5-1974

Nutrition of Sheep Grazing Foothill Big Game Range in Spring

Kurt J. Kotter
Utah State University

NUTRITION OF SHEEP GRAZING FOOTHILL BIG GAME RANGE IN SPRING

by

Kurt J. Kotter

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Range Science

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1974

ACKNOWLEDGEMENTS

I wish to express my gratitude to all who have helped to prepare this thesis. I am particularly indebted to Dr. John C. Malechek for his guidance in planning, conducting, and writing it. I am grateful to my wife for her encouragement and understanding, and to the Utah Agricultural Experiment Station for financial assistance.

Kurt J. Kotter

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Nutrition of Sheep Grazing Foothill

Big Game Range in Spring

by

Kurt J. Kotter, Master of Science

Utah State University, 1974

Major Professor: Dr. John C. Malechek
Department: Range Science

Sheep with esophageal fistulas were used to determine the daily intake, nutritive content and digestibility of forage at three periods and two stocking intensities during the spring of 1972 on a typical foothill range in northern Utah.

Heavy grazing under a season-long regime did not influence the concentrations of dietary chemical components when compared to moderate grazing; however, it did depress the digestibility of cellulose and organic matter. There was a significant decline in the dietary chemical components due to forage maturation. Digestibility of organic matter and cellulose were significantly higher in the early spring as compared to late spring. Daily intake was depressed as a result of the heavy grazing only in early spring.

Heavy grazing intensities on short-term pastures influenced the content of lignin, cellulose and protein in the diet. Digestibility of cellulose and organic matter was depressed during early and late spring as a result of the heavy grazing intensities while protein digestibility was depressed throughout

the season. Intake was significantly lower under heavy grazing in the intermediate period than it was under moderate grazing.

(52 pages)

INTRODUCTION

Foothill ranges are an important land resource in Utah. They are the primary source of spring forage for the livestock industry and they also serve as critical winter range areas for big game. These foothill ranges are generally recognized as a major limiting factor to the production of both livestock and big game in much of the Intermountain area (Cook and Harris, 1968; Scotter, 1967).

The use of domestic livestock to manipulate vegetation on these ranges is a promising management tool that has excellent potential for improving big game habitat values while still allowing grazing use by domestic livestock (Jensen et al. 1972). This is an important point in view of the increasing pressure for removal of domestic livestock grazing from the public lands. However, before this tool can be used effectively; optimum grazing systems need to be developed. A study on the use of domestic animals to manipulate big game winter ranges was initiated in the spring of 1972 by personnel of the Utah Division of Wildlife Resources and the Range Science Department at Utah State University (Project 745 of the Utah Agricultural Experiment Station). Research reported in this thesis deals with the nutritional implications of various grazing regimes upon the domestic livestock involved.

The rationale behind studying the domestic animal is that regardless of how well a specific grazing management system may enhance the range for big game during the winter, if the manipulator animals (in this case sheep)

suffer undue nutritional stress, the technique is not likely to be well received on a practical management basis. The primary objective of this study was to assess the effects of two spring grazing systems and two grazing intensities upon the following nutritional parameters:

1. Chemical composition of sheep's diets with respect to crude protein and fiber components.

2. Apparent digestibility of dietary protein, fiber components, and organic matter.

3. Daily forage intake.

REVIEW OF LITERATURE

The subject of range sheep nutrition in Utah has been researched quite thoroughly (Piper et al., 1959; Cook and Harris, 1950; Cook et al., 1961; Kothmann, 1963; and others). However, there has been relatively little research dealing specifically with sheep nutrition on spring foothill ranges (Cook and Harris, 1952; Cook and Stoddart, 1961), and nothing is known of the effects of different grazing systems on nutrition of the livestock involved. In general, available data indicate that total protein content of the diet decreases while the lignin and cellulose content tend to increase as the season progresses. Digestibility of all constituents generally decreases from early to late spring. More intensive grazing decreases the daily intake of forage and the content of the more desirable nutrients in the forage (Cook et al., 1951). Digestibility of the forage nutrients consumed also decreases with more intensive grazing (Cook et al., 1953, 1962).

Raleigh (1970) pointed out that dry matter intake is often limited by the total feed available. This would be especially true during early spring under a heavy grazing regime. Other workers have raised the possibility that intake may be restricted by the physical capacity of the rumen (Buchanan et al., 1972). This effect would also be more likely to appear during the early part of the growing season when the forage has a high moisture content. Bryant et al.(1970) has summarized the results of heavy grazing pressure on plant and animal responses.

They determined that when the grazing pressure was heavy enough to result in a low availability of forage, the quality of the diet decreased. This quality decrease was attributed to a reduction in the opportunity for selective grazing. Vavra et al. (1973) has reported that the response in animal performance to intensity of grazing was largely through differences in intake and digestibility of the forage.

It is essential to determine the apparent digestibility of the diet in evaluating the range forage. A conventional in vivo digestion-balance trial is usually not feasible for range forage because vegetation may be so sparse or widespread that it is not possible to obtain a large sample of representative forage for use in such trials. Due to the heterogenous nature of the range and to selective grazing, the investigator may need to accept the shortcomings of ratio and in vitro techniques (Wilson et al., 1971).

The problem of measuring forage consumption on rangeland is of primary importance in making an assessment of the nutritive value of forage. The ratio technique developed by Forbes and Garrigus (1948) is often used as the basis for estimating the intake of the grazing animal. By using an internal indicator in the forage, one can determine digestibility by the fecal-index method (Langlands, 1967). The lignin-ratio procedure is the most commonly used technique to estimate intake and diet digestibility in the United States. Two recent reviews concerning methods of estimating the digestibility of grazed forage are available (Van Dyne, 1968; Streeter, 1969).

The validity of the ratio technique depends upon collecting a forage sample that is representative of the animal's diet and upon obtaining a representative sample of fecal material as well as a measure of total fecal output. Three major problems have been associated with the use of lignin as an internal indicator: (1) development of a simplified, repeatable technique for measurement of the lignin in forage and fecal samples; (2) obtaining forage samples with lignin content representative of that consumed by the animal; and (3) constant, repeatable recovery in the fecal material (Theurer, 1970).

In reviewing the procedures for lignin analysis, Van Soest (1964) concluded that the lignin fraction frequently contained proteinaceous material, hemicellulose, and products of a nonenzymatic browning reaction. In other work, Van Soest (1963) showed that interfering proteins and hemicellulose could be removed by treating the forage with an acid detergent solution, and that the nonenzymatic browning reaction could be prevented by keeping the initial drying temperature below 50° C. Lesperance and Bohman (1964) also reported that high drying temperatures significantly influenced lignin content. The lignin content of oven-dried (65° C.) samples was greater than that of samples vacuum-dried (25° C.) or frozen and freeze-dried. Smith et al.(1967) found that lignin was significantly higher in oven-dried (60° C.) samples of fistula forage or feces as compared to freeze-dried samples.

The assumption that lignin is a suitable internal indicator by virtue of its indigestibility is subject to question in view of findings by Wallace and Van

Dyne (1970). They reported apparent digestion coefficients for lignin as high as 46 percent during June. The level of apparent digestibility of lignin decreased throughout the year as the forage matured.

The problems of salivary contamination are inherent in any study where esophageal fistula samples are used. Bath et al. (1956); Lesperance et al. (1960); and Barth et al. (1970) are among the numerous researchers who have investigated this problem. Their results generally showed that the composition of the fistula forage samples is modified by increasing the ash content. Lesperance and Bohman (1964) have reported that the addition of artificial saliva to hay samples, followed by drying, increased the concentration of acid detergent lignin. Recent research (Wallace et al., 1972; Scales et al., 1972) has shown that salivary contamination of grazed forage significantly increases the ash component, but does not change other chemical constituents when they are calculated on an organic matter (OM) basis. These findings provide the basis for expressing the chemical constituents of the forage samples on an organic matter basis in the present study. Harris et al. (1967) also pointed out that the chemical composition of fistula samples should be expressed on an ash-free basis because of the contamination of plants with inorganic materials and the ingestion of soil while grazing.

The in vitro digestion technique has revolutionized the nutritional evaluation of range forage during the last decade. The literature concerning various phases of in vitro digestion work is quite extensive, and exhaustive reviews are

available (Van Dyne, 1962; Hungate, 1966). Wilson et al. (1971) compared several methods of estimating the digestibility of herbaceous forage and browse, but since they had no measure of in vivo digestibility, their results are restricted to comparison between methods. However, they did feel that the two-stage in vitro technique of Tilley and Terry (1963) tended to underestimate apparent digestibility of poorly digestible forage.

DESCRIPTION OF THE AREA

Field research was conducted at the Hardware Ranch, located 15 miles east of Hyrum, Utah. The ranch is owned and operated by the Utah Division of Wildlife Resources. This area is the primary winter range for elk (Cervus canadensis nelsoni) in northern Utah. Mule deer (Odocoileus hemionus hemionus) also frequent the area during the winter season (October thru April). No livestock grazing has been permitted on the ranch since the property was initially purchased by the State in 1946.

The vegetation of the study site is a sagebrush-grass type that is representative of that found on foothill ranges in much of northern Utah and southern Idaho. The predominant shrub species is big sagebrush (Artemesia tridentata). Other shrubs such as bitterbrush (Pursia tridentata), big rabbitbursh (Chrysothamnus viscidiflorus), and snowberry (Symphoricarpos oreophilus) are common. These shrubs, along with forbs such as Pacific aster (Aster chilensis), mule's ear (Wyethia amplexicaulis), and arrowleaf balsamroot (Balsamorhiza sagittata), alternately dominate specific sites (Jensen et al., 1972). Common grasses include Junegrass (Koeleria cristata), Kentucky bluegrass (Poa pratensis), bluebunch wheatgrass (Agropyron spicatum), and Sandburg bluegrass (Poa secunda). The area is marginal between the sagebrush association and the mountain brush association of Stoddart and Smith (1955).

