5-1989

Management, Foraging Behavior, Diet Composition and Forage Quality of Free-Ranging But Herded Camels in Ceeldheer District, Central Somalia

Ahmed A. Elmi
Utah State University

MANAGEMENT, FORAGING BEHAVIOR, DIET COMPOSITION AND FORAGE QUALITY OF FREE-RANGING BUT HERDED CAMELS IN CEELDHEER DISTRICT, CENTRAL SOMALIA

by

Ahmed A. Elmi

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

of

DOCTOR OF PHILOSOPHY

in

Range Science

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1989

ACKNOWLEDGEMENTS

This research was financed by the Somali Government through Somali National University (SNU) in cooperation with the United States Agency for International Development (USAID). Funds were allocated under USAID grant PIOP No. 649-90144A.

I am indebted to Drs. M. A. Nur and J. J. Norris with whose initial help I was able to achieve this career. Acknowledgement is made to my MS committee in University of Arizona, SNU, USAID, and other institutions who assisted at various levels of my research.

I'm very grateful to Dr. T. W. Box whose support and encouragement surpassed my expectation during my program. Without his help, in Somalia and in the United States, this research would not have been completed. I appreciate having had the opportunity to learn from him and to work with him. Special thanks to my committee members Drs. J. Malechek, D. Sisson, R. Fisher, F. Provenza and T. Thurow for their reviews of the manuscript and helpful suggestions. I appreciate the assistance of Dr. Sisson with the analysis of data sets.

Special gratitude is extended to Drs. F. Kinsinger, T. Thurow and F. Thetford for their help in Somalia. I extend thanks to B. Burritt, T. Weber, Dr. A. Gobena, and the Soil, Water and Plant Laboratory technicians (USU) for their assistance in laboratory analysis.

I would not have completed this research without the traditional cultural lessons which I learned from my parents, brothers, sisters and relatives; without the help, direction and guidance of Shadoor

camel owners, especially Abdullahi, Habbad, Geesay and Afay who allowed use of their animals under difficult circumstances; and without the moral support of my Faculty of Agriculture (SNU) staff and students. I owe gratitude to all of them.

I can hardly express in words how important my wife, Khadra, has been in my study from its inception in 1979 (MS) to its conclusion in 1989 (Ph.D.). Her dedication and devotion to our children without my moral and physical presence can only be described as a sacrifice, with the grace of God, for a better future. I give her my heartfelt love and gratitude for her patience and long suffering during those years of my absence. She provided an abundance of light in my life.

At last but not least, I thank D. Brunson who typed the manuscript and my friends in CNR (USU) who made my stay in Logan unforgettable.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF FIGURES

ABSTRACT

Management, Foraging Behavior, Diet Composition and Forage Quality of Free-Ranging But Herded Camels in Ceeldheer District, Central Somalia

by

Ahmed A. Elmi, Doctor of Philosophy

Utah State University, 1989

Major Professor: Dr. Thadis W. Box
Department: Range Science

In Somalia, camel (Camelus dromedarius) survivability and milk production has been higher than for other domestic livestock and contributes substantially to the subsistence of Somali pastoralists. The objective of this research was to study management, foraging behavior and nutrition of camels in their natural habitat to determine how production continues under seasonal nutritional stress.

Management systems of Ceeldheer pastoralists are based on available natural pasture and water. The natural rotation grazing system maintained an ecological equilibrium in the District.

Pastoralists manipulate their herds to suit existing environmental conditions, family needs and labor availability for herding. In herd management, control of breeding males and preferential treatment to increase the female component of the herd are geared to secure continuous milk supply for the family.

Camels were watered only in the dry seasons. They foraged continuously throughout the day the first few days after watering, but foraged mostly in the morning and evening as watering days approached. The quantity of water camels consumed in summer and winter dry seasons were similar.

In winter, milking camels foraged more, travelled shorter distance and rested less than dry ones. In fall, 1986, and spring, 1987, lactating camels spent less time foraging than non-milking animals. Foraging time was the same for both groups in summer 1986, 1987 and fall, 1987. Camels spent more time chewing bones in summer of 1986 in Xarar foraging area than other seasons. Low or high relative humidity together with hot temperature apparently reduced foraging time, increased rumination and idling times in winter and spring seasons.

As forage availability declined, camels ingested a broader array of dietary items in the dry seasons and consumed large amounts of herbaceous plants. The diets of milking and dry camels were similar. Lactating camels consumed more green forage than dry camels in the dry seasons. Shrubs and trees comprised major components of the diets (80.9%). Physical structures of plant species did not prevent feeding on the plants.

Camel diets were rich in crude protein (cp), calcium (Ca), potassiuim and sodium. Phosphorus (P) was deficient. Ca:P ratios were extremely low. Neutral detergent fiber and acid detergent lignin were high. CP intake seemed adequate year round assuming camel protein requirements are similar to other livestock requirements. Digestible energy was deficient in dry seasons. Low energy intake, inadequate

phosphorous availability and water deprivation were probably responsible for the weight loss of camels as the dry season progressed.

(221 pages)

CHAPTER I

INTRODUCTION

O blessed camel mine
You are as beauteous
as the rain that brings forth
pasture rich
beneficence to people and beasts alike ...

Livestock husbandry is the core of the Somali pastoral economy. More than half of the Somali population is directly dependent on animal production. Of all the animals, camels are the most loved and highly valued. They have always been the artery feeding and enriching the Somali culture. Somali poets have chosen the camel as the pillar of their poems and proverbs. The traditional poems used to introduce sections of this study were written in modern Somali orthography by Abokor (1987) and translated into English by A. A. Xange unless otherwise specified.

Somalis praise camels as the symbol of society, social relations and man's emotions (Abokor 1987). Camels produce everything the pastoral Somalis need for survival and have made it possible for them to live in harmony with their extremely harsh environment from generation to generation.

The Climate of Somalia

The climate of Somalia is characterized by alternating wet and dry seasons with highly predictable but sparsely and erratically distributed rainfall during the wet season. Recurrent drought periods

are common. Rainfall is low (50 to 800 mm/yr) and erratic in annual distribution and amount. It is mainly confined to two rainy seasons: 1) Gu (Spring - April to June) and 2) Dayr (Fall - October to November). Two dry seasons, Xagaa (Summer - July to September) and Jiilaal (Winter- December to March) occur between the two rainy seasons in the year.

The north and south movement of the Intertropical Convergence Zone (ICZ) controls the occurrence of these seasons in the Somali climate (reviewed by Hutchinson 1986). Dry monsoonal winds in July to September and December to January (monthly wind speeds average up to 36 km/hr) and warm mean monthly temperatures throughout the year (18-30°C) create a situation where rainfall is only 3 to 50% of the evaporative demand (UNSO 1984). Somalia is a predominantly arid to semi-arid country. Vegetation ranges from desert grassland to subhumid montane forest but is predominantly a deciduous shrubland (Pichi-Sermolli 1957, Box 1968, Hemming 1972).

Under these conditions, forage plants become plentiful during rainy seasons and scarce during dry, or extended drought, periods. During the dry season, range animals are exposed to severe heat, shortage of drinking water and scarcity of nutritious forage (Coughenour et al. 1985). In times of drought, most cattle, sheep and goats become unproductive. Camels, in contrast, produce milk and meat even when other livestock die. Camels saved the lives of many people during the 1973 and 1974-75 droughts in the Sahel and Eastern Africa where only 20-30% of camels died compared to almost 100% loss of indigenous cattle, sheep and goats (Gauthier-Pilters and Dagg 1981).

Importance of Camels in Somalia

In arid regions, camels are used primarily for milk production and secondarily for meat, transportation, riding, hides and skins, and draft (Bulliet 1975, Schwartz 1979, Pratt 1984). In Somalia, camels are not ridden, but are raised for security and social prestige in addition to the economic products.

The welfare of pastoralists of arid zones could be improved by increasing camel production as a source of food. Evans (1979) and Morton (1984) suggested that pastoralists who do not own camels in arid and semi-arid regions of the world should add camels to their livestock business. Livestock production could be increased without a reduction in cattle, sheep and goats, because camels do not directly compete for forage with those species. Because camels are efficient converters of low quality forage and water to milk and meat, pastoralists' food supply would be improved.

Somalia is a key country for camel production. It has more than five million camels (Mukasa-Mugerwa 1981, SOMAC/SAREC 1983, Wilson 1984). This camel population comprises 53.83% of the domestic herbivore biomass (Wilson 1984), or 46.6% tropical livestock units (Wilson and Bourzat 1986). The camels are adapted to the harsh habitat through various anatomical, physiological and behavioral mechanisms. Herded camels choose their diet a from complex mixture of plants available on native rangelands (Coughenour et al. 1985).

Somali pastoralists have historically developed management techniques to make the best use of the ecosystem. Management systems developed by the Somali nomads and accepted for centuries are based on available natural pastures and water. The quantity of forage and

water, a function of the spacial and temporal distribution of annual rainfall during the rainy season, determines the migratory movement of the nomads. They concentrate around water boreholes during dry seasons and disperse during wet seasons (Elmi 1985).

Despite the importance of camels, little is known about their feeding ecology. Even though food habits of camels in semiarid areas of eastern Africa have been described by Knoess (1976), Field (1978), Newman (1979), and others, no seasonal diets have previously been reported comparing milking and dry camels. Nutritional research has been mainly confined to the physiological aspects with very little work on what camels actually eat in the natural environment (Wilson and Bourzat 1986).

Before modern principles of livestock production can be applied to camels, detailed information is needed on their feeding behavior in their natural range. This research, therefore, is designed to study management techniques, foraging behavior, diet composition and dietary nutrition of free-ranging but herded camels in Ceeldheer District, Galguduud Region, Central Somalia.

Objectives

The overall objective of the study was to learn the survival mechanisms of milking and dry camels, foraging free, but herded, in their natural habitat. Both dry and wet seasons were studied but emphasis was placed on the dry season. The specific objectives of the study were four fold:

1. To describe the camel management techniques used by the Ceeldheer camel herders in different seasons for:

1.1 herd structure

1.2 forage

1.3 water

1.4 breeding

1.5 milking, and

1.6 decision making.

2. To compare foraging behavior of milking and non-milking camels:

2.1 to determine the length of time spent on foraging in dry and wet seasons for both types of camels,

2.2 to determine diurnal distance travelled in different seasons by both types of camels,

2.3 to determine whether camels reduce activity during hot hours of the day (or forage more in the morning and evening),

2.4 to correlate the influence of temperature and relative humidity on foraging behavior of camels.

3. To compare diet similarity of lactating and dry camels and determine the botanical composition of their diets.

4. To determine the nutritive content of major plant species consumed by free-ranging camels in their natural habitat.

CHAPTER II

STUDY AREA

This study was conducted in Ceeldheer District, the southern-most district in Galguduud Region, Central Somalia. The district is located at 4°N latitude and 47°E longitude (Fig. 2.1). Its eastern boundary is the Indian Ocean and is about 9000 sq km (Herlocker and Ahmed 1985). Figure 1 shows the area camels foraged one season or another during 1986-87 study period, physiognomic regions, rainfall isohytes, and sand dune areas.

