INFLUENCE OF BROWSE AVAILABILITY ON GOAT DIETS IN AN *ACACIA SENEGAL* SAVANNAH OF SOUTH-CENTRAL KENYA

A Thesis

by

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ABSTRACT

Influence of Browse Availability on Goat Diets in an *Acacia senegal* Savannah of South-Central Kenya. (May 1985)

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Chairman of Advisory Committee: Dr. J. W. Stuth

Seasonal effect of bush canopy on dietary selection and nutrition of goats was evaluated at Kiboko, south-central Kenya from June through November, 1982. Three mature esophageally fistulated East-African goats were used in the study on a one day graze, 28-30 day rest cycle. Treatment paddocks (2.25 ha), twice replicated were established in three bush conditions designated as light, moderate, and heavy with 13.1, 30.7 and 46.8% total canopy cover, respectively.

Dietary habits of the goats reflected a high degree of seasonal flexibility between forage classes, species and plant parts. Grass and grasslike species dominated goat diets in the early-dry period, particularly *Cenchrus ciliaris*, *Sporobolus pellucides*, *Eragrostis caespitosa*, *Digitaria macroblephara* and *Chloris roxburghiana*. *Talinum portulacifolium*, which dominated the forb category, became an important component in the diet composition in the early wet season. Overall, browse played the most important role in the diets of goats mainly in the moderate and heavy bushed treatment paddocks from August through November. *Acacia senegal* pods were the major source of food for goats in July and August. Grasses, forbs and woody species comprised 45%, 7% and 47% of goat diets respectively throughout the study period. Leaves, stems and fruits (seeds, pods and grass inflorescences) from all categories of vegetation

were consumed by goats. However, leaves formed the greatest portion of the goat diets throughout the period of study.

Solanum incanum, *Grewia bicolor*, *Acacia mellifera*, *Acacia senegal*, *Cenchrus ciliaris* and *Sporobolus pellucides* were the most preferred woody and grass species during the early-dry and late-dry seasons while *Talinum portulacifolium*, *Solanum incanum*, *Acacia mellifera*, *Commiphora africana*, *Sporobolus pellucides* and *Chloris roxburghiana* were the most preferred vegetation species in the early-wet season.

Nutritional analysis of extrusa indicated that the goats were able to select diets adequate in protein to meet maintenance requirements throughout the period of study. A potential energy deficiency for maintenance was noted in moderate and heavy bushed conditions in August and heavy bushed conditions in September.

DEDICATION

To Njoko, Wangari, Muiruri and Njeri.

ACKNOWLEDGEMENTS

The author wishes to express his sincere gratitude for the support and assistance of many individuals who made this undertaking a success.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure | Page

CHAPTER I

INTRODUCTION

Kenya is 582,646 km^2 in size and one of the three sister countries referred to as "East Africa." Agriculture dominates Kenya's economy. Of the total land area, 10% is considered as agricultural land. Morgan (1969) reported that the fertile high potential area receives rainfall in excess of 1,000 mm per annum, while rangelands in Kenya receive less than 500 mm of rainfall a year. Eighty percent of the country is classified as a rangeland. This semi-arid region supports 60% of the country's estimated 9 million beef cattle and more than 70% of the estimated 8.5 million sheep and goats (Pratt and Gwynne 1977). In addition, 1.0 million camels are found in this area plus a considerable number of wildlife (Ayuko 1978, Bernstein and Jacobs 1983). The livestock and wildlife in this area depend on natural vegetation for their annual nutritional requirements and production (Pratt and Gwynne 1977).

The majority of the nation's population is concentrated in the high potential areas (Mutoka 1981). Kenya ranks 42nd in the world in size of population and the annual growth rate during 1980 was 3.6%. From 1962 to 1980 the population of Kenya rose from 8 million to 15.8 million. Rangelands will become more important as alternative areas to supply surplus food needed to feed the nation.

The savannahs of south-central Kenya exhibit a wide array of bush conditions which have been in part due to overgrazing by general herbivores and suppression of fire. However, knowledge of the browsing

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preference of goats in this region would be a useful criterion in assessing their potential as bush suppressing agents. Presently, very little information exists as to the role bush plays in the diets of goats in this region, most particularly during the most stressful period, the long dry season extending from June through October. Preconceived ideas and lack of reliable observations about goats prevents a better understanding of the role they play in land use, and in many situations, use of goats is perceived to be harmful to the environment (Lopes and Stuth 1984). Goats possess well-proven powers of endurance and although political and social patterns have rendered them unpopular in the developed areas, their significant contributions to less developed regions continues unabated (French 1970).

Specific objectives of this study were:

1. To evaluate the effect of bush canopy on dietary crude protein, organic matter digestibility and digestible energy of goat diets.

2. To evaluate the effect of bush canopy on dietary botanical composition and species preference by goats.

CHAPTER II

LITERATURE REVIEW

Rainfall in the range areas in Kenya is erratic and one of the main objects of pasture management has often been to work out the best way of regulating grass-burning so as to discourage bush encroachment while at the same time permitting as much grazing as possible (Little and Ivens 1965). Grass burning is practised by pastoralists to obtain the advantage of early regrowth. A monitoring programme in the Serengeti, Tanzania, reported that most of the vegetation changes taking place there can be related to grass fires, although the removal of the larger trees throughout the woodlands is mainly due to elephants (UNESCO 1979). Bush encroachment is a problem on 25 million acres of grazing land in Kenya (Heady 1960). However, some shrubs like leleshwa (*Tarchonanthus camphoratus*) have proved fire resistant, but goat grazing, burning and mowing have been reported to suppress regeneration of thorn trees and shrubs while cattle grazing alone may stimulate regeneration of thorn bush (Bogdan 1954). In semi-arid areas, pasture and fodder crops establishment is a problem associated with clearing of woody vegetation and subsequent control of regenerating bush; furthermore, this problem is closely related with acute lack of adequate water supplies (Van Rensburg 1952).

The usual preferences for leaves of woody species by goats have been exploited as means of suppressing bush species. Early studies have indicated that goats would effectively suppress understory and kill some trees up to 6 inches in diameter (Woods 1903). Goats will open up vegetation, thereby increasing the accessibility of cattle to more nutritious forage. Goats have a big part to play in bush suppression on Kenyan rangelands if synergistics effects between animal species are to be realized in an effort to promote meat production from these areas for the benefit of feeding the ever increasing population.

The goat has been associated with man for up to 10,000 years; today the goat is encountered over a wider geographical area than any other domesticated farm animal (French 1970). The feeding habits of goats in East Africa continue to be a subject of some controversy as goats exhibit great plasticity in food habits. Normally, goats browse rather than graze and therefore any range that does not provide browsing cannot be considered adequate for goat production (Williamson and Payne 1959). Rangelands consist of trees, shrubs, perennial grasses, annual grasses and forbs. Most of these forage species are high in nutrient content during the early growth stage, but the nutritional differences among forage classes become more evident as the plants mature. Chemical composition varies with season because of a changing stem-to-leaf ratio and the maturing process associated with translocation of nutrients in the various plant parts; increases in lignin and cellulose content as plants mature decreases digestibility (Church 1977).

Goats will feed readily on most plants and plant parts available including leaves, stems, fruits, inflorescences of grasses, bark and roots, save poisonous species, when forced to do so. Moreover, goats have a higher threshold for bitter tastes than cattle, which will reject bitter plants consumed by goats (French 1970). Hornby and Van Rensburg (1949) emphasized that goats should not be regarded as agents for clearing bush but rather as agents for slowing down the processes of reversion to bushland when kept in reasonable numbers. In a bushland country goats may furnish other classes of livestock with additional grass by suppressing the competing thickets.

Goats have a prehensile upper lip which allows them to be very discrete in the selection of plant parts (Maher 1945). This prehensile upper lip has been credited for their selection of diet constituents (Rector 1982). Compared to cattle or other larger ungulates, the goat has a higher nutrient requirement (per unit body weight) and higher selective ability. It requires higher nutrient content of the diet and must pick and choose efficiently to obtain a high quality diet. Ruminants select a diet that maximizes energy intake but the magnitude of selectivity is determined by feed abundance (Emlen 1966, Hanley 1980).

Goats are browsers and grazers, however, literature on the goat abounds in the most unfounded ideas concerning its feeding habits (French 1970). Huston (1978) reported that browse (tree leaves, small branches and twigs) provided the major portions of goats' diet. Studies have shown that goats have a unique preference for shrubs and tree leaves whether deciduous or evergreen (Cory 1927, Edwards 1948, Wilson 1957). Although goats are traditionally browsers, they also have been shown to be grazers. French (1970) reported that goats will eat leaves, small branches, weeds, herbs, grasses and roots. Goats have a tendency to change their diets with changing seasons and appear to be highly selective in taking only plants and plant parts palatable to them. However, the presence and accessibility of a plant or plant part will determine its grazing susceptibility.

Knight (1964) observed that goats exhibited wide variation in feeding habits associated with different bushland ecological regions in the South Baringo District of Kenya, as well as seasonal variation of these habits with the same region. Grasses comprised 65.4 to 82.5% of goat diets at the Kelewa ecological site and 38.4% at the Chemogoch site. Comparable dietary values for bushes and forbs were 19.6% and 6% at Kelewa and Chemogoch, respectively. These observations were made at the height of the dry season when most of the more palatable foliage had been consumed and the remaining fodder consisted of the dry stems of grasses, pods and seeds of trees and shrubs. Some unpalatable plant species to all types of livestock were sparingly eaten in times of drought and famine.

Bryant et al. (1979) in a study to illuminate dietary interrelationships among sheep, Angora goats, Spanish goats and white-tailed deer under excellent range conditions on the Edwards Plateau of Texas, noted that Angora goat diets comprised 48 and 40% of grass and browse, respectively. These percentages remained fairly constant throughout the year with tendency to shift back and forth from grass to browse. Spanish goats' diets contained 45% of grass and 42% of browse, respectively, throughout the year.

Wilson (1957) made some observations on the browsing habits of the East African dwarf goat at Serere in the Teso District of Uganda and concluded that the goats preferred browse to herbage which was slightly above their normal head-height. The goats did not appear to be selective regarding plant species but showed some selectivity as it pertains to the stage of growth of available forage and the height of plant material above the ground. He observed that trees and shrubs formed 59%, grasses contributed 33%, and forbs, which were rarely eaten, contributed 7% of the main plant species grazed or browsed by the majority of the goats. The studies by Wilson (1957) and Knight (1964) indicated that goats eat all major categories of forage in East Africa.

The season and the amount of canopy cover will no doubt influence botanical composition of goat diets. Stanles et al. (1942) conducting a study in Tanzania noted that when sufficient numbers of goats are pastured on grassland containing many kinds of regenerating bushes, most of these are kept down to varying heights while only the tall grasses are eaten as freely as bushes. Lopes and Stuth (1984) reported that browse was the dominant diet component, comprising 77 and 51% of the goat diets respectively, on untreated and mechanically-treated plots while on chemically-treated pastures browse was a minor component. Grasses and grasslike plants provided approximately 64% of the goat diets from the tebuthiuron-treated pastures. It was observed that levels of brush management affected the browse component in diets with gradual reduction of the overstory layer as a result of the degree of brush control reflecting a decreasing role of browse in diets from untreated to chemically treated areas. This paper by Lopes and Stuth (1984) points out that even though browse consumption was low in goat diets from tebuthiuron treated pastures nutrition was maintained due to availability of vines which indicated that alternative forages can compensate for loss of browse in some ecosystems.

Results from a study conducted at San Juan Basin Research Center near Hesperus, Colorado, indicated that the diet of goats grazing a

Gambel Oak (*Quercus gambelii*) type was usually composed of 85% oak leaves, approximately 10% forbs and 5% grasses where the animal had access to all the forage after the oak was mechanically treated (Davis and Bartel 1975). These results agree with the claims by Staples et al. (1942) and Edwards (1948) that grasses are seldom eaten by goats when other browse species are available in semi-arid "bush" conditions. Edwards (1948) emphasizes on only one occasion during the dry season was a goat ever seen to eat any species of grass, and that possibly a mistake while sorting out fallen bush leaves. Observations on the plant parts eaten by goats showed that over half the browsing time was spent eating leaves and shoots of trees and bushes and that only inflorescences of grasses were eaten. Wilson (1957) indicated that goats show a special preference for the inflorescences of grasses.

Diets of goats grazing a semi-arid woodland in Western New South Wales, Australia, consisted largely of browse with the leaves as a consistent component along with a large proportion of herbaceous material. Goats appeared to be effective in searching for and utilizing rare species as well as picking dry leaves (Wilson et al. 1975). Goats preferred leaves over stems and consumed 40 and 46% of browse and grass, respectively on an *Acacia* grassland community in Kenya (Ng'ethe and Box 1976). To demonstrate further the importance of leaves to the livestock diets, Wilson (1977) observed that in the rangeland or pastoral areas of Australia, the leaves of trees and shrubs are mostly of low palatability and are not eaten when forage is plentiful, but may make an important contribution to the diets of sheep and goats when herbaceous forage is scarce. As leaf material becomes less available because of defoliation, the amount of leaf in the diet declines (Stobbs 1973).

Goats appear to have a superior adaptation to the arid tropics because of their ability to graze selectively and to take willingly a wide variety of the vegetation (Shelton 1978). The ability of the goats to utilize browse is probably an important factor contributing to their survival, especially in areas where feed is of low quality. Adapting from a group of authors, goats are more efficient digesters of forage, especially the fiber fraction, than other domestic animals (Ademosum 1970, Gihad 1976, Devendra 1977, Sharma and Rajora 1977), and this efficiency enables these animals to adapt better to poor environment where they convert useless browse plants into meat (Gihad et al. 1980).

There is limited information pertaining to the nutritive value of goat diets grazing range plants. Browse (leaves and twigs of trees and shrubs) and forbs generally contain higher levels of crude protein during the growing season than do grasses and grasslike plants (Rector and Huston 1976). Sidahmed et al. (1982) reported that Spanish goats grazing chaparral in California discriminated against plant parts that were low in nitrogen, but high in cell wall contents and cellulose. A conclusion was drawn that the level of nitrogen in the shrubs has a greater effect on digestibility and that immature browse is associated with high nitrogen and cell contents. Dietary *in vitro* nitrogen digestibility was highest in sheep (1.26%), lowest in cattle (1.17%) and intermediate in goats (1.20%) (Squires 1982). Values reported by Wilson et al. (1975) indicated that *in vitro* organic matter digestibility (IVOMD) ranged from 43% in the late winter to 57% in mid-August. This latter peak was associated with high amounts of grass consumption in the diets.

Malechek and Leinweber (1972) reported fiber components in diets of goats were generally similar for both lightly and heavily stocked ranges and that the ratio of cell walls to cell contents was quite low with high level of consumption of *Opuntia* sp. and *Juniperus* sp. On the other hand, high levels of consumption of immature browse leaves, primarily *Quercus* sp., resulted in low levels of cellulose in the diet samples. Wilson (1969) in his review of browse in the nutrition of grazing animals noted that browse has a more consistent crude protein content than grasses, which are typically high in protein at the beginning of the growing season and low in protein when mature. On the other hand, browse has a higher lignin content than grasses. Goats have a tendency to consume a wide array of vegetation that increases the probability of meeting their nutritional requirements. It is evident that consumption favoring the more nutritious plants shifts with the seasons.

Bryant (1977) found that the highest crude protein value 15.6 and 14.5% of Angora and Spanish goats, respectively, occurred in April, and the lowest values 8.4 and 8.7% respectively, occurred in February. Crude protein values were positively associated with browse content of the diet and proportional to grass content. The dietary digestible energy (DE) varied from 2009 to 2721 kcal/kg for Spanish goats and from 2020 to 2705 kcal/kg for Angora goats. Increased levels of DE were related to increased grass and forbs in the diets and to a corresponding decreased amount of browse. Highest dietary DE levels occurred when browse decreased and grass increased in the diets. Malechek (1970) cited dietary crude protein varying from 6 to 14%. Highest dietary crude protein values occurred in early spring while lowest protein levels occurred in the winter. High CP levels were attributed to the increased consumption of immature browse leaves and forbs. Low values of crude protein occurred when the proportions of dry grass in the diets was increased. Apparently, increased levels of CP are associated with increased amount of browse in the diets while increased levels of IVOMD and DE are associated with increased amounts of grass and forbs in the diets.

CHAPTER III

STUDY AREA

General Area Description

The National Range Research Station (NRRS), Kiboko, was the area of study. The station is located in south-central Kenya (Fig. 1) and has an area of 30,000 ha^2. It is bounded on the northwest by the Kiboko river, on the north by the Nairobi-Mombasa highway, and on the south by Mbuinzau and Wikiamba Volcanic Cone. This area is located in ecological zone five and it is marked by latitude 2°55'E with the larger part of the station lying between 900 and 1100 m above sea level (Pratt et al. 1966, Michieka and Van der Pouw 1977, Ndegwa 1983) (Fig. 1). The highest point in this area is the top of Mwailu volcanic cone which is 1127 m above sea level.

The station was started in 1971 by the now defunct FAO/UNDP Range Management Project. The area occupied by the station was a former game reserve heavily infested with tsetse flies (Glossina spp.). The station is currently used for grazing of cattle, sheep and goats. Major wildlife species include eland, zebra, kongoni, impala, gazelles, buffalo and giraffe. Ecology and grazing management are the areas of emphasis of the current research programme at NRRS.

The study site is located approximately 5 km south of the National Range Research Station headquarters, and is within pasture two of a larger experimental unit known as GM2 (Fig. 2).

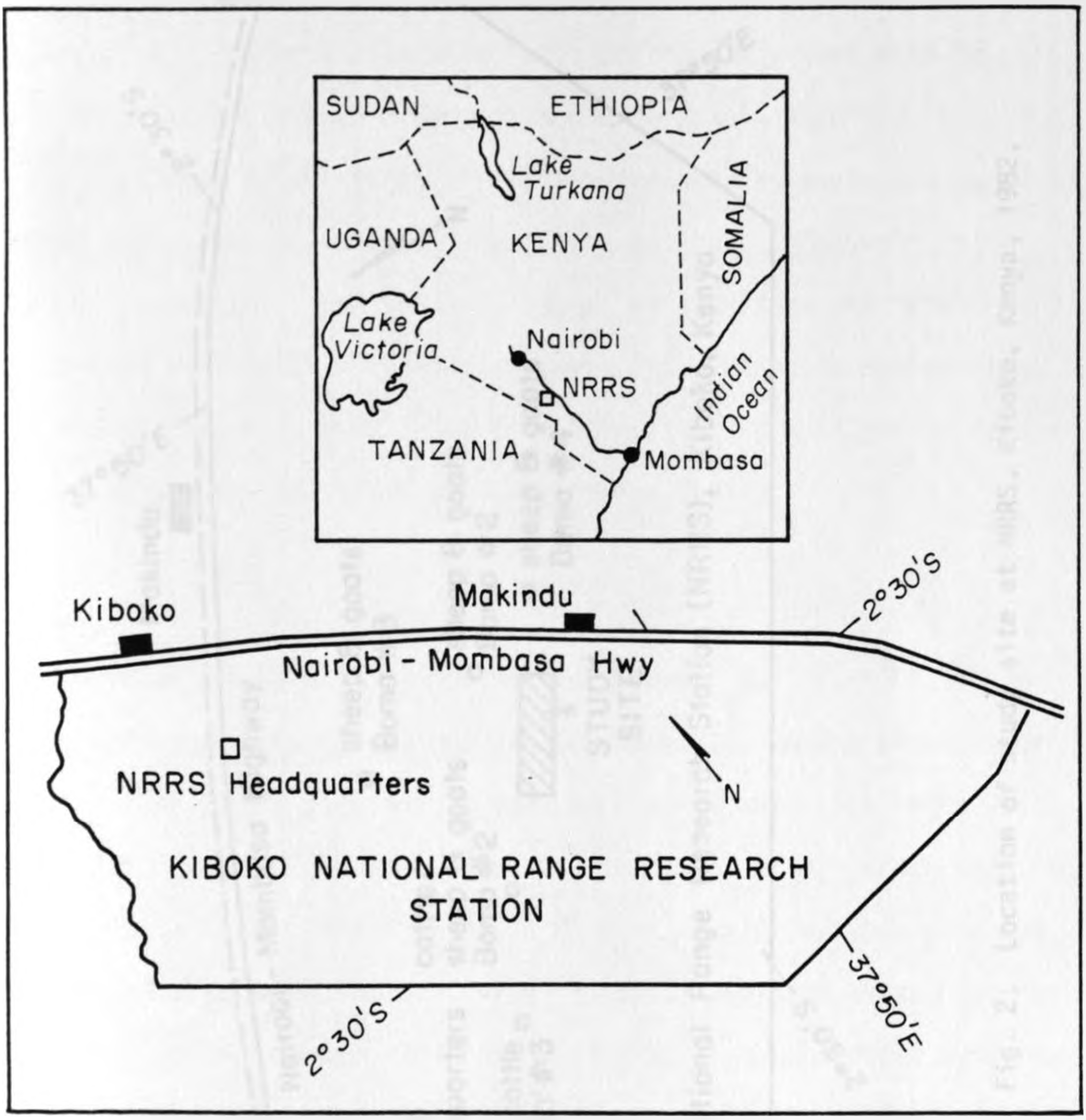

Fig. 1. Location of the National Range Research Station at Kiboko, Kenya.

