INFLUENCE OF AVAILABLE BROWSE ON CATTLE DIETS IN AN *ACACIA* SAVANNAH OF EAST AFRICA

A Thesis

by

PHILIP KIPTORUS KIBET

Submitted to the Graduate College of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 1984

Major Subject: Range Science

INFLUENCE OF AVAILABLE BROWSE ON CATTLE DIETS

IN AN *ACACIA* SAVANNAH OF EAST AFRICA

A Thesis

by

PHILIP KIPTORUS KIBET

Approved as to style and content by:

Jerry W. Stuth
Jerry W. Stuth
(Chairman of Committee)

Fred E. Smeins
Fred E. Smeins
(Member)

T. C. Cartwright
Thomas C. Cartwright

J. L. Schuster
Joseph L. Schuster
(Head of Department)

August 1984

ABSTRACT

Influence of Available Browse on Cattle Diets in an Acacia Savannah of East Africa. (August 1984)

Philip Kiptorus Kibet, B.S., Texas A&M University;

Chairman of Advisory Committee: Dr. Jerry W. Stuth

A six-month study was conducted in southeastern Kenya to determine the influence of varying bush canopy cover on dietary selection and nutrition of mature esophageally fistulated heifers. Replicated moderately stocked paddocks (2.25 ha) each, were grazed one day every 28-30 days from June to November, 1982. Treatment paddocks were designated light, moderate and heavy bush conditions with 12.8, 31.5 and 49.8% total canopy cover, respectively. Acacia senegal, Cordia ovalis and Grewia villosa were the primary woody vegetation which created treatment effect. Digitaria macroblephara increased in composition with increasing canopy cover while Chloris roxburghiana decreased.

Heifer diets were dominated by grass and grasslikes irrespective of seasons. Animals ate more grass, less forbs and least browse across pastures and in all seasons. Animals consumed less grass and grasslike as canopy cover increased. Digitaria macroblephara and Chloris roxburghiana dominated animal diets throughout the study. Although more than 18 woody species were on offer only three species, Acacia senegal, Hermania alhiensis and Boscia sp. were selected by animals. These species constituted less than 1% of the animal diets. When green, animals ate Commelina bengalensis and Talinum kafrum forbs along with grasses. Diets during the long dry season were not diverse as for the wet season.

Digitaria macroblephara, Chloris roxburghiana and Sporobolus pellucides were the major grass selected by the heifers, whereas Bothriochloa insculpta was least preferred grass. Preference ratios indicated that cattle preferred grass and grasslikes, forbs and browse in that order. Boscia sp. was the most preferred browse while Talinum kafrum, Commelina bengalensis and Asparagus sp. were the most preferred forbs. Although Acacia sp. and Hermania alhiensis dominated the study site, they ranked least in diet preference order. Further ecological research is needed to determine the influence by these woody species on herbage production in order to recommend the economic advantage of these dominant species.

All the dietary nutrients met the maintenance requirements of the cattle throughout the study, except for crude protein which was deficient in August and September. There appears to be potential problem for rumen carbon:nitrogen (C:N) balance in cattle due to the relatively high DE values in relation to nitrogen content of the diets.

DEDICATION

This thesis is dedicated to the people who are closest to my heart. First, to my father Kibet Arap Chemitei and my mother Tapartai Kimoi Chemitei of Sinonin Village, Baringo District, RVP, who made my existence possible and therefore responsible in some way for my accomplishment. Second, to those I love very much, my wife Milka J. Kibet and my sons Eric Kipkotir Torus and Enock Kipkoech Torus. They always remembered me in their daily prayers, had faith in me, and gave encouragement when needed.

Finally, I would like to thank God for giving me the wisdom, courage and strength to endure this phase of my life.

DEDICATION

This thesis is dedicated to the people who are closest to my heart. First, to my father Kibet Arap Chemitei and my mother Tapartai Kimoi Chemitei of Sinonin Village, Baringo District, RVP, who made my existence possible and therefore responsible in some way for my accomplishment. Second, to those I love very much, my wife Milka J. Kibet and my sons Eric Kipkotir Torus and Enock Kipkoech Torus. They always remembered me in their daily prayers, had faith in me, and gave encouragement when needed.

Finally, I would like to thank God for giving me the wisdom, courage and strength to endure this phase of my life.

ACKNOWLEDGEMENTS

The author wishes to express sincere thanks to Dr. Jerry W. Stuth, the chairman of my Advisory Committee, for guiding me throughout this undertaking. And to Dr. Fred E. Smeins and Dr. Thomas C. Cartwright for providing valuable information, help and direction needed to complete this project. Without their support and cooperation this study would certainly not have been undertaken, thus I would not have completed my graduate program.

I would also like to recognize the assistance from my sponsors, the Ministry of Livestock Development, Government of Kenya within the Kiboko Range Research Expansion Project, with funding from the United States Agency for International Development as well as Winrock International, the coordinating agency, for providing me with the scholarship opportunity and financial support throughout my academic years. Special thanks are also accorded to Dr. Rod Ward whose invaluable counseling, material and technical support facilitated the completion of my study at NRRS, Kiboko, Kenya. Much gratitude is also extended to David T. Cheruiyot, Ole Kimongo and J. Mulwa Ndetto for their unswerving support during collection and reduction of research data at Kiboko.

I would also like to acknowledge the encouragement and moral support of my family and colleagues during the thesis stage of the program. Finally, I would like to thank my wife and sons for remaining loving and patient in the course of my academic career. Special thanks are also due to Chris Saltsman for typing this manuscript.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

INTRODUCTION

More than 4.5 million cattle graze Kenyan rangelands making beef enterprises vital for this region (Bernsten and Jacobs 1983, Mwandotto 1978). However, stockmen are finding it increasingly difficult to obtain a profit due to uncontrollable factors from range conditions.

Kenya is endowed with few mineral resources, therefore, agriculture is the mainstay of the economy. However, the land suitable for agricultural use is limited by the fact that approximately 20% of the country receives rainfall consistently above 1000 mm per annum (Morgan 1969). Crop, livestock production and the majority of the nation's population are concentration in these high agricultural potential areas (Mutoka 1981).

During the last two decades, the population of Kenya has had a sharp increase from approximately 8 million in 1962 to 15 million people in 1980. This increase has been accompanied by increase in demand for food, thereby necessitating farming in low potential rangelands.

Kenya has approximately 46 million hectares of rangelands, covering 80% of the land area of the country. Major beef production systems are currently restricted to these regions, as a result of intensification of cropping and dairying in the high potential areas. Rangelands carry 60% of the country's estimated 8.5 million sheep and goats, 1.0 million camels (Ayuko 1978), 50% of the national cattle herd of 9.8 million (Bernsten and Jacobs 1983) and considerable wildlife.

Format and citations in this thesis follow the style of the Journal of Range Management.

Kenyan rangelands are subject to seasonal rainfall variability, bush encroachment (Little and Ivens 1965), shortage of free water and low nutrient content of available forage (Payne and Hutchison 1963) and wildlife/livestock competition for scarce range resources.

Present research has shown that bush has both negative and positive influences on animal production. Bush not only supply shade, but also browse that apparently is a very useful source of protein and mineral during the most nutritionally stressful period. Further, bush stimulates changes in plant community of a site by inducing microenvironmental changes. These changes in floral production could have a significant impact on grazing animal's nutrition and diet selection.

It is generally accepted that fire plays a large part in preventing grasslands from developing into wooded vegetation. If grasslands are utilized for grazing without burning to suppress bush, the balance between grasses and woody species is altered in favor of the bush, thus encroachment usually results. In addition, increase in grazing and changes in frequency, time and intensity of burning has led to increased bush encroachment on these rangelands (Skovlin 1971, Van Rensburg 1969, Heady 1960).

Dense stands of bush severely reduce range herbaceous production and much of the forage produced in heavy bushed thickets is not accessible to grazing livestock (Thomas and Pratt 1967), subsequently reducing productivity from these regions. These problems have been recognized in Kenya, yet bush continue to thicken where it is established and to invade former grasslands.

In Kenyan rangelands herbage generally is adequate in quality, if not quantity during and immediately following rains, but the vegetation matures rapidly in the dry season and is greatly reduced in both quality and quantity. Thus, the dry seasons are the periods of low nutritional forage value. Supplementation of livestock on such ranges could alleviate the problem, but knowledge of dietary composition is inadequate.

The objectives in this study were:

1. To determine the influence of kind and amount of bush on botanical composition and dietary selection by cattle, and
2. To determine the influence of kind and amount of bush on dietary crude protein, digestible organic matter and digestible energy of cattle diets.

LITERATURE REVIEW

Whyte (1947) estimated that 75 percent of the trees and shrubs in Africa are browsed to a greater or lesser extent by domestic livestock or game; and there is no doubt that in many of the semiarid regions of East Africa, the contribution of browse to the diet of indigenous cattle is of considerable importance. This is because, compared with grazing forage, browse has a relatively high mineral and crude protein content (Dougal and Bogdan 1958), is less subject to seasonal variation in nutrient content and begins to grow at the end of the dry season before the first rains and before other forage (Whyte 1947), a time when the animal's need for high nutrient content forage intake is high. In addition, Dougal and Bogdan (1958) reported that in some of the semiarid grazing lands very little grass was present for much of the year and the woody vegetation played an essential part of the diet for cattle.

Heady (1960) estimated that in Kenya at least 10 million hectares of rangelands were seriously affected by bush. The presence of various types of woody vegetation results in the important factor limiting the production of livestock. Payne (1963) studied cattle browsing behavior in Tanzania and concluded that during the dry season browse can comprise a significant part of the total nutrient intake. While conducting a water deprivation experiment in Tanzania Payne and Hutchison (1963) noted that the experimental cattle were browsing more frequently as the dry season advanced.

The basis for improving range management and range animal nutrition is a knowledge of the dietary composition (Theurer et al. 1976). Such knowledge would be required for optimal forage allocation to different types of herbivores, selecting types of animals compatible with the forage resource, selecting species for reseeding deteriorated ranges, predicting the outcome of overgrazing by different animals, identifying new species on which to base management and determining the suitability of exotic animals for a particular range type (Holecheck et al. 1982).

Characterization of animal diet on native range is complicated by animal selectivity for certain species, area, plant parts and by heterogenous nature of the herbage available for grazing. It is well documented that under almost all situations livestock graze selectively on range; and both animal and forage attributes affect diet selection (Kothmann 1980). Selectivity by certain animals may vary with animal species, available plants, stage of plant maturity, location, weather, kind of plant (Van Dyne and Heady 1965), and plant chemical components (Blaser et al. 1960, Cook 1959, Hardison et al. 1954).

Certain expressions of forage preferences are similar among all kinds of livestock. Leaf is preferred over stem and green tissue is preferred to mature or dead forage. These preferences generally result in the selection of diets having nutritive value higher than the average of the forage available (Arnold 1960). Poppi et al. (1980) concluded that increasing maturity of pasture caused reduction in mean voluntary intake, digestibility of leaf and stem fractions and nutritive value of forages. They also reported that cattle eat more leaf than stem fractions of grasses because leaves contain more nitrogen than stems and that increasing maturity leads to a decrease in the concentration of nitrogen.

Broad generalizations can be made about dietary preferences of cattle for forage classes, however, these are subject to influence of composition of the available forage. Forage classes are generally selected in proportion to their ability to provide green foliage with grasses mostly heavily eaten by cattle (Arnold 1960).

Cattle are known to consume considerabe amounts of grasses, moderate amounts of forbs and only limited quantities of the browse (Cook et al. 1963, 1965, 1967; Cook 1954, 1956; Smith and Julander 1953; Cook and Harris 1950). However, recent evidence (Rector and Huston 1976) show that many of the forb and browse plants, once thought to be of limited value as animal feed, are actually of superior quality.

In most rangelands the leaves of shrubs and trees are mostly of low palatability and are not eaten when herbaceous forage is plentiful, but many make an important contribution when herbaceous forage is scarce (Wilson 1977).

In considering efficiency of utilization of rangeland vegetation, it is important to recognize the relative importance of all forage species and classes and of their utilization (Rector and Huston 1976). Cattle are known to graze less selectively than other livestock (Dudzinski and Arnold 1973), and are thought to be less able to graze efficiently on short herbage (Cook et al. 1967). Data on animal preference as related to type of forage resource should be established so that subsequent management decisions are based on sound knowledge of forage resources (Bedell 1968).

Selective grazing has certain advantages to the animal but presents a variety of problems to the rancher. Selectivity on ranges with adequate forage quality can increase animal production, but on ranges where forage quality is inadequate, selective grazing can stratify the forage so that a portion is not of suitable quality. The removal of green leaves leaving stems and mature leaves causes a shift in diet quality with increasing utilization (Church 1980).

Dietary composition of cattle diets has been reported to shift with season (Allison and Kothmann 1979, Buchanan et al. 1972), year (Buchanan et al. 1972, Lesperance 1960a) and grazing intensity (Allison and Kothmann 1979, Galt et al. 1969). Growth and wealth of livestock have been associated with digestible protein in range (Cook et al. 1977). Both wild and domestic herbivores select plants or parts of plants that contain more digestible protein than the average available (Swift 1948, Cable and Shumway 1966, Dietz 1970, Bedell 1971, Wallace et al. 1972). Protein content of plants normally decrease with phenological maturation, while the fiber fraction increases (Van Soest and Moore 1965, Nagy et al. 1969).

STUDY AREA

This study was conducted on the National Range Research Station (NRRS), Kiboko, Kenya (Fig. 1). The station is a research facility within the Ministry of Agriculture and Livestock Development. It was established in 1971 by UNDP/FAO project with the objective of researching various facets of range management, wildlife domestication and livestock husbandry. Current fields of research are range ecology and grazing management.

Kiboko, a 30,000 ha station, is located in the arid zone. Pratt et al. (1966) classified this area under eco-climatic zone five and is situated between latitude 2° 10'S and 2° 25'S, longitude 37° 40'E and 37° 55'E. Its elevation varies from 900 to 1100 m above sea-level (Ndegwa 1983, Mwandotto 1978, Michieka and Van der Poun 1977) (Fig. 1). The experiment, as a component of grazing management, was located in an Acacia senegal/Digitaria macroblephara savannah site in pasture two (Fig. 2).

The climate of Kiboko falls under the influence of the intertropical convergence zone (Whyte 1968). It is hot and monsoonal and its monthly average temperatures range from 26.9 to 30.8°C and evaporation is 2000 mm (Mwandotto 1978). There are two rainy and dry seasons in a year. The long dry season starts from March through May while the short wet season is from October through December. The dry seasons have little or no rainfall. The long dry season is from June through September and the short dry season from January through February. Therefore, the station is characterized by bimodal distribution of wet and dry seasons with 615 mm annual rainfall (Michieka and Van der Poun 1977). Monthly

Figure 2. Distribution of rangelands in Lyars and geographical location of Kinder where National Range Research Station is located.

Figure 1. Distribution of rangelands in Kenya and geographical location of Kiboko where National Range Research Station is located.

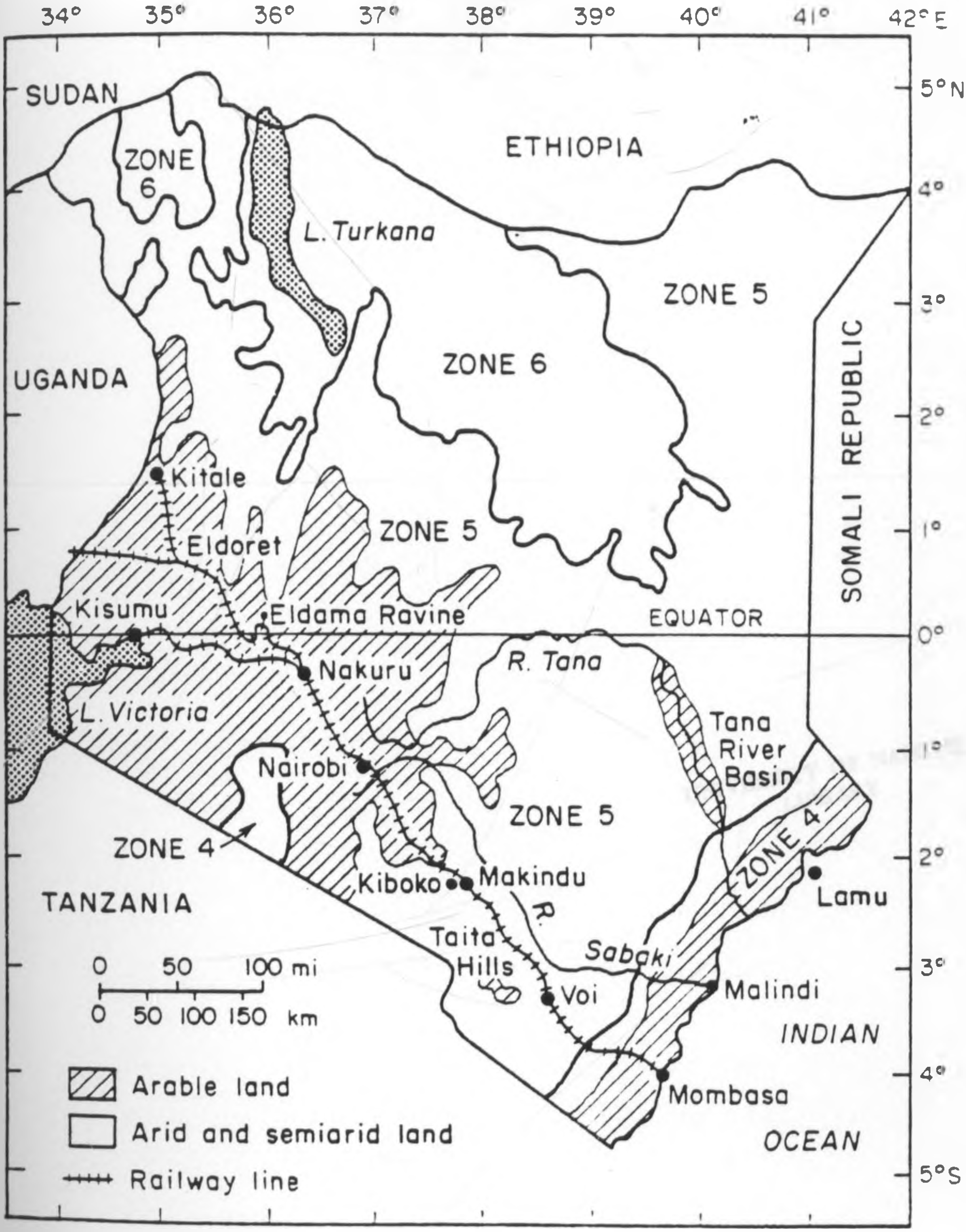
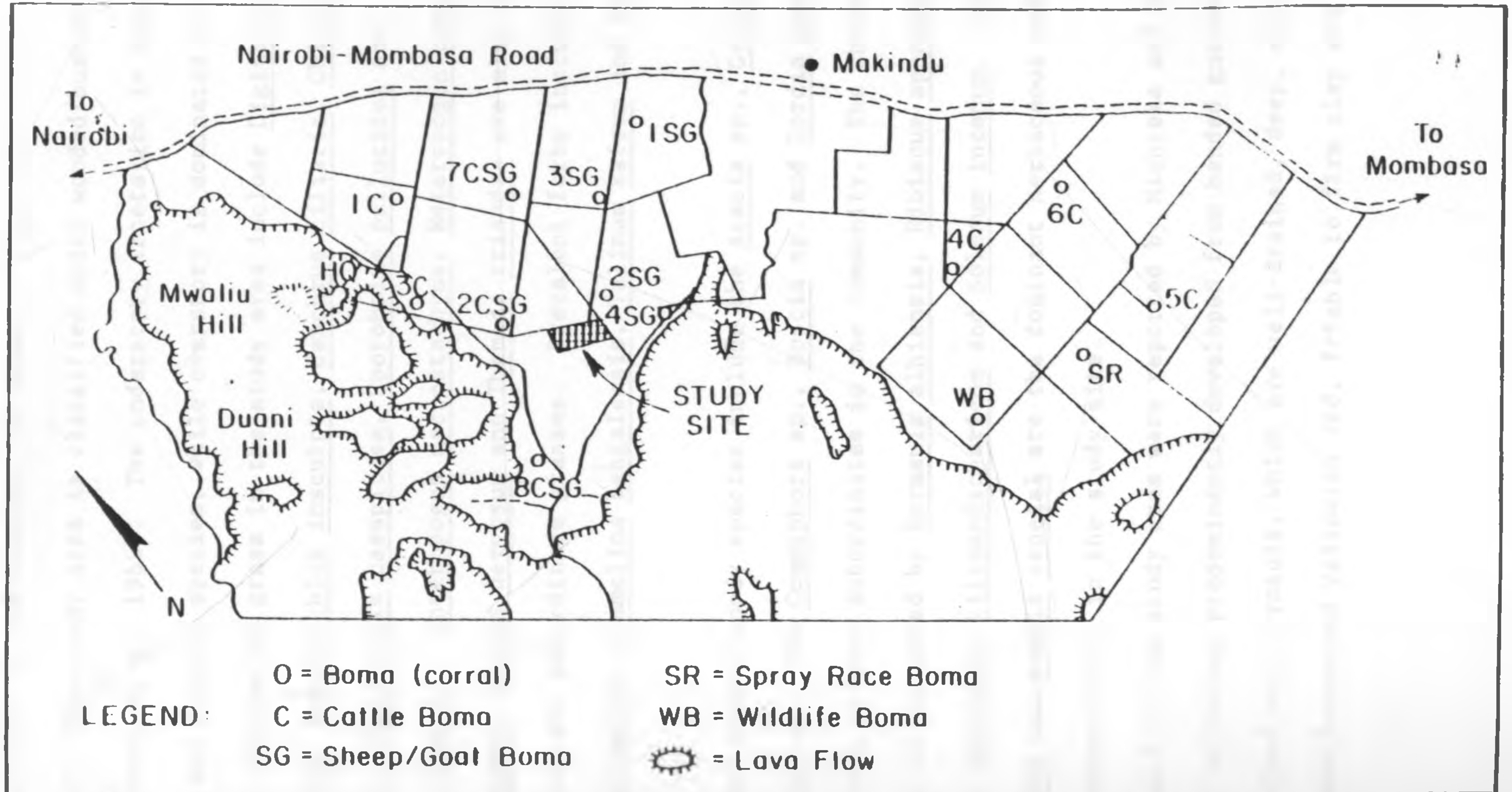

34°
35°
36°
37°
38°
39°
40°
41°
42°E
5°N
4°
3°
2°
1°
0°
1°
2°
3°
4°
5°S
SUDAN
ZONE 6
ETHIOPIA
L. Turkana
ZONE 5
ZONE 6
UGANDA
SOMALI REPUBLIC
Kitale
Eldoret
ZONE 5
Kisumu
Eldama Ravine
EQUATOR
Nakuru
R. Tana
L. Victoria
Tana River Basin
Nairobi
ZONE 5
ZONE 4
ZONE 4
Kiboko
Makindu
Lamu
TANZANIA
R.
Taita Hills
Sabaki
0 50 100 mi
0 50 100 150 km
Voi
Malindi
INDIAN
Mombasa
OCEAN
Arable land
Arid and semiarid land
Railway line

Figure -. Location of study site at National Range Research Station (...). Kiboko, Kenya, 1984.


