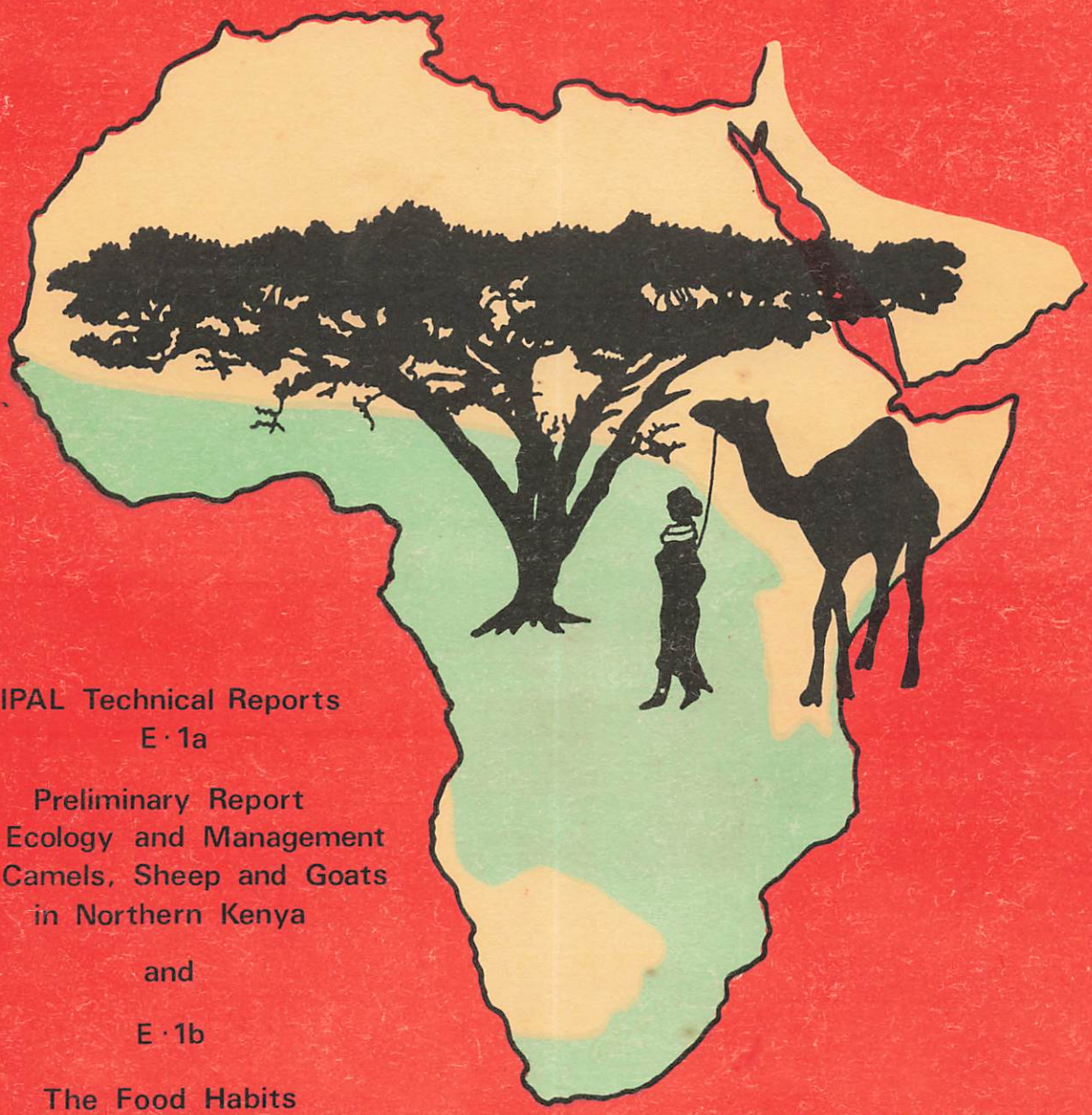
Unesco Programme
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Integrated Project in Arid Lands (IPAL)



IPAL Technical Reports
E · 1a

Preliminary Report
on Ecology and Management
of Camels, Sheep and Goats
in Northern Kenya

and

E · 1b

The Food Habits
of Camels in Northern Kenya

MAN AND THE BIOSPHERE
PROGRAMME

Project 3: Impact
of Human Activities
and Land Use Practices
on Grazing Lands

IPAL Technical Report Number E - 1a

PRELIMINARY REPORT ON ECOLOGY AND MANAGEMENT OF CAMELS, SHEEP AND GOATS IN NORTHERN KENYA

by

C.R., Field (Senior Ecologist, IPAL Field Station, Gatab)

February 1979

UNEP — MAB Integrated Project in Arid Lands

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Summary Introduction to IPAL and the Technical Report Series

The Integrated Project in Arid Lands (IPAL) was established jointly by UNEP and UNESCO in 1976 with the aim of finding direct solutions to the most urgent environmental problems associated with desert encroachment and ecological degradation of arid lands. It forms part of the operations under MAB Project 3, the Secretariat of which is jointly held by UNESCO and FAO, and also those of UNEP's Desertification Unit, established in response to the Plan of Action adopted by the United Nations Conference on Desertification. It is an example of the type of pilot activity that UNEP and UNESCO, together with other organisations and a number of governments, are trying to promote to provide the scientific basis for the rehabilitation and rational development of arid and semi-arid zone ecosystems, through integrated programmes of research (including survey, observation and experimentation), training and demonstration.

During the early operational work of IPAL, a co-ordination unit was established in Nairobi and the initial field-work started in the arid zone of northern Kenya, where a field station has been constructed on the lower slopes of Mount Kulal and a working area demarcated between Lake Turkana and Marsabit Mountain. Work was started on several aspects of the ecology and experimental managment, centred upon the interaction of pastoralists and their livestock with the soils and vegetation of the environment.

During the next two or three years (1979 - 1982), the investigations in progress will be extended and intensified. Initially, new activities within the IPAL project will be started in Tunisia, to be followed by other areas in the arid zone of Africa and the Near and Middle East.

This report is one of a series published by IPAL describing technical findings of the projects and, where appropriate, giving management recommendations relating to the central problems of ecological and sociological degradation in the arid zone. The reports are divided into the following categories distinguished by the base colours of their covers:

A. general, introductory and historical: white.

B. climate and hydrology: blue.

C. geology, geomorphology and soils: brown.

D. vegetation: green.

E. livestock and other animal life: red.

F. social and anthropological: yellow.

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PRELIMINARY REPORT ON ECOLOGY AND MANAGEMENT OF CAMELS, SHEEP AND GOATS IN NORTHERN KENYA

1. Summary

Aerial surveys reveal that about 20% of the lowland portion of the IPAL study area has a carrying capacity which has been exceeded by smallstock and camels alone. These high stocking rates occur near settlement and water. Meanwhile some 40% of the study area is unused due to poor security.

Perennial woody plants comprise 33% of the diet of sheep, 52.4% of the diet of goats and 77.4% of the diet of camels. *Indigofera spinosa* where available, is the most preferred plant species.

It is estimated that about 7% of the primary production in the 200mm rainfall zone is eaten by smallstock and camels. In the area of highest stocking rate intake exceeded production by 21% indicating a degrading environment. Paddock trials although inconclusive so far, suggest that the impact due to trampling and other herbivores, may be greater than expected.

Flock compositions in particular of sheep show a differential loss of adult males. Growth of both smallstock and camel young is stunted by competition with humans for milk. There are a number of causes of mortality in livestock which are listed.

Calculations of human requirements suggest that there is an excess of livestock over needs in the order of about 4 camels or 65 smallstock per Rendille family.

2. Introduction

The spread of desert areas in many parts of the world was the subject of a major international Conference (UNEP, 1977). This conference was in part prompted by a prolonged drought in Sahelian Africa during the early part of the present decade. The drought contributed to a high loss of life among humans and their livestock (Glantz, 1976).

In a review of the subject, Sherbrooke and Paylore (1973) conclude that long term climatic change, compounded with man's activities such as cultivation, irrigation, grazing and burning has produced almost irreversible changes on the margins of the world's deserts. In addition short term climatic fluctuations occur which characteristically have years of ample rainfall followed by almost cyclic droughts. During the years of plenty there is an intensification of agricultural activity and an increase in livestock numbers in areas of marginal potential. In the ensuing drought years the fragile ecosystems face over-utilization and possible disaster from these forms of landuse.

There have been four studies on livestock to date in the IPAL study area. These have been on smallstock (Field, A. C., 1979) camels (Field, C. R., 1979) cattle (UNESCO/UNEP/Hunting Technical Services, 1977) and traditional management of smallstock and camels (TLMP, 1978). This report reviews the work to date on the first two of these studies and concerns the three key species of livestock in the desert ecosystem namely sheep, goats and camels.

3. Objectives

The IPAL Project Document (1978) states that the Project's long term objectives are aimed at finding direct solutions to the most urgent problems associated with desert encroachment. They are also aimed at achieving an understanding for rational management and rehabilitation of arid areas. Among other things the interactions of vegetation and domestic mammals will be studied and demonstrations provided of the results of ecologically orientated management of arid zone ecosystems.