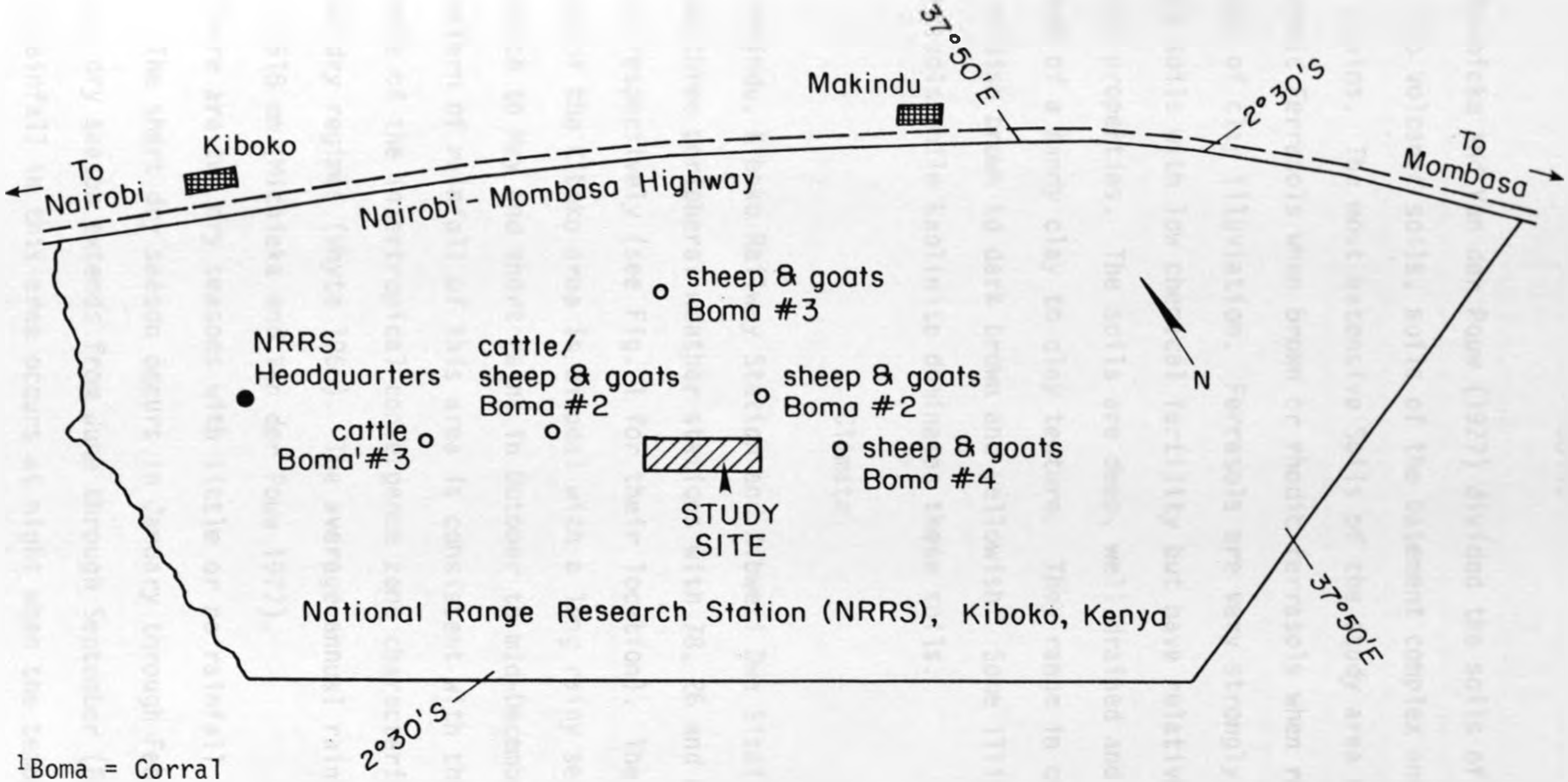

Fig. 2. Location of study site at NRRS, Kiboko, Kenya, 1982.

Soils

Michieka and Van der Pouw (1977) divided the soils of the study area into volcanic soils, soils of the basement complex and soils of the flood plains. The most extensive Soils of the study area with low CEC, are orthic Ferrasols when brown or rhodic ferrasols when red, clay and no signs of clay illuviation. Ferrasols are very strongly weathered and leached soils with low chemical fertility but have relatively good physical properties. The soils are deep, well drained and friable or firm and of a sandy clay to clay texture. They range in colors from dark reddish brown to dark brown and yellowish. Some illite is present in Ferrasols while kaolinite dominates these soils.

Climate

Makindu, Kiboko Railway Station and Kibwezi Dwa Sisal Plantation are the three peripheral weather stations with 78, 26 and 64 years of record, respectively (see Fig. 1 for their location). The rainfall pattern of the Kiboko area is bimodal with a long rainy season expected from March to May and short rains in October to mid-December (Fig. 3). The pattern of rainfall of this area is consistent with that under the influence of the intertropical convergence zone characterized by bimodal wet and dry regimes (Whyte 1968). The average annual rainfall of the area is 615 mm (Michieka and Van der Pouw 1977).

There are two dry seasons with little or no rainfall in any given month. The short dry season occurs in January through February while the long dry season extends from June through September (Fig. 3). Most of the rainfall in this area occurs at night when the temperatures are

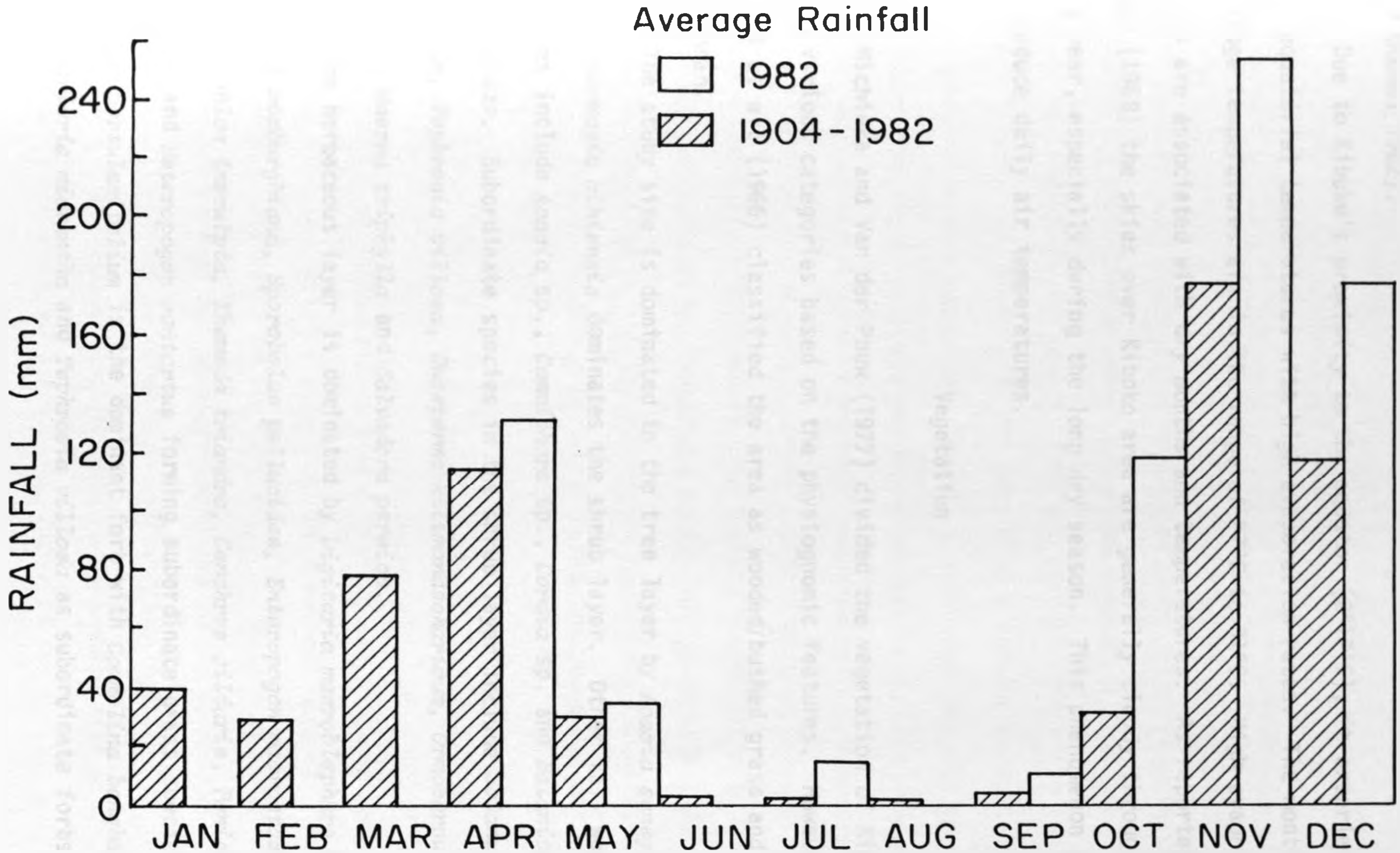

Fig. 3. Monthly average rainfall recorded for sheep and goats boma #2, 1982, approximately 1 km from the study site on NRRS and for 78 years of record at Makindu Meteorological Station.

low (Kemei 1982).

Due to Kiboko's proximity to the equator (2°17'S), it experiences hot equatorial temperatures with high evaporation rates. The monthly average temperatures are in the range of 27°C to 31°C. High evaporation rates are associated with dry months and temperatures. As reported by EAMD (1968) the skies over Kiboko area are generally cloudy throughout the year, especially during the long dry season. This phenomenon tends to reduce daily air temperatures.

Vegetation

Michieka and Van der Pouw (1977) divided the vegetation of Kiboko into various categories based on the physiognomic features. However, Pratt et al. (1966) classified the area as wooded/bushed grassland savannah.

The study site is dominated in the tree layer by *Acacia senegal* while *Hermania alhiensis* dominates the shrub layer. Other tall woody species include *Acacia* sp., *Commiphora* sp., *Cordia* sp. and *Balanites aegyptiaca*. Subordinate species in the shrub layer include *Solanum incanum, Tephrosia villosa, Duosperma kilimandscharicum, Ormocarpum kirkii*, *Maerua triphylla* and *Salvadora persica.*

The herbaceous layer is dominated by *Digitaria macroblephara* with *Chloris roxburghiana, Sporobolus pellucides, Enteropogon macrostachyus, Bothriochloa insculpta, Themeda triandra, Cenchrus ciliaris, Panicum maximum* and *Heteropogon contortus* forming subordinate grass species. *Talinum portulacifolium* is the dominant forb with *Commelina benghalensis, Barleria micrantha* and *Tephrosia villosa* as subordinate forbs.

CHAPTER IV

MATERIALS AND METHODS

Experimental Paddocks

Three bush conditions, twice replicated, were identified in the field based on total canopy cover. A method similar to that used by Pratt et al. (1966) in the general area was used to categorize these bush conditions. The study site was generally a wooded/bushed grassland. Areas with bush cover less than 15%, 15-35% and greater than 35% were designated light, moderate and heavy respectively. All treatment paddocks were marked at each corner with numbered posts. A permanent reference line was marked with a purple concrete post on the edge of the roadside of each treatment paddock. No fencing was utilized as grazing was controlled via herders. Treatment boundaries were delineated with colored flagging tape to aid the herders in containing the animals on the proper treatment paddock. Each replicated treatment paddock was 2.25 ha in size (Fig. 4).

Experimental Animals

A herd of 7 yearling cattle, 3 mature goats and 3 mature sheep were utilized to provide grazing pressure on the treatment paddock. The assigned animal unit value of the herd was 7.3. A safe stocking rate of 5 ha/au was selected as the basis for herd and treatment paddock size. Pratt et al. (1966) had recommended a similar stocking rate for this area. However, any single stocking rate for the whole area would be conservative since the area has a large number of range sites with

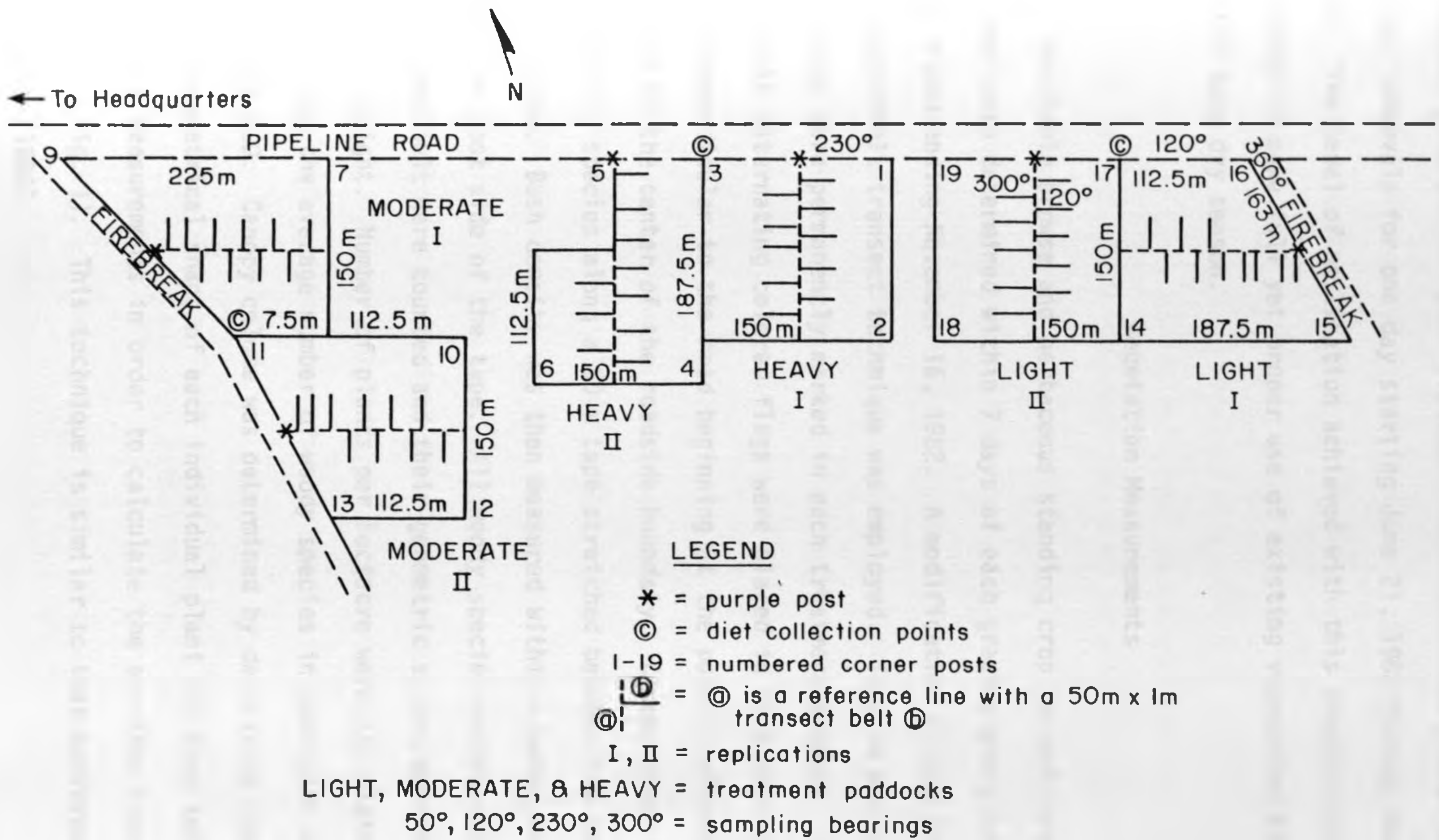

Fig. 4. Paddock and sampling layout of experimental site at NRRS, Kiboko, Kenya.

different potentials. Each treatment/rep paddock was grazed at 28- to 30-day intervals for one day starting June 21, 1982 through November 27, 1982. The level of utilization achieved with this grazing strategy was expected to make full yet proper use of existing vegetation by the end of the long dry season.

Vegetation Measurements

Available browse and herbaceous standing crop in each treatment paddock were determined within 7 days of each grazing event beginning June 9 and ending November 16, 1982. A modification of the line intercept/belt transect technique was employed. Ten, 50 m x 1 m belt transects were permanently marked in each treatment paddock. Reference pins with alternating colored flags were placed in 13 m intervals on a line perpendicular to the road beginning at the purple reference post located at the center of the roadside boundary. Canopy cover of bush was read by species along a 50 m tape stretched between two permanently marked pins. Bush density was then measured within a meter on the reference post side of the tape. All woody species rooted within the prescribed belt were counted and their geometric shapes determined below 1.5 m in height. Number of plants per hectacre were calculated by multiplying the average number of woody species in each plot by a factor of 200. Canopy colume was determined by describing the appropriate geometrical shape of each individual plant and then taking the necessary measurements in order to calculate the ascribed shape (Appendix Fig. 1). This technique is similar to that employed by Lopes and Stuth (1984).

Standing crop of browse was estimated utilizing the "grazing depth" (GD) technique of Lopes and Stuth (1984). GD is the average depth of canopy surface penetration that can be attained by a specific species of grazing animal. Each species grazing depth was determined by observing animals grazing the various woody species and estimating a reasonable depth of grazing under normal and proper stocked conditions. The nearest shrub of each of the sampled species to reference line pins 3, 6 and 9 were sampled for available canopy forage. Three subsamples (30 cm x 30 cm x GD) of current years growth were clipped for each plant. Two subsamples in the widest third of the canopy dimension and one subsample in the middle third of the canopy were clipped to the appropriate grazing depth. Subsamples were taken on one of the four randomly selected cardinal points from the central axis of the canopy dimension (north, south, east and west). Available standing crop of browse was then calculated for each belt transect by multiplying canopy volume (m^3/ha) times canopy volume weight (g/m^3). Since density and canopy volume did not change throughout the long dry season, only available grazing depth (g/cm^3) determinations were made prior to each grazing interval after initial bush measurements. Browse harvest was then oven-dried at 60°C in a forced-air oven for 2 to 3 days and reweighed when dry. All air dry weights of browse were converted to kg/m^3 as follows:

$$kg/m^3 = \frac{\text{dry browse weights (g)} \times 100\ m^3\ (g/m^3)}{\text{(sampling units)}(30 \times 30 \times GD)^3\ (1000g)}$$

Multiplying kg/m^3 by m^3/ha (canopy volume) gave available browse herbage for each sampled species.

Herbaceous standing crop was determined by randomly locating two, $0.5m^2$ quadrats in each belt transect prior to each grazing period. Species composition was visually estimated and the combined grass and combined forb component clipped to ground level and weighed to the nearest gram. Samples from four randomly selected quadrats in each treatment paddock were dried at 60°C together with browse material under the same conditions and all field weights adjusted to oven-dried basis.

