TIME BUDGETS OF MAINTENANCE ACTIVITIES AND DIETARY CHARACTERISTICS OF CAMELS (*Camelus dromedarius*) AND GOATS (*Capra hircus*) IN THE SEMI-ARID SOUTHEASTERN KENYA.

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IN

RANGE MANAGEMENT

(ANIMAL NUTRITION OPTION)

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

This theis is dedicated to my parents, Mr and Mrs Kipkirui arap Maiwa and my wife Mary Munjiru.

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ABSTRACT

The grazing behaviour and dietary characteristics of camels and goats grazing together were studied on a 50 ha plot at Kibwezi Dryland Field station in southeastern Kenya.Tree and shrub densities of woody plants on the site were determined using the Point Centred Quarter Method (PCQ). The production of the herbaceous plants was quantified in dry and wet seasons by clipping all material within $0.25m^2$ quardrats, drying and weighing it. Grazing behaviour was determined using focal observation methods. Microhistological technique was used to determine the dietary botanical composition of camel and goat diets.

Time spent feeding, walking, ruminating, resting and other activities was influenced by both advancing plant maturity which spanned three consecutive 16-day study periods and animal species. Camels spent less time feeding than goats. For both species, feeding took place mainly in the morning and late afternoon. At mid-day, the majority of animals rested or ruminated. Time spent walking was affected by advance in plant maturity in the case of camels alone. This increased from period one to three. The two animal species, however, spent the same time walking in the study. The distribution of walking over the observation day was similar to that of feeding. Ruminating time was not affected by advance in plant maturity for the two species. Camels ,however spent less time ruminating than goats. Animals spent more time resting while standing than when lying. Resting time decreased with advance in plant maturity for both species. Camels, however, spent more time resting than goats. Likewise time spent in other activities decreased with period.

Camel and goat diets were composed primarily of browse in the dry and wet seasons.Its contribution to camel diets was 90.16 % and 93.99 % in the dry and wet seasons, respectively. Its proportion in the goat diets was 77.30 % and 61.31 % in the dry and wet sesaons. Goats were more adept at switching from one forage class to another than camels. The order in which the camels and goats selected plants and their dietary overlap were influenced by season.

Generally dry season plant samples were lower in crude protein (CP) than the wet season samples. The fibre and lignin content of dry season samples was higher than in the wet season samples. Consequently diets selected by camels and goats in the dry season were lower in quality than their wet season diets. Browse was of higher nutritional value than grass in both seasons as most browse species contained higher crude protein (CP), cell solubles (CS) and were more digestible than grass species. Overall, camels and goats met their nutritional requirements in both dry and wet seasons. However, they did not associate preference with nutritional variables of plants such as crude protein (CP), acid detergent fibre (ADF), and dry matter digestibility (DMD), especially in the dry season. These findings form a guideline for range managers in assessing the usefulness of the vegetation resource to camels and goats and how the two species exploit the resource.

INTRODUCTION:

In East Africa rangelands make up about 79 per cent of the total land surface. Kenya has a total land area of 569,260 km^2, of which 80-83% is classified as rangelands, (Pratt and Gwynne, 1977). It has a livestock population of 13.45 million cattle, 6.325 million sheep, 7.5 million goats and 800,000 camels (FAO, 1989). About 100% of the camels and majority of goats and sheep are found in rangelands. Besides, all wildlife is found in these lands.

The common features of rangelands are pronounced water deficiency and high ambient temperatures. Rainfall is also low and erratic in terms of temporal and spatial distribution. These characteristic features make the effective rainfall in the areas minimal, giving rise to characteristic vegetation types. East African rangelands, in essence, constitute a basic resource and therefore their utilization and orderly development demand an understanding of the nature and role of each ecological component . The need, therefore, for sound ecologically based management of the range areas cannot be over emphasized.

The range areas embrace almost all types of vegetation from the semi-arid to afro-alpine moorland. The most important types are deciduous woodland, open and wooded grassland, evergreen and thorn bushland and dwarf shrubland (Pratt and Gwynne, 1977). Grass is the main source of forage for large grazing herbivores such as cattle, while shrubs and trees produce browse for all ruminants and camels in addition to shelter in the semi-arid and arid rangelands.

Greater parts of the range areas of East Africa are occupied by pastoralists or are used by subsistence cultivators who also keep livestock (Pratt and Grwynne, 1977; Coughnour et al., 1985). The pastoral people, especially the nomadic pastoralists, depend almost wholly upon their livestock for food and other necessities. There is often a tendency to stress the cattle component of the pastoral herds. Despite the very important role played by cattle in general,camels and goats enjoy an equal role in societies such as the Rendille, the Turkana and the Somali in Kenya. In addition, goats and sheep, usually provide the very much needed petty cash for households (Witstrand, 1975).

Camel and goat management in pastoral areas is based on traditions passed down from generation to generation. However, with increasing human population, animal populations, changing traditions and customs and decreasing productive capacity of range resourses, there is need for scientific management of these range livestock.

Camels and goats are remarkable for their ability to thrive in environments where scanty rainfall results in seasonal availability of fodder. While their adaptability to harsh environments makes the camels and goats ideal candidates as food-producing animals in marginal areas (Malechek and Provenza, 1983; Yagil, 1986), great emphasis is needed for information on how best to utilize their traits and particularly how to manage them in ecologically sensitive environments.

The quality of range herbage changes with the climatic seasons (Karue, 1975). This causes the range herbivores to modify their feeding behaviour accordingly in order to obtain quality diets especially during the dry season when the crude protein and digestibility of most range plants are low. Knowledge of the behaviour and food habits of range herbivores forms the basis of an efficient management of these animals. By means of behaviour range ungulates relate adaptively not only to different environments but also to changing environmental conditions. Their behaviour is one of the factors which influence their feeding strategy and grazing efficiency, which in turn, affect the level of production. Range herbivore food habits information can be used by range managers in planning common use of range by different herbivore species and in gauging potential food competition among others. From the foregoing, studies of time budgets of maintenance activities and food habits of camels and goats are critical in stragies such as combination ratios and carrying capacity management and subsequent production of both the range resource and animal, respectively. Hence a study was carried out whose objectives were:

a) To assess the time-budgets of maintenance activities of camels and goats grazing together on a common range site.

b) To determine the seasonal botanical composition and quality of camel and goat diets.

2. LITERATURE REVIEW

2.1 GRAZING BEHAVIOUR OF RUMINANTS

The activities which each animal does every day are those concerned with maintenance and survival (Arnold and Dudzinski, 1978) . These are grazing, browsing and feeding on supplements, walking, ruminating, resting, defaecating and urinating. Apart from the last two activities, all the others will directly or indirectly influence the amount of food eaten each day. Intake of feed is a fundamental aspect of an animal's nutritional status because it sets the inputs of nutrients, and is therefore the determinant factor of animal function and response (Musimba, 1986) Grazing behaviour, hence, plays, a role in animal production in that, it determines the feeding strategy and grazing efficiency (Goldson, 1963; Ellis and Travis, 1975; Fraser, 1986).

The act of grazing involves the selection of herbage, its prehension, mastication and swallowing (Arnold and Dudzinski, 1978). The time spent grazing varies with forage structure and availability, the physiological status of the grazing animal, climatic factors (Ellis and Travis, 1975; Arnold and Dudzinski, 1978; Trudell and White, 1981) and forage supplementation (Arnold, 1985; Phillips and Leaver, 1986). Working with the reindeer, Trudell and White (1981) found that grazing and eating times decreased at the respective rates of 1.6 hours and 1.3 hours for each 100 gm^{-2} increase in total biomass. Van Rees and Hutson (1983) also found that the time spent grazing by free range cattle increased markedly as the dry season advanced. The animals spent 7.3 hours at the start of the season compared with 11.5 hours at the end of the season. However, an earlier study by Wilson (1961) working with Zebu cattle in Uganda showed a decrease of 0.8 hour in total grazing time in the dry season. This decrease may have been influenced by factors such as lack of shade in the study area and uniform pasture available. Quality of forage, which also varies with season, has been associated with changes in grazing time of ruminants (Smith, 1959; Harker et al., 1961) As the pasture deteriorates in quality the duration of the grazing activity is increased. Increased grazing time is accompanied by decreased rumination. The longer grazing time as observed with cattle on tropical pastures suggests extensive selectivity (Mugerwa et al, 1973).

The physiological status of an animal is equally important in influencing its grazing time. The animal has increased food requirement if it is pregnant, lactating or experiencing a period of poor nutrition. An animal in that state eats more under all pasture conditions by grazing for a little longer than a dry fat animal. It also eats faster (Arnold and Dudzinski, 1978). Mugerwa et al. (1973) compared early lactating, mid lactating, late lactating and non lactating cows and found that the dry animals idled for much longer time than others, thus making their grazing times the same as those of lactating animals, even though the former (dry) were on the pasture for a long time.

Available time in the field may also be a constraint to the animals as far as feed intake and therefore input of nutrients is concerned. It has been observed that animals with limited available time in the field graze more or less continuously while in the field (Smith, 1961; Bayer, 1986). In those studies the severely kraaled cattle attempted to overcome the disadvantage of the limited grazing time by more intensive grazing and by postponing rumination and resting until they had reentered the kraal in the evening.

Supplementary feeding of grazing animals seems to affect their grazing only if the supplement is of high quality and if fed in adequate amounts. Arnold (1985) working with cattle, horses and sheep found that availability of chaff and grain supplements appeared to reduce drastically the time spent grazing. However, supplementary feeding of hay to cows by Phillips and Leaver (1986) did not elicit much reduction in the grazing time.

Rumination, which is the process of regurgitation, mastication and swallowing of forage previously ingested into the rumen, is regarded as the second most time consuming activity of ruminant animals (Arnold and Dudzinski 1978). It is related to the herbage quality (Mugerwa et al., 1973; Van Soest, 1982) and time spent grazing (Semenye, 1987). Rumination time tends to increase with decreased forage quality. Apparently, a certain level of reticulo-rumen.fill must be reached for the animal to start the process of rumination. The speed with which this level is attained will depend, among other things, on the rate of herbage consumption which, in turn, is influenced by herbage quality and the degree of selectivity of the individual animal (Mugerwa et al., 1973).

The duration of rumination of cattle varies from 1.5 to 10.5 hour a day (Arnold and Dudzinski,1978; Van Soest, 1982). The diel pattern of rumination is largely influenced by the pattern of grazing. Nevertheless, since night grazing is limited, much of the rumination takes place then (Goldson, 1963; Compton and Brundage, 1971; Arnold and Dudzinski, 1978).

Most studies of grazing behaviour have been with cattle, sheep, horses and to a limited extent with goats. Behaviour studies on other domestic livestock species such as camels are very scarce. According to Gauthier-Pilters (1979) camels move constantly taking only small portions from any plant. Only certain small plants, growing separately are eaten almost entirely. Camels disperse widely while grazing especially under drought conditions. She also reported that camels spent 8-10 hours a day grazing in the Sahara.

Askins and Turner (1972) found that Angora goats spend most of their time resting (46.25% of 24 hours) followed by feeding which took about 8.6 hour (35.83%). These goats were found to spend 34.4% of their feeding time grazing and 65.6% browsing. Comparative behavioural studies of camels with other livestock species are lacking.

2.2 FOOD HABITS OF RANGE HERBIVORES

2.2.1 Factors Affecting Range Herbivore Food Habits

The principal goal of resource management on multiple use lands is to provide sustained yields of a variety of plant and animal products. Management of sympatric ungulates on multiple use lands requires knowledge of how species exploit resources available to them (Mcinnis and Varva, 1987) . In contrast to stall-fed animals that receive their rations in amounts and proportions dictated by the husbandman, range animals are free to choose their diets from the complex variety of forage plants available in most native plant communities. Man exerts only limited managerial control through such decisions as season and location of grazing, stocking rates and herd composition. The diet ultimately selected in a particular situation is a function of many interacting plant and animal-related factors (Malechek and Provenza, 1983). The diets selected by free-ranging herbivores are largely influenced by the plant species on offer, their quality and quantity and the structure of the plant communities (Stobbs and Minson, 1979; Trudell and White, 1981).

The nutritive value of the diet selected from a single species pasture depends on the pasture species being grazed, stage of maturity and grazing intensity (Stobbs and Minson, 1979). As the pasture is grazed down animals are forced to eat herbage that contains higher proportion of stems, and diets become more fibrous and lower in digestibility. However, with mixed plant species, diets are affected by factors such as species composition, stage of growth and previous grazing experience of the animal (Provenza and Balph, 1987). The plant species combination and stage of matuarity of plants, among others, reflect the quality of the range. Range quality is considered to be highly correlated with progression in plant phenology, and large ungulates which utilize the range on a seasonal or year-round basis tend to follow this phenological progression by selective grazing (Klein, 1970; Trudell and White, 1981; Schwartz and Ellis, 1981).

The chemical make-up of the plant affects its palatability and important chemical components in this regard are "secondary" plant metabolites such as tannins, volatile oils and alkaloids. The level of these fractions varies with plant species and normally impairs acceptance of those plants with high quantities (Arnold and Dudzinski, 1978). Presence of plant features such as thorns, awns, prickles, dense pubesence and leaf texture also affects a plant's palatability (Malechek and Provenza, 1983; Kibet, 1986).

Animal factors also play an important role in the process of forage selection. These are the unique morphological, physiological and behavioural traits of a particular animal species that interact to determine the animal's feeding strategy (Ellis and Travis, 1975). A conceptual framework for understanding the reasons why ungulates select the kinds of foods that they do has been put forward and tested by Hanley and Hanley (1982). It consists of four morphological parameters: body size, type of digestive system, rumino-reticular volume-to-body weight ratio and mouth size (Hanley 1982).

Among related species with similar digestive capabilities, smaller species require better quality food than do large species because of the former's higher metabolic rate. Due to its lower relative nutrient requirement (per unit weight of body tissue) a larger mammal can meet its nutritional needs with relatively lower quality frage. (Hanley, 1982). Over the course of evolution, these differences have tended to produce, at one end of the spectrum, small ungulates with mouths adapted for carefully selecting discrete, high quality food items and at the other end, large species with mouths adapted for rapid ingestion of large quantities of undifferentiated items often of low quality (Jarman and Sincliar, 1979).

Ruminants are limited by the fact that in order for food to pass from the rumen into the rest of the digestive tract it must be broken down to a certain minimal particle size. This may limit food passage and therefore restrict consumption if forage is fibrous. On the other hand cecal digestors can pass much more plant material through their system daily. Cecal digestors are, thus, adapted to low quality forage.

Animals with high rumino-reticular volume-to-body weight ratio such as cattle and domestic sheep are adapted to digest high cellulose diets (grass). Those with low ratios (e.g. goats) are adapted to digest a high cell soluble and high lignin (forb and browse) diet. The framework is strengthened by the findings of Olsen and Hansen (1977); Bryant et al., (1979); Salter and Hudson (1979); Schwartz and Ellis (1981); Holechek et al., (1982); Hudson and Frank (1987) and Mcinnis and Varva (1987).