The frost-free period is usually 90-130 days, but the growing period may be shortened by drought. The annual precipitation varies from 18 to 26 inches, with the major portion being in the form of snow. The study area lies at an elevation of approximately 6,000 feet.

Soils of the area are of the Ant Flat and Yeates Hollow series (Doell, 1966), and are derived from quartzite and quartzite-calcareous sandstone parent material respectively. These soils range in texture from a loam to a stony, silty clay loam, and they have slow permeability and medium runoff.

METHODS AND PROCEDURES

Work outlined in this thesis was conducted in conjunction with grazing trials designed and supervised by Charles H. Jensen and Arthur D. Smith, Utah Division of Wildlife Resources. These cooperators have provided fenced pastures and intact ewes and lambs for the grazing trials. An outline of grazing treatments and stocking rates is given in the schedule presented in Table 1. Physical lay-out of experimental pastures is illustrated in Figure 1.

Table 1. Schedule of grazing treatments and stocking rates

Pasture			Stocking rate
Season Long	M.[1]	4 May-30 June	42 sheep days/acre[2]
" "	H.	" "	68 " " "
Early	M.	4-24 May	36 " " "
"		" "	78 " " "
Intermediate	M.	24 May- 9 June	39 " " "
"	H.	" "	78 " " "
Late	M.	9-30 June	43 " " "
"		"	90 " " "

[1]M. signifies moderately grazed; H. signifies heavily grazed.
[2]One sheep day is defined as the amount of forage consumed by a 165-16 ewe in one day.

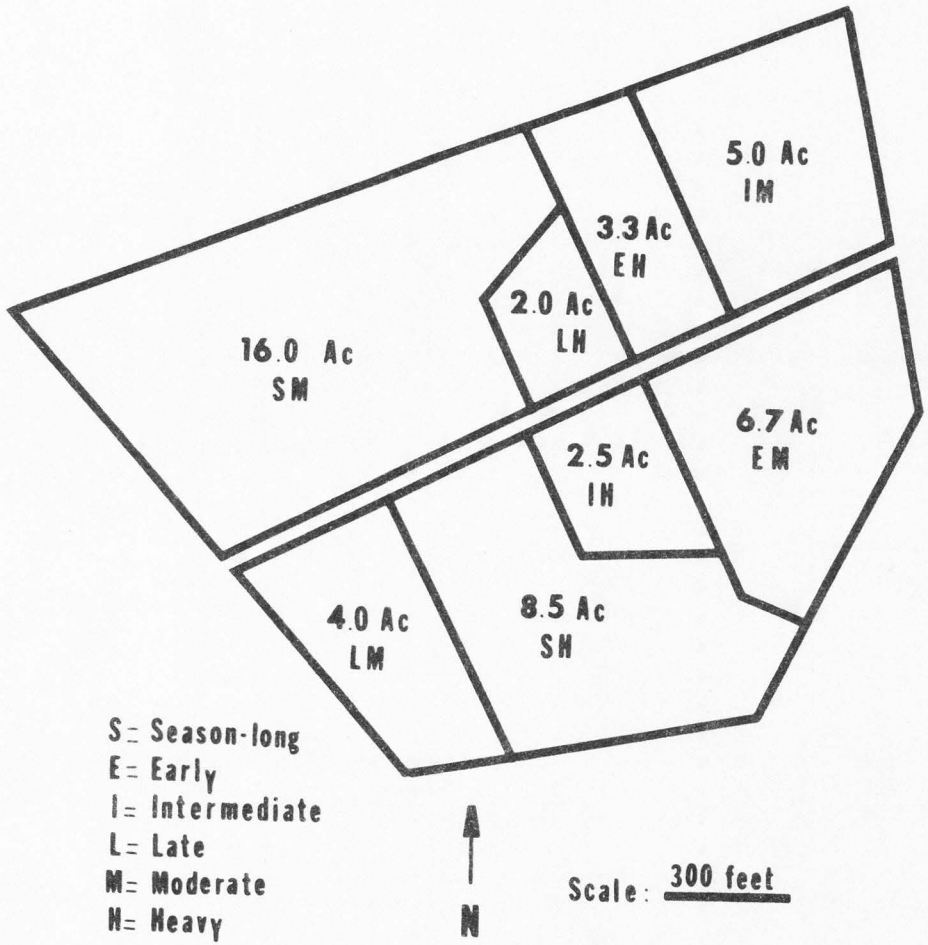

Figure 1. Physical design of experimental pastures. Hardware Ranch.

Pasture sizes were predetermined on the basis of forage quantities necessary to yield the desired level of utilization during a particular grazing period (Jensen, 1971). The desired levels of utilization were defined as 40 percent of the useable forage present at the moderate and heavy intensity respectively. A complete inventory of vegetation present in the pastures was conducted in 1971.

Diet samples representative of forage grazed by the sheep were obtained from esophageally fistulated wethers that were approximately ten months old. These animals were fistulated according to the technique reviewed by Van Dyne and Torell (1964). It is assumed that these surgically modified animals feed like normal intact animals; therefore, the forage collected via fistula can be used in food habit and nutrient composition studies (Short, 1968; Rice, 1970; Cook, 1964; Langlands, 1968).

Field Data Collection

A total of twelve esophageally fistulated sheep were used in the study. Three animals were randomly assigned to each pasture being grazed on 4 May (Table 1). Only four pastures were occupied at any one time during the course of the study. In order to minimize bias, the fistulated animals were randomly reassigned at the beginning of each of the two remaining grazing periods (Intermediate and Late).

In any particular pasture, the fistulated sheep were allowed a six-day preliminary adjustment period prior to the onset of sample collections. Collections of ingested forage material were then made once daily for five consecutive days. Canvas collection bags with screen bottoms were placed on the animals at dawn and the animals were then released and allowed to graze for periods ranging from 30-60 minutes (Van Dyne and Torell, 1964; Price et al., 1964; Harris et al., 1967). Each individual sample was then placed in a plastic freezer bag, cooled in the field in a portable cooler, and transported to the laboratory where it was frozen. In preparation for chemical analysis, the individual forage samples were freeze-dried and composited across days for each wether in each of the collection trials.

Total fecal collections were conducted to determine daily forage intake and in vivo digestibility. The fistulated animals were equipped with fecal collection devices similar to those described by Cook et al. (1952). It is recognized that conventionally a separate group of intact sheep is used for fecal collections while another group of fistulated animals is used to sample the vegetation (Van Dyne, 1968; Price et al., 1964; etc.). However, some researchers have successfully used esophageally fistulated wethers for both total fecal collections, and for forage sampling (Wilson et al., 1971; McManus, 1960, as cited by Van Dyne and Torell, 1964). The design of the grazing systems in the present study did not permit the use of additional animals for fecal collections. Fecal collection devices were placed on the sheep one week prior to the start of the study to

allow time for adjustment of the apparatus to individual animals. The fecal bags remained on the animals for the duration of the study. Price et al. (1964) have compared the feed intake of bagged to nonbagged animals. They did not find a significant difference between the two groups. Cook et al. (1961) also stated that there was no discernable difference in response between animals carrying fecal bags and animals not carrying fecal bags.

Fecal collections began on the third day of each five-day forage collection trial and continued for five consecutive days thereafter (Van Dyne and Lofgreen, 1964). This delay of the fecal collections was to ensure that the fecal material collected was more nearly representative of the forage selected by the animal during the five-day collection trial.

Laboratory Analysis

The nutrient content of the sheep's diets was determined from chemical analyses of the freeze-dried, composite forage samples. The samples were first ground through a Wiley mill to pass a 40-mesh screen and then analyzed for dietary crude protein (total nitrogen x 6.25) by means of the macro-Kjeldahl method (A.O.A.C., 1965). Acid detergent fiber (ADF), and acid detergent lignin (ADL), and cellulose were determined according to Van Soest (1963), and Goering and Van Soest (1970). *In vitro* digestibility determinations were conducted according to Tilley and Terry (1963) with the modification of continuous flushing of the *in vitro* system with carbon dioxide (Van Dyne, 1962). Daily forage

intake and organic matter digestibility were determined using a modification of the microdigestion techniques outlined by Van Dyne and Meyer (1964). Relationships between organic matter digestibility in vitro (Tilley and Terry, 1963), and in vivo (Harris, 1972) were investigated.

An aliquot of feces was taken from each day's total collection for each sheep. These aliquots were composited across days for each sheep in each trial. The fecal samples were then processed and analyzed in the same manner as that described for the forage samples. Digestion coefficients for organic matter, crude protein, and cellulose were calculated according to procedures outlined by Maynard and Loosli (1969).

Statistical Analysis

Data from all nutritional determinations were analyzed by analysis of variance using the least squares procedures (Ostle, 1963). Differences in responses between treatments at individual periods and among periods and trials were tested for statistical significance by Tukey's multiple range test (Ostle, 1963).