Nairobi-Mombasa Road
Makindu
To Nairobi
To Mombasa
1SG
7CSG
3SG
1C
4C
6C
HQ
3C
2SG
2CSG
4SG
5C
Mwaliu Hill
SR
STUDY SITE
WB
Duani Hill
8CSG
N
LEGEND:
O = Boma (corral)
C = Cattle Boma
SG = Sheep/Goat Boma
SR = Spray Race Boma
WB = Wildlife Boma
= Lava Flow

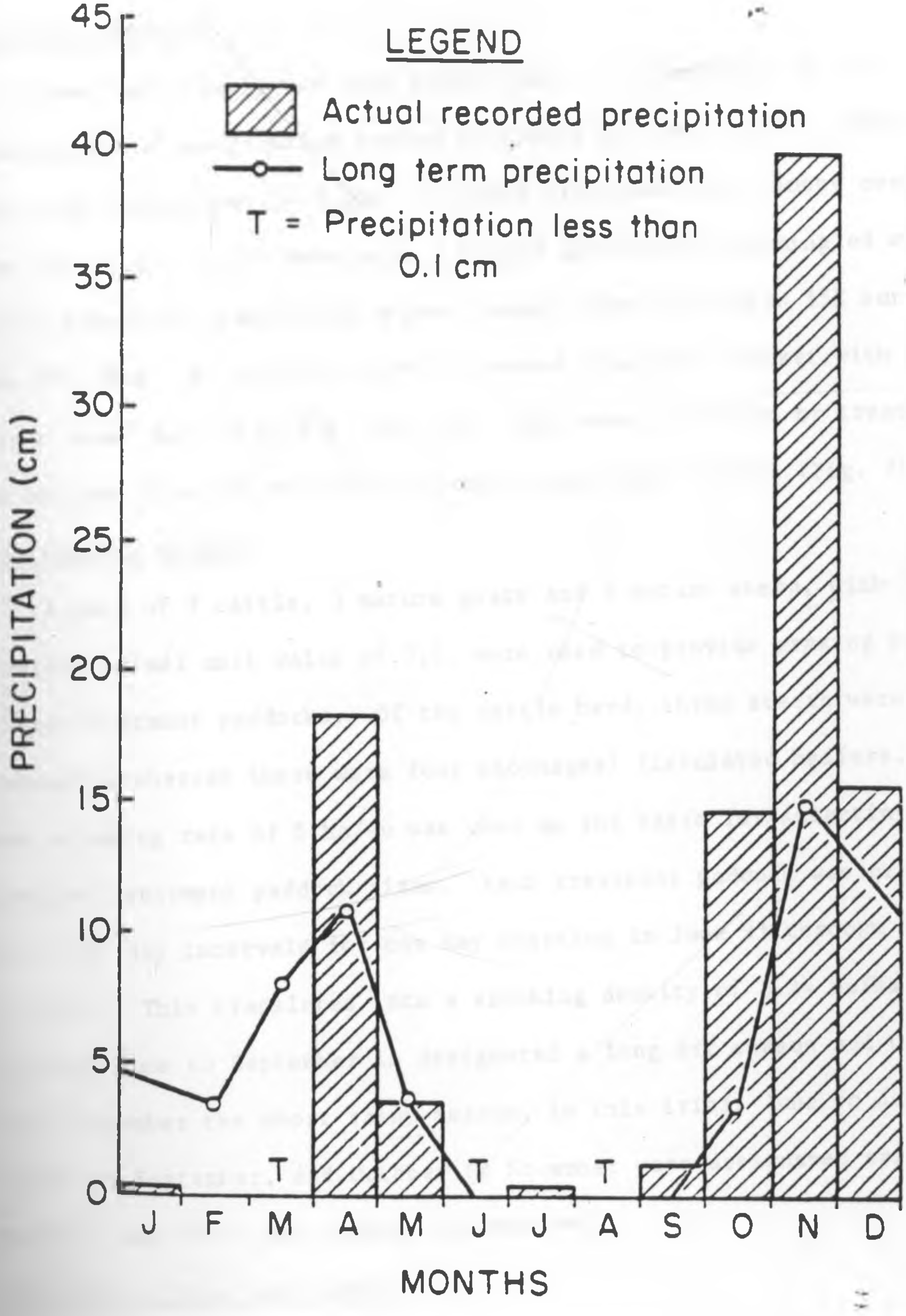
rainfall recorded during the study for Makindu meteorological station, which is adjacent to the station, is shown in Figure 3.

Generally the study area is classified under wooded/bushed grassland savannah (Pratt et al. 1966). The understory vegetation is dominated by herbaceous and shrubby species, while overstory is dominated by trees. The primary species of grass in the study area include Digitaria macroblephara, Bothriochloa insculpta, Cenchrus ciliaris, Chloris roxburghiana, Eragrostis caespitosa, Sporobolus pellucides and Microchloa kunthii. Enteropogon macrostachyus, Heteropogon contortus, Panicum maximum, Sehima nervosum and Themeda triandra are also found in the site, but are subordinate grasses. Prevalent forbs include Berlaria micrantha, Commelina bengalensis, Talinum kafrum and Tephrosia villosa.

The most common woody species include the Acacia sp., Grewia sp. and Balanites sp. The Commiphora sp., Boscia sp. and Cordia gharaf constitute the primary subordinates in the community. The shrub layer of the site is dominated by Hermania alhiensis, Hibiscus aponeurus, Sida ovata, Duosperma kilimandscharicum and Solenum incanum. Digitaria macroblephara and Acacis senegal are the dominant herbaceous and woody species, respectively, in the study site.

The soils of the study area were reported by Michieka and Van der Poun (1977) as having predominantly developed from banded gneises. They were classified as ferrosols, which are well-drained, deep, dark reddish brown to dark brown and yellowish red, friable to firm clay and sandy clays.

Figure 3. Monthly rainfall recorded during the study for Makindu Meteorological Station, and for 78 years of record (1904-1982).


LEGEND
Actual recorded precipitation
Long term precipitation
T = Precipitation less than 0.1 cm
PRECIPITATION (cm)
45
40
35
30
25
20
15
10
5
0
T
T
T
J F M A M J J A S O N D
MONTHS

MATERIALS AND METHODS

Treatment Paddocks

Three bush conditions were identified and categorized by the physiognomic classification system described by Pratt et al. (1966). They were designated (1) light, a wooded grassland with canopy cover less than 15% (Fig. 4); (2) moderate, a wooded grassland intermingled with bushed grassland, exhibiting a bush canopy cover more than 15% but less than 35% (Fig. 5); and (3) heavy, a wooded grassland thicket with a bush canopy cover more than 35% (Fig. 6). Each bush condition or treatment was divided into two replicate paddocks each with 2.25 ha (Fig. 7).

Experimental Animals

A herd of 7 cattle, 3 mature goats and 3 mature sheep, with a combined animal unit value of 7.3, were used to provide grazing pressure on the treatment paddocks. Of the cattle herd, three steers were rumen fistulated whereas there were four esophageal fistulated heifers. The safe stocking rate of 5 ha/au was used as the basis for selecting the herd and treatment paddock sizes. Each treatment paddock was grazed at 28- to 30-day intervals for one day starting in June 21 through November 27, 1982. This translates into a stocking density of 3.24 au/ha. Although June to September is designated a long dry season and October to early December the short rainy season, in this trial, June to July, August to September, and October to November were designated early dry, mid dry, and early wet season, respectively.

Bush Canopy Cover and Density

Ten 50 x 1 m belt transects were permanently marked in a systematic manner in each paddock. The line-intercept method was used to determine

Figure 4. Light bushed treatment paddock.

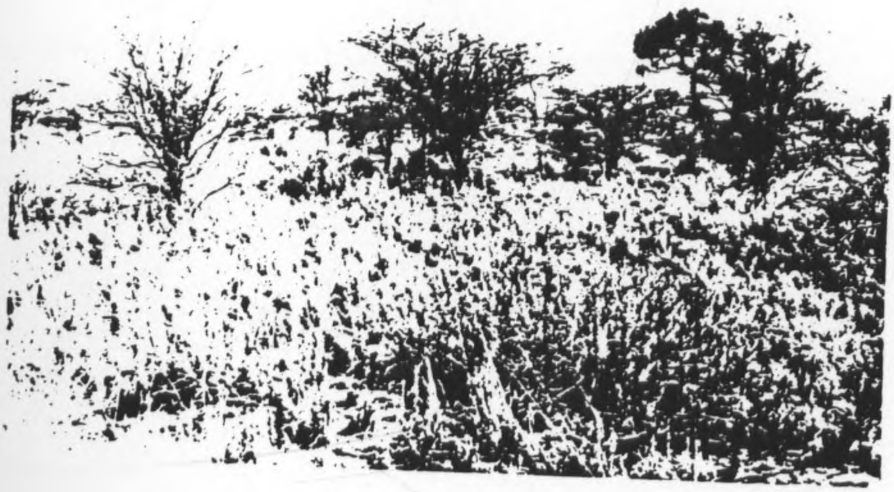
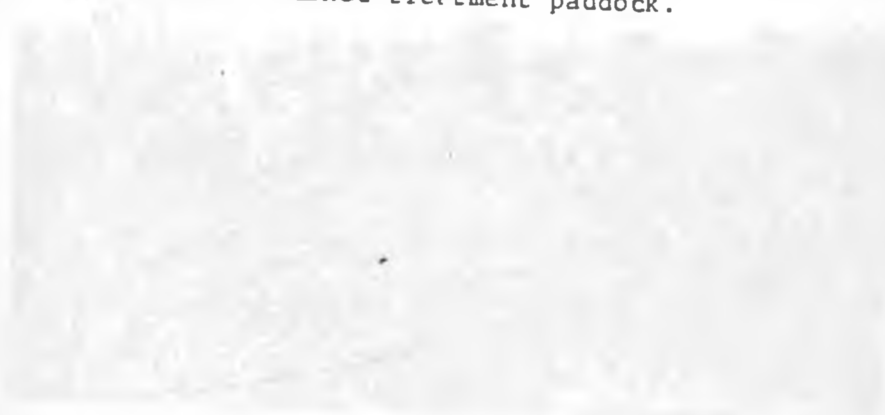
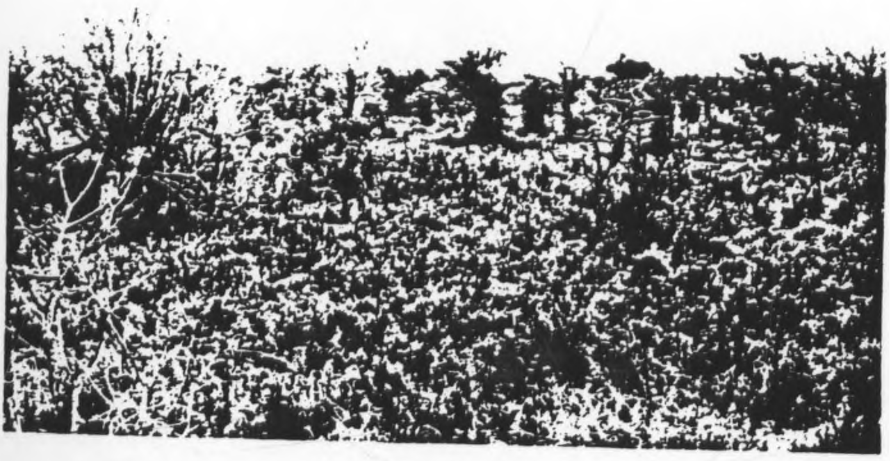
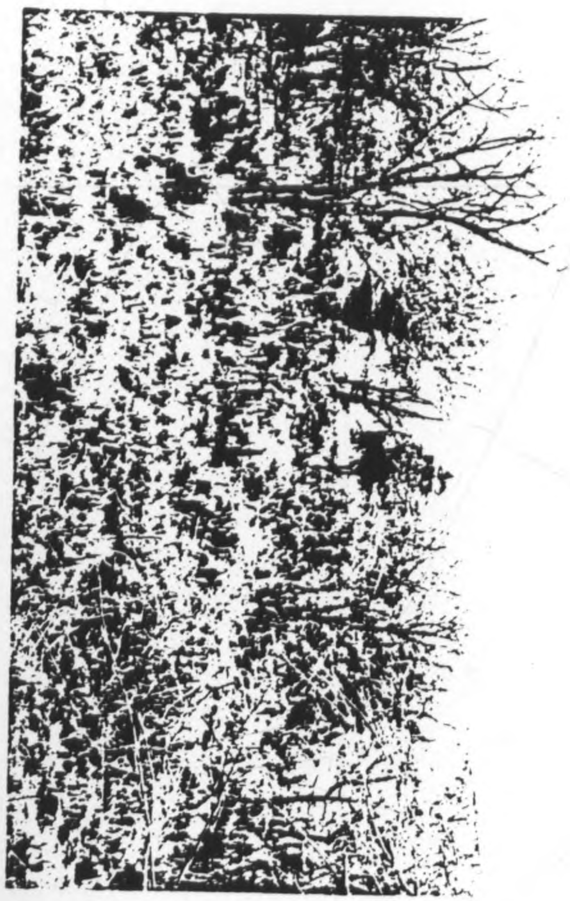


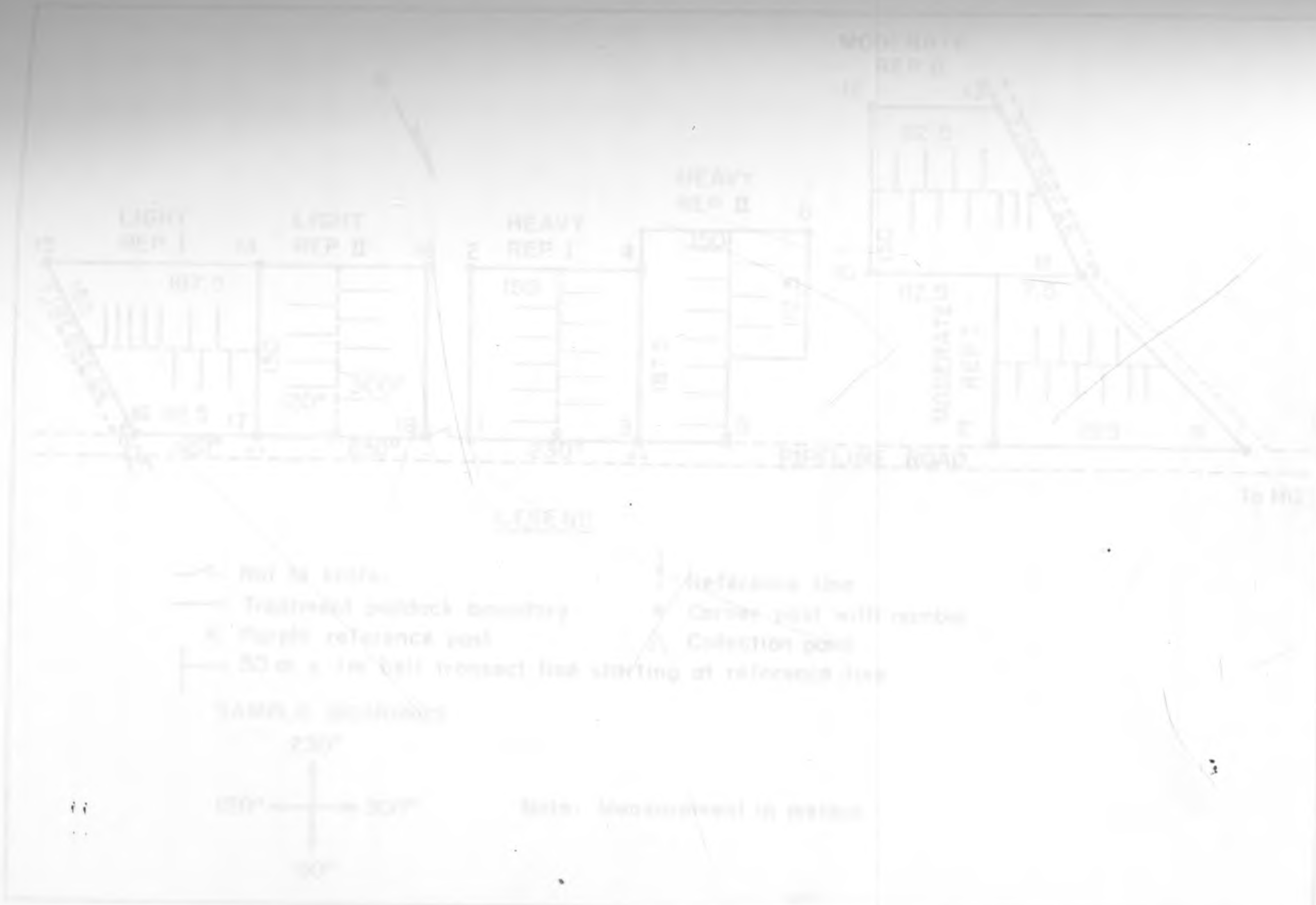
Figure 1. [illegible]

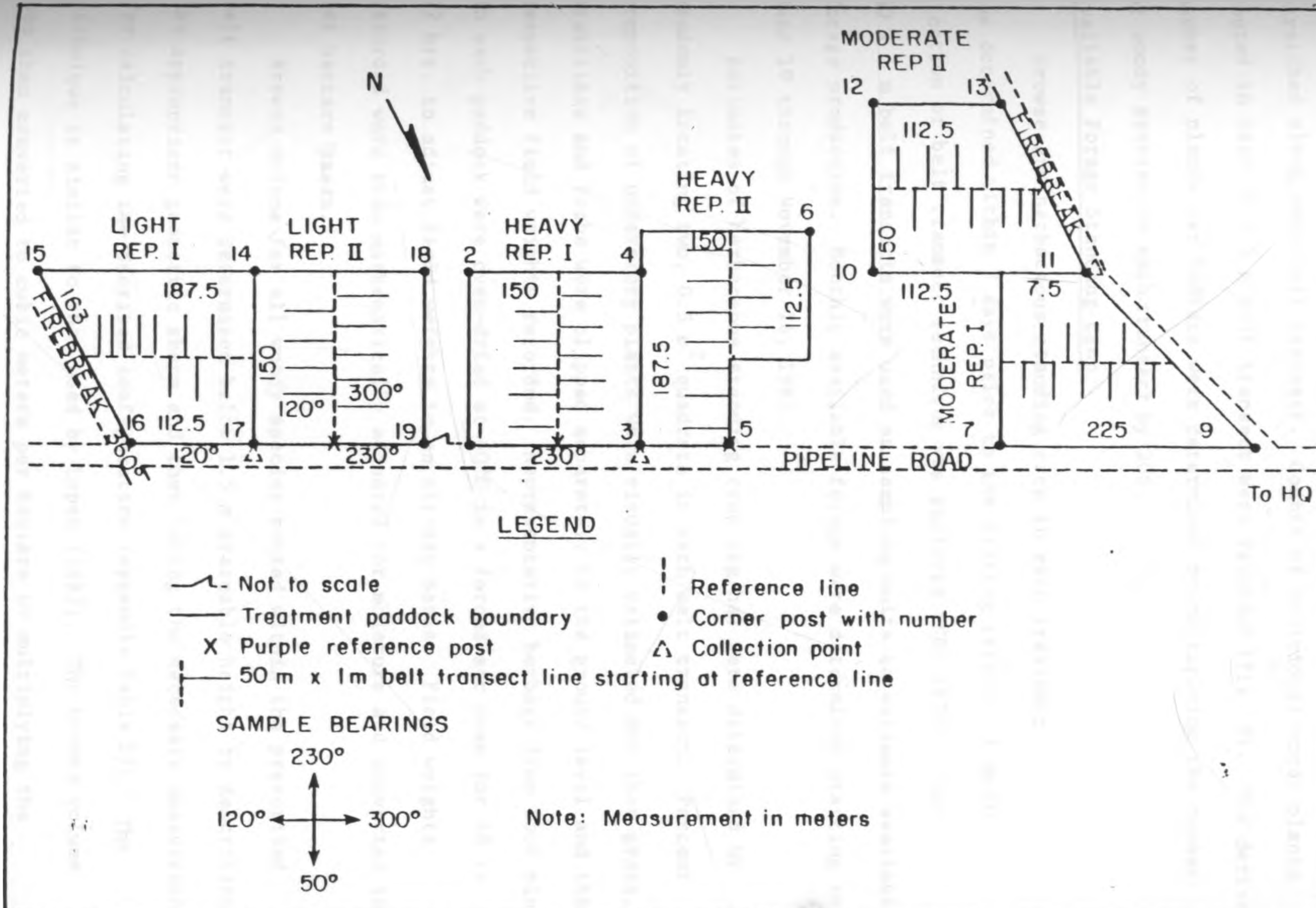
Figure 5. Moderate bushed treatment paddock.








