June	July	August	September	S.E.
IVDMD[b]	48.4^{h}	39.7^{i}	38.7^{j}	36.5^{j}	38.4^{j}	.91
IVOMD[c]	45.7^{h}	37.1^{i}	35.9^{i}	35.3^{i}	37.0^{i}	.86
Crude Protein	20.4^{h}	17.2^{i}	12.8^{j}	9.3^{k}	9.0^{k}	.30
Apparent Digestible Protein[d]	14.9^{h}	6.4^{i}	1.4^{l}	3.0^{k}	3.8^{j}	.19
True Digestible Protein[e]	13.6^{h}	9.8^{i}	6.6^{j}	3.7^{k}	3.7^{k}	.19
ADSP[f]	17.6^{h}	13.0^{i}	9.7^{j}	6.5^{k}	6.8^{k}	.27
Pepsin soluble protein[g]	13.7^{h}	10.1^{i}	6.3^{j}	4.5^{k}	4.4^{k}	.28
Neutral detergent fiber	81.0^{h}	87.2^{i}	86.9^{i}	86.6^{i}	87.1^{i}	.48
Acid detergent fiber	33.2^{h}	39.3^{j}	36.4^{i}	38.5^{j}	38.7^{j}	.40
Acid detergent lignin	4.2^{h}	7.9^{j}	10.0^{i}	7.4^{j}	7.4^{j}	.22
Ash	8.6^{h}	8.6^{h}	8.3^{h}	8.3^{h}	8.6^{h}	.16

[a]All values except IVOMD are expressed as a percent of dry matter.

[b]*In vitro* dry matter digestibility.

[c]*In vitro* organic matter digestibility, expressed as a percent of organic matter.

[d]Calculated from forage and fecal lignin ratio.

[e]Calculated from crude protein intake and fecal crude protein output corrected for endogenous fecal nitrogen.

[f]Acid-detergent soluble protein equals crude protein minus acid-detergent insoluble nitrogen.

[g]Pepsin soluble protein equals crude protein minus pepsin insoluble nitrogen.

[h,i,j,k,l]Means in the same row followed by different superscripts are significantly different (P .01).

following months. The neutral-detergent fiber values were slightly higher than those reported by Telford et al. (1975) from hand-clipped samples from the same station. Lignin values were higher than those reported by McCroskey et al. (1968) during the bermudagrass growing season and may have been a contributing factor to the low IVDMD values.

Average daily forage intakes of dry matter and organic matter are shown for each month in Table IV. In general, forage intake increased ($P<.01$) across the summer when expressed as either kilograms of dry matter or organic matter intake per day. However, intake of forage dry matter and organic matter, expressed as kilograms per 100 kg of steer body weight, was not statistically ($P>.01$) different between months. This suggests that forage intake of steers was limited by bulk-fill throughout the bermudagrass growing season to about 1.8% of body weight. Intake of forage digestible dry matter or digestible organic matter (kilograms or kilograms per 100 kg steer body weight per day) followed similar trends as that observed for forage dry matter or organic matter intake.

Stocking rate, average daily gain, and total gain/ha are shown in Table V. Average daily gain of stockers on bermudagrass was good to excellent from May to June but decreased markedly during the July to August period and increased during the August to September period. The decrease in stocker weight gains during the latter part of the bermudagrass growing season is typical of reported stocker performance on bermudagrass (Brown et al., 1961; Knox, 1978; Utley et al., 1974) and its major criticism by stocker operators.

Stocker average daily gain and intakes of forage dry and organic matter and protein, averaged between months, are shown in Table VI.

Table IV

INTAKES OF FORAGE DRY MATTER AND ORGANIC MATTER BY STEERS (1976)

Item	May	June	July	August	Sept.	S.E.
Dry Matter,						
kg	4.95^{b}	5.02^{b}	5.55^{b}	6.33^{a}	6.75^{a}	.19
kg/100 kg body wt	1.75^{a}	1.64^{a}	1.67^{a}	1.88^{a}	1.93^{a}	.06
Digestible Dry Matter,						
kg	2.40^{ab}	1.99^{c}	2.15^{bc}	2.31^{abc}	2.59^{a}	.08
kg/100 kg body wt	.85^{a}	.65^{b}	.65^{b}	.69^{b}	.74^{ab}	.03
Organic Matter,						
kg	4.53^{b}	4.59^{b}	5.08^{b}	5.81^{a}	6.17^{a}	.18
kg/100 kg body wt	1.60^{a}	1.50^{a}	1.53^{a}	1.73^{a}	1.76^{a}	.06
Digestible Organic Matter,						
kg	2.07^{ab}	1.71^{c}	1.83^{bc}	2.05^{ab}	2.28^{a}	.07
kg/100 kg body wt	.73^{a}	.56^{bc}	.55^{c}	.61^{bc}	.65^{ab}	.02

^{a,b,c,d,e}Means in the same row followed by different superscripts are significantly different ($P<.01$).

TABLE V

STOCKING RATE AND STEER WEIGHT GAIN (1976)

Period	Stocking Rate: Steer days/ha	Weight Gain: Average daily gain, kg	Weight Gain: Total gain /kg/ha
May to June	101.8	.74	76
June to July	101.8	.95	97
July to August	101.8	.16	16
August to September	101.8	.50	51
May to September	407.2	.59	240

TABLE VI

STOCKER DAILY GAINS AND AVERAGE DAILY INTAKES OF FORAGE COMPONENTS AVERAGED BETWEEN MONTHS (1976)

Item	May to June	June to July	July to August	August to September	S.E.
Daily gain, kg	.74^{ab}	.95^{a}	.16^{c}	.50^{b}	.08
Dry Matter,					
kg,	4.99^{c}	5.29^{c}	5.94^{b}	6.54^{a}	.11
kg/100 kg body wt	1.70^{b}	1.66^{b}	1.78^{ab}	1.90^{a}	.04
Digestible Dry Matter					
kg	2.20^{b}	2.07^{b}	2.24^{b}	2.45^{a}	.05
kg/100 kg body wt	.75^{a}	.65^{b}	.67^{b}	.71^{ab}	.02
Organic Matter					
kg	4.56^{c}	4.84^{c}	5.45^{b}	5.99^{a}	.11
kg/100 kg body wt	1.55^{b}	1.52^{b}	1.63^{ab}	1.74^{a}	.03
Digestible Organic Matter					
kg	1.89^{bc}	1.77^{c}	1.94^{b}	2.17^{a}	.04
kg/100 kg body wt	.64^{a}	.56^{c}	.58	.63^{ab}	.01
Crude Protein, g	938^{a}	794^{b}	659^{c}	598^{c}	1.7
Digestible protein, g					
Apparent	533^{a}	208^{b}	132^{c}	224^{b}	8.5
True	585^{a}	436^{b}	306^{c}	241^{d}	10.2
Soluble Protein, g					
Acid detergent	765^{a}	602^{b}	485^{c}	436^{c}	13.4
Pepsin	595^{a}	436^{b}	321^{c}	292^{c}	10.2

^{a,b,c,d,e}Means in the same row followed by different superscripts are significantly different ($P<.01$).