RESULTS AND DISCUSSION

Before a meaningful discussion of the results can be presented it is necessary to identify a problem inherent in this type of nutritional study. Changes in chemical composition of the diet and apparent digestibility can primarily be attributed to two major causes: (1) changes resulting from the effects of the grazing intensities, and (2) changes resulting from the effects of advancing maturity of the vegetation. It is difficult to separate these two causes in a clear-cut manner. One would need data from an ungrazed pasture where only plant maturity would be the variable, and this type of data was simply beyond the scope of this study. In an attempt to avoid confusion with respect to the interpretation of the data presented in this section, the following method of presentation will be used: (1) All significant differences due to treatment effects are presented on the graphs. These differences are based on period means and do not represent differences at a particular point in time. (2) All significant differences due to the effects of forage maturation (differences between periods and among trials) will be presented in tabular form.

Chemical Composition of Diets

Dietary crude protein showed a general decline from early to late spring (Figure 2). This decline was evident in all pastures and at both grazing intensities and the change over time was statistically significant under the

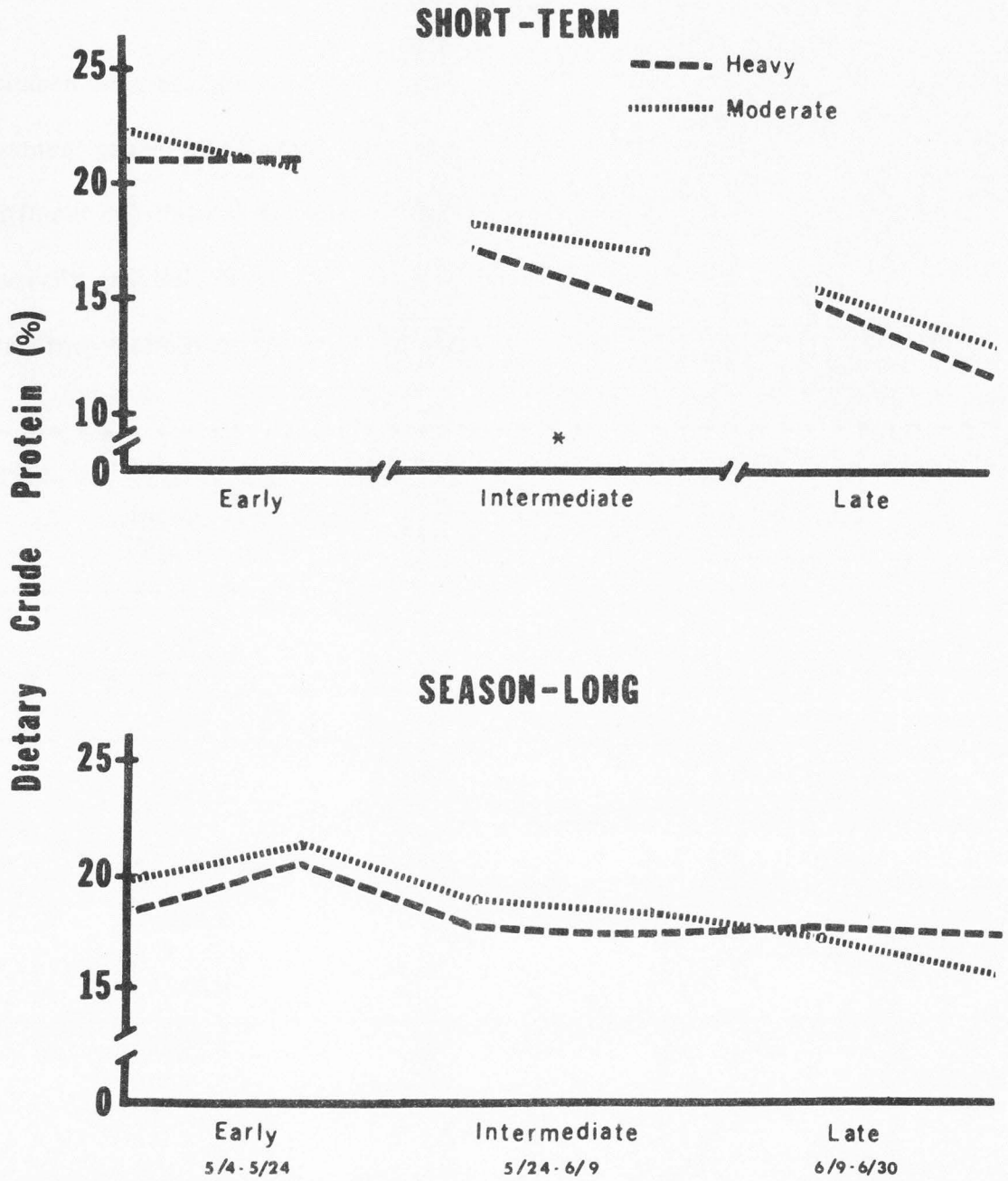

Figure 2. Levels of crude protein in diets selected by sheep grazing heavily and moderately stocked pastures.

periods; whereas, the levels of dietary crude protein on the short-term pastures declined during all three periods (Figure 2). This decline was possibly caused by the rapid utilization of good quality forage in the short-term pastures. Although season-long and short-term pastures received roughly the same levels of utilization by the end of the prescribed grazing period, the short-term pastures reached their predetermined utilization levels in three weeks versus nine weeks on the season-long pastures. Therefore the sheep in the season-long pastures were probably able to maintain their dietary protein at a fairly constant level because they were able to exercise more selectivity in their grazing routine.

Cellulose levels in diets grazed in the two season-long pastures were fairly constant throughout the entire grazing period (Figure 3). There were no significant treatment difference ($P < .05$) on the season-long pastures with respect to cellulose content of the diet (Table 3). However, there was a significant difference ($P < .05$) among trials (Table 2). On the short-term pastures there was a significant difference ($P < .05$) between intensities of grazing during the intermediate period. In this case, the dietary cellulose level was higher on the heavily grazed pasture. Again, this difference between the short-term and season-long pastures was probably due in large part to the fact that the sheep were forced to be less selective on the short-term pastures. This suppression of selectivity was also indicated by the increase of dietary cellulose in both short-term pastures during the latter two grazing periods (Figure 3). The cellulose

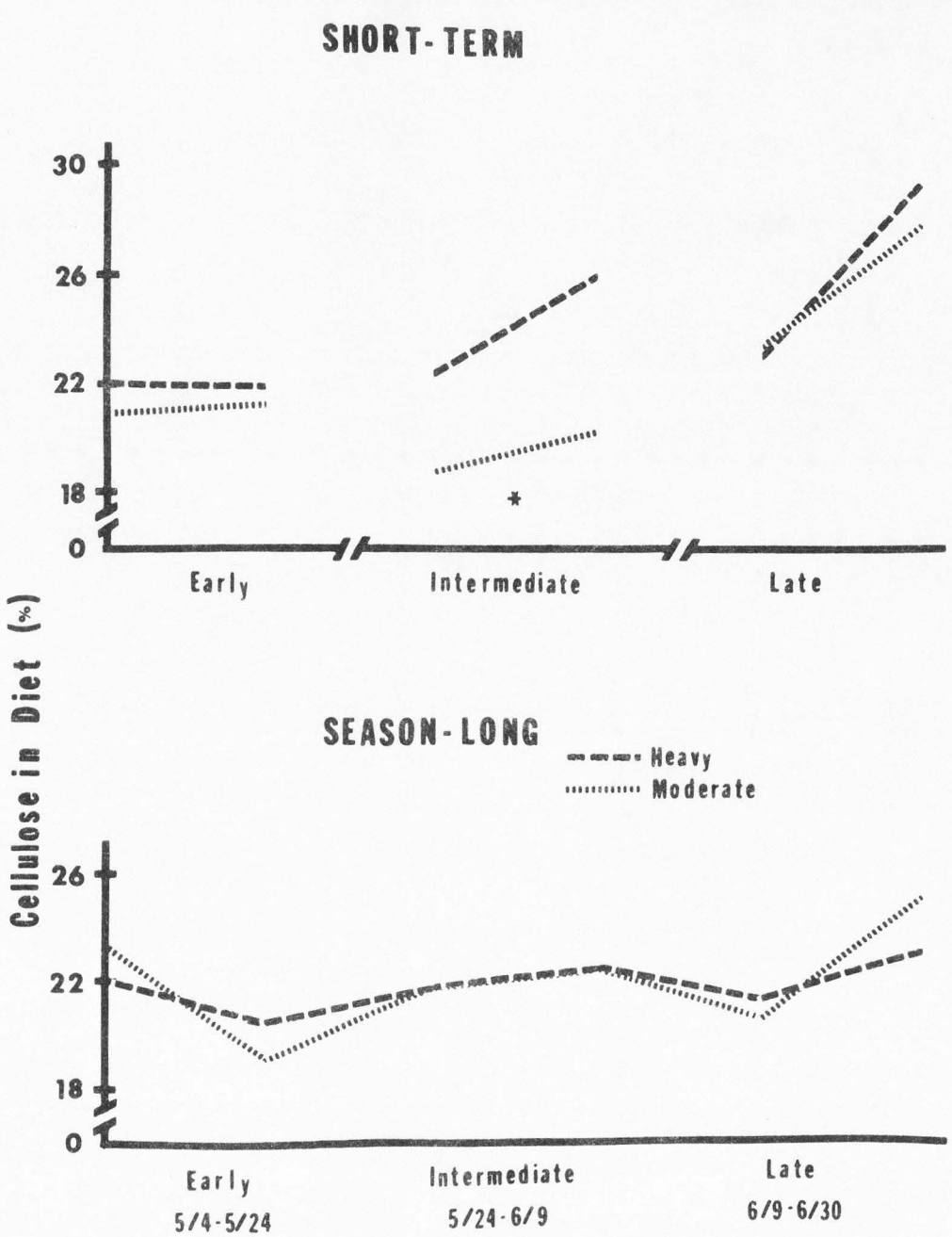

Figure 3. Levels of cellulose in diets selected by sheep grazing heavily and moderately stocked pastures. Astericks denote significant ($P < .05$) differences between treatments.