Animal Measurements

One esophageally fistulated Galla goat with two esophageally fistulated small East African goats were allowed to graze each treatment paddock each morning for two consecutive days until enough extrusa was collected. These animals made up part of the herd that was going to be used for applying the necessary grazing pressure on a one day graze 28- to 30-day cycle. Dietary samples were collected in rectangular sacks of nylon, parachute cloth, fitted with two pieces of nylon cord along two opposite hemmed sides. The cords were then tied around the neck of the animal with the sacks over the esophageal fistula (Appendix Fig. 2). Dietary samples were taken to the center headquarters after collection where they were air dried approximately two days in a nylon-wire screen bottomed rack. Sometimes during bad weather samples were oven dried overnight at 60°C. In all cases dietary samples were analyzed when completely dry. Once dry, each sample was thoroughly mixed and divided into two subsamples. One subsample was ground in a Wiley mill through a 2 mm sieve, stored in plastic 40 diameter vials and shipped to the Range Nutrition Laboratory at Texas A&M University.

The other subsample was labelled and placed in plastic bags for further botanical analysis using a point-frame macrohistological or extrusa fragment analysis technique similar to that described by Lopes and Stuth (1984) and Rector and Huston (1982). Each air dried sample was scattered on a sampling board (25 cm x 45 cm) in two directions so that plant materials fully occupied the board. A rack of 10 spring-loaded pins mounted in a sliding frame at a 45° angle was placed at one end of the board. Each pin in the rack was depressed until a plant fragment was contacted. The contacted fragment was then identified by species if possible and recorded as to whether it was live or dead and leaf, stem, inflorescence or fruit. One hundred fragments were identified per extrusa sample. Dietary fragments of each species encountered in each grazing interval were weighed and percent fragment composition was adjusted to a weight basis. A reference collection along with a diagnostic key for species fragments were made to aid in identification of the various species found in the diets of esophageally fistulated animals.

Chemical Analysis

Crude protein (CP) was determined by the micro-Kjeldahl technique (AOAC 1975). Percent CP was estimated on an organic matter basis by multiplying percent nitrogen by a constant of 6.25 (nitrogen is 16% by weight of the amino acid).

In vitro organic matter digestibility (IVOMD) was determined by utilizing the fermentation stage of Tilley and Terry (1963) and the neutral detergent phase of Van Soest and Wine (1967). Standards of known *in vivo* digestibility were run with samples to correct for variation in laboratory procedure and rumen inoculum to apparent digestibility.

Digestible energy or DE (kcal/kg) was derived from the estimates of digestible organic matter (DOM) by multiplying % DOM by a constant of 4000 kcal/kg of DOM.

Selection Ratios

Selection ratios (SR) were determined utilizing formula adapted by Durham and Kothmann (1977) for different forage species.

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

This procedure considers the proportion of the forage of a given species in the diet relative to what that particular species offers in the treatment paddock. Each selection regime of a given species is given on a scale of -10 to +10. Zero indicates selection in proportion to availability.

Experimental Design

The design of this study was a split plot with treatment as the main effect or factor measured in terms of percent canopy cover and density. Analysis of variance (ANOVA) was conducted to analyze data by treatments (light, moderate and heavy) and months (June through November). Duncan's multiple range test was used to detect differences between significant treatment means. The 95% level of significance was used to test for significant experimental effects.

CHAPTER V

RESULTS AND DISCUSSION

Woody Species Density/Canopy Cover

Bush density

Tree densities were 160, 369 and 410 plants/ha for the light, moderate and heavy bush conditions, respectively. Densities for moderate and heavy treatment paddocks were not significantly different ($\alpha = 0.05$).

Acacia senegal was the dominant tree in the treatment paddocks. There were no significant differences noted in *Acacia senegal* density between moderate and heavy treatment paddocks, but in the light bushed treatment paddocks, density was lower than that of either moderate or heavy bushed paddocks. The other woody species in the tree layer were not significantly different across treatment paddocks (Table 1). *Lannea floccosa*, *Boscia* sp. and *Commiphora riparia* occurred in trace numbers in the light, moderate and heavy bush conditions, respectively. *Acacia senegal*, *Commiphora africana* and *Lannea floccosa* increased in density as the canopy cover increased.

Shrub density was greater in the heavy and moderate treatment paddocks than the light bush paddocks. Shrub densities were 1130, 1474 and 1530 plants/ha in light, moderate and heavy treatment paddocks, respectively. *Hermania alhiensis* was the dominant shrub across all paddocks and did not significantly differ across bush conditions. There was a trend for *Hermania alhiensis* densities to increase with an increase in

Table 1. Bush density (plants/ha) for each treatment paddock in *Acacia senegal* savannah at Kiboko, Kenya, 1982.

Woody species	Treatment paddocks		
	Light	Moderate	Heavy
TREES			
Acacia senegal	50 b[1]	210 a	240 a
A. tortilis	30 ns[2]	42	30
Balanites aegyptiaca	30 ns	21	20
Boscia sp.	20 ns	T	10
Commiphora africana	20 ns	74	90
C. riparia	10 ns	11	T
Lannea floccosa	T[3] ns	11	20
L. sp.	P[4] ns	P	P
Total tree density	160 b	369 a	410 a
SHRUBS			
Abutilon mauritianum	T ns	T	20
Acacia mellifera	20 ns	T	40
Cordia gharaf	T ns	T	20
C. ovalis	T b	63 a	40 ab
Duosperma kilimandscharicum	40 ab	74 a	T b
Grewia similis	130 ns	116	10
G. villosa	20 ns	21	20
Hermania alhiensis	920 ns	1000	1090
Hibiscus sp.	T ns	T	30
Ormocarpum kirkii	T ns	84	80
Solanum incanum	T ns	11	10
Unidentified sp.	T b	105 ab	170 a
Vernonia sp.	10 ns	T	T
Total shrub density	1130 b	1474 a	1530 a
Total bush density	1290 b	1843 a	1940 a

[1]Means followed by the same letter between bush density across treatment paddocks are not significantly different (α = 0.05).
[2]Means are not significantly different (α = 0.05).
[3]Trace.
[4]Present but not found in samples.

total canopy cover. *Cordia ovalis*, *Duosperma kilimandscharicum* and other unidentified species indicated a significant change in densities across bush conditions. The remaining species were underrepresented in samples across the treatment paddocks. *Abutilon mauritianum*, *Cordia gharaf* and *Hibiscus* sp. occurred in trace amounts in the light and moderate bush conditions. *Cordia ovalis*, *Omorcarpum kirkii*, *Solanum incanum* and other unidentified species occurred in trace amounts in the light bush conditions. *Vernonia* sp. was present in trace amounts in the moderate and heavy bush conditions while *Duosperma kilimandscharicum* appeared in trace numbers in the heavy bush conditions. Densities of the unidentified species were highest in the heavy treatment paddocks.

There was no significant difference noted in total bush densities between moderate and heavy bush treatment paddocks (α = 0.05). The total bush densities were 1290, 1843 and 1940 plants/ha for the light, moderate, and heavy bush conditions, respectively.

Bush canopy cover

Tree canopy cover was 6.9%, 22% and 34.7% in the light, moderate and heavy bush conditions, respectively (Table 2). *Acacia senegal* and *Acacia tortilis* occupied the upper-story of the canopy cover while the other shorter trees occupied the lower-story of the canopy cover. However, *Acacia senegal* was the most important single factor causing changes in the tree canopy cover. Canopy cover for trees was different across treatment paddocks (α = 0.05).

Acacia senegal dominated the tree canopy cover across all bush conditions. Of the total tree canopy, *Acacia senegal* contributed 77%, 69%

Table 2. Bush canopy (%) for tree/shrub found in different paddock treatments in the *Acacia senegal* savannah at Kiboko, Kenya, 1982.

Woody species	Treatment paddocks		
	Light	Moderate	Heavy
TREES			
Acacia senegal	5.3 c[1]	15.2 b	28.3 a
A. tortilis	0.4 b	3.8 a	1.8 ab
Balanites aegyptiaca	0.8 ns[2]	2.0	2.0
Boscia sp.	0 ns	0	0.1
Commiphora africana	0.2 ns	0.6	2.4
C. riparia	0 ns	0	0.1
Lannea floccosa	0.1 ns	0	0
L. SP.	0.1 ns	0.4	0
Total tree canopy	6.9 c	22.0 b	34.7 a
SHRUBS			
Abutilon mauritianum	0 ns	0	0.1
Acacia mellifera	0.8 ab	0.1 b	1.0 a
Albizia amara	0.1 ns	0	0
Cordia gharaf	0 ns	0.8	0.7
C. ovalis	0 b	1.1 ab	2.8 a
Dalbergia melanoxylon	0.2 ns	0	0
Duosperma kilimandscharicum	0 b	0.4 a	0 b
Grewia bicolor	0 ns	0	0.5
G. similis	0.3 ns	0.2	0.2
G. villosa	0.5 ns	1.5	1.6
Hermania alhiensis	3.5 ns	4.3	4.6
Hibiscus aponeurus	0.7 a	0.1 b	0.1 b
Maerua triphylla	0.1 ns	0	0
Ormocarpum kirkii	0 ns	0	0.2
Sida ovata	0 ns	0.2	0.3
Vernonia sp.	0.1 ns	0	0
Total shrub canopy	6.3 ns	8.7	12.1
Total bush canopy	13.1 c	30.7 b	46.8 a

[1]Means followed by the same letter across bush cover are not significantly different ($\alpha = 0.05$).
[2]Means are not significantly different across bush cover ($\alpha = 0.05$).

and 82% for light, moderate and heavy bush conditions, respectively. Canopy cover for this tree was significantly different across treatment paddocks. *Acacia tortilis* was significantly different across bush conditions. There was no difference noted in canopy cover of the other tree species across treatment paddocks. *Lannea floccosa* only contributed to the tree canopy cover in the light bush conditions while *Boscia* sp. and *Commiphora riparia* only occurred in the heavy bush condition canopy cover. *Commiphora africana* increased in canopy cover as bush cover increased.

Total shrub cover was 6.3%, 8.7% and 12.1% in the light, moderate and heavy bush conditions, respectively. There was no marked difference in shrub canopy cover across bush conditions ($\alpha = 0.05$). *Hermania alhiensis*, which dominated the shrub layer had the highest canopy cover across bush conditions though not significantly different. *Albizia amara*, *Dalbergia melanoxylon*, *Maerua triphylla* and *Vernonia* sp. contributed only to light bush conditions shrub canopy cover. *Duosperma kilimandscharicum* contributed shrub canopy cover only to moderate bush conditions while *Grewia bicolor* and *Omorcapum kirkii* contributed only to heavy bush condition shrub canopy cover.

Total bush canopy cover was 13.2%, 30.7% and 46.8% for light, moderate and heavy bush conditions, respectively. Total bush canopy cover was significantly different across bush conditions ($\alpha = 0.05$).

Acacia senegal canopy cover significantly increased with increase in density across all treatment paddocks. *Commiphora africana* increased with increase in density across bush conditions though not significantly. On the other hand, *Lannea floccosa* and *Commiphora riparia* canopy cover decreased as their respective densities increased across bush conditions. The remaining trees did not exhibit any bush canopy cover effects. *Abutilon mauritianum* and *Hermania alhiensis* shrub canopy cover increased with increase in their respective densities across treatment paddocks. *Hibiscus* sp. significantly increased in canopy cover as its densities across bush conditions decreased. *Acacia senegal* and *Acacia tortilis* were the primary tree species creating treatment effects in the bush canopy. These two trees comprised 43%, 62% and 64% of the total bush canopy in light, moderate and heavy treatment paddocks, respectively.

Standing Crop

Graminoid herbage

Means for standing herbage of grass and grasslike plants across treatment paddocks were not significantly different at the beginning of the dry season. The lowest recorded grass herbage throughout the study period was 1034 kg/ha at the beginning of the early wet season. An interesting trend in grass herbage as related to the amount of available moisture was noted in the light bushed paddocks. At the beginning of June the available moisture conditions were higher than normal (see Fig. 3) and this was reflected in July graminoid herbage. Although August was a dry month, there were some scattered showers whose effects in available moisture were realized in September graminoid herbage. October rains increased available moisture thus increasing grass herbage in November (Table 3).

Unlike light bushed treatment paddocks whose grass herbage

Month	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α
June	1733 ns[2]	2180	1813	.34	9 ns	13	11	.82	1742 ns	2194	1824	.34
July	2629 a[1]	1820 ab	2272 b	.03	75 ns	6	90	.05	2703 a	1826 b	2362 ab	.01
August	1215 b	2130 a	1856 a	.01	9 ns	T[3]	6	.42	1223 b	2130 a	1862 a	.01
September	2290 a	1591 b	2178 a	.04	T ns	3	T	.38	2290 a	1595 b	2178 ab	.05
October	1034 c	1643 b	2171 a	<.01	3 ns	6	3	.69	1038 c	1649 b	2174 a	<.01
November	2597 a	1595 b	1647 b	<.01	165 ns	28	169	.08	2762 a	1623 b	1816 b	<.01
Mean	1916	1826	1990		44	9	47		1960	1836	2036	

[1]Means followed by the same letter within herbaceous categories are not significantly different ($\alpha = 0.05$).
[2]Means within monthly herbaceous standing crop by categories are not significantly different ($\alpha = 0.05$).
[3]Trace.

increased as the available moisture increased, herbage in moderate and heavy treatment paddocks increased during the dry season. Shrubs and trees in these heavier bushed paddocks apparently modified the environment, thus creating conditions conducive to the growth of graminoids. The greatest overall graminoid herbage was noted in the heavy bushed paddocks dominated by trees, namely *Acacia senegal*.

There was a noticeable decrease in graminoid herbage in August and October in light bushed treatment paddocks which did not occur in the moderate or heavy treatment paddocks. During these two months there were no new grass tillers that were noted in the light bushed paddocks and the older grasses were becoming mature and lignified. Leaf shatter appeared more prominent on the open light bushed treatment paddocks. Fresh wildlife droppings were prevalent on the open light bushed area indicating that animals were grazing in this area. Impalas (*Aepyceros melampus*) and gazelles (*Gazella* spp.) were frequently seen in this area. Occasionally, herders of other station animals, particularly sheep and goats, were careless and allowed animals to graze the study paddocks, especially the light bushed paddocks, as these were easily accessible. Cutter ants, rabbits and rodents, mice in particular, can consume large amounts of graminoids during the dry season and were particularly active on those open sites.

Forb herbage

Forbs were highest at the beginning of the dry and wet seasons. The herbage of this forage class varied between trace and 169 kg/ha throughout the study. Forb herbage was greatly influenced by available moisture. In light bushed paddocks forbs occurred only in trace amounts during September and was lower in June, August and October, respectively. The most prevalent forbs throughout the study period were *Talinum portulacifolium* and *Barleria micrantha.* The herbage of forbs was highest in the heavy bushed paddocks and in the open light bushed treatment paddocks. The presence of more bushes in the moderate bush conditions did not seem to favor the growth of forbs. The decline in the amount of forbs during the dry season when the available moisture was limiting, especially in the light bush conditions might have been accelerated by the presence of wildlife and trespass graziers.

As expected, total herbage was highest in July, September and November in the light bushed paddocks as the available moisture was highest during these three months. Heavy bushed paddocks dominated by trees favored the growth of graminoids and forbs during the dry season.

Standing crop of *Cenchrus ciliaris*, *Bothriochloa insculpta* and *Eragrostis caespitosa* was significantly affected by bush conditions throughout the study period. These species decreased in availability with increases in canopy cover. Conversely, *Digitaria macroblephara* availability increased with increase in canopy cover. Standing crop of *Sporobolus pellucides* and sedges were highest in the heavy bushed conditions and lowest in moderate bushed conditions while *Chloris roxburghiana* was highest in the light bushed treatment paddocks. *Talinum portulacifolium* was highest in heavy bushed paddocks ($\alpha = 0.08$). *Tephrosia villosa* was highest in the heavy bushed paddocks during the wet season ($\alpha = 0.24$) while *Barleria micrantha* was highest in the light bushed treatment paddocks ($\alpha = 0.01$) (Appendix Table 1). It is difficult to assess whether these observed herbage/bush cover relationships are repeatable, or are merely an artifact of sampling or a result of differential grazing by domestic and wild herbivores. Bush/grass relationship of the more abundant species is hypothesized to be a result of past preferrential grazing of more open habitats.

Browse

Generally, there was a trend for greater available browse in the heavy bushed paddocks than either moderate or light bush conditions. However, total available browse was not significantly different across treatment paddocks throughout the study period. Total available browse was highest in June, July and November following increased available moisture. Trees produced 23% of the available browse across all treatment paddocks. Browse herbage decreased during the dry season since most trees had abscised leaves and become dormant; total available browse was in the form of dry leaves, twigs, stems and pods. Woody plants were very sensitive to erratic rains and immediately following such rains, they produced some new leaves. Thus, the pattern of browse production was rather irregular throughout the study period (Table 4).

Hermania alhiensis dominated the shrub layer and provided most of the available browse across treatment paddocks throughout the period of study. Shrubs produced 77% of the available browse herbage accessible to the goats throughout the grazing period. *Acacia mellifera*, *Acacia senegal* and *Grewia villosa* were the woody species that contributed substantially to the total available browse. It was noted that shrubs retained leaves longer than did the trees during the dry season. *Maerua*

Table 4. Monthly available browse (kg/ha) for each canopy condition by derived bush categories in an *Acacia senegal* savannah at Kiboko, Kenya, 1982.

Woody spp.	Bush cover class											
	June/July				August				September			
	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α
Acacia mellifera	2 ns[1]	T	T	.45	T ns	T	T	.13	T ns	T	T	.36
A. senegal	3 b[2]	7 b	17 a	.02	3 ns	4	6	.27	T b	T b	1 a	.03
A. tortilis	2 ns	T[3]	1	.53	T ns	T	T	.13	1 ns	T	T	.19
Balanites aegyptiaca	T ns	T	T	.59	T ns	T	T	.49	T ns	T	T	.64
Commiphora africana	T ns	1	1	.50	T ns	T	T	.34	T ns	T	T	.33
Cordia gharaf	18 ns	T	4	.46	1 ns	T	T	.30	T ns	T	T	.62
Grewia bicolor	5 ns	T	T	.38	T ns	T	T	.38	T ns	T	T	.38
G. similis	T ns	T	T	.32	T ns	T	T	.14	T a	T a	T b	.05
G. villosa	2 ns	2	7	.61	T ns	T	1	.15	T ns	T	T	.61
Hermania alhiensis	4 b	4 b	16 a	.02	4 ns	1	4	.25	1 ns	T	1	.30
Hibiscus aponeurus	T ns	T	T	.38	P	P	P	-	P	P	P	-
H. spp.	T ns	T	T	.27	T ns	T	T	.00	T a	T b	T a	.00
Lannea floccosa	T ns	T	T	.51	T ns	T	T	.64	T ns	T	T	.62
Maerua triphylla	P	P[4]	P	-	P	P	P	-	P	P	P	-
Ormocarpum kirkii	T b	T ab	T a	.02	T b	T ab	T a	.06	T ns	T	T	.03
Solanum incanum	P	P	P	-	P	P	P	-	P	P	P	-
Other species	T ns	T	T	.35	T ns	T	T	.37	T ns	T	T	.62
Unidentified species	T ns	T	T	.18	T b	T ab	T a	.02	T b	T ab	T a	.02
Total available browse	36 ns	13	46	.30	9 ns	6	12	.15	2 ns	1	2	.28

[1] Means across bush conditions for each month are not significantly different (α = 0.05).

[2] Means followed by the same letter across bush conditions for each month are not significantly different (α = 0.05).

[3] Trace.

[4] Present but not found in samples.

Table 4. Continued.