The average daily intakes averaged between months are similar to the monthly data in that intake in kilograms dry and organic matter increased across time. Although forage intakes expressed as kilograms per 100 kg body weight were signigicantly different, they did not account for the marked decrease in steer average daily gains observed during the July to August period.

The protein intake data more closely resembled steer daily gains than did dry or organic matter intakes. During the July to August period steers consumed more ($P<.01$) forage dry matter or organic matter than during the May to June period, but steer gains and protein intakes (g/head/day) were significantly less.

To determine what indices of forage quality accounted for the greatest proportion of the variation in forage intakes, coefficients of determination (R^2 values) were determined by utilizing forage intakes and indices of forage quality pooled across months. The highest R^2 values for each regression model are listed in Table VII. The similarity between the different expressions of forage dry and organic matter intake is indicated by the R^2 values of similar magnitude. The greatest amount of variation (.54) that could be accounted for in forage intake, resulted from the regression of forage dry matter or organic matter intake, (kilograms per head per day) on acid-detergent lignin and pepsin-insoluble nitrogen (% of dry matter). Pepsin-insoluble nitrogen alone, accounted for 52 percent of the variation in dry matter and organic matter intakes, (kilograms per head per day). The consistency of some expression of forage protein content to be included in the regression model suggests that forage protein, rather than fiber fractions, has marked effects on intake. This is in agreement with the conclusion

TABLE VII

COEFFICIENTS OF DETERMINATION (R^2) FOR FORAGE INTAKE REGRESSED ON DIGESTIBILITY AND CHEMICAL COMPOSITION OF HAND-CLIPPED FORAGE SAMPLES (1976)

		Independent Variables[a]							
Dependent Variables	Number of Independent Variables	Acid Detergent Lignin	True Digestible Protein	Acid Detergent Soluble Protein	Pepsin Insoluble Nitrogen	Acid Detergent Insoluble Nitrogen	Dry Matter Digestibility	Organic Matter Digestibility	R^2 Value[b]
Dry Matter, kg,	1				X				.52
	2	X			X				.54 (.54)
Dry Matter, kg/100 kg body wt.	1				X				.22
	2			X	X				.25 (.24)
Digestible Dry Matter, kg	1					X			.34
	2		X					X	.37 (.35)
Digestible Dry Matter, kg/100 kg body wt	1	X							.37
	2				X		X		.44 (.43)
Organic Matter, kg	1				X				.52
	2	X			X				.54 (.54)
Organic Matter, kg/100 kg body wt	1				X				.23
	2			X	X				.25 (.24)
Digestible Organic Matter, kg	1					X			.39
	2			X				X	.43 (.41)
Digestible Organic Matter, kg/100 kg body wt	1	X							.38
	2				X			X	.46 (.45)

[a]Also included in calculation of R^2 But not shown were: crude protein, apparent digestible protein, acid detergent fiber, neutral detergent fiber, neutral detergent solubles and pepsin soluble nitrogen, expressed as % of dry matter.

[b]All R^2 values are significant ($P<.01$), numbers in parentheses are the lowest R^2 value, of K combinations of independent variables.

reached by Moore and Mott (1973) that protein may be the first limiting factor in animal production.

Coefficients of determination for steer daily gains regressed on forage digestibility and chemical composition are listed in Table VIII. The low coefficient (.36) for acid-detergent insoluble nitrogen (the single independent variable that accounted for the greatest variation in steer daily gains) is consistent with the poor relationship commonly observed between animal gains and single indices of forage quality.

When utilizing two independent variables, true digestible protein and acid-detergent fiber, resulted in a considerable increase in the R^2 value (.72).

Coefficients of determination (R^2) for the stocker daily gains regressed on forage intake are shown in Table IX. Intake (g/day) of true digestible protein was the single independent variable, that accounted for the greatest amount of variation (.30) of steer gains. The greatest amount of variation in steer gains, that could be accounted for by two independent variables, dry matter intake and organic matter intake (kg/day), was .51. The regression of stocker gains regressed on three independent variables, that accounted for the greatest proportion of variation (.73) was crude, pepsin-soluble and acid detergent soluble protein intakes (g/day).

Since gain is more closely related to quantity of nutrients consumed, rather than percent of nutrients in the diet, it was expected that intake of nutrients, expressed in absolute amounts would account for a greater proportion of variation in steer gains. However, the inclusion of four independent variables in the regression model increased the R^2 value by only 2% (.74 vs. .72) above the highest R^2 value.

TABLE VIII

COEFFICIENTS OF DETERMINATION (R^2) FOR STEER DAILY GAIN REGRESSED ON FORAGE DIGESTIBILITY AND CHEMICAL COMPOSITION (1976)

		Independent Variables[a]			
Dependent Variables	Number of Independent Variables	Acid-detergent Insoluble Nitrogen	True Digestible Protein	Acid Detergent Fiber	R^2 Value[b]
Steer Daily Gain	1	X		.	.36
	2		X	X	.72

[a]Also included in calculation of R^2 but not shown were: crude protein, apparent digestible protein, neutral detergent fiber, neutral detergent solubles, acid detergent lignin, IVDMD, organic matter digestibility, digestible organic matter, pepsin insoluble nitrogen, acid detergent soluble protein, pepsin soluble protein, expressed as % of dry matter.

[b]All R^2 values are significant ($P<.01$).

TABLE IX

COEFFICIENTS OF DETERMINATION (R^2) FOR STEER DAILY GAIN REGRESSED ON FORAGE INTAKE (1976)

		Independent Variables[a]									
Dependent Variable	Number of Independent Variables	True Digestible Protein[b]	Crude Protein[b]	Pepsin Soluble Protein[b]	Acid Detergent Soluble Protein[b]	Dry Matter kg	Organic Matter kg	Dry Matter[c]	Organic Matter[c]	Digestible Organic Matter[c]	R^2 Value[d]
Steer Daily Gain	1	X									.30
	2					X	X				.51
	3		X	X	X						.73
	4	X						X	X	X	.74

[a]Also included in calculation of R^2 but not shown were: digestible dry matter, kg, digestible dry matter, kg/100 kg body wt. and digestible organic matter, kg.

[b]Expressed as grams per day.

[c]Expressed as kg/100 kg steer body weight.

[d]All R^2 values are significant ($P<.01$).

R^2 values from the regression of gain on forage digestibility and chemical composition (Table VIII).