Table 3. Analysis of variance of the average daily intake, percent digestibility of nutrients in the forage, and chemical composition of the diets of sheep grazing heavily and moderately stocked pastures

(Season-Long)		Mean Squares						
		Daily	Chem. Comp.			Digestibility		
SV	df	intake (gms/day)	lignin	cellu-lose	pro-tein	DM	cellu-lose	pro-tein
Tmts.	1	107474	.23	.42	1.69	465.83*	551.46*	142.39
Prds.	2	13754	31.92*	5.41	27.68	569.63	551.71	831.88
Trls.	3	2000643*	3.94	21.94*	8.80*	193.49*	220.16*	228.53*
Obsv.	29	46882	3.96	2.78	1.39	40.47	83.16	62.85
(Short-Term)								
		Early (Heavy and Moderate)						
Tmts.	1	180320	73.99*	2.00	.85	602.08*	265.08*	685.53*
Trls.	1	7068	5.34	.02	1.34	79.05	7.36	146.30
Tmt. x Trl.	1	19533	.11	.14	6.35*	9.72	.10	2.91
Obsv.	8	132830	2.48	1.09	1.08	40.21	44.32	74.49
		Intermediate (Heavy and Moderate)						
Tmts.	1	210410*	2.08	62.09*	8.66*	12.46	31.03	233.19*
Trls.	1	17100	5.60	19.51*	10.09*	73.97	.01	224.47*
Tmt. x Trl.	1	44287	.34	2.71	1.47	12.92	.10	23.24
Obsv.	8	27261	3.02	1.80	1.21	57.36	53.04	21.63
		Late (Heavy and Moderate)						
Tmts.	1	136314	31.36*	1.02	2.80	853.48*	691.61*	1111.68*
Trls.	1	18486	3.85	90.20*	21.87	76.00*	219.31*	35.03
Tmt. x Trl.	1	224995	7.37*	2.90	.41	129.37*	85.86*	317.23*
Obsv.	8	68671	1.04	7.36	31.13	4.79	6.03	25.34

*Indicates significance ($P < .05$).

levels in the heavily grazed short-term pastures were higher than the corresponding levels of cellulose on the heavily grazed season-long pasture, except during the early period when they were similar. Cook et al. (1965) also showed that the percent cellulose in the diet increased as the utilization increased.

Lignin levels in the diet presented much the same picture as cellulose (Figure 4). On the season-long pastures, there was a gradual but fairly steady increase from early to late spring (Figure 4). This increase was primarily a result of forage maturation. There was no significant difference attributed to grazing intensities on the season-long pastures. However, there was a significant difference in the lignin level between periods (Table 3). The percent lignin in the early period was significantly lower ($P < .05$) than in the intermediate and late periods.

In the short-term pastures there was a definite treatment effect during the early and late periods (Figure 4). In both instances the level of lignin in the diet was significantly higher ($P < .05$) in the heavily grazed pastures. Increased consumption of coarser parts of the plants could partially account for this response. The sheep on the heavily grazed short-term pasture in the late period also consumed more shrubby vegetation. which would normally lead to higher levels of dietary lignin.

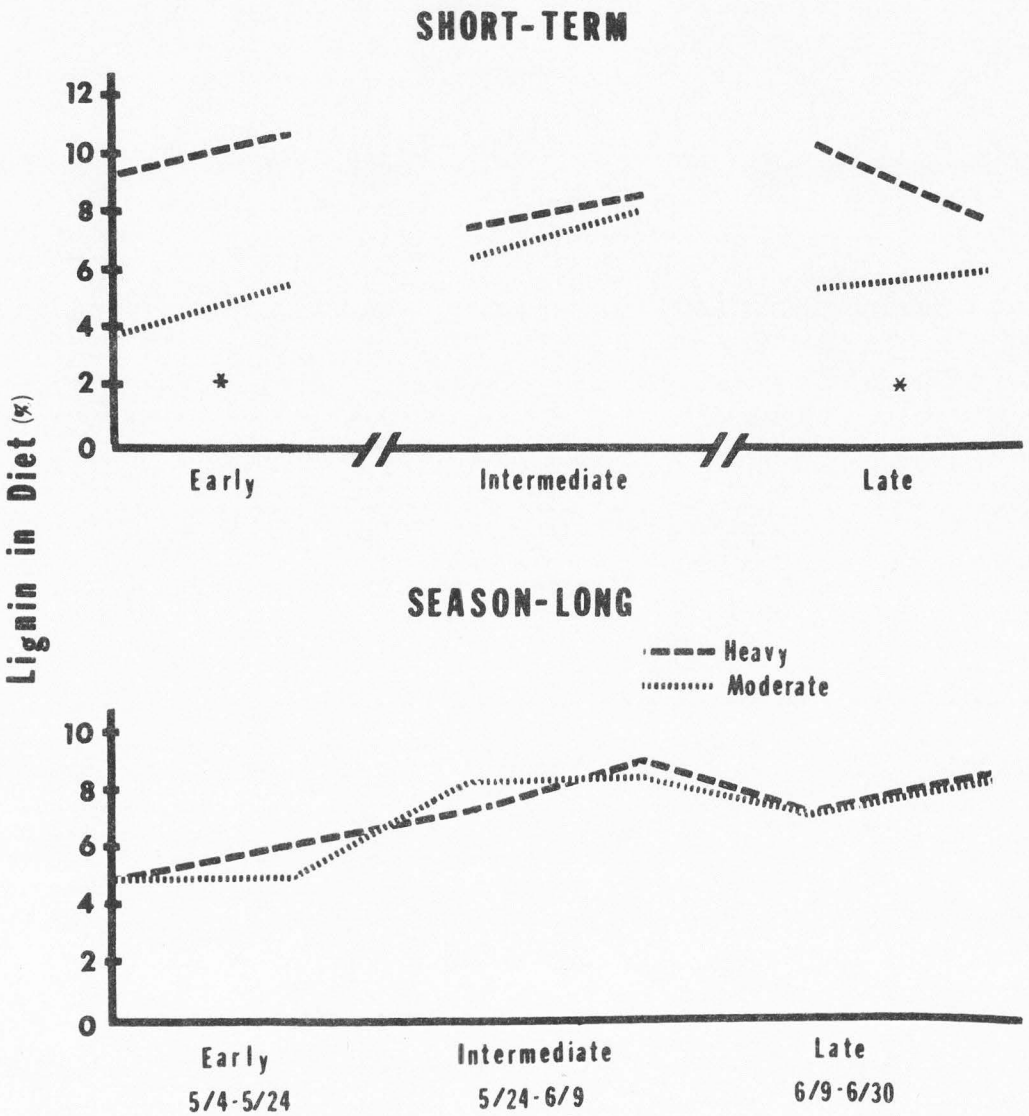

Figure 4. Levels of lignin in diets selected by sheep grazing heavily and moderately stocked pastures. Astericks denote significant ($P < .05$) differences between treatments.

Digestibility of Selected Dietary Components

Apparent digestibility of protein did not differ significantly on the season-long pastures with respect to grazing intensities (Figure 5). However, there was a significant effect over time (Table 2). The digestibility was significantly higher ($P < .05$) during the first trial than during the last trial on the season-long pastures (Table 2). Protein digestibility was significantly depressed ($P < .05$) on the heavily grazed pastures during all three periods under the short-term grazing regime.(Figure 5). Cook et al. (1965) found that on "good" summer range the digestibility of protein was not affected by increased utilization, but on "poor" range it decreased significantly.

The digestibility of cellulose was significantly depressed ($P < .05$) in all but one of the heavily grazed pastures; the exception being the short-term intermediate period (Table 3). In general, cellulose digestibility followed much the same pattern as protein digestibility. Cook et al. (1965) also showed that the digestibility of cellulose was depressed as the utilization increased on both "good" and "poor" ranges.

Trends of organic matter digestibility are presented in Figure 7. The reason both organic matter and cellulose digestibilities are presented in this study is that cellulose digestibility alone does not present a complete picture of the availability of fibrous constituents to the animal. A major problem associated with cellulose digestibility is that hemicellulose, an important plant component,