2.2.2 Camel Food Habits

The majority of camels in the world exist on rangelands and more so in less developed countries (Wilson 1984; Yagil, 1986; Wilson, 1989). Their husbandry and management are based in large part on traditions passed down from generation to generation. Research done to assess how camels exploit the range vegetation resources separately, or when grazing with other ungulates, is limited. Such information is useful in improving their husbandry and management. Nevertheless, camels have acquired the reputation for survivability on harsh, degraded rangelands. They are naturally browsers in their feeding and are remarkable for their ability to thrive on feed that cannot be utilized by most other domestic animals. (Knoess, 1977; Gauthier-Pilters, 1979; Abu- Akkada, 1986 and Yagil, 1986). They are able to graze and browse the full range of plants from the ground level upto the height of about 3.0-3.8 metres depending on the size of the dromedary, and can utilize all grazing plants consumed by cattle, sheep and goats in addition to plants avoided by those species because of their thorns or chemical composition (Knoess et al., 1986).

Camels inhabiting arid and semi-arid pastoral zones are faced with combined food and water deficiencies during the dry period of the year. The growing season of such areas is short and the nitrogen supplies are limited, (Abu-Akkada, 1986). The efficient digestive tract coupled with increased urea recycling have enabled the camels to cope with the hardships (Emmanuel et al., 1976). This is confirmed by the findings of Lechner-Doll et al., (1990) who found that camels had lower mean retention time (MRT) of the digesta in the forestomach than cattle, sheep and goats.

Browse forms a major part of the camel diets both in the dry and growing seasons. Newman (1979) found that shrubs and forbs may comprise upto 70 per cent of the diet of Australian dromedaries during winter, increasing to 90 per cent during summer. Migongo (1984) also found that, although browse comprised a large part of the camel diets (91 per cent) throughout the study period, grass component of the diets was greatest during the driest season. Most trees and shrubs and even some dwarf shrubs in the Northern Kenya where the study was carried out are drought deciduous. This reduction in leafy browse might have caused the animals to graze especially localized stands of *Aristida* species, common in these rangelands in order to meet their dietary requirements (Migongo-Bake and Hansen, 1987). Similar results have been obtained by Coppock et al., (1986). However, Karue (1986) found that during the dry season, the browse plants contributed 97 per cent of the diets of the dromedary and 94 per cent during the growing season. This emphasizes the influence of site and seasonal variation on the forage available to the ungulates using the range.

2.2.3 Goat Food Habits

Goats, like camels, differ fundamentally from sheep and cattle in several morphological traits that appear to render them particularly well adapted to utilization of leaves, buds and fruiting bodies of woody

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plants. They are able to thrive in a wide range of environments and on a great variety of feedstuff (Okello and Obwolo, 1984; Kamau, 1986; Lu, 1990). The most important adaptive features enabling them to adjust to the environment in which they are reared are feeding behaviour, body size and fleece structure. Goats are not only able to select high quality diet and to compensate for their rumination capacity, they also consume more plant species than other domestic livestock (Peters, 1987).

Several studies have been carried out to determine goat diets in various habitats when grazing separately and together with other domestic livestock. They include those of Bryant et al, (1979); Squires (1982); Migongo, (1984); and Coppock et al, (1987a). All tend to confirm the fact that goats are generally browsers or intermediate feeders. Browse component of goat diets however, varies with site and time of the year. For instance in the study of Taylor and Kothmann (1990) in Texas, it was found that grass made up an average of 64% of goats diets over a study period of one year. This was a higher grass consumption by goats than expected and probably resulted because of favourable precipitation and short rest periods between collection periods of extrusa (Taylor and Kothmann, 1990).

2.3 QUALITY OF RANGE FORAGE AND RUMINANT DIETS

The quality of forage may be looked at in terms of the concentration of digestive nutrients (dry matter or specific nutrients) and concentration of components that limit digestibility such as fibre, lignin, silica and Tannins (Hart et al, 1983). It is affected by factors of climate and soil conditions (Cogswell and Kamstra, 1976; Semenye, 1987), plant species and part (Hart et al. 1983) and stage of maturity of the plants (Gaillard, 1962; Stobbs and Minson 1979, Maglad et al., 1986). Climatic and soil conditions are prime determinants of the adaptations of herbage species to any area, and climatic variations in the form of season largely determine herbage quality. Soil characteristics such as texture and richness influence the availability of minerals to the plants. The interaction of the two factors normally result in spatial and seasonal variation in the quality of forage.

Different plant species, due to their genetic make up, have varying capabilities for extraction of soil nutrients and also accumulation of dry matter. The concentration of various dry matter components and their structural arrangements determine the usefulness of the plant to the animals. Studies comparing quality of different plant species include those of Karue (1974); Hart et al, (1983); and Hart and Leibholz, (1990). Comparing the effects of grass species on the degradation of protein and organic matter, Hart and Leibholz (1990) found that the degradability of organic matter in the rumen and in the whole tract of steers was greatest for oats followed by Kikuyu and paspalum grasses. Plant parts though influenced by plants species, differ qualitatively. Leaves are usually more nutritious and of higher degradability than stems. Moreover newly produced leaves are often of higher nutritional value to animals than old ones. (Coppock et al., (1987b).

It is well known that forage quality decrease with advancing maturity of forage species. The nutrient concentration and digestibility decrease and concentration of digestion limiting components increases (Hart et al, 1983). Other studies on changes on the nutritional quality of forage as related to stage of maturity includes those of Greenhagh et al, (1960); Karue, (1974 and 1975); Hart and Leibholz, (1990) and Angell et al., (1990). As the forage plants mature there is normally a decrease in crude protein content and the digestibility of the parts eaten. This is accompanied by an increase in the crude fibre and liqnin content (Stobbs and Minson, 1979) A low protein diet reduces microbial fibre digestion in the rumen and so leads to a fall in cellulose and hemicellulose digestion. This seriously affects the proportion of energy intake used for maintenance and, in most cases, causes animals to lose weight (Provenza and Malechek, 1984). A critical level of crude protein in mature grass is given by Stobbs and Minson (1979) as between 6 and 8 per cent of the dry matter. However, most of the grass species found in arid and semi arid lands are deficient in protein during the dry season.

Range forages are generally composed of grasses, browse and forbs. Each of these has specific characteristics,that affects its value as a forage. Generally, browse is high in protein and lower in energy than grass. Browse is a regular feature of most the African rangeland (Otsyina and Mckell, 1985). It constitutes an important part of the diet of domestic livestock and wildlife. This is particularly true when grass is scarce due to climatic and management factors (Mckay and Frandsen, 1969). Digestibility studies of browse are scarce.

Utilization of forage by livestock in range areas as reported before, is related to availability factors such as abundance of species, height of plant in relation to animals, season of use and the growth forms (Otsyina and Mckell, 1985). Animals select their diets from an array of plant species. In their selective grazing, range ruminants select diets normally higher in quality than the available forage (Meyer et al., 1957; Mckay and Frandsen, 1969, and Coppock et al, 1986). The degree of selectivity by the animals is also a function of the body size. Large animals may be constrained by feed intake rather than the quality. Hence the diets they select may be of lower quality than those of small animals (Meyer et al., 1957; Hanley, 1982). However, exceptions do exist. For example, Coppock et al, (1986) working with cattle, donkeys, sheep, goats and camels, found that the camels, despite their size, not only selected diets composed of plant species largely different from those of other large animals but also diets higher in crude protein and cell solubles and lower in per cent total fibre. However camel diets were typically the lowest in terms of per cent in vitro dry matter digestibility

(IVDMD). Similar results have been, reported by Migongo, (1984) and Tubei (1985).

The utility derived from forage eaten by the herbirvores largely depends on the availability of the various nutrients to the animals body. This is affected by the concentration of secondary components like tannins (Provenza and Malechek 1984). Lignin and cutin are other compounds associated with cell walls of plant cells and are almost indigestible (Hansen et al., 1973). These compounds physically inhibit the digestion of the enclosed cell nutrients (Gaillard, 1962, Stobbs and Minson, 1979, Leng (1990) in his review of factors affecting the utilization of poor quality forages by ruminants, concluded that information on metabolizable energy (ME) and crude protein contents of a feed has little bearing on how animals utilize their feed without measurements made within the rumen and within the animal. Knowledge required to predict production levels will include digestibility, protein availability in the intestines, efficiency of nutrient utilization, the physiological state of the animal and its previous dietary and health history.

3. MATERIALS AND METHODS

3.1. SITE OF STUDY

The study was carried out at Kibwezi Dryland Field Station of the University of Nairobi, in Makueni district. The Latitudinal and longtudinal position of the station is 2.4^0 S and 38^0 E. It is situated some 15 Km from Kibwezi town and has an area of 4,896 ha (Fig. 1). The area comprises gently undulating terrain, ranging in altitutde from 915 to 1000 m above sea level (Touber 1983). It is in ecological zone V (Pratt and Gwynne, 1977).

Kibwezi is characterised by a bimodal rainfall with an annual mean of 656.3 mm (Kenya Meterological Department, 1991) . Average precipitation in the long rains (March-May) is 234.5mm whereas that of the short rains (October - December) is 339.2 mm. The period between June and September is the driest part of the year. Mean daily temperatures range from a miminum of 19.3^0 C to a maximum of 29.8^0C. During the study period there was scarcity of rain in the dry season (September-Oct. 1991). However in the growing season, substantial amounts of rain averaging 740 mm, were received. The average maximum daily temperature was 28 ^{0}C. The dry season was however hotter than the rainy season (November - December) with respective seasonal mean temperature of 32.6^0C and 28.9^0C.

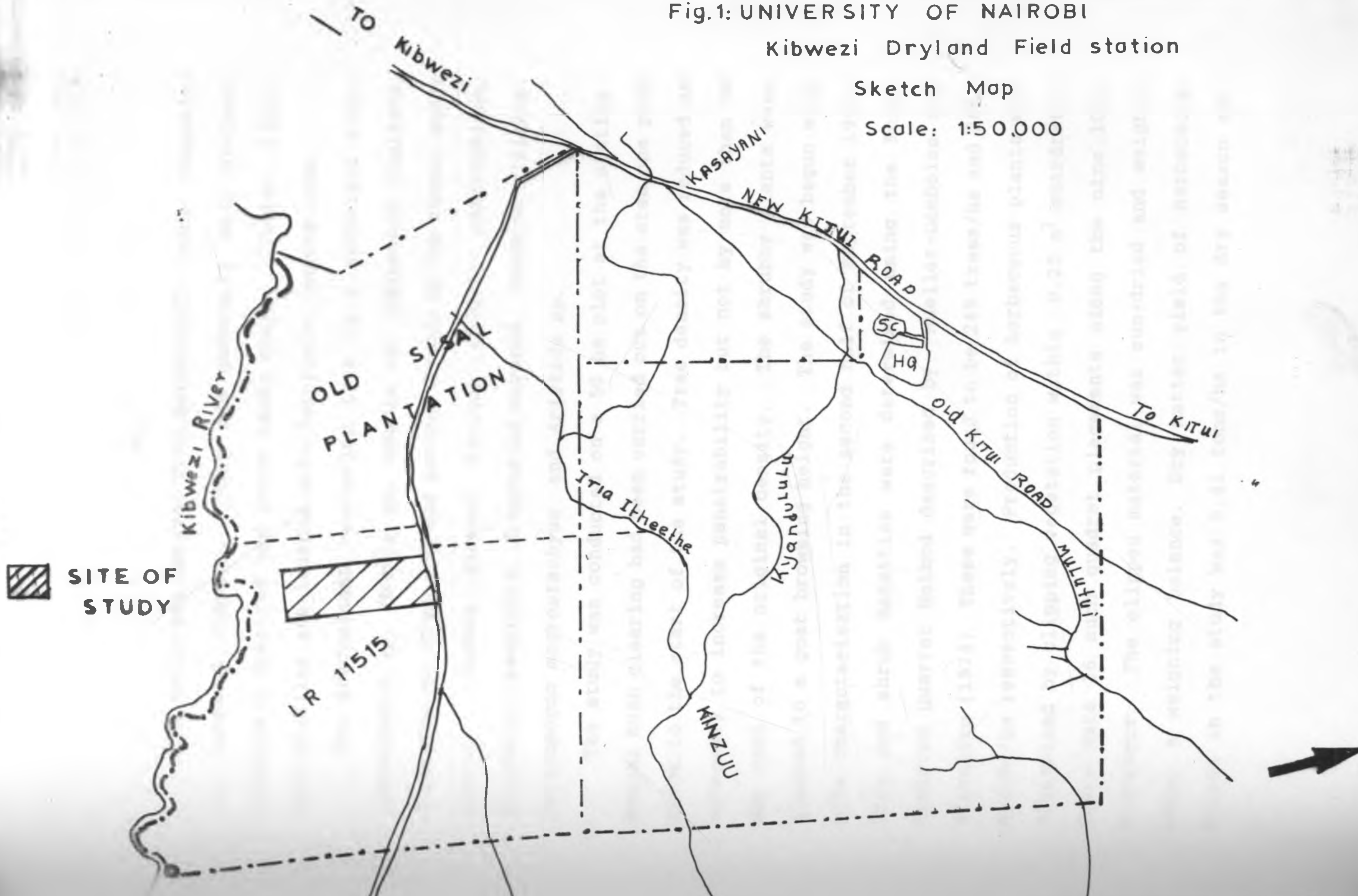

Fig.1: UNIVERSITY OF NAIROBI
Kibwezi Dryland Field station
Sketch Map
Scale: 1:50,000

The soils are derived from metamorphic rocks composing the basement complex. They are generally well drained, moderately deep red and brown sandy clays. (Touber, 1983). Some profiles are ladened with lateritic concretions.

The predominant vegetation type is a shrubland with *Commmiphora sp, Grewia sp, Boscia sp, Adansonia digitata, Combretum sp, Premna sp* and several *Acacia sp* as common woody plants. Common grasses include *Chloris roxburghiana, Eragostis caespitosa, Eragrostis superba, Cenchrus ciliaris, Enteropogon macrostachyus* and *Aristida sp.*

The study was conducted on a 50 ha plot at the station. Manual bush clearing had been carried out on the area one year prior to the start of the study. Tree density was reduced as necessary to increase penetrability but not by more than 50 per cent of the original density. The shrubby plants were slashed to a goat browsing height. The study was begun with site characterisation in the second half of september 1990. Tree and shrub densities were determined using the Point Centered Quarter Method described by Mueller-Domboise and Ellenberg (1974). These were found to be 249 trees/ha and 2667 shrubs/ha resoectively. Production of herbaceous plants was determined by clipping vegetation within 0.25 m^2 quardrats. There were 36 such quadrat placements along the nine 100m transects. The clipped material was sun-dried and weighed using a weighing balance. Dry matter yield of herbaceons plants in the study was 8.41 tons/ha in the dry season and

10.53 tons/ha in the growing seasonn.