LIGHT
REP I
LIGHT
REP II
HEAVY
REP I
HEAVY
REP II
MODERATE
REP II
MODERATE
REP I
LEGEND
Not to scale.
Treatment paddock boundary
Reference line
Collection point
SAMPLE BEARINGS
230°
300°
Note: Measurement in metres


N
LIGHT REP. I
LIGHT REP. II
HEAVY REP. I
HEAVY REP. II
MODERATE REP. I
MODERATE REP. II
FIREBREAK
FIREBREAK
PIPELINE ROAD
To HQ
15
14
18
2
4
6
12
13
10
11
16
17
19
1
3
5
7
9
187.5
163
150
112.5
120°
300°
230°
150
150
187.5
112.5
112.5
150
112.5
7.5
225
LEGEND
Not to scale
Treatment paddock boundary
X Purple reference post
50 m x 1m belt transect line starting at reference line
Reference line
Corner post with number
Collection point
SAMPLE BEARINGS
230°
120°
300°
50°
Note: Measurement in meters

the percent canopy cover by woody species directly over a 50 m tape stretched along each belt transect. Counts of individual woody plants rooted in each 50 x 1 m belt transect were recorded (Fig. 8). The derived number of plants per hectare were determined by multiplying the number of woody species in each transect by 200.

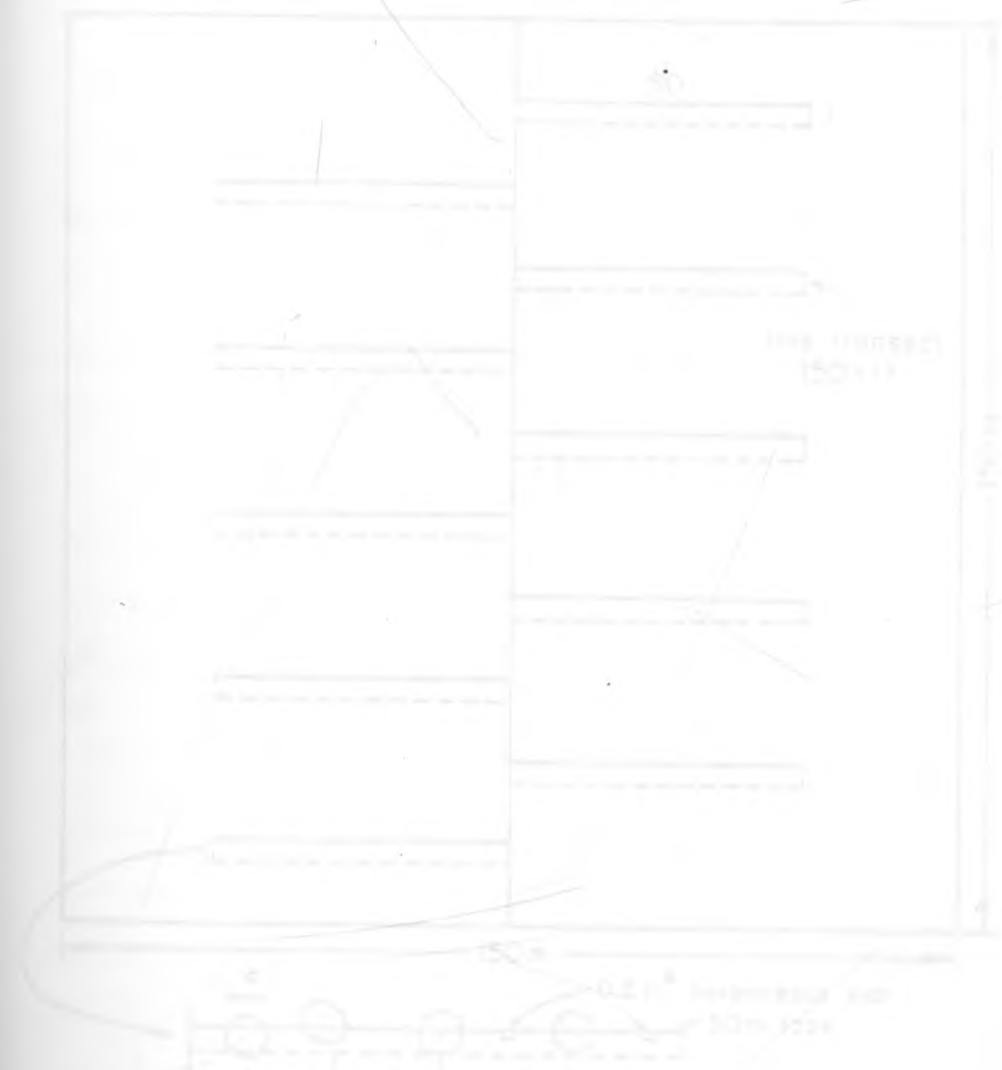
Available Forage Standing Crop

Browse and herbaceous standing crop in each treatment was determined within 7 days prior to the grazing trials. A modification of belt transect technique was employed (NRC 1976). Ten 50 x 1 m belt transects were used as sampling units to estimate available forage production. Monthly available forage were determined starting in June 19 through November 16, 1982.

Estimates of herbaceous standing crop (kg/ha) were determined by randomly locating two, 0.5 m^2 quadrats in each belt transect. Percent composition of understory plants were visually estimated and then grass, grasslikes and forbs were clipped separately to the ground level and their respective field weights recorded. Representative herbage from four plots in each paddock were oven-dried at 60°C in a forced-air oven for 48 to 72 hrs. to adjust field weights to an air-day basis. Field weights recorded were then mathematically adjusted for moisture and converted to a per hectare basis.

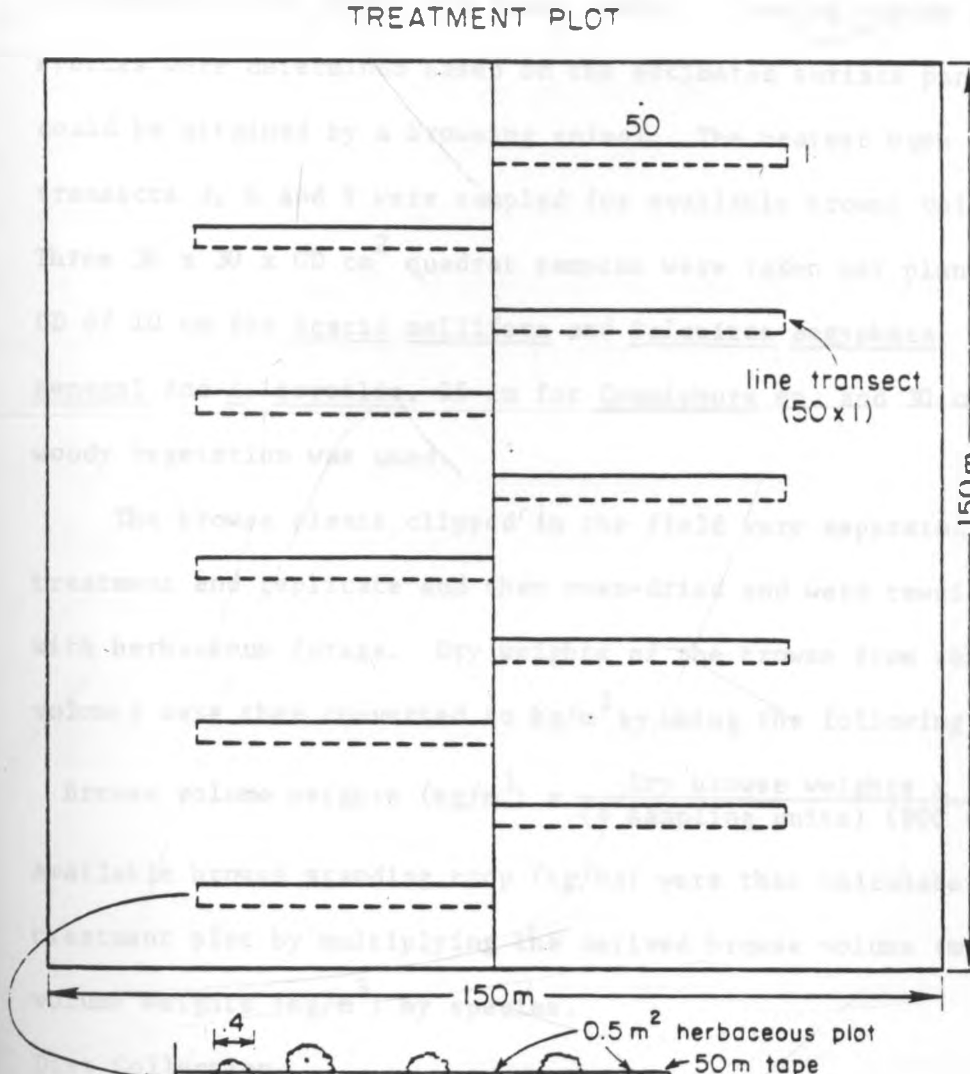
Browse volume for all woody species rooted within the prescribed belt transect were determined below 1.5 m grazeable height by describing the appropriate geometric shape and then taking the necessary measurements for calculating the ascribed configuration (Appendix Table 23). The technique is similar to that used by Lopes (1982). The browse volume was then converted to cubic meters per hectare by multiplying the

TREATMENT PLOT



% Canopy Cover = 4m + 2.0 + 1.6 + 2.0 = 9.6m ÷ 100/50 = 19.4%

Density by species = 3 plants rooted in belt transect only/50m² $\left[\frac{10000m^2}{50m^2}\right]$ = 600 plants/ha



% Canopy Cover = .4m + 2.0 + 1.8 + 2.0 = 6.2m x 100/50 = 12.4%

Density by species = 3 plants rooted in belt transect only/50m^2 $\left[\frac{10000\text{m}^2}{50\text{m}^2}\right]$ = 600 plants/ha summation of browse volume by species rooted in the 50 m^2 belt transect by 200.

Browse volume weights were estimated by utilizing the grazing depth technique (GD) of Lopes and Stuth (1984). Grazing depths per woody species were determined based on the estimated surface penetration that could be attained by a browsing animal. The nearest bush species to transects 3, 6 and 9 were sampled for available browse volume weights. Three 30 x 30 x GD cm^2 quadrat samples were taken per plant species. A GD of 10 cm for Acacia mellifera and Balanites aegyphaca, 15 cm for A. senegal and A. tortilis, 25 cm for Commiphora sp. and 30 cm for other woody vegetation was used.

The browse plants clipped in the field were separated by species, treatment and replicate and then oven-dried and were reweighed when dry with herbaceous forage. Dry weights of the browse from respective volumes were then converted to kg/m^3 by using the following formula:

$$\text{Browse volume weights } (kg/m^3) = \frac{\text{Dry browse weights x } 100 \text{ cm}^3}{(\text{\# sampling units})\ (900\ GD^3)\ (1000\ g)}$$

Available browse standing crop (kg/ha) were then calculated for each treatment plot by multiplying the derived browse volume (m^3/ha) by browse volume weights (kg/m^3) by species.

Diet Collection

Three esophageally-fistulated heifers aged 24-36 month were used to collect forage samples representative of the diet. The heifers were penned overnight and water and salt withheld during the morning collection periods to prevent contamination of the fistula samples and to insure feeding during the collection period. Collections were made early each morning between 0800 and 0900 hr. Canvas bags fitted with wire screen bottoms, similar to those suggested by Van Dyne and Van Horn (1959, were attached to the heifers. The experimental animals were then grazed in the assigned plots until ample sample size were collected. Each animal was used to collect two samples from each treatment once a month.

Dietary samples from each heifer were air-dried on wire screen bottomed racks for two days and if the samples were not dry enough for grinding they were oven-dried for 24 hrs. at 60°C. Dry samples were worked by hand until plant fragments were completely disassociated, then were subdivided. One subsample was ground in a Wiley mill to pass 2mm screen and used in determination of nutrient content, while the corresponding subsample was recorded for botanical composition analyses, using macro-histological or extrusa fragment analysis technique (Lopes 1982, Rector and Huston 1982, Kothmann 1968).

Chemical Analysis

Nitrogen was determined according to AOAC (1975) procedure and *in vitro* digestible organic matter on an ash free basis utilizing the fermentation stage of Tilley and Terry (1963), followed by extraction in neutral detergent (Van Soest and Wine 1967). Standard forages of known *in vivo* digestibility were included in each *in vitro* digestion racks to correct *in vitro* digestible organic matter to apparent digestibility.

Digestible energy (Kcal/kg) were derived from the estimate of digestible organic matter (DOM) by multiplying % DOM by a constant of 4000 Kcal/kg of DOM, while crude protein (CP) was determined by macro-Kjeldahl method (AOAC 1975). Percent crude protein were estimated on an organic matter basis by multiplying percent nitrogen by a constant of 6.25, i.e., 16% of an amino acid weight of nitrogen.

Selection Ratios SR)

Selection ratios were derived by the calculation proposed by Taylor (1973) as follows:

$$SR = \frac{\%\text{ in diet} - \%\text{ available}}{\%\text{ in diet} + \%\text{ available}} \times 10$$

where % in diet and % available refer to the proportion of a given forage species in the diet and the pasture on offer, respectively. The ratio has a scale from -10 to +10 indicating selection status of each species. A value about zero would indicate selection in proportion to availability.

Statistical Analysis

The experiment was a split-plot design with bush canopy levels (treatments) as the main plot factor and the replications as the subplot factcr. The data were subjected to analysis of variance by treatments and months and significant differences among these parameters were separated by Duncan's multiple range test (Steel and Torrie 1980). The 95% significant level was employed to test significant effects. Confidence interval values were derived by using regression analysis on derived selection ratios (Rudolf and Ramon 1981).

RESULTS AND DISCUSSION

Bush Canopy Cover/Density

Total canopy cover for the light, moderate and heavy bush treatments were significantly different with 12.8%, 31.5% and 49.8% canopy cover, respectively. Trees contributed 84% of the total canopy cover, thus were the primary causal factors of change in bush canopy cover. Tree canopy was 8.5, 26.4 and 43.2% in the light, moderate and heavy bush conditions, respectively. Shrubs averaged 5.2% cover as a group, did not differ in canopy cover across bush conditions.

Acacia senegal was the dominant tree species having the greatest single impact on bush canopy conditions, contributing 42.5%, 50.4% and 59% of the total cover for the light, moderate and heavy bush conditions, respectively. *Acacia mellifera*, *A. tortilis* and *Cordia ovalis* were the only subordinate trees in the study area which exhibited a significant change across bush conditions (Table 1), whereas the remaining trees did not differ significantly across pastures.

Hermania alhiensis was the dominant shrub across all bush pastures, averaging 4.1% canopy cover. *Duosperma kilimandscharicum*, *Hibiscus aponeurus* and *Lanea flocossa* were the only shrub species which exhibited no significant difference across bush conditions.

Light canopy cover was dominated by shrubs. The shrubs which appeared only in the light bush paddocks included *Albizia amara*, *Dalbergia melanoxylon*, *Maueria triphulla* and *Solanum incarum*. These species contributed less than 1% of the total canopy cover.

Heavy canopy cover was created primarily by both shrubs and trees. *Acacia* sp. which contributed 61% and *Hermania alhiensis* which contributed

Table 1. Bush canopy (%) for each woody species in the *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities found in each of the bush condition treatments at NRRS, Kiboko, Kenya, 1982.

Species	Bush canopy condition: Light	Moderate	Heavy
TREES			
Acacia mellifera	0.7 ab[1]	0.1 b	1.0 a
A. senegal	5.3 c	15.1 b	28.2 a
A. tortilis	0.4 b	3.7 a	1.8 ab
Albizia amara	0.1 ns[2]	0	0
Balanites aegyptiaca	0.8 ns	2.1	2.0
Boscia sp.	0 ns	0	0.1
Commiphora africana	0.2 ns	0.6	2.3
C. riperia	0 ns	0	0.1
Cordia gharaf	0 ns	0.7	0.6
Cordia ovalis	0 b	1.1 ab	2.8 a
Dalbergia melanoxylon	0.2 ns	0	0
Grewia bicolor	0 ns	0	0.5
G. smilis	0.3 ns	0.2	0.2
G. villosa	0.5 ns	1.5	1.6
Total tree canopy	8.5 c	26.4 b	43.2 a
SHRUBS			
Abutilon mauritianum	0 ns	0	0.1
Duosperma kilimandscharicum	0 b	0.4 a	0 b
Hermania alhiensis	3.5 ns	4.3	4.6
Hibiscus aponeurus	0.7 a	0.1 b	0.1 b
Lanea flocossa	0 b	0 b	0.4
Mauerua triphylla	0.1 ns	0.0	0
Ormocarpum kirkii	0 ns	0	0.2
Sida ovata	0 ns	0.2	0.3
Solanum incanum	0 ns	0	0
Vernonia sp.	0.1 ns	0	0
Unidentified sp.	0.1 ns	0.4	0
Total shrub canopy	4.3 ns	5.1	6.4
Total bush canopy	12.8 c	31.5 b	49.8 a

[1]Means followed by the same letter between bush canopy condition are not different ($\alpha = 0.05$).

[2]No significant difference between bush cover condition ($\alpha = 0.05$).

7% were the dominant woody species. Woody vegetation which appeared only in heavy bush conditions included Abutilon mauritianum, Boscia sp., Commiphora riberia, Grewia villosa, Lanea flocossa and Ormocarpum kirkii. The remaining woody species occurred randomly across bush plots, except Duosperma kilimandscharicum and some unidentified shrubs which occurred in moderate plots.

Acacia sp. were the primary woody species causing differences in canopy cover among treatment plots. Most of the other species were only distributed among bush conditions except Cordia ovalis, Grewia villosa and Hibiscus aponeurus. Cordia sp. and Grewia sp. increased with increasing overall canopy cover while Hibiscus aponeurus decreased as total canopy cover increased.

Total bush density was greater in the heavy bush canopy treatment than in the light bush condition, 3180 vs 1690 plants/ha, respectively. The moderate bush cover treatment did not differ either from the light or heavy bush cover treatments (Table 2).

Tree density was greater on the heavy treatment as compared to the light or moderate bush plots. Total tree densities were 340, 540 and 1540 plants/ha for light, moderate and heavy bush paddocks, respectively. Differences between light and moderate tree densities were not noted. Total shrub density, like total shrub canopy, was not significantly different across pastures.

Acacia senegal had the greatest impact on changes in bush density. It increased in density with increasing canopy cover. Only Cordia ovalis and Grewia villosa exhibited significant increase in density as total canopy cover increased.

Table 2. Derived woody species density (plants/ha) for each bush condition treatment paddock in Acacia senegal/Hermania alhiensis communities at NRRS, Kiboko, Kenya, 1982.

Species	Bush condition paddocks		
	Light	Moderate	Heavy
TREES			
Acacia mellifera	10 ns[1]	0	1
A. senegal	60 c[2]	200 b	970 a
A. tortilis	10 ns	40	50
Albizia amara	0 ns	0	1
Balanites aegyptiaca	40 ns	20	60
Boscia sp.	20 ns	0	0
Commiphora africana	10 ns	50	70
C. riperia	10 ns	10	0
Cordia gharaf	0 ns	10	20
C. ovalis	0 b	90 a	40 ab
Dalbergia melanoxylon	1 ns	0	0
Grewia bicolor	0 ns	0	20
G. smilis	150 ns	90	10
G. villosa	20 b	40 ab	260 a
Total tree density	340 b	540 b	1540 a
SHRUBS			
Abutilon mauritianum	0 ns	0	1
Duosperma kilimandscharicum	40 ab	90 a	10 b
Hermania alhiensis	840 ns	1050	800 ns
Hibiscus aponeurus	0 ns	0	20
Hibiscus sp.	0 ns	0	10
Lanea floccoa	20 ns	0	0
Mauerea triphylla	0 b	0 b	40 a
Ormocarpum kirkii	0 ns	30	140
Sida ovata	600 a	70 b	500 a
Solanum incanum	0 ns	0	10
Vernonia sp.	0 ns	1	0
Unidentified sp.	0 ns	90	150
Total shrub density	1350 ns	1480	1640
Total bush density	1690 b	2020 ab	3180 a

[1]Means followed by the same letter between bush density are not significantly different (α = 0.05).
[2]No significant difference between bush density (α 0.05).

On examination of both canopy cover and density area, Dalbergia melanoxylon was associated with only light bush canopy condition, while Abutilon mauritanium, Cordia gharaf, C. ovalis, Grewia bicolor and Ormocarpum kirkii were not found in the light bush plot. Most of the other trees and shrubs were not significantly different across treatment pastures.

Acacia senegal, Cordia ovalis and Grewia villosa were the primary species which created treatment effect. These trees comprised 45, 56 and 66% of the total canopy in the light, moderate and heavy bush treatments, respectively, indicating an increasing and disproportionate contribution to the overall canopy cover as bush canopy condition increased.

Standing Crop

Herbaceous

Herbaceous standing crop varied from 2713 kg/ha to 1034 kg/ha throughout the study (Table 3, Appendix Table 1). At no time did herbaceous standing crop limit intake of the animals grazing the treatment paddocks (Allison and Kothmann 1979).

Grasses and grasslike species comprised most of the herbaceous standing crop. Forbs contributed less than 10% to the total herbage standing crop at any time of the year.

Herbaceous standing crop across treatment pastures for July was 12% more than for June because of the significant increase of herbage growth in light pastures as a result of available moisture (Table 3). Available moisture seemed to have had a greater impact on grass and grasslike species which dominated the light pastures.

Table 3. Monthly herbaceous standing crop (kg/ha) by derived categories for each bush canopy condition in Acacia senegal/Digitaria macroblephara community in 1982 at NRRS, Kiboko, Kenya.

Month	Herbaceous category: Total grasses			Total forbs			Total herbage		
	Light	Moderate	Heavy	Light	Moderate	Heavy	Light	Moderate	Heavy
June	1590 ns[1]	2198	1728	98 ns	19	7	1688 ns	2217	1735
July	2637 a[2]	1828 b	2410 ab	76 ns	6	81	2713 a	1834 b	2491 a
August	1426 b	2228 a	1740 ab	9 ns	1	9	1435 b	2229 a	1748 ab
September	2152 ns	1634	2181	34 ns	4	7	2186 ns	1637	2182
October	1030 c	1620 b	2172 a	3.4 ns	6	3	1033 c	1626 b	2175 a
November	2410 a	1633 b	1637 b	255 a	29 b	206 ab	2665 a	1662 b	1853 b
Mean	1960	1857	1980	79	11	52	1940	1534	2021

[1]Means within derived herbaceous categories by months are not significantly different ($\alpha = 0.05$).
[2]Means followed by the same letter between bush cover classes within derived herbaceous category are not significantly different ($\alpha = 0.05$).