Experiment II

Dry matter and organic matter digestibility and chemical composition of hand-clipped forage samples are shown in Table X. The May values, 45.0 and 40.9% were significantly higher than the three subsequent months but digestibility was highest ($P<.01$) in September. *In vitro* organic matter digestibility (IVOMD) values were generally lower than the IVDMD values as in Experiment I, and the differences between them were greater. IVOMD values in Experiment I were only about 2 percentage units below the IVDMD values, while in Experiment II they were about four percentage units lower than IVDMD values. It would be expected that changes in IVDMD and IVOMD values for hand-clipped samples could be partially explained by environmental factors (Table XXVIII, Appendix) and forage response to management practices. Some of the decrease ($P<.01$) in digestibility of HC samples from May to June may be due to changes in available forage. Because half of the pasture was mowed 5 days prior to sampling the amount of forage available or the leaf-stem ration may have been altered. The increase ($P<.01$) from June to July and the increase ($P<.01$) from August to September may be the result of fertilization and precipitation (Table XXVIII, Appendix) prior to the sampling dates. The application of 50 kg N/ha on August 3 is not shown by increased digestibility, but adequate rainfall may have been limiting. Forage crude, true digestible protein, and soluble protein content followed a similar pattern of change between intake trials. Here, as with digestibility, protein content and digestibility may have been affected by management. Positive effects of good manage-

TABLE X

DIGESTIBILITY AND CHEMICAL COMPOSITION OF HAND-CLIPPED BERMUDAGRASS FORAGE SAMPLES (1977)

Item[a]	May	June	July	August	September	S.E.
IVDMD[b]	45.0^{k}	36.0^{l}	43.2^{k}	39.9^{l}	51.3^{j}	.92
IVOMD[c]	40.9^{k}	30.1^{m}	38.6^{kl}	35.6^{l}	47.3^{j}	1.07
Crude protein	17.0^{j}	11.5^{k}	6.8^{l}	9.5^{kl}	18.1^{j}	.66
Apparent digestible protein[d]	9.0^{k}	4.3^{l}	1.6^{m}	4.2^{l}	12.2^{j}	.34
True digestible protein[e]	11.1^{j}	6.3^{k}	2.6^{l}	4.9^{k}	12.3^{j}	.40
ADSP[f]	15.3^{j}	9.8^{k}	5.3^{l}	7.6^{kl}	15.2^{j}	.61
Pepsin soluble protein[g]	10.9^{j}	6.5^{k}	3.2^{l}	4.9^{kl}	12.1^{j}	.48
Neutral detergent fiber	75.7^{l}	80.2^{k}	82.4^{jk}	84.4^{j}	83.5^{jk}	.83
Acid detergent fiber	36.6^{j}	37.7^{j}	36.9^{j}	36.3	34.0^{j}	.63
Acid detergent lignin	5.0^{k}	7.0^{j}	6.8^{j}	7.5^{j}	6.6^{j}	.29
Ash	9.5^{kl}	9.5^{kl}	9.8^{k}	9.1^{l}	10.1^{j}	.14
Digestible energy[h]						
Kcal/g	2.0^{k}	1.6^{m}	1.8^{kl}	1.7^{lm}	2.3^{j}	.04
Kcal/ml[i]	1.5^{j}	1.2^{k}	1.5^{j}	1.1^{l}	1.4^{jk}	.05
Density g/ml	$.78^{jk}$	$.79^{j}$	$.82^{j}$	$.65^{k}$	$.59^{l}$	.02

[a] All values except IVOMD, digestible energy and density, expressed as a percent of dry matter.

[b] *In vitro* dry matter digestibility.

[c] *In vitro* organic matter digestibility, expressed as a percent of organic matter.

[d] Calculated from forage and fecal lignin ratio.

[e] Calculated from crude protein intake and fecal crude protein output corrected for endogenous fecal nitrogen.

[f] Acid detergent soluble protein equals crude protein minus acid detergent insoluble nitrogen.

[g] Pepsin soluble protein equals crude protein minus pepsin insoluble nitrogen.

[h] Digestible energy equals gross energy times *in vitro* dry matter digestibility.

[i] Digestible energy (Kcal/g) times density.

[j,k,l,m] Means in the same row followed by different superscripts are significantly different ($P<.01$).

ment and environment could by responsible for the increase in the various forms of protein during the September intake trial.

The neutral-detergent fiber composition of the forage samples was slightly lower throughout Experiment II than Experiment I. Acid-detergent fiber values were about 36% and did not differ significantly throughout the bermudagrass growing season. Acid-detergent lignin values were significantly greater from June to September than in May. The ash content changed significantly, whereas significant differences in ash content were not observed in Experiment I ($P>.01$). Digestible energy content of hand-clipped forage samples were significantly higher in September when expressed in Kcal per gram dry matter but were highest (1.5) in May and July when expressed as Kcal/ml.

Table XI shows the in vitro digestibility and chemical composition of esophageally-collected (ES) forage samples. The ES samples should give better estimates of the composition of forage selected by grazing stockers, while hand-clipped samples should give a better estimate of available forage (Sandiford, 1968). Digestibility of dry matter was lower ($P<.01$) in July and August than in other months. Organic matter digestibility followed a similar pattern, but was more variable and differences from month to month were not statistically different ($P>.01$).

Crude, digestible and soluble protein values of ES forage samples were statistically greater ($P<.01$) in September than in previous months. Forage fiber, lignin, ash, tannin, digestible energy (as Kcal/ml) and density were not significantly different between months. Digestible energy values (Kcal/g) were lower ($P<.01$) in July and August.

The composition of both hand-clipped (HC) and esophageal-collected (ES) bermudagrass forage samples are shown in Table XII. The largest

TABLE XI

DIGESTIBILITY AND CHEMICAL COMPOSITION OF ESOPHAGEAL-COLLECTED BERMUDAGRASS FORAGE SAMPLES (1977)