Three physiognomic regions form the major camel habitat. The first is Xarar--grass-shrubland Transitional zone--adjacent to an extensive grass plain, about 30 km wide, usually level to gently undulating, and extending along the coast. The second is Carroguduud--Central Ridge--about 40 km wide and occupies the center of the District at an elevation of up to 300 m. It has gentle slopes forming gullies on the eastern slopes which carry seasonal streams through the Transitional zone and disappear in the grassland plain, before reaching the coast. The Central Ridge is closed to foraging of livestock during wet seasons (period of most intensive vegetative growth) because of incidence of a riibi, a biting fly which is also a disease vector for animals. The outbreak of riibi fly starts nine days after the onset of the first rain and continues for up to forty-five days. The length of time the fly stays active depends on the duration of the rainy season. The third is Buur--Western inland and into Ceelbuur

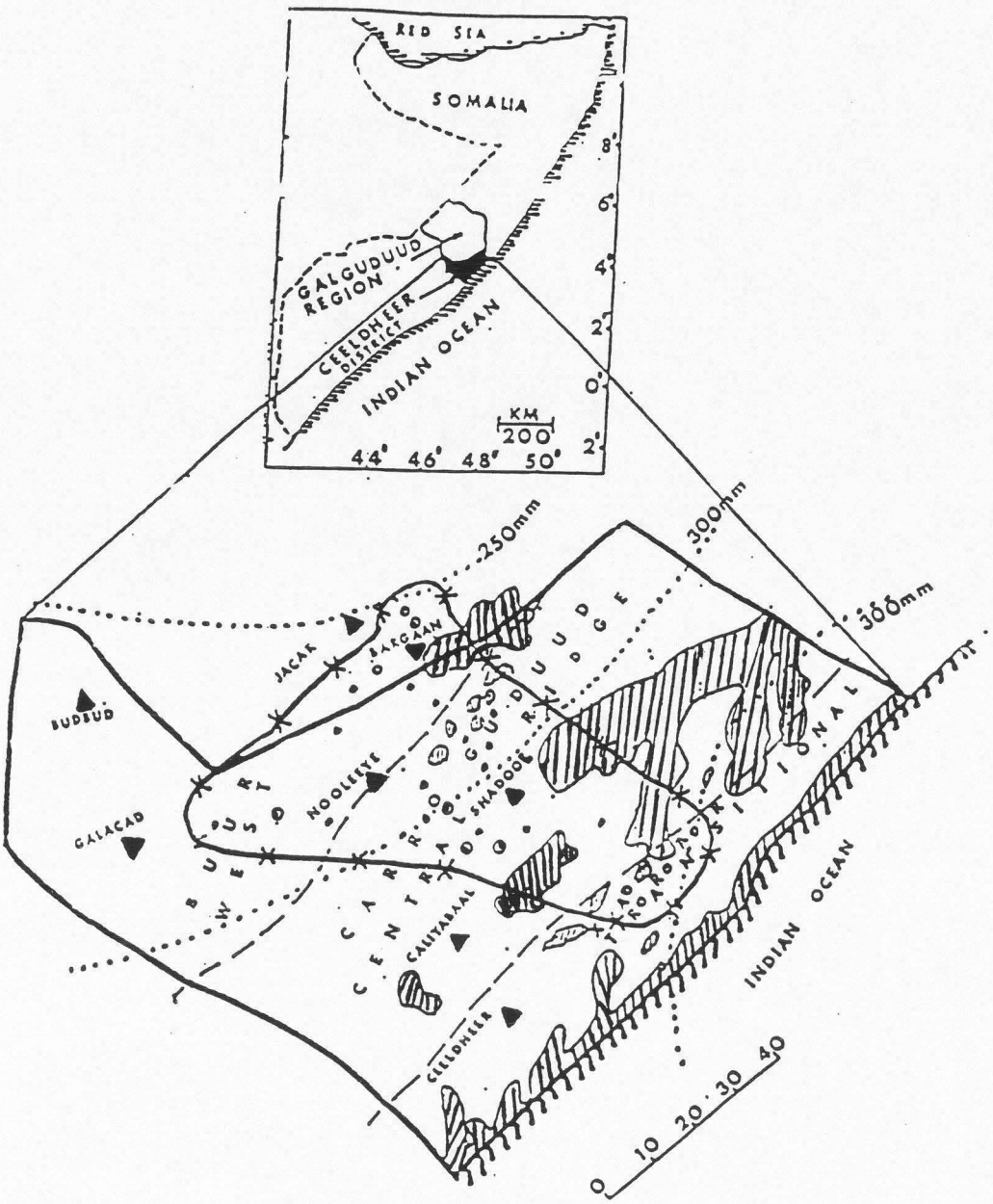

Figure 2.1. Ceeldheer District--three major physiognomic regions--Xarar (Transitional Zone), Carroguduud (Central Ridge), Buur (West); rainfall isohytes; and approximate camel foraging area.

(▲ = Villages; ● = No observation camel camps; o = Observation camel camps; —— = District boundary; ✕✕✕ = Approximate camel foraging area boundary; --- = Physiognomic regions boundary; .... = Rainfall isohytes; ▨ = Sand dune areas).

District--is a plateau. It has level to gently undulating slopes with stabilized, sometimes large, sandhills at an elevation of about 150 m rising gently to the west inland.

The district was extensively studied by Herlocker and Ahmed (1985, 1986) and Herlocker et al. (1987, 1988) in their range ecology and management investigation report. Holt (1985) and Behnke (1988) also studied the agropastoralism aspect of the District and neighboring areas. These publications give detailed information on vegetation, soil, climate and land-use systems.

The Ceeldheer District consists of stabilized sand dunes. These are shallow in the Buur Western area and deep in the Carroguduud Central Ridges. Local outcrops of limestone occur in some places, but most remain covered in the Buur, under the sand.

Different types of sandy soils occur throughout the whole district. White coarse sands predominate in the Coastal Plain, sandy loam in the Transition zone, reddish brown sandy loam in the Central Ridge and sandy loam in the West.

Geomorphologically, beach sand was deposited by the Indian Ocean. The sand was mixed with other surface materials and moved inland and northwards by seasonally high winds. As a result, isolated dune fields of different sizes and shapes were created. At present, three groups of dunes can be easily identified in the district: (1) inland dunes--large monolithic dunes of about 30 km inland; (2) coastal dunes--newly created small dunes near the coast; and (3) stabilized sand dunes in the north and west frontiers of the district. Recent poor farming and grazing practices may have increased the size of the inland sand dunes.

Some of the stabilized sand dunes are becoming active due to human activities. Local land use creates soil erosion problems where vegetation cover is removed or lessened by clearing and overgrazing. A good example is Nooleeye Village where soil erosion and dune formation are readily apparent around wells and poorly managed farms.

Rainfall patterns for the district were interpolated from meteorological stations located outside the district. There are two rainy seasons (April-June and October-November) and two dry seasons (July-September and December-March).

Variability of rainfall is high in amount and location. Rainfall in 1986 in the study area (Ceeldheer District) was below normal. Fall season rains failed and there was a short drought. In 1987, however, rainfall was normal, about that usually expected (Fig. 2.2). The average annual rainfall is about 250-300 mm (RMR 1979). It is lower in the Buur and highest in the Carroguduud Central Ridges. Temperatures range annually from 20-30°C (UNESCO 1979, UNSO 1984) and relative humidity is 73-78% in coastal plains (UNSO 1984). In the Central Ridges and West, temperatures are warmer and relative humidity differences wider from season to season.

The highest rainfall coincides with the highest elevation of the large Central Ridges. This moisture increase is reflected by the existing vegetation. There are three major vegetation types associated with the three physiognomic regions in the district: (1) coastal plains--herbaceous and grass-shrub transitional zones; (2) Central Ridge--dense shrub; and 3) open West shrub vegetation (Fig. 2.3). Shrub vegetation cover and height is greatest on the Central Ridge,

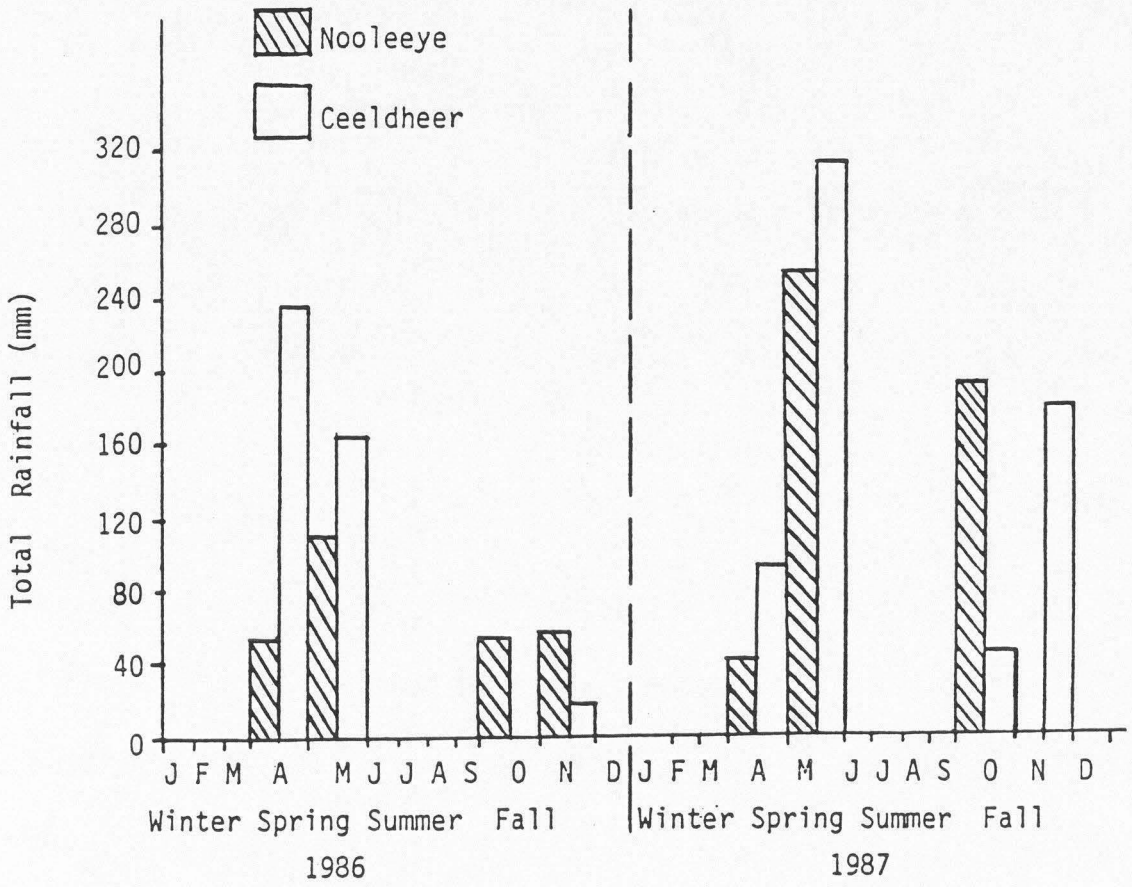

Figure 2.2. Total rainfall (mm) for Nooleeye and Ceeldheer villages during 1986 and 1987 study period. Original data obtained from Central Rangeland Development Project (CRDP).

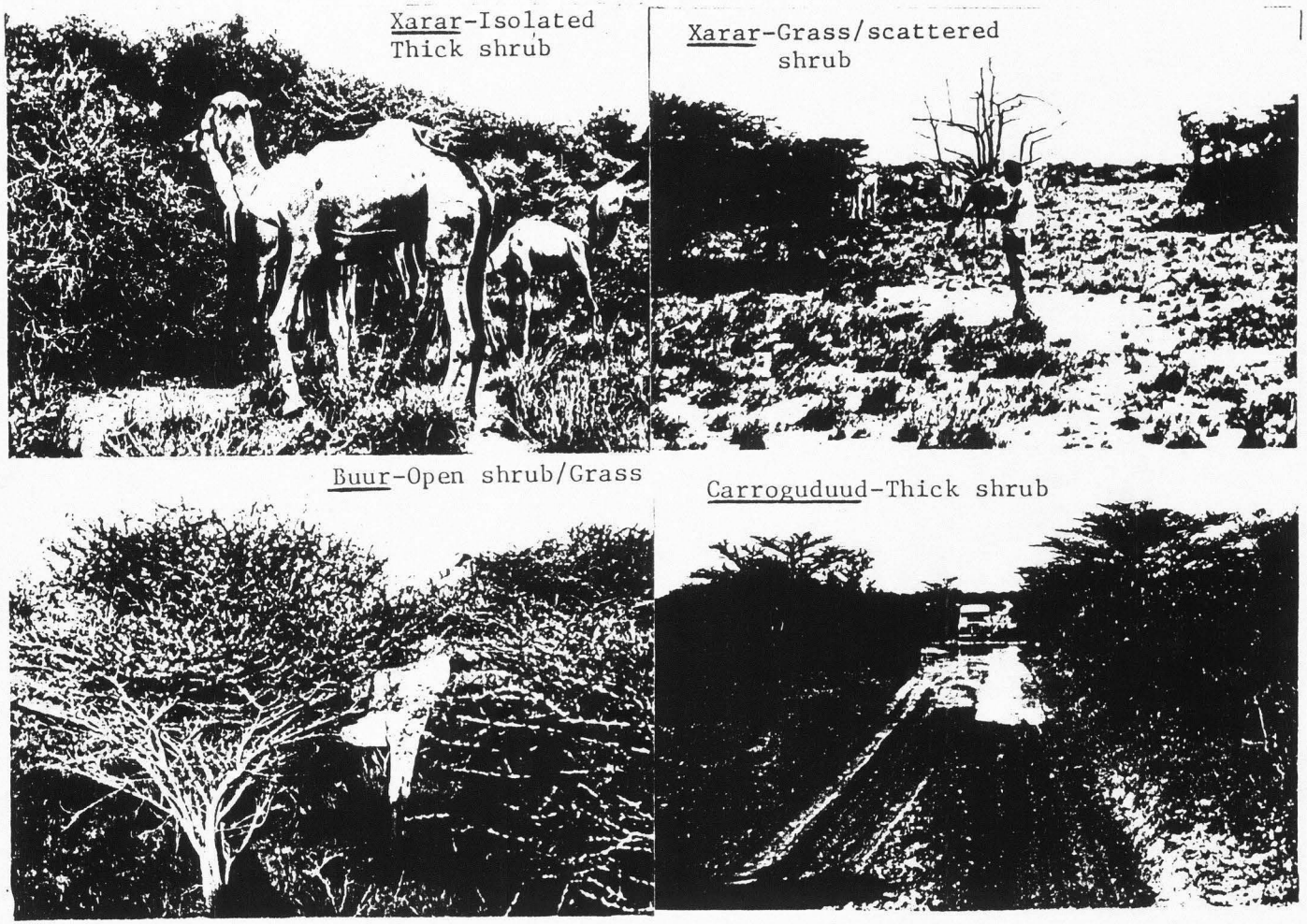

Figure 2.3. Vegetation types for the physiognomic regions where camels foraged (pictorial illustrations).