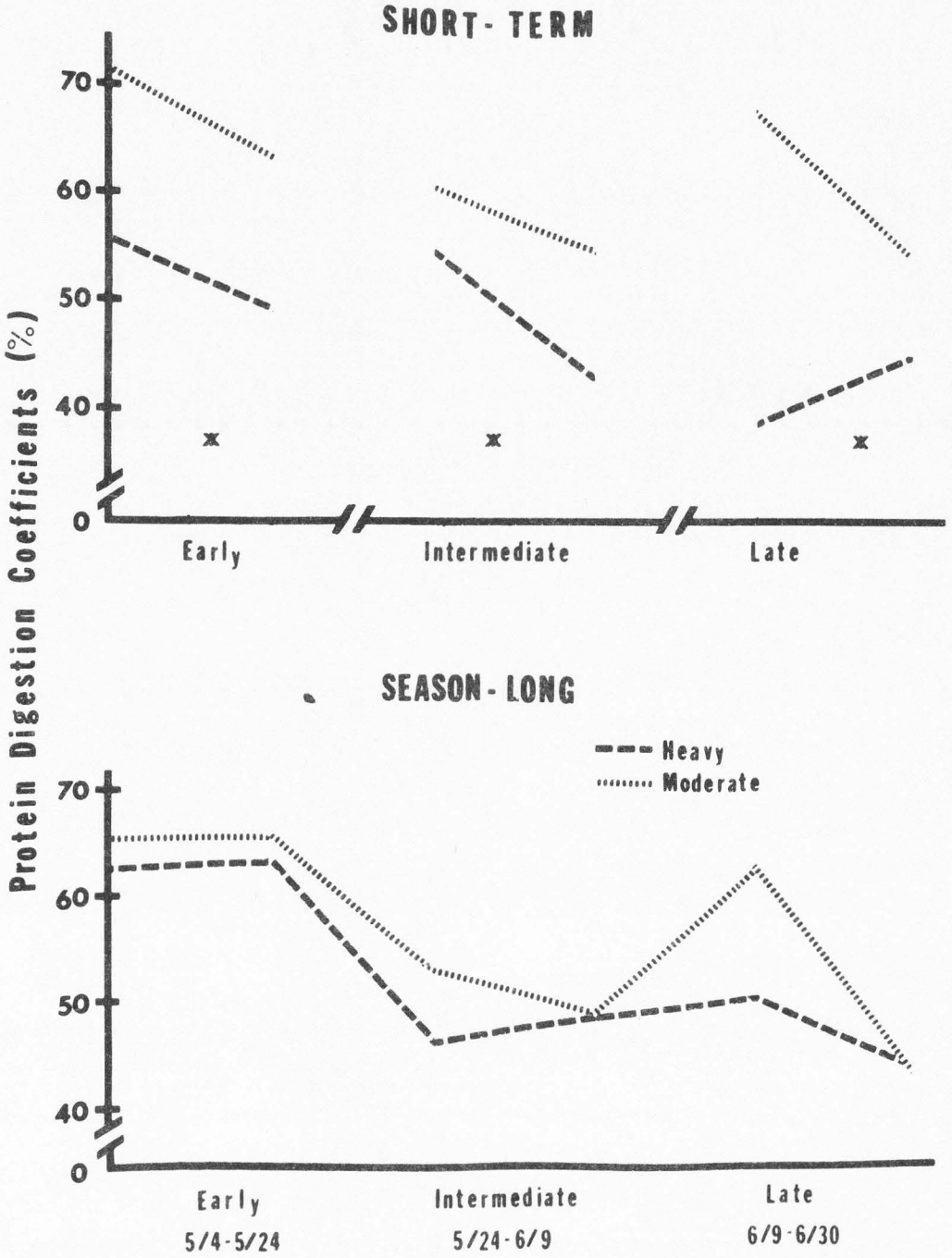

Figure 5. Levels of protein digestibility in diets selected by sheep grazing heavily and moderately stocked pastures. Astericks denote significant ($P < .05$) differences between treatments.

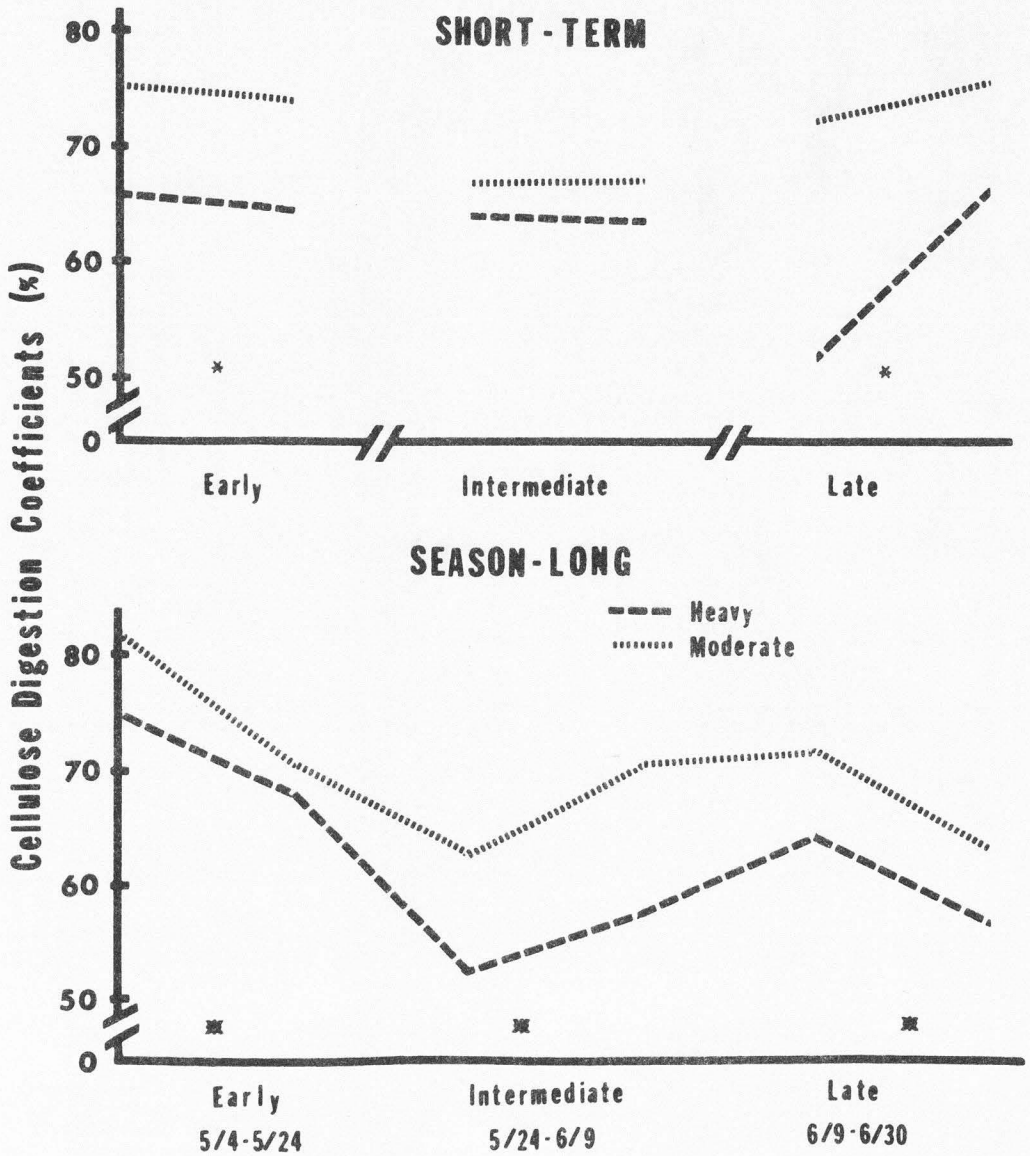

Figure 6. Levels of cellulose digestibility in diets selected by sheep grazing heavily and moderately stocked pastures. Astericks denote significant ($P < .05$) differences between treatments.

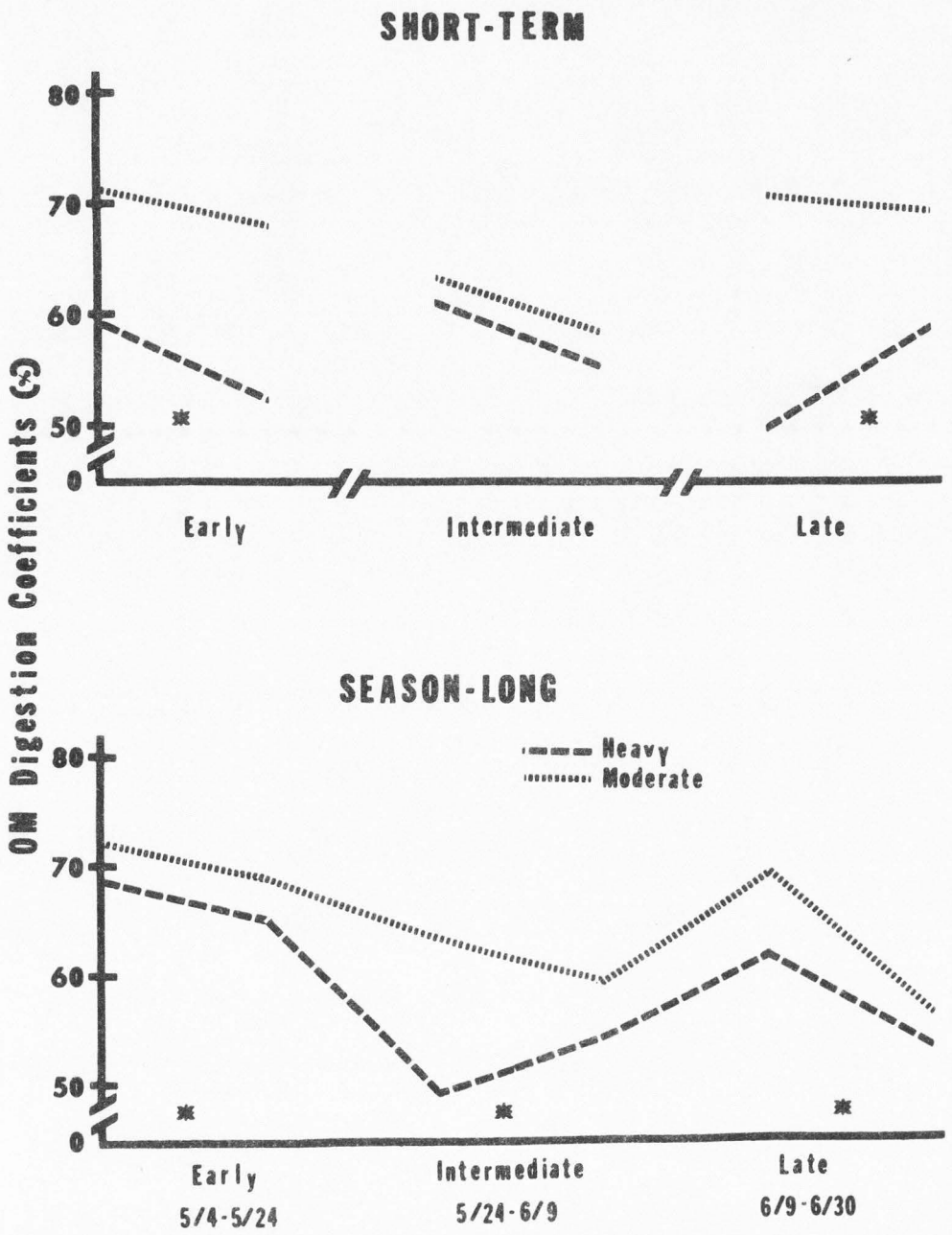

Figure 7. Levels of organic matter digestibility in diets selected by sheep grazing heavily and moderately stocked pastures. Astericks denote significant ($P < .05$) differences between treatments.