Item[a]	May	June	July	August	September	S.E.
IVDMD[b]	54.6^{k}	54.4^{k}	45.6^{kl}	41.2^{l}	54.0^{k}	1.30
IVOMD[c]	54.1^{k}	52.4^{k}	43.8^{k}	39.2^{k}	51.9^{k}	1.71
Crude protein	13.7^{l}	11.9^{l}	7.0^{m}	8.3^{m}	17.0^{k}	.45
Apparent digestible protein[d]	2.7^{m}	5.4^{l}	2.3^{m}	3.8^{lm}	11.7^{k}	.26
True digestible protein[e]	8.9^{l}	8.2^{m}	3.1^{n}	3.7^{n}	11.7^{k}	.32
ADSP[f]	11.7^{l}	10.4^{lm}	5.6^{n}	6.9^{mn}	15.5^{k}	.55
Pepsin soluble protein[g]	9.2^{kl}	7.8^{lm}	3.7^{n}	4.8^{mn}	12.3^{k}	.50
Neutral detergent fiber	71.8^{k}	70.7^{k}	72.8^{k}	73.1^{k}	63.9^{k}	1.91
Acid detergent fiber	37.6^{k}	33.0^{k}	37.8^{k}	37.5^{k}	31.9^{k}	1.25
Acid detergent lignin	6.9^{k}	6.2^{k}	6.2^{k}	6.3^{k}	6.0^{k}	.35
Ash	10.9^{k}	10.5^{k}	11.6^{k}	12.1^{k}	11.2^{k}	.62
Tannins[h]	$.97^{k}$	$.60^{k}$	$.44^{k}$	$.63^{k}$	1.64^{k}	.14
Digestible energy[i]						
Kcal/g	2.3^{k}	2.4^{k}	1.9^{l}	1.8^{l}	2.4^{k}	.05
Kcal/ml[j]	2.2^{k}	2.2^{k}	1.6^{k}	2.1^{k}	2.6^{k}	.32
Density, g/ml	$.93^{k}$	$.95^{k}$	$.87^{k}$	1.20^{k}	1.09^{k}	.13

[a]All values except IVOMD, digestible energy and density, expressed as a percent of dry matter.

[b]In vitro dry matter digestibility.

[c]In vitro organic matter digestibility, expressed as a percent of organic matter.

[d]Calculated from forage and fecal lignin ratio.

[e]Calculated from crude protein intake and fecal crude protein output corrected for endogenous fecal nitrogen.

[f]Acid detergent soluble protein equals crude protein minus acid detergent insoluble nitrogen on a dry matter basis.

[g]Pepsin soluble protein equals crude protein minus pepsin insoluble protein, on a dry matter basis.

[h]Tannins, catechin equivalents.

[i]Digestible energy equals gross energy times in vitro dry matter digestibility.

[j]Digestible energy, Kcal/ml equals Kcal/g times density, g/ml.

[k,l,m,n,o]Means in the same row followed by different superscripts are significantly different ($P<.01$).

TABLE XII

DIGESTIBILITY AND CHEMICAL COMPOSITION OF HAND-CLIPPED AND ESOPHAGEAL-COLLECTED BERMUDAGRASS FORAGE SAMPLES (1977)

Item[a]	May		June		July		August		September	
	HC	ES	HC	ES	HC	ES	HC	ES	HC	ES
IVDMD[b]	45.0	54.6**	36.0	54.4**	43.2	45.6*	29.9	41.2	51.3	54.0
IVOMD[c]	40.9	54.1**	30.1	52.4**	38.6	43.8*	35.6	39.2	47.3	51.9
Crude protein	17.0	13.7**	11.5	11.9	6.8	7.0	9.5	8.3	18.1	17.0
Apparent digestible protein[d]	9.0	2.7**	4.3	5.4	1.6	2.3**	4.3	3.8	12.2	11.7
True digestible protein[e]	11.1	8.9**	6.3	8.2	2.6	3.1*	4.9	3.7	12.3	11.7
ADSP[f]	15.3	11.7*	9.8	10.4	5.3	5.6	7.6	6.9	15.2	15.5
Pepsin available protein[g]	10.9	9.2	6.5	7.8	3.2	3.7	4.9	4.8	12.1	12.3
Neutral detergent fiber	75.7	71.8	80.2	70.7**	82.4	72.8	84.4	73.1**	83.5	63.9*
Acid detergent fiber	36.6	37.6	37.7	33.0	36.9	37.8	36.3	37.5	34.0	31.9
Acid detergent lignin	5.0	6.9**	7.0	6.2	6.8	6.2	7.5	6.3*	6.6	6.0
Ash	9.5	10.9	9.5	10.9*	9.8	11.6**	9.1	12.1**	10.1	11.2*
Tannins[h]		.97		.50		.44		.63		1.63
Digestible energy[i]										
Kcal/g	2.0	2.3**	1.6	2.4**	1.8	1.9	1.7	1.8**	2.3	2.4
Kcal/ml[j]	1.5	2.2*	1.2	2.2*	1.5	1.6	1.1	2.1**	1.4	2.6
Density, g/ml	.78	.93	.79	.95	.82	.87	.65	1.20**	.59	1.09**

[a]All values except IVOMD, digestible energy and density, expressed as a percent of dry matter.

[b]*In vitro* dry matter digestibility.

[c]*In vitro* organic matter digestibility, expressed as a percent of organic matter.

[d]Calculated from forage and fecal lignin ratio.

[e]Calculated from crude protein intake and fecal crude protein output corrected for endogenous fecal nitrogen.

[f]**Acid detergent soluble protein equals crude protein minus acid detergent insoluble protein.**

[g]**Pepsin soluble protein equals crude protein minus pepsin insoluble protein.**

[h]**Tannin, catechin equivalents.**

[i]**Digestible energy equals gross energy times *in vitro* dry matter digestibility.**

[j]**Digestible energy, Kcal/ml equals Kcal/g times density, g/ml.**

*Means in the same row and month are significantly different (P<.05).

**Means in the same row and month are significantly different (P<.01).

differences between HC and ES samples were in digestibility. The differences in digestibility of HC and ES samples were greatest during the June intake trial and illustrate the ability of animals to graze selectively (Hopson, 1971). Other discrepancies which might be due to sampling methods were ash and density because of the content of salivary minerals.

Intakes of forage dry matter and organic matter, calculated from the digestibilities of both HC and ES forage samples and ruminal ammonia and plasma urea concentrations are shown in Table XIII. All expressions of forage intake, calculated from the digestibilities of both hand-clipped and esophageal-collected forage samples differed significantly between months. This is in contrast to the results of Experiment I where intake of dry matter and organic matter (kg/100 kg body wt) were not significantly different. Rumen ammonia concentrations were in the range of 10.4 to 18.2 gm/dl except in the July to August period which corresponded to the period of lowest average daily gains. Plasma urea levels did not reflect the changes in rumen ammonia except in the July intake trial.

Stocking rate and stocker gains are shown in Table XIV. The average daily gains from May to June and June to July were .74 and .95 kg per day in 1976 (Table V) and .54 and .96 kg per day in 1977. Average daily gains decreased ($P<.01$) from July to August to .16 and -.60 kg per day for 1976 and 1977 respectively. This decrease in stocker weight gains is in agreement with work by Brown et al. (1961), Smith (1973), Spooner and Clary (1962) and Knox (1978).