medium on the Western plateau, lower on the grass-shrub Transition zone and almost non-existent on the grassland coastal areas. This physiognomic pattern probably reflects both soil depth and rainfall. The most dense vegetation occurs on the deepest soils in the Central Ridge area which receives the highest rainfall. Plant species are numerous and dominated by woody shrub species. The number of plant species and vegetation cover of the study area are reported in detail by Herlocker and Ahmed (1985, 1986) and Herlocker et al. (1987, 1988). The dominant plant species on these three physiognomic regions where camels foraged throughout the study period are listed in Appendix Table 1. Scientific names of all plant species in this study are from Kuchar and Herlocker (1985) and Kuchar (1986).

Two principal, but interrelated, types of land use are practiced in Ceeldheer District: pastoralism and shifting cultivation. Few families are restricted to a single practice; most people are engaged in both activities (agropastoralism) (Holt 1985, Behnke 1988). Among four livestock species dominating the district, sheep are the least abundant (18%) (RMR 1979). Camels and cattle constitute about 27% each, and goats 28%. Distinct habitat preferences exist among the livestock species. Cattle and sheep prefer the coastal plain grassland and adjacent transitional areas. They are also abundant in drier and open shrublands of the west. Camels and goats prefer open to dense shrubland of the west and central ridge of the district. Camels tend to avoid mobile sand dune and more open shrubland with shallow soils. The ability of the camels to utilize the drier habitat and the preference of cattle for fresh herbaceous grazing is reflected, in

fact, by the increase in abundance of the camels in the Centeral Ridge in the dry season and increase in cattle in the wet season. Seasonal changes in livestock abundance also imply movement in and out of the district. Stocking rate is highest in the dense shrubland of the central ridge and lowest in the drier, more open and lower shrubland in the west and on sand dunes. The mean annual stocking rate is about 12 ha/SSU (@450 kg/ssu) Herlocker and Ahmed (1985). Stocking rates increase in the east during the wet season and in the west during the dry season.

Livestock move considerable distances in search of forage. In the dry periods, camels are taken far outside the villages or even beyond the regular foraging area to other districts where better forage is available. When the district receives better rains than surrounding ones, livestock from drought regions are brought into the area to forage.

Herlocker and Ahmed (1985) classified 75 percent of the district range as fair to good condition. Range condition worsens with proximity to permanent water. The very poor condition areas are mostly large mobile sand dunes, farms, and enclosures fenced with cut-thorn bushes immediately surrounding villages and major wells. Vegetation cover in these areas is either low or absent. Shrubs are heavily hedged. Wind erosion is active. Heavily grazed and often farmed areas extending a few km out from the villages are also poor in condition. Far from villages in the shrubland, however, vegetation is almost intact with significant amounts of grasses and herbaceous species understory. The condition is generally good.

The Ceeldheer District was selected for several reasons. First, the district is one of the priority districts for the Central Rangeland Development Project (CRDP). Project surveys formed a baseline for this study. CRDP personnel, vehicles and facilities were available for my use in the study. Second, the district is one of the typical dry camel rangelands of Somalia. Third, Somali pastoralists in the district were aware of the development activities and were willing to work with me. Camel owners were willing to allow the use of their camels if minimal interference was made of their management system. Forth, communication facilities were available in the range headquarters of Ceeldheer Village and it was easy to accurately trace where the camels forage at any time. Therefore, it was an ideal location for a camel study. Only one exception made it different from the rest of the country: there are no human or animal predators for camels.

CHAPTER III

CAMEL HUSBANDRY AND MANAGEMENT TECHNIQUES IN CEELDHEER DISTRICT

This Chapter discusses camel pastoralism, ownership, herd structure, foraging, watering, breeding, milking and the role of camelmen in Ceeldheer District. It should give an in depth understanding to livestock developers and policymakers of the entire camel production system. Biological, social and economic data already known can be applied to the camel in developing new knowledge that is unique to the camel itself.

Camels in Somalia are herded in groups or units. A camel herd is usually owned by a family unit (husband, wife, children, unmarried sisters and brothers) or by a family unit consisting of married brothers, cousins, in-laws, and their dependents. A typical camel herd may vary from 20-100 head in which approximately 4-20 camels may give birth in each rainy season. Although division of a herd is common in the Somali pastoral society, it did not occur during the study period.

A family camel herd of about 70 head were selected for the study. My assistants and I lived with the camel owner for one month each season. We collected data on 8 visits from February, 1986 to November 1987.

Methods

Camel management strategies and husbandry techniques used by the pastoralists were described. Camel owners were interviewed and their activities observed during the 240 days spent in the field. Interviews and informal discussions with the nomads formed the base for the traditional or accepted practices. Since I lived with the livestock people as one of them, I could observe what they actually did. Management techniques practiced for foraging, watering, breeding, and milking were recorded. Actual water measurements were made in some dry seasons. These measurements, observations and interviews were interpreted using my own experience as a member of a camel raising family.

Ceeldheer Pastoralists

Ceeldheer pastoralists are friendly, honest and open-minded people. Like the rest of the Somali nomads, they are famous for their movement, resistance to hunger and thirst. But their environment is unique in one aspect. In their habitat, no human or animal predators, except for a few foxes and wild dogs (Weer) exist. Unattended sheep or goats are seldom taken by predators and camels are absolutely free of them. When foraging in the home area, camels are left unattended for the whole day. Only a morning and evening check to determine where they will be for milking is required. When they move beyond their home area during biting fly infestations and dry seasons, the camels are given closer attention. Calves are tied to trees or shrubs and herds

stay together in an open area with the calves at night. It is rare that camels spend more than a few nights in one place. Bedding grounds are moved frequently.

Besides being free from predators, Ceeldheer pastoralists generally live in peace. Only occasionally do disputes arise with neighboring clans. They are more sophisticated than their neighbors in dealing with government agencies and maintaining their herd sizes.

In fifteen camel herds in the District, the average number of camels per herd ranged from 50 to 60 head excluding burden camels. Each camel herd is owned by at least two families. Permanent wells are widely dispersed from each other and temporary water reservoirs are few. Farming is confined to small areas of private ownership. Vegetation degradation is prominent only near permanent water sources in villages and misused farming areas surrounding villages. Vegetation condition in the rest of the district is fair to good. Frequent movement of the pastoralists and infestation of biting or disease vector flies leads to a natural rotation grazing system.

The variable nature of the environment, the continual redistribution of livestock wealth between households, and the labor requirement prevent and discourage any widespread or permanent process of wealth accumulation and economic differentiation. Pastoral wealth lies in livestock and, therefore, remains vulnerable to drought and diseases. In addition to this, low fertility rates, slowness of the reproductive cycle, cost and intensive labor requirement of camels, make some pastoralists in Ceeldheer District unable to acquire or build adequate camel herds. Instead, they turn their energy to raising sheep

and cattle as an alternative in the coastal plains. Because of differences in ecological requirements and preference of individuals, pastoralists rear camels with sheep and goats, cattle and small ruminants, or small stock only. It is rare to find camels and cattle raised together.

Camels are the main reserve stock. They are not frequently sold in the traditional pastoral economy. As a result, pastoralists are mistakenly thought to prefer prestige of large herds to the money and goods that could be obtained by selling surplus animals. In the Ceeldheer pastoral environment, this is simply not true. Their strategy is to maintain balanced family herds to secure a stable subsistence and insure optimal production. The herd size must match the family size for proper management.

Pastoralists manipulate their herds to suit existing environmental conditions (nature and location of pasture areas), social organizations, family needs (determine herd composition and size) and labor availability for herding. They maximize livestock productivity to the best of their ability. Based on these factors, members of the same lineage or social groups usually migrate together in the direction dictated by the needs of their livestock.

Ownership and Social Value of Camels

Ownership of camels in general Somali pastoral societies is well documented by Hussein (1984, 1987) and Hjort and Hussein (1986). In Ceeldheer District, camels are individually owned and inherited. This individual ownership is, more or less, nominal. Camels are always

considered as a communal kinship or clan property. The Somali camelmen say "Kin owners herd camels together but each herder pays particular attention to his own individual camel". This famous proverb implies both individual and communal ownership of the animal. Camels are marked with a specific clan brand with a submark which is unique to individual or family.

In time of adversity, such as when a family loses its animals, the individual owner has no absolute right to give or refuse to dispose of his camels. The kin or clan members decide the distribution of animals to the victim from its members. The animals collectively given to the victim by kin or clan include lactating, pregnant and immature camels as well as sheep and goats. Enough are given to allow them to recover from the disaster. Before the donation is undertaken, kinsmen and sometimes friends who share the same habitat come together and examine the causes of herd loss and establish the fact of the loss whether it was due to negligence or to other causes beyond the owner's control. If it is proven that the loss was the owner's fault, a minimum number of animals is given with a strong warning; otherwise a substantial herd is given to the individual victim or family.

On the other hand, the individual camel owner has the right to loan his camels to relatives and friends. Families without enough milk or transport animals are lent lactating or burden camels by either friends or patrilineal kin. These animals are returned without charge to the owner when the need has passed. This kind of individual decision is made by the head of the family usually by consulting family members.

Camel ownership starts at the birth of a child. The father gives his son a young or newly born female camel and other animals as the base of his future herd (Xuddun Xidh). The child also receives gifts from his close relatives (elder brothers, uncles, etc.). As he grows, his herd also grows. At marriage, a portion of the family herd is allocated to him. The allocated herd remains with the family herd. At his father's death, the un-allocated stock is shared among heirs. A new cluster of family holdings emerges; but the animals may continue to be herded together. Camels are herded normally by unmarried young men and teenagers. Women take care of small ruminants and burden camels. If labor shortage exists, young girls assume camel herding, milking and watering.

Camels are status and wealth. Praise poems, proverbs and songs are made for them (Abokor 1987):

... ever-ready are camels for milking sessions
even if from the heavens no rains come
in seasons of plenty
as in drought severe
their milk all and sundry satisfies...

... he who beaks the bones
to drink the marrow therefrom
or feeds on the chest-meat of a camel
strongest of men he would be...

... drought affects not camels
whereas other livestock all perish[1]
under its severity...

[1]Compares camel with cattle, sheep and goats.

... in seasons of plenty and prosperity
when frogs in the pool croak with joy
all four categories[2] are equally productive
but in drought periods
real security in camels remains...

Most camel herders in Somalia use camels for social rituals and customs. For instance, marriage without giving camels to the new father-in-law is unusual to most Somalis. But, in the Ceeldheer District, camel owners do not practice this custom. They do, however, pay camels for blood compensation, slaughter for important religious gatherings or settling disputes between neighboring clans. I witnessed payment to a rival clan of eight large camels and hundreds of thousands of Somali shillings by the clan whose camels I studied. This was payment for two men injured in a stick fight.