Objectives also include studies of traditional livestock management, stocking rates and regimes and the promotion of additional economic outlets for local produce, particularly livestock products.

Immediate objectives include survey of the influence of man and domestic stock on plant communities in the study area, establishing numbers and biomass densities, distribution and movements of livestock, and relating livestock population dynamics to environmental factors. They also include intensive observations on human and livestock populations as the basis for recommendation on range management, carrying capacties, pastoral regimes and land tenure,marketing facilities and so on.

The work described in this report on camels and smallstock is aimed at fulfilling a number of these objectives. The purpose of the camel study has been threefold, namely:

i. To investigate the way in which camels utilize their environment.

ii. To determine the possible role of camels in desert encroachment.

iii. To assess the importance of camels to the people.

From the above the question arises whether it is necessary to manage camels for the good of the people and their environment and how best this can be achieved. (Field, C. R., 1979).

The primary aim of the smallstock project was to elucidate the role of smallstock in the process of desertification in the arid zone (Field, A. C., 1979).

4. Materials and Methods

The methods are similar in both studies and will be considered together.

4. 1 The study area

A study area of 23,000km^2 has been chosen in northern Kenya which includes the Chalbi desert and its surrounding watersheds. It comprises about 30% of Marsabit District (Figures 1 and 2).

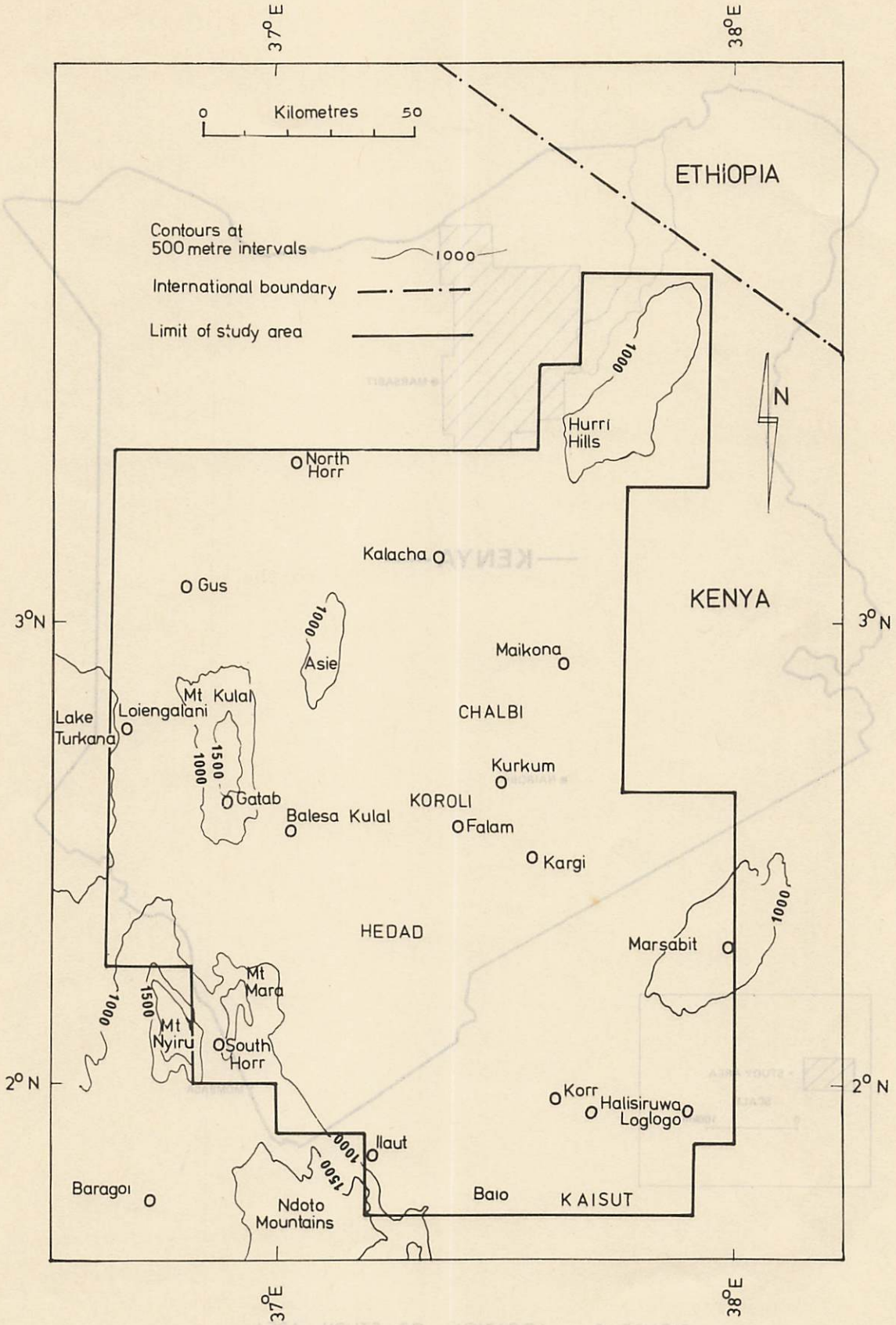


FIGURE 1 THE IPAL STUDY AREA

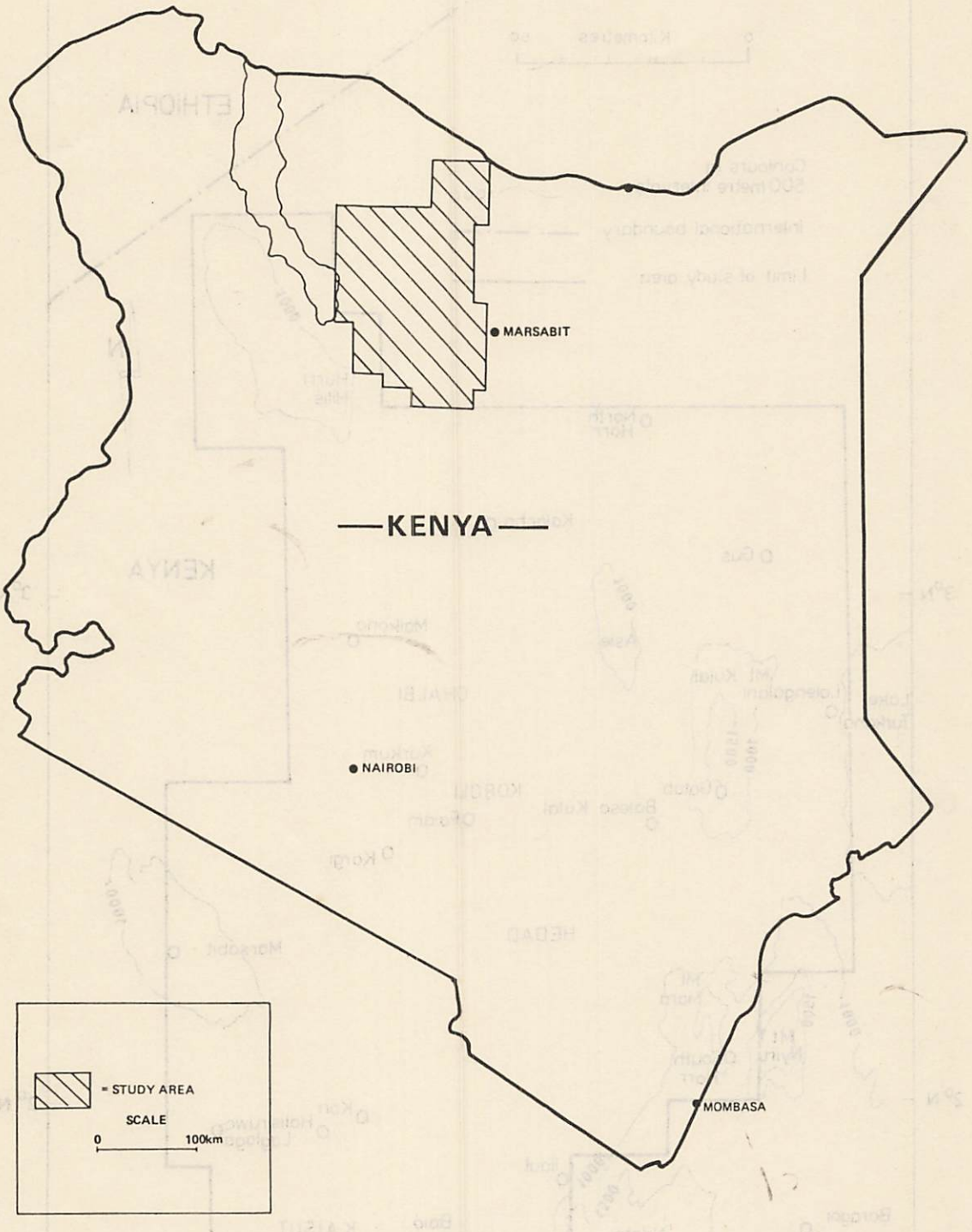


FIGURE 2 LOCATION OF STUDY AREA

The Chalbi desert is an old lake basin, but is normally dry, barren and saline. Lake Turkana at 400m above sea level is the lowest point in the area while the highest point is 2500m on Mt Kulal which lies 30km to the east. The mountain supports evergreen mist forest as do other mountains in the area.