Stocker average daily gains, dry and organic matter, and protein intakes calculated from both HC and ES samples and averaged between

TABLE XIII

INTAKES OF FORAGE DRY MATTER AND ORGANIC MATTER FROM HAND-CLIPPED AND ESOPHAGEAL-COLLECTED FORAGE SAMPLES AND RUMEN AMMONIA AND PLASMA UREA CONCENTRATIONS (1977)

	May		June		July		August		September		S.E.	
Item	HC	ES	HC	ES	HC	ES	HC	ES	HC	ES	HC	ES
Dry matter,												
kg	5.39^{d}	6.53^{i}	6.74^{cd}	9.44^{fg}	8.30^{ab}	8.67^{fgh}	7.38^{bc}	7.53^{hi}	9.59^{a}	10.15^{f}	.36	.40
kg/100 kg body wt	1.68^{c}	2.03^{h}	1.93^{bc}	2.71^{fg}	2.29^{ab}	2.39^{fgh}	2.12^{b}	2.17^{h}	2.67^{a}	2.82^{f}	.10	.36
Digestible dry matter,												
kg	2.42^{c}	3.56^{gh}	2.43^{c}	5.13^{f}	3.59^{b}	3.95^{g}	2.94^{bc}	3.10^{h}	4.91^{a}	5.48^{f}	.17	.20
kg/100 kg body wt	$.75^{c}$	1.11^{g}	$.70^{c}$	1.47^{f}	$.99^{b}$	1.09^{g}	$.85^{bc}$	$.89^{g}$	1.37^{a}	1.52^{f}	.05	.06
Organic matter,												
kg	4.88^{d}	5.82^{i}	6.10^{cd}	8.45^{g}	7.49^{ab}	7.67^{gh}	6.71^{bc}	6.63^{h}	8.62^{a}	9.01^{f}	.94	.35
kg/100 kg body wt	1.52^{c}	1.81^{h}	1.75^{bc}	2.42^{fg}	2.06^{ab}	2.11^{gh}	1.93^{b}	1.91^{h}	2.40^{a}	2.51^{f}	.33	.10
Digestible organic matter												
kg	1.99^{cd}	3.15^{g}	1.83^{d}	4.43^{f}	2.89^{b}	3.35^{g}	2.39^{bc}	2.60^{h}	4.07^{a}	4.68^{f}	.35	.17
kg/100 kg body wt	$.62^{cd}$	$.98^{g}$	$.53^{d}$	1.27^{f}	$.80^{b}$	$.92^{gh}$	$.69^{bc}$	$.75^{h}$	1.13^{a}	1.30^{f}	.04	.05
Rumen ammonia, mg/dl	18.2^{a}		10.4^{c}		4.8^{d}		8.4^{d}		14.3^{b}		.88	
Plasma urea, mg/dl	14.5^{ab}		15.8^{a}		9.3^{c}		13.4^{abc}		11.0^{bc}		1.18	

^{a,b,c,d,e}Means in the same row under the HC column followed by different superscripts are significantly different (P<.01).

^{f,g,h,i,j}Means in the same row under the ES column followed by different superscripts are significantly different (P<.01).

TABLE XIV

STOCKING RATE AND STEER WEIGHT GAIN[a] (1977)

Period	Stocking Rate: Steer days/ha	Weight Gain: Average daily[b] gain, kg/steer	Weight Gain: Total gain kg/ha
May to June	142.5	.99	134
June to July	147.8	.54	91
July to August	84.4	-.60	-27
August to September	76.7	.46	47
May to September	451.4	.35	245

[a]Stocking rate and total gain includes put-and-take steers and an esophageally-cannulated steer.

[b]Average daily gain includes only the 7 steers employed in the intake trials.

months are shown in Table XV. Significant differences were found between periods for all variables except dry matter and organic matter intakes calculated from the digestibility of esophageal-collected samples.

Coefficients of determination (R^2) for forage intake regressed on indices of forage quality are listed in Tables XVI and XVII for HC and ES collected samples, respectively. For most of the expressions of intake, the R^2 values in Tables XVI and XVII are of similar magnitude. However, the variables responsible for the highest R^2 values are not the same between methods of collecting samples. For HC samples soluble protein occurs most frequently while acid-detergent fiber, lignin, and digestible organic matter occur most frequently in ES samples. The greatest proportion of variation that can be accounted for by the indices of forage quality measured on hand-clipped and esophageal-collected forage samples is in digestible dry matter (.85) and digestible organic matter (.84) intakes (kg/head/day).

Tables XVIII and XIX show the R^2 values of steer gain regressed on indices of forage quality for HC and ES collected forage samples, respectively. Again, the highest R^2 values utilizing two independent variables were the same (.71), and the use of esophageal-collected samples did not account for a greater proportion of the variation in steer gains than did the use of hand-clipped samples. The highest R^2 for a single independent variable was 50% greater than for ES forage samples. The variables responsible for the greatest variation in steer gains were more similar, between method of forage sampling than those resulting from the regressions of forage intake on indices of forage quality.

TABLE XV

STOCKER DAILY GAINS AND AVERAGE INTAKES OF BOTH HAND-CLIPPED AND ESOPHAGEAL-COLLECTED FORAGE COMPONENTS, AVERAGED BETWEEN MONTHS (1977)

	May - June		June - July		July - August		August - September		S.E.	
	HC	ES	HC	ES	HC	ES	HC	ES	HC	ES
Daily gains, kg	.99^{b}		.54^{b}		-.60^{a}		.46^{b}		.16	
Dry matter,										
kg	6.11^{a}	7.99^{e}	7.48^{b}	9.02^{e}	7.55^{b}	8.08^{e}	8.05^{b}	8.68^{e}	.20	.23
kg/100 kg body wt	1.82	2.38^{e}	2.10^{b}	2.54^{e}	2.13^{bc}	2.28^{c}	2.27^{c}	2.45^{e}	.05	.06
Digestible dry matter,										
kg	2.48^{c}	4.36^{e}	2.96^{b}	4.51^{e}	2.97^{b}	3.51^{f}	3.49^{a}	4.13^{e}	.08	.11
kg/100 kg body wt	.74^{c}	1.30^{e}	.83^{b}	1.27^{ab}	.84	.99^{c}	.99^{a}	1.17^{b}	.05	.03
Organic matter,										
kg	5.53^{b}	7.14^{e}	6.76^{a}	8.03^{e}	6.83^{a}	7.13^{e}	7.27^{a}	7.67^{e}	.18	.20
kg/100 kg body wt	1.65^{b}	2.13^{e}	1.90^{a}	2.26^{e}	1.92^{a}	2.01^{e}	2.05^{a}	2.17^{e}	.02	.05
Digestible organic matter,										
kg	1.96^{c}	3.84^{e}	2.32^{b}	3.86^{e}	2.54^{b}	2.96^{f}	3.01^{a}	3.49^{e}	.07	.09
kg/100 kg body wt	.59^{c}	1.14^{e}	.65^{bc}	1.09^{ef}	.71^{b}	.83^{g}	.85^{a}	.99^{f}	.02	.02
Crude protein, g	873.^{b}	1027.^{e}	686.^{c}	853.^{f}	617.^{c}	618.^{g}	1113.^{a}	1098.^{e}	22.2	24.1
Digestible protein, g		324.^{f}								
Apparent	405.^{b}	324.^{f}	222.^{c}	352.^{f}	223.^{c}	246.^{g}	662.^{a}	673.^{e}	10.1	11.3
True	530.^{b}	683.^{e}	335.^{c}	501.^{f}	285.^{c}	275.^{c}	694.^{a}	668.^{f}	12.6	14.3
Soluble protein										
Acid detergent	771.^{b}	887.^{e}	568.^{c}	722.^{f}	489.^{d}	505.^{g}	919.^{a}	968.^{e}	4.0	20.7
Pepsin	553.^{b}	683.^{e}	367.^{c}	519.^{f}	310.^{d}	348.^{g}	685.^{a}	742.^{e}	18.5	15.4

