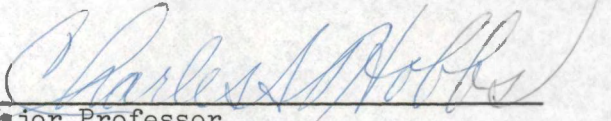


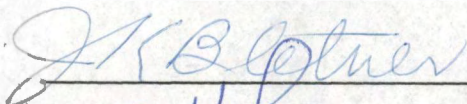
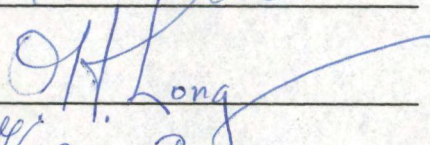
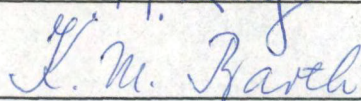
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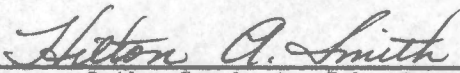
I am submitting herewith a dissertation written by Thomas Watson High, Jr. entitled "Dietary Selectivity by Steers Grazing Two Types of Pasture." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Animal Science.


Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:


Dean of the Graduate School

DIETARY SELECTIVITY BY STEERS GRAZING
TWO TYPES OF PASTURE

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

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
Thomas Watson High, Jr.

March 1966

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CHAPTER I

INTRODUCTION

Although there is currently much interest in increased concentrate feeding in the production of beef, pastures still remain a major source of nutrients for the growing beef cattle industry. Numerous grazing trials at the Tennessee Experiment Station indicate that there are definite differences in the amount and seasonal distribution of animal gains on different pastures common in this State. There is a need for more information regarding the identification of factors which contribute to the differences in quality among various pastures.

Grazing trials must be employed to accurately evaluate the beef-producing potential of pastures. These require a large outlay of land and animals to obtain accurate information, and also require considerable time. It would be desirable to have some more easily obtained measurements which would have a high degree of relationship to animal performance. Tennessee workers have for many years routinely conducted visual appraisals of pastures in connection with steer grazing trials. These appraisals included estimated percentage ground cover and average height of each species, with general considerations of maturity, succulence and other factors.

Chemical analyses of hand-clipped samples have often seemingly held little relationship to animal performance. This could have been due to the failure of the clipped samples to duplicate the diet of the

grazing animal, since many studies have indicated that cattle exert a considerable degree of selectivity of species and plant parts in a pasture mixture. Recently, ruminal and esophageal fistulated cattle and sheep have been used to obtain estimates of the diets selected by grazing animals. The use of ruminal fistulated animals for this purpose is a laborious and distasteful task that requires emptying and flushing the rumen, allowing the animal to graze, and replacing the original contents after the sample is collected. Much time and labor is required. More recently, the development of improved esophageal fistula surgical techniques and fistula closure devices has led to the adoption of this type of fistula by many researchers working in this area.

The objectives of the research reported herein were:

1. To gain information and experience regarding esophageal fistulated animal methodology.
2. To estimate the degree of selective grazing by esophageal fistulated steers grazing fescue-lespedeza and orchardgrass-Ladino clover pasture.
3. To compare certain characteristics of the diets of esophageal fistulated steers grazing these two types of pasture.
4. To determine relationships between characteristics of dietary samples, of clipped samples and of botanical composition of the pasture, and to derive equations for predicting the composition of the grazing animal's diet.
5. To obtain estimates of variation between different observers in making estimations of species composition of pastures.

CHAPTER II

REVIEW OF LITERATURE

I. IMPORTANCE OF SPECIES COMPOSITION OF PASTURES

Most cattle producers recognize the importance of considering species composition in evaluating pastures, due to differences in nutrient content, digestibility, palatability and potential beef yield attributed to different species. Of particular importance seems to be the amount of legume in a pasture mixture. Hobbs, High and Dyer (1965) found definite improvement of animal gains in mixtures containing clover where orchardgrass or tall fescue was the principal grass. Steer daily gains were significantly higher during the summer grazing season on orchardgrass-Ladino clover pasture than on orchardgrass alone with ammonium nitrate applications (1.40 vs. 1.14 pounds). During years when clover content of fescue-clover pastures was about 40 per cent, gains were higher than in years when clover content was 10 per cent or less.

Daily steer gains on old fescue sod in which lespedeza had been established were 1.32 pounds per head compared with daily gains of 1.04 pounds per head on fescue pastures with less than 10 per cent clover, in an experiment reported by High et al. (1965). In some similar work High and Hobbs (1964) found that steers grazing fescue pasture renovated and top-seeded with lespedeza gained 1.45 pounds per head per day, while daily gains of about 1.00 pound per head were common on the same

pastures in years preceding the establishment of lespedeza.

Johnstone-Wallace (1937), following a study of grazing management and plant associations in the northeastern states, concluded that the ideal sward for grazing purposes is leafy, dense and contains about 50 per cent white clover and 50 per cent grass. He felt that such pastures enable a grazing animal to consume the maximum amount of total digestible nutrients.

Wagner (1952) wrote that botanical composition is frequently more important than total yield of herbage, for yield without regard to botanical composition may have little meaning. Many times a change in botanical composition precedes a change in total production and may be the first indication that a change in management is needed.

II. ESTIMATION OF SPECIES COMPOSITION OF PASTURES

Many systems and devices have been used in an attempt to accurately estimate species composition of pastures. Only the more prominent will be reviewed in this paper. Levy (1927) developed the point quadrat, which is commonly used in making botanical estimations of pastures. This device consists of a frame with vertical pins spaced 2 inches apart. In use the pins are lowered to the ground in a pasture at random locations, and the number of hits on each species are recorded as the pins pass through the herbage. A modification of this tool, the inclined point quadrat, was developed by Tinney, Aamodt and Ahlgren (1937). This is similar to the point quadrat except that the pins are inclined at a 45° angle. This enables the pins to be seen easier as they pass through

the standing forage. In some studies the results have been more accurate than with the vertical point quadrat.

Van Keuren and Ahlgren (1957a) placed a 2 x 2 foot frame at twenty random locations in each of seven pastures. Visual estimates of botanical composition and number of hits for both the vertical and inclined point quadrats at four positions were recorded at each location. The material within the frame was harvested and hand separated. The inclined point quadrat gave reliable estimates of composition and was less variable than visual estimates. These workers pointed out that the visual estimator was inexperienced in making such estimates and that a more experienced person would probably be less variable.

These same workers (1957b) studied botanical estimation procedures with four small pasture plots, including a complex five-species mixture and three two-component seedings. Also a large established pasture was used. In the plots an inclined point quadrat was successively placed at six positions and all hits were recorded as the pins were pushed down. In the pasture 24 strips of similar size were located and quadrat readings made at twelve positions in each. Visual estimates of the botanical composition of the strips were made at the same time. The strips were then harvested, visual estimations made of the harvested forage, and samples taken for hand-separation. These workers reported that the inclined point quadrat readings and visual estimates of standing forage appeared to provide satisfactory estimates of percentage composition of the swards studied. The visual estimates were more variable, but F values indicated that only visual estimates of the

harvested forage were more variable than the hand-separation methods.

Leasure (1949) compared the inclined point quadrat and visual estimates by three observers with hand-separation of various pasture mixtures. He reported that while the point quadrat has no bias, based on his work the value determined for a single sample area may be expected to vary as much as 10 per cent from the true composition as determined by hand separation. The average of the visual estimates of three observers was also accurate within 10 per cent, but one of the individuals showed a definite bias by consistently making low estimates. He feels that a combination of visual estimates and point quadrat readings may be used to save time without materially affecting accuracy.

In a comparison of visual estimates of three observers with hand-separation determinations, Tanner, Gamble and Tossell (1960) found less variation in the visual estimation method than in the hand-separation method for determining botanical composition of timothy-alfalfa plots. They felt that visual estimates could be superior considering lower variances of the treatment mean values and the lower cost per estimate.

There is some indication that the experience of the observer is important in making visual estimates, as previously mentioned in the work by Van Keuren and Ahlgren (1957a). Nowasad and Stevenson (1947) found that after practice the per cent composition of plots could be visually estimated fairly accurately. Comparison of visual estimates with occasional checks with hand-separated samples revealed that in no case were the errors as much as 5 per cent.

A line transect, or line intercept, method for estimating ground surface cover was used by Wilm, Costello and Klipple (1944). This involved stretching a thirty-foot cable between two iron stakes in 36 random plots located in 250-300 acre pastures. The average height and classification of all plants that touched the cable were recorded. Canfield (1941) presented proof that this method is satisfactory when used on semi-arid types of vegetation.

Edlefsen, Cook and Blake (1960) used a variation of the line transect method to determine per cent ground cover. They used a 5 x 5 foot square frame with a sliding cross-piece subdivided into 1/16 square foot sections, with each section equal to 0.25 per cent cover. This frame was placed over a series of transects running through the study area, and the number of subdivisions covering each plant species was recorded.

III. ESTIMATION OF THE GRAZING ANIMAL'S DIET AND DEGREE OF SELECTIVE GRAZING

Knowledge of what grazing animals consume from a pasture or range area is necessary for making a complete, accurate evaluation of such areas. Early workers followed cattle, sheep and goats on the range and attempted to record the time each spent eating the various vegetative species (Cory, 1927). A similar approach was taken by Hubbard (1952), but one animal in a herd was chosen for close observation. The animal was followed for a period of 24 hours and the time spent grazing each species was recorded. He felt that cattle showed no preference for

different species but seemed to be governed by availability rather than differences in palatability.

Hardison et al. (1954) studied grazing selectivity exerted on a pasture plot by hand-feeding clipped herbage to one group of steers and allowing another group to graze herbage from a similar plot adjacent to the clipped area. The proximate composition of the grazed herbage was estimated by using the per cent digestibility of the nutrients in the clipped forage, composition of the clipped forage, and composition of the feces of the hand-fed steers as bases. They found that the diet of the grazing steers was higher in crude protein, ether extract, and ash and lower in crude fiber than the harvested forage. All proximate constituents of the grazed herbage were more digestible. The crude protein and ether extract increased and crude fiber decreased with maturity of first-growth herbage. Second-growth herbage contained a higher level of crude protein and a lower level of crude fiber but was somewhat less digestible than first-growth herbage of similar composition.

Detailed study of the composition of grazing animals' diets required the obtaining of samples of forage which very closely approximated the material that the animals were actually consuming. Cook et al. (1958) state that hand-plucking samples is totally inadequate in estimating the diet of grazing steers. This is borne out in work by numerous workers, as will be brought out in this section. This need for obtaining estimates of the diets of grazing animals led to the development of techniques utilizing ruminal and esophageal fistulated cattle and sheep for this purpose.

Ruminal fistulation has been successful for a number of years, so the majority of the earlier work utilized this type of fistula for obtaining samples of the grazing animal's diet. The procedure generally used for collecting forage samples with ruminal fistulated animals (the rumen-evacuation method) is described by Lesperance, Bohman and Marble (1960). This is as follows: The animal is restrained and the fistula plug is removed; next the entire contents of the rumen and reticulum are removed and placed in a suitable container. The sides of the rumen are cleaned with downward strokes of the hand to lessen contamination of the collected sample. Some workers flush the rumen with water at this point. The animal is allowed to graze for 30 to 45 minutes, is again restrained, the ingested sample is removed and the original contents replaced in the rumen. These workers reported that comparisons between feeds of a known composition and fistula samples of these feeds showed that in no case was there a change in crude protein or ether extract, but crude fiber significantly increased in fistula samples of grass hay and alfalfa-concentrate pellets. The most striking change was in ash content, which increased considerably in the fistula samples. The increase was greater with coarse, fibrous feeds.

The rumen-evacuation method was used by Shumway et al. (1963) to study animal selectivity on southern Arizona range. They made collections at 28-day intervals over a period of two years. Hand-clipped samples of the species the cattle were observed grazing were also collected. Crude protein content of the grazed samples averaged 11.22 per cent (range 6.00 to 17.92 per cent), in comparison with an average

protein content of the clipped samples of 6.67 per cent (range 3.64 to 9.23 per cent). This indicates that the animals exerted a considerable degree of selectivity toward material high in protein. However, a significant correlation ($r = .802$) between crude protein content of the grazed samples and that of clipped samples of two main perennial grasses indicates that clipping may have some value in detecting relative dietary changes. Linear regression analysis showed that 1.79 per cent increase in protein content of the grazed forage samples occurred with each 1.00 per cent increase in the grasses ($b = 1.79$). This is believed to represent the selectivity of the animals. Saliva contamination studies showed a slight decrease in crude protein content of alfalfa hay and a slight increase in protein content of cottonseed hulls, as a result of fistula sampling.

In a study of intake, digestibility, nitrogen balance, and metabolizable energy of orchardgrass and fescue pastures, Lesperance, Jensen and Bohman (1963) used the rumen-evacuation technique to determine the chemical content of the diets of steers grazing these two pastures. They found that the fistulated steers grazed forage on orchardgrass pasture that was higher in crude protein and energy and lower in ash than did the steers on fescue. There were no significant differences between pastures for digestibility, nitrogen balance or metabolizable energy. Intact animals consistently gained more weight when grazing the orchardgrass pasture.

Ridley et al. (1963) studied the relationship of animal preference to the botanical composition of irrigated tall fescue-Ladino

clover-bluegrass and orchardgrass-Ladino clover-bluegrass pastures. The rumen-evacuation method was used to obtain samples of the diets of heifers grazing these pastures. The botanical composition of the fistula samples was determined by floating ten small grab-samples in petri dishes and examining them under a dissecting microscope with a dot on one lens. The material was classed as either grass or broad-leaved plants. Botanical composition of the pastures was not highly correlated with that of the forage selected by the heifers. Correlation coefficients for the mixture containing fescue ranged from .277 to .588** and .008 to .523** for the mixture containing orchardgrass. There was significantly less fescue in the rumen samples on the beginning day of the pasture period than on the ending day, indicating that there is more selectivity when the forage is abundant. There was a non-significant difference in this respect for the orchardgrass. Rumen samples had significantly less fescue than the pasture in three of the four periods and significantly less orchardgrass in two of the four periods.