Between the mountains and the Chalbi desert lie a series of ecoclimatic zones with associated vegetation types. Edaphic factors are also important in dictating vegetation communities. The main soil types are those derived from the Marsabit, Kulal and Hurri Hills lava fields and the sandy soils derived from basement mountains to the south.

About 30,000 nomadic and transhumant pastoralists live in the study area (FAO, 1971). They are mainly of the Gabbra and Rendille tribes. There are twelve permanent settlements in the area, situated mostly on the periphery where there is permanent water. The people own about 400,000 head of livestock. Sheep and goats are the most numerous but the biomass of camels is similar to that of smallstock. .The milk of camels and the meat of smallstock form the mainstay of the people's diet (Field, C.R., 1979).

4.2 Numbers and distribution of livestock

At varying intervals the study area has been surveyed systematically by air following the techniques of Norton-Griffiths (1975). The following environmental parameters were recorded on a $25km^2$ grid: soil type; occurence of water; greenness of three categories of vegetation; occurence of burnt vegetation; numbers of livestock and wildlife; presence of occupied and abandoned manyattas (homesteads).

Data from the surveys are sent to the Institute of Terrestrial Ecology, in the U.K. where they are stored in a data bank and subject to computer analysis.

Other information on numbers and movements is obtained from questionnaires and ground observations.

4. 3 Nutritional studies

Feeding observations using the feeding minutes technique modified to enable the calculation of food preferences, have been carried out on camels and smallstock in the study area. Further details of the method are available in Field, A. C. and Field, C. R. (1979).

The chemical composition of the diet is being studied by the collection of key food plants. They are sent through the International Livestock Centre for Africa (ILCA) for proximate analyses, energy and mineral determinations at Hohenheim in West Germany. This is being carried out on a monthly basis immediately after feeding observations have been made. The data will be used as input for the Texas A & M University mathematical model of livestock production systems in use by ILCA.

Water intake is measured whenever there is no surface water and it is available only at a controlled source e.g., well or trough.

Vegetation offtake, comprising both intake and trampling effects is being studied for smallstock and camels in a series of stocking trials in paddocks at the Balesa Kulal. A 40ha paddock complex has been constructed in *Acacia tortilis - Indigofera spinosa* deciduous riverine woodland. It is divided into three 10ha paddocks for camels and four 2.5ha paddocks, three of which are used by smallstock. Stocking rate has been determined on weight per unit area per annum basis and has been similar to those observed near villages (high density), at the limit of village livestock range (medium density) and beyond the range of village livestock (low density). The grass/herb layer and dwarf shrubs have been measured before and after the trial by the IPAL woodland ecologist, Dr. Herlocker. The methods are described in Field, A. C.,(1979).

Intake of vegetation by sheep and goats has been calculated using a method which involves weighing an animal before and after a period of feeding, during which time faeces and urine are collected (Field, A. C., 1979). To date this has not been attempted with camels because of the difficulty of collecting urine.

4. 4 Productivity

The sex and age composition of smallstock flocks and camel herds is obtained from questionnaires.

Recruitment and survival rates are obtained from the Project's herd and flocks. Survival of camels has also been determined by ageing found skulls from their tooth wear and replacement parameters.

The Project has twelve camels and has been loaned another six for research purposes. In addition to being used for nutritional studies they are weighed at monthly intervals and provide information on their rate of growth.

Project animals which are lactating are also used to determine daily milk production and duration of lactation. Milk samples are being collected for chemical analysis by the University of Berlin in cooperation with Dr. Schwartz of the TLMP.

To date very little information has been collected on other aspects of productivity i.e., blood and hides.

4. 5 Human requirements

Human requirements for food can be determined empirically from the literature (Dahl and Hjort, 1976). However, this does not consider requirements for other purposes e.g., transport, trade, marriage and for a safeguard against losses from drought. This information is being collected by the IPAL Public Relations Officers who complete questionnaires concerning ownership of livestock and how they are used.

5. Results

5. 1 Numbers and Distribution

There have been nine aerial surveys to date. Results are as follows:

Date	Estimated Numbers ($\hat{Y}$) and 95% C. L. as % of $\hat{Y}$				Density Km^{-2}	
	Camels		Smallstock		Camels	Smallstock
	Y	95% C.L.	Y	95% C.L.		
July 1976	7,235		65,780	82.7	0.5	4.5
August 1976	14,353		96,483	62.5	0.7	4.9
January 1977	60,450	77.0	389,783	64.1	3.1	19.9
March 1977	24,300	51.0	243,066	37.3	1.2	12.4
June 1977	34,966	51.0	359,366	56.3	1.5	15.6
August 1977	50,267	47.0	366,283	45.8	2.2	15.9
October 1977	26,489		189,232	40.1	1.2	8.2
June 1978	22,730		290,632		1.0	12.6
October 1978	30,723		207,175		1.4	9.6
Mean density					1.4	11.5

C.L. = Confidence Limits

These figures are subject to recalculation after photographs of flocks have been examined. However, it can be calculated that the mean density of camels is equivalent to 1.75 Tropical Livestock Units (TLU) km^{-2} and that of sheep and goats 1.04 TLU km^{-2} — assuming that sheep and goats occur in equal proportions in flocks (Le Houerou and Hoste, 1977).

The marked increase in livestock densities in January 1977 coincided with the end of a period of eight years of below normal rainfall when many of the nomadic 'fora' animals which had been outside the study area returned. Minor emigrations of smallstock occurred in October 1977 and 1978 when rain fell outside the area.

The distribution of livestock in six of the surveys has been plotted on a map of the study area. From this it is apparent that approximately 40% of the area was not used by livestock and lay between the limit of the range of three tribes namely the Rendille, Gabbra and Turkana. This area has most probably been avoided rather than rested deliberately for the following reasons. Within the zone lie several places where inter-tribal fighting and theft of livestock has occurred. People state that insecurity is the main reason for avoiding the area.

The area was not used in 1976 at the end of an eight year drought although other areas were overutilized and livestock was dying. Even during heavy rains when there is abundant food and water in the area it is not used. Thus actual densities in the occupied area are much higher than the means given earlier.

I have taken the mean densities of camels in six aerial surveys and plotted them for each 100km^2 unit of the grid superimposed on the study area. This follows Field, A. C. (1979). The combined camel and shoat data have then been converted to Tropical Livestock Units (TLU's) per km^2 using the conversion of:

1 TLU = 0.8 camel = 11 sheep and goats (Le Houerou and Hoste,1977).

Using their regression for calculating carrying capacity from annual rainfall where:

TLU ha^{-1}yr^{-1} = 0.0169 + 0.0004x and x = rainfall in mm yr^{-1}.

Then the following figures are obtained for carrying capacities:

Mean annual Rainfall in mm	100	200	300	400	500	600	700
TLU km^{-2}yr^{-1}	6	10	14	18	22	26	30

Taking 200mm as the mean annual rainfall in the lowland parts of the study area we find that even in the absence of cattle the carrying capacity is exceeded in 19% of the 100km^2 areas examined. However, one third of these are at the edge of the study area in slightly higher rainfall zones. With the exception of one area at Afarei the remainder occur near to settlements namely Loglogo, Korr, Kargi and Maikona. These coincide with the main areas where desert encroachment is apparent.

5. 2 Nutritional studies

5. 2. 1 Food habits

The feeding observations on sheep and goats (Field, A. C., 1979) involved five different areas and six vegetation types. There were ten sets of observations which usually involved wet and dry season observations in each area. Over five thousand records were made.

The results are summarized as follows:

% in diet of	Trees	Bushes	Dwarf shrubs	Herbs	Grass	Leaf litter
Sheep	2.6	6.7	23.7	29.6	36.9	0.5
Goats	14.9	15.0	22.5	22.0	25.0	0.5

The proportions of plant types eaten by sheep and goats differed significantly at the 0.1% level. Thus about 30% of the diet of goats was comprised of trees and bushes while less than 10% occurred in the diet of sheep. On the other hand sheep ate more grass and herbs. For both sheep and goats there was a highly significant difference in the proportion of browsing and grazing between the wet and dry seasons.

		Dry	Wet
Sheep	Browsing	26.9	38.2
	Grazing	73.1	61.8
Goats	Browsing	44.9	57.4
	Grazing	55.1	42.6

It seems likely that browsing fulfills a roughage requirement in the rains.

Key plant species on the basis of comprising > 20% of the diet are as follows: S - sheep, G - goats, L - lava, B - sand.

Area	Gatab	Luai	Balesa L	Balesa B	Kargi B	N. Horr B
Trees and shrubs						
Acacia mellifera			G			
Euphorbia cuneata			G			G
Grewia species			S+G			
Dwarf shrubs						
Duosperma eremophilum			S			
Indigofera spinosa				S+G	S+G	S+G
Seddera sp.						G
Annual herbs						
Gisekia pharnacoides					S+G	
Grasses						
Eragrostis species	S					
Drake brockmannia sp.						S
Unidentified grasses	G	S+G				S+G

Where it occurs *Indigofera spinosa* is the most favoured plant species.

Camel feeding observations were also carried out in six different vegetation types. These were similar to the sheep and goat study areas except that Gatab was ommitted and additional observations were made below Luai in bushland with a succulent understory (Field, C. R., 1979). The average distribution of camels in the six vegetation types was determined from the aerial surveys. Although there was considerable variation in occupancy from area to area, 16.5% of the total population of camels occurred in the vegetation types observed which themselves were 17.8% of the total area.

Twenty four sets of feeding observations were carried out, three in each type with the exception of one area which had nine. Over 10,000 feeding minutes were recorded and 17,500 records of plant availability.

Average percentage composition (with range) of the diet of camels in the six areas is as follows:

	Trees	Dwarf shrubs	Herbs	Vines	Grass
Mean	29.9	47.5	10.2	1.1	11.2
Range	(2.7-65.1)	(33.9-79.7)	(0.3-23.6)	(0.1-5.1)	(0.5-32.7)

There was considerable variation between plant types and between wet and dry seasons within a type. An assessment of the greenness of the vegetation was made. Two vegetation types were almost twice as green as the rest owing to the presence of perennial subsurface water.

Key plant species comprising more than 20% of the diet are indicated with an asterisk.

Area	Below Luai	Balesa sand	Kargi	N. Horr
Trees and shrubs				
Sueda monoica				*
Dwarf shrubs				
Barleria proxima	*			
Duosperma eremophilum	*			
Indigofera spinosa		*		
Sericocomopsis hildebrandtii			*	
Grasses				
Aristida mutabilis			*	

Dwarf shrubs, in particular *Indigofera spinosa* were the most important plant species in the diet of camels. The salt bush *Sueda* is only available at the bottom of drainages as at North Horr. The grass *Aristida* appeared to be eaten as standing hay when green food was unavailable.

It has been possible to calculate food preferences of camels by comparing species eaten with those available.

At Luai evergreen trees were preferred during a drought but new growth of deciduous trees was preferred after the onset of rains. *Duosperma eremophilum* was avoided when dry but preferred after rain when leafy. Aromatic and spiny plants seemed to be avoided. At North Horr evergreen trees and shrubs such as *Sueda* and *Salvadora* were also preferred in dry periods while the semi-deciduous shrub *Dasyphaera* was preferred when conditions were wet. Thus it can be seen that camels have clear preferences for different plant species which may vary with the seasons.

5. 2. 2 Chemical analyses

Only one set of analyses has been completed to date although ILCA have agreed to handle monthly samples from the Balesa collected over a year.

The analyses to date are of limited value since they represent only one place during drought conditions. All nine samples had above maintenance levels (for cattle) of crude protein. *Indigofera spinosa* had the highest energy content while leaves of three species of tree had lower fibre contents than stems. This no doubt explains the preferences shown for *Indigofera* and for tree leaves rather than stems.

5. 2. 3 Offtake

The paddock offtake trials have been run on two occasions with a third currently taking place. The results to date have been inconclusive for several reasons (Field, A. C., 1979).

(a) Grazing only in the wet season does not typefy year round grazing. An attempt to run the trial in the normally dry month of February has been thwarted by unprecedented heavy rains in January this year.

(b) Intensity of vegetation sampling has been insufficient to show statistically valid changes in the paddocks. Two new systems involving a ten point frame and paired plots are currently in use.

(c) Offtake of trees and large shrubs has not been recorded.

Offtake of *Indigofera spinosa* by sheep and goats in Trial I assuming 11% growth is as follows:

	Offtake in kg/ha	Expected intake kg/ha
Heavily stocked	97.5	29.6
Medium stocked	11.9	13.7
Light stocked	3.9	3.7

The expected intake is calculated from the known stocking rates. Differences between observed and expected may be due to sampling error, offtake by insects (Field, A. C., 1979) or possibly trampling.

5. 2. 4 Food Intake

Three experiments only have been run using male sheep and goats (Field, A. C., 1979). These give a dry matter intake ranging from 2.0% to 3.2% of body weight per day. Clearly more data are needed, but the figures calculated so far are similar to those quoted elsewhere in the literature.

Taking 2.5% as the DM intake of camels per day then mean intake assuming an average weight of 363kg per beast:

for camels it would equal 9.1kg per beast per day

for sheep and goats weighing 25kg it would equal 0.625kg per beast per day.

Therefore, mean intake using figures from Table 1=

for camels = 12.740kg km^{-2} d^{-1}

for shoats = 7.187kg km^{-2} d^{-1}

thus total offtake = 19.927kg km^{-2} d^{-1}

or = 7,273.00kg km^{-2} yr^{-1}

Productivity of the herb and dwarf shrub layers at the Balesa during 1977 was 196,300kg km^{-2} yr^{-1} with 360mm rainfall (Herlocker, pers. comm.). Although there may be a curvilinear relationship between productivity and rainfall it can safely be assumed that for 200mm of rainfall not less than 109,055kg km^{-2} would be produced. Thus about 7% of the production would be consumed by sheep, goats and camels.

Turning now to the area of highest stocking rate it is calculated that intake by sheep, goats and camels could exceed productivity in a year of 200mm rainfall by 21%. On the one hand these calculations do not include production of trees and large shrubs and on the other they do not assess the effect of trampling and offtake by other herbivores. However, it seems likely both on the empirical basis of carrying capacity and on actual calculations of offtake that the area is degrading rapidly.

5. 3. Productivity

5. 3. 1 Sex and age

Sex and age compositions of sheep and goat flocks have been recorded by Field, A. C. (1979) at Gatab, Ngurunit and North Horr. Nine flocks were examined in detail the average sheep : goat ratio being 1 : 1.7. The mean ratio of adult female sheep to young was 1 : 0.9 and for goats 1 : 0.8. The male to female ratio of sheep with no adult incisors was 1 : 1.9 and with 2 - 8 incisors it was 1 : 11.3. In goats the ratios were 1 : 1.3 and 1 : 4.6 respectively.

The ratios of adult female camels to young < 2 yrs. was 1 : 0.4 at 25 Gabbra "Ola", 1 : 0.5 at 25 Rendille "Gob" and 1 : 0.4 at 5 Rendille "Fora".

5. 3. 2 Growth

The growth of lambs and kids is summarized in the following table from Field, A. C.(1979).

Average growth rates in gm d^{-1} to 5 months of age:

		Born during rains	Born in dry season
Goat kids	males	99.4	48.3
	females	75.2	43.7
Sheep lambs	males	107.1	91.9
	females	91.9	86.5

Growth rates of kids are extremely low during the dry season which is probably due to competition between humans and kids for the milk. Growth rates of lambs are better than those reported by Trail and Sacker (1966).

The growth of young camels has been approached in two ways. Firstly, over 300 indigenous camel calves have been weighed and aged during both wet and dry years. Secondly, the seven Project calves are being weighed at monthly intervals.

Of these one has received almost all of the mother's milk while six are receiving approximately 75% of the mother's milk. These animals serve as a standard measure against which to compare the performance of Rendille and Gabbra camel calves. Average growth rate of Rendille and Gabbra camel calves during dry conditions in the first six months was about 222gm per day. There was little improvement in a wet year with liveweight gain of 255g d^{-1}. In contrast, liveweight gains of Project camels ranged from 378g d^{-1} for a calf which had been sick and 467g d^{-1} for a calf whose dam was old to 633 - 655g d^{-1} for the best animals. Thus, under improved conditions the growth potential is about two and a half times the current rate for Rendille and Gabbra camels. The difference is largely attributed to competition for the dam's milk between calf and man. Furthermore, there seems to be a marked growth check at weaning. Liveweight gain for our oldest calf which is 19 months old averages 410g d^{-1} since birth and only 317g d^{-1} over the past six months.

5. 3. 3 Milk production

Studies of milk production by sheep and goats (Field, A. C., 1979) have given the following results. Average production by goats from one teat per milking ranges from 200ml in the second week to 77ml in the twelfth week. It has been calculated (Field, A. C., 1979) that during an entire lactation 29.4 litres of milk are available for the kid and a similar amount for humans. On an annual basis assuming 1.5 lactations, yield would be about 88 litres.

In the case of sheep the lamb usually stays with the ewe at night and so milk available for humans is about a quarter of the total. Field, A. C. (1979) has estimated total lactational yield to be 58.8 litres.

The lactation of four camels has been studied in detail. Estimated mean total production from three of them ranges from 21 litres d^{-1} in the second week to 4.8 litres d^{-1} in the sixteenth week. One camel lost its calf at birth and production was from 2.2 litres d^{-1} in the second week to 3.7 litres d^{-1} in the sixteenth week. Duration of lactation has been from 47 to 67 weeks. Termination of lactation occurs about four to eight weeks after pregnancy. Average daily production for the first ten weeks is about 13 litres and for the remaining 47 weeks it is about 3 litres. This gives a total production per lactation of 1897 litres or 1730 litres yr^{-1}. Under the traditional system about three quartersof this is used by humans i.e., 1300 litres yr^{-1} from each lactating camel.