Erratic rains which fell in August caused a significant increase of herbage standing crop in September more than in August and thereafter decreased as available soil moisture decreased in October. However, standing crop in November increased four times more than October because of the increased herbage growth due to rains which fell in late October and extended into November. November rains caused a flush of herbage high in moisture and low in dry matter content. The highest increase was recorded by light bush pastures dominated by grass and grasslike species. Woody plants created microclimatic conditions in favor of herbage growth in dry periods. Conversely, an opposite trend was noted in the time of available moisture. Light pastures dominated by herbage and with least bush canopy cover produced highest herbage in the wet season, as a result of flush growth of herbage due to favorable growing conditions. In November, the light bush paddocks had approximately 800 kg/ha more herbage than either the moderate or heavy bush paddocks.

Moderate bushed pastures dominated by low-lying trees and shrubs had intermediate influence on herbage standing crop, irrespective of seasons.

Higher rates of decline of light herbage standing crop occurred in August and October, Probably lack of growth and plant maturity was the cause of herbage decline. In addition, sheep/goat pastures were adjacent to the light bushed plots. Consequently, decline of herbage standing crop in these months could be explained by use of herbage by these animals both during and prior to the study. Wildlife herbivores, particularly those which like grazing in open grasslands (kongonis, buffalos, gazelles) for protection against predators could also have contributed to the decline of herbage in the plots. Adjacent to the study area was a pasture which was burned in February 1982. The new growth of resprouts and herbaceous species attracted many wildlife herbivores (gazelles, kongonis, giraffes, buffalos and waterbucks) which drifted to the study pastures creating added pressure to the available forage in the plots. The greater effect was noted in light pastures where it was thought most of the small ruminants concentrated for fear of predators (lions and hyenas).

Digitaria macroblephara and Chloris roxburghiana were the only grass species significantly affected by bush canopy condition throughout the study period (Appendix Table 1). In general, Digitaria macroblephara was higher in the light bush condition. Diversity of other herbaceous species available washigh but in most cases appeared to be insensitive to bush conditions.

Monthly changes in herbaceous standing crop were related to inherent sampling variations in which the 20, 0.5 m^2 plots were unable to overcome differential response to intermittent rains between grazing intervals and unexplained wildlife and sheep/goat use during and prior to trial period.

Available Browse

Available browse declined from June to September in all treatment pastures (Table 4). Heavy bushed canopy pastures as expected, provided more available browse than did the light or moderate plots. No differences were noted between light and moderate bushed paddocks, indicating that available browse would not change appreciably until canopy cover greater than 35% were obtained. Early rains in later part of the dry season caused an increase in available browse in October and November across all treatment paddocks. Again, the differences were

Table 4. Monthly available browse (kg/ha) by derived bush categories for each canopy condition in *Acacia senegal*/*Digitaria macroblephara*/*Hermania alhiensis* community in 1982 at NRRS, Kiboko, Kenya.

Woody Species	Bush cover class																			
	June/July				August				September				October				November			
	L	M	H	α[1]	L	M	H	α	L	M	H	α	L	M	H	α	L	M	H	α
Acacia mellifera	P[2]	1	2	0.1	P	T	T	-	T	P	T	-	P	1	1		P	3	4	
A. senegal	2 b[3]	4 b	24 a	0.02	2 b	2 b	10 a	0.004	1 b	1 ab	5 a	0.03	2 b	3 b	15 a	0.04	14 b	9 b	49 a	0.01
A. tortilis	1 ns[4]	1	2	0.5	1 ns	1	2	0.3	T	T	1	0.5	1 ns	1	2	0.5	T	1	1	0.5
Balanites aegyptiaca	P	T	T	0.4	P	T	T	0.5	T	T	T	0.5	P	T	T	0.4	T	T	P	0.9
Boscia sp.	P	T	P	0.4	P	T	P	0.1	T	P	P	0.1	P	T	P	0.4	P	T	P	0.2
Commiphora africana	2	T	1	0.3	1	T	1	0.2	T	1	1	0.3	1	T	T	0.3	3	T	1	0.2
Grewia similis	1	T	T	0.09	1	1	T	0.2	T	1	T	0.07	9	9	T	0.4	2	P	1	0.4
G. villosa	4 ns	12	34	0.5	1 ns	6	11	0.4	2	T	4	0.5	1 ns	8	4	0.6	7 ns	17	48	0.6
Hermania alhiensis	5 b	9 b	34 a	0.01	5 b	4 b	21 a	0.01	1 b	1 b	5 a	0.01	4 b	5 b	21 a	0.01	18 b	17 b	69 a	0.02
Hibiscus aponeurus	P	2	1	0.4	P	1	3	0.4	1	P	P	0.3	P	1	T	0.4	P	1	1	0.4
Lanea flocossa	T[5]	P	P	0.4	P	T	P	0.4	P	T	P	0.4	T	P	P	0.4	T	P	P	0.4
Sida ovata	T	P	1	0.004	T	P	1	0.003	P	T	T	0.4	T	P	T	0.001	1	T	2	0.4
Solenum incanum	T	P	T	0.2	T	P	T	0.4	P	T	T	0.001	T	P	T	0.4	T	P	2	0.006
Unidentified browse	T	P	P	0.3	T	P	P	0.2	P	T	T	0.1	T	P	P	0.4	T	P	P	0.3
Other sp.	T	P	2	0.2	T	T	T	0.4	T	T	T	0.3	T	P	T	0.2	1	P	1	0.3
Total available browse	15 b	29 b	102 a	0.019	10 b	13 b	41 a	0.001	5 b	7 b	16 a	0.01	9 b	27 ab	44 a	0.03	46 b	47 b	180 a	0.07

[1] Level at which parameter is significently different.
[2] Present but not sampled.
[3] Means followed by the same letter between bush cover class (Light (L), Moderate (M), Heavy (H)) are not significantly different (α = 0.05).
[4] No significant difference between bush cover class (α = 0.05).
[5] Trace.

associated with heavy bushed pastures.

In general, trees produced 59% of the available browse across all pastures. However, browse production was erratic particularly during dry months. This was because the majority of the woody vegetation shed leaves in response to moisture stress. New growth was also curtailed in this period. Consequently, available browse produced during dry season were generally by old leaves and twigs.

Shrubs, dominated by Hermania alhiensis provided 41% of the available browse across pastures. It appeared as if the effect of drought had little impact on shrubs relative to tall trees. On the onset of dry season, majority of the trees lost leaves quicker than did shrubs, leading to sharp drop of available browse from these woody species relative to shrub browse.

Acacia senegal, Hermania alhiensis and Grewia villosa provided most bush for the available browse across all treatments. They were the only woody species showing canopy effects on the amount of browse available for the foraging animals.

During dry months the majority of the woody vegetation shed leaves and stopped new growth, therefore, the available browse for this period was provided by slow leaf-shedding deciduous and evergreen bushes.

Composition of Available Forage

Composition of grasses and grasslikes varied from 89-99% in the lightest bush conditions and 80-99% in the heaviest bush conditions. The treatment paddocks with heavy bush cover were lower in browse composition in June, July and November (Table 5). These months constituted initiation of the dry and the beginning of the wet season. Grasses and grasslike composition was not different across bush conditions during the

Table 5. Grass, forb and browse composition (%) derived from available forage in an *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* community of varying degree of canopy cover in 1982 at NRRS, Kiboko, Kenya.

	Plant species composition											
	Total grass/grasslike				Total forbs				Total browse			
	Light	Moderate	Heavy	(α)[1]	Light	Moderate	Heavy	(α)	Light	Moderate	Heavy	(α)
June	94.5 ab[2]	98.3 a	88.3 b	0.05	3.4 ns[3]	1.0	1.0	0.5	2.2 b	1.0 b	11.29	0.01
July	94.8 ab	98.7 a	91.5 b	0.02	4.0 ns	1.0	4.1	0.1	1.2 ab	1.0 b	4.4 a	0.05
August	90.1 ns	99.5	96.7	0.10	1.2	P[4]	T[5]	0.09	8.7 ns	1.0	3.2	0.2
September	98.8 ns	99.3	98.9	0.7	10 ns	T	T	0.3	1.0 ns	1.0	1.1	0.2
October	95.2 ns	99.0	97.0	0.1	1.2 ns	T	T	0.4	3.6 a	1.0 b	2.8 ab	0.1
November	89.2 a	94.6 a	80.8 b	0.003	9.1 ns	2.5	8.6	0.1	1.7 b	2.9 b	11.6 a	0.0003

[1] Level at which parameter is significantly different.
[2] Means followed by the same letter in the row are not significantly different ($\alpha = 0.05$).
[3] Means within plant composition class are not significantly different ($\alpha = 0.05$).
[4] Present but not sampled.
[5] Composition less than 0.5%.

middle of dry season. Forb composition was not influenced by canopy cover throughout the study period. During the dry season, forb composition never exceeded 4.1%. Yet, when rain began in late October and November, forb composition doubled in each of the treatment paddocks, but never exceeded 10%.

Current year's growth on available browse will remain green long into the dry season and respond to small erratic rainfall and high humidity periods by initiating new leaves. Therefore, it was not unexpected that the heavier bush conditions would have higher composition of browse than the two lower canopy treatments in June-July and October-November. Composition of available browse was similar at both of these periods.

Primary differences between various treatments was from grasses and browse. While browse increased in composition as canopy cover increased, grasses decreased with increasing canopy cover. Those grass species whose composition was affected by degree of canopy cover included Bothriochloa insculpta, Chloris roxburghiana, Digitaria macroblephara and Eragrostis caespitosa ($\alpha = 0.2$). Each aforementioned grass species declined in composition from the light bush treatments to the moderate bush treatment except Digitaria macroblephara, the dominant grass in each of the paddocks. Composition of primary grasses did not differ between the moderate and heavy bush treatments. Chloris roxburghiana was a co-dominant grass on the light bushed paddocks. Most of the other grasses were so low in composition that few differences were noted between bush conditions. They appeared to be randomly distributed with limited relationship to bush cover.

Composition of grass and grasslike increased with month from the time of initiation of the experiment to September and thereafter decreased, following browse and forb increases in composition. It appears, therefore, that there is a negative relationship between grass/grasslike class with other forage classes as far as composition is concerned.

Berlaria micrantha, Commelina bengalensis and Tephrosia villosa were the major contributors of forb composition, whereas Digitaria macroblephara and Chloris roxburghiana produced the highest grass/grasslike composition across pastures throughout the study period. Similarly, Acacia senegal, Hermania alhiensis and Grewia villosa (α = 0.4) dominated the woody vegetation composition in the study area (Appendix Table 2).

The overriding factor in determining composition of available forage classes was seasons. The wet season, a period of growth, seemed to have favored browse and forb composition while the dry period, a plant dominant stage, favored grass/grasslike composition.

Botanical Composition of Heifer Diets

Heifer diets were dominated by grasses, regardless of season grazed. This forage class accounted for 98% while forbs and woody vegetation classes accounted for 2% and less than 1%, respectively (Table 6, Appendix Table 3). Selection for grass and grasslike herbage among pastures did not differ, however, selection decreased with increasing bush canopy cover as a result of the bush influence on the grass and grasslike forages.

Digitaria macroblephara, averaged 93%, and dominated the diets of the animals throughout the study period, but was not different between canopy conditions. Chloris roxburghiana, was the second most abundant grass species in the animal diets. The availability of these two grass

Table 6. Botanical composition (%) of heifer diets selected by month across categories of bush conditions in *Acacia senegal/Hermania alhiensis/Digitaria macroblephara* communities in 1982 at NRRS, Kiboko, Kenya.

Forage class/species	Months					
	June	July	August	September	October	November
GRASS/GRASSLIKE						
Bothriochloa insculpta	1.0	T[3]	T	T	T	T
Cenchrus ciliaris	1.8	1.0	T	T	T	1.0
Chloris roxburghiana	7.1	1.3	T	3.2	5.3	3.8
Digitaria macroblephara	82.9 b[1]	93.9 a	93.2 ab	92.1 ab	87.0 ab	90.9 ab
Eragrostis caespitosa	3.6	1.0	T	1.0	1.4	1.0
Sporobolus pellucides	1.4	1.0	T	1.0	1.0	1.1
Total	93.3 ns[2]	97.8	99.0	98.2	94.9	97.8
FORBS						
Asparagus sp.	T	T	P	P	P	P
Commelina bengalensis	2.4	T	P	P	P	P
Talmim kerform	P	P	T	P	2.1	T
Total	2.4	T	T	T	2.1	T
BROWSE						
Acacia senegal	P[4]	P	P	T	P	P
Boggia sp.	T	T	P	T	T	P
Hermania alhiensis	T	P	T	T	1.4	1.0
Other browse	T	T	T	T	T	T

Table 6. (continued).

Forage class/species	Months					
	June	July	August	September	October	November
Total browse	4.3 ns	2.2	1.0	1.8	3.0	1.2

[1]Means within months were not significantly different ($\alpha = 0.05$).
[2]Means within row with the same letter are not significantly different ($\alpha = 0.05$).
[3]Botanical composition less than 0.5%.
[4]Present but not eaten.

species which ranked highest in the study area could explain why they were the most prevalent in the diets of the animals. Generally, selection for these grasses is dependent on the availability of other forage species and diet preference of animals for a particular forage class/species.

Only the dietary composition of Bothriochloa insculpta, Cenchrus ciliaris, Eragrcstis caespitosa and Sporobolus pellucides was affected by canopy cover. In general these species declined in dietary composition as bush cover increased. Although significant differences were not noted for Chloris roxburghiana, an interesting trend was observed. The species declined in diet after June, constituting less than 1% of the diet until October when moisture condition improved. After rains were received Chloris roxburghiana comprised 2.1 to 4.5% of the diet. Relative to Digitaria macroblephara, a stoloniferous and most available grass species in the study area, Chloris roxburghiana is a low leaf/stem ratio bunchgrass. Probably the animals did not select Chloris roxburghiana due to its low stature and availability in the study area.

Although forb content in the animal diets did not differ across pastures, moderate bushed condition pastures produced diets highest in forbs. Animals selected least forbs in the light condition pastures because of the ample availability of grass and grasslikes in the plots. Commelina bengalensis was the only forb in the diet of the animals from June through August. Once rains began Talinum kafrum and Commelina bengalensis were grazed by the animals. There was no apparent trend in the occurrence of these forbs as they related to canopy cover. It appears that the animals would select for them as they are encountered. Since the species were rare in the plots, one would expect no consistent trends. Minor amounts of Asparagus sp. was eaten in only June when the plant was still green and not highly lignified.

Selection for woody vegetation (browse) by the animals was minimized by availability of herbage in the study area. Only three woody species were found in the diets of the heifers viz Acacia senegal, Boscia sp. and Hermania alhiensis. None of these species constituted over 0.4% of the diet of the animals. Hermania alhiensis, the dominant shrub, was found in the diets more frequently across the grazing period than the other two species. Boscia sp., contributing less than 1% of the total animal diets, dominated the tree browse class throughout the study. This species is evergreen throughout the dry season.

All classes of forages were found in diets selected by animals (Table 6). However, there was a trend of erratic occurrence of plant species in the diets throughout the study. It was noted that botanical composition of diets were diverse when forages were green but limited to what was available when the forages were mature and dry. Therefore, few forage plants were selected when forages reached maturity in the dry season. Springfield and Reynolds (1951), Cook and Stoddart (1953), Cook (1956) and Baker (1975) reported that cattle selected a wide range of forage species when plants were young and growing, but only a few species were selected after forage reached maturity.

Cattle diets shifted toward more grass and less forbs and browse as the dry season advanced. This is probably explained by reduced forb and browse palatability with phenological advancement. Grass consumption ranged from 93 to 99% throughout the study. Other investigators have reported grasses to be the most important component of cattle diets (Cook 1956, Cook et al. 1962, Cook et al. 1967, Van Dyne and Heady 1965, Galt et al. 1969). In this study when they were green, forbs were highly preferred relative to browse.

Although forbs were more in moderate bushed pastures, fewer species were found in diet samples. This probably could be attributed to the higher availability of the preferred grass species. For comparison of weighted and unweighted dietary components see Appendix Table 4.

Diet Preference

Availability of forage species/classes was the overriding factor in determining preferences for certain species/classes of forage by animals. The most available forage species/classes were preferred over less available ones (Tables 7, 8; Appendix Tables 5-16). This was contrary to what other researchers reported (Kothmann 1980, Stuth and Lopes 1984).

Digitaria macroblephara, Chloris roxburghiana and Sporobolus pellucides were the major grasses eaten by the animals. Their preference indices ranged from +2.5 to +0.2, indicating that they were selected based on their proportional availability. The derived category of other grass sp., having mean selection ratios (SR) ranging from +3.4 to +4.9 were also preferred. However, Bothriochloa insculpta with SR of -3.0 was the only grass sp. least preferred by cows. Its low preference indices could have been contributed by its coarseness and aromatic odor. This was the only grass species needing some management manipulation in order for it to be utilized.

Forbs as a class ranked second to grass in preference order, when forage classes were averaged across pastures. Its selective ratio value was +4.9, indicating that it was highly preferred. However, its availability curtailed preference by animals for this class. Preference for forbs were higher in light pastures than the other. Talinum kafrum,

Table 7. Selection ratio values and standard deviation for forage species and classes collected by heifers on bush canopy condi[redacted]ures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in 1982 at NRRS, Kiboko, Kenya.

Species	Early dry June/July Light	Early dry June/July Moderate	Early dry June/July Heavy	Mid dry August/September Light	Mid dry August/September Moderate	Mid dry August/September Heavy	Early wet October/November Light	Early wet October/November Moderate	Early wet October/November Heavy
GRASS									
Bothriochloa insculpta	-3.4 ± 4.4	-2.6 ± 3.8	+3.1 ± 1.8	-3.6 ± 4.4	+1.1 ± 3.1	-3.0 ± 1.8	-5.8 ± 4.4	-6.1 ± 3.1	-5.1 ± 1.8
Cenchrus ciliaris	+6.0 ± 1.8	+5.7 ± 2.6	+2.5 ± 5.0	+1.0 ± 1.8	+5.7 ± 3.4	+4.7 ± 5.0	-1.7 ± 1.8	+5.8 ± 3.4	+5.6 ± 5.0
Chloris roxburghiana	-1.7 ± 0.8	+1.4 ± 0.5	+1.5 ± 1.2	-3.6 ± 0.5	+3.3 ± 0.3	-2.9 ± 1.2	+1.7 ± 0.8	+1.9 ± 0.2	+1.8 ± 1.2
Digitaria macroblephara	+1.7 ± 1.2	-0.8 ± 0.9	+0.4 ± 0.4	+2.4 ± 1.2	-0.5 ± 0.5	+0.4 ± 0.2	+1.3 ± 1.2	+0.4 ± 0.9	+0.2 ± 0.2
Eragrostis caespitosa	+4.3 ± 2.9	+4.0 ± 3.8	+7.7 ± 6.4	+1.4 ± 2.9	+0.9 ± 4.7	+8.1 ± 6.4	+6.3 ± 2.9	-0.6 ± 0.5	+6.7 ± 6.4
Sporobolus pellucides	-0.3 ± 1.5	+3.8 ± 2.0	+1.5 ± 3.6	+1.9 ± 1.5	+1.8 ± 2.5	+3.5 ± 3.6	+3.5 ± 1.5	+3.0 ± 4.7	+6.2 ± 3.6
Total grass	+0.8 ± 0.6	+0.7 ± 0.6	+1.1 ± 0.5	+0.8 ± 0.6	+0.2 ± 0.6	+0.3 ± 0.5	+0.7 ± 0.6	+3.9 ± 2.5	+0.5 ± 0.5
Total herbage	+0.8 ± 0.7	+0.7 ± 0.7	+1.2 ± 0.6	+0.8 ± 0.6	+0.2 ± 0.6	0.3 ± 0.6	+0.8 ± 0.6	+0.2 ± 0.6	+0.7 ± 0.6
FORBS									
Asparagus sp.	+4.1 ± 4.5[1]	+4.1 ± 4.7	NA[3]	NA	NA	NA	NA	NA	NA
Commelina bengalensis	0 ± 0.1	NC	+1.7 ± 3.1	+4.1 ± 3.1	+4.1 ± 1.5	NC	-0.9 ± 0.1	-4.0 ± 1.5	0 ± 3.1
Talinum kafrum	+4.1 ± 4.3	+4.5 ± 3.5	NA	NC	NC	NA	+8.9 ±	+2.2 ± 3.5	+0.5 ± 2.7
Total forbs	+2.3 ± 1.4	+3.7 ± 2.5	+2.3 ± 3.5	+4.1 ± 1.4	+4.1 ± 2.5	NC	+4.9 ± 5.7	-2.1 ± 2.5	+0.7 ± 2.7
BROWSE									
Acacia senegal	-4.5 ± 3.2	NC	NC	NC	NC	NC	NC	NC	NC
Boscia sp.	+4.7 ± 4.1	+9.7 ± 8.3[1]	NC	NC	NA	NC	NA	NA	NC
Hermania alhiensis	NC[2]	-2.6 ± 2.9	NC	NC	NC	NC	NC	-4.2 ± 3.5	NC
Unidentified sp.	+9.0 ± 9.3	+9.0 ± 9.3	+4.7 ± 4.7	+9.5 ± 9.3[1]	+9.4 ± 9.3	+9.6 ± 9.3	+9.6 ± 9.3[1]	+9.8 ± 9.3[1]	+9.7 ± 9.1[1]
Total browse	-0.2 ± 1.4	+5.2 ± 1.0	-2.5 ± 1.4	+1.8 ± 1.4	+3.3 ± 0.6	-2.5 ± 2.7	-0.2 ± 1.4	+0.4 ± 0.6	-3.2 ± 2.7

[1]Species found in diet but not clipped.
[2]Not consumed.
[3]Not available.

June through November, 1982 at NRRS, Kiboko, Kenya.

Bush canopy condition		
Light	Moderate	Heavy
Talinum kafrum	Cenchrus ciliaris	Eragrostis caespitsa
Eragrostis caespitosa	Talinum kafrum	Cenchrus ciliaris
Digitaria macroblephara	Chloris roxburghiana	Sporobolus pellucides
Sporobolus pellucides	Eragrostis caespitosa	Commelina bengalensis
Acacia senegal/Boscia sp.	Sporobolus pellucides	Digitaria macroblephara
Asparagus sp.	Boscia sp.	Talinum kafrum
Commelina bengalensis	Asparagus sp.	Chloris roxburghiana
Cenchrus ciliaris	Commelina bengalensis[1]	Bothriochloa insculpta
Chloris roxburghiana	Digitaria macroblephara	
Bothriochloa insculpta	Hermania alhiensis	
	Bothriochloa insculpta	

[1]Forage species found in diet but not clipped.