3.2 TIME ALLOCATION ANALYSIS

Behaviour activities were categorised into feeding,walking,ruminating,resting and other activities.The latter category included urinating, defaecating and idling. Time spent by camels and goats in the activities was quantified using focal observations method.This part of the study was conducted from 6th December 1990 to 1st February 1991.Eight female camels (*Camelus dromedarius*) and eight female small East African goats (*capra hircus*) were observed for 24 days per species.

Animals were observed from 8.00 a.m in the morning to 4.00 p.m in the evening. Observations were subdivided into three 16-day periods during which each animal species was observed in a two-day alternation. Period I which started on 6th to 21st December 1990 was the wettest part of the short growing season. Period II and II formed a transition between the wet and dry season and they started from 30th December 1990 to 14th January 1991 and from 17th Januar y to 1st February respectively. Eight individual animals of the same species were observed for an hour each in a day. Four individual animals were observed in the morning and four in the afternoon. Each animal was observed on a two minute interval for behavioural activity it was involved in. The resting category of behavioural activities was divided into two: resting while standing or lying.

3.3 DIETARY SELECTION DETERMINATION

Dietary selection of the camels and goats was determined by use of microhistological techniques (Sparks and Malechek, 1968). The method has been widely used for evaluating both domestic and wild ungulate food habits (Tadingar 1986). Microfecal analysis is favoured and has received greater use than any other procedure due to its advantages. These include non-interference with nornmal habits of the animals, unlimited sampling, no restriction on animal movement and the fact that it is the only feasible procedure to use when studying secretive and endangered species (Smith and Shandruk 1979, Holechek *et al.* 1982). Limitations which has been cited with the use of the method include the differential ability of observers to identify and recognise plant fragments under a miscroscope and sample preparation procedures. However, it has been found that with increased and intense training of analysts, the accuracy of estimation will increase (Free *et al.* 1971, Hoelchek *et al.* 1982, Gross *et al.* 1983).

The study ran from 23rd September to 16th October 1990 in the dry season and from 30th November to 22nd December 1990 during the growing season. Faecal samples were collected from 11 camels and 40 goats. The animals grazed together during the day but were corralled separately at night to facilitate faecal sample collection. This was done for a total of 20 days in a season. Dry and wet season faecal samples were crushed,mixed with table salt to prevent further microbial degradation and sundried before storage. Samples of plant species on the site were collected at the same time for both reference slides and quality analysis.Dried samples were ground in a 1-mm Willey laboratory mill for reference slides preparation.

Four consecutive day faecal collections were thoroughly mixed and subsampled for microhistological analysis, giving five compounded samples for each animal species in a season. Faecal samples were washed under running tap water , through a 120 mesh sieve. An aliquot of the samples was put in a test tube and mixed with household bleach as a clearing agent. For each subsample, five microscope slides were mounted using Hoyer's solution (Cavender and Hansen, 1970). Twenty microscope fields were viewed per slide for identifiable plant fragments under 100x magnification (Foppe, 1984).Relative densities of the different plant species recognised in the faecal samples were obtained and used to assess the degree of diet selection and seasonal dietary overlap between animal species.

3.4 DIETARY QUALITY ANALYSIS

Preferred plant species in a season were analysed for chemical composition and dry matter digestibility. The plants were analysed for crude protein (CP) and ash (A.O.A.C., 1980), Neutral Detergent (NDF), Acid Detergent Fibre (ADF), Acid Detergent Lignin (ADL) and cell solubles (Goering and Van Soest, 1969). All samples were analysed in duplicates. Dry matter digestibility (DMD) of the preferred plant species was carried out using the Nylon bag Technique. Compounded diets were made, basing on the relative densities with which the selected plants appeared in the respective dry and wet season camel and goat diets, from the collected samples of the preferred plant species. These compounded diets were also analysed for CP, ash, ADF, NDF, ADL, CS and DMD. (Orskov et al., 1980).

3.5 DATA ANALYSIS

The experiment was a Randomized Complete Block Design, with animal species as blocks and periods as treatments. Data was subjected to a two way analysis of variance (Steel and Torrie 1980) Duncan's New Multiple Range Test was used to seperate means.

The Spearman's Coefficient of Rank Correlation (Snedecor and Cochran, 1967) was used to determine the correlation between animal species dietary preference within season. Also between seasons dietary preferences were compared for each animal species. The following formula was used to calculate the coefficient .

$$r_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

Where

r_s is the Spearman's rank correlation coefficient

d_i = differences in ranks for ith pair of observations.

n = the number of pairs.

r_s lies between -1 and +1. A value of -1 indicates same dietary preference in reverse order. However a value of +1 indicates same dietary preference in the same order.

Food habits of the two animal species were compared by the degree of diet overlap (Horn 1966). The overlap coefficient C_δ varies from 0, for completely distinct samples (no food categories in common), to 1, for identical samples.

$$C_\delta \quad \frac{\sum^{s} X_i \; Y_i}{X_i^2 + Y_i^2}$$

whereas s is the total number of plant species and Xi and Yi are the proportion of the total diet of herbivore species X and Y taken from ith plant species.

Mean chemical composition and dry matter digestibility of compounded diets were compared between animal species within season and within species between seasons, using a student's t test.

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$$C_{\delta} = \frac{2\sum_{i=1}^{s} X_i Y_i}{\sum X_i^2 + \sum Y_i^2}$$

whereas s is the total number of plant species and Xi and Yi are the proportion of the total diet of herbivore species X and Y taken from ith plant species.

Mean chemical composition and dry matter digestibility of compounded diets were compared between animal species within season and within species between seasons, using a student's t test.

4.RESULTS AND DISCUSSIONS

4.1 BEHAVIOUR OF CAMELS AND GOATS

4.1.1 Activity Time Budgets

Feeding: Feeding comprised the prehension, initial mastication and swallowing of the food item. It was the most time consuming activity for both the camels and goats (Table 1).Camels spent 56.56%, 57.81% and 61.77% of the total observation time feeding in period I, II, and III respectively. They did not differ ($P < 0.05$) among themselves. Although camels and goats feeding times were similar in period I and III, goats speny more time ($P < 0.05$) feeding than camels in period II. Overall goats spent more time ($P<0.05$) feeding tham camels in the study. Goats spent 56.93%, 59.74% and 61.70% of the observation time feeding in the respective periods. Time spent feeding increased ($P<0.05$) from period I through period III. On average, both animal species spent more than half of each observation day feeding. However no individual animal was observed to be involved in one activity throughout the one hour observation time.

Walking: Walking time was mainly devoted to search for food, especially during the early part of the study when it was wet.The vegetation contained high proportion of water hence animals were not water stressed.

Walking time was affected by period for camels only. This

Table 1. Proportion of Observation Time Spent in various activities by Camels and Goats (%)
1990/1991 KIBWEZI DRYLAND FIELD STATION.

ACTIVITY	ANIMAL SPECIES	PERIOD I	PERIOD II	PERIOD III
Feeding	Camels	56.56^{a}	57.81^{c1}	61.77^{b}
	Goats	56.93^{a}	59.93^{c2}	61.70^{b}
Walking	Camels	21.46^{a1}	24.79^{c}	27.71^{b1}
	Goats	24.72^{2}	25.57	25.90^{2}
Ruminating	Camels	0.26^{1}	0.26^{1}	0.21^{1}
	Goats	4.48^{2}	4.74^{2}	4.69^{2}
Resting Standing	Camels	8.80^{b1}	6.39^{c1}	4.27^{a1}
	Goats	5.36^{b2}	4.11^{c2}	3.28^{a2}
Lying	Camels	6.98^{b3}	3.96^{c23}	2.60^{a3}
	Goats	2.86^{b4}	1.82^{ac4}	1.15^{a4}
Others	Camels	5.76^{b}	4.11^{c}	3.38^{a}
	Goats	5.57^{b}	4.11^{ac}	4.27^{a}

Row: Means with different superscripts (abc) differ, ($P<0.05$).
Column: Means with different superscripts (1,2,3,4) differ, ($P<0.05$) for specific activity.

increased from period I to III (Table 1). On the other hand goats walking time did not (P <0.05) change with period. Nevertheless the two species were not different (P<0.05).

Ruminating: Goats spent considerably more time ruminating (p<0.05) than camels. Ruminating time was not influenced (p<0.05) by period for the two species (Table 1).

Resting: This was divided into two: Standing-resting and Lying-resting. Animals were recorded as resting when they were not involved in any other behavioural activity apart from standing or lying. All animals rested more (p<0.05) while standing than lying. For both species time spent resting declined with period (p<0.05). Camels spent more (p<0.05) time resting than goats. In general resting time declined (P<0.05) from period I to III. (Table 1)

Other Activities: Other activities declined in proportion from period one to three, for both species. The two species did not differ (p<0.05).

4.1.2. Activity Patterns

Under the conditions ofthe study (i.e, fixed time within which animals were on the field and free movement within the 50- ha plot) the major activities the camels and goats were invloved in were feeding and walking in search of forage.

Other activities taken together took less than 20% of the observation time.

The distribution of the activities of the observation day shows that both camels and goats had distint peak periods of feeding, resting and ruminating. Camels and goats engaged in intensive feeding for the most part of the morning session. This was followed by a period of low level of feeding during which much ofthe day-resting or ruminating was done.

Camels showed two daily peak feeding periods. The first period started right from the time they were let out of their boma (8.00 hrs) to 11.00 hrs in period I and up to 12.00 hrs in periods II and III. The second peak feeding period took a short duration, from 14.00hr-16.00 hrs in period I, II and from 15.00 - 16.00 hrs in period III. In between was a period of relative inactivity, starting from around 12.00 hrs to 14.00 hrs. It was during this part of the day that the camels rested (figs 2, 3, & 4). Some could be seen ruminating at that time. The first peak feeding period covered as high as 60.4%, 61.77% and 65.83% in periods I, II and III respectively. The second peak feeding period covered somewhat lower proportion of the observation time than the first.

Goats had a morning peak feeding period and a relatively indistinct second peak in the afternoon. Unlike camels, goats started with a period of relatively low feeding activity in the early morning, picking up as time went by and reached a peak between 10.00 and 11.00 hours. Following this was a gradual decline in the level of feeding which was accompanied by an increase in the level of ruminating and to some extent resting. The second peak feeding period was more distinct in period III only and it occured between 15.00 and 16.00 hours (figs 5, 6, 7).

Walking was associated with feeding in that when the level of feeding was high, time spent walking was high. This occurred especially during the peak feeding periods. Less walking was done by the animals around midday when feeding was at minimum. This pattern of walking was more marked in camels than in goats.

Ruminating was a peculiar activity in the goats, but not obvious in camels. It was mainly confined to the afternoon session, although some ruminating was done in the early morning. Camels opted to rest when they were not feeding. Resting was, however, more evenly distributed over the whole observation day than was ruminating. Other activities were not restricted to any particular part of the day.