Camels are the only animal used to set a price for a killed person or for bodily harm such as a lost eye, teeth, broken bones, and so on. The blood price depends on the circumstance or social status of the victim and the aggressor. Each unit of a man's body is priced by a certain number of camels. The clan members collectively pay the compensation either in kind or in cash (a camel is the reference price). Usually nomads have pre-fixed reparation for death or for severe injuries. The reparation depends upon whether the action was done deliberately, by negligence, or by accident. The clan sheikhs and leaders determine the compensation to be paid to the victim.

In the pastoralist society, the household is the basic unit, socially as well as economically. Elderly couples, children and

---

[2]Compares camel with cattle, sheep and goats.

sometimes dependents are the core of the family. Households usually operate independently and may be widely dispersed depending on the type and size of the herd. The majority of Ceeldheer pastoralists have two wives. Generally one wife herds sheep and goats and the other stays with the camels. The husband is always the head of the family that includes his married sons (if any). He nominally owns the herd in different subfamilies. However, in most cases he cannot sell or give away animals without the consent of the family members.

Herd Structure

Household need for milk is the major factor governing camel herd structure and composition in the Ceeldheer District. Although camel management depends upon both environmental conditions and family needs, the family size determines milk requirement and labor availability for herding. Thus, families and herds develop together for subsistence. If labor is available and range adequate, herds may be managed for offtake or prestige.

In this study, only one camel herd of about 70 head was studied intensively. Management practices were observed for two years, 1986 and 1987. In addition, many other local owners and herders were interviewed to determine traditions and folklore of management. These interviews provided data in family size and composition.

The study herd was typical of those in the area. It was divided into calves, immature and mature males, and female camels (Table 3.1). Based on total live camels, male calves are 10.6%, female calves 9.4%, immature males 5.9%, immature females 17.6%, mature males 9.4% and

Table 3.1. Camel herd structure during February, 1986, to November, 1987 study period.

Sex groups	age	Number culled/ *died	aborted	offtake	loan	live	total	percent of live total
calf - male	birth - 2 yrs	6				9	15	10.6
- female	" " "	4				8	12	9.4
immature - male	2-5 years	2		4		5	11	5.9
- female	" "	1		1		15	17	17.6
mature - male	> 5 years					8	8	9.4
female	" "		6	2	3	40	45	47.1
subtotal - male		8		4		22	34	
- female		5		3		63	74	
total		13		7		85	108	
male: female ratio		1.6		1.3		0.3	0.3	
percent (%) - male		62		57		26		
- female		38		43		74		

*Died - includes calves culled plus those that died of natural causes (5 male, 1 female culled)
Aborted - includes abortion from embryonic stage to still-born at time of birth
Off-take - includes camels given away for religious purposes, as gifts to relatives and/or blood compensation and those sold for cash for family expenses.

mature females 47.1%. The proportion of milking, dry mature and immature females are 35%, 12% and 15.7% respectively. The majority of the females are bred in the spring (major rainy season, gu) and the rest in the fall (short rainy season, dayr) when forage is plentiful. This pattern is the traditional practice of most other livestock owners in the district.

Calf mortality is high because animals slaughtered at birth are included. Out of the 13 camels that died during the study period, 7.4% and 4.6% of the total were males and females, respectively. Seventy-five percent of the males and 80% of the females that died were calves less then 2 years old. Of the reported calf mortality more than 83% of the male calves and 25% of the female calves were slaughtered at birth by their owners to allow more milk for the family. Offtake of immature and mature camels is low if the slaughtered calves are excluded. Herd increment during the two years studied was 25 percent. Herd loss was 18.5 percent.

In herd management, preference is given to female camels. Camel owners cull male calves for two reasons: 1) to increase the reproductive potential of the herd and 2) to provide more milk for the family. The ratio of mature males to all females is 1:11. Total male-female ratio is, however, 0.3:1. Mature males are used for transportation and breeding. Different males were used for breeding in the study herd.

Breeding

The breeding system practiced by camel owners is based on the successful management of male breeding camels. Considerable control in breeding males is commonly practiced by all Somalis. This has contributed to Somalia being the most populous camel country in the world (Wilson 1984). The camel pastoralists mobility, their milk requirement and the occurrence of two breeding seasons in the Ceeldheer environment make a useful model to study.

Proper breeding is, therefore, very important for Ceeldheer pastoralists subsistence. The breeding periods are Spring (Gu) and Fall (Dayr) rainy seasons. Camel breeding starts at the beginning of the rainy season and continues throughout the season. Thus, selected female camels are bred in each of two times a year if no drought occurs.

Selection of future breeding males starts at birth. Two to three male calves are selected based on their ancestors' history. Special care is given to them. They grow quickly and become sexually mature at the age of five. Special treatment includes providing them a large flow of milk and protecting them from ticks and other parasites. They may not be used for burden. As young potential herd sires they are allowed to breed only a limited number of females. When the male is 5 years old, it is allowed to breed only a few five year old females. If the progeny are good the number bred is increased to 50 females at the age of 8 or 9. A herd sire's breeding life could last up to 20

years. A camel female can be bred for about 22 years. About 10 calves can be produced within this 22 year of breeding life time.

Sometimes, a burden male is used for breeding. During breeding time, however, it is seldom used for transportation. Due to this dual purpose, the pastoralists believe that the breeding life of burden males is short - about 17 years.

Rutting males display secondary masculinity characteristics; fight dangerously one hostile to another, or sometimes attack man. A breeding male does not allow other males older than 2 years to stay in the herd. It does not copulate if other males are on site. The rutting male aggressively keeps its herd isolated from other herds. It frequently moves back and forth and always stands facing the direction of expected intruders. Behavior of breeding males is well documented by Gauthier-Pilters and Dagg (1981).

The breeding male, whether used for burden or not, can serve females day and night throughout the rutting season. The camelmen try to prevent copulation during the day, but give the camel free choice at night. They believe that frequent daytime mating shortens the breeding life of the male.

Pregnancy in camels can be detected by the herders as early as 10 days after mating. They do this by observing pregnancy symptoms in the female such as coiling the tail backward to the hump, frequent urination, lifting head up with ears pointed straight and long neck curved back to the shoulder when a male camel or a man approaches the female camel. These symptoms are prominent after more than a month of pregnancy but are not as pronounced in the first few weeks of

pregnancy. However, due to their pastoral experience, most herders can correctly judge if a camel is pregnant or not within a short period after breeding. The rutting male also detects the pregnancy after a week or so. Gestation period of camels is about 13 months.

Female camels that do not conceive are rebred. Sometimes the female refuses to be rebred voluntarily and the herder forces it to accept the male. A rutting male normally breeds about 50 camels. Some owners believe that it can breed up to 200 camels in each season; but the expected breeding life of the male may be reduced.

Selection of breeding animals and breeding are generally designed to improve productivity. Tolerance to drought and diseases are desired characteristics. Selection of breeding male depends on appearance and behavior, physical strength, and other characteristics of ancestors such as milk production, color, resistance, etc. His progeny are judged by these characteristics. If the owner does not have a breeding male which can fulfill these criteria, he either borrows one from relatives or friends or mixes his herd with another herd with a good breeding male. This action is prearranged with the family who owns an outstanding breeding male.

Breeding males used solely for mating can become sexually active at any season provided unbred camels are in good condition and plenty of forage is available in the dry season. So, even in the winter (long dry season) some camels can be bred. But a burden male used for breeding seldom becomes sexually active in the dry season.

Male camels not required for breeding are trained for transportation or castrated. Training usually starts at the age of 4

years. It takes a few days only. Until the trained camel reaches 9 years of age, it is not used for heavy loads. At the age of 9, the owners say Waxna sugayn, waxna seegayn, which means no load bothers the camel. The animal is at its full strength and may carry the maximum load. At this age the camel can carry about 300 liters of water for 5 hours per day.

The role of a mature male camel is to transport water, nomadic houses and utensils, very young children, weak or sick persons, and lambs and kids in the process of nomadic movement. Loading and unloading is always done very quickly. Recently trained camels get restless and require skilled persons to handle them in the loading and unloading process. Camel herders often chant songs praising the camel (Abokor 1987):

> *... trust in God Almighty*
> *and upon Him strength the burden to bear*
> *O camel mine!*
> *Welfare of the family upon thee rest...*

It is part of the owners strategy to limit working hours and distance travelled to allow the camel time for feeding and resting. Since most of the year is hot, movement is preferred to be early in the morning (3 to 10 a.m.) or late in the afternoon (4 to 10 p.m.). Night travel is used when moonlight is available. Each camel has a rope tied to its head. The rope of the lead camel is held by a guide camelman. Women follow with other camels strung out in a line tied to the tail of one another. The line varies from two to six camels, on average. Generally each household uses 2 or 3 camels for burden. It is not unusual to see each household camel led separately by the owner.

Camels can be used as a beast of burden from age 3 to age 20. After about 20 years of age they are replaced.

Castration of male camels is a common practice in all Somali pastoral societies. Although the major objective of camel castration is to prevent breeding by unwanted or inferior males, castration is also practiced to promote ease of handling and for economic purposes (fattening for sale).

When castrating a camel, its head is tied with a rope; front legs are also tied together, criss-crossed above the fetlock. Then it is forced to sit down. One man holds its lips and bends the neck backward towards the hump and pulls down until one side is flat on the ground. All four legs are tied together (and if necessary to a tree trunk). One person holds the head of the camel to the ground while sitting on its hump. Another person opens the scrotum near the attachment of the hind legs with a sharp blade or razor and removes testicles one at a time. The wound is treated with medicinal plants. Sometimes the wound is washed with the animal's own urine and the cut is filled with camel or horsetail hairs or clean green grass leaves. When the surgery is over, the camel is untied with the head rope hanging. It sits up straight and stands immediately. The camel is tied to a tree for a few hours and released to forage (Elmi 1984).

The process of castration takes about 30 minutes to one hour. Death loss almost never occurs. The wound heals within a few weeks. The camel can be used for work after the wound heals. Camel males can

be castrated any time except when they are very young. Usually they are castrated between 3-5 years of age.

Selection of Foraging Areas

The total annual rainfall, its spacial and temporal distribution, the effective rains after dry seasons and their variation, and tick infestation and outbreak of flies are important factors pastoralists consider when management decisions are made about camel foraging areas. Rangeland is communal except for small individual holdings for farming. Clan members are closely associated with particular areas of pasture without any specific rights of ownership but with traditional clan grazing areas. The boundaries of territories are abstract and reside in individual clan member's minds.

Knowledge of plant species, commonly selected by foraging camels at different times of the year, is fundamental to effective grazing and browsing management. Camel herders learn these at a young age. Some of the knowledge is passed on orally. Some of it is contained in songs, poems and proverbs. Much of it is gained from watching the camels for years. Thus, the pastoralists of the study area, like most Somalis, gained their knowledge through a combination of experience and tradition.