^{a,b,c,d}Means in same row in HC column followed by different superscripts are significantly different ($P<.01$).

^{e,f,g,h}Means in same row in ES column followed by different superscripts are significantly different ($P<.01$).

TABLE XVI

COEFFICIENTS OF DETERMINATION (R^2) FOR FORAGE INTAKE REGRESSED ON DIGESTIBILITY AND CHEMICAL COMPOSITION OF HAND-CLIPPED FORAGE SAMPLES (1977)

Dependent Variables	No Independent Variables	Independent Variables[a]: Neutral Detergent Fiber	Acid Detergent Fiber	Apparent Digestible Protein	Pepsin Soluble Protein	Acid Detergent Soluble Protein	Pepsin Insoluble Nitrogen	R^2 Value[b]
Dry matter, kg	1	X						.48
	2				X	X		.73
Dry matter, kg/ 100 kg body wt	1	X						.40
	2				X	X		.64
Digestible dry matter, kg	1		X					.65
	2				X	X		.84
Digestible dry matter, kg/100 kg body wt	1		X					.68
	2				X	X		.80
Organic matter, kg	1	X						.49
	2				X	X		.73
Organic matter, kg/100 kg body wt	1	X						.41
	2				X	X		.63
Digestible organic matter, kg	1		X					.70
	2			X			X	.85
Digestible organic matter kg/100 kg body wt	1		X					.72
	2			X			X	.83

[a]Also included in calculation for R^2 but not shown were: crude protein, true digestible protein, digestible energy (Kcal/ml) acid detergent lignin, digestible organic matter, dry matter digestibility, organic matter digestibility, digestible energy (Kcal/g), density, acid detergent insoluble nitrogen and neutral detergent solubles, expressed as percentage of dry matter.

[b]All R^2 values are significant ($P<.01$).

TABLE XVII

COEFFICIENTS OF DETERMINATION (R^2) FOR FORAGE INTAKE REGRESSED ON DIGESTIBILITY AND CHEMICAL COMPOSITION OF ESOPHAGEAL-COLLECTED FORAGE SAMPLES (1977)

		Independent Variables[a]									
Dependent Variables	Number of Independent Variables	Acid Detergent Lignin	Digestible Organic Matter	Digestible Energy Kcal/g	True Digestible Protein	Acid Detergent Insoluble Protein	Pepsin Insoluble Protein	Acid Detergent Fiber	Dry Matter Digesti-bility	Organic Matter Digesti-bility	R^2 Value[b]
Dry matter, kg	1	X									.51
	2				X		X				**.66**
Dry matter, kg/ 100 kg body wt	1							X			.46
	2				X		X				.55
Digestible dry matter, kg	1							X			.70
	2	X	X								.79
Digestible dry matter, kg/100 kg, body wt	1							X			.66
	2	X	X								.76
Organic matter, kg	1	X									.50
	2				X		X				.67
Organic matter, kg/100 kg body wt	1							X			.48
	2			X		X					.56
Digestible organic matter, kg	1							X			.70
	2	X	X								.79
Digestible organic matter, kg/100 kg body wt	1							X			.64
	2								X	X	.76

[a]Also included in calculation of R^2 but not shown were: crude protein apparent digestible protein, neutral detergent fiber, neutral detergent solubles, acid detergent soluble protein, pepsin soluble protein, density, digestible energy, Kcal/ml, and tannin, expressed as a percent of dry matter.

[b]All R^2 values are significant ($P<.01$).

TABLE XVIII

COEFFICIENTS OF DETERMINATION (R^2) FOR STEER DAILY GAIN REGRESSED ON DIGESTIBILITY AND CHEMICAL COMPOSITION, FROM HAND-CLIPPED FORAGE SAMPLES, AVERAGED BETWEEN MONTHS (1977)

		Independent Variables[a]			
Dependent Variables	Number of Independent Variables	Acid Detergent Soluble Protein	Dry Matter Digestibility	Digestible Energy, ml	R^2 Value[b]
Steer Daily Gain	1	X			.44
	2		X	X	.71(.69)

[a]Also included in calculation of R^2 but not shown were: crude protein, apparent digestible protein, true digestible protein, pepsin soluble protein, neutral detergent fiber, neutral detergent solubles, acid detergent fiber, acid detergent lignin, digestible organic matter, pepsin insoluble nitrogen, acid detergent insoluble nitrogen, density, digestible energy. Kcal/g, expressed as a percent of dry matter.

[b]All R^2 values are significant ($P<.01$), number in parentheses are the lowest R^2 values of K combintaions of independent variables.

TABLE XIX

COEFFICIENTS OF DETERMINATION (R^2) FOR STEER DAILY GAIN REGRESSED ON DIGESTIBILITY AND CHEMICAL COMPOSITION OF ESOPHAGEAL-COLLECTED FORAGE SAMPLES, AVERAGED BETWEEN MONTHS (1977)

		Independent Variables[a]			
Dependent Variables	Number of Independent Variables	Dry Matter Digestibility	Acid Detergent Fiber	Digestible Energy Kcal/g	R^2 Value[b]
Steer Daily Gain	1			X	.66
	2	X	X		.71(.69)

[a]Also included in calculation of R^2 but not shown were: apparent digestible protein, density tannin, neutral detergent fiber and solubles, acid detergent lignin, digestible energy Kcal/ml, acid detergent insoluble nitrogen, pepsin soluble protein, acid detergent soluble protein, crude protein, pepsin insoluble nitrogen, true digestible protein, digestible organic matter, expressed as a percent of dry matter.

[b]All R^2 values are significant ($P<.01$), numbers in parentheses are the lowest R^2 values of K combinations of independent variables.