Woody spp.	Bush cover class: October, Light	October, Moderate	October, Heavy	October, α	November, Light	November, Moderate	November, Heavy	November, α
Acacia mellifera	T ns	T	T	.36	2 ns	T	T	.45
A. senegal	4 ns	5	9	.31	14 ns	20	23	.77
A. tortilis	3 ns	1	1	.19	1 ns	T	T	.19
Balanites aegyptiaca	T ns	T	T	.62	T ns	T	T	.60
Commiphora africana	T ns	T	T	.33	T ns	1	1	.41
Cordia gharaf	1 ns	T	T	.46	7 ns	T	1	.23
Grewia bicolor	T ns	T	T	.38	T ns	T	T	.38
G. similis	T ab	T a	T b	.06	T ab	1 a	T b	.08
G. villosa	T ns	T	T	.61	14 ns	1	25	.56
Hermania alhiensis	3 ns	1	2	.21	33 ns	20	17	.55
Hibiscus aponeurus	P	P	P	-	1 ns	T	1	.30
H. spp.	T a	T b	T a	.00	P	P	P	-
Lannea floccosa	T ns	T	T	.62	T ns	T	T	.51
Maerua triphylla	P	P	P	-	P	P	P	-
Ormocarpum kirkii	T b	T ab	T a	.04	T b	T ab	T b	.02
Solanum incanum	P	P	P	-	P	P	P	-
Other species	T ns	T	T	.52	1 ns	4	5	.53
Unidentified species	T ns	T	T	.73	P	P	P	-
Total available browse	10 ns	6	12	.49	75 ns	47	74	.54

[1]Means across bush conditions for each month are not significantly different (α = 0.05).

[2]Means followed by the same letter across bush conditions for each month are not significantly different (α = 0.05).

[3]Trace.

[4]Present but not found in samples.

triphylla and *Boscia* sp. remained green during the dry season and provided some available herbage to the foraging animals.

Composition of Available Forage

Percent of available forage

It appears that the composition of grass and grasslike plants across bush treatment paddocks in the month of June was not different. However, grass herbage in light, moderate and heavy bush conditions varied from 85-99.7%, 95-99.5% and 76-99.5%, respectively. The composition of grass and grasslike plants was lowest in November and August, and November and July in light and heavy bush conditions, respectively. In seems the composition of grass and grasslike plants was lowest at the beginning of the dry season, the middle of the dry season and at the beginning of the wet season. It can be inferred that differential degree of leaf fall and limited growth of grasses affected the composition of grass and grasslike plants (Table 5).

Species composition of certain grasses and grasslike plants was affected by canopy cover. *Bothriochloa insculpta*, *Cenchrus ciliaris* and *Chloris roxburghiana* decreased in composition as canopy cover increased. Generally, the species composition of these grasses was higher in the light treatment paddocks than in the moderate and heavy treatment paddocks. Composition of these grasses was not different in moderate and heavy treatment paddocks. *Digitaria macroblephara*, sedges, and *Sporobolus pellucides* were not affected by canopy cover. Apparently, *Digitaria macroblephara* was the dominant grass and contributed the highest species composition across treatment paddocks throughout the period

Table 5. Plant category composition (%) derived from available forage in an *Acacia senegal* savannah of varying degree of bush cover at Kiboko, Kenya, 1982.

	Plant species composition											
	Total grass/grasslike				Total forbs				Total browse			
	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α
June	91.4 ns[2]	91.7	91.9	.99	4.5 ns	7.5	0.6	.45	4.1 ns	0.8	7.5	.14
July	93.9 ab	99.3 a[1]	88.4 b	.01	3.4 ns	0.07	3.0	.11	2.7 ab	0.7 b	8.7 a	.03
August	87.4 ns	99.4	98.6	.07	0.9 ns	T[4]	T	.18	11.8 ns	0.6	1.4	.10
September	99.7 ns	94.5	99.5	.42	T ns	5.2	T	.42	0.3 ns	0.3	0.5	.42
October	98.7 ns	99.5	99.1	.33	P[3]	P	P	-	1.3 ns	0.5	1.0	.33
November	84.6 ab	96.3 a	76.2 b	.03	13.1 ab	1.8 b	20.1 a	.06	2.3 ns	1.9	3.8	.30

[1]Means followed by the same letter within each plant category are not significantly different (α = 0.05).
[2]Means within the same plant species category are not significantly different (α = 0.05).
[3]Present but not found in samples.
[4]Trace.

of study. *Digitaria macroblephara*, *Chloris roxburghiana* and *Bothriochloa insculpta* were the most dominant species in the light bush treatment paddocks in that descending order (Appendix Table 2).

The composition of forbs was highest at the beginning of the dry season, probably because of the increased available moisture following March-May rains. However, forb composition decreased as the dry season progressed. Forbs could not be found in quadrants for October as a result of decreased available moisture. However, there was a dramatic increase in the composition of forbs following increase in available moisture in late October. At the initiation of the study, *Barleria micrantha* and *Tephrosia villosa* were present but in low composition and declined as the dry season progressed. These forbs appeared in November with *Talinum portulacifolium* as the dominant forb, although the latter never exceeded 20% of plant species composition ($\alpha = 0.06$). The trend of forbs as a percent of available forage in light, moderate and heavy bush conditions indicated that canopy cover had no major effect on their contribution to species composition.

The composition of browse was highest at the beginning of the dry season, viz., June-July and at the beginning of the wet season in November. However, the composition of browse as a percent of available forage was similar for all months except in July where the heavy bush condition had the highest composition of browse than either light or moderate bush conditions. It was noted that the light bush conditions was dominated by low spreading shrubs whereas the heavy bush condition was dominated by trees, mainly *Acacia senegal*; the contribution of both light and heavy bush conditions was not dissimilar. *Acacia senegal*, *Cordia gharaf*, *Grewia villosa* and *Hermania alhiensis* dominated the browse component at the beginning of the dry season. The same species dominated woody species composition during the wet season in addition to other unidentified species.

Botanical Composition of Goat Diets

Browse dominated goat diets from the moderate and heavy bushed paddocks from August through November (Table 6). This observation is in general agreement with studies done elsewhere. Wilson (1957) made some observations on browsing habits of East African dwarf goats at Serere in the Teso District of Uganda and concluded that goats preferred browse to herbage. Lopes and Stuth (1984) reported that browse was the dominant diet component comprising 76.6% of goat diets on untreated and mechanically treated plots and that the role of browse in diets decreased with gradual reduction of the overstory layer. Goats have unique preferences for shrub and tree leaves and compared to other domestic livestock they select from a wider array of plants, particularly woody species (Cory 1927, Fraps and Cory 1940, Maher 1945, Edwards 1948, Wilson 1957, and McMahan 1964). Goats are able to secure their nutritional needs by either grazing or browsing and this gives the animals a considerable advantage over cattle or sheep when there are seasonal variations in the quantity of herbage available. It was noted that when there was adequate herbage goats were selective, but during the dry season when there was less herbage selection was minimized. Edwards (1948) assertion that goats are never seen to eat any species of grass contradicts the findings of this study. The role of grass in the diet

Table 6. Botanical composition (%) of goat diets selected by month (on weighted basis) for various categories of bush conditions in an *Acacia senegal* savannah at Kiboko, Kenya, 1982.

Forage class/species	June				July				August			
	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α
GRASSES/GRASSLIKE												
Bothriochloa insculpta	T[2] ns[1]	T	T	.07	T ns	T	T	.07	T ns	T	T	.50
Cenchrus ciliaris	3.1 b[3]	17.1 a	4.7 b	.00	7.1 b	3.5 c	16.4 a	<.01	4.0 a	0.2 b	0.1 b	.01
Chloris roxburghiana	0.1 b	2.2 a	0.2 b	.01	5.2 b	0.6 c	9.6 a	<.01	4.7 a	0.6 b	0.1 b	<.01
Digitaria macroblephara	17.5 b	47.4 a	59.6 a	<.01	72.0 a	18.1 c	59.8 b	<.01	54.5 a	27.4 b	6.0 c	<.01
Eragrostis caespitosa	T b	0.1 b	0.4 a	.05	0.1 b	0.1 b	0.2 a	<.01	0.1 a	T b	T b	.03
Other grasses	T b	T b	0.1 a	<.01	0.6 ns	1.4	0.6	.24	0.1 ns	0.6	T	.42
Sporobolus pellucides	0.1 b	0.8 b	18.8 a	<.01	0.3 b	3.8 a	2.2 a	<.01	29.1 a	1.4 b	1.3 b	<.01
Total grass/grasslike	20.8 b	67.6 a	83.8 a	<.01	85.2 a	27.5 b	88.8 a	<.01	92.4 a	30.1 b	7.6 c	<.01
FORBS												
Talinum portulacifolium	T ns	T	T	.39	T a	T b	T b	.03	P	P	P	-
Total forbs	T ns	T	T	.39	T a	T b	T b	.03	P	P	P	-
BROWSE												
Acacia mellifera	1.1 ab	4.7 a	0.4 b	.08	12.3 a	1.0 b	8.8 ab	.02	P	P	P	-
Acacia senegal	0.7 ns	0.4	0.4	.50	0.1 b	41.0 a	1.0 b	<.01	1.8 a	66.9 b	90.3 a	<.01
Acacia tortilis	T b	T a	T b	<.01	T b	T a	T a	.04	T ns	T	T	.13
Balanites aegyptiaca	T ns	T	0.1	.13	T b	1.6 a	0.2 b	<.01	0.2 ns	0.9	0.7	.55
Commiphora africana	P[4]	P	P	-	P	P	P	-	P	P	P	-
Cordia gharaf	T ns	T	0.1	.29	P	P	P	-	P	P	P	-
Commiphora riparia	P	P	P	-	P	P	P	-	P	P	P	-
Grewia bicolor	33.9 a	3.5 b	8.9 b	<.01	0.8 b	9.7 a	0.1 b	<.01	5.5 a	T b	T b	.01
G. similis	1.3 ns	1.8	3.4	.11	0.2 a	T b	T b	<.01	T ns	T	T	.12
G. villosa	2.6 a	0.2 b	0.1 b	.05	P	P	P	-	P	P	P	-
Hermania alhiensis	T ns	T	T	.39	T b	T a	T b	<.01	T ns	T	T	.53
Other browse	T ns	0.1	0.1	.50	T b	2.3 a	T b	.01	T ns	1.8	0.7	.22
Solanum incanum	38.8 a	9.2 b	1.0 b	<.01	0.6 b	17.0 a	0.1 b	<.01	T ns	0.3	0.8	.27
Total browse	78.5 a	19.9 b	14.3 b	<.01	14.0 b	72.5 a	10.2 b	<.01	7.6 c	69.9 b	92.4 a	<.01

[1]Means not significant (α = 0.05).
[2]Trace.
[3]Means followed by the same letter across bush conditions within each month are not significantly different at α = 0.05.
[4]Present but not found in diet samples.

Table 6. Continued.

Forage class/species	September				October				November			
	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α
GRASSES/GRASSLIKE												
Bothriochloa insculpta	T ns	T	T	.10	P	P	P	-	T ns	T	T	.44
Cenchrus ciliaris	0.1 ns	0.3	0.5	.23	0.7 ns	0.3	T	<.01	T ns	T	T	.17
Chloris roxburghiana	11.2 ns	6.0	7.1	.38	6.4 a	0.1 b	T	.03	26.8 a	3.1 b	3.5 b	<.01
Digitaria macroblephara	48.1 a	17.8 b	6.0 c	<.01	39.4 a	28.8 a	T b	<.01	15.1 ab	33.3 a	8.9 b	<.01
Eragrostis caespitosa	T ns	T	T	.22	P	P	P	-	T ns	T	T	.08
Other grasses	T ns	T	T	.38	0.4 ns	T	T	.32	T ns	T	0.2	.30
Sporobolus pellucides	20.0 a	9.0 b	6.5 b	.01	10.3 a	0.5 b	T b	<.01	0.2 ns	0.1	T	.24
Total grass/grasslike	79.4 a	33.1 b	20.0 b	<.01	57.2 a	29.7 b	0.1 c	<.01	42.1 a	36.5 ab	12.6 b	.06
FORBS												
Talinum portulacifolium	P	P	P	-	43.1 a	14.2 b	18.9 b	.02	T b	17.6 ab	27.9 a	.04
Total forbs	P	P	P	-	43.1 a	14.2 b	18.9 b	.02	T b	17.6 ab	27.9 a	.04
BROWSE												
Acacia mellifera	P	P	P	-	T ns	T	T	.38	14.8 ab	0.5 b	24.7 a	.02
Acacia senegal	18.4 b	60.1 a	58.6 a	<.01	T ns	T	T	.08	0.1 ns	T	0.5	.26
Acacia tortilis	1.3 ns	2.6	T	.29	T ns	T	T	.05	T a	T b	T b	.05
Balanites aegyptiaca	0.2 a	T b	T b	.06	T ns	T	T	.16	T ns	T	T	.43
Commiphora africana	P	P	P	-	1.4 c	29.3 b	80.8 a	<.01	2.1 b	13.8 a	4.3 ab	.07
Cordia gharaf	P	P	P	-	P	P	P	-	P	P	P	-
Commiphora riparia	P	P	P	-	0.1 b	20.6 a	0.5 b	<.01	0.2 b	7.9 ab	16.3 a	.05
Grewia bicolor	T ns	0.1	0.1	.66	P	P	P	-	P	P	P	-
G. similis	T	T	T	.18	T b	4.5 a	T b	.05	T ns	P	P	.44
G. villosa	P	P	P	-	T ns	T	T	.38	P	P	P	-
Hermania alhiensis	P	P	P	-	0.1 ns	0.3	T	.12	P	P	P	-
Other browse	0.6 b	4.1 b	21.3 a	.01	0.5 ab	1.2 a	T b	.11	0.2 b	0.4 b	7.5 a	<.01
Solanum incanum	0.1 ns	T	T	.49	T ns	0.2	T	.11	40.6 a	22.9 ab	6.1 b	.02
Total browse	20.6 b	66.8 a	80.0 a	<.01	2.1 c	56.1 b	81.3 a	<.01	57.8 ns	45.5	59.4	.62

[1]Means not significant (α = 0.05).
[2]Trace.
[3]Means followed by the same letter across bush conditions within each month are not significantly different at α = 0.05.
[4]Present but not found in diet samples.

of goats should not be underestimated.

Goats' diets contained a greater portion of grass than browse or forb at the beginning of the dry season (June-September) and this proportion decreased towards the end of the dry season into the early wet season. There were virtually no forbs in the diets until late in the early wet season. Browse increased in the diets until the end of the dry season, dropped in October and then increased with increase in available moisture. Grasses and grasslike plants, forbs and browse contributed 45%, 7% and 47% respectively of the total diets from June through November.

Grasses and grasslike species in the goat diets across the light bush conditions varied from approximately 21% to 92% increasing as the dry season progressed. Grass was replaced in the diets by forbs during the early wet season. Browse in the diets was surprisingly high at the beginning of the dry season on the light bush condition. Fruits and leaves of *Solanum incanum* and *Grewia bicolor* leaves were the primary browse sources in the diets at this time. Browse declined to 2% by October in the diets of goats grazing the light bushed paddocks. However, when rain occurred in November browse consumption increased to 58%, primarily *Solanum incanum* and *Acacia mellifera* leaves.

Averaged across seasons, grass and grasslike plants in goat diets in the moderate bush conditions was 68% in June but varied from 28% to 37% for the remainder of the study period. Forbs contributed 14-18% of the diets in the moderate bush condition. Browse was low in the diets in the moderate bush condition at the beginning of the dry season but increased to 73% in July and gradually declined to 46% in November.

Goats grazing the moderate bushed paddocks, unlike the light and heavy paddocks, replaced *Digitaria macroblephara* with *Acacia senegal* pods in July. *Acacia senegal* varied from 1% to 90% in the heavy treatment paddocks between July and August. On the other hand, *Acacia senegal* varied from 41% to 67% in the moderate treatment paddocks. In the moderate bushed paddocks the *Acacia senegal* pods were more accessible to goats and pod production appeared to be higher than either in light or heavy treatment paddocks.

The general trends indicated that grass and grasslike species were high in the goat diets in June and July when more grass herbage was available as the woody plant species were more or less in a dormant stage with their leaves shed. Browse, particularly *Acacia senegal* pods increased in the diets during the months of August and September while grasses and grasslike plants decreased in the diets. Forbs consumption in the early wet season increased, thus reducing grass and grasslike species and browse in the diets. Thus, season was the most important factor creating substitutive relationships between grass and grasslike species, browse and forbs in the diet composition of goat diets throughout the study period. Increase of one forage class in the botanical composition of goat diets led to decreased composition of the other forage classes in the composition of goat diets.

Digitaria macroblephara was the most abundant grass species in all treatment paddocks and consequently it was important in goat diets throughout the period of study especially in the light and moderate bushed paddocks. Its composition in the diets varied from trace to 72% on the heavy bush paddocks. Generally, *Digitaria macroblephara* was highest in the diets at the beginning of the dry season and gradually decreased as it was replaced in the diets by browse in August and then by forbs in the early wet season. *Chloris roxburghiana* was the second most abundant grass species with its composition in the goat diets varying from trace to 27%. *Chloris roxburghiana* was higher in the diets in moderate and heavy bush conditions than in the light at the beginning of the dry season. However, during the latter part of the dry season and the early wet season, it was highest in the diets in the light bush condition. *Cenchrus ciliaris* varied from trace to 17% throughout the study period and declined in dietary composition as the dry season progressed. *Sporobolus pellucides* was highest in the diets in the moderate and heavy bush conditions at the beginning of the dry season. It increased in dietary composition in the light bush condition from August to November as the goats shifted from grasses and grasslike species to browse and forbs, respectively.

Forbs were absent in the study area until during the early wet season when they formed an important portion of the goat diets. There was only one prevalent forb in the study area, *Talinum portulacifolium* which varied in the diets from trace to 43%. Selection for *Talinum portulacifolium* by goats was not affected by the bush condition. Increase in forb consumption led to reduced browse and grass consumption in the diet composition in October. By November, *Talinum portulacifolium* had began to flower and the animals shifted back to browse and grass herbage as the latter were increasing in succulence and availability following increased available moisture.

Solanum incanum, a suffrutescent shrub, was high in goat diets in the light bush conditions at the beginning of the dry season but gradually decreased until October then increased to 41% in the diets. Both leaves and fruits of this shrub were preferred by goats. *Grewia bicolor* was important in diets of the animals at the beginning of the dry season, especially in the light bush paddocks, but gradually decreased in the diets as the season progressed. Abscised senescent leaves from this shrub were picked by goats in June and July and formed an important component of the diet. *Acacia senegal* which dominated the tree layer, varied from trace to 90% in the diet composition. The impact of this tree in the diets was realized in moderate and heavy bush conditions as its pods were abundant and accessible to the animals while the herbaceous vegetation continued to mature. *Acacia mellifera* was noted in goat diets at the beginning of the dry season but decreased drastically as the dry season progressed only to be grazed again in the middle of the wet season. *Acacia tortilis, Balanites aegyptiaca, Grewia similis*, *Grewia villosa* and *Hermania alhiensis* contributed little to the diet of goats. None of these woody species contributed more than 5% to the diets of goats. *Hermania alhiensis* was the most abundant shrub in the study area but it was only found in trace amounts in animal diets. It was less preferred by goats relative to other woody vegetation, forbs and herbaceous species. *Commiphora africana* and *Commiphora riparia* remained dormant throughout the dry season but became an important source of forage during the early wet season when the woody species initiated leaf growth. Other browse species low in diet composition were present throughout the study period, particularly *Boscia* sp., *Hibiscus* sp. and *Cordia ovalis*.

Goats not only change their diets with changing seasons but they also shift from either grazing to browsing or vice versa depending on herbage availability. Goats eat shrubs, grass, forbs and other weeds. Wilson (1957) and Knight (1965) observed that goats ate all major forage categories in East Africa. Lopes and Stuth (1984) reported that botanical composition of goat diets is influenced by season and method of bush control. It was noted that selection for forage species by goats was more diverse when the forages were young and green, but as the forages matured selection was limited to a few species, thus reducing botanical composition of the diets; this observation agrees with the findings of our study. Botanical composition of goat diets was more diverse at the beginning of the dry season and at the end of the dry season when forage availability was high and lowest during the mid-dry season when selection was minimal. Arnold (1960) reported that young green forages were more preferred by the foraging animal than mature forage. Diet composition was high towards the end of the dry season when woody species initiated new growth.