Fig 2. DISTRIBUTION OF BEHAVIOUR ACTIVITIES BY CAMELS OVER THE 8 HOUR OBSERVATION DAY (%) PERIOD 1

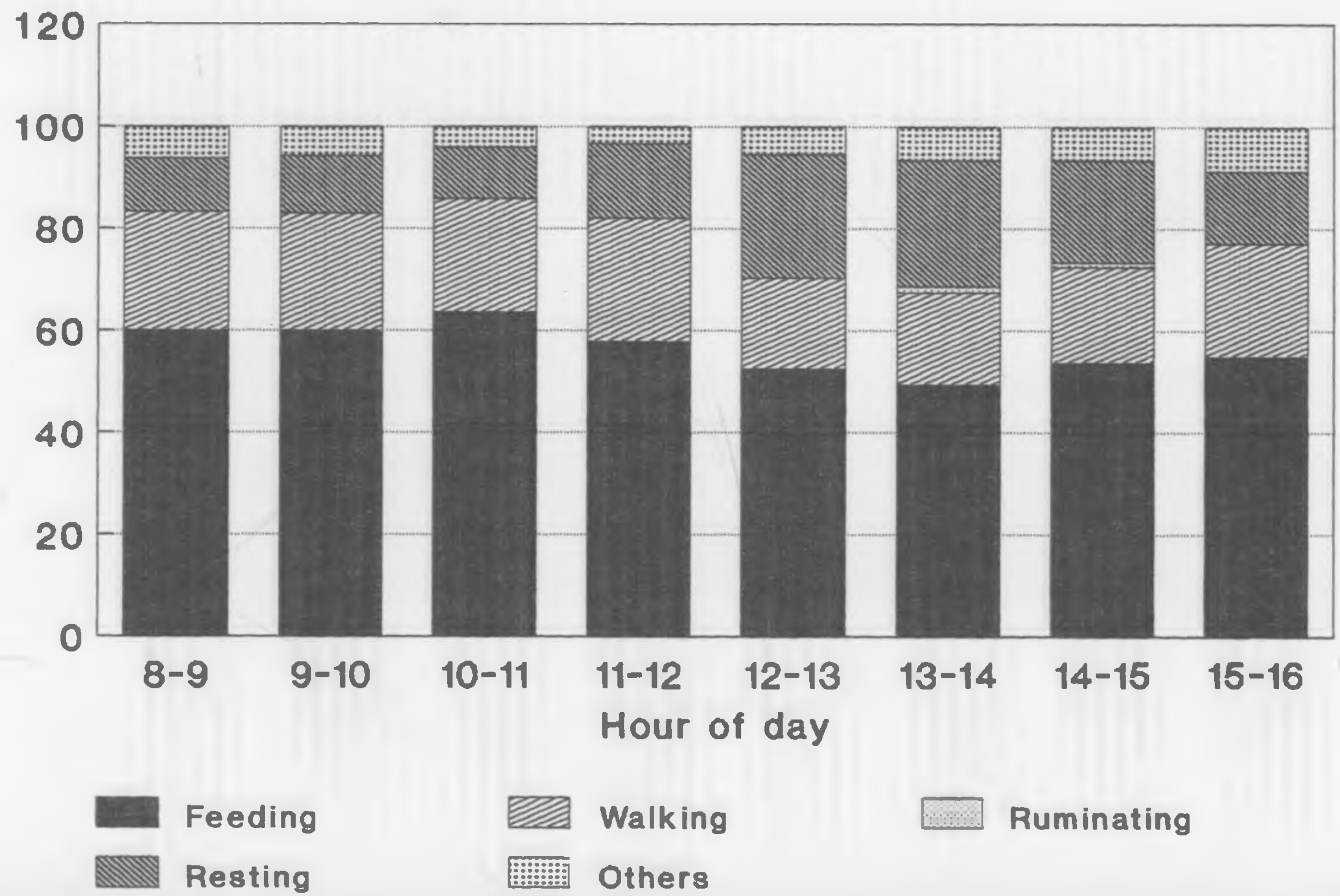


Fig 3. DISTRIBUTION OF BEHAVIOUR ACTIVITIES BY CAMELS OVER THE 8 HR OBSERVATION DAY (%) PERIOD 2

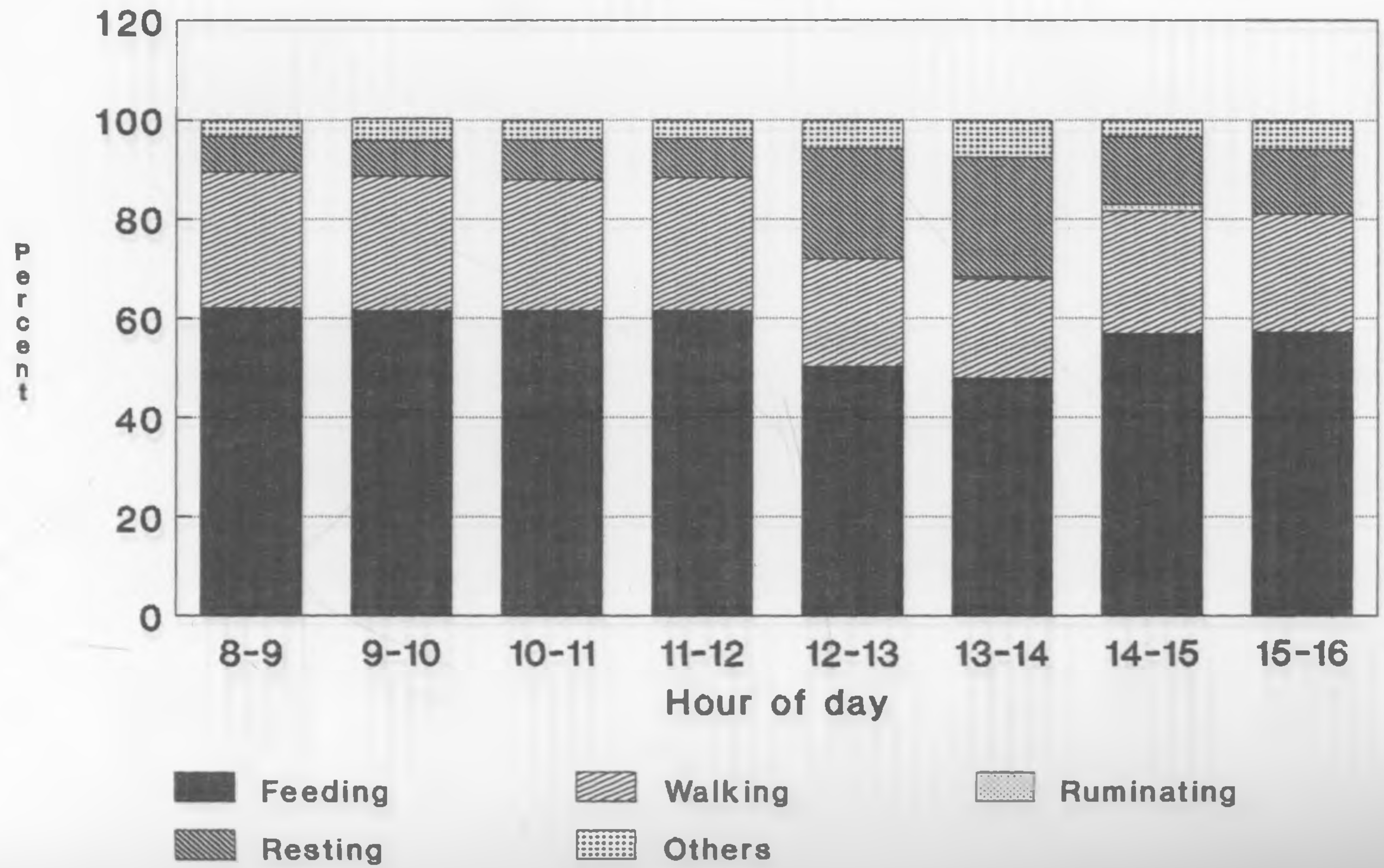


Fig 4. DISTRIBUTION OF BEHAVIOUR ACTIVITIES BY CAMELS OVER THE 8 HR OBSERVATION DAY (%) PERIOD 3

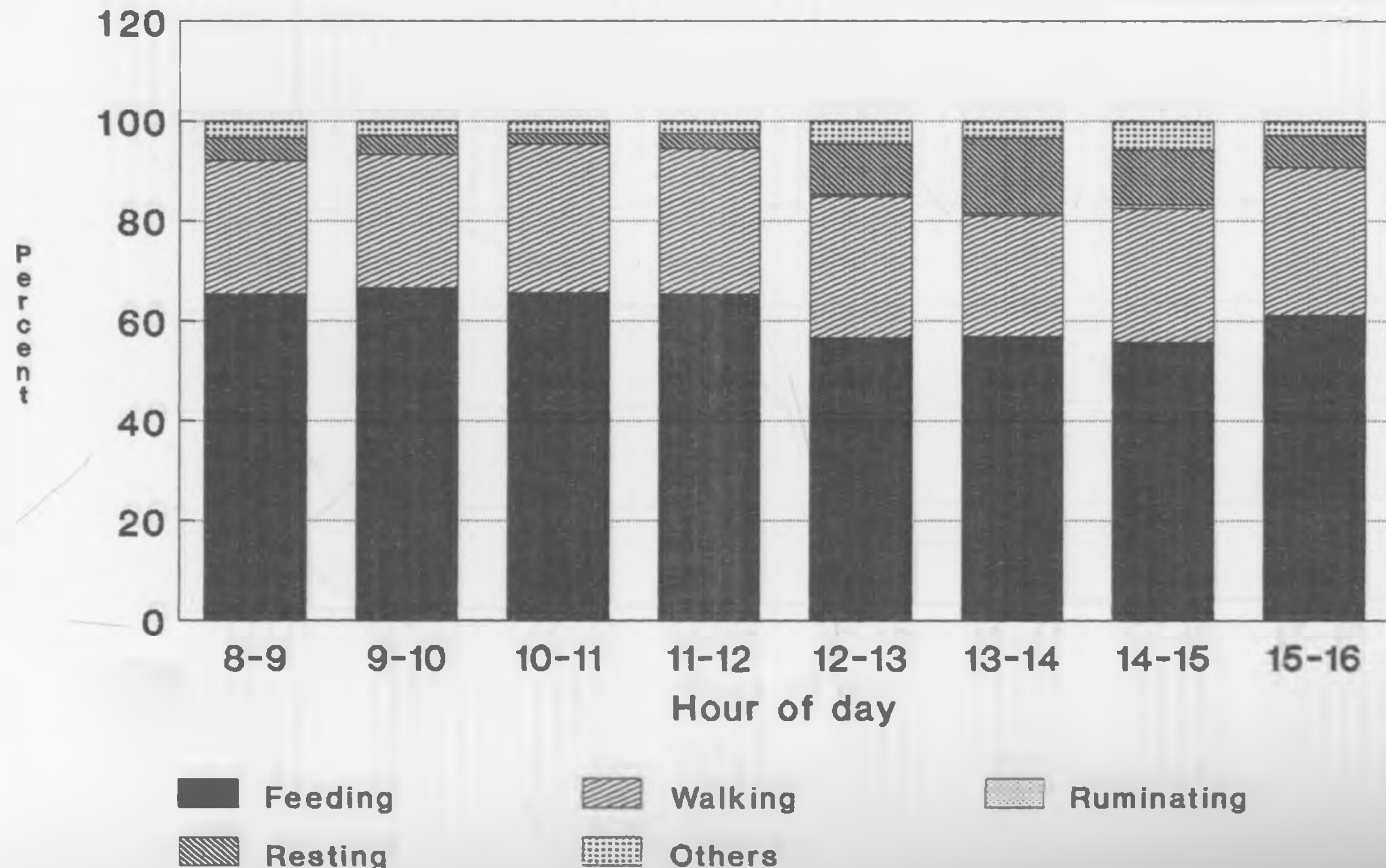
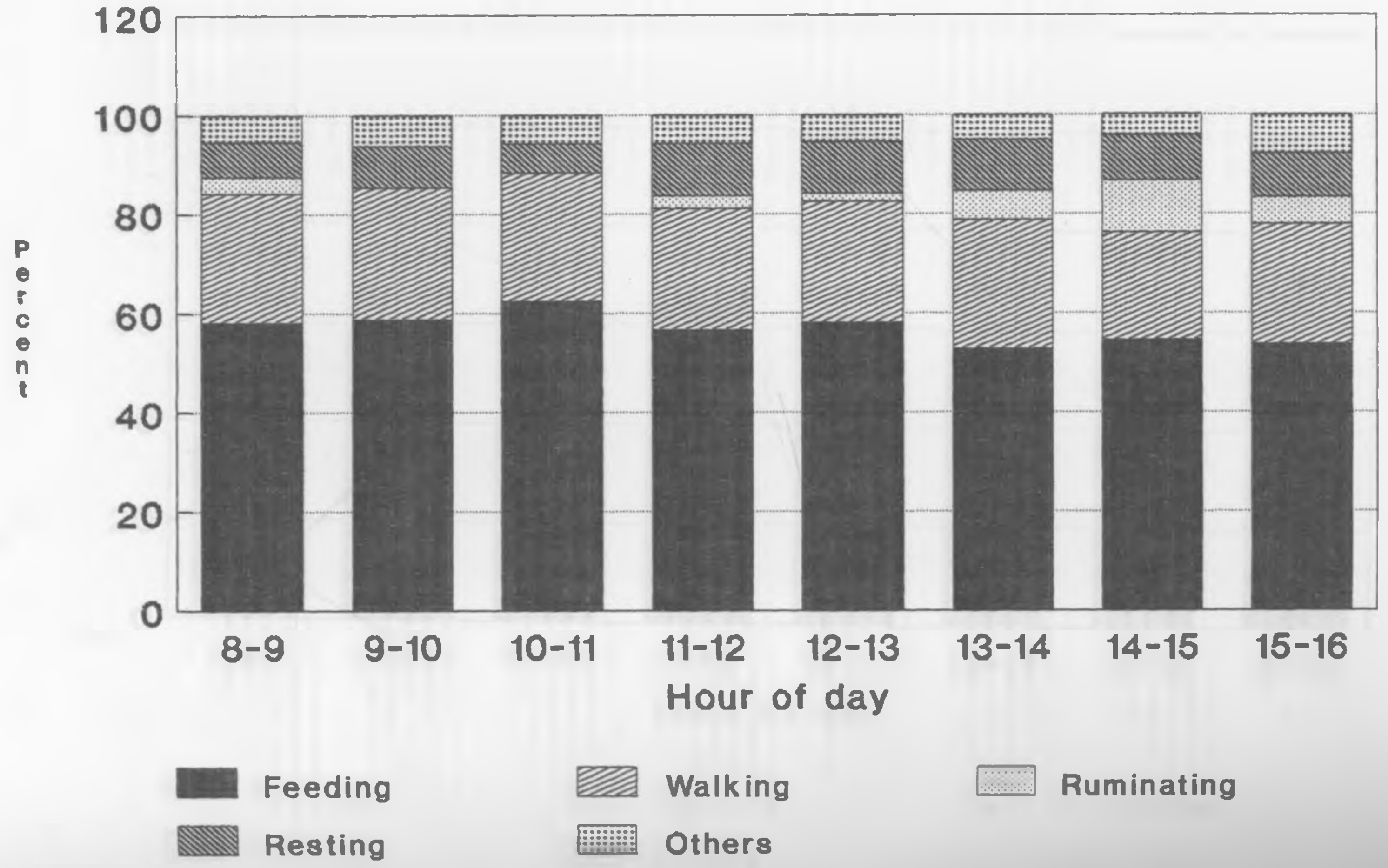