Livestock movement in the Ceeldheer District reflects three basic seasonal patterns of movement (Fig. 3.1). First, livestock in the coastal plain tend to utilize the grassland-shrub ecotone or Transitional zone, Xarar. During early rains outbreaks of gilmi flies occur on the grassland plains. Gilmi is a non-biting fly that does not

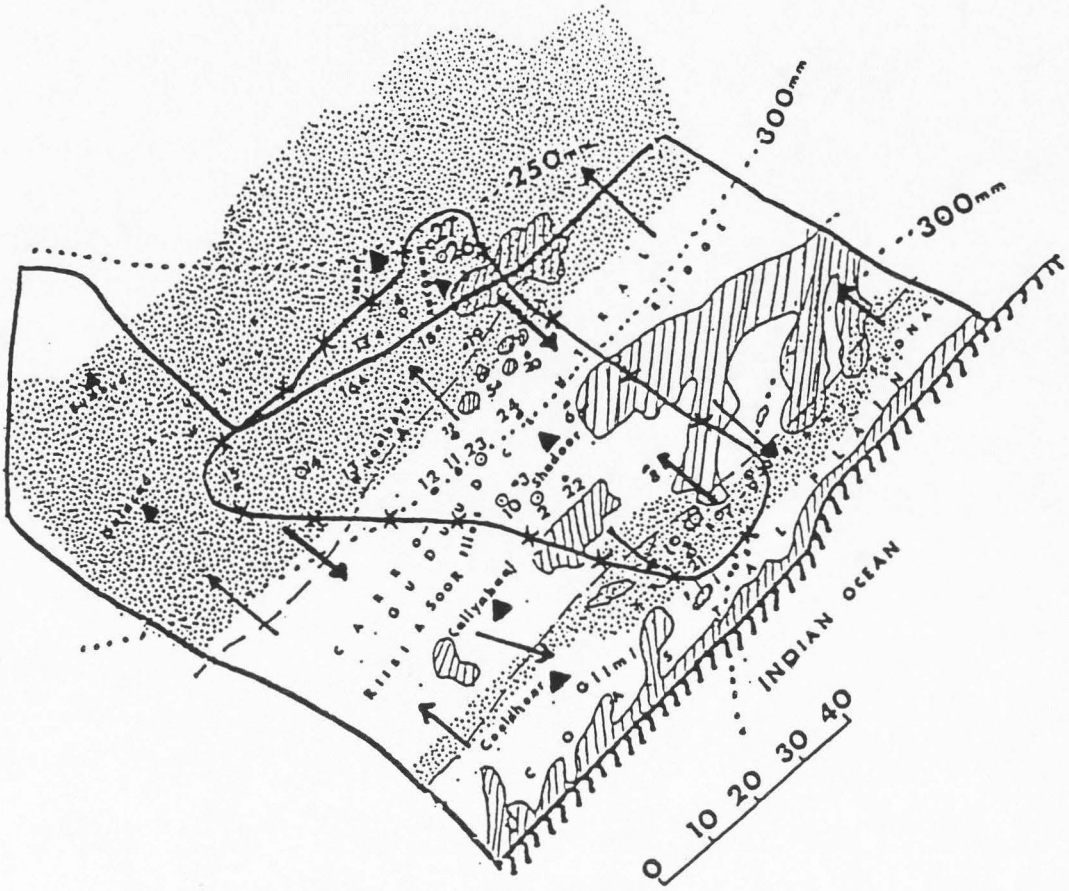

Figure 3.1. Principal early wet and late dry season foraging areas (dots) and direction of camel movement (arrows). Numbers indicate consecutive camel camps where they stayed between one week and one month.

sting. It deposits eggs under the skin of the animal or man where the developing larvae cause irritation and pain. They fly around the eyes and nose of the animals, preventing them from foraging. Camels move to the coastal plains as vegetation dries. Livestock tend to concentrate near wells along the coast in the late dry season.

Second, the dense shrubland on the Central Ridge, Carroguduud, are vacated during the first week of rainfall because of riibi and soor flies. These are very painful biting flies. The riibi fly, which is also a disease vector, outbreak occurs 9 days after the onset of rains. Camels are taken from known infested areas a few days before riibi outbreaks and stay away for about 6 to 8 weeks. Soor flies start the last week of riibi life cycle and stay for about 20 to 30 days. The riibi and soor outbreaks coincide with the peak of vegetation growth. Their life cycles set up natural rotational foraging which allows the Central Ridge to remain in good condition. It is believed to be the best forage producing area in the District. Because of biting flies, camels move either to the West, Buur (the third foraging area), or to the eastern Transitional zone, Xarar, for foraging.

Camels move back to the Central Ridge, Carroguduud, in late wet seasons and remain there until the mid dry season. In late dry season, camels concentrate around permanent wells outside the area.

Tick outbreaks also play an important role in selecting foraging areas. Camels are moved to avoid tick infestations even if plenty of forage is available in either one of these areas. Repicephalus pulchellus, R. longicoxatus, R. pravus, R. sanguinerus, Amblyomma lepidum, A. gemma, Hyalomma impeltatum and others which were not

identified are the most important ticks influencing foraging management in different physiognomic regions at different times of the year.

The length of time camels forage in one particular region, therefore, depends upon forage availability and outbreak of these flies and ticks. They graze and browse the least in the transitional ecotone, Xarar, and the most in the Central Ridge, Carroguduud, and West, Buur (Fig. 3.2). Other factors also influence the management of camels from one foraging region to another as follows:

1. Xarar - Transitional ecotone zone - Camels are moved to this zone for rubbing and body soothing. Without these physical activities, camels may become victims of a bone disease called garbaab which usually attacks shoulder joints, sometimes causing death. During the night calves are tied where there is plenty of fine dust particles for body soothing. The area is infested with a variety of ticks.
2. Carroguduud - The Central Ridge is the best foraging area for camels and other livestock. Intensive tick control is required when animals are in the area. An acaricide is used against ticks by rubbing it to the body surface of each camel once in every 10 days. Calves are tied at night in an Acacia nilotica shrub communities because camelmen believe it is warmer than any other vegetation communities during cool nights. Indicating the importance of this area to camels, pastoralists say "Geel Carroguduud waayey iyo rag kulan waayey iyo naago ciir waayey alla ha kaa deego" meaning

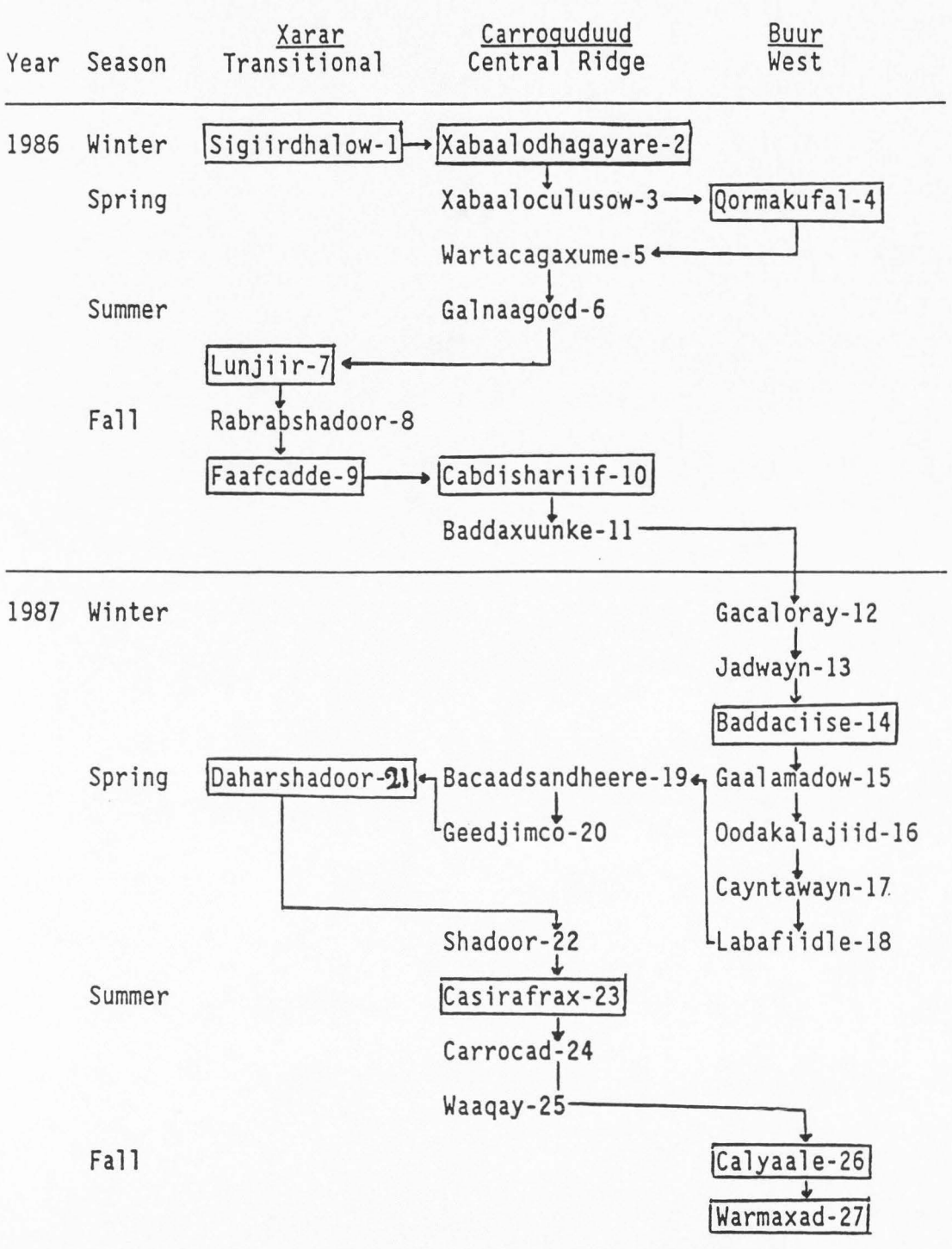

Figure 3.2. Seasonal camel movement in different physiognomic regions. Rectangles are areas camels are observed.

camels without Central Ridge and men without gatherings and women without skim milk is a curse, so pray God not to allow these to happen. In other words, camels break their hunger when foraging the Central Ridge, men get plenty of food and useful news in important meetings where fat animals are slaughtered and women get satisfaction when they have skim milk, their favorite food; without these, life is miserably worthless.

3. Buur - West - Camels are moved to this region because it has fewer ticks and young camels do better than other areas. Camels spend the night in old settlements where plenty of Acacia horrida and Solanium jubae shrubs and trees are available, perhaps, for wind protection or for early morning foraging.

Camels may forage in any one of these regions any time of the year. Traditionally herders spend about half of the year in Carroguduud and the other half in Buur. Major exceptions are during riibi fly outbreaks in the Central Ridge or when drought occurs. To a lesser extent they use the Xarar. Because of ticks and concentration of other livestock from the coastal plains in periods of gilmi fly outbreak, this Traditional zone is used only sparingly by camels.

Camels are specifically moved where better forage is available regardless of season or time of the year. They are always on the move. This movement is preplanned. A few men are sent to survey areas expected to have better forage. These men spend days or even weeks in their surveillance. If better places are found, they mark them.

Bushes are cut and placed where camps will be. Selected sites are usually old settlements. The scouts return home with the information. The marks are respected by all clans unless hostility exists among them. After a day or two, all camel camps move together to the new location.

If no better place is found, however, people stay in the same area but camp sites are frequently moved to old camping areas. They seldom camp in a new place. Camels are herded to different locations every day where evergreen species are available or where the vegetation stays green in the dry seasons.

Watering

Movement of camels from one place to another in search of good green forage minimizes the need for surface water. During wet seasons the study camels did not drink water. They produced well on the lush plants consumed. The plant species consumed contained, on average, 57% moisture. Average water content of plants eaten ranged from a low of 28% in the winter of 1987 to a high of 65.7% in the spring of 1987 (Table 3.2). Most of the plants were shrubs and their moisture content was more than 60% in the wet seasons. Even in the dry season, camels were herded where forage was plentiful with high moisture content (43%) (Table 3.2).

The study camels were watered only in the dry season and drought periods. The dry season was divided into three watering sessions (Table 3.3):

Table 3.2. Total number of plant species sampled, percent moisture contents of major plant species consumed by camels and physiognomic regions camels foraged in dry and wet seasons of 1986 and 1987 study period in Ceeldheer District.

	Dry Seasons			Wet Seasons		
	Summer 1986	Winter 1987	Summer 1987	Fall 1986	Spring 1987	Fall 1987
Total number of plants	23	30	43	47	56	61
Moisture (%) - Range	5-50	3-64	39-79	10-75	37-83	31-80
- Average	33.7	28.0	57.8	45.4	65.7	57.4
Physiognomic Regions	Xarar	Burr	Carroguduud	Xarar/ Carroguduud	Xarar	Burr
	Transitional	West	Central Ridge	Transitional/ Central Ridge	Transitional	West

Average moisture (%): Dry seasons = 42.7%
Wet seasons = 56.8%

Table 3.3. Average amount of water consumed daily (liters) in different watering sessions as the dry season progresses. The information is based on experience of lifetime camel herders.

Camel type	kalhoraad early dry season	kaldhexaad middle dry season	kaldambeed late dry season
≤ 5 years old	30	40	40
mature female	40	65	85
*mature male	50	70	100

*mature male drinks less if the interval of watering is shorter than 13 days.