A similar study was conducted by Lesperance et al. (1960) using ruminal and esophageal fistulated steers to sample bluegrass-white clover and orchardgrass-Ladino clover pastures. Crude protein decreased and crude fiber increased in the dietary samples as the grazing season progressed even though the chemical composition of hand-clipped samples remained fairly constant. This indicates that selectivity was greater during the early part of the grazing period when more forage was available. Botanical analysis revealed that the percentage of grass in the grazing animals' diets increased as the grazing season progressed while

the percentage of broad-leaved plants decreased. Increases in crude fiber and decreases in protein were directly correlated with changes in the per cent grass in the ingested samples. Differences in protein between samples from the two types of fistulas were not observed but lower levels of crude fiber were observed in the esophageal fistula samples, indicating that perhaps complete collections were not made with this type of fistula.

In a large part of the later work concerned with studies of the diets of grazing animals the esophageal fistula has been used rather than the ruminal fistula. Improved surgical techniques and fistula closure devices and the relatively small amount of time and labor required in sampling with the esophageal fistula have contributed to this change. Cook (1964) conducted stall feeding trials to study the percentage of the material eaten that was recovered through the esophageal fistula, and found that 97 per cent of the range forage eaten was recovered.

Blackstone, Rice and Johnson (1965) reported on the effects of saliva contamination on green grass and grass hay collected through esophageal fistulas of wethers. Ash contamination was 2.94 and 3.43 per cent on hay and green grass; nitrogen contamination was 0.43 and 0.19 per cent on hay and green grass, respectively. These workers found that the percentages of known samples that were collected through the fistula varied between animals. Bath, Weir and Torrell (1956) fed chopped alfalfa to esophageal fistulated wethers and found little change in chemical composition except for a significant increase in ash content of the fistula samples.

Esophageal fistulated wethers were used by Weir and Torrell (1959) to study selective grazing on range and irrigated pasture plots. While the fistulated animals were grazing, hand-clipped samples of the forage were obtained by clipping square-foot plots randomly located in the grazing area. The sheep consistently selected forage higher in crude protein and lower in crude fiber than that obtained by hand clipping. Pooling all data showed that sheep selected forage containing 4.1 per cent (± 0.55) more protein and 3.5 per cent (± 0.29) less crude fiber than was found in the hand-clipped samples.

Hoehne, Streeter and Clanton (1965) found that species preference of steers on native Nebraska range changed during the season of June 9 to September 1, based on samples collected by four esophageal fistulated steers. These workers determined botanical composition of the fistula samples by separating the material on a gross morphological basis, drying and weighing each species.

Harker, Torrell and Van Dyne (1964) reported on a study on estimating botanical composition of esophageal fistula samples on a weight basis. They mixed fresh grass and sweet potato vines in proportions of 90 per cent grass and 10 per cent potato vines to 90 per cent potato vines and 10 per cent grass, in gradients of 10 per cent. Four hundred points were read on each sample by passing a tray containing the sample under a binocular dissecting microscope with a crosshair in one eyepiece. Four observers classified each sample. Regression coefficients were calculated for use in predicting forage weight (Y) from percentage of points (X). In this study $Y = X$ was almost as accurate as

linear, quadratic or cubic regression equations to predict per cent weight from per cent points. There were no significant differences among observers, but there was a significant observer x weight interaction.

Van Dyne and Heady (1965) compared diets of esophageal fistulated cattle and sheep grazing mature annual range in California and reported that the diets of the two species differed throughout the summer for about half of the constituents studied. Individual sheep varied more in diet than did individual cattle. These workers pointed out that while this and other cited studies indicate that the esophageal fistula technique holds considerable promise, there are many unanswered questions. One such unknown is the hypothesis that fasted animals yield different results from those which are grazing within their normal daily habits. Another is the matter of differences between morning and afternoon grazing. This study indicated that there may be differences in dietary composition between morning and afternoon and that sampling in the morning only may bias the results.

Microdigestion of esophageal fistula samples and clipped samples of California annual range was compared by Van Dyne and Weir (1964). Artificial rumen and nylon-bag cellulose digestion and nylon-bag dry-matter digestion estimates were obtained. Mixed forage samples obtained from esophageal fistulated animals generally had higher microdigestion estimates by nylon-bag technique than did any of the five species hand-clipped from the range. Microdigestion estimates were correlated with macrodigestion estimates obtained by lignin-ratio techniques under range

grazing or total collection procedures under dry-lot feeding. Over all techniques the correlation between microdigestion and macrodigestion estimates was about 0.72.

IV. ESOPHAGEAL FISTULATION

In a review on the development and use of the esophageal fistula, Van Dyne and Torrell (1964) point out that while the esophageal fistula technique has been used for many years in certain mono-gastric species, it is only in the last decade that the technique has been used widely in ruminants. They state that surgery of the esophagus is difficult, resulting in numerous losses and skepticism regarding the technique and recount the following reasons given by Saint (1929) as to why this difficulty exists: (1) the esophagus lacks a serosa, (2) in order to expose the esophagus in surgery it is necessary to open the mediastinal structures and fascial planes, (3) there is a very poor blood supply to the esophagus, (4) the esophagus cannot be restricted from movement, (5) there is an absence of the greater omentum. In this review, these workers describe a surgical technique which has been successful in their work with both cattle and sheep.

Success of esophageal fistulation in large animals has been very variable and in early developmental stages losses were great. Torrell (1954) attempted four methods of establishing fistulas and reported loss of three out of four sheep. He also established a fistula in a heifer, but she died of a digestive disorder before use. Cook et al. (1958) established esophageal fistulas in four sheep, and reported that three

of the sheep were used successfully for eight months. One sheep lost its cannula because of necrosis two months after installation. They devised a cannula for sheep made of rigid lucite tubing fitted with a screw cap. Nelson (1962) established fistulas fitted with stainless steel cannulae in four steers, but all were unsatisfactory over a period of time. He encountered several complications including loss of cannulae due to pressure necrosis, recurrent lack of appetite, and ulceration of the rumen and reticulum.

Many of the complications in fistula maintenance and sampling arise from the lack of satisfactory closure devices. Lesperance, Bohman and Marble (1960) developed cannulae from modified plastic "T" joints, either 1-1/2 or 2 inches inside diameter. The 1-1/2-inch cannula was too small for the bolus to fall through. With the larger diameter, one animal lost the cannula and died two months later after the workers failed to devise a suitable plug. With another animal the technique appeared successful for 75 days, but the anterior lip of the cannula gradually protruded through the esophagus and skin.

Recently, development of more efficient closure devices has led to greater fistula success. Van Dyne (1962) fistulated five steers and seven sheep. All of the steers survived surgery and were satisfactory for field use; the sheep all survived surgery, but two were killed after several months of field use. He used the surgical technique described by Van Dyne and Torrell (1964). In this review article there is a thorough discussion on various types of closure devices in use, and the advantages and disadvantages of each. It seems that the removable plug

fashioned from plastic pipe, rubber stopper and stainless steel bolt is now preferred by many workers. This helps to lessen the occurrence of necrosis caused by heavy permanent cannulae and clogging of the cannulae which often occurs during sampling. Torrell (1965, personal communication) feels that almost a hundred per cent of the material eaten may be collected through the fistula when the plug is completely removed for sampling. Van Dyne (1965, personal communication) also feels that this removable plug is the easiest to use and presents fewer complications than some of the permanent cannulae.

Greater surgical success has been obtained with young animals than with mature animals. It appears that with the current surgical techniques about 10 per cent of the animals fistulated will not be useful over a long period of time (Van Dyne and Torrell, 1964). Yet, many animals are useful over a long period. Heady and Torrell (1959) reported on an esophageal fistulated wether which had been in use for four years at the time of their study. Van Dyne and Torrell (1964) show a photograph of a bifistulated steer (ruminal and esophageal fistulas) in which the esophageal fistula had been established about 2-1/2 years.

Yarns et al. (1964) reported that nine out of eleven steers that they fistulated have been successfully used and maintained in a healthy condition for 9 to 24 months. Their surgical technique is somewhat different from that used by most workers in that they perform surgery while the animal is standing rather than in a lateral recumbent position. They feel that it is important to maintain normal position of the head and neck during surgery for proper positioning of the fistula.

Described in this paper is a fistula cannula which these workers molded from soft, flexible plastic.

A study of location for esophageal fistulation is reported by Hoene, Streeter and Clanton (1965). They found that the best collections were obtained from fistulas located near the ventral midline of the neck, compared with the left side of the neck and midway between the two extremes. There were, however, several post-operative problems associated with this ventral midline position. These workers feel that esophageal fistulas should be installed at least four months before routine use is attempted. Removing the cannula resulted in bleeding and shrinking of the circumference of the fistula in 5 to 10 minutes when sampling was attempted 30 days after fistulation. After three to four months, some shrinking still occurred but at a much slower rate.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. PASTURES

The pastures in this study had been utilized in steer grazing studies at the University of Tennessee Blount Farm for a number of years. They included tall fescue-lespedeza and orchardgrass-Ladino clover mixtures. In the spring of 1962, the lespedeza was established in old fescue sod by heavy disking and overseeding with 20 pounds of lespedeza seed per acre. Establishment of lespedeza by this means was very successful, and in subsequent years through 1965 a very good stand was maintained through self-reseeding. The orchardgrass-Ladino clover pastures were reseeded in the fall of 1961.

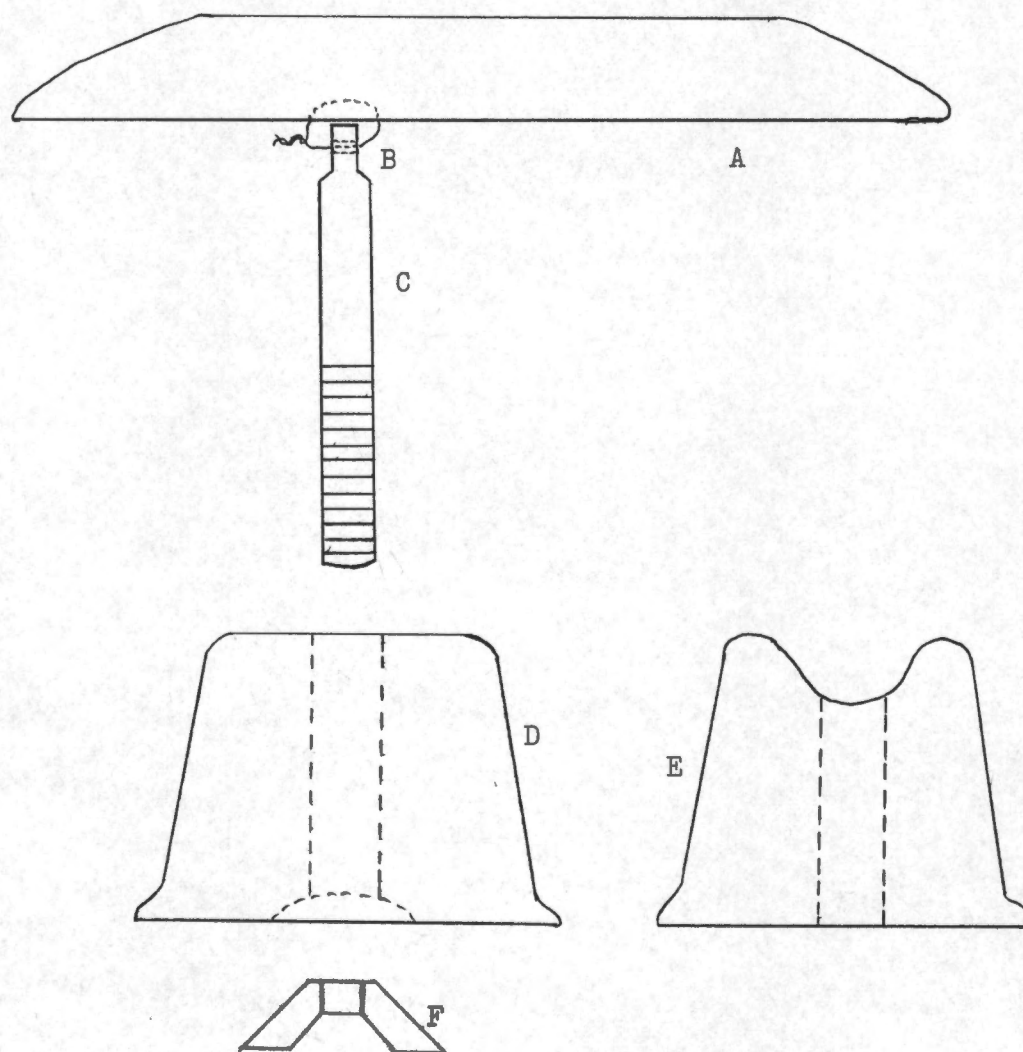
For 3 years prior to this study, these pastures were grazed by yearling steers at the rate of one steer per acre during the period of approximately November 1 to September 1. The average summer animal gains for these years will be presented herein so that typical differences between the two types of pastures in animal performance can be noted.

During the course of the study reported on in this paper, the pastures were grazed by yearling market heifers until about July 1. Following this they were grazed by replacement heifers from the farm beef cattle herd. An effort was made during this study to graze all pastures similarly.

II. ESOPHAGEAL FISTULATION

Five yearling Hereford steers weighing about 600 pounds were fistulated, using the surgical technique described by Van Dyne and Torrell (1964). The animals were held off feed and water for 24 hours prior to surgery. An electrical anesthesia unit was used to anesthetize the animal, and it was placed on the right side with the head and rear legs tied in an extended position. The front legs were tied and pulled away from the animal's neck. The surgical area was clipped and disinfected. A steel rod with a rubber ball attached to the end was passed down the esophagus during surgery and manipulated to aid in locating the esophagus and dissecting through the tissue. The fistula was located near the ventral midline of the neck and halfway between the jaw and brisket. An oval-shaped piece of skin approximately 1-1/2 by 2 inches was removed. The muscles were separated and the esophagus was pulled to the surface of the fistula. A longitudinal slit approximately the length of the fistula opening was made in the esophagus. Sutures passing through the esophagus, submucosa and inner layers of the skin were made around the perimeter of the fistula. A removable plug was installed in the fistula and the animal allowed to recover from the anesthesia. A diagram of the fistula plug is shown in Figure 1.