Assuming that lactation is always terminated by pregnancy and gestation is about 12 months then average milk available per adult female camel yr^{-1} is about half the above. Samples of camel milk are being collected for chemical analysis, but this work is still in its early stages.

5. 3. 4 Blood

Blood is taken by pastoralists from camels and occasionally the Turkana bleed smallstock. It is generally used as a supplement to thediet during dry conditions although it can be taken at any time of the year. Very little data have been collected so far.

5. 3. 5 Mortality

The subject of mortality in sheep and goats is not discussed in Field, A. C. (1979). However, the following contributory factors have been noted as important: pneumonia, enterotoxaemia, lamb gastroenteritis, sheep and goat pox, orf and predation.

In a survey of ten Rendille and Gabbra settlement manyattas the causes of death of 204 camels were ascertained. Of these 45% were less than 2 yrs at death. Major causes of death were drought (35%), tick infections (22%) and camel pox (19%). Among calves ‹ 2 yrs tick infection and camel pox accounted for 76% of deaths. During the drought year of 1976 average mortality of calves ‹ 2 yrs was 45% and › 2 yrs 23%.

About 75 found skulls of camels have been collected in the study area. They are assumed to come from potential mortality as Rendille and Gabbra kill their animals if they are about to die. Skulls from camel calves are likely to be under-represented owing to damage by hyaena so the findings from questionnnaires have been used instead in the construction of a survivorship curve. Found skulls are first assigned age classes based on tooth wear and replacement. The exact age of each class is not known until skulls of known age are found. However if we assume the classes to be of equal duration a classical sigmoid shaped survivorship curve is obtained. Thus between the age of two years and ?twelve there is very little mortality with about 50% of the population surviving to ?13 years. After this the curve steepens and by ?17 years only 25% of the population remains.

5. 4 Human requirements

During a religious ceremony called 'soriu' all camels are brought to the manyatta to be blessed. Taking advantage of this situation I have recorded the number of camels owned by 23 different Rendille households at Kargi. On average there were 16.6 adult female camels per household or 1.4 per person.

In their comprehensive review of human - livestock relationships Dahl and Hjort (1976) refer to a reference family of six persons requiring 13,800kcal per day and 318g protein. In the case of the Rendille households the average number of people present was twice this, so it can safely be assumed that 27,600kcal and 636g protein are required daily.

Using Kon's (1972) values for calorific and protein content of milk (700kcalkg^{-1}), the average Rendille family requires 39kg of milk to fulfill their daily calorie requirements and 17kg for their protein requirements. Now if a lactating camel produces 1300 litres yr^{-1} daily production will be 3.5 litres. Thus about eleven lactating camels are required to supply a Rendille household's calorific requirement and five for its protein requirement. However, there are some 350,000 sheep and goats being kept in the study area while the human population is about 35,000. Thus an average Rendille household may own about 120 smallstock which themselves produce approximately 17,500kcal per day from milk and meat (Dahl and Hjort, 1976). Protein requirements of a Rendille household are easily fulfilled and with an average of eight lactating camels there should be an excess of about 9,500kcal per day equivalent to about four lactating camels or sixty five smallstock. Clearly this enables the Rendille to fulfill certain social obligations such as payment of brideprice and also to purchase grain based food which is calorie rich and would therefore enable his household to survive off fewer head of livestock. It is possible therefore that the supply of famine relief maize might itself permit a general reduction of livestock numbers. I understand that a brideprice among Gabbra and Rendille consists of about eight camels of which at least one should be lactating. Sato (1976) has pointed out that the age-set system of the Rendille and Gabbra seems to be geared to the population growth of camels. Since human calorific requirements appear to fix a lower limit on the number of livestock needed by a household it should prove useful to the owner to convert any undesirable or little used males into cash through slaughter and to use this to purchase grain. For example five 'fora' herds of camels examined so far contained a ratio of bulls to cows of 1 : 5. Even including females in the settlements this is far above the optimum ratio quoted by Dahl and Hjort (1976) of 1 : 17.

6. Conclusions

Results based on three years work are tentative and subject to alteration.

Observations on stocking rates compared with carrying capacities indicate that overstocking is common around villages. Intake figures for small stock and camels also suggest that these areas must be degrading since, with some qualifications, intake may be in excess of annual production of vegetation.

Calculation of human requirements suggest that there is an excess of livestock over needs.

It seems that there are two possible strategies for the pastoralist to cope with the disaster of sedentarization. The first and possibly the easier is to extend their range into unoccupied areas. To achieve this we have seen that it is necessary for the Government to provide improved security. The second involves the sale of a small number of livestock and the purchase with the proceeds of a high calorie supplement to the diet. For this it is first necessary to convince the people — in particular the rich and influential — and to this end we have an expanding Public Relations and Education programme. Secondly, outlets for the produce e.g., auctions, abattoirs and tanneries should be improved and a more favourable price offered by the Livestock Marketing Division of the Kenya Government.

7. Acknowledgements

I wish to thank the Project Field Assistants, Sylvester Masheti, Charles Ratemo and Francis Synehaya for their help with this work. The contributions of the Public Relations Assistants Hussein Yusuf, Alexander Ngaroni and Francis Kereyo are also much appreciated.

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IPAL Technical Report Number E - 1b

THE FOOD HABITS OF CAMELS IN NORTHERN KENYA

by

C.R., Field (Senior Ecologist, IPAL Field Station, Gatab)

June 1978

UNEP — MAB Integrated Project in Arid Lands

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THE FOOD HABITS OF CAMELS IN NORTHERN KENYA

1. Introduction and aims

Early in 1976 UNEP and UNESCO embarked on a Project in northern Kenya on arid land ecology and management. The purpose of the Project was to investigate and determine the factors causing desert encroachment and through an understanding of this to demonstrate methods for rehabilitating the land (UNEP, 1977).

As part of the UNEP/MAB Integrated Project in Arid Lands there have been three studies on livestock to date. These have been on cattle (UNESCO/UNEP/Hunting Technical Services, 1977), smallstock and camels (*Camelus dromedarius L.*).

For the past eighteen months I have been studying camel ecology in the Project's study area in Marsabit District, Northern Kenya with the following aims:

1) To investigate the way in which camels utilize their environment;
2) To determine their possible role in desert encroachment;
3) To assess the importance of camels to the people.

Arising from this is the question whether it is necessary to manage camels for the good of the people and their environment and how best this can be done.

This paper is intended to provide information towards the first of these aims and thereby to determine whether camels contribute to desert encroachment.

2. Materials and methods

2. 1 The study area

Initially an area of 19,600km^2 was chosen in northern Kenya which encompassed the Chalbi desert and its adjacent watersheds. This area is a little more than a quarter of Marsabit District. (Figures 1 and 2, E - 1a, pages 4 and 5)

The Chalbi desert is normally barren and saline, being a lake basin. It stands at 500m above sea level while the highest point in the study area is 2,500m on Mt. Kulal 50km to the southwest. The mountain supports an evergreen mist forest as do other highlands in the area.

Between these two extremes there lies a series of ecoclimatic zones with corresponding vegetation types. Edaphic factors are also important, the principal soils being derived on the one hand from the lavas of Mts. Kulal and Marsabit and on the other from basement mountains to the south which form sand. Vegetation and soils are further described in FAO (1971).

Within our study area live approximately 30,000 nomadic and transhumant pastoralists,principally of the Gabbra and Rendille tribes (FAO,1971). There are about a dozen permanent settlements in the area, situated mostly on the periphery where there is permanent water. The people live off a population of about 400,000 head of livestock. Although sheep and goats predominate numerically, the biomass of camels is similar to that of smallstock. The milk of camels and the meat of smallstock form the mainstay of the peoples' diet.

2. 2 Aerial survey

At irregular intervals the study area had been surveyed systematically by air following the techniques of Norton-Griffiths (1975) and Western (1976).

The following environmental parameters were recorded on a $25km^2$ grid: (a) soil type; (b) occurrence of water; (c) greenness of three categories of vegetation; (d) occurrence of burnt vegetation; (e) number of wildlife and livestock; and (g) presence of occupied or abandoned settlement.

2. 3 Vegetation mapping

A vegetation map of the study area has been prepared (Herlocker, 1979) using aerial photography and ground truth information. It follows the classification system of Pratt and Gwynne (1977).

2. 4 Feeding observations

Feeding observations using the feeding minutes technique (Buechner, 1950) modified to enable the calculation of food preferences (Field, 1970, 1976), have been carried out on camels within the study area. On each occasion an attempt was made to record not less than 300 feeding minutes on different plant species.

Approximately 10 minutes was spent with each animal when it was feeding, before moving on to another. A distance of approximately 5m either side of the head was used for estimation of plant availability.