1. Kalhoraad is the early dry season watering when shrubs and trees shed leaves, herbaceous species become dry, and the majority of green forage disappears. Signs of thirst become obvious in most camels. The interval between watering is two weeks; and amount of water consumed by camels is less than the following two sessions.
2. Kaldhexaad is the middle dry season watering when camels hunt for much reduced green forage and the few evergreen plants. Deciduous shrubs and trees bear no significant amount of edible forage, availability of dry matter is greatly reduced and the animal hardly obtains sufficient forage intake for survival. The interval of watering, on average is about 13 days. The amount of water camels drink is greater than the first session.
3. Kaldambeed is the late dry season watering when camels adapt themselves to the available dry forage. Animals, especially milking camels lose weight. Camels are watered at regular intervals of about 13 days. However, they consume the largest quantity of water compared to other two seasons.

The amount of water a camel requires in middle and late dry season depends on forage availability and its moisture content. Camels are moved constantly to where better feed exists. The animals are kept where the distance to water is not usually more than two days camel walk.

Pastoralists prefer to water camels between 9 a.m. and 3 p.m. When insufficient forage is available camels are watered in the morning. Owners believe that camels consume less water in cool hours of the day than during hot hours. They think it is not good for the health of the camel to let it overdrink on an empty stomach. Camels are allowed, however, to drink as much as they can when plenty of forage is available. The main objective is to increase feeding time which, in turn, increases food intake.

Ceeldheer pastoralists did not like to water their camels from wells with a motorized pump for two reasons. One is that the water smells of diesel and camels did not like the water. Camels also do not like to drink dirty water or water used by other livestock. Water is stored in metal tanks and is cooler in the morning than that from the well; thus camels do not drink to their capacity even in the hottest hours of the day when the tank warms up. Where there is a labor shortage and camels are well nourished, they are watered from the motorized well late in the afternoon. Otherwise, hand-drawn water is used before 2 p.m. When undernourished, however, the camels are watered from the tank in the morning so they will consume less water.

Camels often refused water in the morning even in the middle of the dry season, but drank a large quantity in the hot hours of the day. In cool hours of the dry season or when the camel skin is wet - due to high humidity accompanied by overnight dew or by light showers, which occurs occasionally - camels are not watered. In the long dry winter of 1986, the study camels were not watered for 40 days.

Camels forage throughout the day for the first few days after watering. They tend to forage only in the morning and evening cool hours of the day and rest in the hot hours (11 a.m. - 2 p.m.) as the watering day approaches.

The amount of water camels consumed was estimated through interviewing experienced lifetime camel herders. In the summer of 1986 (short dry season) and the winter of 1987 (long dry season) actual water intake was measured. Most informants agreed that camels drink more water in the winter than in the summer. To verify this, actual measurements were conducted in these seasons using a naar and a barrel (Table 3.4). A naar is a wooden trough or watering container, concave in shape holding about 1/4 of a 200 liter barrel. Both naar and the barrel (cut into halves) were placed side by side supported by wooden posts about a meter above the ground. Waadaan, a leather or plastic container with a long rope, was used to draw water from the bottom of a well more than 16 m deep. Two men alternatively pull out the waadaan full of water. A third man coils the rope behind them. The water is poured into the naar or barrel for the camels to drink. The number of waadaan that was poured into each container and the number of young and adult camels that drank were recorded. The quantity of water in the waadaan was determined using a graduated plastic bucket. The amount of water each group of camels would typically drink was calculated using the information obtained from the informants (40 liters for young and 85-91 liters for adult camels).

The quantity of water consumed from the naar was greater than from the barrel since camels were not used to drinking from barrels. Most

Table 3.4. Estimation of the amount of water consumed by camels in dry summer and winter seasons using actual measurement and information obtained from informants (lifetime camel managers).

Season	Watering		Camel		Amount of Water Consumed (liters)			
					Actual Measurement		Informants*	
	Interval (days)	Method	Number	Type	Total	Average	Total	Average
Summer, 1986	13	Naar** (Waadaan)	54	14 ≤5 yrs old 40 adults	3904	72.3	3960	73.3
Winter, 1987	13	Naar (Waadaan)	17	7 ≤5 yrs old 10 adults	1248	73.4	1190	70.0
	13	Barrell (Waadaan)	8	1 ≤5 yrs old 7 adults	508	72.6	677	84.6

*Average number given under imformants is based on estimate figures given by 14 experienced camelmen from 13 different camel herds -- 40 liters for ≤ 5 years old, 85 liters for adults (in summer) and 40 and 91 liters (in winters), respectively.

**Naar - is a portable trough or a wooden watering container about the size of 1/4 of a barrel, concave in shape. Waadaan is a leather or plastic container with a long rope used to remove water from the bottom of deep wells.

1 Waadaan = 32 liters (Summer, 1986)
= 24 liters (Winter, 1987)

camels refused to drink from the metal trough. Camels first smelled it and then turned away to drink from the naar. Only eight camels drank from the barrel.

For both summer and winter seasons, the interval of watering was 13 days. The water consumed from the naar was about the same in actual measurement (72.3 liters) and estimates from the informants (73.3 liters) in summer. In winter, however, estimates obtained from informants (70 liters) were lower than the actual measurement (73.4). The water consumed from the barrel, 73 liters, were less than estimates from the informants (84.6 liters). The actual measurement was taken about late mid dry season. Thus, the amount of water actually consumed agrees with the average amount of water informants estimated in late middle dry season (Table 3.3). However, this study does not confirm the camel herder's belief that camels drink more water in winter than summer. My figures show no real difference between seasons.

Permanent water sources are located in Ceeldheer (edge of Transition zone in the plain grassland), Nooleeye (border west and Central Ridge) and Bargan (West) (Figs. 2.1 and 3.1). One motorized pump well and a number of wells 16-35 m deep are found in each village. Ceeldheer and Nooleeye are about 50 km apart; Nooleeye and Bargaan about 35 km apart; Ceeldheer and Bargaan about 100 km apart: but in between these latter two villages half a dozen barkad (hand dug, cemented temporary water reservoirs) are available. There are no earthen water reservoirs available. The sandy soil throughout the District cannot hold surface water for more than a few hours after rain. Walls were built around the mouth of some wells. For others,

frames of tree trunks were placed on the mouth in a triangle form against which the rope of the waadaan was pulled. Most of the time people pull the container full of water up vertically. Water from most wells is salty, especially in Ceeldheer village. About 8 to 10 camels drink from the naar at a time.

The watering men chant, sing and yell meaningful camel watering songs (Abokor 1987):

> *... until the skin comes off*
> *the palms of the hands*
> *and the ligaments in man's ribs asunder break*
> *camels will not leave the well satisfied...*

Watering is done on the basis of first come, first drink. The camel herds are not mixed when watering. Each herd is watered separately one after another or simultaneously at different wells.

In general, camels are managed to obtain good forage and drink sufficient water in dry seasons, so that they will maintain themselves in good condition, resist dehydration and become more productive in the future.

Milking

Year long milk production make the camels the most valuable of all livestock in the Somali pastoral society. Management of males for breeding, castrating, culling male calves, and increasing female component of the herd are all techniques geared to secure continuous milk supply to meet food requirements of the family throughout the year. The most important management techniques of milk production developed and successfully practiced for centuries by the camel

pastoralists called "the secret of camel milking" and procedures used are:

1. Salaax (Salah) - Massage - is to produce milk flow without the presence of a calf and with or without using the skin of a dead calf. It is an easy way of inducing the camel to continue producing milk after its calf dies. Simply, the camel is called by its name or other sound expressions, stopped and the udder massaged with or without presenting the skin of the dead calf to her. Mature camels are normally treated this way. The length of milk production without a calf may last up to six months. This procedure is practiced when the family has enough milking camels and does not worry if one becomes dry sooner than expected. It is also used when the owner does not want to force the camel to accept a foster calf or wants to breed her earlier. Massage can be also used when calves are present.
2. Maqaar - Saar - Skin cover - is the use of a calf skin to stimulate milk production when a calf dies of natural causes or is culled by the owner at an early age. Butchering of male calves is common but female calves are slaughtered only during difficult conditions such as drought. Killing of calves makes more milk available for the remaining calves and for the family. The skin of the dead is removed and placed tightly on a foster calf held out of sight of the female expected to adopt

the calf. Fresh milk of the mother of the dead calf is sprinkled on the skin. The mother is then brought to the calf to be adopted. The owner stands between the calf and the camel and allows the female to smell areas covered by the skin of its real calf sprinkled with its milk while the foster calf is suckling. Usually, the camel accepts the new calf immediately; if not, the skin is left on the calf and the calf kept with its foster mother for 2-3 nights. If the calf is still refused, the camel is forced to accept the calf using the tolliin method (to be discussed later). In other cases the skin of the dead calf is used while milking. By using skin stimulation alone, the camel may be encouraged to continue milk production as long as other camels are with calves.

3. Sidig is the use of maternal fluids or afterbirth to bring the female into milk production when a calf is stillborn or culled at birth. Disease or malnutrition may cause some camels to give birth to dead calves before completion of the 13 months gestation period. In other cases the calf is slaughtered at birth. If a camel aborts after seven months of pregnancy, it can be induced to give milk. The stillborn calf is called dhicis (di'is). Most camels in good condition are not allowed to go dry. The eyes of the camel are covered with cloth. The dead calf is taken away. The youngest calf in the

herd or a calf whose mother does not produce sufficient milk is brought to the camel. The calf's mouth is held together with a rope so it will not cry or make noise that the female camel can hear. The fresh maternal fluid is rubbed on the calf's body and it is made to sit in front of the camel. The female is allowed to stand up and its eyes are uncovered. It smells the calf and after a few minutes the calf starts suckling. If the camel refuses the calf, it is lightly punished by bending one of its front legs upward and tying the shin to the forearm. The calf is tied in front of the camel. Standing on three legs, the camel's movement is restricted. It is forced to smell and see the calf. The owner unties the camel every hour or two to see if the camel will accept the calf. During the process the calf is not allowed to see its real mother. It becomes hungry and suckles as time progresses. The female camel seldom refuses the foster calf. If the calf is not accepted, tolliin, a more forceful method is used.

4. Goobqaad - is an adoption of a calf to a foster mother to continue a female in milk production. A process of confusion and disturbance is purposely created by the camelman to make the camel accept the new calf without physical punishment. This tricky technique is used to confuse the camel by replacing one calf with another. Two milking camels which give birth at about the same

time are used. Their calves are always tied together both day and night. Approximately four weeks after birth, when the mother camels forage a distance from the calves, the owner kills one calf. Immediately, he catches the remaining calf and takes it into a dense bush where it is difficult for camels to move freely. The calf cries and makes a horrifying noise. The terrified mother camels try to reach the crying calf. After some time of confusion the man releases the calf and guides it to the direction of the mother whose calf he killed. He prevents the real mother from approaching them. Surprisingly, the foster mother accepts the calf without hesitation as the hungry calf sucks the udder of the confused mother. After the calf finishes suckling, the real mother is allowed to join them. If the foster camel refused to accept the calf tolliin is preformed.

5. Tolliin is a physical punishment used on a camel to force it to accept a foster calf. This technique is used as a last resort when the camel refuses to accept the foster calf by any of the above methods. It is cruel and painful. At least two men are required to perform the procedure. The camel is tied by the head with a strong rope and made to sit down. One man holds the camel's lips, and forces it down on the ground. The other man ties the four legs together criss-crossed above the fetlocks and, in turn, ties them to a tree trunk if

necessary. The camel's anus is blocked by sewing its fleshy skin together or by using a specially prepared wooden clamp called Qaldhac or Qallax (qalda or qallah). The fleshy skin of the anus is pulled out and placed in between the two parts of the clamp. The clamp parts are brought together and tightly tied with a rope to prevent defecation. Breathing through the nose is also prevented by using two small sticks. One of the sticks is put between the lower and upper jaws. The other is placed on the nose in front of the nasal bone. Sometimes a single stick inserted inside the nostrils and wrapped with a rope is used. The sticks are brought together and wrapped with a rope. The camel can only breathe through its mouth. After a few minutes the mouth of the camel is covered with foam. One of the front legs of the camel is also fastened to the ground to prevent movement. The calf is tied to the fastened leg of the camel. Both the camel and the calf stay in this situation for 3 to 4 hours. Then the owner checks whether the camel accepts the calf or not by allowing it to breathe, defecate and be able to smell the calf. Normally after the first punishment the camel accepts the calf. If the calf is refused, however, the punishment will continue for up to 4 days. After that it either accepts the calf or is freed.