Feed was withheld for 24 hours following surgery. The animals were fed only pelleted alfalfa hay for the first 7 days after surgery and then limited amounts of grain were added to the ration. Care was taken that no bedding was available the first 5 days to prevent clogging



- | | |
|--|--|
| A. Section of $\frac{3}{4}$ or 1 inch plastic pipe. | D. Number 12 rubber stopper, side view. Two stoppers may be glued together if necessary. |
| B. Small wire. | E. End view of rubber plug. |
| C. $\frac{1}{4}$ x 2- $\frac{1}{2}$ inch stainless steel bolt with head removed. | F. $\frac{1}{4}$ inch wing nut. |

Figure 1. Diagram of fistula plug.

of the esophagus resulting from consumption of coarse material which could not be swallowed normally. After about 10 days chopped hay was added to the ration.

After 7 days the plugs were removed from the first two steers fistulated and the fistula area was cleaned and treated with antibiotic powder. The plugs were allowed to remain in the other three steers for 2 weeks before being removed for the first time. The sutures were not removed except for small loose pieces.

III. PASTURE SAMPLING

Sample collections were started on April 27, 1965, and continued at approximately 2-week intervals throughout the summer, with the last samples being collected on August 26. Four of the esophageal fistulated steers were selected to be used for regular sampling. These were randomly divided into pairs. The same two steers remained paired during the summer while sampling was in process.

The samples were usually collected on two consecutive days at each sampling period. Two 3-acre pastures of each mixture were used in this study and each pair of steers grazed one pasture of each kind during each sampling period. The following scheme illustrates the sampling procedure used at each sampling period:

	<u>Fescue-Lespedeza</u>		<u>Orchardgrass-Ladino Clover</u>	
	<u>Lot 1</u>	<u>Lot 2</u>	<u>Lot 1</u>	<u>Lot 2</u>
Day 1	Pair 1		Pair 2	
Day 2		Pair 2		Pair 1

When the steers were not grazing the test pastures they were maintained on surplus pasture adjacent to the test plots. This area contained the species included in both types of test pasture in addition to some wild grasses. On the evening prior to the day the pastures were to be sampled, the steers were brought in to a small grass lot adjacent to the corral. On the sampling days the steers were brought into the corral at approximately 7:00 A.M. The fistula plugs were removed and the steers were fitted with collection bags. These bags were constructed of lightweight canvas and had screen wire bottoms to allow saliva run-off. Each pair of steers was put on the allotted pasture and allowed to graze for about 45 minutes. They were then brought back into the corral where the collection apparatus was removed and the fistula plugs replaced.

While the steers were collecting the fistula samples, handclipped samples were taken from the same lots on which the steers were grazing. An effort was made to clip the various species in the approximate proportions in which they appeared in the pasture and to clip at the height at which the steers seemed to be grazing. These clipped samples were intended to represent the average chemical and botanical composition of the pasture from which the steers selected their diets.

IV. SAMPLE PROCESSING, CHEMICAL ANALYSES AND DIGESTION STUDIES

Immediately following collection the fistula and clipped samples were taken to the laboratory. Approximately one-half of each fistula

sample was put into a plastic bag and stored in the freezer for future botanical examination. The remaining half of the fistula samples and the clipped samples were dried in an oven at 65° C. for 48 hours for the clipped samples and for 72 hours for the fistula samples. They were then ground in a Wiley mill and stored in glass bottles for subsequent chemical analyses and nylon-bag digestion studies.

The samples were analyzed for nitrogen (Kjeldahl), ash, cellulose (Crampton and Maynard, 1938) and acid-detergent fiber and detergent lignin (Van Soest, 1963).

A nylon bag in vivo technique was used to study dry matter and cellulose digestion of the samples. Two grams of the ground samples were put into nylon bags approximately 1-1/4 x 2 inches, constructed of nylon parachute material. Duplicate bags were used for each sample. The bags were placed in the rumen of a ruminal fistulated steer which was grazing on the particular type of pasture from which the samples were taken. This necessitated allowing the steer to become adjusted to fescue-lespedeza pasture and running digestion studies of the fescue-lespedeza samples, then following the same procedure on the orchardgrass-Ladino clover pasture. After 48 hours the samples were removed from the rumen, washed gently in tap water and dried for 48 hours at 62° C. Then all material clinging to the exterior of the bags was removed and the bags were weighed to obtain dry-matter digestion. Following this the material was quantitatively removed from the bags and analyzed for cellulose.

V. BOTANICAL EXAMINATION

To obtain estimates of per cent grass and legume in the samples, the fistula samples were examined under a binocular dissecting microscope of 13x magnification and with a dot on one eyepiece. Prior to examination the frozen fistula samples were thawed and washed in a bucket of tap water. The microscope was placed in the center of a board equipped with a guide rail with 25 notches, each approximately 1 cm. apart. The rail could be moved to four positions, each 2 cm. apart. This gave a total of 100 stops on the board. A tray was constructed with a projection on one corner, which fit into the notches on the guide rail. The sample was placed in the tray, evenly distributed and firmed with the hand. The tray was then passed under the microscope and the material appearing under the dot at each of the 100 points was classified as either grass or legume. The total of points as grass or legume then gives the per cent of points of each. In this report, when legume is mentioned, this will actually refer to per cent points in the microscopic examination.

VI. SUBJECTIVE PASTURE EVALUATION

On the days the pastures were sampled, each pasture was traversed and visual estimates made of the percentage of the ground cover occupied by each species, and the average height and stage of maturity of each. Also, general observations such as condition of pasture, color and carrying capacity were noted. A copy of the standard pasture evaluation

form used in this appraisal is shown in Figure 2.

This evaluation was intended to provide a description of the pastures from which the forage samples came, so that an attempt could be made to relate some of these observations, particularly per cent and average height of clover, to certain chemical and botanical constituents of the animal's diet.

In connection with this subjective evaluation, the author and two other persons independently evaluated numerous other pastures on the Blount and Alcoa farms during the summer grazing season. The author's estimates of per cent of species and average height were compared with those of the other evaluators so that some idea of the degree of variability between different individuals could be obtained.

VII. METHODS OF ANALYSIS

Differences between means were analyzed by the analysis of variance procedure of Snedecor (1956). Simple correlation coefficients on both a within pasture types and pooled pasture types basis were calculated on certain characteristics of grazed and clipped pasture forage, visual observations and days from the start of the pasture season. The relationships of clipped sample characteristics, visual observations and pasture days to dietary traits were determined by multiple regression analysis.

PASTURE REPORT

Station _____	Project _____	Date of Period _____
	Sub Period 1	Sub Period 2
	Date No. Days	Date No. Days
Lot No.	No. Animal Days on Pasture	No. Animal Days on Pasture
Regular Animals		
Extra Animals		

SPECIES IN PASTURE

Common Name	% Stand	Height		Stage of Growth
		Range	Av.	
		to		Young - Pre-bloom - Bloom - Seed - Dormant
		to		Young - Pre-bloom - Bloom - Seed - Dormant
		to		Young - Pre-bloom - Bloom - Seed - Dormant
		to		Young - Pre-bloom - Bloom - Seed - Dormant
		to		Young - Pre-bloom - Bloom - Seed - Dormant
		to		Young - Pre-bloom - Bloom - Seed - Dormant

GENERAL CONSIDERATIONS

1. Condition of Pasture: Washy - Succulent - Dry - Tough - Dead
2. Color: Very Green - Green - Drab - Brown
3. Carrying Capacity: Excess - Sufficient - Short - Insufficient
4. Thickness of Sod: Very Dense - Dense - Moderate - Thin
5. Footing: Firm - Soft - Very Soft
6. Grade: Excellent - Very Good - Good - Fair - Poor - Very Poor

Figure 2. Standard Pasture Report Form, University of Tennessee, AH-VS Department.

VIII. PREDICTION OF DIETARY TRAITS

Prediction equations for per cent crude protein, acid-detergent fiber, detergent lignin and nylon-bag digestibility estimates of the dietary samples within each pasture type were calculated from the multiple regression analysis using the following formula:

$$\hat{Y}_i = a + b_1X_1 + b_2X_2 \dots b_kX_k$$

where $a = \bar{Y} + b_1(0 - \bar{X}_1) + b_2(0 - \bar{X}_2) + \dots + b_k(0 - \bar{X}_k)$.

$b_1, b_2 \dots b_k$ are the partial regression coefficients of the dependent variables on the independent variables.

$X_1, X_2 \dots X_k$ are the independent variables measured on the pastures and clipped samples.

$Y_1, Y_2 \dots Y_k$ are the dependent variables measured on the samples selected by the animals.

$\hat{Y}_i$ is the predicted value of the i th dependent variable for specified values of the X 's.

$\bar{Y}_i$ is the mean of the i th dependent variable.

$\bar{X}_k$ is the mean of the k th independent variable.

CHAPTER IV

RESULTS AND DISCUSSION

I. FISTULATION SUCCESS

About 1 to 1-1/2 hours was required for the surgeon and three assistants to complete each fistula operation. This operation had not previously been attempted by the surgeon, so each subsequent operation seemed to proceed more smoothly than the preceding one. Also, the electrical anesthesia unit had not previously been used for esophageal surgery. It was not until the third operation that the proper machine setting was ascertained. The first two animals thrashed about intermittently during the operation, making surgery difficult. Most of this thrashing about seemed to be associated with the accumulation of saliva resulting from blockage of the esophagus by the ball and steel rod which was passed down the esophagus during surgery.

The animals began eating some alfalfa pellets on the second day following surgery, but it was not until the animals were allowed to have some ground ear corn (after 7 days) that their appetites began to return to normal. The animals did not appear to have a great deal of difficulty in swallowing food after the third day. Probably the animals should have been started on the alfalfa pellets about 15 to 30 days before surgery so that they could have become more accustomed to them.

One of the steers lost the fistula plug on the second day after surgery and it was replaced with a great deal of difficulty. The plug remained out overnight, and the circumference of the fistula had decreased considerably.

The plugs were removed from the first two steers after one week and the fistula area was cleaned and treated with antibiotic powder. The plugs were not removed from the other three steers until 2 weeks after surgery. In this case there was much less difficulty in replacing the plugs. The fistulas seemed to have less tendency to shrink in diameter than was the case with the steers that had their plugs removed after 1 week. Based on this experience, it would seem advisable to allow the fistulas to heal for 2 weeks before the plugs are removed for the first time.

When the plugs were removed, the sutures were found imbedded in the tissue surrounding the fistula to the extent that they could not be removed. The few loose pieces of suture material were removed. Leaving the sutures in the fistulas resulted in no difficulties.

Four of the steers were successfully used in sampling for 8 months following surgery. A plug could not be satisfactorily installed in the fifth steer. The perimeter of the fistula on this steer was prone to stretch, and regardless of the size of the plug that was installed the fistula would stretch to the point that excess loss of saliva and regurgitated rumen contents occurred around the fistula. This animal became very emaciated and eventually was lost. This particular animal was the one that lost its fistula plug 2 days after surgery, but it is

not known if this was related to the subsequent problem with the fistula.

Some leakage of saliva and forage juices occurred around the fistula plugs of the four remaining steers, but this did not appear to affect the well-being of the animals. All of them gained considerable weight while on pasture and were in a thrifty condition at the end of the summer sampling period. Probably as a result of the saliva loss, the steers exhibited abnormal salt-hunger.

Two of the steers had fistulas with an excessive tendency to shrink in diameter as the summer sampling season progressed and it was necessary to install smaller plugs in these. About 2 months following the last sampling period, one of these steers lost its plug and the fistula completely closed, so that the animal could be maintained normally without a fistula plug. Based on these limited observations, there seems to be a relationship between animal type and maintenance of desirable fistulas. The two steers discussed above were rather small-boned, compact animals. The other two animals, which had very satisfactory fistulas, were larger framed, more growthy individuals. This relationship may not hold in all animals, but large-framed, growthy animals are suggested for future fistula subjects.

After the fistulas had healed and the steers were moved to pasture, the animals could be managed almost like normal ones, except that they had to be observed daily so that the fistula plugs could be replaced should they become dislodged. Several times during the course of the sampling season plugs were found missing from some of the steers, but in only one case did this appear to have an adverse effect on

the animal. Apparently one of the steers which had lost a plug went undetected for a period of more than a day. This steer appeared sick and unthrifty for a period of several weeks afterwards, probably due to an excessive loss of saliva and regurgitated rumen contents. This did not, however, seem to affect his value as a sampling agent.

II. PASTURE SAMPLING

Sampling with the fistulated steers was first attempted about 5 weeks after the last steers were fistulated. The results indicated that more time than this should be allowed following surgery before the steers are used for sampling. After a 30- to 45-minute sampling period the circumference of the fistulas had decreased to such an extent that it was almost impossible to replace the plugs. It was necessary to grind some of the plugs to a smaller size before they could be re-inserted into the fistula openings. Fortunately, once the plugs were forced back into the fistula openings the muscles surrounding the fistulas relaxed somewhat and it was eventually possible to again use the larger plugs, except with steers that had fistulas that showed an excessive tendency to shrink. This shrinking continued to occur to a lesser degree with each sampling period for about 10 to 12 weeks after surgery. Also, during this time considerable bleeding occurred around the perimeter of the fistula with removal of the plugs. These observations agree with those reported by Hoehne, Streeter and Clanton (1965) and their recommendations are that 4 months be allowed before the fistulated animals are used for sampling.

Generally, good samples were obtained from all of the steers. About 90 per cent of the possible samples were obtained. The 10 per cent failures were due to a number of causes: failure of an animal to graze, loss of the wire bottom on the collection bags or the collection bag falling out of position during grazing.

The amount of forage collected by the animals varied from about 100 to 400 grams, air-dry weight. Generally, the steers with the smaller fistulas collected smaller quantities of forage, although this was not always the case. One individual steer consistently collected more grazed material than did the other animals and this animal also masticated the forage to a greater degree than the others. It is possible that the greater quantity of forage collected through this steer's fistula was the result of the forage being reduced to smaller particles prior to being swallowed.