Commelina bengalensis and Asparagus sp. were mostly consumed in June and November when their availability peaked due to the rains which enhanced their growth.

Woody species (browse) as a class was least preferred by animals. Browse in the moderate pastures were more preferred by the heifers. This was because the browse was more available in that the plots were dominated by shrubs and short trees. Shrubs and trees in light pastures were least preferred relative to other browse in other plots because there were more preferred available herbage. In heavy pastures browse were dominated by tall trees.

Majority of the browse were not available during dry season because the woody species shed leaves to reduce moisture stress. Consequently, their SR were the lowest in this period. Boscia sp. was the most preferred browse in the study area. Its preference indices were high when its leaves were green, i.e., during the rainy season (Appendix Tables 5-10).

Although Hermania alhiensis was within cattle grazing height, it was not preferred by the cows. Acacia was another browse which was least preferred by cattle because of its thorns and small leaves which could not be consumed by cattle.

Seasons influenced availability of forbs and browse greater than it did to grasses. In dry season availability of forbs and browse declined at a faster rate, whereas grass leaves dried but were readily available for grazing. Consequently, the preferences for grass were higher than that for the other forage classes.

Diet preference by cattle for forage classes were grasses, forbs and browse, in descending order. This was in agreement with the findings of other researchers (MacMahan 1964, Cook et al. 1966).

In conclusion, it can be recommended that grazing management should be based on the utilization of Digitaria macroblephara because it is the most preferred and available forage species in the study area.

In order that all forage classes to be preferred in proportion to their availability, the SR should be between ± 3. Based on this fact, moderate pastures seemed to produce mixed diets of the animals. To enhance animal production management should manipulate the use of forages outside this range.

Much research work is needed in order to more adequately understand the effects of bush on cattle diets. It appears from this study that bush canopy cover less than 50% has no major negative effect on cattle diets as long as adequate herbaceous standing crop is maintained.

Chemical Composition

Selection for Plant Parts

The diets of the animals was dominated by leafy fractions throughout the study. However, stems contributed heavily to the diets of animals during dry period (Table 9). Many studies indicate that leaves are major part in livestock diets (Allison and Kothmann 1979, Durham and Kothmann 1977, Galt et al. 1969). Selection for leafy material in this study was prominent in wet seasons. During dry season, leafy material in the diets decreased due to maturation of plants, subsequently animals ate considerable amounts of stems at this time.

Live diet fragments increased with precipitation and declined with drought. Selection for live fragments from August through November, a period of dry weather, was significantly lower than the other months.

Table 9. Composition (%) of heifer diets selected from various bush canopy condition pastures (Light (L), moderate (M), Heavy (H)) in Acacia senegal/Hermania alhiensis/Digitaria macroblephara community in 1982 at NRRS, Kiboko, Kenya.

Bush canopy categories	Plant part ratios					
	Leaf	Stem	Leaf:Stem	Live	Dead	Live:Dead
June						
L	71.5 ns[1]	28.5 ns	2.5 ns	50.8 ns	49.2 ns	1.0 ns
M	71.3	28.7	2.5	49.7	50.3	1.0
H	74.3	25.7	2.9	46.1	53.9	0.9
α[3]	0.6	0.6	0.6	0.5	0.5	0.6
July						
L	68.8 ns	31.2 ns	2.2 ns	27.7 ns	77.3 ns	0.9 ns
M	70.8	39.2	1.8	29.7	70.3	0.4
H	69.3	31.7	2.2	29.9	70.1	0.4
α	0.5	0.5	0.8	0.1	0.1	0.2
August						
L	58.5 ns	41.5 ns	1.4 ns	25.7 ab[2]	73.3 ab	0.4 ab
M	62.5	37.5	1.7	32.6 a	67.4 b	0.5 a
H	53.9	46.1	1.2	23.2 b	76.8 a	0.3 b
α	0.2	0.2	0.2	0.05	0.05	0.05
September						
L	60.7 a	39.3 b	1.5 b	32.3 b	67.7 a	0.6 a
M	53.3 c	46.7 a	1.1 b	42.1 b	57.9 b	0.7 a
H	70.5 a	29.5 c	2.4 a	30.8 b	69.2 a	0.4 b
α	0.007	0.001	0.01	0.001	0.001	0.002
October						
L	56.8 ns	43.2 ns	1.3 ns	53.9 c	46.1 a	1.2 c
M	62.9	37.1	1.7	78.6 a	21.4 c	3.7 a
H	62.5	37.5	1.7	66.6 b	33.4 b	2.0 b
α	0.3	0.3	0.3	0.001	0.001	0.001
November						
L	77.9 ns	22.2 ns	3.5 ns	98.7 ns	1.3	75.9
M	75.4	24.6	3.1	100	--	--
H	74.7	25.3	3.0	100	--	--
α	0.3	0.3	0.2	0.4	0.4	--

[1]Means within pastures are not significantly different (α = 0.05).
[2]Means within columns with the same letter are not significantly different (α = 0.05).
[3]Level at which a parameter is significantly different.

This was because of the plant maturation and lowered availability of green forage available. Upon the onset of rains in late October, animals ate green forage, thus November diets had very few dead forage parts. During the dry season, stems produced most of the green forage in the diets. It is indicated that animals prefer green forage over dead (Church 1980, Cook et al. 1966, Arnold 1960). In this study, animals ate most stems during dry period because they were selecting for green plant material which was predominantly produced by stems.

Chemical Composition of Heifer Diets

In general the dietary components met the requirements of the animals during wet season whereas crude protein (CP) was the only deficient nutrient in the dry period (Table 10).

The CP maintenance requirement for a 400 kg heifer is 8.5% (NRC 1976). During wet season, i.e., in June, October and November, the CP exceeded the heifer requirements while in dry season it was below the required level. The nutrient deficiency was caused by forages maturity and the lack of forbs in the animal diets. Browse which was expected to increase the nutritional value of the diets were not eaten in this period because most bushes had shed leaves at this time and grass availability was high. So the animals consumed grasses which are generally known for being low in CP content. Many researchers have indicated that nutritive content of forages decline as seasons progress into dry season and plants mature (Allison and Kothmann 1979, Wallace et al. 1972, Van Soest 1967). This study agreed with the concepts as far as CP was concerned.

Diets eaten in the moderate and heavy bushed condition plots in June contained highest CP because of the presence of both forbs and

Table 10. Dietary crude protein (%), digestible organic matter (%) and digestible energy (Kcal/kg) of fistulated heifers grazing *Acacia* dominated rangeland of varying canopy cover from June through November, 1982 at NRRS, Kiboko, Kenya.

Bush cover	Month						
	June	July	August	September	October	November	Mean
				Crude protein			
Light	8.3 b[1]	8.8 ab	8.0 b	8.1 a	19.2 a	15.8 ns[2]	11.3 a
Moderate	10.6 a	9.4 a	8.6 a	7.5 b	17.0 a	16.5	11.8 a
Heavy	11.0 a	7.7 c	7.5 b	6.8 c	9.7 b	15.6	9.7 b
α-value[3]	0.0004	0.0001	0.0001	0.0001	0.0001	0.2	--
Mean	10.0	8.6	8.0	7.5	15.3	16.0	10.9
				Digestible organic matter			
Light	63 ns	62 a	62 ns	60 ns	63 a	72 a	63 ns
Moderate	62	60 b	62	59	60 b	72 a	62
Heavy	62	60 b	61	60	60 b	70 b	62
α-value	0.06	0.004	0.2	0.2	0.0001	0.001	--
Mean	62	61	62	60	61	71	62
				Digestible energy			
Light	2416 b	2475 a	2438 ns	2406 ns	2505 a	2884 a	2526 ns
Moderate	2441 ab	2383 b	2487	2356	2263 b	2889 a	2470
Heavy	2503 a	2394 b	2467	2385	2176 b	2822 b	2454
α-value	0.05	0.005	0.3	0.2	0.0001	0.002	--
Mean	2453	2417	2464	2382	2315	2865	2483

[1]Means within month by dietary parameter followed by the same letter are not significantly different (α = 0.05).
[2]No significant treatment effect was noted within month of dietary parameter (α = 0.05).
[3]Level at which a parameter is significantly different.

browse in the diet. In July, the beginning of dry season, animals ate diets least in CP due to the effect of forage maturity on nutrient content of diets. Although this month was considered as a dry one, the mean CP (8.6%) was not below the maintenance requirement of heifers due to the new growth of forages as a result of the late June rains carry-over effect into July. No new growth was noted in August and September, thus the dietary nutrients were depressed by low nitrogen content in diets. Streeter et al. (1968) attributed the decrease in nitrogen content of sheep diets to a continual decline in nitrogen content of forage species throughout the summer grazing season. Similar results were recorded by Scales et al. (1971), Smith et al. (1968) and Rosiere et al. (1975). Other researchers indicate that CP probably decline because of late summer temperatures (Thetford et al. 1971), advancing maturity (Scales et al. 1971), Smith et al. (1968), Streeter et al. (1968), and the lack of forage regrowth due to the absence of precipitation (Ventura et al. 1975).

Mean percentage in vitro digestible organic matter (IVDOM) content of the forage selected by animals exceeded the maintenance requirement of a 400 kg heifer (NRC 1976). Diets selected from light bushed condition pastures produced the highest IVDOM across all pastures and months. This was because the pastures were dominated by grass and grasslikes which are generally high in organic matter digestibility. IVDOM decreased as dry season progressed from June to September and thereafter increased with moisture availability. Similar results were reported by Scales et al. (1971) using yearling cattle and by Streeter et al. (1968). It appears that bush canopy cover affected dietary IVDOM. Heavier bushed pastures provided nearly similar dietary nutrient different from light pastures.

However, irrespective of canopy cover and seasons diets from all pastures met or exceeded the maintenance requirement of heifers.

The NRC (1976) requirements for digestible energy (DE) of a 400 kg heifer is 2.0 Mcal/kg. In this study this requirement was met through the study period, although declining trends were noted as dry period set. As IVDOM, light pastures produced diets highest in DE because of the high availability of grasses and grasslikes in the plot. Plant maturity and less availability of high nutritive forages depressed DE content in dry season, whereas plant diversity increased its content during wet season.

Dietary constituents for November were exceptionally high as compared to the other months. In this month animals ate a greater diversity of forage species as plant availability was not limiting. In addition, animals consumed more forbs and browse in the month as compared to other months.

Generally, it appears that there is no problem of dietary DE and IVDOM associated with the condition of this study. CP is deficient during the dry seasons only. This problem could be corrected by either supplementation or manipulation of grazing management. Utilization of nitrogen (N) by rumen organism is influenced by the availability of carbohydrates (Church 1979). In this study, data provided a contradiction of what other workers have established. However, Warner (1976) noted that starch reduced production of amino acids by in vitro fermentation due to an increased utilization of ammonia for microbial growth. The soils of the study area are low in nitrogen, leading to low nitrogen in forages (Michieka and Van der Poun 1977).

Management Implications

Based on earlier reports, bush encroachment into savannah range has negative impacts on herbage production (Thomas and Pratt 1967). Since herbage make up a major part of cattle diets, encroachments of bushes definitely reduce animal production from these ranges by limiting herbage availability. In addition, thick bushes limit cattle movement and accessibility to forage. Thickets, also provide hiding places to predators of livestock.

Although this study was hoped to recommend solutions of dry period problems, not much was achieved because rains continued throughout the study period. In spite of erratic rains in July through September, forages were shown to have sustained high nutrient content throughout this period. In general, dietary nutrient deficiency was not apparent. However, CP deficiency occurred in August and September. This deficiency could be corrected through better grazing management.

Acacia savannah could benefit cattle through biological bush control. This could be accomplished with goats which would open up bush, control the spread of shrubs and short trees, and by so doing, increase accessibility of forage to cattle. MacMahan (1964) found that browse comprised over 50% of the goat's diets in the Edwards Plateau region of Texas.

Digitaria macroblephara, the dominant grass, seemed to be the key species in the study site. It was the most available, most preferred and most adapted to the locality. It suffices, therefore, to recommend that this grass should be the key management species in the area and the grazing management decisions should be based on the use of this grass.

Given the conditions of the study, i.e., high standing crop, high percentage of preferred grass, especially Digitaria macroblephara, and periodic showers that maintained green culms throughout the season, one would give the following recommendations: (1) that the nitrogen to carbon imbalance could be corrected by feeding animals with molasses mixed with urea (NPN trial has been conducted in the station and its final report is yet to be written), (2) that animals' low nutritional requirements be timed to coincide with the time of low forage nutrient content (August and September), and (3) that breeding should begin in January so that calving starts in October when both nutrient content of forages and the animals' nutritional requirements due to lactation are high. It should be noted that starting breeding in January would lead to weaning during dry season. Weaners would, therefore, be exposed to poor quality forage. This problem could be corrected by setting aside a weaning pasture and feeding molasses mixed with urea. In this study, data to recommend best breeding time is inadequate, therefore, research to support this recommendation is needed. The results of NPN trial and this study would assist in the provision of sound recommendations in the future.

CONCLUSION

Bush canopy cover was determined to be 12.8, 31.5 and 49.8% for light, moderate and heavy paddocks, respectively. Trees dominated heavier bushed pastures, whereas shrubs dominated ligher ones. Acacia senegal and Hermania alhiensis was the dominant tree and shrub, respectively, across pastures. There were more woody species diversity in heavily bushed pastures relative to lighter bushed pastures. Acacia sp. were the dominant trees in the heavily bushed pasture. In general, Acacia senegal, Cordia ovalis and Grewia villosa were the primary woody vegetation creating bush treatment effects.

Moisture availability determined available herbaceous standing crop in that wet season forage production was higher than dry season. They varied from 2713 to 1034 kg/ha. Grass and grasslikes dominated herbage production while forbs were available only in wet seasons. In dry seasons, heavily bushed pastures produced more herbage than light plots which may be due to the effect of bushes on herbage growth. Probably bush microclimatic influence sustained herbage growth. In the wet seasons, lighter plots produced more herbage because these forage species dominated the plots. Digitaria macroblephara and Chloris roxburghiana were the primary producers of herbaceous standing crop in the study area.

Available standing browse in the study area was produced mainly by trees. However, this production was not sustained throughout all seasons because majority of the browse species were deciduous. Whereas, trees produced more available browse in the wet season, shrubs and evargreen species produced most browse in the dry season. Acacia senegal, Hermania alhiensis and Grewia villosa provided for the most available browse across pastures and seasons.

Grass and grasslikes dominated forage species composition during dry seasons, but were reduced by browse and forb species composition in wet seasons. As canopy cover increased browse composition increased but grass ocmposition decreased. Digitaria macroblephara and Chloris roxburghiana dominated grass composition while Acacia senegal, Hermania alhiensis and Grewia villosa (= 0.4) dominated the woody species composition. The forb composition was dominated by Berlaria micrantha, Commelina bengalensis and Tephrosia villosa.

Heifers ate more grass and grasslikes, less forbs and least browse across pastures and in all seasons consumption for grass decreased with increase in canopy cover. Excluding Acacia senegal and Hermania alhiensis, heifers selected forage species with highest composition in the study area. This observation was irregular as compared to previous researchers (Kothmann 1980).

Apart from CP which was deficient in August and September (dry season), all dietary nutrients met the maintenance requirements of the heifers. However, there appears to be a potential problem for rumen C:N balance in cattle due to the relatively high DE in relation to nitrogen content of the diets.

LITERATURE CITED

Allison, C. D. and M. M. Kothmann. 1979. Effects of pressure on forage intake and diet quality of range cattle. Proc. West. Sec. Amer. Soc. Anim. Sci. 30:174-178.

A.O.A.C. 1975. Official Methods of Analysis (12th ed.). Association of Official Analytical Chemists, Washington, D.C.

Arnold, G. W. 1960. Selective grazing by sheep of two forage species at different stages of growth. Aust. J. Agric. Res. 11:1026-1033.

Ayuko, L. J. 1978. Management of rangelands in Kenya to increase beef production: Socio-economic constraints and policies. Proc. Internat. Rangeland Congr., Denver, Colo. 1:82-86.

Beck, Reldon. 1975. Steer diets in southeastern Colorado. J. Range Manage. 28:48-52.

Bedell, T. C. 1968. Seasonal forage preferences of grazing cattle and sheep. J. Range Manage. 21:291-297.

Bedell, T. E. 1971. Nutritive value of forage and diets of sheep and cattle from Oregon subclover-grass mixtures. J. Range Manage. 24:125-133.

Bernsten, R. H. and A. H. Jacobs. 1983. Socio-economic aspects of range research in Kenya: A plan for reaching the ultimate target groups. Submitted to Deputy Director, Research Division, Ministry of Livestock Development, Government of Kenya.

Blaser, R. G., R. C. Hames, Jr., H. T. Bryant, W. A. Hardison, J. P. Fontenot and R. W. Engel. 1960. The effects of selective grazing on animal output. pp. 601-606. In: Proceedings of the 8th Internat. Rangeland Congr.

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

Cable, D. R. and R. P. Shumway. 1966. Crude protein in rumen contents and in forage. J. Range Manage. 19:124-128.

Church, D. C. 1979. Digestive Physiology and Nutrition of Ruminants. Vol. 1. Digestive Physiology (2nd edition). O&B Books, Inc. Corvallis, Oreg.

Church, D. C. 1980, Digestible Physiology and Nutrition of Ruminants. O&B Books, Inc., Corvallis, Oreg.

Cook, C. W. 1954. Common use of summer range by sheep and cattle. J. Range Manage. 7:10-13.

Cook, C. W. 1956. Range livestock nutrition and its importance in the intermountain region. 17th Annual Faculty Honor. Lecture, Utah State Agricultural College.

Cook, C. W. 1959. The effects of site on the palatability and nutritive content of seed wheatgrass. J. Range Manage. 12:289-292.

Cook, C. W. and L. E. Harris. 1950. The nutritive value of range forage as affected by vegetation type, site and stage of maturity. Utah Agr. Exp. Sta. Bull. 342.

Cook, C. W. and L. A. Stoddart. 1953. The quandry of utilization and preference. J. Range Manage. 6:329-335.

Cook, C. W., K. Taylor and L. E. Harris. 1962. The effects 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.

Cook, C. W., J. T. Blake and J. W. Call. 1963. Use of esophageal fistula for collecting forage samples from both sheep and cattle grazing in common. J. Anim. Sci. 22:579-581.

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

Cook, C. W., L. E. Harris and M. C. Young. 1967. Botanical and nutritive content of cattle and sheep under single and common use on mountain range. J. Anim. Sci. 26:1169-1174.

Dietz, D. R. 1970. Animal production and forage quality: Definition and components of forage quality. In: Range and Wildlife Habitat Evaluation -- A Research Symposium, pp. 1-9, U.S. Dept. Agr., Misc. Pub. No. 147.

Dougall, H. W. and A. V. Bogdan. 1958. Browse plants of Kenya with special reference to those occurring in South Baringo. E. Agric. Agric. For. J. 23:236-245.

Dudzinski, M. L. and G. W. Arnold. 1973. Comparison of diets of sheep and cattle grazing together on sown pastures on the southern tablelands of New South Wales by principal components analysis. Aust. J. Agr. Res. 24:899-912.

Durham, A. J. and M. M. Kothmann. 1977. Forage availability and cattle diets on the Texas Coastal Prairie. J. Range Manage. 30:103-106.

Galt, H. D., B. Theurer, J. H. Ehtenreich, W. H. Hale and S. C. Martin. 1969. Botanical composition of diets of steers grazing a desert grassland range. J. Range Manage. 22:14-19.

Cook, C. W. 1954. Common use of summer range by sheep and cattle. J. Range Manage. 7:10-13.

Cook, C. W. 1956. Range livestock nutrition and its importance in the intermountain region. 17th Annual Faculty Honor. Lecture, Utah State Agricultural College.

Cook, C. W. 1959. The effects of site on the palatability and nutritive content of seed wheatgrass. J. Range Manage. 12:289-292.

Cook, C. W. and L. E. Harris. 1950. The nutritive value of range forage as affected by vegetation type, site and stage of maturity. Utah Agr. Exp. Sta. Bull. 342.

Cook, C. W. and L. A. Stoddart. 1953. The quandry of utilization and preference. J. Range Manage. 6:329-335.

Cook, C. W., K. Taylor and L. E. Harris. 1962. The effects 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.

Cook, C. W., J. T. Blake and J. W. Call. 1963. Use of esophageal fistula for collecting forage samples from both sheep and cattle grazing in common. J. Anim. Sci. 22:579-581.

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

Cook, C. W., L. E. Harris and M. C. Young. 1967. Botanical and nutritive content of cattle and sheep under single and common use on mountain range. J. Anim. Sci. 26:1169-1174.

Dietz, D. R. 1970. Animal production and forage quality: Definition and components of forage quality. In: Range and Wildlife Habitat Evaluation -- A Research Symposium, pp. 1-9, U.S. Dept. Agr., Misc. Pub. No. 147.

Dougall, H. W. and A. V. Bogdan. 1958. Browse plants of Kenya with special reference to those occurring in South Baringo. E. Agric. Agric. For. J. 23:236-245.

Dudzinski, M. L. and G. W. Arnold. 1973. Comparison of diets of sheep and cattle grazing together on sown pastures on the southern tablelands of New South Wales by principal components analysis. Aust. J. Agr. Res. 24:899-912.

Durham, A. J. and M. M. Kothmann. 1977. Forage availability and cattle diets on the Texas Coastal Prairie. J. Range Manage. 30:103-106.

Galt, H. D., B. Theurer, J. H. Ehtenreich, W. H. Hale and S. C. Martin. 1969. Botanical composition of diets of steers grazing a desert grassland range. J. Range Manage. 22:14-19.

Heady, H. F. 1960. Range management in East Africa. Government Printer. Nairobi, Kenya.

Holecheck, J. L., M. Varra and R. D. Pieper. 1982. A review of methods for determining the botanical composition of range herbivore diets. J. Range Manage. 35:309-315.

Kothmann, M. M. 1968. The botanical composition and nutrient content of the diet of sheep grazing on poor condition pasture compared to good condition pasture. Ph.D. Diss., Texas A&M University, College Station, Tex.

Kothmann, M. M. 1980. Nutrition of livestock grazing on range and pasture lands, pp. 56-90. In: D. C. Church (ed.), Digestive Physiology and Nutrition of Ruminants. O&B Books, Inc., Corvallis, Oreg.