Camel herders believe that too much colostrum causes diarrhea and is dangerous to the calf. The consumption of colostrum by the calf is regulated. The remaining colostrum is milked either for human consumption, or most often, poured on the ground. If it is not milked out, it may cause udder infection or reduction in milk. In the first four days the flow is almost pure colostrum. If the camel is in good condition, has plenty of forage, and is genetically capable of producing more milk, regulation of the calf's milk consumption continues for about two weeks. The milk produced by most camels is sufficient for its calf and one adult person in the first few months. The camel can be milked any time but a 2 hour interval between milking or suckling is desirable. The quantity of milk per milking period decreases with the time interval between milking in the day. Normally, camels are milked two times per day (morning and evening).

Ceeldheer camel owners milk most of their camels for at least twelve months. Milk sufficient for good growth is given to the calf for the first six months. The calf stays with its mother day and night. The calf is separated from its mother when the camels are brought to the camp at 6 p.m. and again about 4 a.m. in the morning. The camel is milked for the family approximately three hours after calf separation. For the second half of the year, the family shares the milk equally with the calf. Two teats on most camels are protected from suckling. If the calf suckles two camels, one is completely protected by tying all four teats with specially prepared soft acacia fiber called <u>marag</u>. After milking the calf is allowed to suckle.

The camel teats are prevented from being suckled in a variety of ways. Either front or back two teats or right or left two teats but not diagonal teats, are tied together. Teats are protected alternatively so that the calf does not suckle the same teats every day. The unsuckled teats are believed to produce less milk. The calf is allowed to suckle 6 to 8 hours for the first-half of the year and 3 to 4 hours for the second half of the year. Milking camels sometimes get lost from their calves. Camels can go for about two weeks without milking before affecting the length of the milk production of the camels. Once milking starts again it takes only about 3 days for regular milk flow and normal taste to return. A prolonged period of two weeks or more without milking may cause a camel to go dry.

At birth, camelmen clean out the calf's mouth and nose and make sure that it breathes normally. They check it for injuries. Camelmen try to insure there is enough milk for the calves in the first 6 months. Growth rate depends on management given to individual calves. A study done in Kenya, among the Gabra and Rendille, indicates that calves allowed most milk gained 2.5 times more weight per day than those on limited supply of milk (Field 1979).

Traditionally calves are weaned between 12-18 months of age. Early weaning results in stunted growth. Early weaning is recommended only when forage quality and availability are poor. When early weaning is required, the calf is gradually weaned by tying most of the teats to deny it full access to the mother's milk.

In regular weaning, several techniques are used. One is jiil - a stick fork with four pointed ends tied on the top of the nose of the

calf to pierce the mother when it tries to suck. Another is tying big pointed thorns, spines, or needles to the teats. A third is inserting a wooden stick to the tongue of the calf or slicing the tongue to discourage the calf from suckling. Sometimes all these techniques may not be effective. In such cases, calves are separated from mothers for a period of time.

Calf mortality is high in the first one or two years (Table 3.1). One of the factors that contribute to early calf death is believed to be diseases caused by inappropriate teeth growth. When the calf is about one year old certain teeth which are believed to cause physiological disorders and excessive dizziness are removed by gum surgery with a pointed knife or dagger before they emerge. The presence of these teeth is recognized by symptoms such as abnormal regurgitation and chewing and lack of foraging, loss of activities and weight loss.

Camel milk is consumed fresh or sour. It can be preserved for weeks without special treatment except for sterilizing containers with smoke. Camel herders have different names for different stages milk goes through before consumption:

1. Fresh - dhay - salty-sweet, laxative
2. Transitional stage - Waraaba-qandhis - looks like melted white wax, not favorable to drink.
3. Sour (in different successive stages); major stages are:
   a. Suusac (suusa) - 1st stage
   b. Gadhoodh - 2nd stage
   c. Dhanaan - 3rd stage

d. Jinow - 4th stage, separated into solids and watery fluid, may cause chest burn.

Camel pastoralists also divide milk into three categories according to nutritional quality:

1. Birth to four months - Subaq - meaning butter - implies full of fat, most nutritious.
2. Four to eight months - Soor - meaning food, also very nutritious, whoever drinks may not need other food.
3. Eight months to the end of lactation - Sun - meaning poison. This does not mean real poison, but indicates that one cannot survive with camel milk alone. It is least nutritious and water component is very high.

These classifications of milk by experienced camelmen have not been proven scientifically. However, data suggest that camel milk is nutritious and high in minerals and vitamin C during early lactation. The water content of camels milk increases during the latter stages of lactation or in time of drought (Knoess 1976, Ohri and Joshi 1961, Shalash 1979, Yagil 1982).

Role of Camelmen

Analysis of camel management is far from complete without discussing the role of camelmen. The life of Ceeldheer pastoralists is based on livestock. Camels are especially important because they supply them milk, meat and transportation. Camel owners, in turn, take care of the camels. Their most important task is to find forage and water for them.

Pure nomadism seems to be disappearing in the Ceeldheer District. Here pastoralists are involved in shifting agriculture. While some grow beans and sorghum, others keep the original life of livestock herding.

Camels are a source of pride and prestige for the people. Camels are herded according to their needs, enjoying freedom of movement from one place to another. This free movement of camels keeps the vegetation in good condition and minimizes desertification.

Camel herding is hard, tedious and tiresome. Days are spent in the scorching sun of arid and semiarid areas. Despite this, camel herders are proud of their work and their ability to withstand hunger and thirst more than other livestock herders. They live in complete independence and self-confidence. They are very careful in decision making because the slightest mistake they make may be fatal. Each decision is one for survival.

The camel owners live simply and free. They dislike outside pressure from authorities beyond their control. They can go without food for days and never complain. When a camelman travels long distances in search of lost camels or for other important purposes, he does not take food with him except for a few liters of water to sip when he feels thirsty or prays. Food is provided by people in camps he visits. He wraps himself with a sheet or blanket and sleeps on bare ground. He rests on grasses under the shade of trees in the day time or close to shrubs for wind protection at night. Most of the time camel herders wear no shirts, but they seldom walk without shoes.

They are strong believers in Allah. When food and water are scarce, they never despair but strive with an absolute confidence in Allah. They seem free of fear and worry because of their strong beliefs in God and confidence they have in themselves.

They know their environment very well. They have names for all plants, soil types and they can clearly explain in detail, the topography and landscape wherever they once herded their camels. Types of plant growth, growth form, species diversity from one area to another, camel preference in different seasons of the year, plant saltiness, flowering time of each species, etc. are well documented in their minds. They can easily differentiate which plant species increase milk production when eaten by camels or tell from the smell of the milk the plant species camels consumed. They know those plant species useful for medicinal purpose.

Camel herders are capable in distinguishing their own individual camels from their friends' or clan's by their foot prints; pace; toe size and shape; sound, age and size of camel bell. They can tell from foot prints whether the animal was loaded or not, tired or fresh, lame or had only one eye; walking or foraging; thirsty or watered, and so on. They also distinguish people by their footprints and type of shoes they wear. Gauthier-Pilters and Dagg (1981) reported similar observation in Northwest Africa.

Pastoralists can walk hundreds of km in a roadless wilderness without losing their directions. Even at night they find their destination using stars for guidance. They have exceptionally good memory. They easily remember the smallest details of important events

that happened decades ago and pass them to younger generations orally in a story or a poem.

Camel owners become very suspicious when they encounter something new or extraordinary. My camel research is a good example. Camel owners had never seen anyone count the number of bites of animals, watch the movement of the camels lips from dawn to dusk without interruption, tie pedometers on the legs of the camels, collect plant species camels consume, or measure temperature and relative humidity with shining glasses (i.e. thermometers). It was a mystery to them.

At the first calving season following my presence camels gave birth to more male than female calves. A drought followed in the fall which was supposed to be a wet season. Camels gave less milk and refused to be bred. Some of the men concluded that my presence was bad luck to their livestock and themselves. They decided not to let us follow their camels. Every time they prayed, whenever they came together for important meetings, or in religious ceremonies, they begged God to destroy anybody whose intention was to harm them.

Because of their strong beliefs in Allah and the respect they have for their sheikhs and elder leaders, they left the ultimate decision to them. I was only following one of their sheikh leaders' camels. He approved our study. Others forgave us and allowed us to continue the study.

In another incident some camels became sick in the spring rainy season while we were with them. About 13 camel herd owners came together and decided to beg God to cure the camels. They slaughtered sheep and read Quraan the whole night. The evil among them departed.

The neck of individual camels were tied with a thread of sheep skin. They do the same thing for sick people, too. This type of religious curing is called Quraan Saar.

Despite the superstitious beliefs, the camel owners of Ceeldheer District are polite and respectful among themselves. They observe a hierarchy essential to the families, kins and clan survival in their hostile environment full of enmity. The existence of strong social bonds and traditional clan structure advocates interdependence of pastoral societies and efficient manipulation of their ecosystem. Herdsmen come together not only to exploit their natural resources better, but to protect themselves against misfortunes and insecurity. Exchange of livestock within and between groups is a common practice to spread risks and build supportive relationships.

Elders are specially respected for their experience. Their advice is always considered in decision making. Meetings are held to learn from each other and to study each other while drinking tea. Serious issues such as rain, herds, movement, etc. are discussed afterwards. Each person in the meeting drinks at least three cups of tea before sheep or goat meat is served with rice or beans. Pastoralists drink tea saturated with sugar for energy when milk is not plentiful. Otherwise, milk is the most important food served with meat, rice, beans, etc.

Camel milk is the most valuable food; whoever has it proudly offers it to his guests. It is also used as a substitute for water when the latter is scarce and difficult to obtain. For forty-eight hours, in the middle of fall drought season, we did not drink water.

We left our vehicle in Shadoor village about 25 km away. One week's ration and 40 liters of water were loaded on a camel's back. After six hours of night travel, we reached the camel camp. It was planned to use the water for drinking and cooking only. Foregoing washing faces and hands was not uncommon during the study period, even in the wet season. On the third day 6 liters of water were remaining for us. In the evening of the same day we found ourselves without water. Some camel searchers drank while we were away from the camp with the herd. It was too far to fetch water and there was no water to cook with. Fortunately, lack of water is not new to the pastoralists. They poured three kg of sorghum directly on wooden containers full of hot ash and roasted it. Dry pop-sorghum with plenty of camel milk was served for dinner. It was really delicious. No wonder camelmen say, "water is soul but camel milk is life" (Yagil and Etzion 1985). Even though camel milk is the most important component of the pastoralists' diet, Ceeldheer pastoralists consume agriculture products such as beans, rice and flour when they are available.

Hospitality is necessary for the nomads in their daily activities. Visiting, talking and dancing (for youth) are some of the most important entertainment in their migratory life. In their poems, songs and riddles, camels are the most precious animal. They are compared to the most beautiful women, the most precious jewels and the finest weapons (Abokor 1987).

The rainy season is the peak of labor shortage in Ceeldheer District pastoralists. Camels and small ruminants are moved far away from home areas due to riibi and other biting fly infestations. During

this time farming is conducted on the privately held plots. Labor has to be divided into farming, camel herding and small stock husbandry. Some people go to herd livestock. Others are left behind to farm or send children to the Quraanic school. The livestock grazing areas and farm locations are, most of the time, more than 100 km apart and require days to travel from one to the other.

Decision Making

Decision making in pastoral society is not simple. In Ceeldheer District pastoral community, settling an issue involves two different processes. One is when dealing with external agents (government, researcher). A simplified decision flow between the pastoral community and external agents and within pastoral groups is shown in Figure 3.3. The other involves internal pastoral community practices such as livestock management, security and religious decisions.

The pastoral community leaders are the governing body in decision making processes. The clan or subclan members together with the government choose a person from the clan leaders to serve as a linkage between the pastoral community and external agents. This person is called nabaddoon, peace maker, or seeker.