Although goats are traditionally browsers they are also noted to eat a large proportion of herbaceous plants. Shelton (1978) reported that goats appear to have superior adaptation than cattle or sheep to the arid tropics because of their ability to graze selectively and to take willingly a large variety of the vegetation. A similar view was portrayed by Gihad et al. (1980) that goats' high digestive efficiency accounts for their successful adaptation to poor environments where they convert woody plants into meat. The ability of the goat to utilize browse is probably an important factor contributing to its survival in areas where herbaceous forage supply is low. In this study herbaceous forage availability was lowest in August and September and it was during this time that browse formed a major component of goat diets.

The botanical composition of goat diets indicated an interesting trend throughout the study period. At the beginning of the dry season there was more grass and grasslike plants in the diets than either browse or forbs, but as the dry season progressed, grass decreased while browse increased in the diets. In the early wet season, however, forbs increased in the diets relative to grass or browse.

Selection for Plant Parts

Selection for plant parts by foraging animals varied with seasons. Leafy materials dominated goat diets at the beginning and at the end of the study period. However, stems and fruits contributed substantially to the goat diets during the dry season (Table 7). It has been reported that pods and seeds of *Acacia senegal* may contain 22% CP and 40.1% CP, respectively (Göhl 1981). Therefore, pods are a useful source of CP for goats during the dry season. Leaves are major components in livestock diets (Davis and Bartel 1975), Wilson et al. 1975, Ngethe and Box 1976, Durham and Kothmann 1977, Allison and Kothmann 1979). Leafy portions were largely consumed during the wet season when more palatable forage was available. As the dry season progressed, leafy materials decreased in the diets and stems and fruits increased. During this time, woody and herbaceous species were becoming mature and there was a tendency for the animals to switch from grazing to browsing.

As reported by other researchers (Cory 1927, Edwards 1948, Wilson

Table 7. Plant part composition (%) of goat diets selected from light, moderate and heavy bush cover paddocks in an *Acacia senegal* savannah at Kiboko, Kenya, 1982.

Bush cover conditions	Plant parts						
	Leaf	Stem	Fruit	Leaf:stem	Live	Dead	Live:dead
June							
Light	64.9 a[1]	32.2 ns[2]	2.9 ns	3.6 ns	58.1 a	41.9 ns	1.4 a
Moderate	36.9 b	46.3	4.4	1.1	46.6b	53.4	0.9 b
Heavy	66.9 a	31.1	2.0	3.6	51.1 ab	48.9	1.0 ab
α	.03	.15	.48	.08	.04	.29	.04
July							
Light	18.3 c	78.3 a	3.5 b	0.3 c	37.0 b	64.3 a	0.6 ns
Moderate	52.0 a	25.8 c	22.3 a	2.9 a	53.3 a	46.8 b	1.1
Heavy	25.0 b	49.8 b	0.3 c	0.6 b	49.3 a	50.7	1.0
α	-	< .01	< .01	-	< .01	< .01	< .01
August							
Light	41.7 a	55.3 a	3.0 c	0.8 ns	13.3 ns	86.8 ns	0.2 ns
Moderate	22.4 b	32.9 b	43.9 b	0.8	12.3	87.8	0.1
Heavy	13.4 c	17.3 c	69.3 a	0.8	8.9	91.1	0.1
α	< .01	< .01	< .01	.98	.15	.15	.19
September							
Light	33.0 ns	52.3 a	14.7 b	0.7 ns	7.8 ns	92.3 ns	0.1 ns
Moderate	30.9	41.3 ab	28.0 ab	0.8	16.9	83.1	0.3
Heavy	34.8	32.3 b	32.8 a	1.1	18.2	81.8	0.2
α	.81	.02	.05	.33	.18	.18	.24
October							
Light	84.2 b	15.7 a	0.2 a	5.4 b	85.4 b	14.6 a	5.8 b
Moderate	89.1 b	10.7 a	0.3 a	8.3 b	92.7 ab	7.3 ab	12.7 b
Heavy	99.1 a	0.9 b	T b	>100 a	99.8 a	0.3 b	>100 a
α	< .01	< .01	< .01	.02	< .01	< .01	< .01
November							
Light	71.6 a	20.3 a	8.1 ns	3.5 ns	94.5 a	5.5 b	17.2 b
Moderate	79.7 a	11.7 b	8.7	6.8	97.3 a	2.8 b	34.8 a
Heavy	57.7 b	14.8 ab	2.5	3.9	73.2 b	36.8 a	2.0 c
α	< .01	.10	.25	.08	< .01	.15	.24

[1]Means within columns each month with the same letter are significantly different (α = 0.05).
[2]Means within columns each month are not significantly different (α = 0.05).

1957) goats were noted to have a strong preference for shrubs and tree leaves whether green or dry, particularly in the dry season after the herbaceous materials had dwindled. Live plant parts in the diets of goats increased with increase in available moisture and decreased as the season progressed. Selection for live plant parts was highest at the beginning and end of the study period but lowest in August and September. During the wet season, green forage was more available and goats consumed more leaves. However, during the dry season the green forage was unavailable and the animal selection for plant parts shifted from leaves to stems and mast. The pattern of diet selection for plant parts by goats compares to that of small ruminant game animals reported by McMahon (1964) and Hoppe et al. (1977). Goats are intermediate selector feeders and when compared with cattle or sheep, they select from a wider array of woody plant leaves (Fraps and Cory 1940, Maher 1945, McMahan 1964). Stems remained green during the dry season and produced most of the green forage in the diets. Pods containing live seeds were substantially eaten during the dry season. *Solanum incanum* fruits containing glyco-solanine and regarded as highly toxic to livestock were largely consumed by goats throughout the study period. However, goats are known for having a higher threshold for bitter tastes than cattle and therefore consume a large proportion of bitter plants (French 1970). Pods, particularly from *Acacia senegal*, played a very important role in the diets of goats during the months of August and September. Pods were highest in the diets from moderate and heavy treatment paddocks.

Leaves were highest in the goat diets at the beginning of the dry season and towards the end of the study period. Leaves were selected randomly from treatment paddocks across the period of study. However, a marked increase of leafy materials in the diets was noted in October and November following lush growth, particularly the *Commiphoras*. Stemmy materials were highest in the diets from light bushed paddocks. More leaves were consumed throughout the study period than either stems or mast. Leaf/stem ratios were highest following increased precipitation at the beginning and at the end of the study period. Although the ratios were lowest during the dry season, canopy cover seems to have no effects. Leaf/stem ratios do not appear to be biologically interpretable in this data set.

The percent live materials appear to have been randomly selected from the treatment paddocks and the proportions of the live materials were highest at the beginning and end of the study period. October and November had the highest green materials in the goat diets while July, August and September had the lowest live materials in the diets. It appears that live materials in the diets increased with increase in available moisture. Dietary live/dead ratios across treatment paddocks were random, and therefore no biological meaning can be derived from them. In this study it was observed that goats consume both live and dead materials. As compared to cattle or sheep, the ability of the goat to digest more efficiently the fiber fraction of forage is probably a factor in avoiding starvation during the most stressful period when the forage is of low quality and unavailable (Ademosum 1970, Gihad 1976, Sharma and Rajora 1977, and Devendra 1978).

As reported in a study by Wilson (1957) during lush growth in

October and November, it was observed that goats showed a special preference for the inflorescences of grasses, particularly those of *Digitaria macroblephara.* Preference for leaves of woody species and forbs was shown. However, isolated cases of geophagia, or tendency for the animal to eat soil, was noted during the dry season in the heavy treatment paddock. This could be explained by the herbage probably being deficient of certain minerals.

Chemical Composition of Goat Diets

Goat diets were high in grass, browse and forbs at the beginning of the dry season, middle of the dry season and in the early wet season, respectively. Crude protein (CP) was generally high in diets from moderate and heavy bushed conditions due to high proportion of browse (Table 8). Browse (leaves, twigs and pods of shrubs and trees) generally contains higher levels of CP than do grasses (Rector and Huston 1976, Lopes and Stuth 1984). CP increased gradually from the beginning of the dry season and reached its peak in the early wet season. This trend of CP is in agreement with views of other researchers. Wilson (1969) in his review of browse in the nutrition of grazing animals noted that browse has a more consistent CP content than grasses, which are typically high in crude protein at the beginning of the growing season and low in protein when mature. Malechek (1970) reported that high levels of CP increased with the consumption of immature browse leaves and forbs, while low values of CP occurred when the proportion of dry grass in the diets was increased. Bryant (1977) reported a similar observation that CP values were inversely associated with browse content of the diet and

Table 8. Dietary crude protein (%), *in vitro* organic matter digestibility (%), and digestible energy (kcal/kg) of esophageally fistulated goats grazing an *Acacia senegal* savannah of varying bush conditions throughout the dry season (June-September) and early wet season (October-November) at Kiboko, Kenya, 1982.

Bush condition	Month						
	June	July	August	September	October	November	Mean
				Crude protein			
Light	11.6 ns[1]	10.3 b[2]	9.3 b	11.0 b	23.7 b	17.6 a	13.9 b
Moderate	12.4	13.7 a	14.0 a	16.3 a	27.9 a	14.2 b	16.4 a
Heavy	12.8	11.4 b	14.7 a	14.8 a	28.3 a	16.8 a	16.5 a
α - value	.20	< .01	< .01	< .01	< .01	< .01	--
Mean	12.3	11.8	12.7	14.0	26.6	16.2	15.6
				Organic matter digestibility			
Light	60.1 b	62.5 a	57.7 a	54.7 ns	70.0 ns	72.3 ns	62.9 ns
Moderate	63.9 a	60.3 b	52.3 b	57.4	68.6	74.1	62.8
Heavy	65.1 a	60.0 b	46.8 c	53.2	69.7	68.7	60.6
α - value	< .01	< .01	< .01	.38	.90	.14	--
Mean	63.0	60.9	52.3	55.1	69.4	71.7	62.1
				Digestible energy			
Light	2403.5 ns	2500.7 a	2307.6 a	2189.2 ns	2798.0 ns	2893.5 ns	2515.4 ns
Moderate	2267.8	2410.7 b	2092.1 b	2295.7	2742.8	2962.4	2461.9
Heavy	2603.4	2399.4 b	1873.3 c	2128.0	2787.4	2746.6	2423.0
α - value	< .01	.01	< .01	.37	.90	.14	--
Mean	2424.9	2436.9	2091.0	2204.3	2776.1	2867.5	2466.8

[1]Means are not significantly different across bush cover within month and nutritional paddocks (α = 0.05).
[2]Means followed by the same letter are not significantly different across bush cover within month and nutritional paddocks (α = 0.05).

proportional to grass content.

Organic matter digestibility (IVOMD) was high in the diets at the beginning of the dry season but decreased by the middle of the dry season followed by a steady increase until the end of the study period. This trend followed a decrease in grass and grasslike plants in the goat diets followed by an increase in forbs, immature browse and grass as the available moisture increased. Values reported by Wilson et al. (1975) indicated that IVOMD was low in the diets in late winter but high in mid-August. This latter peak was associated with high amount of grass consumption in the diets. Presence of grass and grasslike plants and forbs in goat diets is associated with increased IVOMD.

The trend of digestible energy (DE) in the diets of goats throughout the study period was in close agreement with the observations reported by Bryant (1977) where increased levels of DE were related to increased grass and forbs in the diets and to a corresponding decreased amount of browse. Like IVOMD, DE was high in the diets at the beginning of the dry season when grass and grasslike plants increased in the diets but decreased with increased browse in the diets in August and September. However, DE increased as forbs, grass and immature browse increased in the diets in response to increased precipitation.

CP was different across bushed treatment paddocks throughout the study period except in the month of June. CP was greatest on the moderate and heavy bushed paddocks than light bushed paddocks except in November. A 20 kg goat has a maintenance plus low activity CP requirement of 7.7% (NRC 1981). Thus, there was no apparent CP deficiency in the forages throughout the study period. *Acacia senegal* pods were a useful source of CP in the diets of goats during the mid-dry season and as reported by Göhl (1981) pods and seeds may contain 22% CP and 40.1% CP, respectively.

Moderate and heavy bushed paddocks were high in IVOMD in June, where herbaceous herbage was greater than in the light bushed paddocks but the reverse trends were observed in July, August and October in the light bushed paddocks. Canopy cover had its greatest dietary effects in August where increase in canopy cover resulted in reduced IVOMD. In September and October, IVOMD in the goat diets from light and moderate bushed paddocks exceeded those from heavy bushed paddocks ($\alpha = 0.38$) and ($\alpha = 0.14$), respectively. Only in August and September was the IVOMD maintenance requirement lower than 58.5% for a 20 kg goat (NRC 1981).

Goats on moderate and heavy bushed paddocks were deficient in DE in August while only the heavy bushed paddocks exhibited energy problems in September. Therefore, as bush cover increases, the critical energy deficiency period in mid-dry season increases. The NRC (1981) DE maintenance requirement for a 20 kg goat is 1.46 Mcal/kg. The study met this requirement from June through November except in the heavier bushed treatment paddocks in the dry season when most of the herbaceous materials were not available to the animal.

Selection Order

Variation in species preference by goats was dynamic across months, June through November, reflecting the true flexible nature in their dietary selection (Table 9). To assist in the interpretation of the results obtained in this study, three preference categories were derived

Table 9. Monthly selection order across all canopy treatments of species found in diets of goats grazing an *Acacia senegal* savannah at Kiboko, Kenya, 1982.

Preference category[1]	MONTH June	July	August
Preferred	*Solanum incanum*	*Solanum incanum*	*Solanum incanum*
	Grewia bicolor	*Grewia bicolor*	*Grewia bicolor*
	Acacia mellifera	*Acacia mellifera*	*Sporobolus pellucides*
	Grewia similis	*Cenchrus ciliaris*	*Balanites aegyptiaca*
	G. villosa	*Sporobolus pellucides*	*Cenchrus ciliaris*
	Cenchrus ciliaris	*Acacia senegal*	*Acacia senegal*
	Sporobolus pellucides	*Balanites aegyptiaca*	
	Eragrostis caespitosa	*Grewia similis*	
	Cordia gharaf	*Chloris roxburghiana*	
	Acacia senegal		
	Digitaria macroblephara		
Indifferent	*Balanites aegyptiaca*	*Eragrostis caespitosa*	*Digitaria macroblephara*
	Acacia tortilis	*Acacia tortilis*	*Chloris roxburghiana*
	Chloris roxburghiana	*Digitaria macroblephara*	*Eragrostis caespitosa*
	Sedge sp.	*Talinum portulacifolium*	*Acacia tortilis*
	Talinum portulacifolium	*Hermania alhiensis*	*Hermania alhiensis*
	Other forbs	*Bothriochloa insculpta*	*Grewia similis*
	Bothriochloa insculpta		*Bothriochloa insculpta*
	Hermania alhiensis		
	Tephrosia villosa		
Avoided	*Commiphora africana*	Sedge sp.	Sedge sp.
	Boscia sp.	*Commiphora africana*	*Acacia mellifera*
	Cordia ovalis	*Cordia gharaf*	*Commiphora africana*
	Duosperma kilimandscharicum	*Grewia villosa*	*Cordia gharaf*
	Hibiscus sp.	*Boscia* sp.	*Grewia villosa*
	Lannea floccosa	*Cordia ovalis*	*Boscia* sp.
	Ormocarpum kirkii	*Duosperma kilimandscharicum*	*Cordia ovalis*
		Hibiscus sp.	*Duosperma kilimandscharicum*
		Lannea floccosa	*Hibiscus* sp.
		Ormocarpum kirkii	*Lannea floccosa*
			Ormocarpum kirkii

[1]Preference categories were selected on the basis of mean selection ratios, standard errors, and associated confidence intervals. See Appendix Tables 3, 4 and 5.

Table 9. Continued.

Preference category[1]	MONTH		
	September	October	November
Preferred	*Acacia senegal*	*Talinum portulacifolium*	*Solanum incanum*
	Grewia bicolor	*Solanum incanum*	*Acacia mellifera*
	Sporobolus pellucides	*Commiphora africana*	*Commiphora africana*
	Solanum incanum	*Sporobolus pellucides*	*Talinum portulacifolium*
	Cenchrus ciliaris	*Cenchrus ciliaris*	*Sporobolus pellucides*
	Chloris roxburghiana		*Chloris roxburghiana*
	Balanites aegyptiaca		
	Acacia tortilis		
Indifferent	*Digitaria macroblephara*	*Balanites aegyptiaca*	*Digitaria macroblephara*
	Grewia similis	*Chloris roxburghiana*	*Acacia senegal*
	Bothriochloa insculpta	*Digitaria macroblephara*	*Eragrostis caespitosa*
		Grewia similis	*Acacia tortilis*
		Acacia tortilis	*Cenchrus ciliaris*
		Eragrostis caespitosa	*Balanites aegyptiaca*
		Acacia mellifera	*Bothriochloa insculpta*
		Grewia villosa	*Grewia similis*
		Hermania alhiensis	
		Acacia senegal	
Avoided	*Eragrostis caespitosa*	*Bothriochloa insculpta*	Sedge sp.
	Sedge sp.	Sedge sp.	*Tephrosia villosa*
	Acacia mellifera	*Cordia gharaf*	Other forbs
	Commiphora africana	*Grewia bicolor*	*Cordia gharaf*
	Cordia gharaf	*Boscia* sp.	*Grewia bicolor*
	Grewia villosa	*Cordia ovalis*	*G. villosa*
	Hermania alhiensis	*Duosperma kilimandscharicum*	*Hermania alhiensis*
	Boscia sp.	*Hibiscus* sp.	*Boscia* sp.
	Cordia ovalis	*Lannea floccosa*	*Cordia ovalis*
	Duosperma kilimandscharicum	*Ormocarpum kirkii*	*Duosperma kilimandscharicum*
	Hibiscus sp.		*Lannea floccosa*
	Lannea floccosa		*Ormocarpum kirkii*
	Ormocarpum kirkii		

[1]Preference categories were selected on the basis of mean selection ratios, standard errors, and associated confidence intervals. See Appendix Tables 3, 4 and 5.

from selection ratios, associated standard error means and confidence intervals (Appendix Tables 3, 4, 5). These preference categories include preferred, indifferent and avoided. Preferred species are assumed to be those which are readily consumed when encountered by the animal regardless of the associated species in close proximity. Preferred species exhibited positive selection ratios and confidence intervals across canopy conditions. Indifferent species are those grazed by the animal if encountered with no preferred species in close proximity. Degree of utilization of indifferent species is determined by the diversity and proximity of associated plants. Indifferent species exhibited negative selection ratios and negative confidence intervals. The selection ratio range assigned to this category was 0 to -4.8. Species in the "avoided" category are not readily grazed by the animal when encountered regardless of the diversity or proximity of other species. Avoided species exhibited extreme negative selection ratios of -10. Generally, a significant reduction in preferred and indifferent species must take place before increased grazing pressure can be exerted on these least preferred species. Those species in the preferred category will be primarily targets for bush control programs. Control of species which are avoided by goats will be difficult to achieve under proper stocking regimes.

The order in which plant species are selected by goats is important. A plant species encountered after feeding from a palatable species will be avoided whereas the same species will be relished after the animal encounters an unpalatable plant. Animals will eat the more preferred species until either they are satiated or the species are significantly depleted (on a per plant basis) before they move to the next most preferred species. Intake of the preferred species will be determined by its own abundance but also by the abundance of the associated preferred species (Crawley 1983). Hafez (1968) stated that sheep and cattle select leaf in preference to stem and green material in preference to dry. Therefore, preference ratio or the proportion of the species in diet divided by proportion of the species in the habitat, is important in determining species preference.

In this study availability and abundance of forage species in the treatment paddocks played a major role in determining preference for these species (Appendix Table 8). Generally, preference was highest in woody species than in herbaceous species throughout the study period. Studies indicate that goats select plant species and plant parts that are more easily digested and fermented because of their small rumen volume to body volume ratio (Hofman 1973, Schwartz and Said 1981). This study indicates that green materials were more preferred than dry materials, leaves were preferred to stems and that although some species were highly preferred by goats at certain times during the course of the study, their contribution to the diets was limited because of low availability in the treatment paddocks.

Generally, there were more preferred species at the beginning of the dry season than in the early wet season (Table 9). This could be explained by the greater abundance of species following increased available moisture in October and November, which limited grazing to a few individual species. The number of indifferent species was lowest in September possibly due to limited availability of these species.

Similarly, the number of avoided species was largest in the same month. Availability played an important part in determining preference values for indifferent and avoided species.

Certainly, *Solanum incanum* was the most preferred woody species across all months and treatment paddocks. Goats ate both leaves and fruits of this species. Although the fruits of *Solanum incanum* contain glyco-solanine as the active ingredient, this did not appear to adversely affect the goats while feeding on this species. Except for the camel, goats are known to have a higher threshold for bitter tastes than cattle or sheep (Hafez 1968, French 1970). *Grewia bicolor* was equally preferred across treatment paddocks from June through September but its preference decreased as the dry season progressed. Goats ate both green and abscised leaves from this species. In October and November, goats did not consume *Grewia bicolor* due to its unavailability in the treatment paddocks. *Acacia mellifera* leaves were preferred by goats at the beginning of the dry season and during the wet season when the woody species initiated new leaf growth. Goats tended not to consume this species in the moderate bush paddocks during the mid-dry and the early wet seasons. *Grewia* sp. were only important in the diets of goats at the beginning of the study period and thereafter became indifferent and avoided species as their availability in the treatment paddocks declined. However, preference of *Grewia villosa* increased when available with a corresponding decrease in canopy cover.

Cenchrus ciliaris was preferred by goats from the beginning of the study period until the beginning of the early wet season. Thereafter, this species became less preferred due to increase in abundance of more preferred associated species. When available, *Cenchrus ciliaris* increased in preference as canopy cover increased. However, *Sporobolus pellucides* was preferred across all months and treatment paddocks. *Cenchrus ciliaris* and *Sporobolus pellucides* were the key preference grass species contributing to diets throughout the grazing period. *Eragrostis caespitosa* and *Cordia gharaf* were only preferred by goats in June and thereafter they became less preferred and avoided as the dry season progressed.

Preference for *Acacia senegal* across treatment paddocks was not affected by bush canopy cover. This species was preferred by goats from June through September. *Acacia senegal* pods formed a major component of goat diets in the early dry and mid-dry seasons. Pod selection during these periods had no biological interpretation with respect to bush cover. Selection of *Acacia senegal* is a function of vegetation patterns associated with each treatment paddock except in the light bushed treatment paddocks. Selection ratios of *Acacia senegal* were high because the pods had fallen and therefore they were neither sampled nor their production determined in the sampling process.

Although *Digitaria macroblephara* was the most dominant grass with the highest species composition across all treatment paddocks throughout the study period, it was only preferred in proportion to availability and its preference decreased as the dry season progressed. Its preference was particularly low in the moderate and heavy treatment paddocks. Mast and leaves of *Balanites aegyptiaca* were preferred from July through September. However, this species was less preferred during the wet season. Preference for *Balanites aegyptiaca* was highest in the light and moderate treatment paddocks probably due to greater availability of mast. The only two grass species that exhibited some canopy effects on preference were *Chloris roxburghiana* and *Sporobolus pellucides*. Preference for *Chloris roxburghiana* exhibited no particular trend across months but it was more preferred than avoided. Preference for this species decreased with increase in canopy cover whereas *Sporobolus pellucides* tended to increase in preference as the canopy cover decreased. Preference for *Talinum portulacifolium* was determined by its availability and was highly preferred in October regardless of the other preferred associated species in close proximity. This species together with *Solanum incanum* were insensitive to canopy cover in terms of diet selection. Other forbs were either less preferred or avoided by goats possibly due to their low availability in the treatment paddocks. *Commiphora africana* was not available during the early and mid-dry seasons but its leaves formed a major pprtion of the diet during transition of dry to wet seasons in October and November. *Acacia tortilis* was found in goat diets in September possibly due to initiated growth following erratic rains that fell in August. However, its preference was more realized in the light treatment paddocks than either moderate or heavy treatment paddocks.

Bothriochloa insculpta and sedge sp. were less preferred and avoided throughout the period of study. *Tephrosia villosa* which was only available at the beginning of the dry season and late in November was more avoided than preferred. *Hermania alhiensis*, the most abundant woody species in the shrub layer was sparingly eaten by goats and was less preferred and avoided even when available. Goats did not show any preference for *Boscia* sp., *Cordia ovalis*, *Duosperma kilimandscharicum*, *Hibiscus* sp., *Lannea floccosa* and *Ormocarpum kirkii*. These species were avoided relative to other associated preferred species.

CHAPTER VI

MANAGEMENT IMPLICATIONS

Man has lived with the goat from time immemorial. However, the goat has been described as a half-forgotten friend, and has been a target for much abuse and humor (Mackenzie 1957). This pernicious image of the goat is pervasive among people with prejudiced opinions. Nevertheless, the goat is an animal that can be easily sustained. It belongs to the *Bovidae* family or hollow horned animals. The goat is perhaps the most important animal of value to man in the tropics. Goats have a unique ability to adapt and maintain themselves in harsh environments (Devendra and Burns 1970). The goat population represents about 15% of the total world population of grazing domestic animals with the largest concentrations found in Africa and the Indian sub-continent (Devendra and Burns 1970). Goats are multi-purpose animals producing meat or chevon, milk, skins and hair. However, in East Africa more use is made of chevon and skins than of goat milk or hair. Although goat meat consumption is associated with some ceremonies or festivities, the demand for goats is growing, especially among urban populations. The focus is on range areas to supply this increasing demand for chevon. Apart from supplying meat demand, goats have an important role to play in range areas - that of suppressing bush encroachment.

Overgrazing of rangelands by large ungulates is a well documented factor in East Africa that has resulted in bush encroachment to an excessive degree. Under conditions of heavy overstocking with cattle, it is hard to maintain seasonal grass fires and invading shrubs, including

Acacia spp., readily establish from seeds on denuded ground. The resulting thickets if not suppressed at the earliest opportunity by goating result in reduced carrying capacity for cattle and establishment of tsetse flies (*Glossina* spp.) population. People depending upon cattle products are forced to move out to look for more suitable area to maintain their subsistence production system. Overgrazing also leads to accelerated loss of top soil thus rendering the area infertile and incapable of supporting herbaceous production. In order for goats to be effectively used to suppress bush encroachment, grazing pressure should be applied before bush grows out of reach. Cattle numbers should be kept as low as possible to avoid overgrazing whereas the rate of stocking with goats should be set at a level which is below that which would induce exposure of the ground cover by heavy grazing or browsing. Although goats prefer browsing to grazing and will utilize a wide range of plant species, they can also feed on very short grass by means of their prehensile tongues and mobile upper lips. Studies, including this one, have indicated that even among the browse species, some plants and plant parts are more preferred by goats than others. The idea that animals are selective in their feeding habits leads to the inference that any good range management aimed at increasing livestock productivities should incorporate all classes of livestock in well balanced numbers in order to maintain the range in good conditions. Knowledge of species preference by any class of livestock will be an added advantage necessary to achieve the ethics of "good management."

Results obtained in this study indicate that goats are able to derive a large proportion of their nutritional requirements from browsing and would therefore not compete with cattle directly. Where these two stock classes are herded together, goats would assist in controlling the resprouting undesirable invading bush species, while at the same time would open up the vegetation for better utilization by cattle.

In East Africa, land browsed by goats under any grazing method is given no rest during the year not even during the dry season. Surprisingly, this study indicated that except for DE in heavier bushed paddocks during the dry season, all nutrient requirements for maintenance were met. Shrubs, especially *Acacia senegal* pods, were high in crude protein (CP) during the dry season while grasses and forbs were adequate in energy for maintenance. It was noted that availability of forage was the crucial factor determining the nutrition of goats throughout the study period but not the quality of the diet.

The most critical period in the nutrition of goats is during the dry season when DE for maintenance is below requirements in the heavier bushed paddocks. Although animals in rangelands of East Africa are not often supplied with supplemental feeds due to vastness of the area and limited availability of such supplementary feeds, it suffices to say 0.9 kg starch equivalent per 100 kg per day may be needed in order to maintain energy requirements of the goats while 3 kg of starch equivalent per gallon of milk produced will be needed during lactation (Mackenzie 1957). In case of protein deficiency, which was not apparent during the course of the study, 0.09 kg digestible protein per 100 kg bodyweight would be adequate for maintenance while 0.6 kg digestible protein per gallon of milk would be needed during lactation (Mackenzie 1957). Molasses and urea would be the cheapest sources of energy and protein, respectively for the range areas. Kids should be dropped in October when the vegetation is rich in nutrients and forage availability is adequate both for maintenance and lactation.

Summary

The study indicated that total bush densities were 1290, 1843 and 1940 plants/ha in light, moderate and heavy bushed paddocks, respectively. The resultant total canopy cover derived from bush densities were 13.1%, 30.7% and 46.8% in the light, moderate and heavy bush conditions, respectively. *Acacia senegal* and *Acacia tortilis* were the only two trees which created significant canopy effects in the treatment paddocks.

Moisture was the main factor determining herbage production across seasons. Graminoid herbage was highest at the beginning of the dry season and at the end of the study period (November). However, canopy cover was noted to have an effect on graminoid herbage. The greatest overall graminoid herbage was noted in the heavy bushed paddocks dominated by trees. The lowest recorded graminoid herbage throughout the study period was 1034/ha in October.

Similarly, forb herbage was also greatly influenced by moisture availability. Herbage was highest at the beginning of the dry and wet seasons. *Talinum portulacifolium* and *Barleria micrantha* were the most prevalent forbs in the study paddocks. Forbs seemed to do better under trees and in the open but not under low-lying bushes in the moderate treatment paddocks. There was a decline in forb herbage during the dry season.

There was more available browse in the heavy bushed paddocks than either moderate or light bushed conditions. Browse herbage decreased during the dry season since most trees had become dormant with their leaves abscised. One distinction between trees and shrubs was that the latter retained their leaves longer than did the trees during the dry season. *Acacia mellifera, Acacia senegal* and *Grewia villosa* were the three woody species that contributed substantially to the total available browse.

Digitaria macroblephara was the most dominant grass and contributed the highest species compositon across bush conditions throughout the grazing period. It was noted that *Bothriochloa insculpta, Cenchrus ciliaris* and *Chloris roxburghiana* decreased in composition as canopy cover increased. Forbs as a percent of available forage increased in the diets with increase in available moisture whereas canopy cover had no major effect on their contribution to species composition. However, the composition of available browse in the total available forage was similar for all months except in July, where the heavy bush conditions had the highest composition of browse than either light or moderate bushed treatment paddocks.

Botanical composition of goat diets indicated that grass portion was greatest in the diets than either browse or forbs at the beginning of the dry season. However, browse had a substitutive effect in the diets during the dry season when most of the herbaceous materials were highly lignified. Forbs were an important component of the diet in October and November, especially *Talinum portulacifolium*. Goat diets contained 45%, 7% and 47% of grasses and grasslike species, forbs and browse, respectively.

When available, green forage was preferred to dead forage throughout the study period. More leaves were consumed by goats than any other plant part in the course of the study. However, fruits (pods, mast, inflorescence and seeds) formed an important part of goat diets during dry season. *Acacia senegal* pods formed the largest portion of fruits in the goat diets during the dry season. The role *Acacia senegal* pods play in the nutrition of goats should be further investigated in order to incorporate this species in the management of desirable plant species in the range areas of East Africa. Moisture availability played a large role in determining availability of plant parts selected by goats.

Crude protein (CP) was generally high in diets from moderate and heavy bushed conditions due to high proportion of browse. *In vitro* organic matter digestibility (IVOMD) was high in the diets at the beginning of the dry season but decreased in diets by the middle of the dry season followed by a steady increase as forbs, immature browse and grass increased with increased available moisture. Digestible energy (DE) increased as forbs, grass and immature browse increased in the diets in response to increased precipitation. DE was below maintenance requirements of goats in the heavier bushed paddocks during mid-dry season. Otherwise, the study met all the other nutrient requirements for maintenance.

Warren et al. (1984) observed that shrubs were the most important foods of goats, contributing over half of the diet in summer. Species of *Acacia* were noted to contribute significantly to Spanish goat diets in summer. Generally, this study is in agreement with the results of Warren et al. (1984). Browse species were more preferred by goats than grasses throughout the period of study. *Solanum incanum*, *Acacia mellifera*, *Commiphora africana* and *Talinum portulacifolium* were the most preferred species during the wet season while *Solanum incanum, Grewia bicolor, Acacia senegal, Acacia mellifera, Cenchrus ciliaris* and *Sporobolus pellucides* were the key woody and grass species contributing highly to diet preferrence throughout the grazing period.

Cenchrus ciliaris and *Sporobolus pellucides* were the most preferred grass species throughout the period of study. *Talinum portulacifolium*, *Solanum incanum*, *Grewia bicolor*, *Acacia senegal*, *Acacia mellifera*, *Balanites aegyptiaca* and *Commiphora africana* were the most preferred forbs and woody species throughout the study period. *Acacia senegal* and *Balanites aegyptiaca* pods and mast, respectively, were very important components in the goat diets during the dry season. The species mentioned above are potential key species on which sould management should be based in this area in order to meet the nutritional requirements of goats as well as other classes of livestock. Preliminary studies in ecology carried out at NRRS indicate that burning during the dry season is effective in top-killing some of the undesirable browse and grass species such as *Hermania alhiensis*, *Grewia* spp. and *Bothriochloa insculpta*. Interestingly, *Hermania alhiensis* is the most dominant shrub in the study area but contributed very little if any to the diets of goats. However, a good balance of woody species and herbaceous species should be maintained in order to provide goats and other classes of livestock a chance to select preferred species while minimizing dietary overlap.

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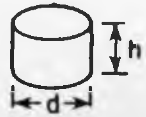
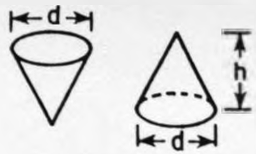
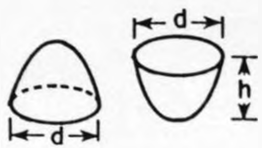
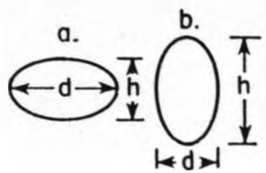
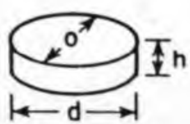
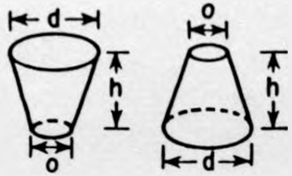
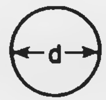
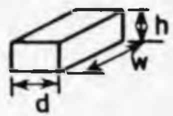
APPENDIX

GEOMETRIC FORMULAE

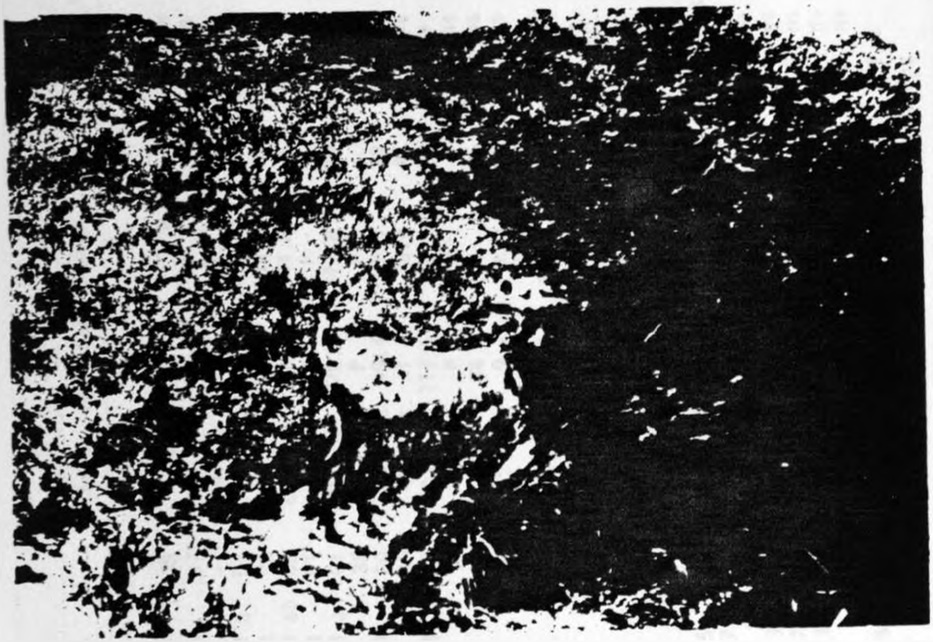
DIAGRAM	OUTER DIMENSION	INNER DIMENSION
cylinder	$v = \pi(d/2)^2 h$	$v = \pi(d/2-2x)^2(h-x)$
cone	$v = \frac{\pi(d/2)^2 h}{3}$	$v = \frac{\pi(d/2-2x)^2(h-x)}{3}$
paraboloid	$v = \frac{\pi(d/2)^2 h}{2}$	$v = \frac{\pi(d/2-2x)^2(h-x)}{2}$
ellipsoid	$v_a = 4/3\,\pi h^2 d$ $v_b = 4/3\,\pi h d^2$	$v_a = 4/3\,\pi(h-x)^2(d-2x)$ $v_b = 4/3\,\pi(h-x)(d-2x)^2$
cube	$v = h^3$	$v = h(h-2x)(h-2x)$
spheroid	$v = 4/3\,\pi h(d/2)(d/2)$	$v = 4/3\,\pi(h-x)\left(\frac{d-2x}{2}\right)\left(\frac{d-2x}{2}\right)$

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		$v = \frac{\pi h(d^2 + do + o^2)}{12}$	$v = \frac{\pi (h-x) [(d-2x)^2 + (d-2x)(o-2x) + (o-2x)^2}{12}$
8	Quarter Sphere		$v = \frac{4/3\,\pi d^3}{4}$	$v = \frac{4/3\,\pi (d-x)^3}{4}$
9	Quadrant Cylinder		$v = .785\,d^2 h$	$v = .785\,(d-2x)^2 (h-x)$
10	Parabolic Cone		$v = \frac{\pi (d/2)^2 h}{3} + \frac{\pi (d/2)^2 o}{2}$	$v = \frac{\pi (d/2-x)^2 (h-x)}{3} + \frac{\pi (d/2-x)^2 (o-x)}{2}$
11	Parabolic Frustrum		$v = \frac{\pi h_1 (d^2 + do + o^2)}{12} + \frac{\pi (d/2)^2 h_2}{2}$	$v = \frac{\pi h_1\ (d-2x)^2 + (d-2x)(o-2x) + (o-2x)^2}{12} + \frac{\pi (d/2-2x)^2 (h_2 - x)}{2}$

SHAPE CODE	SHAPE NAME	DIAGRAM	GEOMETRIC FORMULAE OUTER DIMENSION	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



Appendix Table 1. Monthly herbaceous standing crop (kg/ha) by individual species for each bush canopy condition in an *Acacia senegal* savannah at Kiboko, Kenya, 1982.