Some problems with the sample being contaminated with regurgitated rumen contents is reported in the literature. This problem did not occur in this study. Probably the relatively short sampling period of 30 to 45 minutes and the fact that the sampling was done at the time of day that the steers would normally be grazing lessened this possibility.

III. SELECTIVE GRAZING

In this study, the measure of the degree of selective grazing by the animals is regarded as the differences between the characteristics of grazed and clipped forage samples from the same pasture. Within each lot, the diet of the animals grazing that lot is represented by the

average of the fistula samples collected by two steers. The material from which these animals selected their diets is represented by the hand-clipped samples and visual observations of the botanical composition of the pastures. Table I gives a description of the pastures at each sampling date.

The chemical constituents of the forage are presented on a per cent of organic-matter basis, to correct for wide differences in ash content between the grazed and clipped samples. Grazed samples averaged 11.09 per cent ash compared to 7.18 per cent for the clipped samples. The higher ash content of the fistula samples is attributed to saliva contamination.

Statistical significance reported in this and subsequent sections of this report will be at the 5 per cent level of probability or less. No distinction is made for levels higher than 5 per cent.

Fescue-Lespedeza Pasture (F-L)

The characteristics of the selected forage and the available F-L forage are presented in Table II. The most marked difference between grazed and clipped samples is in crude protein content. In every sampling period the animals selected forage that was higher in protein than the clipped forage, though this selectivity showed a tendency to diminish near the end of the grazing season. The peak protein content of both the grazed and clipped forage occurred on July 14, which corresponded approximately with the period in which the lespedeza content of the pasture reached its peak (Table III). However, even though the

TABLE I

BOTANICAL COMPOSITION^a (PER CENT) AND AVERAGE HEIGHT (INCHES)
OF PASTURES AT EACH SAMPLING PERIOD

Date	Fescue-Lespedeza Pasture						Orchardgrass-Ladino Clover Pasture								
	Fescue			Lespedeza			Orchardgrass			Clover			Crabgrass		
	% Ht.	Av.	% Ht.	% Ht.	Av.	% Ht.	% Ht.	Av.	% Ht.	% Ht.	Av.	% Ht.	% Ht.	Weeds %	
May 13	84	6.0	13	2.5	0	0	3	66	6.0	26	2.8	0	0	3	
May 31	69	4.5	28	3.0	0	0	3	65	4.5	30	2.8	0	0	5	
June 10	53	4.5	44	4.0	0	0	3	58	5.2	28	2.8	8	1.0	6	
June 30	51	4.0	44	5.0	0	0	5	55	4.8	30	3.0	6	1.0	9	
July 14	40	7.5	50	6.5	5	3.0	5	54	6.0	22	5.0	18	4.5	6	
July 26	40	5.0	50	6.5	6	3.0	4	57	7.5	20	3.5	16	3.5	7	
Aug. 12	33	5.0	48	6.5	12	3.0	7	55	6.0	18	2.0	22	3.7	5	
Aug. 25	35	4.5	45	7.0	15	3.5	5	60	4.5	10	2.0	25	4.0	5	

^aBased on visual estimation.

TABLE II
COMPARISON OF GRAZED AND CLIPPED SAMPLES OF FESCUE-LESPEDEZA PASTURE^a

Date	% Crude Protein			% Acid-Detergent Fiber(ADF)			Characteristic % Detergent Lignin			% Cellulose Digestion			% Dry-Matter Digestion		
	Grazed	Clipped	Difference	Grazed	Clipped	Difference	Grazed	Clipped	Difference	Grazed	Clipped	Difference	Grazed	Clipped	Difference
May 13	23.76	16.40	+7.36	43.66	37.44	+6.22	7.80	3.68	+4.12	69.10	58.21	+10.89	59.45	47.71	+11.74
May 31	21.96	13.87	+8.09	44.54	40.90	+3.64	8.28	4.08	+4.20	60.66	55.44	+5.22	47.50	36.37	+11.18
June 10	25.12	17.32	+7.80	46.42	38.94	+7.48	11.90	4.84	+7.06	61.78	58.32	+3.46	40.27	41.26	-0.99
June 30	23.88	18.23	+5.65	53.18	36.91	+16.99	15.44	5.58	+9.86	61.13	61.02	+0.11	48.29	43.98	+4.31
July 14	27.32	20.74	+6.58	50.01	34.30	+15.71	17.58	5.76	+11.82	68.32	68.38	-0.06	50.02	52.19	-2.17
July 26	23.43	18.12	+5.31	54.28	37.36	+16.92	21.56	6.15	+15.41	61.76	59.39	+2.37	43.31	43.26	+0.05
Aug. 12	20.96	16.65	+4.31	54.52	34.66	+19.86	24.41	6.40	+18.01	53.07	58.82	-5.75	36.99	46.54	-9.55
Aug. 25	18.20	14.76	+3.44	54.00	38.22	+15.78	20.10	7.70	+12.40	59.80	47.27	+12.53	39.97	49.95	-9.98
Mean	23.06	17.01	+6.05	50.20	37.34	+12.86	15.88	5.52	+10.36	61.95	58.36	+3.59	45.73	45.16	+0.57

^aChemical analyses are presented on a per cent of organic-matter basis.

TABLE III
COMPARISON OF LEGUME COMPOSITION OF THE PASTURE AND
FORAGE SELECTED; FESCUE-LESPEDEZA^a

Date	Per Cent Legume	
	Forage Selected	Pasture
May 13	14	13
May 31	27	31
June 10	35	42
June 30	41	44
July 14	52	50
July 26	44	50
August 12	49	47
August 25	48	45

^aLegume composition of the pasture was determined by visual observation and that of the grazed forage by microscopic examination.

lespedeza remained at a high level for the remainder of the grazing season, protein content of both grazed and clipped samples gradually decreased in each subsequent sampling period after July 14. Possibly the lespedeza exhibited a corresponding decrease in protein content after it reached its mature height, but samples of pure lespedeza were not analyzed for protein content during this time. Figure 3 shows the season-long relationship between protein content of the grazed and clipped samples.

An unexpected relationship was found between acid-detergent fiber (ADF) and detergent lignin content of the grazed and clipped forage. In all periods the ADF and lignin content of the forage selected by the steers was higher than that of the clipped forage and seemed to be abnormally high in the fistula samples. Even though ADF and lignin remained fairly constant throughout the season in the clipped samples, a sharp increase was noted in the grazed forage as the grazing season progressed. On August 12, the lignin content of the dietary samples reached a level of 24.41 per cent of the organic-matter of the sample. Van Dyne and Torrell (1964) suggest that ensalivation of the grazed samples and high-temperature drying may bias lignin values. Work by MacDougall and DeLong (1942) and Van Soest (1962) show that water and high drying temperature cause a non-enzymatic browning reaction in which carbohydrate degradation products condense with protein. This dark colored polymeric material is insoluble in 72 per cent H_2SO_4 and thus would cause a positive bias in lignin determinations. In this present study, the samples were dried at 62° C. which may have been high enough

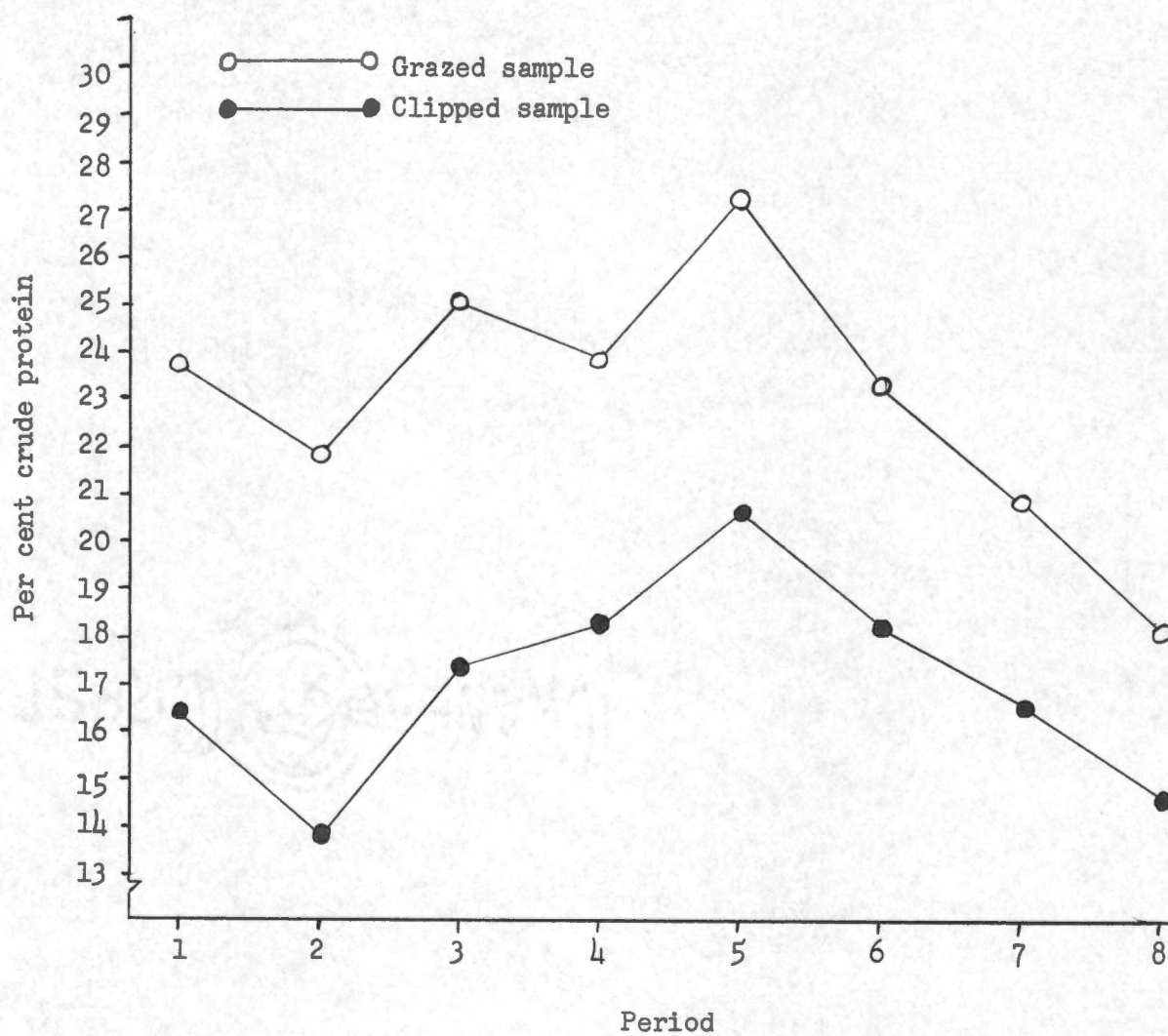


Figure 3. Seasonal comparison of protein content of clipped and dietary samples of fescue-lespedeza pasture.

to cause this effect. Van Soest (1965) reported that drying of forages at temperatures above 50° C. showed significant increases in yield of lignin and fiber. He suggests that values for ADF and lignin in dried forage can be corrected on the basis of the nitrogen content of the ADF which is a sensitive assay for the non-enzymic browning reaction. Early in the grazing season, the fistula samples remained fairly green after drying, but as the season progressed the dried samples took on a dark brownish-black appearance. This could possibly be related to the sharp increase in ADF and lignin values of the fistula samples as the season progressed. Certainly more work is needed to evaluate the effects of saliva contamination and drying temperature on the fiber and lignin analyses of esophageal fistula forage samples.

There was no consistent relationship between nylon-bag cellulose and dry-matter digestibility of grazed and clipped forage. On some dates digestibility was higher for clipped forage and on other dates it was higher for grazed forage.

The percentage of the animals' diets which consisted of legume (primarily lespedeza) very closely paralleled the per cent ground cover of legume in the pasture as determined by visual estimation (Table III, page 37). This suggests that the steers exerted little or no selectivity toward either fescue or lespedeza. The unpalatability of fescue is well recognized, so it was expected that the animals' diets would contain a high proportion of lespedeza in relation to its frequency in the pasture mixture. Three possible explanations come to mind regarding this apparent lack of selectivity toward legume: (1) the animals do not prefer

lespedeza to fescue, (2) the botanical estimates of the fistula samples or the pasture, or both, were inaccurate, (3) the two species were so closely intermingled in the pasture that it was impossible for the cattle to selectively graze either. The author tends to believe that the last mentioned item is the most likely explanation since the species were indeed very closely intermingled. Also, the viney nature of lespedeza may possibly have resulted in some identification errors in the microscopic examination of the fistula samples. Another factor to consider is that crabgrass became prominent in the pasture mixture at about the same time that lespedeza became of importance. It was not possible to consistently distinguish fescue from crabgrass in the botanical examination. Possibly much of the grass in the samples from the middle to the latter part of the season was crabgrass rather than fescue. During much of this time the crabgrass was in a young, succulent state and probably was more palatable than was fescue. Possibly the steers were selecting either lespedeza or crabgrass in preference to fescue.