is not given due consideration. Van Dyne and Meyer (1964) used the in vitro digestibility of cellulose as the basis for determining daily intake. In a later study Van Dyne and Heady (1965) showed that in the early summer there was no significant correlation between the dietary content of grass stems and dietary cellulose. This would perhaps tend to invalidate the use of cellulose digestibility as a predictor of intake on a spring range such as found in this study.

The apparent digestibility of organic matter (Figure 7) was significantly depressed ($P < .05$) in the same manner as the digestibility of cellulose. This response was noted on all but one of the heavily grazed pastures. The lone exception as was also true with cellulose, was the intermediate short-term pasture (Figure 7). On the season-long pasture there was a significant effect among trials (Table 2). The digestibility was significantly higher ($P < .05$) during the early trials as compared with the trials in the late period.

Examination of the apparent digestibility patterns of protein (Figure 5), cellulose (Figure 6), and organic matter (Figure 7) suggests a close relationship between nutrient digestibility and the level of lignin (Figure 4) found in the diet. Without exception, when lignin levels were high, there was a corresponding decrease in the digestibility of the various components measured. While this relationship may be valid, care should be used in its interpretation. In this study lignin was used as the internal indicator in the forage to establish the ratio necessary to calculate the apparent digestibilities of the three nutrients discussed. If the assumption of indigestibility of lignin was not met, there would result an

artificial, inverse relationship between percent lignin and the various digestion coefficients.

Daily Intake

The heavy grazing intensity did significantly depress ($P < .05$) the daily intake of organic matter during the early period on the season-long pastures (Figure 8). There was also a significant depression ($P < .05$) of intake in the heavily grazed short-term pasture during the intermediate period (Figure 8). Under the season-long regime, the daily intake varied significantly ($P < .05$) among the various trials (Table 2). It is interesting to note that overall, intake was at its lowest level during the intermediate period (Figure 8).

Several factors are responsible for restricted forage intake. Arnold (1970) has stated that a limited amount of total dry matter available and/or a shortage of palatable plants from which the animals can select their diets will limit forage intake. Campling (1970) has stated that the slow rate of passage of digesta resulting from poorly digestible forage will also tend to cause a reduced intake. In this study it appears that a combination of these limiting factors depressed the daily intake. On the heavily grazed short-term pasture in the early period, the lower intake was probably the result of a limited amount of total available dry matter. Limited utilization data presently available shows that during the early period there was little, if any, difference in the kinds of plants consumed in the two short-term pastures. Lignin in the diet of animals

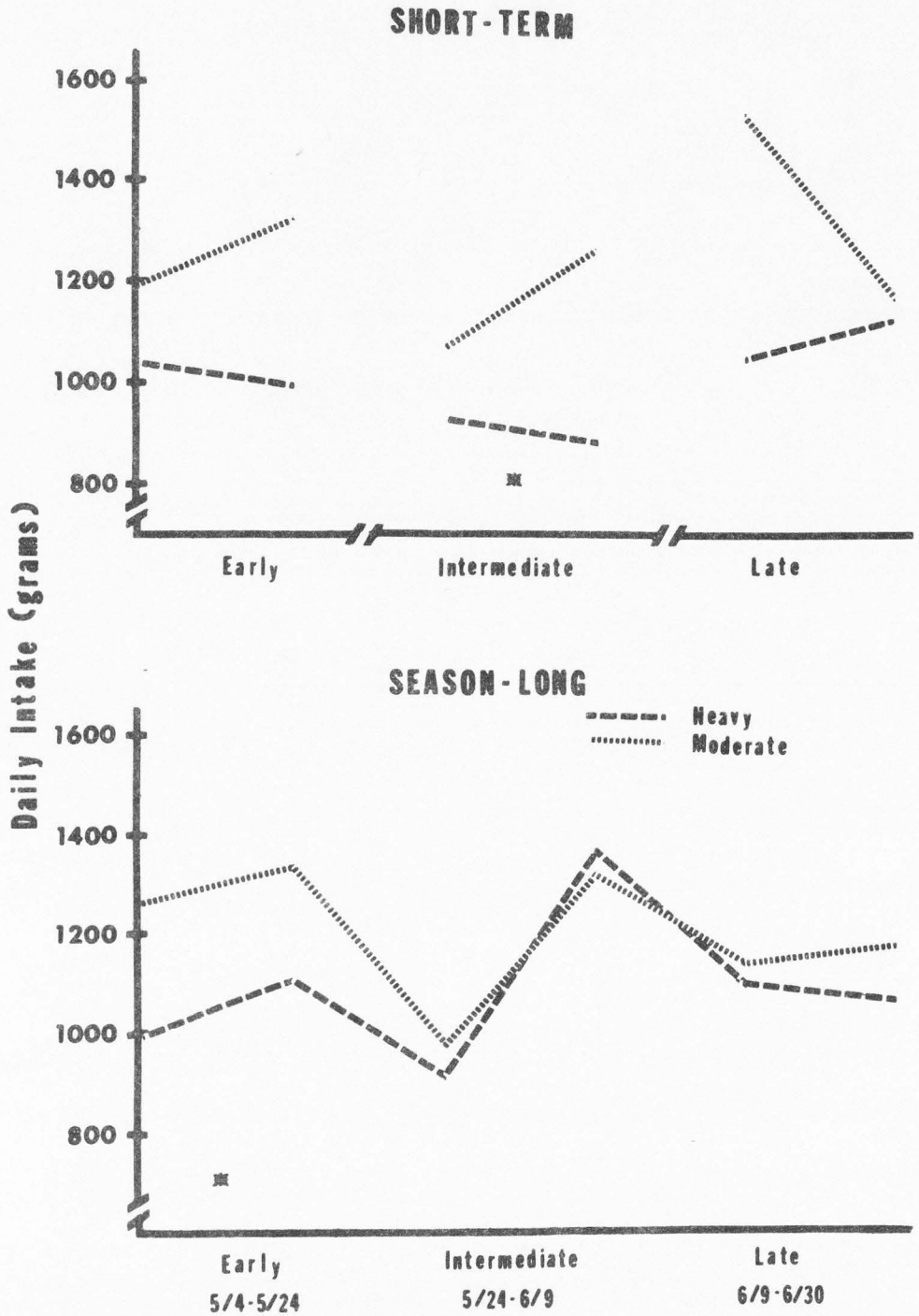

Figure 8. Daily intake of organic matter selected by sheep grazing heavily and moderately stocked pastures. Astericks denote significant ($P < .05$) differences between treatments.

grazing the heavily grazed short-term pasture in the early period was twice as high as that on the moderately grazed pasture (Figure 4). This indicates that although the sheep generally consumed the same plant species in both pastures, those on the heavily grazed pasture were forced to eat portions of the plants that were generally more fibrous. Digestibility of fiber components was significantly lower ($P < .05$) on the heavily grazed short-term pasture during the early period (Figure 5, Figure 6, Figure 7). As Campling (1970) pointed out, this lower digestibility could possibly account for a reduction in forage intake.

On the season-long pastures the depressed intake in the early period (Figure 8) probably cannot be attributed to a limited amount of available dry matter. In this case, the lignin content of the diet at both grazing intensities is nearly identical (Figure 4). Also, the apparent digestibilities for both grazing intensities are generally quite similar during the early period. This would seem to rule out the limiting factor proposed by Campling (1970). Arnold (1970) has noted that as the feed supply decreases, the grazing animals can compensate by eating plant species that they had previously ignored. The animals tend to spend a greater proportion of their grazing time seeking favored plant species that are in low supply. This behavior could possibly lead to a reduced forage intake because the animals in essence would spend more time "looking" and less time "eating". There is evidence to support this idea in the season-long pastures. In the heavily grazed pasture the sheep grazed mule's ear extensively. However, in the moderately grazed pasture mule's ear was almost completely ignored.

Preferable plant species such as Junegrass and Pacific aster were heavily utilized in both pastures.

During the intermediate and late periods the intake on both season-long pastures was nearly identical. It should be mentioned here that one reason for this could be the fact that the degree of utilization on the season-long, heavily grazed pasture was not consistent with the other heavily grazed pastures (Table 1). During the intermediate period several sheep were removed from the heavily grazed season-long pasture because of poor performance, thus reducing the grazing pressure and subsequent total utilization. The marked increase in daily intake during the intermediate period reflects an adequate supply of fairly high quality forage in the season-long pastures. On the intermediate short-term pasture, intake was depressed on the heavily grazed pasture in much the same manner as during the early period (Figure 8). The fact that intake increased on the moderately grazed short-term pasture while there was a corresponding decrease on the heavily grazed pasture indicates that a combination of the limiting factors proposed by Arnold (1970) were operating to depress intake.