Category	Bush canopy class											
	June				July				August			
	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α
GRASS/GRASSLIKE												
Aristida keniensis	T ns[1]	T	1.1	.38	3.8 a	T b	T b	.07	.8 ns	1.1	1.0	.97
Annuals	100.9 ns	26.7	4.5	.37	P ns	P	P	-	P ns	P	P	-
Andropogon sp.	P ns	P	P	-	38 ns	T	T	.39	P ns	P	P	-
Bothriochloa insculpta	198.6 a[2]	110.3 ab	25.7 b	.03	175.2 ns	290.1	133.7	.30	84.7 ns	117.4	121.8	.87
Cenchrus ciliaris	139.2 a	179	109.3	.78	68.8 ns	173.4	108.7	.70	69 ns	16.8	44.8	.60
Chloris roxburghiana	380.9 a	133.3 b	235.3 ab	.05	642.5 a	53.1 b	344.8 ab	<.01	206.9 ns	137.5	282.5	.40
Cymbopogon pospochilli	T[3] ns	39.0	13.3	.51	P ns	P	P	-	P ns	P	P	-
Digitaria macroblephara	494.9 b	1420.8 a	1053.8 a	.01	1212 ns	970.3	1377.8	.28	618.6 b	1534.4 a	1158.6 a	<.01
Enteropogon macrostachyus	14.1 ns	T	T	.38	P ns	P	P	-	P ns	P	P	-
Eragrostis caespitosa	136.2 ns	73.6	13.8	.60	143.0 ns	69.4	9.1	.19	82.6 ns	149.1	20.20	.26
Heteropogon contortus	94.2 ns	T	T	.38	44.2 ns	T	9.4	.47	T ns	T	27.2	.38
Microchloa kunthii	86.5 ns	164.9	140.4	.50	103.9 ns	117.5	156.5	.57	37.6 b	102.5 a	43.5 ab	.06
Others	T ns	.7	T	.38	P ns	P	P	-	7.9 ns	T	T	.38
Panicum maximum	T ns	3.5	T	.38	T b	34.8 a	T b	.06	23.3 ns	T	22.4	.62
Sedge sp.	6.5 ns	T	37	.34	15.8 ns	9.7	6.3	.55	8.6 ns	7.7	17.7	.57
Sehima nervosum	T ns	21.3	T	.38	T ns	T	5.9	.37	P ns	P	P	-
Sporobolus pellucides	81.1 ns	7.8	180	.33	108.6 ns	102.1	119.9	.99	74.9 ns	63.4	116.5	.82
Themeda triandra	P[4] ns	P	P	-	73.7 ns	T	T	.39	P ns	P	P	-
Unidentified spp.	P ns	P	P	-	P ns	P	P	-	P ns	P	P	-
Total Grass	1733	2181	1814		2630	1820	2272		1215	2130	1856	
FORBS												
Barleria micrantha	2.9 ns	5.2	3.5	.62	66.2 ab	4.4 b	90.1 a	.05	9.3 ns	T	T	.11
Commelina benghalensis	1.6 ns	4.0	.7	.27	8.5 ns	1.2	T	.42	P ns	P	P	-
Indigofera sp.	T b	2.8 a	T b	<.01	P ns	P	P	-	P ns	P	P	-
Other forbs	3 ns	T	2.3	.61	P ns	P	P	-	P ns	P	P	-
Talinum portulacifolium	T ns	T	3.7	.12	P ns	P	P	-	P ns	P	P	-
Tephrosia villosa	1.4 ns	.9	.3	.61	P ns	P	P	-	T ns	T	6	.38
Unidentified forbs	.3 ns	.4	T	.54	P ns	P	P	-	P ns	P	P	-
Total forbs	9.2	13.3	10.5		74.7	5.6	90.1		9.3	T	6	
Total herbage	1742	2194	1825		2705	1826	2362		1224	2130	1862	

[1]Means across treatment for each month are not significantly different (α = 0.05).
[2]Means across treatments for each month are different (α = 0.05).
[3]Trace.
[4]Present but not found in samples.

Appendix Table 1. Continued.

Category	Bush canopy class											
	September				October				November			
	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α
GRASS/GRASSLIKE												
Aristida keniensis	T ns	1.4	T	.38	T ns	1.8	T	.38	14.9 ns	T	1.8	.42
Annuals	P ns	P	P	-	P ns	P	P	-	P ns	P	P	-
Andropogon sp.	P ns	P	P	-	18 ns	P	P	.38	T ns	T	.6	.38
Bothriochloa insculpta	312.1 ns	118.7	66.6	.25	138.2	128.9	148.8	.97	165.4 ns	105.3	102.6	.59
Cenchrus ciliaris	91.7 a	30.1	57	.60	67.3	8.5	15.4	.12	229.48 a	38.6 b	19.7 b	.05
Chloris roxburghiana	519.7 a	44.4 b	291.7 ab	.05	245	236.9	189	.81	632.8 a	87.6 b	82.6 b	<.01
Cymbopogon pospochilli	P ns	P	P	-	P ns	P	P	-	P ns	P	P	-
Digitaria macroblephara	791.5 b	1073.6 ab	1505.8 a	.01	378.3 c	1041.4 b	1779.3 a	<.01	1195.7 ns	1154.3	1289.3	.84
Enteropogon macrostachyus	33.9 ns	T	T	.15	P ns	P	P	-	7.4 ns	T	T	.38
Eragrostis caespitosa	247.7 ns	194.2	4.0	.11	49 ns	113.7	T	.16	51 ns	62.8	40.5	.93
Heteropogon contortus	19.0 ns	T	T	.38	P ns	P	P	-	68.6 ns	T	T	.38
Microchloa kunthii	82.9 a	34.5 ab	16.9 b	.04	16.7 ns	46	25.8	.20	31.4 ns	43.8	30	.73
Others	P ns	P	P	-	P ns	P	P	-	9.9 ns	11	14.3	.96
Panicum maximum	15.9 ns	5.3	T	.46	1.9 ns	T	3.9	.56	T ns	T	22	.35
Sedge sp.	.6 ns	T	4.0	.24	2.9 ns	T	T	.38	14 ns	10.2	7.3	.71
Sehima nervosum	T ns	1.8	T	.38	P ns	P	P	-	P ns	P	P	-
Sporobolus pellucides	65.4 ns	87.3	230.3	.32	37.3 ns	65.7	9	.40	97.5 ns	14.5	36.6	.68
Themeda triandra	109.6 ns	T	2.0	.38	80.2 ns	T	T	.15	79.1 ns	6.8	T	.19
Unidentified spp.	T ns	T	T	-	P ns	T	T	-	P ns	P	P	-
Total Grass	2290	1591	2178	-	1035	1643	2171	-	2597	1535	1647	-
FORBS												
Barleria micrantha	P ns	P	P	-	P ns	P	P	-	123.5 a	12.5 b	12 b	.01
Commelina benghalensis	P ns	P	P	-	T ns	1.4	T	.38	11.7 ns	6.7	1.8	.38
Indigofera sp.	P ns	P	P	-	P ns	P	P	-	P ns	P	P	-
Other forbs	P ns	P	P	-	3.4 ns	4.5	3	.90	P ns	P	P	-
Talinum portulacifolium	P ns	P	P	-	P ns	P	P	-	23.8 ns	6.5	128.8	.09
Tephrosia villosa	P ns	P	P	-	P ns	P	P	-	T ns	1.8	17.8	.24
Unidentified forbs	T ns	3.4	T	.38	P ns	P	P	-	5.9 ns	T	8.4	.18
Total forbs	T	T	T	-	3.4	5.9	3	-	164.9	27.5	168.8	-
Total herbage	2290	1594	2178		1038	1649	2174		2762	1563	1816	

[1]Means across treatment for each month are not significantly different (α = 0.05).
[2]Means across treatments for each month are different (α = 0.05).
[3]Trace.
[4]Present but not found in samples.

Appendix Table 2. Plant species composition (%) derived from available forage in an *Acacia senegal* savannah of varying degrees of canopy cover at Kiboko, Kenya, 1982.

Category	Plant species composition											
	June				July				August			
	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α
GRASS/GRASSLIKE												
Bothriochloa insculpta	13.2 a[1]	5.1 b	1.0 b	.01	8.1 ns	13.5	6.9	.36	8.5 ns	5.6	6.8	.86
Cenchrus ciliaris	8.0 ns[2]	7.3	5.0	.81	2.0 ns	5.5	3.4	.64	7.5 ns	0.5	2.8	.19
Chloris roxburghiana	22.9 a	5.8 b	13.4 ab	.01	22.8 a	3.9 b	13.7 ab	.01	18.2 ns	4.7	18.6	.10
Digitaria macroblephara	31.5 b	63.5 a	51.3 a	<.01	44.2 ns	53.1	56.4	.29	34.3 b	73.6 a	60.3 a	<.01
Sedge sp.	0.5 ns	T	2.7	.33	0.5 ns	0.6	0.3	.79	0.4 ns	0.3	0.8	.56
Sporobolus pellucides	4.1 ns	0.3	8.0	.23	3.5 ns	4.7	4.1	.95	4.8 ns	3.2	2.7	.73
FORBS												
Barleria micrantha	0.2 ns	0.3	0.4	.71	3.6 ns	0.4	4.2	.09	1.3 a	T b	T b	.05
Commelina benghalensis	P ns	P	P	-	P ns	P	P	-	P ns	P	P	-
Talinum portulacifolium	T[3] ns	T	0.5	.10	P ns	P	P	-	P ns	P	P	-
Tephrosia villosa	0.1 ns	0.1	T	.54	P ns	P	P	-	T ns	T	0.1	.38
Unidentified forbs	T ns	T	T	.58	P ns	P	P	-	P ns	P	P	-
BROWSE												
Acacia mellifera	0.2 ns	T	T	.40	0.1 ns	T	T	.42	0.1 ns	T	T	.37
Acacia senegal	0.2 b	0.5 ab	1.4 a	.03	0.1 b	0.4 b	0.8 a	.01	1.8 ns	0.5	0.5	.44
Acacia tortilis	0.1 ns	T	0.1	.28	T ns	T	T	.82	0.1 ns	T	T	.19
Balanites aegyptiaca	T ns	T	T	.61	T ns	T	T	.45	T ns	T	T	.36
Boscia sp.	T ns	T	T	.37	T ns	T	T	.37	T ns	T	T	.23
Commiphora africana	T ns	T	0.1	.35	T ns	T	T	.27	T ns	T	T	.53
Cordia gharaf	1.9 ns	T	0.5	.49	0.5 ns	T	0.1	.49	0.1 ns	T	T	.32
Cordia ovalis	T ns	T	T	.22	T ns	T	T	.21	T ns	T	T	.30
Commiphora riparia	T ns	T	T	.38	T ns	T	T	.38	T ns	T	T	.37
Grewia bicolor	0.5 ns	T	T	.38	0.1 ns	T	T	.38	T ns	T	T	.39
Grewia similis	T ns	T	T	.40	T ns	T	T	.21	2.1 ns	T	T	.39
Grewia villosa	0.1 ns	0.1	2.0	.42	0.1 ns	0.1	0.5	.53	5.0 ns	T	0.1	.39
Duosperma kilimandscharicum	T ns	T	T	.25	T ns	T	T	.17	0.4 ns	T	T	.39
Hermania alhiensis	0.3 b	0.2 b	1.1 a	.01	0.1 b	0.2 b	0.6 a	.01	2.2 ns	0.1	0.3	.28
Hibiscus aponeurus	T ns	T	T	.38	P ns	P	P	-	P ns	P	P	-
Hibiscus sp.	T ns	T	T	.29	T ns	T	T	.12	0.4 ns	T	T	.37
Lannea flocoosa	T ns	T	T	.47	T ns	T	T	.46	T ns	T	T	.60
Maerua triphylla	P[4] ns	P	P	-	P ns	P	P	-	P ns	P	P	-
Ormocarpum kirkii	T ns	T	T	.01	T ns	T	T	.37	T ns	T	T	.07
Solanum incanum	P ns	P	P	-	P ns	P	P	-	P ns	P	P	-
Other browse	T ns	T	T	.34	T ns	T	T	.35	0.4 ns	T	T	.37
Unidentified browse	T ns	T	T	.31	T ns	T	T	.04	T ns	T	T	.09

[1]Means followed by the same letter between bush conditions are not significantly different (α = 0.05).
[2]No significant difference between bush canopy condition (α = 0.05).
[3]Trace.
[4]Present but not found in samples.

Appendix Table 2. Continued.

Category	Plant species composition											
	September				October				November			
	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α	Light	Moderate	Heavy	α
GRASS/GRASSLIKE												
Bothriochloa insculpta	11.9 ns	6.1	5.0	.36	10.9 ns	7.5	6.8	.67	7.2 ns	7.4	6.6	.98
Cenchrus ciliaris	4.0 ns	1.5	2.0	.58	4.9 a	0.5 b	1.0 b	.04	6.4 a	2.1 ab	0.7 b	.07
Chloris roxburghiana	25.7 a	2.6 b	14.7 ab	.01	24.9 ns	13.1	13.7	.15	23.7 a	8.5 b	8.1 b	.02
Digitaria macroblephara	33.9 b	69.5 a	66.5 a	<.01	42.0 b	65.3 a	75.1 a	<.01	42.4 b	64.9 a	62.9 a	.02
Sedge sp.	T ns	T	0.2	.27	0.3 ns	T	T	.38	0.6 ns	0.5	0.5	.96
Sporobolus pellucides	2.8 ns	5.2	10	.32	3.2 ns	3.6	0.9	.57	3.8 ns	3.8	1.6	.64
FORBS												
Barleria micrantha	P ns	P	P	-	P ns	P	P	-	4.0 a	0.9 b	0.6 b	.02
Commelina benghalensis	P ns	P	P	-	P ns	P	P	-	0 ns	0	0	-
Talinum portulacifolium	P ns	P	P	-	P ns	P	P	-	0.9 b	0.5 b	5.1 a	.06
Tephrosia villosa	P ns	P	P	-	P ns	P	P	-	T ns	0.7	0.8	.48
Unidentified forbs	T ns	0.2	T	.36	P ns	P	P	-	0.2 ns	T	0.4	.21
BROWSE												
Acacia mellifera	T ns	T	T	.36	T ns	T	P	.28	0.1 ns	T	T	.54
Acacia senegal	T ns	T	T	.15	0.4 ns	0.4	0.7	.63	0.6 ns	1.3	1.2	.47
Acacia tortilis	0.1 ns	T	T	.17	0.4 ns	T	T	.11	0.1 ns	T	T	.22
Balanites aegyptiaca	T ns	T	T	.55	T ns	T	T	.61	T ns	T	T	.57
Boscia sp.	T ns	T	T	.13	T ns	P	P	.15	T a	P b	P b	.04
Commiphora africana	T ns	T	T	.21	T ns	T	T	.43	T ns	0.1	0.1	.28
Cordia gharaf	T ns	T	T	.60	T ns	T	T	.58	0.3 ns	T	0.1	.43
Cordia ovalis	T ns	T	T	.37	T ns	T	T	.19	P ns	T	T	.32
Commiphora riparia	T ns	T	T	.38	P ns	T	P	.38	P ns	T	P	.38
Grewia bicolor	T ns	T	T	.38	T ns	P	P	.38	T ns	P	P	.38
Grewia similis	T ns	T	T	.12	T ns	T	P	.08	T ns	0.1	T	.14
Grewia villosa	T ns	T	T	.82	T ns	T	T	.77	0.5 ns	0.1	1.0	.55
Duosperma kilimandscharicum	T ns	T	T	.02	T a	T ab	P b	.04	T ab	T a	P b	.02
Hermania alhiensis	0.1 ns	T	T	.26	0.3 ns	0.1	0.1	.11	1.2 ns	1.0	1.4	.89
Hibiscus aponeurus	P ns	P	P	-	P ns	P	P	-	T ns	T	0.1	.17
Hibiscus sp.	T a	T a	T ab	.05	T a	T b	T b	<.01	P ns	P	P	-
Lannea floccosa	T ns	T	T	.62	P ns	T	T	.60	P ns	T	T	.56
Maerua triphylla	P ns	P	P	-	P ns	P	P	-	P ns	P	P	-
Ormocarpum kirkii	T ns	T	T	.13	P ns	T	T	.18	T ns	T	P	.07
Solanum incanum	P ns	P	P	-	P ns	P	P	-	P ns	P	P	-
Other browse	9.1 ns	P	T	.49	T ns	T	T	.51	0.1 ns	0.2	0.5	.13
Unidentified browse	T ns	T	T	.17	T ns	T	T	.95	P ns	P	P	-

[1]Means followed by the same letter between bush conditions are not significantly different (α = 0.05).
[2]No significant difference between bush canopy condition (α = 0.05).
[3]Trace.
[4]Present but not found in samples.

Appendix Table 3. Dietary selection ratio values for forage classes by species consumed by goats on light, moderate and heavy bush conditions in an *Acacia senegal* savannah at Kiboko, Kenya, 1982.

Species	Selection ratio values								
	June			July			August		
	Light	Moderate	Heavy	Light	Moderate	Heavy	Light	Moderate	Heavy
GRASS/GRASSLIKE									
Bothriochloa insculpta	- 10.0[1]	- 10.0	- 4.5	- 10.0	- 10.0	- 4.9	- 9.9	- 3.3	- 10.0
Cenchrus ciliaris	+ 5.3	+ 7.7	+ 6.4	+ 7.3	+ 5.7	+ 8.5	+ 5.5	+ 7.9	+ 6.0
Chloris roxburghiana	- 8.9	+ 1.6	- 7.0	- 2.4	+ 2.9	+ 2.2	- 1.2	+ 0.7	- 8.2
Digitaria macroblephara	- 1.6	- 0.0	+ 2.4	+ 2.3	- 7.6	+ 0.1	+ 3.8	- 4.7	- 6.5
Eragrostis caespitosa	+ 6.0	+ 4.1	- 1.8	- 3.3	- 5.9	+ 5.8	- 4.3	+ 3.3	- 10.0
Sporobolus pellucides	+ 3.4	+ 8.4	+ 7.7	+ 8.2	+ 5.1	+ 6.9	+ 7.8	+ 5.9	+ 8.0
Sedge sp.	- 10.0	NC	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0
FORBS									
Talinum portulacifolium	NC[2]	+ 10.0	- 10.0	NC	+ 10.0	NC	NA	NA	NA
Tephrosia villosa	- 10.0	- 10.0	- 10.0	NA[4]	NA	NA	NC	NC	- 10.0
Other forbs	- 10.0	- 10.0	NC	NA	NA	NA	NA	NA	NA
BROWSE									
Acacia mellifera	+ 9.3	+ 10.0	+ 9.5	+ 9.5	+ 10.0	+ 8.6	- 10.0	NC	- 10.0
Acacia senegal	+ 6.4	+ 2.8	- 2.9	+ 6.6	+ 9.9	+ 1.0	- 1.6	+ 8.7	+ 9.9
Acacia tortilis	- 10.0	+ 6.8	- 10.0	- 10.0	- 1.4	+ 7.1	- 10.0	- 2.0	- 10.0
Balanites aegyptiaca	- 10.0	- 3.3	+ 6.0	- 10.0	+ 10.0	+ 8.5	+ 5.7	+ 8.1	+ 6.9
Commiphora africana	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0
Cordia gharaf	+ 0.0	NC	+ 7.9	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0
Grewia bicolor	+ 9.8	+ 10.0	+ 10.0	+ 9.0	+ 10.0	+ 10.0	+ 8.2	+ 10.0	+ 10.0
G. similis	+ 6.9	+ 9.9	+ 10.0	- 0.1	- 1.4	+ 10.0	- 2.5	- 10.0	NC
G. villosa	+ 9.4	+ 7.9	+ 5.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0
Hermania alhiensis	- 10.0	- 9.8	- 10.0	- 10.0	- 2.7	- 10.0	- 8.8	- 3.8	- 9.4
Solanum incanum	+ 10.0[3]	+ 10.0	+ 10.0	+ 10.0	+ 10.0	+ 10.0	+ 10.0	+ 10.0	+ 10.0
Boscia sp.	- 10.0	NC	NC	- 10.0	NC	NC	- 10.0	NC	NC
Cordia ovalis	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0
Duosperma kilimandscharicum	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC
Hibiscus sp.	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0
Lannea floccosa	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0
Ormocarpum kirkii	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0

[1]Present in the sampling area but poorly preferred by goats.
[2]Present in the treatment paddock but not consumed by goats.
[3]Highly preferred by goats.
[4]Not available in the treatment paddock.

Appendix Table 3. Continued.

Species	Selection ratio values								
	September			October			November		
	Light	Moderate	Heavy	Light	Moderate	Heavy	Light	Moderate	Heavy
GRASS/GRASSLIKE									
Bothriochloa insculpta	- 10.0	- 0.8	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 5.6
Cenchrus ciliaris	+ 2.3	+ 7.2	+ 8.0	+ 3.3	+ 8.3	+ 8.5	- 10.0	- 2.3	- 10.0
Chloris roxburghiana	+ 0.3	+ 6.3	+ 4.2	- 4.1	- 3.7	- 4.5	+ 0.2	+ 2.8	+ 4.0
Digitaria macroblephara	+ 1.8	- 5.1	- 7.5	- 0.9	- 4.7	- 9.0	- 5.0	- 3.8	- 6.0
Eragrostis caespitosa	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	NC	+ 2.0	- 10.0	- 10.0
Sporobolus pellucides	+ 8.4	+ 7.6	+ 5.4	+ 8.1	+ 6.3	+ 8.3	+ 6.8	+ 1.0	+ 1.4
Sedge sp.	- 10.0	NC	- 10.0	- 10.0	NC	NC	- 10.0	- 10.0	- 10.0
FORBS									
Talinum portulacifolium	NA	NA	NA	+ 10.0	+ 10.0	+ 10.0	+ 0.5	+ 8.5	+ 5.0
Tephrosia villosa	NA	NA	NA	NA	NA	NA	NC	- 10.0	- 10.0
Other forbs	NA	NA	NA	NA	NA	NA	- 10.0	NC	- 10.0
BROWSE									
Acacia mellifera	- 10.0	NC	- 10.0	- 3.3	NC	- 10.0	+ 9.9	+ 10.0	+ 9.7
Acacia senegal	+ 10.0	+ 10.0	+ 9.9	- 6.7	- 10.0	- 10.0	+ 3.6	- 10.0	- 8.3
Acacia tortilis	+ 2.5	+ 9.8	- 10.0	+ 1.5	- 10.0	- 10.0	- 10.0	- 10.0	+ 0.0
Balanites aegyptiaca	+ 7.9	- 3.3	+ 3.3	+ 0.0	+ 2.0	- 10.0	- 3.3	- 10.0	- 10.0
Commiphora africana	- 10.0	- 10.0	- 10.0	+ 9.9	+ 8.8	+ 10.0	+ 6.6	+ 6.9	+ 8.7
Cordia gharaf	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0
Grewia bicolor	+ 7.1	+ 10.0	+ 10.0	- 10.0	NC	NC	- 10.0	NC	NC
G. similis	+ 3.9	- 10.0	+ 10.0	- 6.0	+ 0.9	NC	- 7.1	- 10.0	NC
G. villosa	- 10.0	- 10.0	- 10.0	- 10.0	- 5.0	- 10.0	- 10.0	- 10.0	- 10.0
Hermania alhiensis	- 10.0	- 10.0	- 10.0	- 7.7	- 7.1	- 10.0	- 10.0	- 10.0	- 10.0
Solanum incanum	+ 10.0	+ 10.0	NC	+ 10.0	+ 10.0	+ 10.0	+ 10.0	+ 10.0	+ 10.0
Boscia sp.	- 10.0	NC	NC	- 10.0	NC	NC	- 10.0	NC	NC
Cordia ovalis	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0
Duosperma kilimandscharicum	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC
Hibiscus sp.	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	- 10.0	NA	NA	NA
Lannea floccosa	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0
Ormocarpum kirkii	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0	NC	- 10.0	- 10.0

[1]Present in the sampling area but poorly preferred by goats.
[2]Present in the treatment paddock but not consumed by goats.
[3]Highly preferred by goats.
[4]Not available in the treatment paddock.

Appendix Table 4. Standard error mean values for forage classes by species consumed by goats on light, moderate and heavy bush conditions in an *Acacia senegal* savannah at Kiboko, Kenya, 1982.

Species	Standard error mean values								
	June			July			August		
	Light	Moderate	Heavy	Light	Moderate	Heavy	Light	Moderate	Heavy
GRASS/GRASSLIKE									
Bothriochloa insculpta	0.0[1]	0.0	4.9	0.0	0.0	3.3	0.02	2.8	0.0
Cenchrus ciliaris	1.7	1.0	1.7	1.3	1.7	1.0	1.8	1.4	2.7
Chloris roxburghiana	1.0	2.2	1.8	1.8	2.4	1.5	1.8	2.1	1.4
Digitaria macroblephara	1.4	0.7	0.8	0.7	0.8	0.5	0.9	1.0	1.3
Eragrostis caespitosa	2.7	3.0	4.8	3.3	4.0	2.3	3.7	3.3	-
Sporobolus pellucides	2.8	1.6	1.3	1.3	1.9	1.6	0.9	1.7	1.4
Sedge sp.	-[2]	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FORBS									
Talinum portulacifolium	-	-	0.0	-	0.0	-	-	-	-
Tephrosia villosa	0.0	-	-	-	-	-	-	-	-
Other forbs	-	0.0	-	-	-	-	-	-	-
BROWSE									
Acacia mellifera	0.7	0.0	0.5	0.5	0.0	1.4	0.0	-	0.0
Acacia senegal	2.2	1.8	2.3	1.4	0.03	2.1	3.3	0.5	0.03
Acacia tortilis	0.0	2.1	0.0	0.0	4.04	2.0	0.0	5.0	0.0
Balanites aegyptiaca	0.0	6.7	2.7	0.0	0.02	1.4	2.6	1.8	2.8
Commiphora africana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cordia gharaf	-	-	-	-	-	-	-	-	-
Grewia bicolor	0.23	0.0	0.0	0.95	0.0	1.8	-	-	-
G. similis	2.1	0.09	0.0	3.7	4.04	0.0	3.7	0.0	-
G. villosa	0.47	1.3	5.0	0.0	0.0	-	0.0	0.0	0.0
Hermania alhiensis	0.0	0.23	0.0	0.0	1.8	0.0	1.17	1.9	0.5
Solanum incanum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boscia sp.	0.0	-	-	0.0	-	-	0.0	-	-
Cordia ovalis	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0
Duosperma kilimandscharicum	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-
Hibiscus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lannea floccosa	-	-	-	-	-	-	-	-	-
Ormocarpum kirkii	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0

[1]Present in the sampling area but not consumed by goats.
[2]Not present in the sampling area.

Appendix Table 4. Continued.

Species	Standard error mean values								
	September			October			November		
	Light	Moderate	Heavy	Light	Moderate	Heavy	Light	Moderate	Heavy
GRASS/GRASSLIKE									
Bothriochloa insculpta	0.0	2.9	0.0	0.0	0.0	0.0	0.0	2.3	0.0
Cenchrus ciliaris	2.5	1.5	1.4	2.1	1.7	1.5	0.0	3.6	0.0
Chloris roxburghiana	1.6	1.5	1.6	1.7	2.4	2.8	1.7	2.1	1.7
Digitaria macroblephara	0.9	0.9	0.8	1.4	1.1	1.0	0.8	1.2	0.9
Eragrostis caespitosa	0.01	0.0	-	0.0	0.0	-	4.9	0.0	0.0
Sporobolus pellucides	1.0	1.3	1.8	1.3	1.9	1.7	1.8	3.1	4.0
Sedge sp.	0.0	-	-	-	-	-	0.0	0.0	0.0
FORBS									
Talinum portulacifolium	-	-	-	0.0	0.0	0.0	5.0	1.4	2.2
Tephrosia villosa	-	-	-	-	-	-	-	-	0.0
Other forbs	-	-	-	-	-	-	0.0	-	0.0
BROWSE									
Acacia mellifera	0.0	-	-	6.7	-	-	0.1	-	0.3
Acacia senegal	0.03	0.004	0.03	3.3	0.0	0.0	2.7	0.0	1.4
Acacia tortilis	3.7	0.2	0.0	3.4	0.0	0.0	0.0	0.0	5.8
Balanites aegyptiaca	2.0	6.7	4.2	4.5	4.9	0.0	6.7	0.0	0.0
Commiphora africana	0.0	0.0	0.0	0.06	1.2	0.0	3.3	1.8	1.1
Cordia gharaf	-	-	-	-	-	-	-	-	-
Grewia bicolor	-	0.0	-	-	-	-	-	-	-
G. similis	3.03	0.0	-	4.0	3.5	-	2.9	0.0	-
G. villosa	0.0	0.0	-	0.0	5.0	-	0.0	0.0	-
Hermania alhiensis	0.0	0.0	0.0	1.5	1.6	0.0	0.0	0.0	0.0
Solanum incanum	0.0	0.0	-	-	0.0	-	0.0	0.0	0.0
Boscia sp.	0.0	-	-	0.0	-	-	0.0	-	-
Cordia ovalis	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0
Duosperma kilimandscharicum	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-
Hibiscus sp.	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-
Lannea floccosa	-	-	-	-	-	-	-	-	-
Ormocarpum kirkii	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0

[1]Present in the sampling area but not consumed by goats.
[2]Not present in the sampling area.

Appendix Table 5. Dietary prediction values (confidence intervals) for various forage classes by individual species consumed by goats in light, moderate and heavy bush conditions in an *Acacia senegal* savannah at Kiboko, Kenya, 1982.

Species	Prediction values											
	June						July					
	Light		Moderate		Heavy		Light		Moderate		Heavy	
	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL
GRASS/GRASSLIKE												
Bothriochloa insculpta	-10.0[1]	-10.0	-10.0	-10.0	-14.0	+ 5.0	-10.0	-10.0	-10.0	-10.0	-11.4	+ 1.4
Cenchrus ciliaris	+ 1.9	+ 8.7	+ 5.8	+ 9.6	+ 3.1	+ 9.6	+ 4.8	+ 9.9	+ 2.4	+ 9.1	+ 6.6	10.5
Chloris roxburghiana	-10.9[3]	- 7.0	- 2.7	+ 5.8	-10.5	- 3.5	- 5.8	+ 1.1	- 1.7	+ 7.6	- 0.8	+ 5.2
Digitaria macroblephara	- 4.4	+ 1.1	- 1.5	+ 1.5	+ 0.9	+ 3.9	+ 1.0	+ 3.7	- 9.1	- 6.1	- 0.9	+ 1.1
Eragrostis caespitosa	+ 0.8	+11.2	- 1.7	+10.0	-11.2	+ 7.7	- 9.8	+ 3.2	-13.7	+ 1.9	+ 1.4	+10.3
Sporobolus pellucides	- 2.2	+ 8.9	+ 5.2	+11.6	+ 5.2	+10.2	+ 5.7	+10.6	+ 1.3	+ 8.9	+ 3.9	+10.1
Sedge sp.	-	-	-	-	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
FORBS												
Talinum portulacifolium	-	-	-	-	-10.0	-10.0	-	-	+10.0	+10.0	-	-
Tephrosia villosa	-10.0	-10.0	-	-	-	-	-	-	-	-	-	-
Other forbs	-	-	-	-10.0	-10.0	-	-	-	-	-	-	-
BROWSE												
Acacia mellifera	+ 7.8	+10.7	+10.0	+10.0	+ 8.5	+10.5	+ 8.5	+10.5	+10.0	+10.0	+ 5.8	+11.4
Acacia senegal	+ 2.1	+10.6	- 0.8	+ 6.3	- 6.9	+ 1.1	+ 3.8	+ 9.4	+ 9.8	+10.0	- 3.3	+ 5.2
Acacia tortilis	-10.0	-10.0	+ 2.7	+10.9	-10.0	-10.0	-10.0	-10.0	- 9.4	+ 6.5	+ 3.2	+11.0
Balanites aegyptiaca	-10.0	-10.0	-16.4	+ 9.7	+ 0.8	+11.2	-10.0	-10.0	+ 9.9	+10.0	+ 5.7	+11.3
Commiphora africana	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
Cordia gharaf	-	-	-	-	-	-	-	-	-	-	-	-
Grewia bicolor	+ 9.3	+10.2	+10.0	+10.0	+10.0	+10.0	+ 7.2	+10.9	+10.0	+10.0	+10.0	+10.0
Grewia similis	+ 2.8	+10.9	+ 9.7	+10.1	+10.0	+10.0	- 7.4	+ 7.2	- 9.3	+ 6.5	+10.0	+10.0
Grewia villosa	+ 8.5	+10.3	+ 5.3	+10.4	- 4.8	+14.8	-10.0	-10.0	-10.0	-10.0	-	-
Hermania alhiensis	-10.0	-10.0	-10.2	- 9.3	-10.0	-10.0	-10.0	-10.0	- 6.2	+ 0.8	-10.0	-10.0
Solanum incanum	+10.0[2]	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0
Boscia sp.	-10.0	-10.0	-	-	-	-	-10.0	-10.0	-	-	-	-
Cordia ovalis	-	-	-10.0	-10.0	-10.0	-10.0	-	-	-10.0	-10.0	-10.0	-10.0
Duosperma kilimandscharicum	-10.0	-10.0	-10.0	-10.0	-	-	-10.0	-10.0	-10.0	-10.0	-	-
Hibiscus sp.	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
Ormocarpum kirkii	-	-	-10.0	-10.0	-10.0	-10.0	-	-	-10.0	-10.0	-10.0	-10.0

[1] Present in the sampling area but avoided by the animals.
[2] Highly preferred by goats.
[3] Values below or above $\pm$10 are still projected within a 95% confidence interval.

Appendix Table 5. Continued.

Species	Prediction values											
	August						September					
	Light		Moderate		Heavy		Light		Moderate		Heavy	
	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL
GRASS/GRASSLIKE												
Bothriochloa insculpta	-10.0	- 9.9	- 8.9	+ 2.3	-10.0	-10.0	-10.0	-10.0	- 6.4	+ 4.9	-10.0	-10.0
Cenchrus ciliaris	+ 2.0	+ 9.0	+ 5.2	+10.7	+ 0.8	+11.2	- 2.7	+ 7.3	+ 4.2	+10.2	+ 5.3	+10.7
Chloris roxburghiana	- 4.8	+ 2.5	- 3.5	+ 4.9	-10.9	- 5.4	- 2.9	+ 3.5	+ 3.4	+ 9.2	+ 1.0	+ 7.4
Digitaria macroblephara	+ 2.1	+ 5.5	- 6.7	- 2.8	- 9.0	- 3.9	+ 0.0	+ 3.6	- 7.0	- 3.3	- 9.1	- 5.9
Eragrostis caespitosa	-11.5	+ 2.9	- 3.2	+ 9.9	-	-	-10.0	- 9.9	-10.0	-10.0	-	-
Sporobolus pellucides	+ 6.0	+ 9.6	+ 2.7	+ 9.2	+ 5.3	+10.7	+ 6.5	+10.3	+ 5.0	+10.2	+ 1.7	+ 9.0
Sedge sp.	-10.0	-10.0	-10.0	-10.0	-10.0	-	-	-	-	-	-	-
FORBS												
Talinum portulacifolium	-	-	-	-	-	-	-	-	-	-	-	-
Tephrosia villosa	-	-	-	-	-	-	-	-	-	-	-	-
Other forbs	-	-	-	-	-	-	-	-	-	-	-	-
BROWSE												
Acacia mellifera	-10.0	-10.0	-	-	-10.0	-10.0	-10.0	-10.0	-	-	-	-
Acacia senegal	- 8.2	+ 4.9	+ 7.7	+ 9.7	+ 9.8	+10.0	+ 9.9	+10.0	+10.0	+10.0	+ 9.9	+10.0
Acacia tortilis	-10.0	-10.0	-11.6	+ 7.6	-10.0	-10.0	- 4.7	+ 9.7	+ 9.4	+10.2	-10.0	-10.0
Balanites aegyptiaca	+ 0.5	+10.8	+ 4.5	+11.6	+ 1.3	+12.4	+ 4.0	+11.8	-16.4	+ 9.7	- 4.9	+11.6
Commiphora africana	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
Cordia gharaf	-	-	-	-	-	-	-	-	-	-	-	-
Grewia bicolor	+ 4.6	+11.7	-	-	-	-	+ 1.5	+12.7	-	-	+10.0	+10.0
Grewia similis	- 9.7	+ 4.7	-10.0	-10.0	-	-	- 2.1	+ 9.8	-10.0	-10.0	-	-
Grewia villosa	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-	-
Hermania alhiensis	-11.1	- 6.5	- 7.6	- 0.1	-10.4	- 8.3	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
Solanum incanum	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	-	-
Boscia sp.	-10.0	-10.0	-	-	-	-	-10.0	-10.0	-	-	-	-
Cordia ovalis	-	-	-10.0	-10.0	-10.0	-10.0	-	-	-10.0	-10.0	-10.0	-10.0
Duosperma kilimandscharicum	-10.0	-10.0	-10.0	-10.0	-	-	-10.0	-10.0	-10.0	-10.0	-	-
Hibiscus sp.	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
Ormocarpum kirkii	-	-	-10.0	-10.0	-10.0	-10.0	-	-	-10.0	-10.0	-10.0	-10.0

[1] Present in the sampling area but avoided by the animals.
[2] Highly preferred by goats.
[3] Values below or above $\pm$10 are still projected within a 95% confidence interval.

Appendix Table 5. Continued.

Species	Prediction values											
	October						November					
	Light		Moderate		Heavy		Light		Moderate		Heavy	
	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL
GRASS/GRASSLIKE												
Bothriochloa insculpta	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	- 1.2	-10.0	-10.0
Cenchrus ciliaris	- 0.8	+ 7.4	+ 5.1	+11.6	+ 5.4	+11.5	-10.0	-10.0	- 9.3	+ 4.8	-10.0	-10.0
Chloris roxburghiana	- 7.5	- 0.7	- 8.4	+ 1.0	-10.1	+ 1.0	- 3.1	+ 3.4	- 1.4	+ 6.9	+ 0.7	+ 7.4
Digitaria macroblephara	- 3.7	+ 1.9	- 6.9	- 2.5	-10.9	- 7.0	- 6.6	- 3.4	- 6.1	- 1.5	- 7.7	- 4.2
Eragrostis caespitosa	-10.0	-10.0	-10.0	-10.0	-	-	- 7.6	+11.6	-10.0	-10.0	-10.0	-10.0
Sporobolus pellucides	+ 5.6	+10.7	+ 2.5	+10.1	+ 5.1	+11.6	+ 3.3	+10.2	- 5.1	+ 7.1	- 6.5	+ 9.3
Sedge sp.	-10.0	-10.0	-	-	-	-	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
FORBS												
Talinum portulacifolium	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0	- 4.8	+14.8	+ 5.8	+11.3	+ 0.6	+ 9.4
Tephrosia villosa	-	-	-	-	-	-	-	-	-	-	-10.0	-10.0
Other forbs	-	-	-	-	-	-	-10.0	-10.0	-	-	-10.0	-10.0
BROWSE												
Acacia mellifera	-16.4	+ 9.7	-	-	-	-	+ 9.7	+10.1	-	-	+ 9.1	+10.3
Acacia senegal	-13.2	- 0.1	-10.0	-10.0	-10.0	-10.0	- 1.7	+ 8.8	-10.0	-10.0	-11.0	- 5.7
Acacia tortilis	- 5.2	+ 8.3	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-11.3	+11.3
Balanites aegyptiaca	- 8.8	+ 8.8	- 7.6	+11.6	-10.0	-10.0	-16.4	+ 9.7	-10.0	-10.0	-10.0	-10.0
Commiphora africana	+ 9.8	+10.0	+ 6.5	+11.1	+10.0	+10.0	+ 0.1	+13.2	+ 3.4	+10.5	+ 6.6	+10.9
Cordia gharaf	-	-	-	-	-	-	-	-	-	-	-	-
Grewia bicolor	-	-	-	-	-	-	-	-	-	-	-	-
Grewia similis	-13.8	+ 1.8	- 5.9	+ 7.7	-	-	-12.7	- 1.6	-10.0	-10.0	-	-
Grewia villosa	-10.0	-10.0	-14.8	+ 4.8	-	-	-10.0	-10.0	-10.0	-10.0	-	-
Hermania alhiensis	-10.6	- 4.9	-10.2	- 4.1	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
Solanum incanum	-	-	+10.0	+10.0	-	-	+10.0	+10.0	+10.0	+10.0	+10.0	+10.0
Boscia sp.	-10.0	-10.0	-	-	-	-	-10.0	-10.0	-	-	-	-
Cordia ovalis	-	-	-10.0	-10.0	-10.0	-10.0	-	-	-10.0	-10.0	-10.0	-10.0
Duosperma kilimandscharicum	-10.0	-10.0	-10.0	-10.0	-	-	-10.0	-10.0	-10.0	-10.0	-	-
Hibiscus sp.	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-	-	-	-	-	-
Ormocarpum kirkii	-	-	-10.0	-10.0	-10.0	-10.0	-	-	-10.0	-10.0	-10.0	-10.0

[1]Present in the sampling area but avoided by the animals.
[2]Highly preferred by goats.
[3]Values below or above ±10 are still projected within a 95% confidence interval.

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