To facilitate observations the Project has a herd of nine camels of mixed sex and age composition. Most of the observations have been made on the Project's herd but in remote areas indigenous Gabbra and Rendille camels were observed.

Observations were made at different seasons of the year in order to determine the relative importance in the diet of annual plants and perennials as well as their growth stages. They have been made in six different vegetation types as follows:

Type	Composition	Approximate % of the total area
I	*Acacia drepanolobium* woodland with *Duosperma eremophilum* understory	0.1
II	*Commiphora/Acacia mellifera* bushland with *Euphorbia* and *Plectranthus* understory	0.4
III	*Acacia reficiens/A. mellifera* bushland with *Sericocomopsis* understory	4.2
IV	*Acacia tortilis* woodland with *Duosperma* and/or *Indigofera spinosa* unerstory	5.6
V	*Acacia reficiens* bushland	5.6
VI	*Sueda monoica* evergreen shrubland	1.9
	Total	17.8%

These types follow the climatic gradient with Type I at the top lying between 1500m and 1800m above sea level and Type VI at the bottom at 500m.

Types I to III occur on lava derived soils, Types IV and V on sand and Type VI on saline soils fringing the Chalbi desert.

2. 5 Rainfall records

Daily read rain gauges have been operated in Types V and VI and monthly read storage gauges in the other vegetation types.

2. 6 Chemical analyses

Difficulty has been experienced in obtaining chemical analyses of forage samples. On one occasion however, material was collected from six plant species three of which were subsequently separated into leaf and stem fractions prior to analysis. After drying, proximate analyses, energy determinations and mineral analyses were carried out.

3. Results

3. 1 Camel distribution in relation to vegetation types

The mean numbers of camels occurring during six aerial surveys in 1976 and 1977 have been calculated for $25km^2$ unit areas. From this two parameters have been determined in Table 1:

(a) The percentage of each vegetation type used or occupied by camels during any of the surveys.

(b) The proportion of the estimated total camel population occurring in each vegetation type.

TABLE 1

Camel distribution in relation to vegetation

Vegetation type	a % Occupance by camels	b % of total camels in type
I	0.0	0.0
II	0.0	0.0
III	12.1	0.6
IV	55.2	11.6
V	18.2	1.8
VI	60.0	2.5
Total	-	16.5

3. 2 Feeding observations

3. 2. 1 General

A total of twenty four different sets of feeding observations were carried out. Nine of these were in vegetation Type IV while three sets of observations were made in each of the other five types. On three occasions plant availability was not recorded. Table 2 shows the feeding minutes and available minutes recorded in each vegetation type.

TABLE 2

Summary of feeding observations,
plant availability and preference in each vegetation type

Vegetation type	Total feeding minutes	Total available minutes	Mean % preference
I	2,145	4,045	53.0
II	1,010+618	2,087	48.4
III	484+245	751	64.4
IV	3,297+250	6,870	48.0
V	1,537	2,320	66.2
VI	1,311	1,610	81.4
Total	9,784+1,113	17,683	55.3

Where feeding minutes are preceded by + there were no observations on availability and these figures have not been used in calculating mean % preference.

3. 2. 2 Composition of the diet

All plants eaten have been classified according to the following types: trees and large shrubs (more than 1m tall); dwarf shrubs (less than 1m tall); herbs or forbs; vines, and grass. The mean composition of the diet of camels and an assessment of the greenness of vegetation in the six plant types is shown in Table 3.

TABLE 3

Mean composition of the diet of camels
and an assessment of the greenness of vegetation

	Percentage composition of diet					% Greenness		
Plant type	Trees	Dwarf shrubs	Herbs	Vines	Grass	Trees & shrubs	Herbs	Grass
I	65.1	33.9	0.3	0.2	0.6	33	17	7
II	13.7	79.7	6.0	0.0	0.5	33	13	3
III	28.1	38.1	15.9	0.6	17.2	38	17	33
IV	18.3	44.9	23.6	5.1	8.0	63	46	38
V	2.7	51.9	12.1	0.7	32.7	37	52	12
VI	51.7	36.7	3.3	0.1	8.1	71	38	31

A percentage of the total number of feeding minutes has been calculated for each plant species eaten by camels. The percentage composition of the five species of plant which form the highest proportion of the diet in each vegetation type is listed in Table 4.

3. 2. 3 Food preferences

A preference percentage has been calculated for each plant species in each vegetation type. It is the number of minutes a plant species is eaten expressed as a percentage of the number of minutes it is available.

Tables 5a, b, c, show those plants for which camels had more than 75% preference or less than 25% preference. Only plants available for more than 50 minutes have been included. Rainfall during the two months prior to observations is also shown.

No plant species fell between the set limits in Type III.

3. 2. 4 Chemical analyses of plants

Results of proximate and energy analyses of samples collected in Type IV on 20th October 1976 are shown in Table 6. All figures are percentages of dry matter except for energy which is in Kilocalories per gram dry matter.

TABLE 4

Percentage composition of camel diet in six vegetation types

Species	Category	Vegetation type I	II	III	IV	V	VI	Overall Mean	Rank
Acacia drepanolobium (Harms ex) Sjöestedt	Tree	19.6	-	-	-	-	-	3.3	-
A. nilotica (L.) (Willd. ex) Del	Tree	5.7	-	-	-	-	-	1.0	-
Aristida mutabilis Trin. & Rupr.	Grass	-	-	14.7	-	30.3	-	7.5	2
Barleria proxima Lindau	Dwarf shrub	17.0	23.2	-	-	-	-	6.7	4
Blepharis linariifolia Pers.	Herb	-	-	-	10.4	-	-	1.7	-
Cadaba ruspolii Gilg	Tree	-	-	-	-	-	5.8	1.0	-
Commiphora sp. Rend: Rumwe	Tree	8.4	-	-	-	-	-	1.4	-
Cordia sinensis Lam.	Tree	-	-	-	-	-	-	1.7	-
Dasyphaera prostrata (Gilg) Cavaco	Dwarf shrub	-	-	-	-	-	18.1	3.0	-
Duosperma eremophilum Napper	Dwarf shrub	9.4	23.4	11.1	-	-	-	7.3	3
Gisekia pharnaceiodes L.	Herb	-	-	-	4.9	-	-	0.8	-
Heliotropium albohispidum Bak.	Dwarf shrub	-	-	10.9	-	-	-	1.8	-
Indigofera spinosa Forsk	Dwarf shrub	-	16.6	-	36.0	12.8	-	10.9	1
Indigofera cliffordiana Gillet	Dwarf shrub	-	-	-	-	8.2	-	1.4	-
Kedrostis gijef (J.F. Gmel.) C. Jeffr.	Vine	-	-	-	5.1	-	-	0.9	-
Maerua crassifolia Forsk	Tree	-	4.0	-	-	-	-	0.7	-
Plectranthus ignarius Schwenf.	Dwarf shrub	-	7.4	-	-	-	-	1.2	-
Salvadora persica L.	Tree	-	-	-	5.1	-	7.3	2.1	-
Sericocomopsis hildebranditii Schinz	Dwarf shrub	-	-	7.5	-	27.7	-	5.9	-
Sueda hortensis Gmel.	Dwarf shrub	-	-	-	-	-	18.6	3.1	-
S. monoica (Forsk. ex) J.F. Gmel.	Tree	-	-	-	-	-	37.8	6.3	5
Zaleya pentandra (L.) Jeffrey	Herb	-	-	-	-	4.5	-	0.8	-

Rend = Rendille name

TABLE 5a

Percentage preference shown by camels for different plant species

	Vegetation Type I			Vegetation Type II	
Date	24.9.76	29.10.76	6.1.77	4.9.76	29.11.76
Rainfall in mm. in previous 2 months	0.0	0.0	122.5	0.0	75.0
Acacia drepanolobium			98.7		
A. etbaica Schweinf.		87.5			
A. nilotica	80.2				
Asparagus africanus Lam.		0.0			
Balanites aegyptiaca (L.) Del.	88.7				
Barleria proxima	92.5	96.1		94.7	
Boscia angustifolia A. Rich.	99.1				
Combretum sp.	100.0				
Commiphora sp. *Rendille:* Rumwe			97.6		
Duosperma eremophilum				5.7	80.7
Euphorbia heterochroma *Pax*				1.7	
Unidentified grass species				0.0	5.5
Indigofera spinosa				92.4	
Kleinia kleinioides (Sch. Bip) M.R.F. Taylor				5.7	
Leucas pododiskos Bullock			87.5		
Maerua crassifolia				93.9	
Plectranthus igniarius	8.8	21.4		0.0	

TABLE 5b

Percentage preference shown by camels for different plant species

	Vegetation Type IV								Vegetation Type V		
Date	19.10.76	26.11.76	19.5.77	20.5.77	15.6.77	16.6.77	20.7.77	21.12.77	18.11.76	11.2.77	18.8.77
Rainfall in mm in previous 2 months	0.0	34.0	133.0	133.0	97.5	97.5	20.0	190.0	38.8	42.3	0.0
Acacia reficiens Wawra subsp. misera (Vatke) Brenan									0.0		0.0
A. senegal (L.) Willd.									0.0		
A. tortilis (Forsk.) Hayne		3.0									
Aerva lanata (L.) Juss.			1.0	0.7		0.0					
Aristida mutabilis											90.8
Balanites orbicularis Sprague											0.0
Blepharis linariifolia					100.0	96.1		93.2			
Boscia coriacea Pax	89.0										
Cordia sinensis		86.2									
Digera muricata (L.)				11.4							
Duosperma eremophilum	8.5								89.1		
Gisekia pharnaceiodes			82.8	20.3			8.0				
Indigofera spinosa	88.0	98.4	97.4				97.0		80.3	98.0	
I. cliffordiana								86.5	79.6		
Kedrostis gijef.						98.9					
Leptothrium senegalense (Kunth) Clayton	84.4										
Lycium europaeum L.	1.3										
Maerua crassifolia	82.5										
Sericocomopsis hildebrandtii						100.0			93.6	96.5	
Ipomoea Kotschyana Choisy			6.7	11.8						80.4	

TABLE 5c

Percentage preference shown by camels for different plant species

	Vegetation Type VI		
Date	22.2.77	26.4.77	29.8.77
Rainfall in mm. in previous 2 months	18.7	82.2	0.0
Cadaba ruspolii	87.0		
Dasyphaera prostrata		100.0	
Salvadora persica			95.6
Sueda hortensis	90.5	100.0	
S. monoica	98.2		89.2

TABLE 6

Chemical analyses of plant samples from Vegetation Type IV

Species	Part	Protein	Fibre	Fat	Ash	NFE*	Energy
Boscia coriacea	Leaves	12.38	35.75	11.00	19.25	21.62	4.19
Boscia coriacea	Stems	15.37	51.77	4.72	8.66	19.48	4.20
Duosperma eremophilum	Whole	7.13	35.41	6.88	21.69	28.89	3.55
Indigofera spinosa	Whole	9.48	43.94	4.99	13.73	27.86	4.69
Leptothrium senegalense	Whole	12.37	45.72	4.87	5.56	31.48	4.20
Maerua crassifolia	Leaves	16.27	10.22	8.32	27.71	37.48	3.29
Maerua crassifolia	Stems	11.53	52.08	6.04	6.17	24.18	4.51
Salvadora persica	Leaves	10.90	13.32	5.46	32.79	37.53	2.82
Salvadora persica	Stems	16.03	37.37	4.61	18.10	23.89	3.53

* NFE - Nitrogen free extract

TABLE 7

Mineral analyses of plant samples from Vegetation Type IV

Species	Part	%Ca	%Na	%K	Parts million^{-1} P
Boscia coriacea	Leaves	1.55	0.02	1.05	10
Boscia coriacea	Stems	0.98	0.02	1.14	5
Duosperma eremophilum	Whole	5.46	0.15	1.45	10
Indigofera spinosa	Whole	3.78	0.10	0.55	15
Leptothrium senegalense	Whole	0.27	0.05	0.65	5
Maerua crassifolia	Leaves	3.21	0.07	3.00	5
Maerua crassifolia	Stems	0.82	0.02	1.03	5
Salvadora persica	Leaves	3.71	0.20	0.75	5
Salvadora persica	Stems	3.35	0.33	1.45	5

4. Discussion

4. 1 The vegetation types

Seventy three vegetation types have been described in the study area (Herlocker, 1979). Thus the mean proportion of the area of each vegetation type is 1.4%. In this study plant types have varied considerably in area with Types I and II on Mt. Kulal being below average, Types III, IV and V larger than average and Type IV near to the overall mean. Reasons for choosing Type I were because it was an important area for cattle centred on Gatab, S. Mt. Kulal and the possibility of competition for food between cattle and camels was of interest; also towards the end of a seven year period of below average rainfall this and Type II were among the few areas supporting some green vegetation. Type II which is adjacent to Type I was burnt in 1968 (Teasdale, personal communication). The effect of this burning on the vegetation and hence on the diet of camels was also of interest. Feeding observations of camels in Type VI which is dominated by *Sueda monoica*, an evergreen saltbush, are likely to have widespread application because of this species' Saharo-Arabian distribution (Waisel and Ovadia, 1972). The remaining areas were chosen for their size and/or importance to camels.

4. 2 Camel distribution

The aerial surveys show that camel distribution in the study area was uneven. More than half of plant Types IV and VI, less than a quarter of II and V and none of Types I and II were occupied by camels.

Type IV is riverine vegetation and Type VI fringes the Chalbi desert. Both have subsurface water and so remain green during drought. Greenness, palatability and nutritive value may be important factors in the preference of camels for plants growing near subsurface water. Another factor may be salt. Camels are highly dependant on salt for drought tolerance and disease resistance (Leitch, 1940; Schmidt-Nielsen, 1959; Bremaud, 1969; Maloiy, 1972a). Salts tend to accumulate at the bottom of the catena and in drainage basins such as the Chalbi desert i.e., Types IV and VI, respectively. They are most likely to be leached out of soils on mountain slopes i.e., in Types I and II.

The dromedary is also vulnerable to a sudden fall in temperature such as would accompany the steep ascent of one of the isolated mountains in the study area. These three factors help explain the observed preference of camels for Types IV and VI and their avoidance of Types I and II.

Another important factor in the distribution of camels is that herdsmen avoid certain places. Intertribal strife still occurs in this area and there are zones of relative insecurity lying between the core areas of the three main camel keeping tribes — the Gabbra, Rendille and Turkana. Thus, during the six aerial surveys some 41% of the study area was never occupied by camels. This is probably the main reason for the low occupance and small proportion of camels in Types III and V. Such areas could be used should security improve.

4. 3 Feeding observation

4. 3. 1 Dietary composition

Over 10,000 feeding minutes have been recorded (Table 2). One third of these was made in Type IV. This was because the Project was carrying out a grazing offtake experiment with camels, sheep and goats in this area which necessitated more frequent observations.

The greenness of the vegetation is important in interpreting the feeding observation (Table 3). Mean greenness of trees and shrubs in Types I, II, III,and V was remarkably similar (range 33 - 38%). Types IV and VI were almost twice as green probably owing to perennial subsurface water. A similar pattern applied for herbs and grasses with the exception of herb greenness in Type V which was very high. Two of the three sets of observations in this type followed soon after 36 - 39mm of rain to which herbs responded very rapidly.

The proportion of trees and large shrubs in the diet of camels in Type I was significantly higher than that of Types II and V ($P < 0.025$). The lower proportion of trees in diets in Type II is no doubt due to their scarcity resulting from the fire in 1968.

In Type V the dominant tree *Acacia reficiens*, is deciduous and not eaten by camels. The higher proportion of herbs in diets of camels in Types III and IV was probably a seasonal effect reflecting their abundance during wet months since this did not hold for Type IV during dry months. More dwarf shrubs occurred in the diet of camels in Type II than in Types III and the wet months of Type IV, but this was only significant at $P < 0.25$. Vines and grasses varied considerably in different observations on camel diet.

Twenty two plant species of thirteen families are among the five most important in the diet of camels in the different vegetation types. (Table 4). The *Acanthaceae* are represented by three species in the top five and there are seven other families with two plant species present.

In our Project herbarium however, *Gramineae* are most frequent with 60 species followed by 32 species of *Compositeae*, 26 species of *Acanthaceae* amd 18 species of *Papilionaceae*. Thus, it appears that plants of the family *Compositeae* are avoided by camels and that *Gramineae* are eaten less frequently than would be expected.

Summing the mean percentages of plants in Table 4 by family reveals that the following contribute most to the diet of camels.

Acanthaceae	15.7%
Papilionaceae	12.3%
Chenopodiaceae	9.4%
Amaranthaceae	8.9%
Gramineae	7.5%

Among the plant categories nine are dwarf shrubs, eight trees while the remainder are herbs, grasses and vines.

The dwarf shrub *Indigofera spinosa* is the most important plant species in the diet of camels. This was also remarked upon by FAO (1971). It is more common in lowland areas and is replaced on high ground by the dwarf shrubs *Barleria proxima* and *Duosperma eremophilum* which are also important to camels.

Acacia species are only important to camels at the top of the drainage in Type I where they remain green after other plants dry out. Conversely, the halophytic species *Sueda* and *Dasyphaera*, are restricted in their distribution to Type VI and hence only occur in the diet of camels in this type. It has been said (Waisel and Ovadia, 1972) that "*Sueda monoica* is not grazed, presumably because of the high content of salt and organic acids in the leaves". However, local herdsmen and this study suggest that salt acquisition is precisely the reason for the importance of this plant in the diet of camels. Other species of *Sueda* are eaten by camels in Tunisia, (Burgemeister, 1975) and a little in northwest Sahara (Gauthier-Pilters, 1969). In Bolivia *Sueda* species and the saltbush *Atriplex* are used exclusively for sheep grazing during the dry period from April to November (McKell, 1975).