In Vitro vs In Vivo Predictions of Organic Matter Digestibility

Wilson et al. (1971) maintain that the Tilley and Terry (1963) *in vitro* technique tends to underestimate the apparent digestibility of forages that are poorly digested. They contend that some material of bacterial origin is occluded in the residues of the *in vitro* fermentations. In this study *in vivo* digestibilities

of the various components measured (as predicted by lignin ratio) were fairly high during the early period. There was then a general decline in digestibility as the grazing season progressed. It was postulated that as the season progressed and forage became less digestible due to advancing maturity, the ability of the in vitro technique to predict the digestibility (in vivo) would decrease. The coefficients of determination (r^2) were .761, .652, and .664 for the early, intermediate, and late periods respectively (Figure 9). This apparent decline in the predictive ability of the in vitro technique over time was not statistically significant. The small sample size (24/period) was a factor partially responsible for the lack of significant difference between periods.

Variability

The determination of the number of animals required to estimate nutritional parameters within a specified percent of the mean with a stated level of confidence is a practical way to portray variability. The data presented in Table 4 shows the wide range of variation associated with the measurement of various nutritional parameters in this study. The validity of the lignin-ratio technique as an estimator of daily intake appears to be subject to considerable doubt (Table 4). Wallace and Van Dyne (1970) have stated that lignin is digestible to some extent in young plants. They also point out that lignin is not a distinct chemical entity, and that it varies in chemical nature among plant groups. Variability associated with the use of the in vitro technique to estimate daily

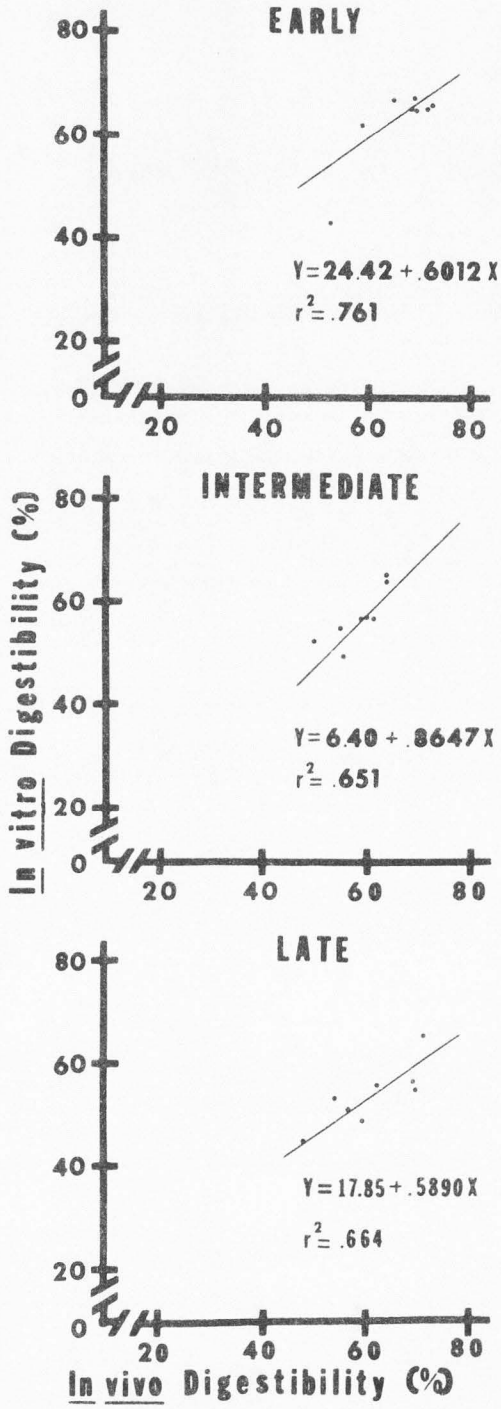

Figure 9. Comparisons of organic matter digestibilities as determined by in vitro and in vivo techniques for each of the three grazing periods.

Table 4. The number of animals required to estimate various nutritional parameters within 10 percent of the mean at the 95 percent confidence level

Pasture and Intensity	Daily Intake		Chem. Comp.			Dig. Coef.			
								OM	
	lignin ratio	in vitro	lig-nin	cellu-lose	pro-tein	cellu-lose	pro-tein	in vivo	in vitro
Season-long Hvy.									
Early	1	3	12	1	3	2	8	3	1
Int.	15	6	11	1	1	18	6	16	7
Late	27	5	6	2	6	14	19	6	4
Season-long Mod.									
Early	29	5	18	6	1	5	9	3	2
Int.	2	3	38	7	1	3	4	2	9
Late	2	2	10	6	3	3	20	7	5
Short-term Hvy.									
Early	11	1	12	1	1	2	4	3	3
Int.	8	1	26	3	5	2	9	3	4
Late	4	3	17	13	6	7	11	6	1
Short-term Mod.									
Early	35	5	28	1	2	3	10	5	2
Int.	9	3	12	2	1	5	50	9	3
Late	17	5	5	4	5	1	8	1	5

intake is a great deal lower than with the lignin-ratio method (Table 4), however, we were not able to detect or quantify the magnitude and direction of bias that might be associated with this technique.

The number of animals used in this study was generally adequate to estimate the percent cellulose and protein in the diet. The high variability associated with the determination of lignin might be somewhat misleading because since the levels of lignin were quite small (4-11 percent); even small deviations from the average resulted in a relatively high variance. Part of this variation could be associated with the problem of accurate lignin analysis on lush, immature forages.

The variability in the prediction of digestibility of cellulose and protein is quite high (Table 4). Again the problems associated with lignin analysis are probably partially responsible for the high variation. It appears that the variability associated with estimates of organic matter digestibility is somewhat less when calculated by using an *in vitro* technique, but the variability with the *in vivo* technique is actually quite reasonable (Table 4).

SUMMARY AND CONCLUSIONS

During the spring of 1972 a study was conducted on a foothill range of northern Utah to determine the effects of two spring grazing systems and two grazing intensities upon daily intake, nutritive content, and digestibility of sheeps' diets. Twelve esophageally fistulated wethers provided representative diet samples as they grazed with intact ewe-lamb pairs on heavily and moderately stocked pastures throughout May and June.

Grazing intensities on season-long pastures did not influence the concentrations of dietary chemical components, but heavy grazing under this regime did depress the digestibility of cellulose and organic matter. The digestibility of protein was not affected by the heavy grazing. Time had a significant effect on the dietary chemical components. Lignin content in the diet was significantly lower in the early period than in the remaining two periods. Protein content of the diet was significantly higher in the early trials than in the last two trials. Digestion coefficients for organic matter and cellulose were all significantly higher in the early period than in the remaining two periods. Daily intake was depressed as a result of the heavy grazing during the early period, but there was no significant difference between periods.

Grazing intensities on the short-term pastures markedly influenced dietary chemical components. Under heavy grazing, lignin content in the diet was significantly higher than under moderate grazing during the early and late

periods. Cellulose content of the diet was significantly higher in the intermediate and late periods on heavily grazed ranges. The content of dietary crude protein was significantly lower on the heavily grazed range during the intermediate period. The digestibility of organic matter and cellulose was depressed under heavy grazing in both the early and late periods. Protein digestibility was depressed in all three periods as a result of the heavy grazing. Daily intake was significantly lower under heavy grazing in the intermediate period.

The following generalizations can be drawn from this investigation:

1. Heavy grazing on the short-term pastures drastically reduced the quality and digestibility of the forage consumed in early and late spring, but had little appreciable effect during the intermediate period.

2. Under the season-long grazing system, heavy grazing (at the rate used in this study) did not adversely affect the nutritional quality of forage consumed, but did depress the quantitative parameters of intake and digestibility.

LITERATURE CITED

A.O.A.C. 1965. Official methods of analysis (10th ed.). Association of Official Agricultural Chemists. Washington, D.C. 957 pp.

Arnold, G. W. 1970. Regulation of food intake in grazing ruminants. In: A. T. Phillipson (Ed.). Physiology of digestion in the ruminant. Oriel Press, Newcastle Upon Tyne, England. 264-276.

Barth, K.M., J.E. Chandler, M.E. Fryer, and H.C. Wang. 1970. Effects of saliva and drying temperatures on composition and digestibility of forage samples collected through asophageal fistulas. J. Anim. Sci. 31:794-798.

Bath, D.L., W. C. Torell. 1956. The use of the esophageal fistula for the determination of consumption and digestibility of pasture forage by sheep. J. Anim. Sci. 15:1166-1171.

Bohman, V.R., and A.L. Lesperance. 1967. Methodology research for range forage evaluation. J. Anim. Sci. 26:820-826.

Bryant, H.T., R.E. Blaser, R.C. Hammer, Jr., and J.P. Fontenot. 1970. Symposium on pasture methods for maximum production in beef cattle: Effect of grazing management on animal and area output. J. Anim. Sci. 30:153-158.

Buchanan, H., W.A. Laycock, and D.A. Price. 1972. Botanical and nutritive content of the summer diet of sheep on a tall forb range in southwestern Montana. J. Anim. Sci. 35:423-430.