Tables XX and XXI show the highest R^2 values for steer gain regressed on dry matter, organic matter and protein intakes, calculated from HC and ES forage samples, respectively. The R^2 values for single and paired independent variables of ES collected forage samples accounted for a greater proportion of variation than those of HC samples. True digestible protein intake (Table XXI) as a single independent variable accounted for the greatest amount of variation in steer gains (.52) and true digestible protein and crude protein intake, as two independent variables, account for the greatest amount of variation (.66). However, digestible energy (kcal/day), digestible organic matter (kg/day) and digestible dry matter (kg/day) intakes calculated from hand-clipped forage digestibilities accounted for an equal proportion of the variation, accounted for by true digestible protein (g/day), digestible dry matter (kg/day), and digestible energy (Kcal/day) intakes calculated by esophageal-collected forage digestibilities. These results differ from the results of stocker weight gain regressed on <u>in vitro</u> and chemical indices of forage quality in that true digestible protein intakes (Tables XX and XXI) account for the greatest proportion of variation in stocker weight gain while protein content of the forage does not account for the greatest amount of variation (Tables XVIII and XIX).

Because of the research showing decreased ruminal dry matter digestion when rumen ammonia concentrations are limiting (Satter and Slyter, 1974) it has been suggested that rumen ammonia levels below 5 mg/dl might decrease forage intake by reducing dry matter digestion. Egan (1965) reported increased intake, cellulose digestion and ruminal ammonia concentrations of sheep infused with either casein or urea

TABLE XX

COEFFICIENTS OF DETERMINATION (R^2) FOR STEER DAILY GAIN REGRESSED ON FORAGE INTAKE, FROM HAND-CLIPPED FORAGE VALUES, AVERAGED BETWEEN MONTHS (1977)

Dependent Variables	Number of Independent Variables	Independent Variables [a]: Digestible Energy Kcal/day	Digestible Organic Matter, kg	Crude Protein, g	Digestible Dry Matter, kg	Acid-detergent Soluble Protein, g	R^2 Value [b]
Steer Daily Gain	1					X	.23
	2		X	X			.57
	3	X	X		X		.71(.70)

[a] Also included in calculation of R^2 but not shown: dry matter, kg and kg/100 kg body wt, organic matter, kg and kg/100 kg body wt, digestible organic matter, kg/100 kg body wt, apparent digestible protein, true digestible protein, acid detergent soluble protein, dry matter, 1/day, Kcal digestible energy/day.

[b] All R^2 values are signigicant ($P<.01$), numbers in parentheses are the lowest R^2 alues of independent variables.

TABLE XXI

COEFFICIENTS OF DETERMINATION (R^2) FOR STEER DAILY GAIN REGRESSED ON FORAGE INTAKE, FROM ESOPHAGEAL-COLLECTED FORAGE VALUES, AVERAGED BETWEEN MONTHS (1977)

		Independent Variables[a]				
Dependent Variables	Number of Independent Variables	True Digestible Protein, g	Crude Protein, g	Digestible Dry Matter, kg	Digestible energy, Kcal/day	R^2 Value[b]
Steer Daily Gain	1	X				.52
	2	X	X			.66
	3	X		X	X	.71(.69)

[a]Also included in calculation of R^2 values but not shown were: dry matter, kg, organic matter kg, dry matter 1/day, dry matter kg/100 kg body wt, organic matter kg/100 kg body wt, digestible organic matter kg, acid detergent soluble protein, digestible dry matter kg/100 kg body wt, digestible organic matter kg/100 kg body wt.

[b]All R^2 values are significant ($P<.01$), numbers in parentheses are the lowest R^2 value of K combinations of independent variables.

inter-duodenium. To see if rumen ammonia levels would account for any variation in forage dry matter or organic matter intakes, coefficients of determination were calculated for intake (dry matter and organic matter, kg/head/day) regressed on rumen ammonia. The coefficients of determination for dry matter and organic matter intakes calculated from HC and ES forage digestibilities are shown in Tables XXII and XXIII. The R^2 values are of greater magnitude for forage intakes calculated from the digestibilities of HC forage samples, but are not significant and do not account for more than 15 percent of the variation of dry matter or organic matter intakes (kg/head/day).

Coefficients of determination for ruminal ammonia and plasma urea concentrations regressed on various estimates of the available forage protein content calculated from hand-clipped and esophageal-collected forage samples are listed in Tables XXIV and XXV. The highest R^2 values for ruminal ammonia regressed on hand-clipped samples were higher (.75 vs. .55) than ruminal ammonia regressed on protein content of esophageal-collected forage samples, when only one independent variable was used. The R^2 values with 2 and 3 independent variables were only slightly higher and with four variables the R^2 values were identical. R^2 values for plasma urea regressed on available protein content from hand-clipped and esophageal-collected forage samples were of similar magnitude though different forms of available protein were used to calculate the highest coefficients of variation, as shown in Tables XXIV and XXV.

TABLE XXII

COEFFICIENTS OF DETERMINATION (R^2) FOR FORAGE INTAKE, FROM HAND-CLIPPED SAMPLES, REGRESSED ON RUMINAL AMMONIA AND PLASMA UREA CONCENTRATION (1977)

Dependent Variables	Number of Independent Variables	Independent Variables: Ruminal Ammonia mg/dl	Independent Variables: Plasma Urea mg/dl	R^2 Value[a]
Dry matter, kg	1		X	.11
	2	X	X	.15
Organic matter, kg	1		X	.11
	2	X	X	.15

[a] R^2 values are not statistically significant ($P>.05$).

TABLE XXIII

COEFFICIENTS OF DETERMINATION (R^2) FOR FORAGE INTAKE FROM ESOPHAGEAL-COLLECTED SAMPLES REGRESSED ON RUMINAL AMMONIA AND PLASMA UREA CONCENTRATIONS (1977)

		Independent Variables		
Dependent Variables	Number of Independent Variables	Ruminal Ammonia mg/dl	Plasma Urea mg/dl	R^2 Values [a]
Dry matter, kg	1	X		.033
	2	X	X	.033
Organic matter, kg	1	X		.028
	2	X	X	.028

[a] R^2 values are not statistically significant (P>.05).

TABLE XXIV

COEFFICIENTS OF DETERMINATION (R^2) FOR RUMINAL AMMONIA AND PLASMA UREA REGRESSED ON DIGESTIBLE AND SOLUBLE PROTEIN INTAKE OF HAND-CLIPPED FORAGES (1977)

		Independent Variables[a]				
Dependent Variables	Number of Independent Variables	Apparent Digestible Protein	True Digestible Protein	Acid-detergent Soluble Protein	Pepsin Soluble Protein	R^2 Value
Ruminal Ammonia mg/dl	1			X		.75**
	2			X	X	.80**
	3	X	X	X		.81**
	4	X	X	X	X	.81**
Plasma Urea mg/dl	1			X		.03[ns]
	2			X	X	.24 *
	3	X	X		X	.27*
	4	X	X	X	X	.36*

[a]Expressed as percent of dry matter.