The grass *Aristida mutabilis* is somewhat anomalous in the diet of camels. It comprised more than 10% of the diet on three occasions only. However, all were from three to five months after heavy rain in April and May 1977. At that time *Aristida mutabilis* formed almost pure stands, dried out rapidly to standing hay and probably had a high protein content. In October 1977 when there was very little green vegetation in Type V, *Aristida mutabilis* comprised 98% of the observed diet.

These observations explain how Sato (1976) concluded that the diet of camels feeding near Korr in the study area, comprised as much as 29% grass. Although a larger figure than obtained in this study (8.1%) it may have been due to restriction of observations to an area dominated by standing hay such as *Aristida mutabilis*. In the north west Sahara Gauthier-Pilters (1958) states that camels ate 44% *Aristida plumosa* in the month of June when it is very dry and *Aristida pungens* in July and August (Gauthier-Pilters, 1969, 1972, 1974).

4. 3. 2 Food preferences

Overall preference was above 50% (Table 2) which implied that once a camel entered an area of suitable forage it would concentrate for some time in that area. The absence of annual plants during dry periods also contributes to a higher overall preference. However, there was some variation in preference between vegetation types. Types II and IV were preferred less, the former because half the observations were during extreme drought and the latter because an abundance of relatively unpalatable herbs germinated when the drought broke and were available during the four observations in May and June 1977. Type VI which had palatable perennial saltbush (*Sueda* species) was preferred more than average.

The criteria of > 75% and < 25% preference are useful indicators of preferred and avoided food plants, respectively (Table 5a, b, c).

In plant Type I six species of plant were preferred on occasion but did not feature in the top five. Of these five were trees and one *Leucas pododiskos*, a dwarf shrub. Three of the species were evergreen and preferred in September when it was dry, the other two were Acacias. *A. etbaica* produced leaf just before the rains and was preferred in October and *A. drepanolobium* was preferred after the onset of the rains and the production of abundant young leaves. Two shrubs *Asparagus africana* and *Plectranthus igniarius* were sometimes avoided. *Asparagus* has large thorns which give it protection while *Plectranthus* is highly aromatic although occasionally eaten for its moisture.

In plant Type II camels showed seasonal differences in preference for *Duosperma eremophilum*. In September 1976 when it was dry and leafless the plant was avoided; but by November there had been rain and it was green and preferred. Four plants were avoided, *Kleinia kleiniodes* and *Plectranthus* which are aromatic, *Euphorbia heterochroma* which has latex and is spiny and grasses, probably because of their high fibre content.

In Type IV in addition to the top five species in the diet the following were preferred at times: three species of tree, two dwarf shrubs and one grass. The latter *Leptothrium senegalense*, was available in October 1976 as standing hay. Six species of plant were avoided from time to time. The perennial herb, *Aerva lanata*, was eaten on three occasions only. In Mauritania Gauthier-Pilters (1969) noted that the related *A. javanica* was also avoided by camels. The herb *Gisekia pharnaceoides* was preferred in one area in May 1977, but shortly afterwards was avoided in an adjacent area. This suggests uneven drying of this herb. The herb *Ipomoea Kotschyana* was not sc much avoided as overlooked since it is prostrate and grows beneath dwarf shrubs. *Duosperma* was again avoided under dry conditions in October 1976.

In vegetation Type V however, *Duosperma* was preferred along with three other dwarf shrubs soon after the onset of rain. Two deciduous *Acacia* species; *A. reficiens* and *A. senegal* were avoided early in the rains and the former in the dry season also.

All the species preferred in Type VI were in the top five of the diet of camels. The evergreen trees *Sueda monoica, Cadaba ruspolii* and *Salvadora persica* were preferred in the dry months while the semi-deciduous *Dasyphaera prostrata* was preferred in April which was wet.

4. 3. 3 Chemical composition of food plants

The chemical analyses to date are of limited value because they are from one plant type at the end of the drought in October 1976. On that occasion the top five plant species in the diet of camels were all collected together with *Duosperma* which was eaten very little (Tables 5b, 6). Of the top five only *Salvadora* was preferred on less than 80% of the occasions it was available. The camels tended to select the leaves of trees in preference to stems. In the case of *Maeru crassfifolia* they would grip a branch between their incisors and palate and strip off and eat only the small leaves. This can be explained by the higher fibre content of all the stems analysed when compared with the leaves. In addition fibre is believed to inhibit digestibility of other components (MacDonald, et al, 1966). Most herbivores select for energy and possibly protein (Field, 1976). All the plants analysed had above maintenance levels of protein (7%), although *Duosperma* with the least may have been inadequate. *Indigofera spinosa* had the highest energy content.

The phosphorus content of the plants analysed was low, giving an unbalanced Ca:P ratio. Sodium was also low.

4. 3. 4 Offtake of vegetation by camels

Assuming that the daily dry matter intake (D.M.I.) of a camel is 2.5% of its body weight, there being no evidence that they differ from other large ungulates in this respect (Field, 1977), and that the mean liveweight of a camel is similar to that of the Project's herd, i.e. 363kg, then the mean daily D.M.I. is 9.1kg per camel. This is higher than the D.M.I. recorded by Maloiy (1972b) but unfortunately he does not quote individual camel weights.

From the six aerial surveys the overall mean density of camels in the study area and its extensions was 1.62km^{-2}. Thus, the mean daily D.M.I. is estimated to 14.7kg km^{-2}; while the mean annual D.M.I. by camels was 5380.8kg km^{-2}.

The combined productivity of the herb and dwarf shrub layer in April/May 1977 has been calculated for plant Type IV (UNEP/MAB/IPAL, 1977). The average for seven paddocks was 62,729 ± 24,526kg dry matter km^{-2}. This production was obtained with 133mm rainfall which is little more than half the average annual rainfall of 250mm (FAO, 1971). On this basis the annual dry matter productivity of the herb and dwarf shrub layers would be 117,911kg km^{-2}.

In the study area as a whole therefore, camels consume approximately 4.6% of this production. However, there are two qualifications to this statement. Firstly, there has been no calculation of the productivity of trees. Hence, approximately 30% should be subtracted from the intake figures. Then camels consume approximately 3.2% of the annual production of dwarf shrubs, herbs and grasses.

Secondly, camels are not distributed evenly throughout the study area (Table 1). In studying desert encroachment we are interested in those areas around villages and waterholes which have the highest stocking rates as they may act as foci for the spread of deserts. The highest observed mean density of camels is 8.0km^{-2} but densities of 3 to 4 km^{-2} are not uncommon. At the highest density, offtake of the dwarf shrub-herb layer would be of the order of 15.8% of the production.

Had camels been the only herbivores this degree of offtake might be tolerable if not desirable. However, sheep and goats probably eat rather more than camels near villages and waterholes while cattle, other large herbivores and phytophagous insects as well as trampling may well account for the remainder. Even at mean densities of 3 to 4km^{-2} the impact of camels is far from negligible.

5. Conclusions

Camels feed principally on dwarf shrubs and to a lesser extent on trees and larger shrubs. Their anatomy is adapted for this purpose, their height and long neck enable them to reach the lower branches of most trees, yet unlike the giraffe *Giraffa camelopardalis* Matschie, they have no difficulty in feeding on dwarf shrubs almost at ground level. Herbs, grasses and vines contribute less to the diet of camels and this mostly during or shortly after rain. Thus the camel concentrates on woody perennial plants which are deep rooted and remain green and palatable despite drought and desert conditions.

Camels show definite preferences for certain plant species although they may not be abundant in the available herbage, while some common plants are avoided. Of the latter some may contain aromatic compounds or latex which are repellant. Small thorns, e.g. those present on *Indigofera spinosa* and *Barleria proxima* do not render a plant unpalatable to camels, but large thorns, e.g. those of mature *Acacia* species, probably afford partial protection to the plant.

Limited chemical analyses show that browse stems are more fibrous than leaves and are probably avoided for this reason. In this respect the camel behaves like a concentrate browser which has a low fibre intake and a rapid passage rate (Hofman, 1973). Energy and protein are probably the main factors for which camels select, but the evidence is inconclusive.

Calculations of offtake by camels indicate that although it is not great for the study area as a whole, there are foci of persistant camel concentration where it is higher. In these areas offtake by camels and other herbivores together with human/livestock requirements for thorn trees used in the construction of night pens, can and does lead to desert encroachment.

Unfortunately, in our study area in Western Marsabit District the physiological advantages that camels have when compared with other livestock which should enable them to be more mobile and relatively independent of water, are not fully exploited. This is because of the persistence of traditional inter-tribal raiding which leads to zones of insecurity amounting to about 40% of the study area. Such zones are effectively placed by their owners beyond the reach of camels and as a consequence they are concentrated on the remaining land.

6. Acknowledgements

I wish to thank the following: Sylvester Masheti and Hussein Ahamed Yussuf for assistance with feeding observations; the Project's camel herdsmen for help in identifying plants; the Rendille and Gabbra camel owners who permitted us to work with their animals; the Department of Animal Production, University of Nairobi for chemical analyses and the East African Herbarium for identifying plants. My colleague Dr. Herlocker and my wife Alison have supplied valuable information.

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