The nabaddoon carries proposals (for example development projects, research studies, etc.) from external agent to pastoral community leaders. The proposals are studied and digested by the religious and community leaders in a series of meetings. Before they reach any conclusion, they call a general meeting for the community members and

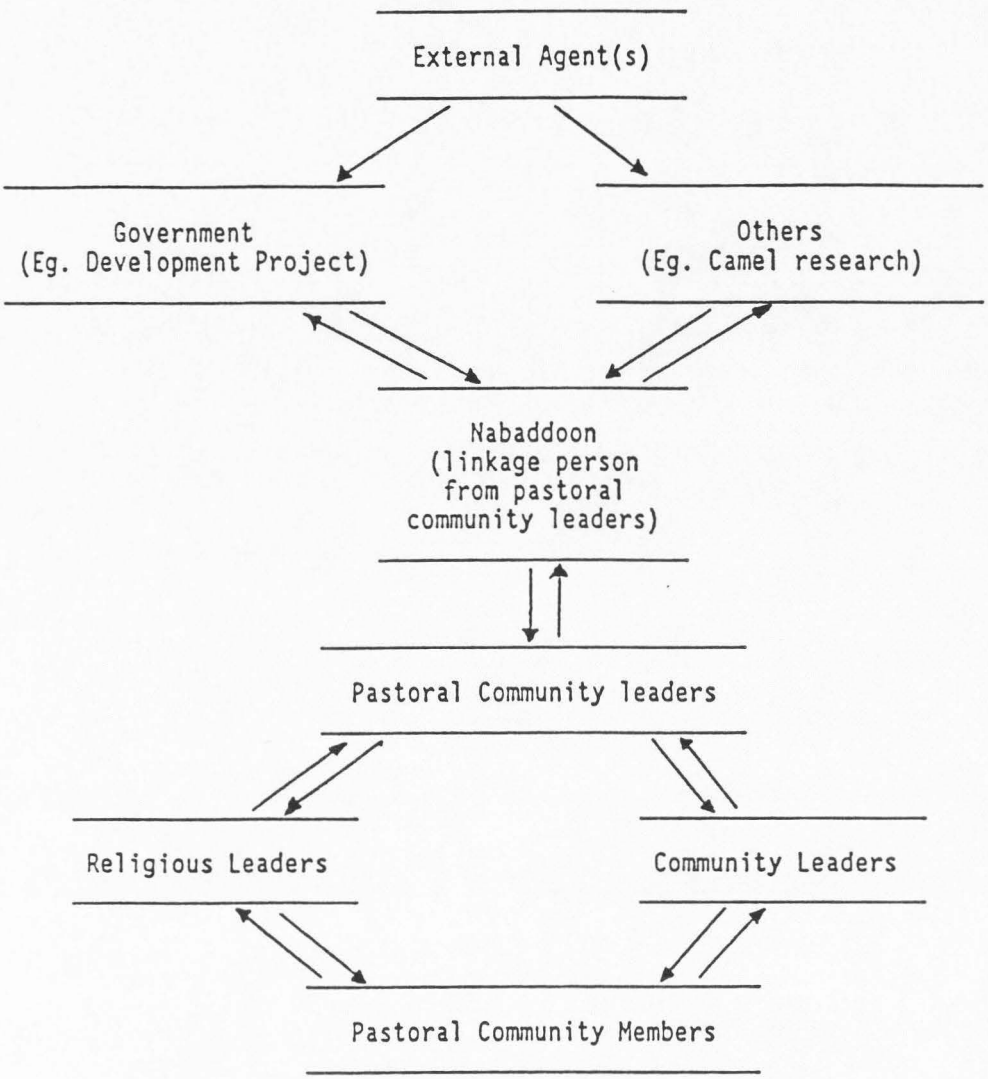

Figure 3.3. Simplified decision flow between pastoral community and external agents in Ceeldheer District.

make the final judgement. The decision is passed to the external agent through the nabaddon.

Management decisions such as movement of livestock from one place to another are made by pastoral community members with the consent of their leaders. Religious meetings are traditional and generally decided by religious leaders.

Decisions concerning security between clans, subclans or within kin groups are made by the governing body. When foraging, farming, watering, etc., disputes arise, the pastoral community members report to their leaders. The leaders thoroughly study the issues. They dispatch a fact finding mission. When the mission gathers sufficient information, the leaders either make their own final judgement or call a general meeting for the community members depending upon the seriousness of the dispute and reach a verdict on the spot or later. They always try to avoid external involvement in solving their problems even if it is between two rival clans.

The clan coherence is relatively strong in Ceeldheer District pastoral society. They have centralized authority within as well as outside the clan. Although the community leaders have full authority in decision making, they are not absolute rulers but share the power with their clan members, including young camelmen, for the welfare of the community.

Conclusion

Ceeldheer camel owners are rational and goal-oriented in their livestock husbandry and management. They are aware of the need to

conserve their grazing lands and highly cognizant of the benefits to be gained from their camels. The great attention they pay to productivity, endurance, drought and disease resistance in selecting breeding stock are indications of wise traditional management. Camel raising within the pastoral system is an arduous enterprise. The viability is fragile and can be easily destroyed as the system itself is subjected to increasing pressure from within and outside. However, camel pastoralism is the only efficient way of exploiting most of Ceeldheer District where cultivation is almost impossible due to the nature of the soil and vegetation. Farming and intensive livestock breeding do not seem appropriate at this moment and will only lead to irreversible destruction to the successfully existing pastoral-vegetation-animal equilibrium. Creation of sufficient economic development to provide permanent employment in pastoral areas needed to intensify agriculture production in rangelands is not feasible either now nor in the near future. It is, therefore, important to identify successful means of improving and, at the same time, preserving camel pastoralism as the base for future development. To achieve this, integrated research that accounts for the customs, lifestyle, internal logic--both social and economic--of the pastoralists system is necessary.

CHAPTER IV

FORAGING BEHAVIOR OF CAMELS IN CEELDHEER DISTRICT: ACTIVITY TIME BUDGET, DISTANCE TRAVELLED AND EFFECTS OF WEATHER CONDITIONS ON FORAGING BEHAVIOR

The amount of time camels spend on foraging activities is neither clear nor specific in available literature. In Afar territory of Ethiopia, camels browse primarily in the wet seasons and graze in the dry season (Gebremariam 1987). The normal foraging time for Afar camels is from sunrise to sunset. In the Sahel of Africa, Wilson (1984) indicates that on good, medium and poor quality forage areas, camels require 4, 6-8 and 10 or more hours for feeding. Gauthier-Pilters (1979) estimates the foraging time required 10-12 hours a day. Newman (1979) states camels feed about 6 hours and ruminate 6 hours in a 12 hour day. In Northern Kenya, Pratt and Gwynne (1977) report that camels rest more than 6 hours without feeding when thirsty in the dry seasons.

The foraging time reported in the existing camel literature does not reflect the actual time the animal spends specifically on plant consumption. It includes the time spent on movement from one plant or group to another when foraging. My study provides more accurate and reliable information on foraging time allocation by camels in their natural environment. It gives an insight into understanding the effective time budget of the animal in different activities (foraging,

rest rumination, rest idling, bone chewing, milking/suckling, walking-includes scratching, rolling, rubbing), distance travelled and effect of weather conditions on foraging behavior in dry and wet seasons. My hypotheses were that camels increase foraging time in the dry seasons; do not reduce foraging activities during hot hours of the day in different seasons; exhibit no change in daily distance travelled and that temperature and relative humidity do not affect foraging behavior of camels. The specific objectives were: 1) to determine the length of time spent on different activities, 2) to determine whether camels lower activity during the hot hours of the day, 3) to determine diurnal distance travelled by camels in different seasons and 4) to determine influence of temperature and relative humidity on foraging time.

Methods

Foraging Behavior

The study was conducted in Ceeldheer District, Central Somalia. Ten camels (five milking, five non-milking) were randomly selected for individual observation. The camels ranged from 6-15 years old and were in good condition. Milking camels were in the same stage of lactation (i.e. they gave birth in Spring, 1986). Each camel was observed 12 hours a day in each season for 6 seasons in 1986 and 1987 study period. Observations were made in morning (6-10 a.m.), midday (10 a.m.-2 p.m.) and evening (2-6 p.m.) to see if camels forage differently during hot or cool hours. The observations started, not on calender date, but on the onset of rains. They occurred at approximately five to fifteen days after rainfall in the wet-season and about the middle of each dry

season. The Winter and Spring of 1986 observations were used to design and initiate the study. Quantitative data from those periods were not used in the analysis. Data were collected with consistent methods in the Summer and Fall of 1986 and Winter, Spring, Summer and Fall of 1987 and were used for this analysis.

Observations started about 6 a.m and continued to about 6 p.m. The camel selected for study each day was followed without interruption. Actual bite counts by species and time spent on each bolus were recorded. The time of the day at which any other activities occurred and the amount of time spent in various activities were also recorded. Three persons (the researcher and two technicians using stop watches) recorded the bite counts and time spent on each activity. These three people (a recorder and two bite and time counters) were used to assure accuracy in seeing the camel in dense shrub. Camels move frequently between shrubs or protrude their necks inside thick bushes. To get accurate bite and mouthful counts, the three persons stood in a triangle around the foraging camel. One person was always in a position to clearly see the mouth of the camel and identify its movements. The three man team allowed an observer to take a short break without interrupting the observation. Camels were used to close human presence and, therefore, our presence did not alter their behavior.

The major activities observed and their definitions are as follows:

1. Foraging--act of feeding which includes browsing and grazing in which the camel moves its head down, up, or sideways

from plant or branch of plant to another, taking a number of bites which makes a mouthful.

Browsing--consumption of trees and shrubs by the camel. When browsing, the camel was in an upright position with its head upward, sideways, parallel to its shoulder, above its knee or high up above its hump, stretching its hind legs backward and front legs perpendicular to the ground, sometimes one hind leg relaxed, depending on the height of the plant consumed, taking a mouthful of browse at a time, relaxing its head, chewing and swallowing.

Grazing--consumption of grasses, forbs and herbaceous softwood shrubs (suffrutescents) below the camel's knee. The camel grazed by moving its head horizontally from plant to plant, taking a mouthful of herbage, straightening its head upward parallel to its hump, chewing and swallowing.

Foraging time--total time spent in browsing and grazing during the 12-hour observation period.

2. Rest Rumination--standing or sitting in an upright position without locomotive activity, chewing its cud or involved only in regurgitation, remastication and reswallowing of ingesta.

Rest Rumination time--total time spent in rest rumination.

3. Rest Idling--standing or sitting in an upright position without being engaged in any other physical activities except occasionally protecting itself from irritating insects.

Rest Idling time--total time spent in rest idling.

4. Milking/Suckling-the activity of inducing the camel to give milk either by massage, initial suckle of the calf followed by milking and suckling, or simply suckling by the calf alone. In both cases, the camel stands still but may defecate and urinate before milk let-down and may ruminate throughout milking/suckling process which usually takes 3-5 minutes.

   Milking/Suckling time--total time spent in milking/suckling.

5. Bone/Soil Chewing--the activity of picking up bones, snails or licking termite mounds.

   Bone/soil chewing time--total time spent in chewing bones or licking soils.

6. Other Activities--include walking, holding its head upright, from one place to another or from one plant to another while foraging, scratching parts of its body against a tree, or rubbing its body in dust, drinking rain water, or social interaction. Total time spent on these activities was obtained by difference from the 12-hour observation time.

Night observations included general husbandry practices and limited individual animal observations. The camel herd was brought near the camp each night at about 6 pm. All camels spent the night together in an open, unfenced, natural area. Calves were tied to trees

or shrubs. In each season, individual camels were observed for three nights by recording browsing and grazing occurrence only.

Temperature and Relative Humidity

Temperature and humidity measurements were taken to correlate the effect of heat with the foraging behavior of the camels. Three standard laboratory thermometers were hung under the shade of a tree 20 cm, 150 cm, 200 cm above the ground. The hanging heights simulated the average vegetation height: 1) herbaceous, 2) low shrubs, and 3) high shrubs and trees that comprise diets.

Relative humidity was measured and recorded at hourly intervals (also for temperature) during the 12-hour camel observation using a dry-wet bulb hygrometer. The wet bulb was filled with distilled water and kept full for the whole day.

Diurnal Distance Travelled

The daily distance travelled by camels was estimated by using digi-pedometers. