

February 26, 1971

To the Graduate Council:

I am submitting herewith a thesis written by Samuel Winfred Coleman entitled "True Selective Grazing Exhibited by Beef Cattle as Determined After Adjusting for Esophageal Fistula Effects." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Karl M. Barth
Major Professor

We have read this thesis
and recommend its acceptance:

Charles D. Hobbs

J. B. McLaren

Accepted for the Council:

Heber A. Smith
Vice Chancellor for
Graduate Studies and Research

TRUE SELECTIVE GRAZING EXHIBITED BY BEEF CATTLE AS DETERMINED
AFTER ADJUSTING FOR ESOPHAGEAL FISTULA EFFECTS

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Samuel Winfred Coleman
March 1971

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation and gratitude to all those who have contributed throughout the course of graduate study and in the preparation of this thesis, especially to the following:

To Dr. K. M. Barth, major professor, for his guidance, patience, and concern throughout the course of graduate study, especially in the preparation of this thesis.

To Dr. C. S. Hobbs, Department Head of Animal Husbandry-Veterinary Science, for serving on the graduate committee and for suggestions in reviewing this manuscript.

To Dr. J. B. McLaren, for his valuable advice in the statistical analysis of the data and for his constructive criticism in the preparation of this manuscript.

To the secretaries in the Animal Husbandry Department, especially Mrs. Imogene Hood, for their assistance in typing this thesis.

To fellow graduate students, especially Mr. C. D. Lane, professors and friends, for their encouragement and assistance throughout the course of graduate study.

To his parents for their sacrifice and encouragement throughout undergraduate and graduate studies.

To the staff of The University of Tennessee Computing Center for the use of facilities which made possible the statistical analysis of these data.

ABSTRACT

During the spring, summer, and fall of 1965, 1966, and 1967 grazing trials with beef cattle were conducted to study the effects of selective grazing on chemical composition and dry matter digestibility of pasture forage samples. Samples collected from esophageal-fistulated animals were adjusted for losses of leached-out nutrients, mainly nitrogen-free extract and ether extract (NFE + EE), and for artificial increases (due to the loss of other nutrients) in the percentage of acid-detergent fiber (ADF).

Two types of pasture species combinations, tall fescue-lespedeza and orchardgrass-Ladino clover, were used in this study. The chemical composition and dry matter digestibility of forage samples selected by grazing animals were compared to the composition and digestibility of forage samples hand-clipped from the same pastures, which represented the average of the available forage. The differences between these two types of pasture samples were attributed to selectivity.

The results of this study indicate that grazing animals select forage higher in crude protein and lower in ADF and NFE than the average of the available forage. The differences were significant ($P < .05$) for all components from tall fescue and lespedeza pastures but differences for ADF from orchardgrass and Ladino clover pastures were significant only at the 90 percent level of probability.

The greatest degree of selectivity was observed in June and July and the lowest was observed in August and September for tall fescue and lespedeza pastures. Similar patterns were observed for the orchardgrass

and Ladino clover pastures except that the lowest degree of selection occurred in September. Also, the grazing animals exhibited greater selection while grazing fescue and lespedeza pastures.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
II. REVIEW OF LITERATURE	3
Methods of Measuring Selectivity.	3
Methods of measuring botanical selectivity	4
Hand-plucking method	6
Before-and-after method	6
Key forage plant method	7
Use of fistulated animals	7
Effects of Selectivity	9
Botanical selectivity	9
Chemical selectivity	10
Digestibility	11
Factors Affecting Selectivity	12
Stocking rate	12
Species of animals	13
Maturity and time in season	14
III. EXPERIMENTAL PROCEDURE	15
Pastures	15
Fistulated Steers	17
Sampling Technique	17
Chemical Analyses and Digestibility	18
Statistical Analysis	19

CHAPTER	PAGE
IV. RESULTS AND DISCUSSIONS	21
Adjustment for Fistula Effect	21
The problem	21
Adjustment of grazed-sample data	22
Adjusting for NFE and ADF	22
Selectivity	23
Fescue-lespedeza pastures	23
Orchardgrass-clover pastures	27
Conclusion	29
V. SUMMARY	31
LITERATURE CITED	33
APPENDIX	37
VITA	44

LIST OF TABLES

TABLE		PAGE
1.	Percent Legume of Pastures by Months	16
2.	Chemical Composition and Dry Matter Digestibility of Selected and Available Samples by Months for Fescue- Lespedeza Pastures	24
3.	Chemical Composition and Dry Matter Digestibility of Selected and Available Samples by Months for Orchardgrass-Clover Pastures	28
4.	Chemical Composition and Dry Matter Digestibility of Forage Samples by Collection Dates	38

CHAPTER I

INTRODUCTION

Ever increasing levels of animal production per unit of feed are necessary as agricultural land area is reduced and human consumption of animal products increases. Therefore, improvement of the nutritive value of pasture forages becomes more important. This necessitates the use of good methods to measure this nutritive value. Compared to other feeds, the nutritive value of pasture forages is difficult to determine primarily because of continuous changes in plant maturity and botanical composition, and because there is no direct method of measuring the amount of forage consumed. However, forage consumption can be estimated by using indicators or total fecal collections.

Furthermore, it is difficult to determine the quality of forages consumed by grazing animals because animals graze selectively. If sufficient forage is available, they prefer certain plant species over other plant species, or one part of the same plant over another part of the same plant. Various problems have arisen in an attempt to measure selectivity. These problems include difficulty in obtaining a representative sample of the animal's diet, prevention of contamination and minimizing losses of various nutrients of this representative sample. Fistulated animals have been used to collect samples which represent the diet chosen by the grazing animal. However, passing forages through the fistula causes gains of certain nutrients and losses of others.

The purpose of this study was to determine the degree of selectivity exhibited by beef animals grazing pasture mixtures of tall

fescue and lespedeza or orchardgrass and Ladino clover after the effects of sample collection and preparation are removed. The chemical components and dry matter digestibility of forages available to the grazing animal were compared to those of the forage selected by animals fitted with esophageal fistulas. The data represents sample collections from grazing seasons during three successive years divided into months.

CHAPTER II

REVIEW OF LITERATURE

I. METHODS OF MEASURING SELECTIVITY

Several methods have been used to determine what the grazing animal consumes. This was usually compared chemically and botanically to what was available in the pasture. Differences in the quality of these two samples were an indication of the occurrence and degree of selective grazing.

In most studies, the samples were usually analyzed chemically for the proximate constituents ash, crude protein, ether extract, and crude fiber according to A.O.A.C. (1965) methods. Nitrogen-free extract was found by difference. Fiber and lignin was usually determined as acid-detergent fiber and acid-insoluble lignin according to the method of Van Soest (1963).

Digestibility of selected forage was determined by either macro- or micro-digestion methods. The macro-digestion technique used by Hardison et al. (1954) and Meyer, Lofgreen, and Hull (1957) consisted of a series of trials to compare the digestibility of selected and available forages by total-collection and indicator methods.

The digestibility of selected and available forages has also been compared by micro techniques. Van Dyne (1963) used an in vitro fermentation method while the nylon bag method (Van Dyne, 1962) may also be used.

Methods of Measuring Botanical Selectivity

Various methods have been used to measure the botanical composition, of both the animal's diet and of the available forage. Tinney, Asmodt, and Ahlgren (1937) reviewed five of these methods which were the (1) string method, (2) specific frequency method, (3) percent frequency method, (4) percent area method, and (5) point quadrant method.

The string method utilizes a 36-inch piece of string stretched horizontally 12 inches above the ground. Anything vertically beneath the string is counted either as bare ground, grass, broadleaf, or, if, desired, the species of each forage. This method eliminates personal error and is not particularly tedious.

The specific-frequency method utilizes a grid square divided into 25-5 cm.squares. The presence of a species in a square is recorded. This method is not suited for pastures over three inches high. The percent-frequency method is similar to the specific-frequency method except the crowns in each square are counted rather than upper parts of the plants.

Square frames of fifty centimeters divided into smaller squares of 10 centimeters or more are used for the percent area method. The observer estimates the percent area covered by each species and by bare ground. The accuracy of this method depends on the observer.

The point-quadrant method is probably the most widely used by recent researchers. The point quadrant consists of two horizontal pipes mounted on 12-inch legs. The pipes contain a row of 10 holes spaced two inches apart and 14-inch adjustable needles are fitted into these holes. The needles are pushed downward until they touch a plant. Tinney et al. (1937) made adjustments in this method to overcome the decreased

visibility in tall, thick forage by slanting the needles to a 45 degree angle. The number of hits for a species and the estimate of the percent ground covered by a species is recorded. With this method a researcher actually may estimate more than a total of 100 percent cover.

In measuring the botanical composition of grazed samples collected either from a rumen fistula or an esophageal fistula, the most successful and most used method is the optical point quadrant method. Lesperance et al. (1960b), Harker, Torell and Van Dyne (1964), and Grimes, Watkin, and May (1965), have described the method as follows: a binocular dissecting microscope, set at low power, is fitted with either a cross-hair or small dot on one lens. Harker et al., (1964) placed it over an 88 by 29.5 cm. board equipped with a guide rail notched with 40 notches 1 cm. apart. The rail contained pegs at each end which fitted into a series of five holes in each end of the board placed 1 cm. apart. A tray with projections in opposite corners to fit the notches on the guide and containing the material to be examined is placed next to the guide. The particle immediately beneath the dot or crosshairs is recorded as the specie at that observation point. The tray was moved to the next notch and another observation is made. When 40 observations were made, the guide is moved to the next notch and another 40 observations were made until 200 observations are made and recorded. The tray is then reversed and the process repeated until a total of 400 observations are recorded. Lesperance et al. (1960b) floated the ingesta in ten Petri dishes and recorded ten observations per sample. They used white paper with ten parallel lines beneath the dishes. The edge of the dish was placed on the first line, the observation was made and then it

was moved to the second. Ridley et al. (1963), Van Dyne and Heady (1965), and Grimes et al. (1965) also used this 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. This sample is compared to a sample which represents available forage. The hand-plucking method fails to give an accurate picture of the forage actually consumed by the animals and is subject to human bias (Harris et al., 1967).

Before-and-After Method

The "before-and-after" method was described by Cook (1964). Paired plots or strips are used. The first plot of the pair is harvested before the animal grazes and the second plot of the pair is harvested after grazing. Differences in chemical composition between forages harvested before and after grazing are attributed to selectivity. Cook (1964) also described the "cage method." Under range conditions, cages of various sizes are randomly placed throughout the range to protect the plots that represent the "available" forage. The range is then grazed by animals after which similar plots as those protected by the cages are harvested. The difference in chemical composition between the protected and grazed plots are attributed to selectivity. A disadvantage of these methods is that the protected or "before-grazing" plot may fail to represent the actual available forage at any one time as the grazing season progresses.

Key Forage Plant Method

The Bureau of Land Management (1968) described the "key forage plant method" as an ocular estimate which determines varying degrees of utilization range from "slight," which shows no evidence of grazing, to "severe" in which the range or pasture has a mown appearance. Selectivity exists if there is a difference in utilization between key plant species. Davis (1969) observed that more clover than grasses was utilized or removed and that orchardgrass was utilized to a greater extent than tall fescue.

Use of Fistulated Animals

Many researchers feel that the best method for determining the animal's diet is to use the animal itself (Lesperance, Bohman, and Marble, 1960a; Heady and Torell, 1958; and Jefferies and Rice, 1969). The rumen-evacuation method has been successfully used to obtain samples which represent the diet of the animal. To use this method, an animal with a permanent rumen fistula is required. Lesperance et al. (1960a) describes the method as follows:

The animal was first restrained and the rumen plug removed; next, the entire contents from the rumen and reticulum were removed and placed in a suitable container. The sides of the rumen were cleaned by downward strokes of the hand. This step was essential to lessen contamination of the collected sample. After the rumen was evacuated, the animal was allowed to sample the forage for 30 to 45 min. At this time the animal was again restrained, the ingested sample removed, and the former rumen contents replaced in the rumen.

Harris et al. (1967) suggested that the rumen may be quickly rinsed and the water removed by a small pump rather than cleaning with the hand.

The use of the esophageal-fistulated animals is a very old method and dates back to Magendie, who fistulated a horse in 1847 (Van Dyne and

Torell, 1964). Several recent workers have introduced improvements in the establishment of esophageal fistulas (Cook et al., 1958; Van Dyne and Torell, 1964). Torell (1954) introduced the technique of which a modified version is in use today by most investigators. Varied degrees of success of the operative procedure and subsequent maintenance (from 100 percent fatalities within one year to less than 10 percent losses) have been observed (Harris et al., 1967). The size and type of fistula and type of closing device are important in this respect.

When the animal is not used for sampling, the fistula is closed by one of several closing devices. Torell (1954) stitched polyethylene medical tubing to the skin, inserted steel pins on either side of the fistula through the tubing, and laced them together closing the opening. Recent modifications include a plastic or metal cannula with a cap for closing (Cook et al., 1958). Van Dyne and Torell (1964) made still other modifications in the closing device which include a rubber plug and stainless steel pin, held in place by a strip of plastic pipe fitted in the esophagus to close the fistula.

Lesperance et al. (1960a) noted that the rumen fistula offered the advantage of giving a total collection and Harris (1968) found it to be better than the esophageal fistula for sampling some coarse dry grasses. The rumen fistula is also easier to establish and maintain (Van Dyne and Torell, 1964). However, the rumen-evacuation method is very time consuming and is more distasteful to the attendant (Cook, 1964).

Certain problems have arisen in using esophageal fistulated animals to study selectivity. Van Dyne and Torell (1964) and Harris et al., (1967) noted that salivary ash was the primary contaminant in

Maturity and Time in Season

As the grazing season progresses, the plants contained in a pasture mature unless they are clipped or grazed. Arnold (1961) studied the effects of maturity on the selectivity of phalaris and clover pasture with sheep by cutting and pen feeding to one group and grazing the other group at the rate of eight sheep per acre. Total fecal collections were made with the use of harnesses.

While the pasture was young and succulent and the clover in bloom, there was only a small difference in the organic matter digestibility between selected and available forage. Later, however, as phalaris began flowering, the digestibility of the available forage dropped rapidly while the grazing animals continued to select a diet high in organic matter digestibility. This difference was attributed to selectivity. According to Heady and Torell (1959), animals showed high preference for burr clover leaves in May and for seed in July over filaree, soft chess, and annual resident grasses. However, during the winter months, burr clover was selected very little and grasses were more prevalent in fistula samples. Weir et al. (1959) noted similar results, with grass being selected over filaree and burr clover early but being avoided later.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. PASTURES

The pastures of this study consisted of four three-acre plots of tall fescue (*Festuca arundinacea*) and Korean lespedeza (*Lespedeza stipulacea*), and four similar plots of Orchardgrass (*Dactylis glomerata*), and Ladino clover (*Trifolium repens*) located at The University of Tennessee's Blount Farm. The tall fescue was initially established in 1954. The orchardgrass-Ladino clover plots were reseeded in the fall of 1961. In the spring of 1962, the old fescue sod was disked and overseeded with lespedeza.

These pastures were subjectively evaluated at two-week intervals during the experimental period. This evaluation included estimating percentage species composition, the average height of the primary species, and stage of growth. General considerations were given the pastures as to the color and condition of pasture, carrying capacity, thickness of sod, and footing.

In 1965, lespedeza percentages ranged from 13 percent in May to 50 percent in July while clover percentages remained above 20 percent from May to August (Table 1). However, during the last year (1967), lespedeza percentages were always below 10 percent. Clover percentages for that year were comparable to former years.

These pastures have been used for grazing studies for several years and animal performance differences between the two types of

TABLE 1
PERCENT LEGUME OF PASTURES BY MONTHS^a

	1965				1966				1967			
	Fescue Lespedeza 1 ^b	4	2	Orchardgrass- Clover 3	Fescue- Lespedeza 1	4	2	Orchardgrass- Clover 3	Fescue- Lespedeza 1 & 5	4 & 7	Orchardgrass- Clover 2 & 6	3 & 5
May	22.0	19.0	29.0	25.0	3.0	3.5	15.5	20.0	1.0	1.0	25.0	15.0
June	45.0	45.5	25.0	32.5	4.0	4.7	14.3	22.3	5.0	4.0	16.5	25.0
July	56.0	44.0	16.5	25.0	17.5	10.0	17.5	12.5	2.0	10.0	5.0	12.0
Aug.	52.5	40.0	11.5	17.0	16.0	16.5	12.0	10.0	10.0	10.0	15.0	10.0
Sept.					11.0	10.0	18.5	15.0	1.0	1.0	5.0	5.0
Oct.					13.5	6.0	17.5	25.0				
Nov.					15.5	3.0	16.5	24.0				

^a Based on visual observation.

^b Pasture number.

pastures have been determined. The stocking rates for the pastures during this study were as follows: in 1965, three yearling market heifers were grazed until about July 1, after which time the pastures were grazed by replacement heifers from the farm beef cattle herd; in 1966, the pastures were grazed by three yearling steers per three-acre plot throughout the grazing season from May 5 to November 18; and in 1967, four yearling steers and one rumen-fistulated steer were rotated at two-week intervals between the two plots of previously established pasture pairs within each pasture type. These animals were weighed periodically and ADG for each period was calculated.

II. FISTULATED STEERS

The original five animals used in this series of experiments were obtained in Franklin, Tennessee, and fitted with esophageal fistulas using similar surgical techniques and closing devices as those described by Van Dyne and Torell (1964). Post-operation care for these animals was according to that described by High (1966). Others were similarly fistulated later.

During the collection period and while not being used for forage collection purposes, the animals were kept in a separate pasture adjacent to the experimental plots. This pasture contained a mixture of the four forage species found in the experimental plots.

III. SAMPLING TECHNIQUE

Grazed samples, representative of the animals' selected diet, were collected by the use of the esophageal-fistulated steers according

to the method of High (1966). Collections were made on the following dates in 1965: May 11, 25; June 8, 29; July 13, 27; and August 11, 23. In 1966, the following collection dates were used: May 5, 19; June 2, 16, 30; July 14, 28; August 11, 25; September 9, 23; October 8, 21; and November 4, 18. The dates in 1967 were: May 5; June 5, 30; July 28; August 29; and September 22.

On sampling days, the animals were brought to a corral and fitted with collection bags made of light-weight canvas and with a screen bottom to allow saliva drainage. The animals were allowed to graze the allotted pastures for approximately 45 minutes. They were then returned to the corral, collection apparatus removed, and the fistula plugs replaced.

Hand-clipped samples, representing forage available to the animals, were simultaneously collected. An effort was made to sample the various species in the approximate proportions in which they appeared in the pasture. These clipped samples were intended to represent the average chemical and botanical composition of the pastures from which the animals selected their diet.

IV. CHEMICAL ANALYSES AND DIGESTIBILITY

The grazed and clipped samples were taken immediately to the laboratory. The clipped samples taken in 1965 and 1966 were dried in an oven at 65°C. for 48 hours and fistula samples were dried 72 hours. In 1967, all samples were dried in a forced air oven at 50°C. for 72 hours. After air equilibration, the samples were ground in a Wiley mill using a 20-mesh screen and stored in glass jar for subsequent chemical analysis and digestion studies.

The samples were analyzed for nitrogen, ash, and moisture according to A.O.A.C. (1965) methods and for acid-detergent fiber (ADF) and acid-insoluble lignin (AIL) by the Van Soest (1963) method.

Ash values, represented on a dry matter basis, were used to obtain the percent organic matter. Crude protein, ADF, AIL, and NFE + EE was expressed on an organic matter basis. NFE + EE values were calculated by the following formula:

$$\text{Percent NFE + EE} = 100 - (\text{Percent Crude Protein} + \text{Percent ADF}).$$

Digestibility of the samples was determined by the nylon bag in vivo technique described by High (1966) in 1965 and 1966, and by the in vitro artificial rumen technique of Tilley and Terry (1963) in 1967.

Rumen-fistulated steers were used for the nylon bag digestions and for obtaining rumen liquor for in vitro digestible dry matter (IVDDM) determinations. These animals were maintained with the esophageal steers on the pasture containing mixed species which was adjacent to the experimental pastures.

V. STATISTICAL ANALYSIS

Separate least squares analyses of variance according to the procedure outlined by Harvey (1960) were made for tall fescue-lespedeza and orchardgrass-clover pastures using the following linear mathematical model:

$$Y_{ijklm} = u + r_i + m_j + yr_k + t_l + (mt)_{jl} + e_{ijklm}$$

Where: Y_{ijklm} = The percentage of crude protein, acid detergent fiber, acid insoluble lignin, nitrogen-free extract + ether extract and

digestible dry matter for the m^{th} observation of the l^{th} treatment in the k^{th} year and the j^{th} month of the i^{th} replication.

Where: u = the theoretical population mean.

r_i = the effect of the i^{th} replication

where $i = 1, 2$ as follows:

Fescue-lespedeza Orchardgrass-clover

1. Lot 1 Lot 2

2. Lot 4 Lot 3

m_j = effect of the j^{th} month where

$j = 5, 6, 7, 8, 9, 10, 11$ as follows:

5. May 8. August

6. June 9. September

7. July 10. October

11. November

yr_k = effect of the k^{th} year where

$k = 1, 2, 3$, as follows:

1. 1965 3. 1967

2. 1966

t_l = effect of the l^{th} treatment

where $l = 1, 2$, as follows:

1. available forage

2. selected forage

$(mt)_{jl}$ = the effect of the interaction between month and treatment for the l^{th} treatment and the j^{th} month.

CHAPTER IV

RESULTS AND DISCUSSIONS

I. ADJUSTMENT FOR FISTULA EFFECT

The Problem

Unrealistic values for certain nutrients selected by grazing animals have been reported. There are certain effects caused by passing forage through a fistula which alter the amounts of some plant constituents. Most researchers have recognized the presence of minerals in rumen and saliva which cause an apparent increase in ash percentages of selected forage samples. Other constituents which may be altered, especially when reported on a percentage basis, are acid-detergent fiber (ADF), acid-insoluble lignin (AIL), and the soluble-carbohydrate fraction (NFE).

Most researchers have reported greater crude protein values for selected forage than for corresponding available forage. Many of the same researchers have reported higher values for ADF percentages in the same diet. It seems unlikely, however, that both crude protein and ADF would increase in the same plant material. The following may explain this phenomenon: as the grazing animal chews the forage and mixes it with the saliva, part of the carbohydrates (NFE) might be dissolved in the saliva and lost from the sample by leaching through the screen bottom of the collection bag. As the percentage of one constituent (NFE) decreases, the percentages of the other constituents must increase. Thus ADF as the greatest chemical constituent would artificially increase the most.

This active loss of NFE in the sample and a resulting artificial increase in ADF was in fact found by Kazzal (1969), who studied the effects on the chemical composition of collecting forage samples through an esophageal fistula. Therefore, fistula samples have to be adjusted by adding the leached NFE back to the sample thus decreasing the percentage of ADF.

Adjustment of Grazed-Sample Data

Because there is a differential NFE loss from each plant species, it is necessary to know the percentage of each species selected (Botanical selectivity) by the grazing animal. Since botanical selectivity data were available in 1965 only, a botanical selection index for each species and month was calculated for 1966 and 1967 from the 1965 data (High, 1965) in the following manner:

The percent legume selected by the grazing animal was divided by the percent legume in the available pasture to yield this botanical selection index, which was either slightly greater or less than unity. It was multiplied by the percentage of that particular species appearing in the pasture for a particular month to obtain the percent of that species selected.

Adjusting for NFE and ADF

Adjustments were made for ADF and NFE percentages for orchardgrass and tall fescue based on the findings of Kazzal (1969) and for Ladino clover and lespedeza based on the work of Barth et al. (1970).

The percentage NFE lost from passing the forage through a fistula was determined for each of the four species found in the experimental

pastures. This was accomplished by subtracting the percent NFE in the clipped sample which was passed through the fistula from that of the clipped control sample. The difference, representing the percent NFE lost, was divided by the percent NFE present in the clipped control sample yielding the percent NFE lost.

An adjustment factor, including the percentage of NFE lost, was calculated in order to obtain the original percentage of NFE in the forage sample before leaching. The formula for finding the adjustment factor (AF) for NFE is:

$$\text{NFE adjustment factor} = 100 - \frac{(\% \text{ selected legume})(\% \text{ NFE} + \text{EE of legume lost through fistula}) + (\% \text{ selected grass})(\% \text{ NFE} + \text{EE of grass lost through fistula})}{100}$$

The adjusted NFE percentage is then found by the following formula:

$$\text{Adjusted NFE} = \frac{\text{unadjusted \% NFE} + \text{EE}}{\text{NFE adjustment factor}}$$

by subtracting the percent crude protein and NFE + EE from the 100 percent organic matter.

II. SELECTIVITY

Fescue-Lespedeza Pastures

The chemical composition and dry-matter digestibility by months of the adjusted selected forage, the average of the available forage, and the differences due to selectivity are presented in Table 2. The percentages of ash are not reported, since Kazzal (1969) found that animals did not select for or against ash content and differences observed between selected forage samples and available forage samples were due to

TABLE 2
CHEMICAL COMPOSITION AND DRY MATTER DIGESTIBILITY OF SELECTED AND AVAILABLE
SAMPLES BY MONTHS FOR FESCUE-LESPEDEZA PASTURES

Nutrient	TMT	LEAST SQUARES MEANS						
		May	June	July	Aug.	Sept.	Oct.	Nov.
Crude Protein ^a	Selected	21.1	22.0	22.2	19.0	20.1	21.6	18.3
	Available	16.7	15.1	15.6	16.5	15.8	16.8	14.3
	Difference	4.4	6.9	6.6	2.5	4.3	4.8	4.0
Acid-Detergent Fiber	Selected ^b	35.5	35.9	39.5	36.7	35.6	33.9	30.6
	Available	37.7	40.0	39.6	38.4	38.4	36.4	37.2
	Difference	-2.2	-4.1	-0.1	-1.7	-2.8	-2.5	-6.2
Nitrogen-free Extract and Ether Extract	Selected ^b	43.4	42.1	38.3	44.3	44.4	44.5	51.0
	Available	45.6	44.9	44.8	45.1	45.8	46.8	48.5
	Difference	-2.2	-2.8	-6.5	-0.8	-1.4	-2.3	-7.5
Digestible Dry Matter	Selected	64.5	61.2	61.7	61.7	60.8	67.3	63.5
	Available	61.3	56.3	58.2	59.2	58.9	61.5	57.7
	Difference	3.2	4.9	3.5	2.5	1.9	5.8	5.8

^aOrganic matter basis.

^bAdjusted for effects of fistula.

* (.01 < P < .05).

** (P < .01).

the effect of collecting a forage sample through an esophageal fistula.

In fescue-lespedeza forages, the crude protein content of selected forage over the entire grazing season was greater than that of available forage. This difference was highly significant ($P < .01$) and is in agreement with results from many investigators (Hardison et al., 1954; Meyer, et al., 1957; Weir and Torell, 1959; Van Dyne and Heady, 1965c; Jensen et al., 1966; Guthrie et al., 1968; Cook, 1966; Jefferies and Rice, 1969; Kazzal, 1969). These differences in crude protein content due to selection varied throughout the grazing season. The greatest differences between selected and available forages were observed in June and July and the smallest difference was found in August. Except in August, animals selected forages at least 4 percent higher in protein content than the protein content of the available forage. It is probably that in August, there was not as much forage from which to select.

Grazing animals selected forage containing significantly ($P < .01$) less ADF than the available forage contained while grazing fescue and lespedeza pastures. This is in agreement with the findings of several researchers (Weir and Torell, 1959; Weir et al., 1959; Edlefson et al., 1960; Bredon et al., 1967) and in contrast with those of others (Hill, 1965; Kiesling et al., 1969) who found more ADF in grazed samples than in available samples. However, data in the latter studies were not adjusted for fistula effects. Kazzal (1969), who adjusted for fistula effects found a slight decrease in ADF percentage in grazed samples. Variations occurred as the season progressed, but were not statistically significant at the 95 percent level. There was very little difference

due to selectivity in July, probably due to lack of forage. In the other months excepting November, grazed samples contained 1.7 percent to 4.1 percent less ADF than available forage contained. In November, the animals selected forage containing 6.2 percent less ADF than was found in the available forage.

The NFE + EE content of selected forage was significantly ($P < .05$) less than that of the NFE + EE content of the average of the available forage. The results varied from month to month but showed no particular pattern which might have resulted from plant maturity or other seasonal factors. However, in August and September, the differences were rather small, again presumably caused by the lack of forage available from which to select.

The animals also selected forage significantly ($P < .01$) higher in digestible dry matter (DDM) than the average of the available forage. This is in agreement with results by Hardison et al. (1954), Lofgreen and Meyer (1956), and Meyer et al. (1957). The difference due to selectivity varied as the season progressed. Smaller differences were found in August and September, presumably because there was very little forage to select from. Greatest differences were found in October and November.

After fiber and soluble carbohydrate fractions had been adjusted for fistula effects, it appeared that animals grazing fescue and lespedeza pasture selected a diet higher in quality than the average forage in the pasture. That is, they selected forage more highly digestible, containing more crude protein and less fiber than forage representing the average in the total pasture. In general, selection was greatest

during June and July when lespedeza was growing and the grasses were somewhat more mature and the late fall (November) when grasses were again plentiful and degree of maturity was variable. At this time the animals tended to select parts of the plant which are less fibrous and which contained more nitrogen. Selectivity was less in late summer (August and September) when there was usually very little forage to select from.

Orchardgrass-Clover Pastures

As shown in Table 3, animals grazing orchardgrass and Ladino clover pastures selected a diet significantly ($P < .01$) higher in crude protein than the average forage available in the pasture. The average selected forage was 3.5 percent higher, which was not as great as the 4.8 percent higher with fescue and lespedeza forage. Jensen et al. (1966) also found higher selectivity in tall fescue than in orchardgrass pastures. In August, the difference in crude protein content due to selectivity was similar with both species. The difference in the degree of selectivity among months were not statistically significant. Animals grazing orchardgrass and clover selected a diet containing more crude protein than animals grazing fescue and lespedeza. This indicates that even though animals exhibit a greater degree of selectivity while grazing fescue-lespedeza they will select a better diet when grazing orchardgrass-clover pasture because there is better forage from which to select.

The ADF percentages in selected forage was lower than that in the average of the available forage, but was only significant at the 90 percent level. The degree of selectivity (difference between selected and

TABLE 3
CHEMICAL COMPOSITION AND DRY MATTER DIGESTIBILITY OF SELECTED AND AVAILABLE
SAMPLES BY MONTHS FOR ORCHARDGRASS-CLOVER PASTURES

Nutrient	TMT	LEAST SQUARE MEANS							
		May	June	July	Aug.	Sept.	Oct.	Nov.	Mean
Crude Protein	Selected	20.8	24.8	23.8	22.1	18.5	22.3	23.3	22.2
	Available	17.1	19.8	18.4	19.7	17.0	19.8	18.8	18.7
	Difference	3.7	5.0	5.4	2.4	1.5	2.5	4.5	3.5**
Acid-Detergent Fiber	Selected ^a	35.9	39.3	37.2	40.5	34.5	33.6	30.7	35.9
	Available	37.7	38.9	39.5	37.2	38.1	34.0	34.8	37.2 ^c
	Difference	- 1.8	0.4	- 2.3	3.3	- 3.6	- 0.4	- 4.1	- 1.3 ^c
Nitrogen-free Extract and Ether Extract	Selected ^b	43.3	35.9	39.0	37.4	46.9	44.1	45.9	41.8
	Available	45.1	41.3	42.0	43.2	44.9	46.2	45.1	44.0
	Difference	- 1.8	- 5.4	- 3.0	- 5.8	2.0	- 2.1	0.7	- 2.2*
Digestible Dry Matter	Selected	69.7	69.6	67.3	66.0	62.8	66.2	67.0	66.9
	Available	66.0	64.5	62.7	63.3	61.5	63.4	62.4	63.4
	Difference	3.7	5.1	4.6	2.7	1.3	2.8	4.6	3.5**

^aOrganic matter basis.

^bAdjusted for effects of fistula.

^c(.05 < P < .10).

* (.01 < P < .05).

** (P < .01).

available forage) among months was variable and no apparent trend can be established. In August, animals appeared to select forage higher in ADF. Data from August are probably responsible for the lack of statistical significance in the ADF mean. Over the entire grazing period, the diets of animals grazing both types of pasture was quite similar in ADF content.

NFE + EE percentages in selected forage were significantly ($P < .05$) lower than in available forage. These results compare favorably with those of Kazzal (1969). The greatest difference occurred during the months of June and August which might explain the high ADF values in selected forage during those months.

Grazing animals selected a diet that was significantly ($P < .01$) more digestible than the average of the available forage. The selectivity did not vary significantly as the grazing period progressed but a pattern was observed. During May, June, and July, when more forage was available, and also in November, the animals exhibited a higher degree of selectivity. Selectivity was lowest in September when the digestibility of available forage was the lowest. The difference in digestibility due to selectivity was slightly higher with fescue and lespedeza pastures than with orchardgrass and clover pastures. As with crude protein, animals grazing orchardgrass and clover selected a more digestible diet than animals grazing fescue and lespedeza.

Conclusion

In conclusion, it might be stated that animals tend to select a diet higher in crude protein and lower in ADF and NFE while grazing either tall fescue and lespedeza or orchardgrass and clover pastures.

The chosen diet was also more digestible than the available forage as indicated by these data. A seasonal pattern can be observed for both types of pastures. There is usually little selectivity until late spring or early summer (June and July) when selection is at its peak. This is a time when there is a mixture of both legumes and grasses, and when there is abundant forage to select from. In mid-summer to early fall (August through October, depending on the species) selectivity is at a minimum. The forage at this time is scarce and what is available is uniformly fibrous and low in crude protein and soluble carbohydrates. There is another increase in selectivity in the fall when the forage is in different stages of maturity and when there is ample forage available. These data also indicate that animals grazing fescue and lespedeza pastures exhibit a greater degree of selectivity than animals grazing orchardgrass and clover pastures.

CHAPTER V

SUMMARY

During the spring, summer, and fall of 1965, 1966, and 1967 grazing trials with beef cattle were conducted to study the effects of selective grazing on chemical composition and dry matter digestibility of pasture forage samples. Samples collected from esophageal-fistulated animals were adjusted for losses of leached-out nutrients, mainly NFE + EE, and for artificial increases (due to the loss of other nutrients) in the percentage of acid-detergent fiber (ADF).

Two types of pasture species combinations, tall fescue-lespedeza and orchardgrass-Ladino clover, were used in this study. The chemical composition and dry matter digestibility of forage samples selected by grazing animals were compared to the composition and digestibility of forage samples hand-clipped from the same pastures, which represented the average of the available forage. The differences between these two types of pasture samples were attributed to selectivity.

The results of this study indicate that grazing animals select forage higher in crude protein and lower in ADF and NFE than the average of the available forage. The differences were significant ($P < .05$) for all components from tall fescue and lespedeza pastures but differences for ADF from orchardgrass and Ladino clover pastures were significant only at the 90 percent level of probability.

The greatest degree of selectivity was observed in June and July and the lowest was observed in August and September for tall fescue and

lespedeza pastures. Similar patterns were observed for the orchardgrass and Ladino clover pastures except that the lowest degree of selection occurred in September. Also, the grazing animals exhibited greater selection while grazing fescue and lespedeza pastures.

LITERATURE CITED

LITERATURE CITED

- A.O.A.C. 1965. Official Methods of Analysis (10th Ed.). Association of Official Agricultural Chemists. Washington, D. C.
- Arnold, G. W. 1961. Effects of pasture maturity on the diet of sheep. Australian J. Agr. Res. 12:17.
- Barth, K. M., J. E. Chandler, M. E. Fryer, and H. C. Wang. 1970. Effects of saliva and drying temperature on composition and digestibility of forage samples collected through esophageal fistulas. J. Anim. Sci. 31:794.
- Blaser, R. E., R. C. Hammes, H. T. Bryant, W. A. Hardison, J. P. Fontenot, and R. W. Engel. 1960. The effect of selective grazing on animal output. Proc. Eighth Intern. Grassland Congr.
- Bohman, V. R., and A. L. Lesperance. 1967. Methodology research for range forage evaluation. J. Anim. Sci. 26:820.
- Bureau of Land Management. 1966. Utilization Handbook: Key forage plant method. United States Dept. of Interior. Bureau of Land Management. Form 4412-12.
- Cook, C. W. 1964. Symposium on nutrition of forages and pastures: Collecting forage samples representative of ingested material of grazing animals for nutritional studies. J. Anim. Sci. 23:265.
- Cook, C. W., J. L. Thorne, J. T. Blake, and J. Edlefson. 1958. Use of an esophageal-fistula cannula for collecting forage samples by grazing sheep. J. Anim. Sci. 17:189.
- Conner, J. M., V. R. Bohman, A. L. Lesperance, and F. F. Kinsing. 1963. Nutritive evaluation of summer range forage with cattle. J. Anim. Sci. 22:961.
- Davis, D. I. 1969. Prediction of body weight gain of beef cattle from volatile fatty acids, visual pasture score, and chemical analyses of forage and the relationship of body weight gain to forage intake. Unpublished Doctoral dissertation, The University of Tennessee, Knoxville.
- Grimes, R. C., B. R. Watkin, and J. R. Gallagher. 1966. An evaluation of pasture quality with young grazing sheep. II. Chemical composition, botanical composition and in vitro digestibility of herbage selected by esophageal-fistulated sheep. J. Agric. Sci. 66:113.
- Grimes, R. C., B. R. Watkin, and P. F. May. 1965. The botanical and chemical analysis of herbage samples obtained from sheep fitted with oesophageal fistulae. J. Brit. Grassland Soc. 20:168.

- Guthrie, L. C., G. H. Rollins, and G. E. Hawkins. 1968. Evaluation of the esophageal-fistula cannula and hand-clip methods for sampling coastal bermudagrass pastures. *J. Dairy Sci.* 51:710.
- Hardison, W. A., J. T. Reid, C. M. Martin, and P. G. Woolfolk. 1954. Degree of herbage selection by grazing cattle. *J. Dairy Sci.* 37:89.
- Harker, K. W., D. T. Torell, and G. M. Van Dyne. 1964. Botanical examination of forage from esophageal fistulas in cattle. *J. Anim. Sci.* 23:465.
- Harris, L. E. 1968. Range nutrition in an arid region. Thirty-sixth faculty honor lecture. Utah State University, Logan.
- Harris, L. E., G. P. Lofgreen, C. J. Kercher, R. J. Raleigh, and V. R. Bohman. 1967. Technique of research in range livestock nutrition. *Utah Tech. Bull.* 471.
- Harvey, W. A. 1960. Least-squares analysis of data with unequal subclass numbers. *USDA Agr. Res. Ser.* 20-8.
- Heady, H. F., and D. T. Torell. 1959. Forage preferences exhibited by sheep with esophageal fistulas. *J. Range Manage.* 12:28.
- Heinemann, W. W., and T. S. Russell. 1969. Evaluation of rotation grazed pastures from esophageal and hand gathered forage samples. *Agron. J.* 61:547.
- High, T. W. 1966. Dietary selectivity by steers grazing two types of pasture. Unpublished Doctoral dissertation, The University of Tennessee, Knoxville.
- Jefferies, N. W., and R. W. Rice. 1969. Nutritive value of clipped and grazed range forage samples. *J. Range Manage.* 22:192.
- Jensen, E. H., A. L. Lesperance, V. R. Bohman, and J. R. Ridley. 1966. Pasture evaluation with fistulated cattle and conventional agronomic techniques. *Proc. Ninth Intern. Grassland Congr.*
- Kazzal, N. T. 1969. Selectivity and contamination influences upon levels of chemical composition and digestibility of samples obtained from esophageal-fistulated steers grazing two types of pasture. Unpublished Master's thesis, The University of Tennessee, Knoxville.
- Lesperance, A. L., V. R. Bohman, and D. W. Marble. 1960a. Development of techniques for evaluating grazed forage. *J. Dairy Sci.* 43:682.
- Lesperance, A. L., E. H. Jensen, V. R. Bohman, and R. A. Madsen. 1960b. Measuring selective grazing with fistulated steers. *J. Dairy Sci.* 43:1615.

- Lofgreen, G. O., and J. H. Meyer. 1956. A method for determining total digestible nutrients in grazed forage. *J. Dairy Sci.* 39:268.
- Meyer, J. H., G. P. Lofgreen, and J. L. Hull. 1957. Selective grazing by sheep and cattle. *J. Anim. Sci.* 16:766.
- Ridley, J. R., A. L. Lesperance, E. H. Jensen, and V. R. Bohman. 1963. Relationship of animal preference to botanical composition of irrigated pastures. *J. Dairy Sci.* 46:128.
- Tilley, J. M. A., and R. A. Terry. 1963. A two-stage technique for the in vitro digestion of forage crops. *J. British Grassland Soc.* 18:104.
- Tinney, F. W., O. S. Asmødt, and H. L. Ahlgren. 1937. Preliminary report of a study on methods used in botanical analysis of pasture swards. *J. Am. Soc. of Agron.* 29:835.
- Torell, D. T. 1954. An esophageal fistula for animal nutrition studies. *J. Anim. Sci.* 13:878.
- Van Dyne, G. M. 1963. An artificial rumen system for range nutrition studies. *J. Range Manage.* 16:146.
- Van Dyne, G. M., and H. F. Heady. 1965a. Dietary chemical composition of cattle and sheep grazing in common on a dry annual range. *J. Range Manage.* 18:78.
- Van Dyne, G. M., and H. F. Heady. 1965b. Interrelations of botanical and chemical dietary components of animals grazing dry annual range. *J. Anim. Sci.* 24:305.
- Van Dyne, G. M., and H. F. Heady. 1965c. Botanical composition of sheep and cattle diets on a mature animal range. *Hilgardia, Calif. Agr. Exp. Sta.* 36(13):465.
- Van Dyne, G. M., and D. T. Torell. 1964. Development and use of the esophageal fistula. A review. *J. Range Manage.* 17:7.
- Van Soest, P. J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. *J. Ass. Official Agr. Chem.* 46:829.
- Weir, W. C., J. H. Meyer, G. F. Lofgreen. 1959. Symposium on forage evaluation: VI. The uses of the esophageal fistula, lignin and chromagen techniques for studying selective grazing and digestibility of range and pasture by sheep and cattle. *Agron. J.* 51:235.

APPENDIX

TABLE 4

CHEMICAL COMPOSITION AND DRY MATTER DIGESTIBILITY
OF FORAGE SAMPLES BY COLLECTION DATES

Date	Crude Protein ^a	Acid-Detergent Fiber ^a	N-Free Extract + Ether Extract ^a	Digestible Dry Matter
Fescue-Lespedeza Available Samples				
May 11, 1965	16.4	37.4	46.2	47.8
May 25, 1965	13.9	40.9	45.2	36.3
June 8, 1965	17.3	38.9	43.7	41.3
June 19, 1965	18.2	36.9	44.9	43.9
July 13, 1965	20.7	34.3	44.9	52.2
July 27, 1965	18.1	37.4	44.5	43.3
Aug. 11, 1965	16.6	34.7	48.7	46.5
Sept. 3, 1965	14.8	38.2	47.0	41.3
May 6, 1966	21.0	34.4	44.6	82.7
May 19, 1966	18.2	38.8	43.0	75.5
June 2, 1966	15.5	37.6	46.9	75.4
June 16, 1966	14.8	40.0	45.2	72.1
June 30, 1966	11.8	43.6	44.6	66.3
July 14, 1966	12.3	43.0	44.6	65.8
July 28, 1966	12.4	42.8	44.8	69.4
Aug. 11, 1966	15.6	40.5	43.8	71.6
Aug. 25, 1966	19.2	38.7	42.0	75.0
Sept. 8, 1966	18.4	38.4	43.2	74.2
Sept. 22, 1966	16.2	38.4	45.3	73.4
Oct. 7, 1966	18.2	35.4	46.4	78.2
Oct. 20, 1966	15.7	36.2	48.1	78.3
Nov. 3, 1966	13.6	37.9	48.6	72.9
Nov. 17, 1966	15.3	35.3	49.4	75.9
May 6, 1967	14.5	36.5	48.9	65.1
June 6, 1967	14.7	41.2	44.1	56.9
June 30, 1967	13.7	40.9	45.4	54.7
July 30, 1967	16.1	39.5	44.4	61.1
Aug. 29, 1967	14.5	39.2	46.3	60.3
Sept. 23, 1967	14.0	38.1	47.9	63.4

TABLE 4 (continued)

Date	Crude Protein ^a	Acid-Detergent Fiber ^a	N-Free Extract + Ether Extract ^a	Digestible Dry Matter
Fescue-Lespedeza Unadjusted Selected Samples				
May 11, 1965	23.8	43.7	32.6	59.5
May 25, 1965	21.8	46.8	31.4	37.5
June 8, 1965	25.1	46.4	28.5	40.3
June 19, 1965	23.9	50.5	25.6	49.2
July 13, 1965	28.0	50.1	21.9	50.1
July 27, 1965	23.4	54.3	22.3	43.3
Aug. 11, 1965	21.0	54.5	24.5	37.0
Sept. 3, 1965	18.2	54.0	27.8	39.9
May 6, 1966	22.5	43.9	33.6	82.7
May 19, 1966	22.0	52.3	25.7	78.6
June 2, 1966	22.2	44.2	33.6	84.2
June 16, 1966	20.8	48.8	30.4	85.1
June 30, 1966	18.6	44.8	36.6	79.6
July 14, 1966	19.0	49.9	31.1	70.7
July 28, 1966	23.4	46.8	29.9	80.6
Aug. 11, 1966	19.6	42.0	38.4	77.0
Aug. 25, 1966	20.5	51.9	27.6	83.7
Sept. 8, 1966	20.6	47.6	31.8	85.3
Sept. 22, 1966	24.2	44.1	31.7	85.7
Oct. 7, 1966	23.5	45.2	31.3	85.7
Oct. 20, 1966	20.0	45.8	34.2	82.5
Nov. 3, 1966	17.2	44.6	38.2	81.9
Nov. 17, 1966	19.7	43.2	37.2	86.3
May 6, 1967	17.2	48.4	34.3	65.4
June 6, 1967	20.9	53.7	25.4	64.3
June 30, 1967	22.7	50.2	27.1	42.7
July 30, 1967	19.2	53.5	27.4	64.5
Aug. 29, 1967	15.1	49.3	35.6	66.0
Sept. 23, 1967	17.4	45.9	36.8	49.0

TABLE 4 (continued)

Date	Crude Protein ^a	Acid-Detergent Fiber ^a	N-Free Extract + Ether Extract ^a	Digestible Dry Matter
Fescue-Lespedeza Adjusted Selected Samples				
May 11, 1965	23.8	31.0	45.3	59.5
May 25, 1965	21.8	33.1	45.1	37.5
June 8, 1965	25.1	32.9	42.0	40.3
June 19, 1965	23.9	37.9	38.2	49.2
July 13, 1965	28.0	38.3	33.7	50.1
July 27, 1965	23.4	43.0	33.6	43.4
Aug. 11, 1965	21.0	41.6	37.4	37.0
Sept. 3, 1965	18.2	39.3	42.5	39.9
May 6, 1966	22.5	32.3	45.1	82.7
May 19, 1966	22.0	42.9	35.1	78.2
June 2, 1966	22.2	29.8	48.1	84.2
June 16, 1966	20.8	36.7	42.5	85.1
June 30, 1966	18.6	30.4	51.0	79.6
July 14, 1966	19.0	38.9	42.1	70.7
July 28, 1966	32.4	33.6	43.0	80.6
Aug. 11, 1966	19.6	26.5	53.9	77.0
Aug. 25, 1966	20.5	41.5	37.9	83.7
Sept. 8, 1966	20.6	35.8	43.6	85.3
Sept. 22, 1966	24.2	32.5	43.2	85.7
Oct. 7, 1966	23.5	33.6	42.7	85.6
Oct. 20, 1966	20.1	33.1	46.9	82.5
Nov. 3, 1966	17.2	30.5	52.3	81.9
Nov. 17, 1966	19.7	29.6	50.6	86.3
May 6, 1967	17.2	36.9	45.9	65.4
June 6, 1967	20.9	42.8	36.2	64.4
June 30, 1967	22.7	40.2	37.1	42.7
July 30, 1967	19.2	42.2	38.6	64.5
Aug. 29, 1967	15.1	36.4	48.4	66.0
Sept. 23, 1967	17.4	33.9	48.7	49.0

TABLE 4 (continued)

Date	Crude Protein ^a	Acid-Detergent Fibra	N-Free Extract + Ether Extract ^a	Digestible Dry Matter
Orchardgrass-Clover Available Samples				
May 11, 1965	15.2	38.3	46.5	59.0
May 25, 1965	16.6	40.3	43.0	51.9
June 8, 1965	24.6	35.1	40.3	53.8
June 19, 1965	23.7	36.1	40.2	63.1
July 13, 1965	22.1	37.5	40.4	47.9
July 27, 1965	19.5	36.5	44.1	53.5
Aug. 11, 1965	16.9	36.1	47.0	52.8
Sept. 3, 1965	15.5	38.2	46.3	45.3
May 6, 1966	21.6	33.2	45.2	80.0
May 19, 1966	19.8	39.0	41.2	77.9
June 2, 1966	20.6	37.4	42.0	77.9
June 16, 1966	16.5	41.4	42.4	71.5
June 30, 1966	19.6	41.1	39.1	75.2
July 14, 1966	13.9	42.9	43.3	71.2
July 28, 1966	20.2	38.2	41.5	76.1
Aug. 11, 1966	24.0	37.1	39.9	78.0
Aug. 25, 1966	23.0	38.0	39.0	75.8
Sept. 8, 1966	15.8	38.5	45.6	72.6
Sept. 22, 1966	22.9	37.5	39.6	80.5
Oct. 7, 1966	20.8	35.5	43.6	74.1
Oct. 20, 1966	21.8	33.1	45.1	80.2
Nov. 3, 1966	20.4	36.1	43.5	74.3
Nov. 17, 1966	20.2	34.1	43.1	77.8
May 6, 1967	13.7	37.0	49.3	66.3
June 6, 1967	17.6	41.5	40.8	62.1
June 30, 1967	17.4	40.3	42.3	61.4
July 30, 1967	18.6	40.1	41.4	66.1
Aug. 29, 1967	16.6	37.9	45.2	60.5
Sept. 23, 1967	15.4	38.4	46.2	61.4

TABLE 4 (continued)

Date	Crude Protein ^a	Acid-Detergent Fiber ^a	N-Free Extract + Ether Extract ^a	Digestible Dry Matter
Orchardgrass-Clover Unadjusted Selected Samples				
May 11, 1965	20.3	43.0	36.7	53.8
May 25, 1965	20.8	47.6	31.5	52.9
June 8, 1965	27.9	43.9	28.2	55.2
June 19, 1965	26.9	45.3	27.8	61.5
July 13, 1965	28.0	44.6	27.3	57.3
July 27, 1965	22.1	46.5	31.4	52.2
Aug. 11, 1965	17.5	44.3	38.4	49.6
Sept. 3, 1965	16.0	46.0	38.0	47.7
May 6, 1966	23.1	46.3	30.6	84.6
May 19, 1966	23.6	49.4	27.0	88.0
June 2, 1966	27.7	47.9	24.4	84.1
June 16, 1966	24.1	48.6	27.2	85.9
June 30, 1966	22.6	48.6	28.8	75.4
July 14, 1966	23.6	53.0	23.4	77.1
July 28, 1966	24.9	41.9	33.2	84.2
Aug. 11, 1966	25.3	48.3	26.5	81.4
Aug. 25, 1966	26.1	51.4	22.5	85.1
Sept. 8, 1966	18.5	47.5	33.9	78.7
Sept. 22, 1966	24.4	45.4	30.1	80.7
Oct. 7, 1966	25.6	45.9	28.5	82.8
Oct. 20, 1966	22.0	43.9	34.0	77.0
Nov. 3, 1966	20.3	43.8	36.0	76.6
Nov. 17, 1966	29.4	41.4	29.2	84.8
May 6, 1967	17.9	49.3	32.7	70.6
June 6, 1967	21.1	55.7	23.2	67.7
June 30, 1967	24.6	50.1	25.3	70.7
July 30, 1967	22.1	49.2	28.7	66.8
Aug. 29, 1967	21.1	56.8	22.1	61.6
Sept. 23, 1967	16.6	48.3	35.0	57.8

TABLE 4 (continued)

Date	Crude Protein ^a	Acid-Detergent Fiber ^a	N-Free Extract + Ether Extract ^a	Digestible Dry Matter
Orchardgrass-Clover Adjusted Selected Samples				
May 11, 1965	20.3	29.9	49.8	53.8
May 25, 1965	20.9	36.5	42.7	52.9
June 8, 1965	27.9	33.8	38.3	55.2
June 19, 1965	26.9	35.3	37.8	61.4
July 13, 1965	28.0	34.8	37.2	57.3
July 27, 1965	22.1	35.3	42.6	52.2
Aug. 11, 1965	17.5	30.8	51.7	49.5
Sept. 3, 1965	16.0	32.6	51.4	47.7
May 6, 1966	23.1	34.7	42.2	84.6
May 19, 1966	23.6	39.1	37.2	87.9
June 2, 1966	27.7	39.4	32.9	84.1
June 16, 1966	24.1	39.2	36.6	85.9
June 30, 1966	22.6	39.0	38.4	75.4
July 14, 1966	23.6	45.0	31.4	77.1
July 28, 1966	24.9	29.9	45.1	84.2
Aug. 11, 1966	25.3	38.7	36.0	81.4
Aug. 25, 1966	26.1	43.6	30.4	85.1
Sept. 8, 1966	18.5	35.1	46.3	78.7
Sept. 22, 1966	24.4	34.7	40.8	80.7
Oct. 7, 1966	25.6	35.9	38.5	82.8
Oct. 20, 1966	22.0	31.9	46.1	77.0
Nov. 3, 1966	20.3	31.0	48.8	76.6
Nov. 17, 1966	29.4	31.1	39.5	84.8
May 6, 1967	17.9	37.1	45.0	70.6
June 6, 1967	21.1	47.5	31.4	67.8
June 30, 1967	24.6	41.3	34.1	70.6
July 30, 1967	22.1	38.7	39.2	66.8
Aug. 29, 1967	21.1	49.1	29.8	61.6
Sept. 23, 1967	16.6	35.9	47.4	57.8

^aOrganic-matter basis.

VITA

Samuel Winfred Coleman was born in Carroll County near Huntingdon, Tennessee, on March 7, 1947. He attended elementary school in McMoresville; Tennessee, and graduated from Trezevant High School in 1965. In September, 1965, he entered The University of Tennessee at Martin and received a Bachelor of Science degree in Agriculture in 1969. While an undergraduate student, he was a member of the University Marching Band and was a member of the Pi Sigma Phi Honorary Society. He was also selected to Who's Who in American Colleges and Universities.

In September, 1969, he received a National Defense Education Act Fellowship and began graduate study in the Department of Animal Husbandry at The University of Tennessee. He received the degree of Master of Science with a major in Animal Husbandry in March, 1971. He is a member of the American Society of Animal Science and of Alpha Zeta honorary agricultural fraternity.