Fig 5. DISTRIBUTION OF BEHAVIOUR ACTIVITIES BY GOATS OVER THE 8 HR OBSERVATION DAY (%) PERIOD 1



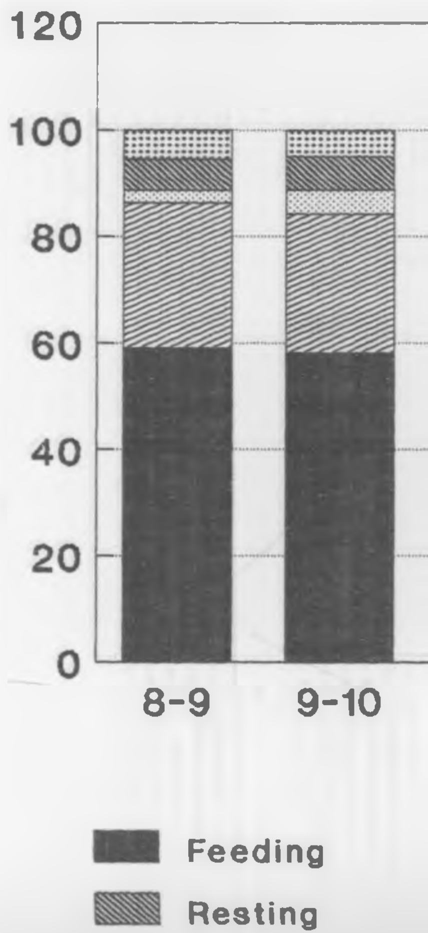

120
100
80
60
40
20
0
Percent
8-9
9-10
Feeding
Resting

Fig 6.DISTRIBUTION OF BEHAVIOUR ACTIVITIES BY GOATS OVER THE 8HR OBSERVATION DAY (%) PERIOD 2

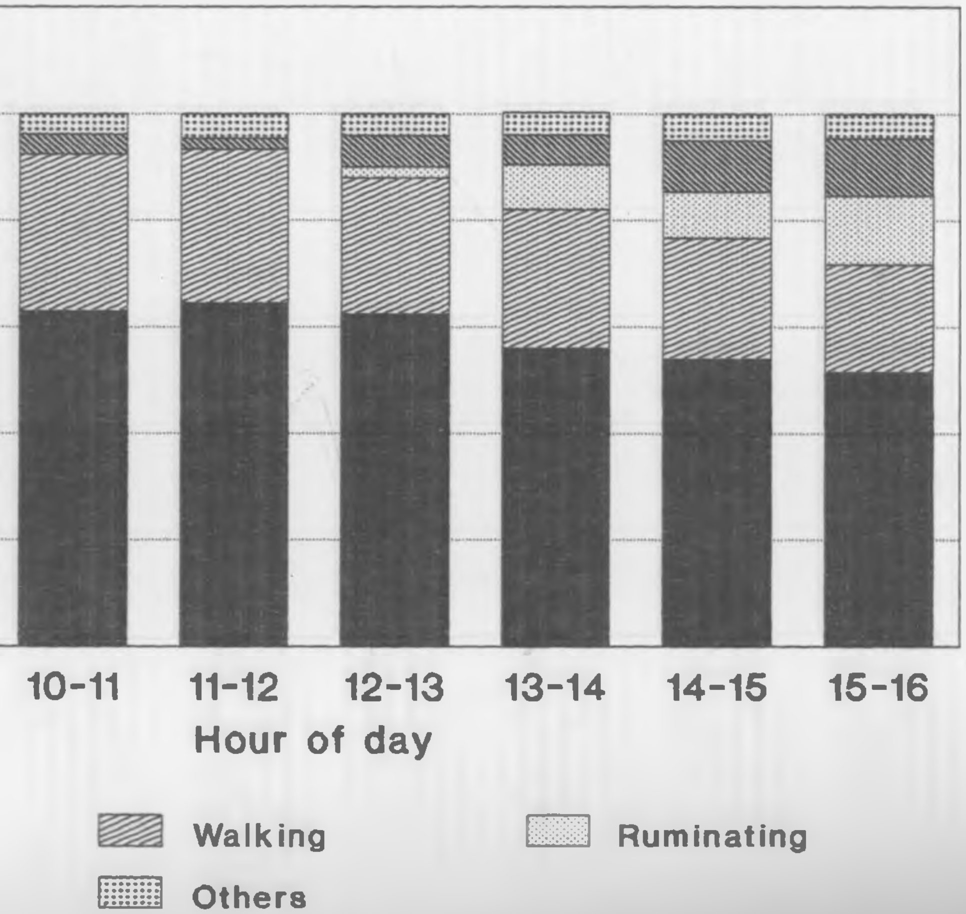
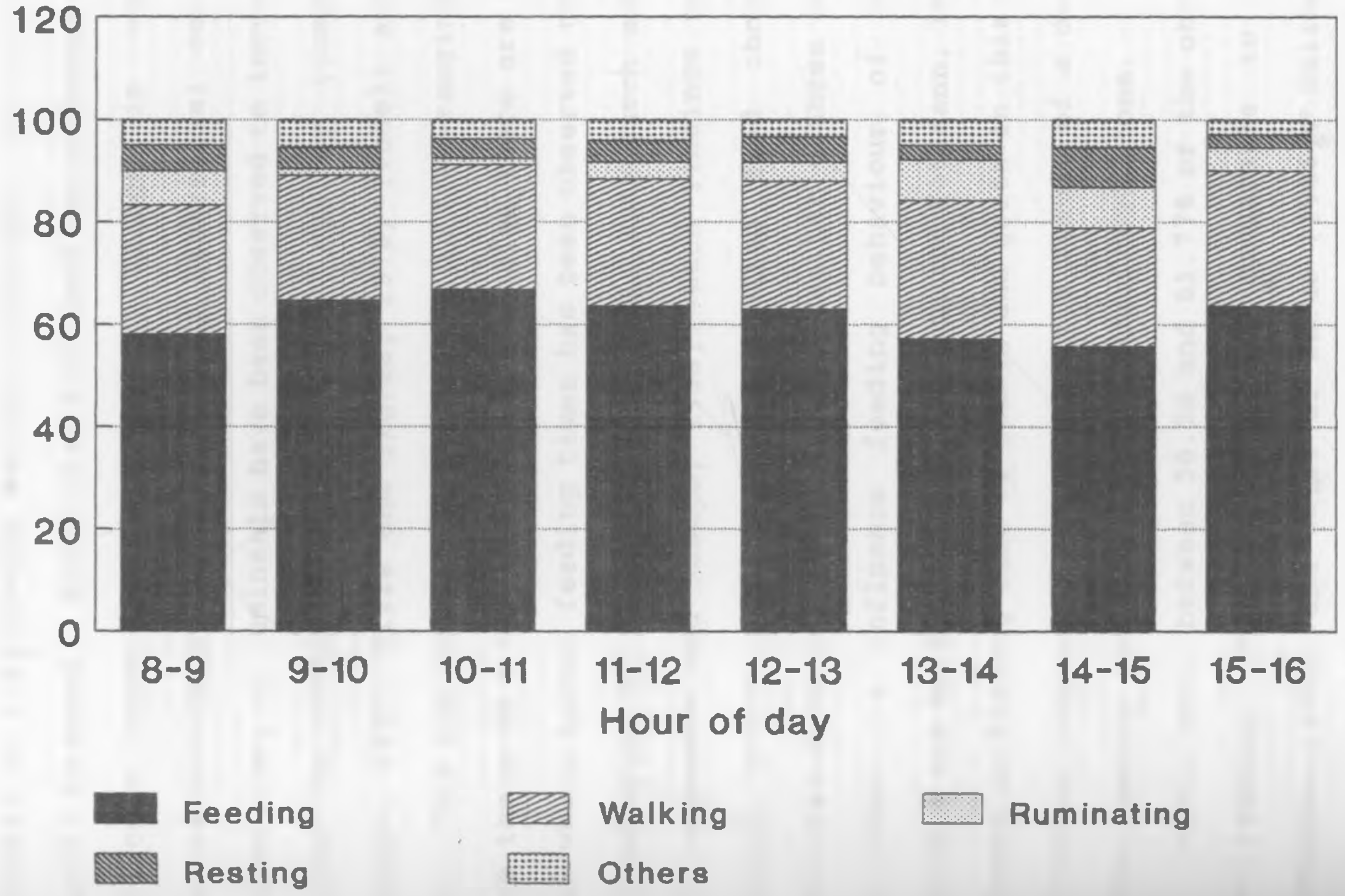


Fig 7.DISTRIBUTION OF BEHAVIOUR ACTIVITIES BY GOATS OVER THE 8 HR OBSERVATION DAY (%) PERIOD 3



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4.1.3 Discussion

Time Budgets: Feeding was the major activity in which the animals were involved. Feeding times for both camels and goats increased as the growing season progressed. Advance in plant maturity is usually associated with decline in forage quality. Herbivores normally respond to change in vegetation characteristics by adjusting their behavioural activities. Feeding times of ruminants have been observed to increase with decline in forage availability or quality (Compton and Brundage, 1971; Ellis and Travis, 1975; Trudell and White, 1981). This has normally been observed in free-ranging animals where there is a variety of plant species.There are however, cases where animal feeding times has been observed to decline with maturity of plant (Wilson, 1961; Ruckebusch and Bueno, 1978; Alhassan and Kabuga, 1988). Such findings have been obtained under conditions of limited feed choices and restricted movement among others. Weather changes have also been shown to influence feeding behaviour of ruminants (Malechek and Smith 1976 and Anderson and Kothmann, 1980). The increase in feeding time of camels and goats in this study as the season progressed was probably a result of a decline in forage quality and changes in weather conditions.

Camels spent between 56.56 and 61.77% of the observation time feeding. These results are comparable to 62.% of Dessalagne (1985) and 56.9% of Karue (1986). Unlike goats, camels spent less time feeding at any one particular feeding station. This probably explains the increase in time spent walking that accompanied feeding time as the growing season progressed.

Goats spent between 56.93 and 61.70% of the observation time feeding. They could, however, spent longer time feeding at one feeding station than camels. This probably explains why their walking time did not change drastically with period. These results cannot be directly compared with those of Askins and Turner (1972) because in this study the goats were observed only during the day and penned at night. Greater feeding time of goats relative to camels can be attributed to their small body size and mouth parts, and hence were more selective with respect to plant parts. However, it is possible that camels consumed greater amounts of forage. This observation supports the theory that larger animals satisfy their energy requirements with less foraging time than smaller animals when food is abundant, but may spend relatively more time foraging when food is scarce (Ellis *et al.* 1976). These results are in contrast to those by Alhasan and Kabuga (1988) with respect to foraging time-size related theory.

Resting times tended to decrease with advance in the grazing season. Periodical resting times changed for camels but not ruminating times. The same was observed in goats. On average camels resting and ruminating times throughout the study period were less than 16% and 0.5% respectively. Those of goats were less than 10% and 5% respectively. These are far less resting and ruminating times compared to those of animals with grazing available for 24 hours. Nevertheless, since no feeding took place at night, I presumed that much of resting and ruminating took place then. Grazing animals tended to increase feeding time and postpone resting and ruminating probably in response to changing forage quality. It has been observed in other ruminants that resting and ruminating are postponed during daylight in cases where animals were corralled at night (Smith 1950; Bayer, 1986). Goats engaged in frequent and more intense ruminating than did camels. This can be explained by the fact that the stomach volume of goats, is smaller than that of camels. This possibly caused the goats to attain that feed capacity required to elicit ruminating much faster than camels.

Time spent on other activities somewhat decreased with period. This again may have been a postponement by animals of less vital activities such as idling in order to spent more time in the search for and eating the food.

Activity Patterns: The overall activity patterns of camels and goats were similar. The intensity with which they undertook various activities differs to some degree. Camels engaged in prolonged intensive feeding for most of the morning session followed by a lull just before noon and early afternoon, before they picked up again in the late afternoon. Goats on the other hand, started with a low key feeding early in the morning, picking up with time to reach a peak just before midday. The level of feeding gradually declined thereafter before an indistinct peak feeding period set in in the late afternoon. Similar feeding patterns have been observed with other ungulates (Goldson, 1963, Sneva, 1970; Askins and Turner, 1972; Mugerwa et al, 1973; Ellis and Travis, 1975; Arnold, 1985; and Hudson and Frank, 1987). The animals fed actively in the morning and late afternoon when the heat from the sum was not intense. Around midday they opted to rest or ruminate. Most animals and especially camels were observed to rest under shade. Hence resting was probably a heat avoidance tactic of camels. Walking was associated with feeding, hence its distribution pattern over the observation day resembled the feeding pattern.

Other activities were evenly distributed over the whole observation day. Activities like urinating and defaecating had no specific pattern. Idling was, however, observed more in the afternoon especially in goats.

4.2 FOOD HABITS OF CAMELS AND GOATS

4.2.1 Dietary Botanical Composition

Camels fed predominantly on browse plants in both dry and wet seasons. The proportion of browse in camel diets was 90.16% and 93.99% in the respective seasons, the remainder being taken up by grass. Their dietary niche breadth did not significantly change with season. In the dry season camels showed high preference for *Boscia coriacea* (20.82%) followed closely by *Stiganotaenia sp* (19.10%) and *Abutilon mauritanum* (11.77%). These plants comprised at least 50% of the dry season camel diets. Other species individually comprised less than 10% of the diets (Table 2). In the wet season there was a slight shift of food preference with a decreased selection of *Boscia corriacea* and increased contribution of other plants to the diets. Preference was for *Stiganotania sp* (25.92%) followed by *Grewia sp* (14.58%); *Abutilon mauritanum* (14.525); *Sterculia rhynchocarpa* (11.89%) and *Commiphora schmperi* (11.48%). Camels also consumed other plants which, constituted less than 5% each.

Goats primarily consumed browse plants in both seasons. The proportion of this class of forage, however, varied widely from the dry season (77.70%) to the growing season (61.31%). Unlike the camels, goats ate more grass in the growing season (38.83%) than in the dry season (22.33%). Goat dietary niche breadth was similar to that of camels in the dry season but was narrower in the growing season. It is noteworthy that the proportion of browse in goat diets was lower ($P< 0.05$) than that in camel diets in both seasons. Goats were more adept at switching from not only one forage class to another but also from one plant species to another within a particular forage class. In both seasons no plant species individually constituted more than 20% of the goat diets. Goats selected *Abutilon mauritanum* (18.22%); *Stiganotaenia sp* (17.89%); *Eragrostis caespitosa* (9.48%) and *Acalypha fruticosa* (6.43%)

in that order. These plant species made up at least 50% of their diets in the dry season. (Table 3). In the growing season the food selection shifted substantially. Plant species which ranked lower in the dry season diets were most selected with. *Commiphora schimperi* ranking highest (16.28%). This was followed by *chloris roxburghiana* (15.11%), *Eragrostis caespitosa* (13.68%) and *Stiganotaenia spp.* (11.41%) in that order.

Table 2: Botanical Composition of Camel Diets in the Dry and Wet Seasons 23 rd SEPT - 16 OCT 1990.

	SPECIES	RELATIVE PROPORTIONAL DIET (%)			
		DRY		WET	
	Trees and Shrubs	X	SD	X	SD
1.	*Boscia coriacea*	20.82±	6.02	0.34±	0.58
2.	*Stiganotaenia spp*	19.10±	5.18	25.92±	8.26
3.	*Abutilon mauritanum*	11.77±	5.11	14.52±	5.17
4.	*Commiphora schimper*	8.75±	6.18	11.48±	3.81
5.	*Grewia spp*	6.11±	3.40	14.58±	5.90
6.	*Sterculia rhynchocarpa*	3.79±	3.72	11.89±	3.46
7.	*Acalypha fruticosa*	3.46±	1.79	2.02±	1.29
8.	*Ecbolium ruvulutum*	2.71±	2.49	2.40±	2.09
9.	*Entada abyssinica*	2.35±	2.07	2.73±	2.48
10.	*Asparagus racesmosus*	2.03±	2.15	0.20±	0.28
11.	*Acacia tortilis*	0.70±	1.08	1.33±	1.86
12.	*Acacia mellifera*	0.56±	0.47	-	
13.	*Acacia senegal*	0.36±	0.67	0.75±	0.92
14.	*Boswellia rivae*	-		0.12±	0.27
15.	*Fruits*	1.00±	0.91		-
16.	*Other dicots*	6.65±	1.76	5.68±	1.43
	Grasses				
1.	*Enteropogon macrostachyus*	2.30±	2.58	1.09±	1.29
2.	*Eragrostis caespitosa*	2.02±	2.58	0.23±	0.37
3.	*Chloris roxburghiana*	0.56±	0.85	1.12±	1.05
4.	*Echinocloa haploclada*	0.16±	0.36	1.23±	1.27
5.	*Other monocots*	4.80±	4.10	2.34±	1.63

Table 3: Botanical Composition of Goat Diets in the Dry and Wet Seasons 30th Nov-22nd Dec 1990.