Orchardgrass-Ladino Clover Pasture (O-C1)

A comparison of certain characteristics of grazed and clipped O-C1 forage is presented in Table IV. In all sampling periods through July 14, the steers selected forage that was higher in crude protein content than was the case with the clipped samples. After July 14, there were no differences. The failure of the steers to select forage higher in protein in the latter part of the grazing season is probably related to a lack of forage high in protein from which to select. By this

TABLE IV
COMPARISON OF GRAZED AND CLIPPED SAMPLES OF ORCHARDGRASS-LADINO CLOVER PASTURE^a

Date	% Crude Protein			% Acid-Detergent Fiber(ADF)			Characteristics % Detergent Lignin			% Cellulose Digestion			% Dry-Matter Digestion		
	Grazed	Clipped	Difference	Grazed	Clipped	Difference	Grazed	Clipped	Difference	Grazed	Clipped	Difference	Grazed	Clipped	Difference
May 13	20.30	15.22	+5.08	45.18	38.27	+6.91	7.94	4.24	+3.70	71.40	68.37	+3.03	53.79	58.95	-5.19
May 31	20.90	16.62	+4.28	47.38	40.34	+7.04	8.94	4.48	+4.46	68.86	56.68	+12.18	53.84	51.86	+0.98
June 10	27.92	24.61	+3.31	43.90	35.14	+8.76	8.75	4.16	+4.59	73.64	72.72	-0.08	55.24	53.82	+1.42
June 30	26.91	23.70	+3.21	45.30	36.09	+9.21	10.47	4.96	+5.51	75.20	69.41	+5.79	61.38	63.04	-1.66
July 14	28.04	22.12	+5.92	44.62	37.50	+7.12	10.83	5.49	+5.34	75.42	75.59	-0.17	57.24	47.90	+9.34
July 26	21.96	21.96	0.00	46.48	36.24	+10.24	11.52	5.52	+6.00	70.80	70.22	+0.58	52.20	53.56	-1.36
Aug. 12	17.08	17.63	-0.55	44.26	36.11	+8.15	10.47	6.00	+4.47	73.28	66.68	+6.60	49.52	53.75	-3.23
Aug. 25	15.99	15.55	+0.44	45.98	38.17	+7.81	10.34	6.40	+3.94	72.47	62.70	+9.77	47.65	45.30	+2.35
Mean	22.39	19.68	+2.71	45.39	37.23	+8.16	9.91	5.16	+4.75	72.64	67.80	+4.84	53.74	53.53	+0.21

^aChemical analyses are presented on a per cent of organic-matter basis.

time both the orchardgrass and clover had reached a state of maturity and summer dormancy. Some research workers have found that selectivity toward material high in protein is greater early in the grazing period when there is an abundance of forage (Lesperance et al., 1960; Ridley et al., 1963). Figure 4 illustrates the season-long relationship between the protein content of grazed and clipped forage from O-C1 pastures.

As was the case with F-L pasture, ADF and lignin values were higher for the grazed samples than for the clipped samples of O-C1 forage. However, the pattern of seasonal change in ADF and lignin content of O-C1 pasture was considerably different from that of the F-L pasture. Per cent ADF of the O-C1 forage was relatively constant throughout the season for both grazed and clipped samples and differences between the two types of samples did not appear to exhibit any variation related to seasonal change. Per cent lignin of both grazed and clipped forage tended to increase as the grazing season progressed and the differences between the two were relatively constant. Apparently, the factor which causes the ADF and lignin content of grazed forage to be higher than clipped forage acts differently in F-L forage than in O-C1 forage. At no time did the fiber and lignin values of the O-C1 grazed samples reach the extremely high levels that were observed in the F-L grazed samples. This suggests a need for a detailed study on the effects of esophageal fistula collection on ADF and lignin analyses. Possibly correction factors could be derived for adjusting the values of the fistula samples.

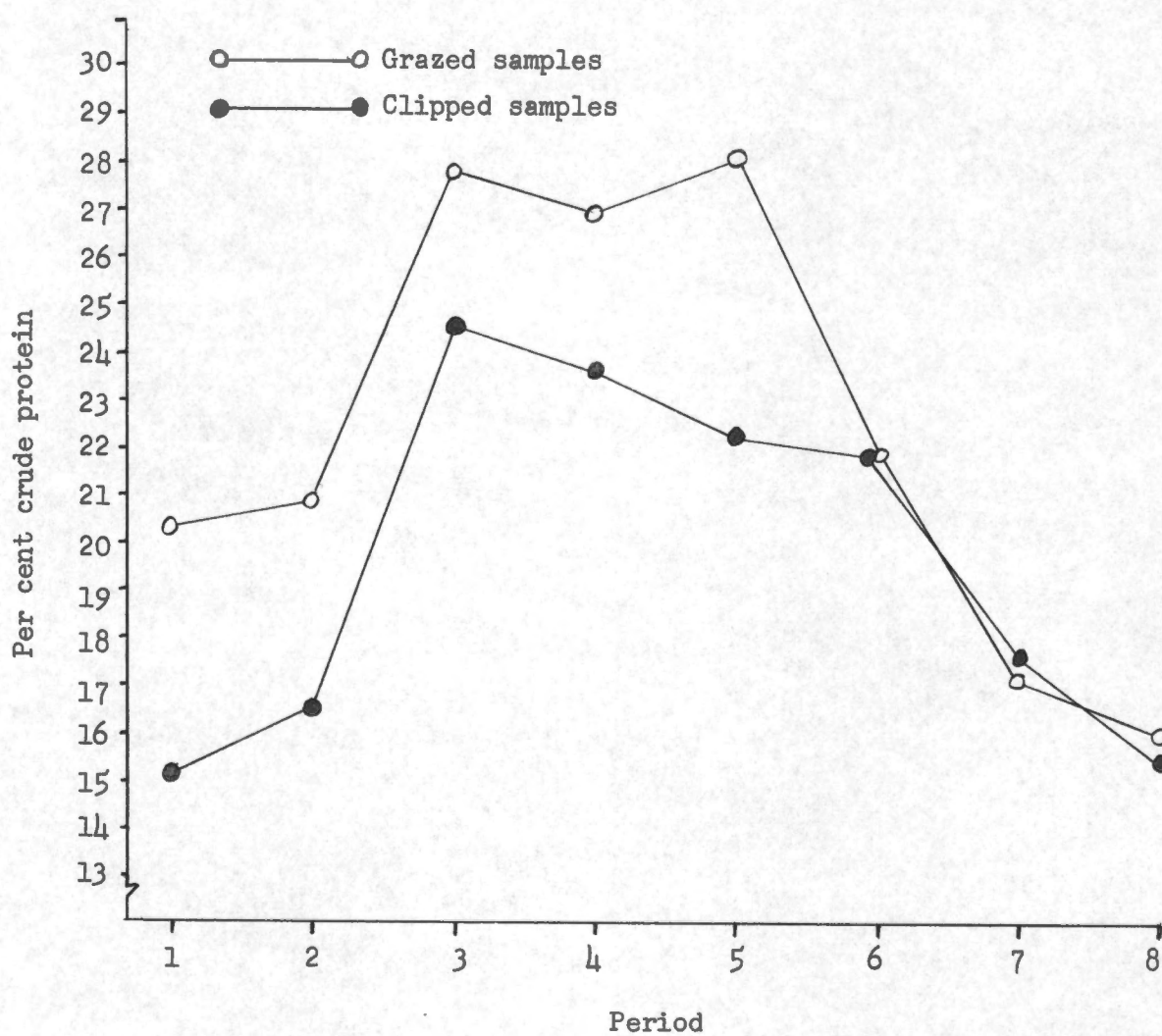


Figure 4. Seasonal comparison of protein content of clipped and dietary samples of orchardgrass-Ladino clover pasture.

Differences between grazed and clipped samples for nylon-bag cellulose and dry-matter digestibility were not consistent. Generally, cellulose digestion tended to be higher in the grazed samples, but in the first period the clipped sample was higher and in three periods there were no differences. Dry-matter digestion values were more variable than cellulose digestion, particularly for the clipped samples.

The legume composition of the O-C1 pasture and fistula samples from the pasture is shown in Table V. In three periods (June 10, June 30, July 14) the steers selected clover in slightly greater proportion than its proportion in the pasture. The apparent lack of selection toward clover in the other periods can possibly be explained by also considering the height of the clover as well as the per cent ground cover. More will be discussed about this in a later section. The author feels that identification of species in the microscopic botanical examination of the fistula samples is easier with O-C1 forage than with F-L forage. Crabgrass was a prominent component of the pasture mixture during the middle and latter part of the season. It was not possible to distinguish it from orchardgrass in the botanical examination of the fistula samples.

The total season means and standard errors for certain traits of grazed and clipped samples of both F-L and O-C1 pasture are shown in Table VI. Steers grazing both types of pasture selected forage that was significantly higher in crude protein than the forage in hand-clipped samples. This selectivity appeared to be greater on the F-L pasture than on the O-C1 pasture since the difference between grazed and clipped

TABLE V
COMPARISON OF LEGUME COMPOSITION OF THE PASTURE AND
FORAGE SELECTED; ORCHARDGRASS-LADINO CLOVER^a

Date	Per Cent Legume	
	Forage Selected	Pasture
May 13	15	26
May 31	16	30
June 10	31	28
June 30	36	30
July 14	30	22
July 26	16	20
August 12	7	18
August 25	8	10

^aLegume composition of the pasture was determined by visual observation and that of the grazed forage by microscopic examination.

TABLE VI
SEASON MEANS AND STANDARD ERRORS FOR TRAITS OF
GRAZED AND CLIPPED FORAGE^a

Trait	Type of Sample			
	Grazed		Clipped	
	Mean (%)	S.E.	Mean (%)	S.E.
Fescue-Lespedeza Pasture				
Crude protein*	23.06	0.75	17.01	0.59
Cellulose*	32.86	0.31	34.31	0.62
ADF*	50.20	1.22	37.34	0.59
Detergent lignin*	15.88	1.52	5.52	0.33
Cellulose digestion*	61.95	1.44	58.35	1.69
Dry-matter digestion	45.73	2.08	45.16	1.72
Orchardgrass-Ladino Clover Pasture				
Crude protein*	22.39	1.22	19.68	1.03
Cellulose	34.93	0.41	34.70	0.52
ADF*	45.39	0.40	37.23	0.55
Detergent lignin*	9.91	0.43	5.16	0.22
Cellulose digestion*	72.64	0.89	67.80	1.56
Dry-matter digestion	53.74	1.16	53.40	1.68

^aChemical analyses are presented on a per cent of organic-matter basis.

*Means for grazed and clipped samples are significantly different ($P < .05$).

F-L was 6.05 per cent and was only 2.71 per cent for O-C1.

Both ADF and lignin were significantly higher in the grazed forage than in the clipped forage for both types of pasture. This difference was much greater, however, for F-L forage where there was an average difference between grazed and clipped samples of 12.86 and 10.36 per cent for ADF and lignin, respectively. For O-C1 pasture, this difference was 8.16 and 4.75 per cent for ADF and lignin, respectively. At present the significance of these differences is not known.

Cellulose digestibility of the forage selected by the steers was significantly higher than that of clipped samples from both types of pasture. However, dry-matter digestibility of grazed and clipped forage was almost identical within each pasture type. Per cent cellulose was significantly different between types of samples in F-L forage but not in O-C1 forage.

In this study, it is evident that the animals did graze selectively as measured by differences between hand-clipped and dietary samples in crude protein content and cellulose digestibility of the forage. This supports work reported by other workers on selectivity on various types of range and pasture. Shumway et al. (1963) reported grazed samples of Arizona range forage averaged 11.22 per cent crude protein compared with an average crude protein content of 6.67 per cent for clipped samples from the same range. Van Dyne and Weir (1964) found that mixed forage samples collected from esophageal fistulated steers generally had higher nylon-bag cellulose and dry-matter digestibility values than any of five species hand-clipped from the area from which the fistula samples were collected.

IV. COMPARISON OF DIETS OF ANIMALS ON TWO TYPES OF PASTURE

Yearling steers have consistently made higher gains on O-C1 pasture than on F-L pasture at the Tennessee Experiment Station (High et al., 1965). On the same plots involved in this present study, steers in the preceding 2 years made average daily gains of 1.72 pounds per head on O-C1 and 1.48 pounds per head on F-L, for the period of approximately April 1 to September 1 (High and Hobbs, 1964). During the course of this present study, yearling market heifers grazing these same plots made average daily gains of 1.42 pounds per head on the O-C1 pasture and 1.12 pounds per head on the F-L pasture, for the period of April 6 through July 1. Possibly the F-L heifers would have gained slightly more had they been allowed to remain on the pasture a month longer to take advantage of the abundant supply of lespedeza. However, they were nearing market condition and were in need of a short concentrate feeding period before being marketed.

There is a need for determining factors in the animal's diet which may be related to this difference in animal performance on these two types of pastures as well as all pastures in general. This is one of the basic problems in pasture evaluation. For a proper statistical study of this problem, a number of years of work is needed in which dietary samples and animal performance data can be obtained from the same pastures. Performance could be correlated with various constituents of the animal's diet and possibly equations could be derived for

predicting animal performance from dietary constituents. In this present study differences in the diets of animals grazing the two types of pasture were evaluated to obtain some indication of factors which may relate to differences in quality of the pastures.

A comparison of the season-long averages of certain characteristics of the diets of steers grazing F-L and O-C1 pastures is presented in Table VII. Generally, protein is considered as an important quality factor in forages. In this respect the difference was slightly in favor of F-L, but was statistically non-significant (23.06 vs. 22.39 per cent). Protein content tended to be higher in the O-C1 diets during the middle of the grazing season and higher in the F-L diets in the latter part of the grazing season (Figure 5). This might be expected, considering that Ladino clover made the greatest contribution to the diet during the period when protein content of O-C1 was the highest and in the latter part of the season the lespedeza was at a high level in the F-L diet while Ladino clover made up a very small portion of the O-C1 diet. In grazing studies of these plots, animal gains have generally tended to be higher on F-L than on O-C1 during the latter part of July and in August.

Cellulose content of the dietary forage was 32.86 and 34.93 per cent for F-L and O-C1, respectively. This difference was not significant.

Fiber and lignin values were significantly higher in the F-L pasture. Since there is the previously mentioned possibility of bias in these values, it is not known if the relative differences in fiber and lignin content of the dietary samples from the two types of pasture can be accepted. If these differences do actually exist, they could possibly

TABLE VII
 CERTAIN CHARACTERISTICS OF THE DIETS OF STEERS GRAZING TWO
 TYPES OF PASTURES; SEASON MEANS^a

Trait	Per Cent	
	Fescue- Lespedeza	Orchardgrass- Ladino Clover
Crude protein	23.06	22.39
Cellulose	32.86	34.93
Acid-detergent fiber*	50.20	45.39
Detergent lignin*	15.88	9.91
Cellulose digestibility*	61.95	72.64
Dry-matter digestibility*	45.73	53.74

^aChemical analyses are presented on a per cent of organic-matter basis.

*Means are significantly different ($P < .05$).