Lesperance, A. L., E. H. Jensen, V. R. Bohman and R. A. Madsen. 1960a. Development of techniques for evaluating grazed forage. J. Dairy Sci. 43:682-685.

Little, E. C. S. and G. W. Ivens. 1965. The control of bush by herbicide in tropical and subtropical grassland. Herbage Abstr. 35:1-12.

Lopes, A. L. 1982. Spanish goats diets as influenced by bush management in the Post Oak Savannah of Texas. M.S. Thesis, Texas A&M University, College Station, Tex.

Lopes, A. L. and J. W. Stuth. 1984. Dietary selection and nutrition of Spanish goats as influenced by brush management. J. Range Manage. (In press).

MacMahan, G. A. 1964. Comparative food habits of deer and three classes of livestock. J. Wildl. Manage. 28:798-808.

Michieka, D. O. and B. J. Von der Poun. 1977. Soils and vegetation of Kiboko Range Research Station. A semi-detailed report. No. 53 (Draft ed.). K.S.S., N.A.L., Ministry of Agriculture, Kenya.

Morgan, W. T. W. 1969. East Africa - its people and resources. Nairobi Oxford University Press.

Mutoka, D. T. 1981. Horticultural marketing in Kenya - conduct and performance. M.S. Thesis, Texas A&M University, College Station, Tex.

Mwandotto, B. J. 1978. Factors affecting weaning weights of the small East African shorthorn zebu, Friesian X Boran and Friesian X Sahiwall cattle at Kibrko and Buchuma, Kenya. M.S. Thesis, University of Nairobi, Kenya.

Heady, H. F. 1960. Range management in East Africa. Government Printer. Nairobi, Kenya.

Holecheck, J. L., M. Varra and R. D. Pieper. 1982. A review of methods for determining the botanical composition of range herbivore diets. J. Range Manage. 35:309-315.

Kothmann, M. M. 1968. The botanical composition and nutrient content of the diet of sheep grazing on poor condition pasture compared to good condition pasture. Ph.D. Diss., Texas A&M University, College Station, Tex.

Kothmann, M. M. 1980. Nutrition of livestock grazing on range and pasture lands, pp. 56-90. In: D. C. Church (ed.), Digestive Physiology and Nutrition of Ruminants. O&B Books, Inc., Corvallis, Oreg.

Lesperance, A. L., E. H. Jensen, V. R. Bohman and R. A. Madsen. 1960a. Development of techniques for evaluating grazed forage. J. Dairy Sci. 43:682-685.

Little, E. C. S. and G. W. Ivens. 1965. The control of bush by herbicide in tropical and subtropical grassland. Herbage Abstr. 35:1-12.

Lopes, A. L. 1982. Spanish goats diets as influenced by bush management in the Post Oak Savannah of Texas. M.S. Thesis, Texas A&M University, College Station, Tex.

Lopes, A. L. and J. W. Stuth. 1984. Dietary selection and nutrition of Spanish goats as influenced by brush management. J. Range Manage. (In press).

MacMahan, G. A. 1964. Comparative food habits of deer and three classes of livestock. J. Wildl. Manage. 28:798-808.

Michieka, D. O. and B. J. Von der Poun. 1977. Soils and vegetation of Kiboko Range Research Station. A semi-detailed report. No. 53 (Draft ed.). K.S.S., N.A.L., Ministry of Agriculture, Kenya.

Morgan, W. T. W. 1969. East Africa - its people and resources. Nairobi Oxford University Press.

Mutoka, D. T. 1981. Horticultural marketing in Kenya - conduct and performance. M.S. Thesis, Texas A&M University, College Station, Tex.

Mwandotto, B. J. 1978. Factors affecting weaning weights of the small East African shorthorn zebu, Friesian X Boran and Friesian X Sahiwall cattle at Kiboko and Buchuma, Kenya. M.S. Thesis, University of Nairobi, Kenya.

Nagy, J. G., T. Hakonson and K. L. Knox. 1969. Effects of quality on food intake in deer. Trans. No. Amer. Wildl. Natur. Resource Conf. 34:146-154.

Ndegwa, W. N. 1982. Vascular plant flora of Kiboko Range Research Station, Kenya. M.S. Thesis, Texas A&M University, College Station, Tex.

N.R.C. 1976. Nutrient requirements of domestic animals, No. 4. Nutrient requirement of beef cattle. 5th revised ed. National Academy of Science, National Research Council, Washington, D.C.

Payne, W. J. A. 1963. A brief study of cattle browsing behavior in a semi-arid area of Tanzania. East Afric. Agric. For. J. 29:131-133.

Payne, W. J. A. and H. G. Hutchison. 1963. Water metabolism of cattle in East Africa. J. Agric. Sci. 61:255-266.

Poppi, D. P., B. W. Norton, D. J. Minson and R. W. Hendricksen. 1980. The validity of the critical size theory for particles leaving the rumen. J. Agric. Sci. 94:275-280.

Pratt, D. J., P. J. Greenway and M. D. Gwynne. 1966. A classification of East African rangelands, with an appendix of terminology. J. Appl. Ecol. 3:369-382.

Rector, B. S. and J. E. Huston. 1976. Nutrient composition of some Edwards Plateau forage plants. Texas Agr. Exp. Sta. PR-3399.

Rector, B. S. and J. E. Huston. 1982. Composition of diets selected by livestock grazing in combination. p. 320. In: Abstract of papers. Joint Meeting, Am. Soc. Anim. Sci. and Canada Society.

Rosiere, R. E., R. F. Beck and J. D. Wallace. 1975. Cattle diets on semiarid grassland: botanical composition. J. Range Manage. 28:89-93.

Rudolf, J. F. and C. L. Ramon. 1981. SAS for linear models: A guide to the ANOVA and GLM procedures.

Scales, G. H., C. L. Streeter and A. H. Dehman. 1971. Nutritive value and consumption of range forage. Proc. West. Sec. Amer. Soc. Anim. Sci. 22:83-88.

Skovlin, J. M. 1971. A method of determining range condition and trend in Kenya. Terminal Report. Range Management Div., Minidstry of Agriculture, Kenya. UND/FAO. 75 p. (mimeo).

Smith, J. D. and O. Julander. 1953. Deer and sheep competition in Utah. J. Wildl. Manage. 17:101-112.

Nagy, J. G., T. Hakonson and K. L. Knox. 1969. Effects of quality on food intake in deer. Trans. No. Amer. Wildl. Natur. Resource Conf. 34:146-154.

Ndegwa, W. N. 1982. Vascular plant flora of Kiboko Range Research Station, Kenya. M.S. Thesis, Texas A&M University, College Station, Tex.

N.R.C. 1976. Nutrient requirements of domestic animals, No. 4. Nutrient requirement of beef cattle. 5th revised ed. National Academy of Science, National Research Council, Washington, D.C.

Payne, W. J. A. 1963. A brief study of cattle browsing behavior in a semi-arid area of Tanzania. East Afric. Agric. For. J. 29:131-133.

Payne, W. J. A. and H. G. Hutchison. 1963. Water metabolism of cattle in East Africa. J. Agric. Sci. 61:255-266.

Poppi, D. P., B. W. Norton, D. J. Minson and R. W. Hendricksen. 1980. The validity of the critical size theory for particles leaving the rumen. J. Agric. Sci. 94:275-280.

Pratt, D. J., P. J. Greenway and M. D. Gwynne. 1966. A classification of East African rangelands, with an appendix of terminology. J. Appl. Ecol. 3:369-382.

Rector, B. S. and J. E. Huston. 1976. Nutrient composition of some Edwards Plateau forage plants. Texas Agr. Exp. Sta. PR-3399.

Rector, B. S. and J. E. Huston. 1982. Composition of diets selected by livestock grazing in combination. p. 320. In: Abstract of papers. Joint Meeting, Am. Soc. Anim. Sci. and Canada Society.

Rosiere, R. E., R. F. Beck and J. D. Wallace. 1975. Cattle diets on semiarid grassland: botanical composition. J. Range Manage. 28:89-93.

Rudolf, J. F. and C. L. Ramon. 1981. SAS for linear models: A guide to the ANOVA and GLM procedures.

Scales, G. H., C. L. Streeter and A. H. Dehman. 1971. Nutritive value and consumption of range forage. Proc. West. Sec. Amer. Soc. Anim. Sci. 22:83-88.

Skovlin, J. M. 1971. A method of determining range condition and trend in Kenya. Terminal Report. Range Management Div., Minidstry of Agriculture, Kenya. UND/FAO. 75 p. (mimeo).

Smith, J. D. and O. Julander. 1953. Deer and sheep competition in Utah. J. Wildl. Manage. 17:101-112.

Smith, T. M., A. L. Lesperance, V. R. Bohman, R. A. Breehbill and K. W. Brown. 1968. Intake and indigestibility of forages grazed by cattle on a southern Nevada range. Proc. West. Soc. Amer. Anim. Sci. 19:277.

Springfield, H. W. and H. G. Reynolds. 1951. Grazing preferences of cattle for certain reseeding grasses. J. Range Manage. 4:83-87.

Steel, R. G. B. and J. H. Torrie. 1980. Principles and Procedures of Statistics. 2nd ed. McGraw-Hill Book Company, New York.

Streeter, C. L., D. C. Clanton and D. E. Hoehne. 1968. Influence of advance in season on nutritive forage consumed by grazing cattle. Ph.D. Thesis, Univ. of Nebraska, Lincoln.

Swift, R. W. 1948. Deer select most nutritious forages. J. Wildl. Manage. 12:109-110.

Taylor, C. A., Jr. 1973. The botanical composition of cattle diets on a 7-pasture, high-intensity, low-frequency grazing system. M.S. Thesis, Texas A&M University, College Station, Texas.

Thetford, F. O., R. D. Pieper and A. B. Nelson. 1971. Botanical and chemical composition of cattle and sheep on pinyon-juniper grassland range. J. Range Manage. 24:425-431.

Theurer, C. B., A. L. Lesperance and J. D. Wallace. 1976. Botanical composition of the diet of livestock grazing native range. Arizona Agr. Exp. Sta. Bull. 233.

Thomas, D. B. and D. J. Pratt. 1967. Bush control studies in the drier areas of Kenya. IV. Effects of controlled burning on secondary thickets in upland *Acacia* woodland. J. Appl. Ecol. 4:432-435.

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

Van Dayne, G. M. and H. F. Heady. 1965. Dietary chemical composition of cattle and sheep grazing on a dry annual range. J. Range Manage. 18:78-86.

Van Dyne, G. M. and J. L. Van Horn. 1959. The hole in the throat technique. Montana Wool Growers 33:52.

Van Rensburg, H. J. 1969. In: Management and utilization of pastures. East Africa Pasture and Fodder Crop Studies. FAO/UNDP 3:1-118.

Van Soest, P. J. 1967. Development of a comprehensive system of feed analyses and its application to forages. J. Anim. Sci. 26:119-128.

Van Soest, P. J. and R. H. Wine. 1967. Use of detergents in the analysis of fibrous feeds. IV. The determination of plant cell wall constituents. J. Assoc. Official Anal. Chem. 50:50-55.

Ventura, M. J., E. Moore, O. C. Ruelke and D. G. Franke. 1975. Effects of maturity and protein supplementation on voluntary intake and nutrient digestibility of pargola digitgrass hays. J. Anim. Sci. 40:769-774.

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., J. C. Free and A. H. Denham. 1972. Seasonal changes in herbage and cattle diets on Sandhill grassland. J. Range Manage. 25:100-104.

Warner, A. C. I. 1976. Rumen metabolism of nitrogenous compounds. pp. 227-252. In: D. C. Church (ed.), Digestible Physiology and Nutrition of Ruminants (2nd ed.). O&B Books, Corvallis, Oreg.

Whyte, R. O. 1947. The use and misuse of shrubs and trees as fodder. Jt. Publ. Commonwealth Agr. Bureau 10.

Whyte, R. O. 1968. Grasslands of the Monsoon. Frederick A. Praeger, Publ., New York.

Wilson, A. G., S. M. Hirst and R. P. Ellis. 1977. Determination of feeding preferences in wild ruminants from fecal samples. J. Wildl. Manage. 41:70-75.

Appendix

Appendix Table 1. Monthly herbaceous standing crop (kg/ha) by derived categories for Light (L), Moderate (M) and Heavy (H) canopy condition in *Acacia senegal*/*Digitaria macroblephara* community in 1982 at NNRS, Kiboko, Kenya.

Species/forage class	Herbaceous category											
	June				July				August			
	L	M	H	α	L	M	H	α	L	M	H	α
Bothriochloa insculpta	199 ns[1]	110	26	0.2	175 ns	282	157	0.5	85 ns	117	123	0.7
Cenchrus ciliaris	149 ns	129	39	0.3	47 ns	130	119	0.8	26 ns	25	45	0.1
Chloris roxburghiana	381 a[2]	134 b	182 ab	0.02	643 a	85 b	340 b	0.002	234 ns	136	270	0.4
Digitaria macroblephara	495 b	1420 a	1170 a	0.003	1160 b	934 b	1523 a	0.05	748 b	1633 a	1159 ab	0.006
Eragrostis caespitosa	136 ns	74	14	0.6	155 ns	66	9	0.1	89 ns	149	20	0.3
Microchloa kunthii	86 ns	182	69	0.06	104 ns	114	157	0.6	18 b	95 a	44 ab	0.05
Sporobolus pellucidea	81 ns	38	135	0.1	109 ns	176	94	0.3	118 ns	64	13	0.4
Other grass/grasslikes	63	1389	1146	--	244	41	11	--	88	1009	1111	--
Total grass/grasslikes	1590 ns	2198	1728	0.1	2637 a	1828 b	2410 a	0.07	1426 b	2228 a	1741 ab	0.01
Total forbs	98 ns	19	7	0.4	70 ns	6	81	0.07	9 ns	1	7	0.4
Total herbage	1688 ns	2217	1735	0.2	2713 a	1834 b	2491 a	0.02	1435 b	2229 a	1748 ab	0.01

[1]Means within derived herbaceous categories by month are not significantly different ($\alpha = 0.05$).
[2]Means followed by the same letter between bush cover classes within derived herbaceous category are not significantly different ($\alpha = 0.05$).

Appendix Table 1 (continued).

Species/forage class	Herbaceous category											
	September				October				November			
	L	M	H	α	L	M	H	α	L	M	H	α
<u>Bothriochloa insculpta</u>	312 ns	135	76	0.2	141 ns	129	149	0.4	165 ns	105	101	0.2
<u>Cenchrus ciliaris</u>	92 ns	34	57	0.4	42 ns	9	15	0.3	119 ns	39	20	0.2
<u>Chloris roxburghiana</u>	416 ns	44	294	0.2	206 ns	224	189	0.9	643 a	91 b	83 b	0.0001
<u>Digitaria macroblephara</u>	792 b	1096 a	1497	0.03	402 c	1041 b	1779 a	0.0001	1196 ns	1166	1289	0.9
<u>Eragrostis caespitosa</u>	247 ns	194	4	0.1	49 ns	104	0	0.2	51 ns	69	41	0.9
<u>Microchloa kunthii</u>	83 a	35 ab	206	0.05	18 ns	46	26	0.2	31 ns	47	44	0.8
<u>Sporobolus pellucides</u>	66 ns	87	230	0.4	63 ns	66	9	0.1	105 ns	68	36	0.1
Other grass/grasslikes	144	9	4	--	109	1	5	--	10	48	31	--
Total grass/grasslikes	2152 ns	1634	2182	0.2	1030 c	1620 b	2172 a	0.0001	2410 ns	1633	1647	0.004
Total forbs	35 ns	3	--	0.2	3 ns	6	3	0.7	255 a	296	206 ab	0.01
Total herbage	2187 ns	1637	2182	0.2	1033 c	1626 b	2175 a	0.0001	2665 a	1662 b	1853 b	0.0006

[1]Means within derived herbaceous categories by month are not significantly different (α = 0.05).
[2]Means followed by the same letter between bush cover classes within derived herbaceous category are not significantly different (α = 0.05).

Appendix Table 2. Plant species composition (%) derived from available forage in an Acacia senegal/Hermania alhiensis/Digitaria macroblephara community of varying degree of canopy cover in 1982 at NRRS, Kiboko, Kenya.

Forage class/species	June				July				August			
	L	M	H	α[1]	L	M	H	α	L	M	H	α
GRASS/GRASSLIKES												
Bothriochloa insculpta	12.3 a[2]	5.2 b	1.1 b	0.008	8.0 ns	13.0	7.0	0.3	7.2 ns	5.6	6.8	0.9
Carex sp.	1.4	P	1	0.5	1.0 ns	1.0	1.0	0.9	T	T	1.0	0.5
Cenchrus ciliaris	8.4 ns[3]	4.7	2.8	0.4	1.0 ns	4.0	3.0	0.6	4.9 ns	1.1	2.0	0.4
Chloris roxburghiana	24.0 a	6.3 b	8.0 b	0.003	22.0 a	4.9 b	12.5 ab	0.007	19.2 ns	5.0	16.7	0.09
Digitaria macroblephara	32.5 b	62.5 a	56.6 a	0.0018	43.1 ns	54.1	57.7	0.1	39.7 b	73.4 a	62.8 a	0.002
Enteropogon macrostachyus	1.0	P	P	-	P	P	P	-	P	P	P	-
Eragrostis caespitosa	4.2 ns	4.0	1.0	0.6	5.0	3.9	T	0.2	6.4 ns	6.3	1.1	0.3
Microchloa kunthii	4.5 ns	10.0	5.6	0.2	3.7 ns	7.5	7.1	0.3	3.5 ns	4.5	1.8	0.8
Sporobolus pellucides	5.0 ns	2.3	7.7	0.4	3.5 ns	8.6	2.6	0.3	6.5 a	1.2 ab	1.0 b	0.05
Other grasses	1.4	2.9	3.5	-	11.5	2.2	4.7	-	2.7	T	4.4	-
FORBS												
Asparagus sp.	P[4]	P	P	-	P	P	P	-	P	P	P	-
Commelina bengalensis	T[5]	T	1.0	0.2	T	T	P	0.4	P	P	P	-
Indigofera sp.	T	T	T	0.002	P	P	P	-	P	P	P	-
Talinum kafrum	P	T	T	0.02	P	P	P	0.3	P	P	P	0.3
Other forbs	3.2	0.4	T	-	4.6	T	4.1	-	1.2 ns	P	T	-
BROWSE												
Acacia senegal	P	T	3	0.005	T	T	1.0	0.005	1.0	T	1.0	0.2
Boscia sp.	P	P	P	0.3	P	P	P	0.3	T	P	P	0.2
Grewia villosa	1.0	T	4	0.4	1.0	T	1.7	0.5	1.6	T	T	0.3
Hermania alhiensis	1.0	T	4	0.04	T	T	1.0	0.01	1.0	T	1.5	0.1
Other browse	T	T	T	-	P	T	1.0	-	5.8	T	1.7	-

[1] Level at which parameter is significantly different.
[2] Means followed by the same letter in the row are not significantly different (α = 0.05).
[3] Means within plant composition class are not significantly different (α = 0.05).
[4] Present but not sampled.
[5] Composition less than 0.5%.

Appendix Table 2 (continued).

	Plant species composition											
	September				October				November			
	L	M	H	α	L	M	H	α	L	M	H	α
GRASS/GRASSLIKES												
Bothriochloa insculpta	12.3 ns	6.8	5.8	0.4	11.5 ns	7.3	6.6	0.6	6.8 ns	7.1	4.8	0.8
Carex sp.	P	P	T	0.4	T	P	P	0.4	1.0 ns	1.0	1.0	0.9
Cenchrus ciliaris	4.0 ns	1.8	2.4	0.7	5.0 ns	1.0	1.0	0.1	3.7 ns	2.1	1.0	0.2
Chloris roxburghiana	21.1a	2.3 b	14.2 ab	0.03	11.9 ns	12.7	13.0	0.8	23.4 a	6.5 b	6.3 b	0.002
Digitaria macroblephara	36.9 b	67.8 a	64.9 ab	0.003	45.9 b	66.3 a	74.1 a	0.01	41.8 b	65.6 a	58.8 ab	0.04
Enteropogon macrostachyus	P	P	P	-	P	P	P	-	P	P	P	-
Eragrostis caespitosa	10.4	13.4	T	0.1	3.4	5.5	P	0.2	1.7 ns	4.8	2.3	0.7
Microchloa kunthii	6.0 a	1.8 b	1.3 b	0.04	2.0 ns	2.8	1.2	0.2	1.3 ns	3.1	3.2	0.3
Sporobolus pellucides	3.4 ns	4.9	9.9	0.3	3.8 ns	3.6	1.0	0.4	4.2 ns	3.4	3.1	0.9
Other grasses	4.7	1:0	T	-	11.7	T	T	-	3.3	1.1	T	-
FORBS												
Asparagus sp.	P	P	P	-	P	P	P	-	P	P	P	-
Commelina bengalensis	1.0	P	P	0.2	P	T	P	0.4	1.0	1.0	P	0.4
Indigofera sp.	P	P	P	-	P	P	P	-	P	P	P	-
Talinum kafrum	P	P	P	0.2	P	T	T	0.09	P	T	T	0.1
Other forbs	T	T	P	-	1.2	T	T	-	8.1	1.5	8.4	-
BROWSE												
Acacia senegal	T	T	T	0.2	T	T	T	0.4	T	1.0	2.7	0.02
Boscia sp.	P	P	P	0.3	P	P	P	0.4	P	P	P	0.2
Grewia villosa	T	P	1.0	0.5	1.0	T	T	0.6	1.0	T	1.6	0.6
Hermania alhiensis	T	T	T	0.3	1.0	T	P	0.4	1.0 b	1.0 b	3.8 a	0.002
Other browse	T	T	0.1	-	1.7	1.0	2.5	-	T	0.9	2.6	-

[1]Level at which parameter is significantly different.
[2]Means followed by the same letter in the row are not significantly different (α = 0.05).
[3]Means within plant composition class are not significantly different (α = 0.05).
[4]Present but not sampled.
[5]Composition less than 0.5%.

Appendix Table 3. Botanical composition of heifer diets selected by month from various bush canopy conditions (Light (L), Moderate (M) and Heavy (H)) in *Acacia senegal/Hermania alhiensis/Digitaria macroblephara* community in 1982 at NRRS, Kiboko, Kenya.