Campling, R.C. 1970. Physical regulation of voluntary intake. In: A. T. Phillipson (Ed.). Physiology of digestion in the ruminant. Oriel Press, Newcastle Upon Tyne, England. 226-234.

Cook, C. W. 1964. Collecting forage samples representative of ingested material of grazing animals for nutritional studies. J. Anim. Sci. 23:265-272.

_____ and L.E. Harris. 1950. The nutritive content of the grazing sheep's diet on summer and winter ranges of Utah. Utah Agr. Exp. Sta. Bul. No. 472. 55pp.

Cook, C.W., and L.E. Harris. 1952. The nutritive value of cheatgrass and crested wheatgrass on spring ranges in Utah. J. Range Manage. 5:331-337.

_____ and _____. 1968. Nutritive value of seasonal ranges. Utah Agr. Exp. Sta. Bul. No. 472. 55 p.

_____, M. Kothmann, and L.E. Harris. 1965. Effect of range condition and utilization on nutritive intake of sheep on summer ranges. J. Range Manage. 18:69-73.

_____, J.E. Mattox, and L.E. Harris. 1961. Comparative daily consumtion and digestibility of summer range forage by wet and dry ewes. J. Anim. Sci. 20:866-870.

_____, and L.A. Stoddart. 1961. Nutrient intake and livestock responses on seeded foothill ranges. J. Anim. Sci. 20:36-41.

_____, _____ and L.E. Harris. 1952. Determining the digestibility and metabolizable energy of winter range plants by sheep. J. Anim. Sci. 11:578-584.

_____, _____ and _____. 1953. Effects of grazing intensity upon the nutritive value of range forage. J. Range Manage. 6:51-54.

_____, K. Taylor, and L.E. Harris. 1962. The effect of range condition and intensity of grazing upon daily intake and nutritive value of the diet on desert ranges. J. Range Manage. 15:1-6.

Doell, D.D. 1966. Effects of summer cattle grazing on big-game winter range in northern Utah. Unpub. M.S. Thesis. Michigan State University. 55 p.

Forbs, R.M. and W.P. Garrigus. 1948. Application of a lignin ratio technique to the determination of the nutrient intake of grazing animals. J. Anim. Sci. 7:373-377.

Goering, H.K., and P.J. Van Soest. 1970. Forage fiber analysis (apparatus, reagents, procedures and some applications). U.S. Dept. Agr. Agricultural Handbook No. 379. 20 p.

Harris, L.E. 1972. Nutrition research techniques for domestic and wild animals. Vol. 1. An International Record System and Procedures for Analyzing Samples. Pub. by L.E. Harris, Logan, Utah. 184 p.

_____, G. P. Lofgreen, C.J. Kercher, R.J. Raleigh, and V.R. Bohman. 1967. Techniques of research in range livestock nutrition. Utah Agr. Exp. Sta. Bul. No. 471. 86 p.

Hungate, R.E. 1966. The rumen and its microbes. New York: Acad. Press. 533 p.

Jensen, C.H. 1971. The effect of grazing animals upon winter game ranges. Job Final Report. Utah Proj. W-105-R. Job No. A-4g. 34 p.

Jensen, C.H., A.D. Smith, and G. W. Scotter. 1972. Compatability of sheep and big game use on a northern Utah foothill rangeland. J. Range Manage. 25:346-352.

Kothmann, M.M. 1963. The effect of range condition and intensity of grazing upon the daily intake and nutritive value of the diet of sheep on summer ranges in northern Utah. M.S. Thesis. Utah State University, Logan, Utah. 59 p.

Langlands, J.P. 1967. Studies on the nutritive value of the diet of grazing sheep: II. Comparison of oesophageal fistula and fecal index techniques for the indirect estimation of digestibility. Anim. Prod. 9:325-331.

_____. 1968. The feed intake of grazing sheep differing in age, breed, previous nutrition, and live weight. J. Agri. Sci., Camb. 71:167-172.

Lesperance, A.L., and V.R. Bohman. 1964. Chemical changes in forage induced by sampling preparation. Proc. West. Sect. Amer. Soc. Anim. Sci. 15:54-59.

_____, _____ and D.W. Marble. 1960. Development of a technique for evaluating grazed forage. J. Dairy Sci. 43:682-685.

Maynard, L.A., and J.K. Loosli. 1969. Animal nutrition. 6th ed. McGraw-Hill Book Co., New York. 613 p.

Ostle, B. 1963. Statistics in research. 2nd ed. Iowa State University Press. Ames, Iowa. 583 p.

Piper, R.O., C.W. Cook, and L.E. Harris. 1959. The effect of intensity of grazing upon nutritive content of the diet. J. Anim. Sci. 18:1031-1037.

Price, D.A., I.L. Lindahl, K.R. Frederiksen, P.J. Reynolds, and C.M. Cain, Jr. 1964. Nutritive quality of sheep's diet on tall forb range. Proc. West. Sec. Amer. Soc. Animal Prod. 15:60-67.

Raleigh, R.J. 1970. Manipulation of both livestock and forage management to give optimum production. J. Anim. Sci. 30:108-114.

Rice, R.W. 1970. Stomach content analysis: A comparison of the rumen vs. esophageal techniques. In: Range Wildlife Habitat Evaluation - A Research Symposium. U.S. Dept. Agr. Misc. Publ. 1147. 127-132.

Scales, G.H., C.L. Streeter, and A.H. Denham. 1972. Chemical composition of esophageal fistula samples. Proc. West. Sect. Amer. Soc. Anim. Sci. 23:192-196.

Scotter, G.W. 1967. Range resources and big game management. Utah Sci. 28:192-196.

Short, H.L. 1970. Digestibility trials: in vivo techniques. In: Range and Wildlife Habitat Evaluation - A Research Symposium. U.S. Dept. Agr. Misc. Publ. 1147. 79-84.

Smith, T.M., A.L. Lesperance, and V.R. Bohman. 1967. Drying methods related to changes in chemical composition. Proc. West. Sect. Amer. Soc. Anim. Sci. 18:285-291.

Stoddart, L.A., and A. D. Smith. 1955. Range Management. 2nd ed. McGraw-Hill Book Co., New York. 433 p.

Streeter, C.L. 1969. A review of techniques used to estimate the in vivo digestibility of grazed forages. J. Anim. Sci. 29:757-768.

Theurer, B. 1970. Chemical indicator techniques for determining range forage consumption. In: Range and Wildlife Habitat Evaluation - A Research Symposium. U.S. Dept. Agr. Misc. Publ. 1147. 111-119.

Tilley, J.M.A., and R. A. Terry. 1963. A two-step technique for the in vitro digestion of forage crops. J. Brit. Grassland Soc. 18:104-111.

Van Dyne, G.M. 1962. Micro-methods for nutritive evaluation of range forages. J. Range Manage. 15:303-314.

_____. 1968. Measuring quantity and quality of the diet of large herbivores. In: F.B. Golley and H.K. Buechner (eds.). A practical guide to the productivity of large herbivores. Blackwell Scientific Publication, Oxford and Edinburgh, England. 54-95.

_____and H.F. Heady. 1965. Interrelations of botanical and chemical dietary components of animals grazing dry annual range. J. Anim. Sci. 24:305-312.

_____and G.P. Lofgreen. 1964. Comparative digestion of dry annual range forage by cattle and sheep. J. Anim. Sci. 23:823-829.

_____and J.H. Meyer. 1964. A method for measurement of forage intake of grazing livestock using microdigestion techniques. J. Range Manage. 17:204-208.

_____and D.T. Torell. 1964. Development and use of the esophageal fistula: a review. J. Range Manage. 17:7-19.

Van Soest, P.J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. Assn. Offic. Agr. Chem. 46:829-835.

_____. 1964. Symposium on nutrition and forage and pastures: New chemical procedures for evaluating forages. J. Anim. Sci. 23:838-846.

Vavra, M., R.W. Rice, and R.E. Bement. 1973. Chemical composition of the diet, intake and gain of yearling cattle on different grazing intensities. J. Anim. Sci. 36:411-414.

Wallace, J.D., D.N. Hyder, and G.M. Van Dyne. 1972. Salivary contamination of forage selected by esophageal fistulated steers grazing sandhill grassland. J. Range Manage. 25:184-187.

Wallace, J.D., and G.M. Van Dyne. 1970. Precision of indirect methods for estimating digestibility of forage consumed by grazing cattle. J. Range Manage. 23:424-432.

Wilson, A.D., W.C. Weir, and D.T. Torell. 1971. Comparison of methods of estimating the digestibility of range forage and browse. J. Amin. Sci. 32:1046-1050.

VITA

Kurt James Kotter

Candidate for the Degree of

Master of Science

Thesis: Nutrition of Sheep Grazing Foothill Big Game Range in Spring

Major Field: Range Management

Biographical Information:

Personal Data: Born at Nampa, Idaho, 14 June 1944, son of James R. and Helen Pallesen Kotter; married Lana Woodward 18 July 1966; four children--Rochelle, JaNae, Kandice, and Tyler.

Education: Attended elementary schools in Nampa, Jerome and Fruitland, Idaho; graduated fron Nampa High School in 1962; received the Associate of Science degree from Ricks College in 1966; received the Bachelor of Science degree from Utah State University, with a major in game management, in 1968.

Professional Experience: 1973 employed as a Range Conservationist with the Bureau of Land Management, Burley, Idaho; 1971-1973, research assistant, Range Department, Utah State University; 1971, summer employment with the Utah Division of Wildlife Resources as a waterfowl biological aide; 1968-1970, U.S. Army, Vietnam veteran; 1967, summer employment with the Forestry Science Laboratory as a range aide.