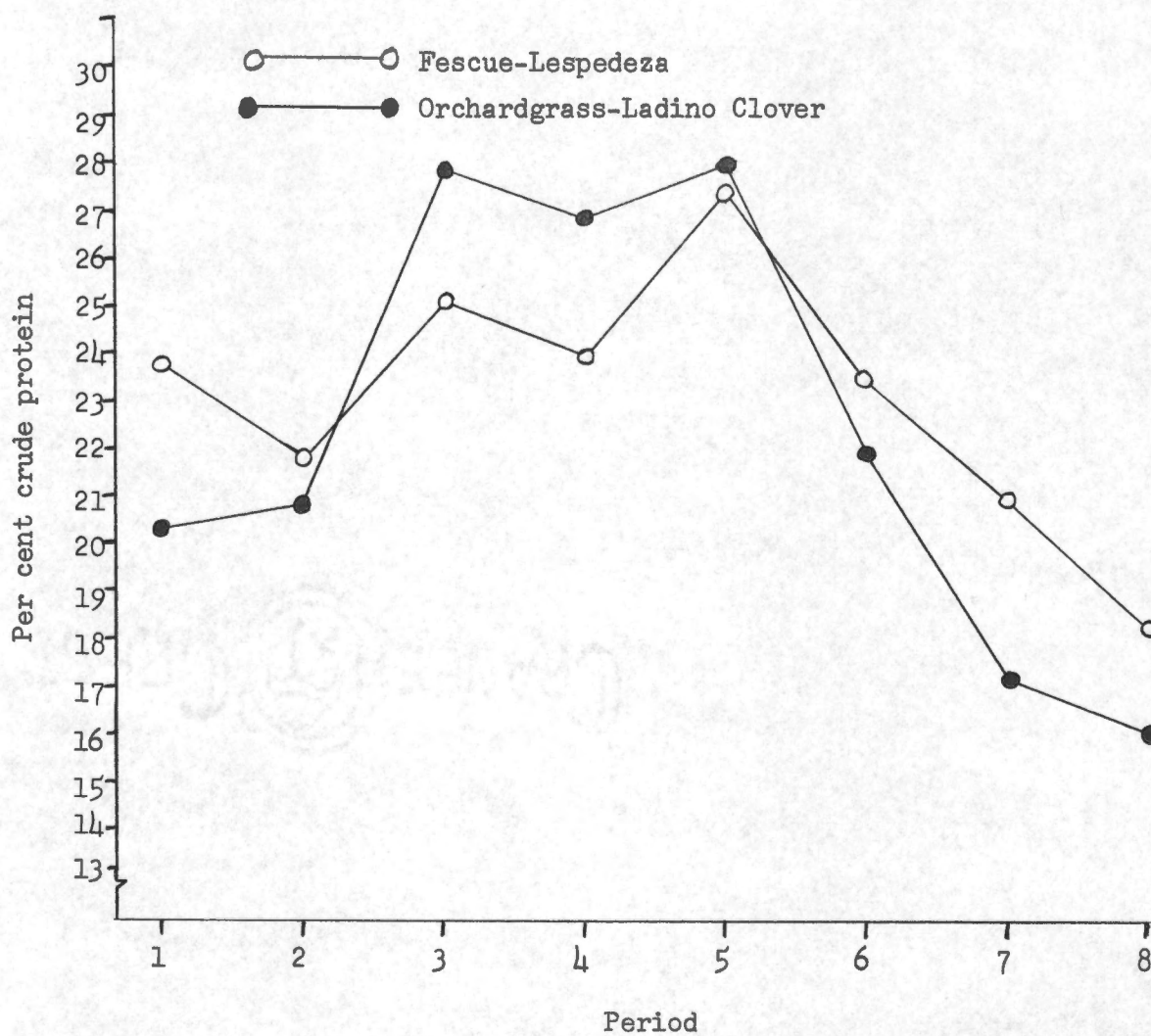


Figure 5. Seasonal variation in crude protein content of the diet of steers grazing fescue-lespedeza and orchardgrass-Ladino clover pastures.

be important factors in explaining differences in animal performance. Van Soest (1963) reported highly significant negative correlations between ADF and lignin content and digestibility of several roughages. Figure 6 illustrates the seasonal variation in fiber and lignin content of dietary samples of F-L and O-C1 pasture. Orchardgrass-clover exhibited a fairly moderate increase in level of fiber and lignin compared with F-L which began a sharp increase after the third period (June 10). This increase in lignin content of F-L forage may possibly be attributed, at least partly, to an increasing amount of lespedeza in the diet of the animals as the season progressed. Van Soest (1963) showed that ADF and lignin content of lespedeza was considerably higher than that of most grasses. Thus an increase of lespedeza in the diet in relation to grass might be expected to be expressed in increased ADF and lignin content of the dietary samples.

Average cellulose and dry-matter digestibility as determined by nylon-bag studies were significantly higher for O-C1 dietary samples than for F-L dietary samples, 72.64 per cent compared to 61.95 per cent for cellulose digestibility and 53.74 per cent compared to 45.73 per cent for dry-matter digestibility. These factors could reflect important differences in quality between these pastures. In the first period, cellulose digestibility did not differ and dry-matter digestibility favored F-L, but in all subsequent periods both digestibility values were higher for O-C1 forage (Figure 7).

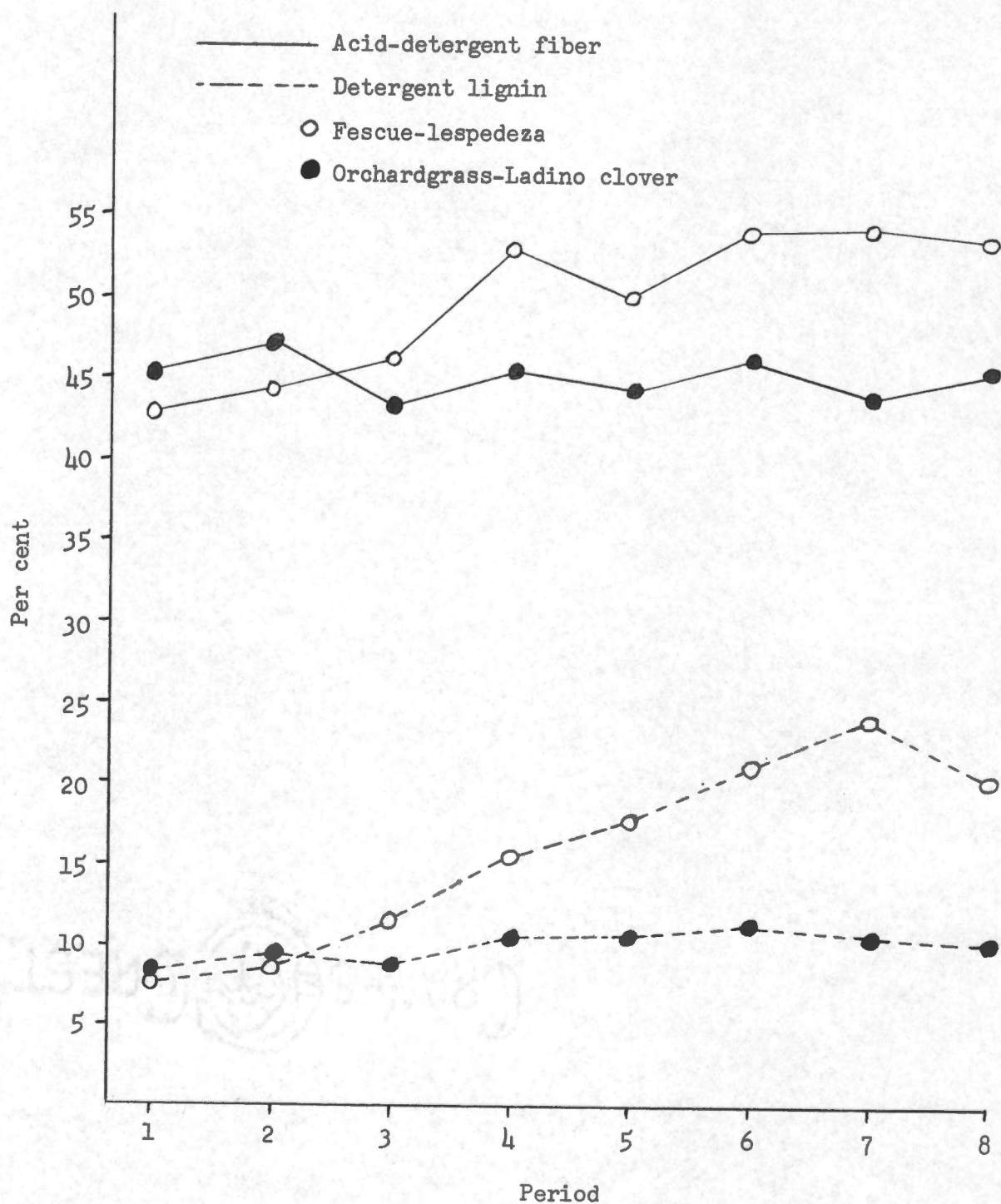


Figure 6. Seasonal variation in acid-detergent fiber and detergent lignin in the diet of steers grazing fescue-lespedeza and orchardgrass-Ladino clover pasture.

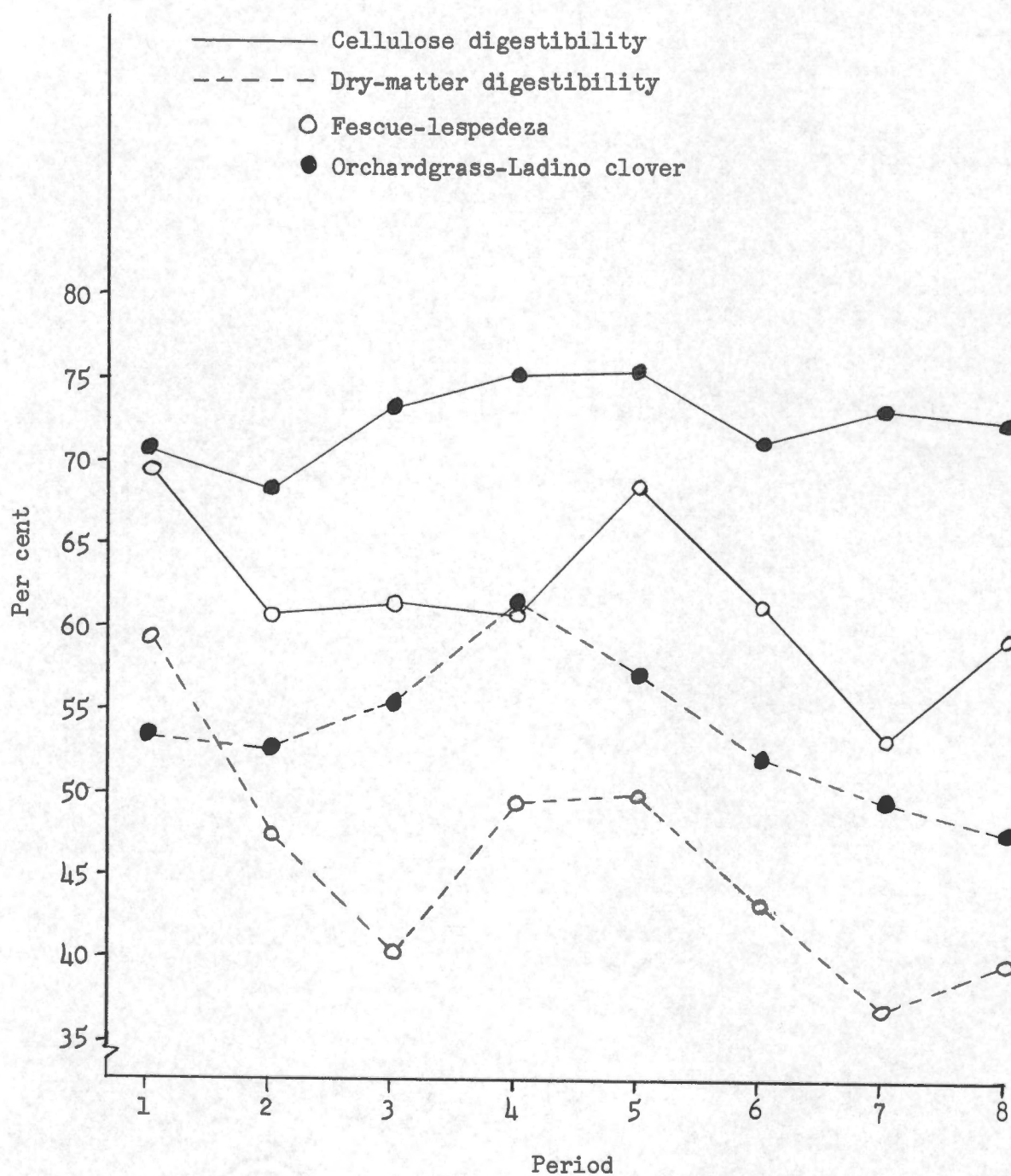


Figure 7. Seasonal variation in cellulose and dry-matter digestibility of dietary samples of fescue-lespedeza and orchardgrass-Ladino clover pastures.

V. RELATIONSHIPS AMONG CHARACTERISTICS OF PASTURES AND SAMPLES

Simple correlations between characteristics of grazed and clipped pasture samples, per cent legume in the pasture, legume index of the pasture (per cent legume x average height) and days from the start of the pasture season were calculated both on a within pasture and pooled basis. However, in most instances the relationships were so different between pastures that a pooled correlation is meaningless, so only the within pasture correlations will be presented. Correlation coefficients for F-L pasture are presented in Table VIII and those for O-C1 pasture in Table IX.

Grazed and Clipped Samples

Generally, there were indications that traits of the clipped samples may have some predictive value in relation to the diet of the animals, even though the means of most characteristics of grazed and clipped samples were significantly different. In both F-L and O-C1 pastures there were highly significant correlations ($r = 0.78$ and 0.80) between crude protein content of clipped samples and forage selected by the animals. Shumway et al. (1963) reported about the same correlation ($r = 0.80$) between clipped samples of range forage and animal-selected forage from the same area. This suggests that clipped samples may have value for detecting changes in the protein content of the grazing animal's diet or for predicting the actual protein content of the diet within the pasture types and grazing period employed in this study.

TABLE VIII

SIMPLE CORRELATION COEFFICIENTS AMONG CERTAIN CHARACTERISTICS OF GRAZED AND CLIPPED SAMPLES
AND VISUAL OBSERVATIONS; FESCUE-LESPEDEZA PASTURE^a

Traits	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Crude protein, grazed sample													
(2) ADF ^b	-.41												
(3) Detergent lignin, "	-.30	.81											
(4) Cellulose dig., "	.43	-.40	-.48										
(5) Dry-matter dig., "	.50	-.55	-.67	.83									
(6) Crude protein, clipped sample	.78	.08	.26	.18	.23								
(7) ADF	-.11	-.31	-.52	.05	.08	-.60							
(8) Detergent lignin, "	-.57	.78	.82	-.33	-.63	-.07	-.21						
(9) Cellulose dig., "	.68	-.02	-.13	.18	.31	.57	-.37	-.37					
(10) Dry-matter dig., "	-.18	.20	.12	.46	.28	-.05	-.26	.35	.03				
(11) % legume in grazed sample	-.22	.54	.45	.01	-.20	-.02	-.35	.57	.28	.54			
(12) % legume in pasture	-.05	.75	.73	-.39	-.62	.32	-.33	.63	.22	.05	.49		
(13) Legume index of pasture ^c	-.11	.72	.78	-.20	-.55	.32	-.48	.66	.18	.11	.57	.93	
(14) Days from start of pasture season	-.51	.82	.91	-.50	-.77	.02	-.35	.94	-.29	.21	.50	.74	.77

^aCorrelations of .50 and .66 required for significance, ($P < .05$) and ($P < .01$), respectively.

^bADF is acid-detergent fiber.

^cLegume index = % ground cover of legume x average height of legume.

TABLE IX

SIMPLE CORRELATION COEFFICIENTS AMONG CERTAIN CHARACTERISTICS OF GRAZED AND CLIPPED SAMPLES
AND VISUAL OBSERVATIONS; ORCHARDGRASS-LADINO CLOVER PASTURE^a

Traits	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Crude protein, grazed sample													
(2) ADF ^b	-.16												
(3) Detergent lignin, "	.09	.31											
(4) Cellulose dig., "	.15	-.74	-.47										
(5) Dry-matter dig., "	.82	-.11	-.01	.20									
(6) Crude protein, clipped sample	.80	-.24	.27	.14	.53								
(7) ADF	-.27	.50	-.34	-.15	-.12	-.68							
(8) Detergent lignin, "	-.56	.12	.48	.00	-.67	-.36	.05						
(9) Cellulose dig., "	.66	-.49	.30	.42	.50	.76	-.72	-.08					
(10) Dry-matter dig., "	.17	-.16	-.01	-.08	.40	.17	-.37	-.53	.13				
(11) % legume in grazed sample	.85	-.14	.30	.00	.81	.70	-.38	-.46	.59	.29			
(12) % legume in pasture	.63	-.02	-.13	-.07	.53	.44	-.07	-.72	.13	.42	.46		
(13) Legume index of pasture ^c	.88	-.05	.13	.08	.76	.69	-.20	-.54	.54	.28	.73	.71	
(14) Days from start of pasture season	-.52	.03	.49	.05	-.60	-.16	-.15	.92	.00	-.42	-.40	-.77	-.55

^aCorrelations of .50 and .66 required for significance, ($P < .05$) and ($P < .01$), respectively.

^bADF is acid-detergent fiber.

^cLegume index = % ground cover of legume x average height of legume.

In the F-L samples there was also a highly significant correlation between lignin content of grazed and clipped forage. Relationships among other characteristics in F-L pasture were very low. For O-C1 pasture, correlation between ADF, lignin and digestibility estimates of grazed and clipped forage ranged from 0.40 to 0.50 and approached significance at the 5 per cent level.

Pasture Days and Grazed Samples

Number of days from the date of the beginning of the grazing season (April 6) was significantly negatively correlated with crude protein content and cellulose and dry-matter digestibility estimates and positively correlated with fiber and lignin content of the diet of steers grazing F-L pasture. On O-C1 pasture, only crude protein content and dry-matter digestibility were significantly related to the progressing grazing season, with correlation coefficients of $-.52$ and $-.60$. Increasing days in the grazing season is likely to be one of the most variable factors in the relation it may have to the animal's diet from year to year. Pasture days as such is probably related to the diet only as it affects changes in maturity of the forage, species composition and other factors which may alter the animal's diet. During the grazing season in which this study was conducted rainfall distribution was excellent. It would be worthwhile to conduct a similar study during a year when rainfall was less ideal and compare the effects of such a grazing season on animal diets.

Visual Observations and Characteristics of the Diet

Visual observations of legume per cent and height in the pastures would be valuable if they had a high degree of relationship to certain traits of the animal's diet. These observations are relatively easy to obtain and could become a routine part of pasture management. In the case of O-C1 pasture, per cent ground cover of clover and legume index appear very promising as predictors of quality of the grazing animal's diet. There were significant correlation coefficients of 0.63 and 0.53 between per cent clover in the pasture and crude protein content and dry-matter digestibility, respectively, of the forage selected by the animals. However, highly significant correlations of 0.88 and 0.76 existed between legume index and these same two characteristics of the diet. This suggests that per cent and height of clover provide more valuable information than per cent clover alone and that these may be important, relatively easily obtained criteria in pasture evaluation.

The relationships among these factors were completely different in F-L pasture from what they were in O-C1 pasture. Correlations of per cent lespedeza and legume index with crude protein content on the diet were very low and negative. There were significant negative correlations of per cent lespedeza and legume index with dry-matter digestibility. Also, these two visual observations had highly significant positive relationships to fiber and lignin content of the diet. The failure of legume content of the pasture to bear the same relationship to the diet in both types of pasture suggests that the contributions of Ladino clover and lespedeza to the characteristics of the diet are considerably

different. The very low correlation between lespedeza and protein content of the diet can be seen in Figure 8. From about the middle of the grazing season, the lespedeza content of the pasture remains at a fairly constant level. However, during this period the protein content of the diet gradually decreases. Lespedeza content of the diet during this latter part of the season was about equal to that of the pasture. This suggests that there may be a considerable decrease in protein content of the lespedeza during this period. It would be interesting to obtain samples of pure Ladino clover and lespedeza during the course of the spring and summer grazing season and compare changes in chemical composition over time.

Legume Content of the Grazed Sample

In the case of O-C1 grazed samples, correlation coefficients of per cent clover in the sample with crude protein content and dry-matter digestibility of the sample were highly significant ($r = 0.85$ and 0.81). These correlations are very similar to those obtained for legume index with protein content and dry-matter digestibility of the dietary samples ($r = 0.88$ and 0.76). The correlation of legume index with per cent clover in the sample was also highly significant ($r = 0.73$). These relationships impart some degree of confidence in the botanical examination of the fistula samples of O-C1 forage since it is expected that per cent clover in a grass-clover mixture would be highly related to protein content of that sample.

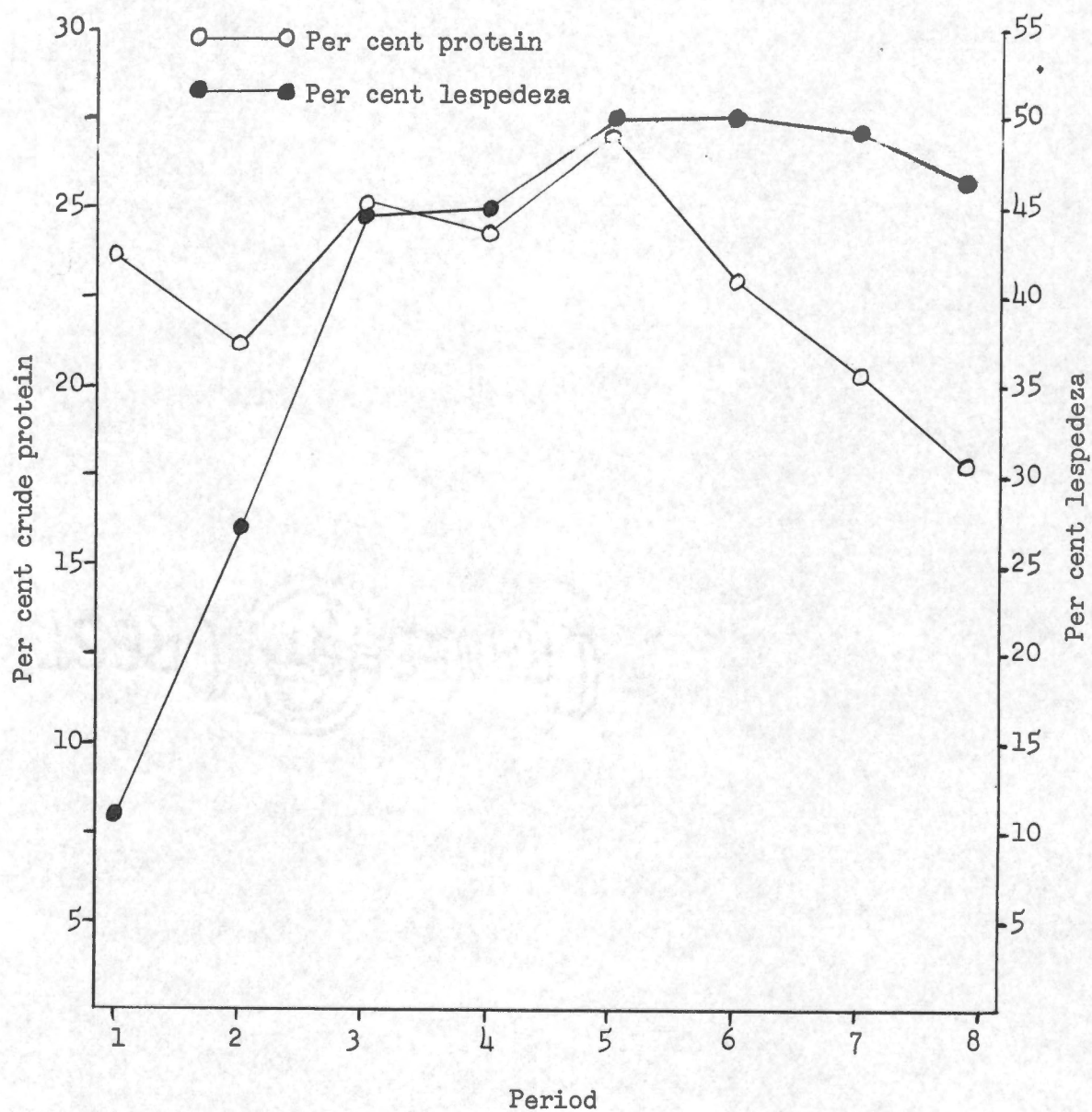


Figure 8. Seasonal relationship of crude protein content of the diet and per cent lespedeza of the pasture.

Relationships between per cent lespedeza in the samples and the chemical and digestibility characteristics of the samples were generally very low, except for ADF and lignin content which were moderately high ($r = 0.54$ and 0.45). As was the case in the O-C1 samples, the relationships of lespedeza in the sample to other sample characteristics was similar to the relationships of the same characteristics to legume content of the pasture. From these data the effect of lespedeza in the diet is very variable at different times during the summer grazing season, but previously mentioned animal performance data show that it is valuable to the animal when combined with tall fescue.

VI. PREDICTION OF CHARACTERISTICS OF THE DIET

Multiple regression analyses using characteristics of clipped samples, legume estimates of the pastures and pasture days as independent variables and characteristics of the dietary samples as dependent variables were conducted. The purpose of these analyses was to determine combinations of traits which would be relatively easy to obtain and which would be valuable in predicting the various traits of the diet of a steer grazing F-L or O-C1 pasture during the spring and summer grazing season. The results of these analyses which appear to be of the most value appear in Table X (F-L pasture) and Table XI (O-C1 pasture).

Fescue-Lespedeza Pastures

Pasture days and (pasture days)² accounted for more of the variation in protein content of the diet (72 per cent) than did any other

TABLE X
SIMPLE CORRELATIONS (r), PARTIAL REGRESSIONS (b) AND
SQUARED MULTIPLE REGRESSION COEFFICIENTS (R²) OF
VARIOUS PASTURE MEASUREMENTS ON DIETARY
CHARACTERISTICS OF FESCUE-LESPEDEZA
PASTURE

Dependent ^a Variable	Independent ^b Variable	r	b
Crude protein	Pasture days	-.511	0.437
	(Pasture days) ²	-.611	0.003
	R ²		0.717**
Crude protein	Crude protein	0.784	1.189
	Cellulose	-.113	0.421
	ADF	-.292	0.144
	Detergent lignin	-.573	-.739
	Cellulose digestibility	0.683	0.036
	Dry-matter digestibility	0.182	0.027
	R ²		0.930**
Crude protein	Crude protein	0.784	0.979
	R ²		0.615**
Acid-detergent fiber	% lespedeza	0.754	0.114
	Pasture days	0.815	0.076
	R ²		0.714**
Detergent lignin	Pasture days	0.914	0.159
	R ²		0.836**
Cellulose digestibility	Crude protein	0.180	2.477
	Cellulose	0.235	1.184
	ADF	0.047	0.959
	Detergent lignin	-.331	-1.520
	Cellulose digestibility	0.175	-.255
	Dry-matter digestibility	0.462	0.778
	R ²		0.750**
Dry-matter digestibility	Pasture days	-.768	-.162
	R ²		0.590**

^aDependent variables are measured on the diet of the animal.

^bIndependent variables are measured on the pasture or clipped samples from the pasture in which the dietary samples were obtained.