	SPECIES	RELATIVE PROPORTION IN DIET(%)			
		DRY SEASON		WET SEASON	
	Trees and Shrubs	X	SD	X	SD
1.	*Abutilon mauritanum*	18.22±	11.64	2.92±	1.70
2.	*Stiganotaenia* spp	17.89±	8.73	11.41±	4.23
3.	*Acalypha fruticosa*	6.43±	2.84	1.67±	1.65
4.	*Grewia* SPP	5.11±	2.03	8.38±	5.21
5.	*Commiphora schimperi*	4.35±	2.99	16.28±	4.27
6.	*Boscia coriacea*	4.02±	3.00		-
7.	*Entada abyssinica*	3.62±	3.78	0.31±	0.68
8.	*Asparagus racesmosus*	3.59±	2.91		-
9.	*Ecbolium ruvulutum*	3.42±	3.63	6.60±	4.22
10	*Boswellia rivae*	1.81±	2.04	1.22±	2.09
11.	*Sterculia rhynchocarpa*	1.72±	1.57	5.99±	3.78
12.	*Maerua kirkii*	0.39±	0.87	0.34±	0.48
13.	*Lannea triphylla*	0.11±	0.25	1.12±	1.24
14.	*Acacia tortilis*	0.09±	0.22	0.07±	0.15
15.	*Fruits*	1.56±	1.76		-
16.	*Other dicots*	5.37±	2.59	4.90±	1.63
	Grasses				
1.	*Eragrostis caespitosa*	9.48±	6.62	13.68±	4.58
2.	*Enteropogon macrostachyus*	3.80±	2.34	2.18±	1.71
3.	*Panicum deustum*	1.79±	1.50	3.66±	2.66
4.	*Chloris roxburghiana*	0.70±	0.62	15.11±	5.89
5.	*Other monocots*	6.56±	4.66	4.20±	2.64

4.2.2 Dietary Overlap

The dietary overlap between camel and goat diets and the order of plant selection by each herbivore between seasons were particularly sensitive to seasonal changes. In the dry season camels and goats selected plant species in the same order (Table 4). However in the wet season the order of selection by both species was different, hence the widely disparate correlation coefficients of the dry and wet seasons camel and goats diets. Camels and goats had 14 plant species common to their diets in the dry season. In the wet season, 13 plant species were common to their diets. Camels selected their dry and wet season diets in the same order resulting in a significant ($P<0.05$) correlation coefficient (Table 4).Their dry and wet season diets had 16 plant species in common. Goats on the other hand selected their diets in the dry season in a different order from that of the wet season.Goats, however, had 16 plant species common to their dry and wet season diets.

Using the coefficient of the diet overlap C it was found that the diet overlap between camel and goat diets was higher (0.91) in the dry season than in the wet season(0.64). Notably these coefficeints show that the dietary overlaps for the two species were, nevertheless, relatively strong in the dry and wet seasons.

Table 4. Spearman's Rank Correlation Coefficient of Camel and Goat Diets
Sept. - Dec 1990

Diets Compared	Season/ Animal Species	Number of Plant Species in Common: N	Correlation Coefficient: r.	Significance of r
	(a) Season			
Camels vs Goats	Dry Season	14	0.637	*
	Wet season	13	0.241	ns
	(b) Animal Species.			
Dry Season vs Wet Season	Camels	16	0.562	*
	Goats	16	0.453	ns

(i) * Correlation Coefficients are Significant ($P < 0.05$)
(ii) ns Correlation Coefficients are not Significant ($P > 0.05$)

4.2.3 Discussion

The forage class compositions of the herbivore diets in this study were similar to those observed for the species in other shrubland ecosystems. Camel diets were made up predominantly of browse in both dry and growing seasons, in line with earlier findings (Field, 1978; Wangoi, 1984; Tubei, 1985; Karue 1986 and Coppock et al., 1987a). The grass component of the camel diets was higher in the dry season than in the wet season. This may be due to the fact that most of browse plants dropped their leaves in the dry period. Similar phenomena have been observed by Migongo, (1984) and Coppock et al (1986). In Karue's (1986) study, however, the grass component of camel diets was higher in the wet season than in the dry season.

Camels tended to concentrate on thornless browse plants. Of the identified browse plants in the diets thorny plants contributed as little as 2% of the total diets in both seasons. This is probably due to ease of harvesting thornless plants. These results are comparable to those of Karue (1986). *Boscia coriaeca* was one of the plants which retained their leaves in the dry period. Its contribution to camel diets in the growing season was much lower than in the dry season. This suggests that it is not necessarily palatable. Hence its great contribution in the latter period may have been based on availability *Stiganotaenia sp* featured prominently in the diets both in the dry and growing seasons suggesting that it was palatable to camels. *Grewia sp* together with *Abutilon mauritanum* contributed significantly to the camel diets in the dry and wet season. The selection of the plants may have been on the basis of availability or palatability Seasonal goat diets were more variable thus confirming their reputation as highly opportunistic mixed feeders (Pratt and Gwynne 1977; Lu, 1990). They fed on more browse plants in the dry season than in the wet season. The contribution of browse to their diets was nevertheless, higher than of grass in the study. These results compare well with those of Migongo(1984), Coppock et al (1986). However they are at variance with those of Ngethe and Box (1976), Bryant et al (1979) and Taylor and Kothmann (1990) in which grass was more than browse. *Abutilon mauritanum* had the highest contribution to the goat diets in dry season compared to other plant species. Its contribution in the growing season, however, dropped significantly, suggesting that its selection in the dry period was based on its availability rather than palatability. *Commiphora schimperi* whose contribution to goat diets in the dry spell was significantly lower, was top of the list in the growing season. Since the species was abundant in the area (despite its loss of leaves in the dry period) it was probably selected on the basis of both availability and palatability. Two grass species featured prominently in the wet season goat diets. *Chloris roxburghiana* , comprised less than 1% in the dry season diets and was second most preferred in the wet season, suggesting that its high nutritive value in the latter season may have been the basis for its selection. Taylor and Kothmann (1990) assert in their study that the high grass contribution in the goat diets was made possible by high precipitation which maintained the grass nutritive value at a high level.

The correlation coefficient of the camel and goat diets was statistically significant ($P < 0.05$) in the dry season but not in the wet season. This suggests that these herbivores selected diets in a similar order during the dry period. The low correlation in the wet season diets implies that the species selected their diets in significantly differnt orders. Goats showed more flexibility in diet switching, basing on environmental conditions.

Dry and wet season camel diets were significantly ($P< 0.05$) correlated. This means that camels selected diets in as much the same order in the dry season as in the wet. The correlation of dry and wet season goat diets was not significant. This implies that goats selected diets in the dry season in a significantly differnt order from that of the wet. This hinge on their ability to rapidly change their diets.

The diet overlap coefficient for camels and goats was higher in the dry season than in the wet season. This suggests that the magnitude to which the herbivores selected plant species diets in the same order is high in the dry period, thus implying higher level of potential competition in that period than in the wet. Dietary overlap, however, is not sufficient evidence for exploitative competition (Colwell and Futuyma, 1971) and consequences of overlap partially depend upon availability of the resource. Spatial feeding differences of the herbivores are also of considerable influence as concerns the intensity of exploitative competition. The results were a departure from expected trends. However, despite their size, camels are well known for their selective feeding behaviour facilitated by their narrow muzzle, bifid upper lip and mobile tongue (Mukasa-Mugera 1981). Hanley (1982) noted that there are exceptions to the body size-related classification of ungulates in predicting their diets and probably camels should be best contrasted within a size gradient of other browsers.

4.3 NUTRITIONAL CHARACTERISTICS OF CAMEL AND GOAT DIETS

4.3.1 Chemical Composition and Dry Matter Digestibility of Preferred Plants

Generally chemical composition and dry matter digestibility were influenced by season and forage class. The CP and DMD of species were lower ($P< 0.05$) in the dry season than in the wet season. Conversely ADF content was higher ($P<0.05$) in the dry season than in the wet season. Overall, CS, NDF, ADL and ash content of species were, however, similar in both the dry and wet seasons. Browse species were generally higher ($P <0.05$) in CP, CS, and ADL than grass in the dry and wet seasons. The DMD of browse was higher ($P<0.05$) than that of grass only in the dry season. Grass was, however, higher ($P<0.05$) in NDF and ADF than browse in dry season.

Plant species in dry season camel diets (Table 5) had a mean CP of 11.7% and ranged from a low of 3.7% (*Eragrostis caespitosa*) to a high of 19.0% (*Acacia senegal*). Those selected in the wet season had a mean CP of 17.3% and ranged from 9.9% (*Boswellia rivae*) to 24.0% (*Stiganotaenia sp*). Species in dry season goat diets averaged 11.2% CP (Table 6) with a range of 3.7% (*Eragrostis caespitosa*) to 16.3% (*Stiganotaenia sp*). In the wet season species selected by goats had a mean CP of 17.5% and the same range as those in wet season camel diets.

Dry matter digestion coefficients of species selected by camels in the dry season ranged from 32.0% (*Enteropogon macrostachyus*) to 77.0% (*Stiganotaenia* spp.). The species in dry season goat diets had the same range of digestibility as that of camel diets. In the wet season, species in camel and goat diets ranged in DMD from a low of 52.2% (*Commiphora schimperi*) to a high of 86.6% (*Acalypha fruticosa*). Dry matter digestibility of selected species appears to be strongly correlated with ADL for browse and CF for grass.

Table 5. Chemical Composition and Dry Matter Digestibility of Plants selected by Camels (%) 1990 Kibwezi Dryland Field Station, Kenya.

SEASON	SPECIES	DM	CP	CS	NDF	ADF	ADL	ASH	DMD
	Tress and shrubs								
Dry Season	*Stiganotaenia Spp*	93.2	16.3	42.3	57.3	33.0	10.4	11.2	77.0
	Grewia spp	90.9	14.4	32.8	67.2	46.4	18.9	10.1	64.4
	Abutilon Mauritanum	93.0	10.4	36.9	63.1	41.4	12.7	8.0	62.0
	Sterculia rhynchocarpa	93.0	13.6	32.7	67.3	45.1	12.5	8.8	54.9
	Commiphora schimperi	91.4	12.6	44.7	55.3	45.6	24.7	6.3	37.5
	Entada abyssinica	92.6	14.4	52.3	47.7	38.9	5.4	10.0	66.9
	Ecbolium ruvulutum	92.0	9.9	37.5	62.5	49.0	9.2	10.0	52.4
	Acalypha fruticosa	92.0	11.7	46.8	53.2	35.2	10.8	10.9	68.7
	Acacia tortilis	93.0	14.6	47.0	53.0	45.1	18.1	6.0	42.4
	Acacia mellifera	94.1	13.1	42.7	57.3	40.8	10.0	6.0	53.9
	Acacia senegal	94.0	19.0	56.9	43.1	29.2	9.6	7.5	76.4
	Boscia coriacea	93.5	13.4	30.4	69.6	43.3	12.0	6.5	43.2
	Asparagus racesmosus	94.1	12.9	14.7	85.3	58.5	17.6	10.0	50.9
	Grasses								
	Enteropogon macrostachyus	94.0	7.3	18.0	82.0	48.2	7.4	11.5	31.9
	Eragrostis caespitosa	93.8	3.7	17.7	82.3	52.4	6.6	8.3	34.8
	Chloris roxburghiana	94.0	5.7	19.6	80.4	47.4	6.5	10.3	34.4
	Echinocloa haploclada	93.0	5.3	21.6	78.4	53.6	7.2	15.3	33.4
	Mean	93.0^{a}	11.7^{a}	35.0^{a}	65.0^{a}	44.3^{a}	11.7^{a}	9.2^{a}	52.1^{a}
Wet Season	Trees and Shrubs								
	Stiganotaenia Spp	91.7	24.0	45.3	54.7	32.8	7.8	12.1	85.3
	Grewia spp	92.8	20.0	35.3	64.7	41.8	14.0	11.5	67.1
	Abutilon mauritanum	92.3	23.2	44.3	55.7	30.8	2.6	9.0	81.1
	Sterculia rhynchocarpa	91.3	16.3	38.3	61.7	37.9	9.8	9.2	63.0
	Commiphora schimperi	91.4	15.3	51.2	48.8	38.6	21.7	8.4	52.2
	Entada abyssinica	91.4	21.5	60.0	40.0	29.2	6.2	10.2	82.3
	Ecbolium ruvulutum	91.9	16.3	41.8	58.2	42.5	7.3	9.3	68.5
	Acalypha fruticosa	90.9	20.7	58.7	41.1	28.1	5.4	12.4	86.6
	Acacia tortilis	92.5	15.4	53.4	46.6	39.4	14.7	5.0	57.7
	Acacia senegal	92.8	19.9	59.9	40.1	28.9	12.3	7.8	84.2
	Boscia coriacea	95.3	15.5	41.6	58.4	39.6	10.1	13.3	57.7
	Boswellia rivae	90.8	9.9	35.6	64.4	45.0	18.1	2.8	61.5
	Asparagus racesmossus	93.0	19.0	19.2	80.8	54.2	14.3	8.0	59.2
	Grasses								
	Echinocloa haploclada	92.8	12.5	26.3	73.7	46.2	3.9	16.0	60.6
	Chloris roxburghiana	92.1	16.1	24.8	75.2	44.5	5.9	12.0	55.1
	Enteropogon macrostachyus	93.3	14.9	22.5	77.5	40.6	2.8	9.3	73.0
	Eragrostis caespitosa	94.0	12.9	19.6	80.4	46.8	3.8	9.0	63.4
	Mean	92.4^{a}	17.3^{b}	39.9^{a}	60.1^{a}	39.2^{b}	9.5^{a}	9.7^{a}	68.1^{b}

Seasons means with different superscripts (a,b) differ ($P<0.05$)

Table 6. Chemical Composition and Dry Matter Digestibility of Plants selected by Goats (%) 1990 Kibwezi Dryland Field Station