Forage class/species	June				July				August			
	L	M	H	α[1]	L	M	H	α	L	M	H	α
GRASS												
Bothriochloa insculpta	T[2]	1.0	T	0.5	T	1.0	T	0.6	T	T	T	0.02
Cenchrus ciliaris	1.8 b[3]	4.2 a	1.0 c	0.001	T	1.0	1.0	0.7	T	T	T	0.04
Chloris roxburghiana	5.3 ns[4]	9.3	9.1	0.3	1.0 ns	1.9	1.7	0.5	T	T	T	0.01
Digitaria macroblephara	87.4 ns	76.6	86.7	0.001	97.6 ns	95.5	95.9	0.0001	98.1 ns	98.4	99.2	0.001
Eragrostis caespitosa	4.5 a	5.3 a	2.0 b	0.05	1.0	1.0	T	0.0002	1.0	T	T	0.09
Sporobolus pellucides	1.0 b	3.0 a	1.1 b	0.02	1.0 ns	1.0	1.0	0.4	T	T	T	0.04
Total grass	92.6 ns	99.1	99.8	0.4	99.8 ns	99.9	99.8	0.9	99.9 ns	99.9	99.7	0.4
FORBS												
Asparagus sp.	T	T	P[4]	0.6	P	P	P	-	P	P	P	-
Commelina bengalensis	6.9	P	T	0.4	P	P	P	0.4	P	P	8.2	-
Talinum caffrum	P[5]	P	P	0.4	P	P	P	-	P	P	P	-
Total forbs	7.0 ns	T	T	0.4	P	P	P	-	P	P	8.2	0.4
BROWSE												
Acacia senegal	P	P	P	-	P	P	P	-	P	P	P	0.4
Boscia sp.	P	1.0	P	0.3	P	P	T	0.6	P	P	P	-
Hermania alhiensis	P	T	P	-	P	P	P	-	P	P	T	-
Unidentified browse	T	T	P	0.4	T	T	T	0.2	T	T	T	0.8
Total browse	T	1.0	P	0.3	T	T	T	0.3	T	T	T	0.2

[1]Level at which parameter is significantly different.
[2]Composition less than 0.5%.
[3]Means within row with the same letter are not significantly different (α = 0.05).
[4]Means within bush canopy were not significantly different (α = 0.05).
[5]Present but not eaten.

Appendix Table 3 (continued).

Forage class/species	September				October				November			
	Botanical composition											
	L	M	H	α	L	M	H	α	L	M	H	α
GRASS												
Bothriochloa insculpta	T	T	T	0.5	T	T	T	0.06	T	T	T	0.6
Cenchrus ciliaris	T	T	T	0.2	T	T	T	0.9	1.0 b	1.3 a	1.0 b	0.001
Chloris roxburghiana	1.0	T	1.0	0.03	2.3 ns	2.1	4.5	0.9	4.1 ns	3.9	3.4	0.7
Digitaria macroblephara	97.1 ns	89.0	97.9	0.1	94.3	93.2	89.2	0.8	93.0 ns	92.5	93.9	0.004
Eragrostis caespitosa	1.1	1.6	T	0.004	2.3 a	1.5 ab	1.0 b	0.0002	T	1.0	T	0.1
Sporobolus pellucidea	1.0 b	3.0 a	1.1 b	0.02	1.0 ns	1.0	1.0	0.4	T	T	T	0.4
Total grass	99.9 ns	91.6	99.9	0.4	99.9 a	97.9 ab	95.3 b	0.1	99.6 ns	97.7	99.6	0.9
FORBS												
Asparagus sp.	P	P	P	-	P	P	P	-	P	P	P	-
Commelina bengalensis	P	8.0	P	-	P	P	P	-	T	T	T	0.3
Talinum kafrum	P	P	P	-	T	1.7	4.6	0.0001	T	T	T	0.09
Total forbs	P	8.0	P	1.4	T	1.7	4.6	0.0002	T	T	T	0.6
BROWSE												
Acacia senegal	P	P	P	-	P	P	P	-	P	P	P	-
Boscia sp.	P	P	P	-	P	P	P	-	P	P	P	-
Hermania alhiensis	P	T	P	-	T	T	T	0.02	T	P	P	-
Unidentified browse	T	T	T	0.9	T	T	T	0.004	T	T	T	0.2
Total browse	T	T	T	0.9	T	T	T	0.01	T	T	T	0.2

[1] Level at which parameter is significantly different.
[2] Composition less than 0.5%.
[3] Means within row with the same letter are not significantly different (α = 0.05).
[4] Means within bush canopy were not significantly different (α = 0.05).
[5] Present but not eaten.

Appendix Table 4. Unweighted fragments (%) of heifer diets selected by month from various categories of bush condition pastures in Acacia senegal/ Hermania alhiensis/Digitaria macroblephara community in 1982 at NRRS, Kiboko, Kenya.

Species	Bush condition pastures											
	June				July				August			
	L	M	H	α[1]	L	M	H	α	L	M	H	α
Acacia senegal	P[2]	P	P[3]	-	T	P	P	-	P	P	T	0.4
Asparagus sp.	T[3]	T	P	0.6	P	P	P	-	P	P	P	-
Bothriochloa insculpta	T	10	T	0.5	58	T	T	0.04	T	10	T	0.02
Boscia sp.	P	T	P	0.3	T	P	T	0.6	P	P	P	-
Cenchrus ciliaris	12 a[4]	17 a	10 b	0.001	10 ns	10	1.0	0.7	10 ns	10	10	0.06
Chloris roxburghiana	19 a	18 a	10 b	0.001	10 ns	10	1.0	0.5	10 ns	10	10	0.06
Commelina bengalensis	P	T	P	0.4	P	P	P	0.4	P	P	P	-
Digitaria macroblephara	51 c	36 b	72 a	0.0001	50 b	60 b	70 a	0.0001	63 b	67 b	71 a	0.001
Eragrostis caespitosa	12 a	10 ab	10 b	0.05	20 a	10 b	10 b	0.002	12 ns	8	T	0.09
Hermania alhiensis	P	P	P	-	P	P	P	-	P	P	P	-
Sporobolus pellucides	T	10	10	0.02	10 ns	10	10	0.4	7 ns	6	6	0.4
Talinum kafrum	P	T	P	0.4	P	P	P	-	P	P	P	-
Unidentified herbage	T	P	P	0.4	T	T	T	0.2	1	1	T	0.8
Total grass/grasslike	98 ns[5]	92	100	0.1	99	100	99	0.1	99 ns	100	100	0.1
Total forbs	T	T	P	0.4	T	P	T	0.6	P	P	P	
Total herbage	98 ns	92	100	0.1	99	100	100	0.1	99 ns	100	100	0.1
Total browse	T	T	P	0.3	T	T	T	0.3	1	T	T	0.9

[1] Level at which parameter is significantly different.
[2] Present but not consumed.
[3] Percent diet fragment less than 0.5%.
[4] Means within row were not significantly different (α = 0.05).
[5] Means within row with the same letter are not significantly different (α = 0.05).

Appendix Table 4 (continued).

Species	Bush condition pastures											
	September				October				November			
	L	M	H	α	L	M	H	α	L	M	H	α
Acacia senegal	P	P	P	-	P	P	P	-	P	P	P	-
Asparagus sp.	P	P	P	-	P	P	P	-	P	P	P	-
Bothriochloa insculpta	5 ns	5	4	0.5	4 a	3 ab	2 b	0.05	1 ns	1	1	0.6
Boscia sp.	P	P	P	-	P	P	P	-	P	P	P	-
Cenchrus ciliaris	6 ns	4	6	0.2	2 ns	2	2	0.9	5 b	8	8	0.01
Chloris roxburghiana	9 ab	7 b	10 a	0.03	13 ns	12	13	0.9	2 ns	2	1	0.7
Commelina bengalensis	P	P	P	-	P	P	P	-	P	P	P	-
Digitaria macroblephara	63 ns	62	68	0.1	59 ns	59	61	0.8	57 b	59 b	61 a	0.004
Eragrostis caespitosa	10 b	16 a	5 c	0.004	15 a	12 a	3 b	0.0022	9 ns	7	5	0.1
Hermania alhiensis	P	P	P	-	P	1	P	0.02	P	P	P	-
Sporobolus pellucidus	7 ns	5	8	0.1	6 ns	7	7	0.7	11 ns	9	8	0.1
Talinum kafrum	P	P	P	-	T	3	10	0.0001	1	T	T	0.1
Unidentified herbage	T	T	T	0.9	T	1	2	0.004	1	T	T	0.3
Total grass/grasslikes	100 ns	100	100	0.5	100 a	95 b	88 c	0.001	97 b	99 a	99 a	0.002
Total forbs	P	P	P	-	T	3	9	0.0001	1	T	T	0.01
Total herbage	100 ns	100	100	0.9	100 a	98 b	97 b	0.002	98 b	100	100 a	0.03
Total browse	T	T	T	0.8	T	2	1	0.01	2	T	T	0.2

[1] Level at which parameter is significantly different.
[2] Present but not consumed.
[3] Percent diet fragment less than 0.5%.
[4] Means within row were not significantly different (α = 0.05).
[5] Means within row with the same letter are not significantly different (α = 0.05).

Appendix Table 5. Selection ratio values for forage species and classes collected by heifers on bush canopy condition pastures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in June. 1982 at NRRS, Kiboko, Kenya.

Forage class/species	Bush canopy condition		
	Light	Moderate	Heavy
GRASS			
Bothriochloa insculpta	-5.2 ± 4.4	-0.4 ± 3.1	0.5 ± 1.8
Cenchrus ciliaris	+1.8 ± 1.8	+5.7 ± 3.4	+2.2 ± 5.0
Chloris roxburghiana	-1.2 ± 0.8	4.9 ± 0.2	0.1 ± 1.2
Digitaria macroblephara	+2.2 ± 1.2	-2.7 ± 0.5	+1.2 ± 0.2
Eragrostis caespitosa	4.7 ± 2.9	+4.2 ± 4.7	7.3 ± 6.4
Sporobolus pellucides	-4.7 ± 1.5	+3.4 ± 2.5	-2.2 ± 3.6
Total grass	0.7 ± 0.6	+0.4 ± 0.6	+1.3 ± 0.5
Total herbage	0.7 ± 0.6	0.5 ± 0.6	+1.4 ± 0.6
FORBS			
Asparagus sp.	+8.2 ± 9.3[1]	8.2 ± 9.3	NA
Commelina bengalensis	0 ± 0.1	NC	3.3 ± 6.1
Talinum kafrum	+8.2 ± 8.5	+9.0 ± 6.9	NA
Total forbs	+4.3 ± 2.8	+7.4 ± 4.9	+4.6 ± 6.9
BROWSE			
Acacia senegal	-9.3 ± 6.4	NC	NC
Boscia sp.	NA[2]	+9.9 ± 8.3[1]	NA
Hermania alhiensis	NC[3]	-5.1 ± 5.8	NC
Unidentified sp.	8.2 ± 9.3[1]	+8.2 ± 9.3	NA
Total browse	-4.0 ± 1.4	6.7 ± 0.6	NC

[1] Species found in diet but not clipped.
[2] Species not available.
[3] Species not consumed.

Appendix Table 6. Selection ratio values for forage and classes collected by cows on bush canopy condition pastures in Acacia senegal/ Hermania alhiensis/Digitaria macroblephara communities in July, 1982 at NRRS, Kiboko, Kenya.

Forage class/species	Bush canopy condition		
	Light	Moderate	Heavy
GRASS			
Bothriochloa insculpta	-1.6 ± 4.4	-4.8 ± 3.1	-3.3 ± 1.8
Cenchrus ciliaris	+5.7 ± 1.8	+0.8 ± 3.4	2.8 ± 5.0
Chloris roxburghiana	-2.2 ± 0.7	+4.6 ± 0.2	-0.2 ± 1.2
Digitaria macroblephara	+1.2 ± 1.2	+0.7 ± 0.5	+0.7 ± 0.2
Eragrostis caespitosa	+3.8 ± 2.9	3.2 ± 4.7	+8.0 ± 6.4
Sporobolus pellucides	+4.1 ± 1.5	-0.9 ± 2.5	+5.2 ± 3.6
Total grass	0.9 ± 0.6	+0.7 ± 0.6	+0.9 ± 0.5
Total herbage	0.8 ± 0.8	0.6 ± 0.6	0.9 ± 0.6
FORBS			
Asparagus sp.	NA[1]	NA	NA
Commelina bengalensis	NA	NC[2]	NC
Talinum kafrum	NC[2]	NC	NA
Total forbs	NC	NC	NC
BROWSE			
Acacia senegal	NC	NC	NC
Boscia sp.	+9.4 ± 8.2[3]	NA	NC
Hermania alhiensis	NC	NC	NC
Unidentified sp.	+9.8 ± 9.3[3]	+9.4 ± 9.3	+9.4 ± 9.3[3]
Total browse	+3.6 ± 1.4	-0.2 ± 0.6	-5.0 ± 2.7

[1] Species not available.
[2] Species not consumed.
[3] Species found in diet but not clipped.

Appendix Table 7. Selection ratio values for forage and classes collected by cows on bush canopy condition pastures in Acacia senegal/ Hermania alhiensis/Digitaria macroblephara communities in August 1982 at NRRS, Kiboko, Kenya.

Forage class/species	Bush canopy condition		
	Light	Moderate	Heavy
GRASS			
Bothriochloa insculpta	-3.0 ± 4.4	-0.5 ± 3.1	-4.3 ± 1.8
Cenchrus ciliaris	+0.2 ± 1.8	+7.4 ± 3.4	+5.3 ± 5.0
Chloris roxburghiana	-3.3 ± 0.8	1.5 ± 0.2	-4.0 ± 1.2
Digitaria macroblephara	+2.2 ± 1.2	-0.5 ± 0.5	+0.6 ± 0.2
Eragrostis caespitosa	+2.8 ± 2.9	+1.0 ± 4.7	+7.2 ± 6.4
Sprobolus pellucides	+0.3 ± 1.5	3.2 ± 2.5	+8.0 ± 3.6
Total grass	0.8 ± 0.6	+0.3 ± 0.6	+0.5 ± 0.5
Total herbage	0.9 ± 0.6	0.3 ± 0.6	0.5 ± 0.6
FORBS			
Asparagus sp.	NA[1]	NA	NA
Commelina bengalensis	+8.2 ± 6.1[2]	NA	NA
Talinum kafrum	NC[3]	NC	NA
Total forbs	+8.2 ± 2.8	NC	NA
BROWSE			
Acacia senegal	NC	NC	NC
Boscia sp.	NC	NA	NC
Hermania alhiensis	NC	NC	NC
Unidentified sp.	+9.6 ± 9.3[1]	+9.4 ± 9.3	+9.8 ± 9.3[1]
Total browse	-1.7 ± 1.4	+3.9 ± 0.6	-5.9 ± 2.7

[1] Species not available.
[2] Species found in diet but not clipped.
[3] Species not consumed.

Appendix Table 8. Selection ratio values for forage and classes collected by cows on bush canopy condition pastures in *Acacia senegal*/ *Hermania alhiensis*/*Digitaria macroblephara* communities in September, 1982 at NRRS Kiboko, Kenya.

Forage class/species	Bush canopy condition		
	Light	Moderate	Heavy
GRASS			
Bothriochloa insculpta	-4.2 ± 4.4	-1.7 ± 3.1	-1.7 ± 1.8
Cenchrus ciliaris	+1.7 ± 1.8	+4.0 ± 3.4	+4.1 ± 5.0
Chloris roxburghiana	-3.9 ± 0.2	+5.0 ± 0.2	-1.7 ± 1.2
Digitaria macroblephara	+2.6 ± 1.2	-0.4 ± 0.5	0.3 ± 0.2
Eragrostis caespitosa	+ 0 ± 2.9	+0.8 ± 4.7	+9.0 ± 6.4
Sporobolus pellucides	+3.4 ± 1.5	+0.4 ± 2.5	-1.1 ± 3.6
Total grass	+0.7 ± 0.6	+0.1 ± 0.6	+0.2 ± 0.5
Total herbage	+0.6 ± 0.6	+0.1 ± 0.6	0.2 ± 0.6
FORBS			
Asparagus sp.	NA[1]	NA	NA
Commelina bengalensis	NC[2]	+8.2 ± 3.0[3]	NC
Talinum kafrum	NC	NC	NA
Total forbs	NC	+8.2 ± 4.9	NC
BROWSE			
Acacia senegal	NC	NC	NC
Boscia sp.	NA	NA	NC
Hermania alhiensis	NC	NC	NC
Unidentified sp.	+9.4 ± 9.5[3]	+9.4 ± 9.3	+9.4 ± 9.3[3]
Total browse	+5.2 ± 1.4	+2.6 ± 0.6	1.0 ± 2.7

[1]Species not available.
[2]Species not consumed.
[3]Species found in diet but not clipped.

Appendix Table 9. Selection ratio values for forage and classes collected by cows on bush canopy condition pastures in Acacia senegal/Hermania alhiensis/Digitaria macroblephara communities in October 1982 at NRRS, Kiboko, Kenya.

Forage class/species	Bush canopy condition Light	Moderate	Heavy
GRASS			
Bothriochloa insculpta	-4.7 ± 4.4	-4.5 ± 3.1	-4.7 ± 1.8
Cenchrus ciliaris	-4.9 ± 1.8	+5.6 ± 3.4	2.8 ± 5.0
Chloris roxburghiana	-1.2 ± 0.8	-0.1 ± 0.2	-0.1 ± 1.2
Digitaria macroblephara	+1.3 ± 1.2	-0.6 ± 0.5	-1.0 ± 0.2
Eragrostis caespitosa	+6.3 ± 2.9	+3.8 ± 4.7	+9.9 ± 6.4
Sporobolus pellucides	+2.5 ± 1.5	+3.1 ± 2.5	+8.1 ± 3.6
Total grass	+0.7 ± 0.6	-0.1 ± 0.6	-0.4 ± 0.5
Total herbage	+0.7 ± 0.6	+0.1 ± 0.6	+0.1 ± 0.6
FORBS			
Asparagus sp.	NA[1]	NA	NA
Commelina bengalensis	NA	NC[2]	NA
Talinum kafrum	+8.2 ± 8.5	+9.9 ± 6.9	NA
Total forbs	+8.2 ± 8.5	9.5 ± 4.9	NA
BROWSE			
Acacia senegal	NC[3]	NC	NC
Boscia sp.	NA	NA	NC
Hermania alhiensis	NC	-8.4 ± 6.9	NC
Unidentified sp.	+9.4 ± 9.3[3]	+9.8 ± 9.3	+9.9 ± 9.3[3]
Total browse	-5.1 ± 1.4	+6.1 ± 0.6	0.8 ± 2.7

[1]Species not available.
[2]Species not consumed.
[3]Species found in diet but not clipped.

Appendix Table 10. Selection ratio values for forage and classes collected by cows on bush canopy condition pastures in *Acacia senegal*/ *Hermania alhiensis*/*Digitaria macroblephara* communities in November, 1982 at NRRS, Kiboko, Kenya.

Forage class/species	Bush condition canopy		
	Light	Moderate	Heavy
GRASS			
Bothriochloa insculpta	-6.8 ± 9.4	-7.7 ± 3.1	-5.5 ± 1.8
Cenchrus ciliaris	+1.6 ± 1.8	+5.9 ± 3.4	+8.3 ± 5.0
Chloris roxburghiana	-2.2 ± 0.8	+3.9 ± 0.2	+3.7 ± 1.2
Digitaria macroblephara	+1.3 ± 1.2	-0.5 ± 0.5	+0.4 ± 0.2
Eragrostis caespitosa	+6.3 ± 2.9	+2.1 ± 4.7	+3.5 ± 6.4
Sporobolus pellucides	+4.5 ± 1.5	4.6 ± 2.5	+4.3 ± 3.6
Total grass	+0.7 ± 0.6	+0.5 ± 0.6	+1.3 ± 0.5
Total herbage	0.8 ± 0.6	+0.5 ± 0.6	1.3 ± 0.6
FORBS			
Asparagus sp.	NA [1]	NA	NA
Commelina bengalensis	-1.8 ± 0.1	-7.9 ± 3.0	+ 0 ± 6.1
Talinum kafrum	+9.6 ± 8.5 [2]	+4.3 ± 6.9	-0.9 ± 5.3
Total forbs	1.5 ± 2.8	-4.1 ± 4.9	+1.3 ± 6.9
BROWSE			
Acacia senegal	NC [3]	NC	NC
Boscia sp.	NA	NA	NC
Hermania alhiensis	NC	NC	NC
Unidentified sp.	+9.8 ± 9.3[1]	+9.4 ± 9.3	+9.8 ± 9.3[1]
Total browse	-1.9 ± 1.4	-5.4 ± 0.6	-7.1 ± 2.7

[1] Species not available.
[2] Species found in diet but not clipped.
[3] Species not consumed.

Appendix Table 11. Preference order (in decreasing order) for forage species and classes selected by cows on the bush canopy condition pastures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in June, 1982 at NRRS, Kiboko, Kenya.

Bush canopy condition[1]		
Light	Moderate	Heavy
Asparagus sp.	*Boscia* sp.	*Bothriochloa insculpta*
Talinum kafrum	*Talinum kafrum*	*Eragrostis caespitosa*
Eragrostis caespitosa	*Asparagus* sp.	*Commelina bengalensis*
Chloris roxburghiana	*Cenchrus ciliaris*	*Cenchrus ciliaris*
Digitaria macroblephara	*Chloris roxburghiana*	*Digitaria macroblephara*
Cenchrus ciliaris	*Eragrostis caespitosa*	*Chloris roxburghiana*
Commelina bengalensis	*Sporobolus pellucides*	*Hermania alhiensis*
Sporobolus pellucides		
Bothriochloa insculpta		
Acacia senegal		

[1]Forage species found in diet but not clipped.

Appendix Table 12. Preference order (in decreasing order) for forage species and classes selected by cows on the bush canopy condition pastures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in July, 1982 at NRRS, Kiboko, Kenya.

Bush canopy condition		
Light	Moderate	Heavy
Boscia sp.[1]	*Chloris roxburghiana*	*Eragrostis caespitosa*
Cenchrus ciliaris	*Eragrostis caespitosa*	*Sporobolus pellucides*
Sporobolus pellucides	*Cenchrus ciliaris*	*Cenchrus ciliaris*
Eragrostis caespitosa	*Digitaria macroblephara*	*Digitaria macroblephara*
Digitaria macroblephara	*Sporobolus pellucides*	*Chloris roxburghiana*
Chloris roxburghiana	*Bothriochloa insculpta*	*Commelina bengalensis*
Bothriochloa insculpta	*Talinum kafrum*	*Acacia senegal*
Talinum kafrum	*Hermania alhiensis*	*Boscia* sp.
Acacia senegal	*Acacia senegal*	*Hermania alhiensis*
Hermania alhiensis		

[1]Forage species found in diet but not clipped.

Appendix Table 13. Preference order (in decreasing order) for forage species and classes selected by cows on the bush canopy condition pastures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in August, 1982 at NRRS, Kiboko, Kenya.

Bush canopy condition		
Light	Moderate	Heavy
Commelina bengalensis[1]	*Cenchrus ciliaris*	*Sporobolus pellucides*
Eragrostis caespitosa	*Sporobolus pellucides*	*Eragrostis caespitosa*
Digitaria macroblephara	*Chloris roxburghiana*	*Cenchrus ciliaris*
Sporobolus pellucides	*Eragrostis caespitosa*	*Digitaria macroblephara*
Cenchrus ciliaris	*Bothriochloa insculpta*	*Chloris roxburghiana*
Bothriochloa insculpta	*Digitaria macroblephara*	*Bothriochloa insculpta*
Chloris roxburghiana	*Talinum kafrum*	*Acacia senegal*
Talinum kafrum	*Acacia senegal*	*Boscia* sp.
Acacia senegal	*Hermania alhiensis*	*Hermania alhiensis*
Boscia sp.		
Hermania alhiensis		

[1]Forage species found in diet but not clipped.

Appendix Table 14. Preference order (in decreasing order) for forage species and classes selected by cows on the bush canopy condition pastures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in September, 1982 at NRRS, Kiboko, Kenya.

Bush canopy condition		
Light	Moderate	Heavy
Sporobolus pellucides	*Commelina bengalensis*[1]	*Eragrostis caespitosa*
Digitaria macroblephara	*Chloris roxburghiana*	*Cenchrus ciliaris*
Cenchrus ciliaris	*Cenchrus ciliaris*	*Digitaria macroblephara*
Eragrostis caespitosa	*Eragrostis caespitosa*	*Sporobolus pellucides*
Chloris roxburghiana	*Sporobolus pellucides*	*Chloris roxburghiana*
Bothriochloa insculpta	*Digitaria macroblephara*	*Bothriochloa insculpta*
Commelina bengalensis	*Bothriochloa insculpta*	*Commelina bengalensis*
Talinum kafrum	*Talinum kafrum*	*Acacia senegal*
Acacia senegal	*Acacia senegal*	*Boscia* sp.
Hermania alhiensis	*Hermania alhiensis*	*Hermania alhiensis*

[1]Forage species found in diet but not clipped.

Appendix Table 15. Preference order (in decreasing order) for forage species and classes selected by cows on the bush canopy condition pastures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in October, 1982 at NRRS, Kiboko, Kenya.

Bush canopy condition		
Light	Moderate	Heavy
Talinum kafrum	*Talinum kafrum*	*Eragrostis caespitosa*
Eragrostis caespitosa	Unidentified sp.	*Sporobolus pellucides*
Sporobolus pellucides	*Cenchrus ciliaris*	*Cenchrus ciliaris*
Digitaria macroblephara	*Eragrostis caespitosa*	*Digitaria macroblephara*
Chloris roxburghiana	*Sporobolus pellucides*	*Chloris roxburghiana*
Bothriochloa insculpta	*Chloris roxburghiana*	*Bothriochloa insculpta*
Cenchrus ciliaris	*Digitaria macroblephara*	*Acacia senegal*
Acacia senegal	*Bothriochloa insculpta*	*Boscia* sp.
Hermania alhiensis	*Hermania alhiensis*	*Hermania alhiensis*
	Commelina bengalensis	
	Acacia senegal	

Appendix Table 16. Preference order (in decreasing order) for forage species and classes selected by cows on the bush canopy condition pastures in Acacia senegal/Hermania alhiensis/Digitaria macroblephara communities in November, 1982 at NRRS, Kiboko, Kenya.

Bush canopy condition		
Light	Moderate	Heavy
Talinum kafrum[1]	Cenchrus ciliaris	Cenchrus ciliaris
Eragrostis caespitosa	Sporobolus pellucides	Sporobolus pellucides
Sporobolus pellucides	Talinum kafrum	Chloris roxburghiana
Cenchrus ciliaris	Chloris roxburghiana	Eragrostis caespitosa
Digitaria macroblephara	Eragrostis caespitosa	Digitaria macroblephara
Chloris roxburghiana	Digitaria macroblephara	Commelina bengalensis
Commelina bengalensis	Bothriochloa insculpta	Talinum kafrum
Bothriochloa insculpta	Commelina bengalensis	Bothriochloa insculpta
	Hermania alhiensis	Acacia senegal
	Acacia senegal	Boscia sp.
		Hermania alhiensis

[1]Forage species found in diet but not clipped.

Appendix Table 17. Botanical composition of heifer diets selected by month from various bush canopy condition pastures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in June, 1982 at NRRS, Kiboko, Kenya.

Species	Bush canopy condition		
	Light	Moderate	Heavy
GRASS/GRASSLIKES			
Bothriochloa insculpta	3.4 ns[1]	4.8 ns	4.3 ns
Cenchrus ciliaris	12.0 a[2]	17.4 a	4.4 b
Chloris roxburghiana	18.8 a	18.1 a	8.0 b
Digitaria macroblephara	50.6 b	36.3 c	72.0 a
Eragrostis caespitosa	11.5 a	9.8 ab	6.4 b
Sporobolus pellucides	1.8 b	5.8 a	4.9 a
Unidentified herbage	--	--	--
Total grass/grasslikes	98.3 ns	92.1 ns	100.0 ns
FORBS			
Asparagus sp.	0.1 ns	0.1 ns	--
Commelina bengalensis	--	1.9 ns	--
Talinum kafrum	--	0.2 ns	--
Total forbs	0.1 ns	2.2 ns	--
Total herbaceous	98.4 ab	94.3 b	100.0 a
BROWSE			
Acacia senegal	--	--	--
Boscia sp.	--	1.9 ns	--
Hermania alhiensis	--	--	--
Unidentified browse	0.1	--	--
Total browse	0.1 ns	1.9 ns	--
PLANT PART			
Leaf	71.5 ns	71.3 ns	74.3 ns
Stem	28.5 ns	28.8 ns	25.7 ns
Leaf:Stem	1:3 ns	1:3 ns	1:3 ns
Live	50.8 ns	49.7 ns	46.1 ns
Dead	49.2 ns	50.3 ns	53.9 ns
Live:Dead	1:1	1:1	1:1

[1]Means within bush canopy condition are not significantly different (α = 0.05).
[2]Means on a line followed by the same letter are not significantly different (α = 0.05).

Appendix Table 18. Botanical compotion of heifer diets selected by month from various bush canopy condition pastures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in July, 1982 at NRRS, Kiboko, Kenya.

Species	Bush canopy condition		
	Light	Moderate	Heavy
GRASS/GRASSLIKES			
Bothriochloa insculpta	5.8 a[2]	4.7 ab	3.5 b
Cenchrus ciliaris	5.0 ns[1]	5.0 ns	5.7 ns
Chloris roxburghiana	14.3 ns	13.4 ns	11.9 ns
Digitaria macroblephara	5.5 b	62.1 a	66.0 a
Eragrostis caespitosa	11.3 a	7.5 b	3.7 a
Sporobolus pellucides	8.3 ns	7.1 ns	8.3 ns
Total grass/grasslikes	99.3 ns	99.8 ns	99.0 ns
Total herbage	99.3 ns	99.8 ns	99.8 ns
FORBS			
Asparagus sp.	--	--	--
Commelina gengalensis	--	--	0.8 ns
Talinum kafrum	--	--	--
Total forbs	--	--	0.8 ns
BROWSE			
Acacia senegal	--	--	--
Boscia sp.	0.3 ns	--	0.3 ns
Hermania alhiensis	--	--	--
Unidentified shrubs	0.8 ns	0.3 ns	0.3 ns
Total browse	1.1 ns	0.3 ns	0.5 ns
PLANT PART			
Leaf	68.5 ns	70.8 ns	73.4 ns
Stem	31.5 ns	29.2 ns	26.6 ns
Leaf:Stem	1:3 ns	1:3 ns	1:3 ns
Live	22.7 ns	29.7 ns	29.9 ns
Dead	77.3 ns	70.3 ns	70.1 ns
Live:Dead	1:0.3	1:0.5	1:0.5

[1]Means within bush canopy condition are not significantly different ($\alpha = 0.05$).

[2]Means on a line followed by the same letter are not significantly different ($\alpha = 0.05$).

Appendix Table 19. Botanical composition of heifer diets selected by month from various bush canopy condition pastures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in August, 1982 at NRRS, Kiboko, Kenya.

Species	Bush canopy condition Light	Moderate	Heavy
GRASS/GRASSLIKES			
Bothriochloa insculpta	3.8 ab[2]	5.1 a	2.7 b
Cenchrus ciliaris	5.1 b	7.3 a	6.3 ab
Chloris roxburghiana	9.6 a	6.8 b	7.1 b
Digitaria macroblephara	62.5 b	66.8 b	71.3 a
Eragrostis caespitosa	11.5 ns[1]	7.7 ns	6.9 ns
Sporobolus pellucides	6.9 ns	6.3 ns	5.4 ns
Total grass/grasslikes	99.4 ns	100.0 ns	99.6 ns
Total herbage	99.4 ns	100.0 ns	99.6 ns
FORBS			
Asparagus sp.	--	--	--
Commelina bengalensis	--	--	--
Talinum kafrum	--	--	--
Total forbs	--	--	--
BROWSE			
Acacia senegal	--	--	0.1 ns
Boscia sp.	--	--	--
Hermania alhiensis	--	--	--
Unidentified shrubs	0.6 ns	0.5 ns	0.3 ns
Total browse	0.6 ns	0.5 ns	0.4 ns
PLANT PARTS			
Leaf	58.5 ns	62.5 ns	53.8 ns
Stem	41.5 ns	37.5 ns	46.2 ns
Leaf:Stem	1:2 ns	1:2 ns	1:1 ns
Live	25.7 ns	32.6 ns	23.2 ns
Dead	74.3 ns	67.4 ns	76.8 ns
Live:Dead	1:0.4 ns	1:0.5 ns	1:0.3 ns

[1]Means within bush canopy condition are not significantly different ($\alpha = 0.05$).

[2]Means on a line followed by the same letter are not significantly different ($\alpha = 0.05$).

Appendix Table 20. Botanical composition of heifer diets selected by month from various bush canopy condition pastures in _Acacia senegal_/ _Hermania alhiensis_/_Digitaria macroblephara_ communities in September, 1982 at NRRS, Kiboko, Kenya.

Species	Bush canopy condition		
	Light	Moderate	Heavy
GRASS/GRASSLIKES			
Bothriochloa insculpta	5.1 ns[1]	4.8 ns	4.1 ns
Cenchrus ciliaris	5.7 ns	4.3 ns	5.8 ns
Chloris roxburghiana	9.2 ab[2]	7.0 b	10.2 a
Digitaria macroblephara	63.3 ns	62.4 ns	68.3 ns
Eragrostis caespitosa	10.4 ab	15.8 a	4.8 b
Sporobolus pellucides	6.8 ns	5.3 ns	7.8 ns
Total grass/grasslikes	99.7 ns	99.7 ns	99.7 ns
Total herbage	99.7 ns	99.7 ns	99.7 ns
FORBS			
Asparagus sp.	--	--	--
Commelina bengalensis	--	--	--
Talinum kafrum	--	--	--
Total forbs	--	--	--
BROWSE			
Acacia senegal	--	--	--
Boscia sp.	--	--	--
Hermania alhiensis	--	--	--
Unidentified shrubs	0.3 ns	0.3 ns	0.3 ns
Total browse	0.3 ns	0.3 ns	0.3 ns
PLANT PARTS			
Leaf	62.1 a	53.3 b	68.0 a
Stem	37.9 b	46.7 a	32.0 b
Leaf:Stem	1:2	1:1	1:3
Live	29.6 b	42.0 a	30.8 b
Dead	70.4 a	58.0 b	69.2 a
Live:Dead	1:0.5	1:0.7	1:0.5

[1]Means within bush canopy condition are not significantly different ($\alpha = 0.05$).
[2]Means on a line followed by the same letter are not significantly different ($\alpha = 0.05$).

Appendix Table 21. Botanical composition of heifer diets selected by month from various bush canopy condition pastures in *Acacia senegal*/*Hermania alhiensis*/*Digitaria macroblephara* communities in October, 1982 at NRRS, Kiboko, Kenya.

Species	Bush canopy condition		
	Light	Moderate	Heavy
GRASS/GRASSLIKES			
Bothriochloa insculpta	4.1 a[2]	2.3 ab	2.4 b
Cenchrus ciliaris	1.7 ns[1]	1.8 ns	1.8 ns
Chloris roxburghiana	13.3 ns	12.4 ns	13.0 ns
Digitaria macroblephara	59.3 ns	58.5 ns	60.5 ns
Eragrostis caespitosa	14.9 a	12.2 a	3.3 b
Sporobolus pellucides	6.3 ns	6.8 ns	7.2 ns
Total grass/grasslikes	99.6 a	94.4 b	88.0 a
Total herbage	99.7 a	97.7 b	97.6 b
FORBS			
Asparagus sp.	--	--	--
Commelina bengalensis	--	--	--
Talinum kafrum	0.1 b	3.3 b	9.5 a
Total forbs	0.1 b	3.3 b	9.5 a
BROWSE			
Acacia senegal	--	--	--
Boscia sp.	--	--	--
Hermania alhiensis	0.0 b	1.1 a	0.0
Unidentified shrubs	0.3 b	0.9 b	2.4 a
Total browse	0.3 b	2.0 a	2.4 a
PLANT PARTS			
Leaf	56.8 ns	61.8 ns	62.5 ns
Stem	43.2 ns	38.2 ns	37.5 ns
Leaf:Stem	1:2	1:2	1:2
Live	53.9 c	78.6 a	66.6 b
Dead	46.1 a	21.4 c	33.4 b
Live:Dead	1:2	1:4	1:2

[1]Means within bush canopy condition are not significantly different ($\alpha = 0.05$).
[2]Means on a line followed by the same letter are not significantly different ($\alpha = 0.05$).

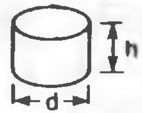
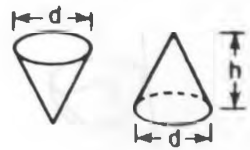
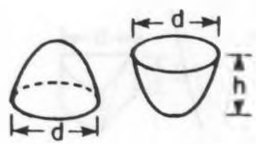
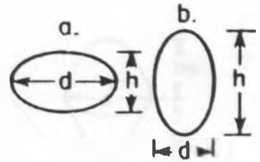
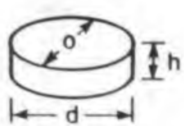
Appendix Table 22. Botanical composition of heifer diets selected by month from various bush canopy condition pastures in *Acacia senegal*/ *Hermania alhiensis*/*Digitaria macroblephara* communities in November, 1982 at NRRS, Kiboko, Kenya.

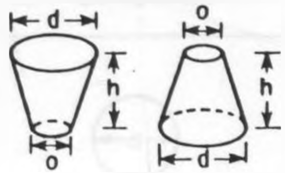
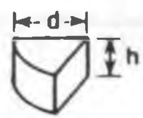
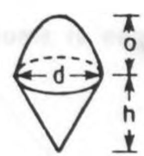
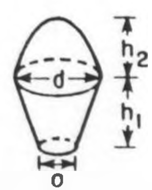
Species	Bush canopy condition		
	Light	Moderate	Heavy
GRASS/GRASSLIKES			
Bothriochloa insculpta	1.3 ns[1]	1.0 ns	1.4 ns
Cenchrus ciliaris	5.2 b[2]	8.4 a	7.5 a
Chloris roxburghiana	15.1 ns	14.6 ns	13.9 ns
Digitaria macroblephara	56.8 b	58.9 b	63.4 a
Eragrostis caespitosa	7.8 ns	7.3 ns	4.8 ns
Sporobolus pellucides	10.9 ns	9.3 ns	7.8 ns
Total grass/grasslikes	97.1 b	99.4 a	99.4 a
Total herbage	98.2 b	99.7 a	99.5 ab
FORBS			
Asparagus sp.	--	--	--
Commelina bengalensis	0.6 ns	0.1 ns	--
Talinum kafrum	0.5 ns	0.2 ns	0.1 ns
Total forbs	1.1 ns	0.3 ns	0.1 ns
BROWSE			
Acacia senegal	--	--	--
Boscia sp.	--	--	--
Hermania alhiensis	--	--	--
Unidentified shrubs	1.0 ns	0.3 ns	0.8 ns
Total browse	1.0 ns	0.3 ns	0.8 ns
PLANT PARTS			
Leaf	77.8 ns	75.7 ns	73.5 ns
Stem	22.3 ns	24.3 ns	26.4 ns
Leaf:Stem	1:4	1:3	1:3
Live	98.7 ns	99.0 ns	98.8 ns
Dead	1.3 ns	1.0 ns	1.2 ns
Live:Dead	1:89	1:100	1:93

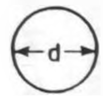
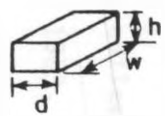
[1]Means within bush canopy condition are not significantly different ($\alpha = 0.05$).
[2]Means on a line followed by the same letter are not significantly different ($\alpha = 0.05$).

Fig. 25: Geometric formulae used in deriving browsable volume

Appendix Table 23: Geometric formulae used to derive browseable volume

SHAPE CODE	SHAPE NAME	DIAGRAM	GEOMETRIC FORMULAE OUTER DIMENSION	INNER DIMENSION
1	Cylinder		$v = \pi (d/2)^2 h$	$v = \pi (d/2 - 2x)^2 (h - x)$
2	Cone		$v = \frac{\pi (d/2)^2 h}{3}$	$v = \frac{\pi (d/2 - 2x)^2 (h - x)}{3}$
3	Paraboloid		$v = \frac{\pi (d/2)^2 h}{2}$	$v = \frac{\pi (d/2 - 2x)^2 (h - x)}{2}$
4	Oblate/Prolate Spheroid		$v_a = 4/3\, \pi h^2 d$ $v_b = 4/3\, \pi h d^2$	$v_a = 4/3\, \pi (h - x)^2 (d - 2x)$ $v_b = 4/3\, \pi (h - x)(d - 2x)^2$
5	Square		$v = h^3$	$v = h(h - 2x)(h - 2x)$
6	Ellipsoid		$v = 4/3\, \pi h (d/2)(o/2)$	$v = 4/3\, \pi (h - x)\left(\frac{d - 2x}{2}\right)\left(\frac{o - 2x}{2}\right)$

SHAPE CODE	SHAPE NAME	DIAGRAM	GEOMETRIC FORMULAE: OUTER DIMENSION	GEOMETRIC FORMULAE: INNER DIMENSION
7	Conic Frustrum		$v = \dfrac{\pi h(d^2 + do + o^2)}{12}$	$v = \dfrac{\pi(h-x)[(d-2x)^2 + (d-2x)(o-2x) + (o-2x)^2]}{12}$
8	Quarter Sphere		$v = \dfrac{4/3\,\pi d^3}{4}$	$v = \dfrac{4/3\,\pi (d-x)^3}{4}$
9	Quadrant Cylinder		$v = .785\,d^2 h$	$v = .785\,(d-2x)^2(h-x)$
10	Parabolic Cone		$v = \dfrac{\pi(d/2)^2 h}{3} + \dfrac{\pi(d/2)^2 o}{2}$	$v = \dfrac{\pi(d/2-x)^2(h-x)}{3} + \dfrac{\pi(d/2-x)^2(o-x)}{2}$
11	Parabolic Frustrum		$v = \dfrac{\pi h_1(d^2 + do + o^2)}{12} + \dfrac{\pi(d/2)^2 h_2}{2}$	$v = \dfrac{\pi h_1\ (d-2x)^2 + (d-2x)(o-2x) + (o-2x)^2}{12} + \dfrac{\pi(d/2-2x)^2(h_2-x)}{2}$

SHAPE CODE	SHAPE NAME	DIAGRAM	GEOMETRIC FORMULAE OUTER DIMENSION	GEOMETRIC FORMULAE INNER DIMENSION
12	SPHERE		$v = 4/3\pi(d/2)^3$	$v = 4/3\pi(d/2 - 2x)^3$
13	RECTANGLE		$v = hwd$	$v = (h-x)(w-2x)(d-2x)$

d,o = diameter
h = height
x = grazing depth
w = width

If $v < 0$, then browsable volume is equal to the outer dimensions of that individual shrub

VITA

Kiptorus Kibet Arap Moi was born on December 24, 1947 at Sinonin Village in Baringo District, RVP, Kenya, to Mr. Kibet Arap Chemitei and Mrs. Tapartai Kimoi Chemitei. He received his early education at Sinonin AIM, Poror D.E.B. Intermediate and Sinonin FP schools from 1955 to 1967, with breaks in between the schools. In 1964 he sat and passed K.P.E. and was selected to join Kabarnet S. School the following year, but lack of school fees let him down. So from 1965 to 1967, he worked as a farm laborer, hotel keeper, a young farmer and a trader. In 1967, his parents and friends urged him to go back to school. In 1971, Kibet graduated from Kebarnet S. School, attended Egerton College in 1972 and graduated in March 1975 with a diploma in Range Management.

From April 1, 1975 to December 1980, Kibet worked as Assistant Range Research Officer at Kiboko Range Research Station under Cattle Section. In late 1980, he was awarded Winrock/USAID/GOK Scholarship, thus had his undergraduate studies at Texas A&M University from January 1981 and graduated with a B.S. in Range Science in May 1982. From June to December 1982, he collected data for his thesis at NRRS, Kiboko, Kenya and in January 1983, he enrolled at Texas A&M University as a graduate student. His permanent address is Sinonin F. P. School, P.O. Box 48, Eldama Ravine, Kenya.