**Highly significant (P < .01).

TABLE XI

SIMPLE CORRELATIONS (r), PARTIAL REGRESSIONS (b) AND SQUARED
MULTIPLE REGRESSION COEFFICIENTS (R^2) OF VARIOUS PASTURE
MEASUREMENTS ON DIETARY CHARACTERISTICS OF
ORCHARDGRASS-LADINO CLOVER PASTURE

Dependent ^a Variable	Independent ^b Variable	r	b
Crude protein	Legume index R^2	0.876	0.144 0.768**
Crude protein	Crude protein R^2	0.800	0.977 0.640**
Detergent lignin	Crude protein	0.268	0.266
	Cellulose	-.606	-.444
	ADF	-.340	0.306
	Detergent lignin	0.483	1.750
	Cellulose digestibility	0.299	-.080
	Dry-matter digestibility R^2	-.005	0.153 0.715**
Dry-matter digestibility	Legume index R^2	0.765	0.102 0.586**

^aDependent variables are measured on the diet of the animal.

^bIndependent variables are measured on the pasture or clipped samples from the pasture in which the dietary samples were obtained.

**Highly significant ($P < .01$).

combinations except all measurements of the clipped forage combined which accounted for 93 per cent. The quadratic pasture days term was included in the equation to account for the non-linear relationship of protein in the diet and pasture days. The one single measurement with the most predictive value was crude protein in the clipped sample which explained 62 per cent of the variation in protein content of the diet. Per cent lespedeza in the pasture and legume index did not make a significant contribution toward explaining dietary protein (less than 3 per cent, combined).

Per cent lespedeza in the pasture and pasture days when used in combination accounted for 72 per cent of the variation in fiber content of the diet. This estimate was not increased significantly by including legume index in the equation. The combination of all clipped sample measurements explained no more of the fiber variation than did per cent lespedeza and pasture days. Pasture days alone explained 84 per cent of the variation in dietary lignin whereas the combination of all clipped sample measurements accounted for only 2 per cent more.

The only equation that significantly accounted for cellulose digestibility of the diet was one in which all clipped sample measurements were included which explained 75 per cent of the variation. Pasture days alone explained 59 per cent of the variation in dry-matter digestibility.

Generally, pasture days had the most value in predicting diets of steers grazing F-L pastures. Some idea of the yearly variation in the effect of pasture days would need to be determined before the real

predictive value of this factor could be determined. As was previously mentioned the affect of pasture days is probably related to changes in maturity and species composition of pastures which in turn affect the animal's diet.

Orchardgrass-Ladino Clover Pastures

Legume index was the most important single measurement in predicting traits of the grazing animals diet. This factor accounted for 77 per cent of the variability in dietary protein and 59 per cent of the variation in dry-matter digestibility of the dietary O-C1 samples. This is a promising outcome, since legume index is a relatively easy measurement to obtain and could be used in routine pasture evaluation. Crude protein content of the clipped samples was also a good predictor of dietary protein, accounting for 64 per cent of the variation.

Significant contribution toward explaining variation in dietary lignin was made by the combination of all clipped sample measurements which accounted for 72 per cent of the variability. No combination of factors significantly explained variation in fiber content or cellulose digestibility of the dietary samples.

Prediction Equations

The variables and means used in computing prediction equations are shown in Table XII. Prediction equations from the regression analyses in Tables X and XI (pages 64 and 65) are presented in Tables XIII and XIV. It is felt that these equations hold the most value for predicting certain characteristics of diets of cattle grazing F-L and

TABLE XII
VARIABLES AND MEANS USED IN CALCULATING PREDICTION EQUATIONS

Symbol	Variable	Mean (per cent)	
		F-L	O-C1
Y_1	Crude protein, grazed sample	23.01	22.39
Y_2	ADF, grazed sample	50.89	45.36
Y_3	Detergent lignin, grazed sample	16.55	10.10
Y_4	Cellulose digestibility, grazed sample	61.96	72.68
Y_5	Dry-matter digestibility, grazed sample	46.08	53.21
Y_6	Legume in grazed sample	42.71	19.14
X_1	Legume in pasture	40.93	22.71
X_2	Legume index of pasture	233.20	67.71
X_3	Days from start of pasture season	94.93	94.93
X_4	$(X_3)^2$		
X_5	Crude protein, clipped sample	17.15	19.19
X_6	Cellulose, clipped sample	33.70	34.62
X_7	ADF, clipped sample	37.07	37.15
X_8	Detergent lignin, clipped sample	5.65	5.18
X_9	Cellulose digestibility, clipped sample	58.92	67.90
X_{10}	Dry-matter digestibility	46.34	52.65

TABLE XIII
PREDICTION EQUATIONS FOR DIETARY CHARACTERISTICS OF
STEERS GRAZING F-L PASTURE

Variables ^a	Equations
<u>Prediction of Crude Protein Content</u>	
X ₃ X ₄	$\hat{Y}_1 = 8.28 + .44(X_3) - .003(X_4)$
X ₅ X ₆ X ₇ X ₈ X ₉ X ₁₀	$\hat{Y}_1 = -16.31 + 1.19(X_5) + .42(X_6) + .14(X_7) - .74(X_8) + .04(X_9) + .03(X_{10})$
X ₅	$\hat{Y}_1 = 6.38 + .98(X_5)$
<u>Prediction of Acid-Detergent Fiber Content</u>	
X ₁ X ₃	$\hat{Y}_2 = 38.80 + .11(X_1) + .08(X_3)$
<u>Prediction of Detergent Lignin Content</u>	
X ₃	$\hat{Y}_3 = 1.36 + .16(X_3)$
<u>Prediction of Cellulose Digestibility</u>	
X ₅ X ₆ X ₇ X ₈ X ₉ X ₁₀	$\hat{Y}_4 = -94.96 + 2.48(X_5) + 1.85(X_6) + .96(X_7) - 1.52(X_8) - .25(X_9) + .78(X_{10})$
<u>Prediction of Dry-Matter Digestibility</u>	
X ₃	$\hat{Y}_5 = 61.63 - .16(X_3)$

^aRefer to Table XII, page 68, for symbols of variables.

TABLE XIV
PREDICTION EQUATIONS FOR DIETARY CHARACTERISTICS
OF STEERS GRAZING O-CL PASTURE

Variables ^a	Equations
<u>Prediction of Crude Protein Content</u>	
X ₂	$\hat{Y}_1 = 12.91 + .14(X_2)$
X ₅	$\hat{Y}_1 = 3.58 + .98(X_5)$
<u>Prediction of Detergent Lignin Content</u>	
X ₅ X ₆ X ₇ X ₈ X ₉ X ₁₀	$\hat{Y}_3 = -.290 + .27(X_5) - .44(X_6) + .31(X_7) + 1.75(X_8) - .08(X_9) + .15(X_{10})$
<u>Prediction of Dry-Matter Digestibility</u>	
X ₂	$\hat{Y}_5 = 46.44 + .10(X_2)$

^aRefer to Table XII, page 68, for symbols of variables.

O-C1 pasture during the period of April 6 through August 31.

VII. VARIATION BETWEEN STEERS

The reliability of samples obtained from esophageal fistulated animals should be reflected in the variation between steers grazing the same pasture at the same time. In this study, two pairs of steers grazed two kinds of pasture at each sampling period. The analysis of the differences within each pair for certain characteristics of the diet they selected is presented in Table XV. F values indicated that differences between steers were not significant. In most cases the per cent variation of the individuals from the mean of the pair was less than 3 per cent, and in no case was over 4 per cent. This indicates that during the course of this study variation between animals was very low.

VIII. VARIATION BETWEEN OBSERVERS IN MAKING LEGUME ESTIMATES

In the case of O-C1 pastures, correlation and regression analyses have shown that legume index of these pastures is valuable in predicting certain characteristics of the diet of grazing steers, particularly crude protein and dry-matter digestibility. If observations on legume content of pasture is to be used in routine pasture evaluation, some knowledge of variation between different observers is needed. The author and two other persons who had previously had no experience made legume percentage and height estimates in numerous pastures during the course of the summer grazing season. At the beginning of this study the estimates were discussed among the three observers, but during the

TABLE XV

VARIABILITY BETWEEN STEERS WITHIN PAIRS IN CERTAIN
DIETARY CHARACTERISTICS^a

Dietary Trait	Pair 1		Pair 2	
	Difference ^b	Per Cent Variability ^c	Difference ^b	Per Cent Variability ^c
Fescue-lespedeza pasture				
Crude protein	1.18	2.71	1.81	3.71
Acid-detergent fiber	3.00	2.96	0.98	0.99
Dry-matter digestibility	0.46	1.03	1.45	1.53
Orchardgrass-clover pasture				
Crude protein	0.86	1.90	1.50	3.80
Acid-detergent fiber	1.00	1.09	0.24	0.27
Dry-matter digestibility	0.68	0.64	1.77	1.72

^aDifferences between steers within pairs were not significant ($P \geq .05$).

^bDifference between steers within a pair was obtained by subtracting the smallest value from the largest value within a pair.

^cPer cent variability represents the per cent either animal in a pair deviated from the mean of the pair.

remainder of the summer they were made independently. The results of this study are shown in Table XVI. Since the author (observer 1) was the only experienced observer and the prediction equations discussed in the previous section were derived from his estimates, each of the other two observers' (observers 2 and 3) estimates were compared to his for the purposes of this analysis. A paired analysis was used in which the differences between observers were tested by means of a t test. Also, simple correlations among observers were calculated.

Although there was only 2 per cent difference in the mean legume percentage estimates by observers 1 and 2, wide differences in some individual estimates resulted in a highly significant difference between these two observers. Observers 1 and 3 did not differ. Correlation of estimates by observers 2 and 3 to those of observer 1 was identical ($r = 0.82$), indicating that the predictive values of the estimates were similar.

Observers 2 and 3 consistently made legume height estimates that were higher than those by observer 1, and these differences were highly significant. Correlation of height estimates by observer 1 and observer 2 was significant but low ($r = 0.45$). There was a highly significant correlation ($r = 0.67$) between observer 1 and observer 3 for height estimates. There was a tendency for both percentage and height estimates of the three observers to come closer together in the latter part of the season, suggesting that increased experience may improve agreement between observers.

TABLE XVI
COMPARISON OF LEGUME PERCENTAGE AND HEIGHT ESTIMATES
BY THREE OBSERVERS

	Comparison 1 Observer 1 and Observer 2	Comparison 2 Observer 1 and Observer 3
<u>Legume percentage</u>		
Mean:		
Observer 1	23.0	25.2
Other observer	21.0	26.2
Mean difference	2.0**	1.0
Correlation (r)	0.82**	0.82**
<u>Legume height</u>		
Mean:		
Observer 1	3.5	3.0
Other observer	5.7	4.4
Mean difference	2.2**	1.4**
Correlation (r)	0.45*	0.67**

*Significant at the 5 per cent level of probability.

**Significant at the 1 per cent level of probability.

CHAPTER V

SUMMARY

Esophageal fistulas were installed in five yearling Hereford steers and were fitted with simple removable plugs. These fistulated steers were used to obtain samples of forage representing the diets of steers grazing two types of pasture beginning about 5 weeks after the fistulas were installed.

Pasture mixtures of tall fescue-annual lespedeza (F-L) and orchardgrass-Ladino clover (O-C1) were used in this study. Two lots of each type of pasture were sampled by esophageal fistulated steers and hand-clipping at approximately 2-week intervals over the period of May through August, 1965. The fistulated steers grazed in pairs. Each pair sampled one lot of each type of pasture at each sampling period. An attempt was made to hand-clip samples that would represent the average of the forage from which the steers selected their diets.

All samples were analyzed for ash, crude protein, cellulose, acid-detergent fiber and detergent lignin. There were wide differences in ash content of grazed and clipped samples which were probably due to saliva contamination of the fistula samples. The results of these analyses were presented on an organic-matter basis to correct for these differences. Cellulose and dry-matter digestibility estimates of all samples were made by use of a nylon-bag in vivo technique.

Botanical composition of the grazed samples was determined by passing a tray containing the sample under a binocular dissecting microscope and classifying 100 points as either grass or legumes. Visual observations of per cent ground-clover and average height of the legumes in the pasture were made at each sampling period. Three observers made visual observations of legume content of numerous other pastures during the course of this study to obtain some measure of observer variability.

Differences between grazed and clipped samples were considered to be measures of the degree of selective grazing by the steers. These differences were analyzed by analysis of variance procedure. Relationships among pasture observations and grazed and clipped samples were measured by means of simple correlation and multiple regression analyses. Equations for predicting traits of the steers' diets were computed from the multiple regression analysis.

The results of the study were:

1. Four of the five fistulated steers were suitable for sampling over the period of this study. Considerable bleeding and shrinking of the fistulas occurred for the first three sampling periods indicating that more time should be allowed after surgery before the steers are used.

2. Steers grazing both types of pasture selected diets significantly higher in protein content than was the case with the clipped samples, but this difference was greater in the F-L pasture than in the O-C1 pasture. Cellulose digestibility of the grazed forage was also greater than that of the clipped forage in both pasture mixtures.

3. There was an apparent effect of fistula collection on fiber and lignin analyses of grazed samples as these constituents were much greater in the grazed samples than in the clipped samples. The differences were much wider in F-L forage than in O-C1 forage. Possible reasons for these differences are discussed.

4. Protein content of the diets of steers grazing the two types of pasture did not differ over the period of this study. Fiber and lignin values were significantly higher in the F-L diets, and cellulose and dry-matter digestibility were higher in the O-C1 diets.

5. Protein content of the clipped samples was highly correlated with that of the grazed samples in both pastures and accounted for 62 per cent of the variation in dietary protein content of F-L pasture and 64 per cent in O-C1 pasture.

6. Legume index of the pasture (per cent legume x average height of legume) explained 77 per cent of the variation in protein content and 59 per cent of the variation in dry-matter digestibility of the dietary samples from O-C1 pasture.

7. Visual observations on F-L pasture were very poorly related to characteristics of the diets of steers. Only pasture days were very valuable in predicting dietary traits on this type of pasture.

8. Differences between fistulated steers within a pair for dietary traits were not significant.

9. Differences in estimates of three observers for legume height in pastures were significant and one pair of observers differed in legume percentage estimates. Estimates for legume percentage were

highly significantly correlated ($r = 0.82$) indicating that the predictive value of the estimates were similar. Correlations for legume height were lower ($r = 0.45$ and 0.67 for two comparisons).

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