SEASON	SPECIES	DM	CP	CS	NDF	ADF	ADL	ASH	DMD
	Tress and shrubs								
Dry Season	*Abutilon mauritanium*	93.0	10.4	36.9	63.1	41.4	12.7	8.0	61.9
	Stiganotaenia Spp	93.2	16.3	42.7	57.3	33.0	10.4	11.1	77.0
	Acalypha fruticosa	92.0	11.4	46.8	53.2	35.2	10.8	10.9	68.7
	Grewia spp	90.9	14.4	32.8	67.2	46.4	19.0	10.1	64.4
	Comminiphora	91.4	12.6	44.7	55.3	45.6	24.7	6.3	37.5
	Boscia coriacea	93.5	13.4	30.4	69.6	43.3	12.0	6.5	43.2
	Entoda abyssinica	92.8	14.4	52.3	47.7	38.9	5.4	10.0	66.9
	Asparagus racesmosus	94.1	12.9	14.7	85.3	58.5	17.5	10.0	50.9
	Wcbolium ruvulutuna	92.0	10.0	37.5	62.5	49.0	9.2	10.0	52.4
	Boswellia rivae	92.8	8.2	30.7	69.3	40.0	20.3	3.4	56.0
	Sterculia rhynchocarpa	93.0	13.5	32.7	67.3	45.1	12.5	8.8	54.9
	Maerua spp	95.3	15.6	48.3	51.7	37.4	17.2	9.0	57.6
	Lannea triphyla	93.1	12.0	44.9	55.1	43.8	17.3	9.5	51.9
	Acacia tortilis	93.0	14.6	47.0	53.0	45.1	18.1	6.0	42.4
	Grasses								
	Eragrostis caespitosa	93.8	3.7	17.7	82.3	52.4	6.6	8.3	34.8
	Enteropogon macrostachys	94.0	7.3	18.0	82.0	48.2	7.4	11.5	32.0
	Panicum denstum	91.9	5.3	18.6	81.4	51.8	3.3	17.1	52.0
	Chloris roxburghiana	94.0	5.7	19.6	80.4	47.4	6.5	10.3	34.4
	Mean	93.0[a]	11.2[a]	34.2[a]	65.8[a]	44.6[a]	12.8[a]	9.26[a]	52.2[a]
Wet Season	Trees and Shrubs								
	Abutilon mauritanum	92.3	23.2	44.3	55.7	30.8	2.6	9.0	81.1
	Stiganotaenia Spp	91.7	24.0	45.3	54.7	32.8	7.8	12.1	85.3
	Acalypha fruticosa	90.9	20.7	58.9	41.1	28.1	5.4	12.4	86.6
	Grewia spp	92.8	20.0	35.3	64.7	41.8	14.1	11.5	67.1
	Commiphora schimperi	91.4	15.3	51.2	48.8	38.6	21.7	8.4	52.2
	Entada abyssinica	91.5	21.5	60.0	40.0	29.2	6.2	10.2	82.3
	Ecbolium ruvulutum	91.9	16.3	41.8	58.2	42.5	7.3	9.3	68.5
	Boswellia rivae	90.8	9.9	35.6	64.4	45.0	18.1	2.8	61.5
	Sterculia rhynchocarpa	91.3	16.3	38.3	61.7	37.9	9.8	9.2	63.0
	Maerua spp	94.1	22.6	53.2	46.8	31.9	10.8	10.2	73.4
	Lannea triphylla	92.6	14.3	51.7	48.3	38.0	13.4	8.6	65.3
	Acacia tortilis	92.5	15.4	53.4	46.6	39.4	14.7	5.0	57.7
	Grasses								
	Eragrostis caespitosa	94.0	12.9	19.6	80.4	46.8	3.8	9.0	63.4
	Enteropogan macrostachyus	93.3	14.9	22.5	77.5	40.6	2.8	9.3	73.0
	Panicum denstum	92.0	16.8	30.0	70.0	39.3	2.8	14.0	71.6
	Chloris roxburghiana	92.1	16.1	24.8	75.2	44.5	5.9	12.0	55.1
	Mean	92.2[a]	17.5[b]	41.6[a]	58.4[a]	37.9[b]	9.2[a]	9.5[a]	69.1[b]

Season means with different superscripts (a,b) differ (P<0.05)

4.3.2 Nutritional Characteristics of Diets

Influence of season on the dietary nutritional characteristics of both animal species was observed. In general, dietary CP and DMD were higher ($P<0.05$) in the wet season than in the dry season, whereas the reverse was true for ADL.(Table 7)

Crude protein values were divergent for the two species in the wet seasons. Camels selected diets higher ($P<0.05$) in CP than goats in wet season. Dry season camel dietary CP (11.42%) was 14.8% higher than that of goats (9.94%). In the wet season the margin was wider by 19.5 percent points. Wet season camel dietary CP was higher ($P<0.05$) than their dry season diets by 62.7% whereas that of goats was higher by 56.4%. CS content was higher ($P<0.05$) for camels in the wet season than in the dry season. However the proportion of this fraction in goat diets was similar ($P<0.05$) in the two seasons. On the whole, camels diets contained higher ($P<0.05$) amounts of CS than goat diets.

Table 7:Dietary Nutritional Characteristics of Camel and Goat Diets (percent).

	Livestock Species			
	Camels		Goats	
Nutritional variable	Dry Season	Wet Season	Dry Season	Wet Season
Crude protein	11.4^{a}	18.6^{b}	9.9^{ac}	15.6^{d}
Cell soluble	44.3^{a}	47.9^{b}	43.7^{ac}	42.6^{cd}
Neutral detergent fibre	55.7^{a}	52.1^{c}	56.3^{ad}	57.4^{bd}
Acid detergent fibre	36.5^{bc}	33.0^{a}	34.7^{ad}	36.8^{b}
Acid detergent lignin	11.5^{b}	9.7^{ac}	10.2^{cd}	8.9^{a}
Ash	7.43	9.6	8.1	9.3
Dry matter digestibility	49.3^{a}	66.9^{b}	50.2^{ac}	59.2^{c}

Row means with different superscripts differ $P<0.05$)

Influence of season on fibre content in the diets was more pronounced in camel diets than in goat diets. The proportion of NDF and ADF in camel diets was higher in the dry season than in the wet. However wet season goat diets were similar in NDF and ADF to their dry season diets (Table 7). Goat diets were higher in NDF and ADF than camel diets in both seasons. ADL concentration in diets was higher in the dry season than in the wet season though not as widely affected as the CP contents for the two species. Camels selected diets higher ($P<0.05$) in ADL than goats in dry season only.

Dietary dry matter digestion coefficients were widely affected by season. The influence of season on this diet characteristic appeared to be independent of the animal species. This is because although dry season camel and goat diets were more or less similar in digestibility, the wet season camel diets were higher in DMD than than the goat diets. Dry season goat diets were 1.8% more digestible than camel diets. However in the wet season, camel diets were 12.86% more digestible than goat diets. Overall, wet season diets were more digestible than dry season diets.

4.3.3 Relationship Between Some Plant Nutritional Characteristics and Preference

Seasonal dietary preference was correlated to CP, ADF and DMD. Correlation coefficients (Table 8) did not show any strong ($P>0.05$) association and in case of goats were not consistent with respect to season. Except for camels in the wet season where CP appeared to be fairly positively correlated to preference ($r=0.582$) animals did not seem to associate any nutritional variable with the order in which they selected diets. Nevertheless, going by the values of r, the correlation between ADF and preference appeared to be consistently negative.

Table 8: Correlation of Plant Nutritional Characteristics with Preference 1990

Plant Characteristic	Livestock Species			
	Camels		Goats	
Dry Season	r-value*	N	r-value*	N
Crude protein	0.287	17	0.068	18
Acid detergent fibre	-0.292	17	-0.309	18
Dry matter digestibilty	0.187	17	0.424	18
Wet Season				
Crude protein	0.582	17	-0.112	16
Acid detergent fibre	-0.345	17	0.452	16
Dry matter digestibility	0.304	17	-0.437	16

* All r. values are not significant (P>0.05)

4.3.4 Discussion

The analytical and DMD data presented indicate the useful roles different forage classes play in supporting livestock under dynamic environmental conditions in pastoral areas. While all selected plants had higher CP and DMD coefficients in the growing season than in the dry season, browse was generally of better quality, particularly with respect to CP and CS, than grass. The high protein and low fibre values in browse may have been an advantage to the browser especially during the dry season when the nutritive value of grass was low due to decreased protein and increased fibre level. The crude protein of browse was above the critical minimum (6-7%),(Stobbs and Minson, 1979) in all seasons. Grass was, however, deficient in CP during the dry season but adequate in the wet season. These results were consistent with earlier findings (Mckay and Frandsen 1969, Karue 1974, Wilson 1977, Mecha and Adegbola 1980 and Wilson and Harrington 1980).

The fibre and lignin contents influenced the DMD of forage species. Browse was generally lower in fibre content but higher in ADL than grass except for *Asparagus racesmosus* whose NDF and lignin content was high. This resulted due to high proportion of stem in the plucked samples as the plant has very small needle-like leaves. Dry matter digestibility appeared to be associated with the amount of lignin in browse as those plants with high ADL were fairly low in digestibility. However, in grass, the amount of fibre is associated with digestibility. While that was the general trend, species maintained some degree of individuality with respect to the amount and rate of change of various fractional components. On the whole the magnitude of change in digestibility of forage from the dry season to the wet was narrower for browse than grass. This was consistent with the observations of Mcleod (1973). The results obtained in this study were higher than those of Coppock et al (1987b) but similar to those of Karue (1974). They can be explained by the soil differences of the sites and plant species. Although Wilson (1977) observed that shrubs were higher in ash content than trees, that difference was not readily discernible from the results of this study.

Overall the camel and goat diets were adequate for animal maintenance in terms of crude protein throughtout the study period. Dry season diets were, nevertheless, lower in nutritional value than those of the wet season. Camel diets were 32.8% and 116% higher in CP than 8.6% CP maintenance requirement (NRC 1976) for a 400kg steer in the dry and wet seasons respectively. Goat diets, on the other hand, were 8% and 69% higher in CP than 9.2% CP maintenance requirement for a goat (NRC 1981). These results were similar to those of Wilson et al (1975) and Bryant et al (1980). In case of prolonged drought the results show that goats are more likely to be disadvantaged than camels which were more adept at selecting diets high in CP. These results confirm those of Coppock et al (1986) where camels, besides selecting higher CP diets overall, were the only ones to meet their maintenance requirements in the dry periods.

The fibre content of the diets followed the expected seasonal trends in case of camels only. Goat diets had slightly higher fibre content in the wet season than in the dry, This can be explained by the high proportion of the grass component in their diets in the wet season. Goats being more of mixed feeders than camels, had greater amount of fibre in their diets throughout the study period. With respect to ADL, camel diets were higher than goat diets probably because of the high proportion of browse. As expected this fraction was lower in proportion in the wet season diets since young plants have low lignin content compared to mature ones. The fibre content of the camel and goat diets was comparable to those observed by Malechek and Leinweber (1972) and Coppock et al (1986). Dietary ADL however, was slightly higher than the findings of the former but similar to those of the latter research workers.

Dietary dry matter digestibility did not show any widely divergent species influences on the diets in the dry season. Wet season camel diets, however, had higher dry matter digestion coefficient than those of goats. Again the high grass component in the goat diets coupled with high consumption of the low digestible *Commiphora schimperi* could explain the low coefficient of digestion then. High digestion coefficient of camel diets in the wet season is not in agreement with observations of Tubei (1985) and Coppock at (1986). The stage at which plant samples were hand plucked may have influenced this divergence. High lignin content together with other digestion inhibitors in the dry season diets, may have contributed to the low diet digestibility, especially those of camels. The results obtained were genrally higher than those of Malechek and Leinweber (1972) and Coppock et al (1986) but were comparable to those of Wilson et al (1975).

Although the animals met their nutritional requirements, they did not seem to strongly associate preference with any analytical and digestibility variables of the forage species. For example *Commiphora schimperi* and *Chloris roxburghiana*, with low digestion coefficients and moderate or low CP were highly acceptable to goats in the wet season. *Boscia coriacea* had low digestion coefficient and moderate CP content in the dry season yet it was the most consumed by camels then. Camels in the wet season appeared to have associated preference with CP of selected species. This to some extent contradicts the observation of Carew et al (1980) where animals preference correlated more with ADF and CF than CP probably due to the different site and plant conditions.

5. RECOMMENDATIONS

As the study was carried out over two seasons within a year, obviously further research work needs to be done to cover all seasons and probably for a number of years inorder to establish a more widely represenative behaviour pattern of how camels and goats adapt to the constantly changing enivormental conditions. However, some inference were drawn from the rseults of this and the following recommendations made:

i) Both animal species increased their feeding time as the transition period advanced from the wet to the dry season. Given the fixed foraging time in the field and accompanying change in quality of forage, animals were forced to postsponed non vital activities such as resting inorder to devote more time to feeding. It is recommended that in pastoral areas such as in Kibwezi, where livestock graze during the day and are corralled at night, foraging time allowed should be increased during the dry season. This could be achieved through letting out animals as early as 07.00 hrs bringing them to the bomas a little later than 16.00 hrs as was the case in the study.

ii) The distribution pattern of behaviour activities over the observation day showed that the intensity of feeding was highest early in the morning and late in the afternoon. By letting out the animals early in the morining and bringing them to kraals late in the afternoon, the animals will have time to engage in intensive feeding and therefore satisfy their appettite during the dry seasons. They are also able to avoid the heat stress during midday.

iii) Dietary botanical composition results show that camels and goats selected plants such as *stiganotaenia sp* and *Grewia spp* which were of low relative occurrence in the field. In terms of bush management and control in this enivironment, the importance of such plants to livestock species in the area should be considered and retained as a source of livestock feed.

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APPENDIX TABLES

A7.1 RAINFALL DATA FOR DWA SISAL ESTATE DURING THE STUDY PERIOD (1990/91) KIBWEZI -KENYA IN mm

	MONTH				
	1990		1991		
DATE	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
1	0	0	0	4.7	31.7
2	0	0	0	57.5	0.7
3	0	0	0	20.0	0.5
4	0	0	0	7.2	4.0
5	0	0	0	15.4	9.4
6	0	0	0	15.8	0
7	0	0	0.6	3.4	0
8	0	0	4.5	7.7	0
9	0	1.4	7.6	0	1.0
10	0	0	0	3.9	0
11	0	0	0	14.7	0
12	0	0	2.1	1.7	0
13	0	0	0	19.5	0
14	0	0	66.3	29.0	0
15	0	0	18.3	17.9	0
16	0	0.6	0	1.5	0
17	0	0	54.6	42.7	0
18	0	2.2	0.	32.5	0
19	0	0	0	5.	0
20	0	0	43.4	1.8	0
21	0	4.2	1.8	2.7	0
23	0	0	0	17.4	0
24	0	1.0	32.0	0.5	0
25	0	0	18.0	11.6	0
26	0	0.9	0.6	3.9	0
27	0	1.4	16.1	11.6	0
28	0	0	5.2	4.5	0
29	0	0.8	2.8	14.3	0
30	0	0	0	34.3	0
31		0		16.9	0
Total	0	12.5	273.9	419.6	47.3

A7.2 TEMPERATURE DATA FOR DWA SISAL ESTATE DURING THE STUDY PERIOD 1990/1991 KIBWEZI KENYA IN ^{0}C

	MONTH				
DATE	SEPTEMBER 1990	OCTOBER 1990	NOVEMBER 1990	DECEMBER 1990	JANUARY 1991
1	32.8	32.0	33.2	29.8	28.4
2	33.4	31.9	32.5	29.2	29.0
3	32.9	32.9	34.5	29.8	29.2
4	32.6	33.2	32.7	29.1	29.4
5	33.1	33.5	29.1	29.2	28.7
6	32.7	32.7	32.9	29.1	29.4
7	33.2	32.5	33.4	28.8	30.2
8	33.5	32.8	32.0	29.2	29.5
9	33.4	29.9	31.4	26.7	28.9
10	32.7	31.7	31.1	28.0	29.6
11	33.3	32.6	31.2	27.9	29.6
12	32.0	32.1	32.7	28.3	28.4
13	32.8	32.8	32.3	28.2	28.0
14	32.9	33.1	31.7	28.7	28.4
15	32.5	33.2	29.0	27.6	28.6
16	33.0	32.5	29.7	29.2	29.2
17	32.1	32.9	28.1	28.9	29.7
18	32.9	32.8	29.1	28.0	29.6
19	31.8	31.9	29.8	28.3	30.3
20	32.2	32.3	30.2	27.8	29.4
21	30.8	30.4	29.3	28.6	29.7
22	33.4	32.6	29.9	29.5	30.4
23	33.1	33.0	20.6	29.3	30.5
24	32.4	31.4	30.2	28.7	31.2
25	34.1	31.4	30.1	28.7	31.5
26	32.7	31.7	30.5	29.0	31.8
27	32.3	32.1	30.2	29.0	32.7
28	32.2	33.6	28.7	29.5	32.4
29	31.8	33.4	29.2	29.1	31.6
30	32.9	32.9	29.2	28.2	30.2
31		33.5			31.8

B7.1 DENSITIES OF TREE SPECIES AS DETERMINED BY POINT - CENTRED QUARTER METHOD 1990

KIBWEZI DRYLAND FIELD STATION-KENYA

SPECIES	Relative Density %	NUMBER PER HECTARE
Commiphora schimperi	25.0	62.0
Commiphora riparia	16.7	41.0
Acacia tortilis	16.1	40.0
Acacia mellifera	14.1	40.0
Albizia anthelmintica	5.2	13.0
Commiphora baluensis	4.7	10.0
Sterculia rhynchocarpa	3.1	8.0
Adansonia digitata	2.6	7.0
Commiphora usambarensis	2.6	5.0
Commiphora africana	2.1	5.0
Acacia senegal	1.6	4.0
Boscia corriacea	1.6	4.0
Stiganotaenia arareacea	1.6	4.0
Albizia vasiola	1.0	1.0
Cassia Kaesneri	1.0	1.0
Terminalia braunii	1.0	1.0

B.7.2 DENSITIES OF SHRUB SPECIES AS DETERMINED BY POINT - CENTRED QUARTER METHODS 1990 KIBWEZI DRYLAND FILED STATION

SPECIES	Relative Density%	NO. PER HECTARE
Duosperma Kilimandscharica	*44.8*	*1195.0*
Combretum hexalatum	*10.4*	*278.0*
Acalypha fruticosa	*9.9*	*264.0*
Lepidagathis scariosa	*7.8*	*208.0*
Grewia bicolor	*5.2*	*139.0*
Grewia similis	*4.7*	*125.0*
Grewia villosa	*2.6*	*69.0*
Premna hildebrandthi	*2.6*	*69.0*
Combretum oculeatum	*2.6*	*69.0*
Abutilon mauritarium	*2.1*	*56.0*
Acacia brerispica	*2.1*	*56.0*
Boacia anqustifolia	*1.1*	*28.0*
Combretum apiculeatum	*1.1*	*28.0*
Lannea triphylla	*1.0*	*14.0*
Tenantia senii	*1.0*	*14.0*
Orchna inermis	*1.0*	*14.0*

C7.1 MEAN PROPORTION OF OBSERVATION TIME SPENT IN VARIOUS ACTIVITIES BY CAMELS IN PERIOD ONE (%) C7.1
6-21ST DEC. 1990 KIBWEZI DRYLAND FIELD STATION

	ACTIVITY					
				RESTING		
Animal No.	Feeding	Walking	Ruminating	Standing	Lying	Others
4	56.25	21.67	0.83	9.17	5.83	6.25
6	55.83	24.17	0.42	8.33	3.75	5.00
11	57.92	19.17	0.42	9.58	7.50	4.42
9	56.67	21.25	0.00	9.17	7.50	4.99
1	56.25	21.67	0.42	8.33	7.08	6.67
3	57.50	19.58	0.00	8.75	7.08	7.08
7	54.58	21.67	0.00	8.33	8.75	6.67
5	57.50	22.50	0.00	8.75	8.33	5.00

C7.2 MEAN PROPORTION OF OBSERVATION TIME SPENT IN VARIOUS ACTIVITIES BY CAMELS IN PERIOD TWO (%) 30 DEC 1990-14TH JAN 1991 KIBWEZI DRYLAND FIELD STATION

	ACTIVITY					
				RESTING		
Animal No.	Feeding	Walking	Ruminating	Standing	Lying	Others
4	57.50	23.75	0.83	8.33	3.75	5.42
6	57.08	25.42	0.42	10.00	3.75	3.33
11	59.16	25.00	0.00	7.50	4.17	4.17
9	57.50	25.83	0.42	9.17	3.33	4.58
1	57.92	23.75	0.42	8.33	3.75	5.83
3	58.33	25.83	0.00	7.50	2.92	5.42
7	58.33	23.75	0.00	7.50	5.00	5.42
5	56.67	25.00	0.00	8.75	5.000	4.58

C7.3 MEAN PROPORTION OF OBSERVATION TIME SPENT IN VARIOUS ACTIVITIES BY CAMELS IN PERIOD THREE % 17 TH JAN-1ST FEB 1991 KIBWEZI DRYLAND FIELD STATION

	ACTIVITY					
				RESTING		
ANIMAL NO.	FEEDING	WALKING	RUMINATING	STANDING	LYING	OTHERS
4	61.25	27.50	0.00	4.58	3.75	2.92
6	60.42	27.92	0.00	5.00	2.08	4.17
11	63.75	28.33	0.00	3.75	1.67	2.50
9	62.92	29.17	0.42	3.33	1.25	2.92
1	62.08	26.25	0.42	5.00	2.08	4.17
3	60.80	27.50	0.00	4.58	3.33	3.75
7	62.50	27.08	0.42	3.75	2.92	3.33
5	60.42	27.92	0.42	4.17	3.75	3.33

C7.4 MEAN PROPORTION OF OBSERVATION TIME SPENT IN VARIOUS ACTIVITIES BY GOATS IN PERIOD ONE. (%) 6TH -21TH DEC 1990 KIBWEZI DRYLAND FIELD STATION

	ACTIVITY					
				RESTING		
ANIMAL NO.	FEEDING	WALKING	RUMINATING	STANDING	LYING	OTHERS
62	58.33	24.17	3.75	6.67	2.08	5.00
71	56.25	24.17	5.00	5.00	3.75	5.83
64	57.50	25.42	3.75	5.00	2.92	5.42
54	56.25	25.83	4.58	5.00	4.17	4.17
66	56.25	24.17	4.17	5.83	2.08	7.08
58	57.50	25.83	4.58	4.58	2.08	5.42
61	56.67	23.47	5.42	6.25	2.08	5.83

C7.5 MEAN PROPORTION OF OBSERVATION TIME SPENT IN VARIOUS ACTIVITIES BY GOATS IN PERIOD TWO (%)
30TH DEC 1990-14TH JAN 1991 KIBWEZI DRYLAND FIELD STATION

	ACTIVITY					
				RESTING		
ANIMAL NO.	FEEDING	WALKING	RUMINATING	STANDING	LYING	OTHERS
62	60.42	26.25	4.58	3.75	1.25	3.75
71	59.58	26.67	4.17	5.00	1.67	2.92
64	62.08	26.67	5.00	2.50	1.25	3.33
54	58.75	24.58	5.00	4.58	2.50	4.58
66	58.33	24.58	4.17	4.58	2.92	5.42
58	60.83	26.25	4.58	4.17	0.00	4.17
72	59.17	24.58	5.42	4.17	2.08	4.58
61	58.75	25.00	5.00	4.17	2.92	4.17

C7.6 MEAN PROPORTION OF OBSERVATION TIME SPENT IN

VARIOUS ACTIVITIES BY GOATS IN PERIOD TWO (%) 17TH JAN-1ST FEB 1 KIBWEZI DRYLAND FIELD STATION

	ACTIVITY					
				RESTING		
ANIMAL NO.	FEEDING	WALKING	RUMINATING	STANDING	LYING	OTHERS
62	62.50	24.58	4.58	3.33	0.42	4.58
71	60.83	26.25	5.00	2.92	0.83	4.17
64	61.25	25.83	4.17	3.33	0.83	3.75
54	61.67	24.58	5.00	2.92	1.67	4.17
66	61.25	23.75	4.58	4.17	1.67	4.58
58	62.92	25.83	3.75	3.33	0.42	3.75
72	61.25	24.17	5.00	2.92	2.08	5.00
61	61.67	24.17	5.42	3.33	1.25	4.17

D7.1 MEAN DISTRIBUTION OF BEHAVIOUR ACTIVITIES OVER THE 8-HR OBSERVATION DAY BY CAMELS (%) PERIOD I 6TH-21 DEC 1990 KIBWEZI DRYLAND FIELD STATION

	TIME OF DAY (HOURS)							
ACTIVITY	8.00-9.00	9.00-10.00	10.00-11.00	11.00-12.00	12.00-13.00	13.00-14.00	14.00-15.00	15.00-16.00
FEEDING	60.00	60.00	63.75	57.92	52.50	49.58	53.75	55.00
WALKING	24.16	22.92	22.50	24.16	17.92	18.75	19.16	22.08
RUMINA-TING	0.00	0.00	0.00	0.00	0.00	1.25	0.83	0.00
RESTING								
STANDING	7.50	9.16	5.00	8.33	11.67	11.25	8.33	9.16
LYING	2.08	2.08	4.58	6.25	12.50	12.50	10.83	5.00
OTHERS	6.25	5.00	4.16	3.33	5.42	6.67	6.67	8.75

D7.2 MEAN DISTRIBUTION OF BEHAVIOUR ACTIVITIES
OVER THE 8-HR OBSERVATION DAY BY CAMELS (%)
PERIOD II 30TH DEC 1990-14JAN 1991
KIBWEZU DRYLAND FIELD STATION

	TIME OF DAY (HOURS)							
ACTIVITY	8.00 9.00	9.00 10.00	10.00 11.00	11.00 12.00	12.00 13.00	13.00 14.00	14.00 15.00	15.00 16.00
FEEDING	62.08	62.92	61.67	62.08	50.42	47.92	57.92	57.50
WALKING	27.50	27.08	26.25	26.67	21.67	20.00	25.00	24.17
RUMINATING	0.00	0.00	0.00	0.00	0.00	0.42	1.25	0.00
			RESTING					
STANDING	5.00	5.00	4.58	5.00	13.75	16.67	6.25	10.83
LYING	2.08	0.83	3.75	2.50	8.33	7.50	5.00	1.67
OTHERS	3.33	4.16	3.75	3.75	5.83	7.08	4.58	6.25

D7.3 MEAN DISTRIBUTION OF BEHAVIOUR ACTIVITIES OVER THE 8-HR

OBSERVATION DAY BY CAMELS (%) PERRIOD III 17TH JAN-1ST FEB 1991
KIBWEZI DRYLANF FIELD STATION

	TIME OF DAY (HOURS)							
ACTIVITY	8.00-9.00	9.00-10.00	10.00-11.00	11.00-12.00	12.00-13.00	13.00-14.00	14.00-15.00	15.00-16.00
FEEDING	65.42	66.67	65.83	65.42	56.67	57.08	55.83	61.25
WALKING	26.66	26.66	30.42	29.17	28.33	24.17	26.67	29.58
RUMINA-TING	0.00	0.00	0.00	0.00	0.42	0.42	0.83	0.00
RESTING								
STANDING	3.33	2.08	1.25	2.08	5.42	10.00	7.08	2.92
LYING	1.25	1.66	0.83	0.83	4.58	5.00	3.33	3.33
OTHERS	3.33	2.92	1.66	2.50	4.58	3.33	5.83	2.92

D.7.4 MEAN DISTRIBUTION OF BEHAVIOUR ACTIVITIESS
OVER THE 8-HRS OBSERVATION DAY BY GOATS (%)
PERIOD I 6TH -21ST DEC 1990
KIBWEZI DRYLAND FIELD STATION

	TIME OF DAY (HOURS)							
ACTIVITY	8.00-9.00	9.00-10.00	10.00-11.00	11.00-12.00	12.00-12.00	13.00-14.00	14.00-15.00	15.00-16.00
FEEDING	58.33	58.75	62.50	56.67	58.33	52.92	54.58	53.75
WALKING	25.83	27.92	25.83	23.75	24.16	24.58	21.67	24.16
RUMINA-TING	3.33	0.00	0.00	3.33	2.92	7.92	10.42	7.92
RESTING								
STANDING	5.00	5.83	5.00	5.83	7.08	5.00	4.58	4.58
LYING	2.08	2.08	0.83	3.75	2.50	4.58	3.75	3.33
OTHERS	5.42	5.42	5.83	6.67	5.00	5.00	5.00	6.25

D7.5 MEAN DISTRIBUTION OF BEHAVIOUR ACTIVITIES OVER THE 8-HR OBSERVATION DAY BY GOATS (%) PERIOD II
30TH DEC 1990-14TH JAN 1991 KIBWEZI DRYLAND FIELD STATION
TIME OF DAY (HOURS)

ACTIVITY	8.00-9.00	9.00-10.00	10.00-11.00	11.00-12.00	12.00-13.00	13.00-14.00	14.00-15.00	15.00-16.00
FEEDING	59.58	60.42	63.75	65.00	62.92	56.25	56.25	52.92
WALKING	27.50	26.25	29.58	28.75	25.00	25.83	21.25	20.42
RUMINA-TING	2.08	3.33	0.00	0.00	2.50	8.33	10.00	11.67
RESTING								
STANDING	4.58	4.58	2.08	2.08	2.92	4.17	5.00	7.50
LYING	1.25	0.83	1.25	0.42	2.92	1.67	3.33	2.92
OTHERS	5.00	4.58	3.33	3.75	3.75	3.75	4.17	4.58

D7.6 MEAN DISTRIBUTION OF BEHAVIOUR ACTIVITIES OVER THE 8-HR OBSERVATION DAY BY GOATS (%) PERIOD III 17TH - 1ST FEB 1991 KIBWEZI DRYLAND FIELD STATION

	TIME OF DAY (HOURS)							
ACTIVITY	8.00-9.00	9.00-10.00	10.00-11.00	11.00-12.00	12.00-13.00	13.00-14.00	14.00-15.00	15.00-16.00
FEEDING	59.17	64.17	66.25	64.58	62.92	57.92	55.42	63.33
WALKING	25.42	24.16	24.16	23.17	25.83	26.25	23.75	25.83
RUMINATING	5.83	2.50	1.25	3.33	2.92	8.33	8.75	4.58
RESTING								
STANDING	3.75	4.16	3.75	2.92	2.50	1.67	4.58	2.50
LYING	0.83	0.00	0.83	0.83	2.50	1.25	2.50	0.42
OTHERS	5.00	5.00	3.75	4.17	3.33	4.58	5.00	3.33

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