*P<.05.

*P<.01.

[ns]R^2 values are not statistically significant (P>.05).

TABLE XXV

COEFFICIENTS OF DETERMINATION (R^2) FOR RUMINAL AMMONIA AND PLASMA UREA REGRESSED ON DIGESTIBLE AND SOLUBLE PROTEIN INTAKE OF ESOPHAGEAL-COLLECTED FORAGES (1977)

		Independent Variables[a]				
Dependent Variables	Number of Independent Variables	Apparent Digestible Protein	True Digestible Protein	Acid-detergent Soluble Protein	Pepsin Soluble Protein	R^2 Value
Ruminal Ammonia, mg/dl	1				X	.54**
	2	X			X	.77**
	3	X	X	X		.80**
	4	X	X	X	X	.81**
Plasma Urea, mg/dl	1		X			.03[ns]
	2		X	X		.14[ns]
	3	X		X	X	.20[ns]
	4	X	X	X	X	.36**

[a]Expressed as a percent of dry matter.

**P<.01.

[ns]R^2 values are not statistically significant (P>.05).

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TABLE XXVI

DAILY AVERAGE (X±S.E.) FECAL OUTPUT (KG) CALCULATED
FROM FECAL CHROMIUM CONTENT (1976)

	May				June				July				August				September			
	day				day				day				day				day			
Steer No.	1	2	3	X±S.E.	1	2	3	X±S.E.	1	2	3	X±S.E.	1	2	3	X±S.E.	1	2	3	X±S.E.
10	2.3	2.1	2.4	2.3±.09	3.2	3.4	3.3	3.3±.06	3.3	3.0	3.8	3.4±.23	4.8	4.7	5.1	4.8±.12	5.0	4.8	4.3	4.7±.21
11	3.2	2.8	3.1	3.1±.12	2.8	3.2	3.4	3.1±.18	3.2	2.9	2.8	3.0±.12	4.1	3.8	4.2	4.0±.12	4.4	4.2	3.6	4.1±.24
12	2.1	2.6	2.5	2.4±.15	3.2	3.4	3.2	3.2±.07	3.9	3.9	3.8	3.9±.03	3.8	4.3	4.7	4.3±.26	4.9	4.1	4.1	4.4±.27
13	3.5	2.3	2.5	2.8±.37	4.9	3.6	3.6	4.0±.43	3.9	4.5	3.7	4.0±.07	4.6	4.6	4.4	4.5±.07	4.4	4.3	4.3	4.3±.03
14	2.6	2.6	2.6	2.6±.00	2.6	3.1	2.8	2.9±.15	3.7	3.5	3.6	3.6±.06	4.0	4.4	4.1	4.2±.12	4.1	4.1	4.0	4.1±.03
15	2.0	2.1	2.5	2.2±.15	2.7	2.9	2.8	2.8±.06	4.0	2.7	3.0	3.2±.39	3.4	3.4	3.4	3.4±.00	4.3	4.3	3.6	4.1±.23
16	3.1	2.4	3.8	3.1±.40	2.3	2.6	2.7	2.5±.12	2.8	3.1	3.1	3.0±.10	3.6	3.7	3.7	3.7±.03	4.2	3.8	3.9	4.0±.12
17	2.2	2.8	2.2	2.4±.20	2.4	2.9	2.4	2.6±.17	2.9	3.1	3.9	3.3±.31	3.2	3.2	3.5	3.3±.10	3.9	4.0	3.3	3.7±.22

TABLE XXVII

DAILY AND AVERAGE ($\bar{X}$±S.E.) FECAL OUTPUT (KG) CALCULATED FROM CHROMIUM CONTENT (1977)

	May				June				July				August				September			
	Day				Day				Day				Day				Day			
Steer No.	1	2	3	$\bar{X}$ ±S.E.	1	2	3	$\bar{X}$ ±S.E.	1	2	3	$\bar{X}$ ±S.E	1	2	3	$\bar{X}$ ±S.E.	1	2	3	$\bar{X}$ ±S.E.
01	2.9	3.0	3.0	3.0±.03	3.7	3.7	6.0	4.5±.77	5.8	4.0	4.9	4.9±.52	5.4	5.3	5.1	5.3±.09	4.3	4.0	4.3	4.3±.09
02	2.7	3.0	7.4	4.4±1.52	3.9	3.9	4.1	3.9±.07	4.3	3.8	4.3	4.1±.17	4.0	3.9	3.8	3.9±.06	7.2	6.6	3.7	5.8±1.08
14	2.9	2.7	2.9	2.8±.07	3.6	4.0	5.8	4.5±68	4.9	4.0	5.1	4.7±.34	5.3	3.9	4.4	4.5±.41	4.1	3.3	4.9	4.1±.46
22	3.5	2.9	2.8	3.1±.22	5.0	3.9	4.9	4.6±.35	5.1	4.9	3.4	4.5±.54	4.5	4.0	4.2	4.6±.35	6.9	4.7	5.7	5.8±.64
30	2.7	2.9	3.0	2.9±.09	5.5	4.2	5.2	5.0±.39	4.6	5.5	7.4	5.8±.83	3.3	4.7	3.9	4.0±2.71	3.9	4.2	7.4	5.1±1.12
50	2.7	2.5	3.2	2.8±.21	4.4	4.8	4.5	4.6±.12	4.7	4.8	3.4	4.3±.45	4.7	5.4	4.1	4.7±.38	4.3	4.6	5.3	4.8±.30
51	2.6	2.8	2.6	2.7+.07	4.0	3.2	4.0	3.7+.27	4.3	3.91	13.7	7.30+3.20	5.1	4.2	3.9	4.4+.36	3.6	6.7	3.4	4.6+1.07

TABLE XXVIII

TOTAL MONTHLY RAINFALL, AVERAGE DAILY TEMPERATURE, BLACK-BULB TEMPERATURE, AND RADIANT HEAT

	Rainfall, cm	Average Daily Temperature, °C	Rainfall, cm	Average Daily Temperature, °C	Black-bulb Temperature, °C	Radiant Heat[a]
May	7.0	17.5	28.5	19.4	31.8	6
June	.3	24.2	5.1	25.8	38.4	8.1
July	.7	26.7	4.8	27.8	40.8	7.9
August	1.9	27.6	7.4	25.8	38.0	8.6
September	4.6	21.7	2.5	25.3	34.0	8.1

[a]Radiant heat equals Black-bulk temperature minus air temperature.

VITA[2]

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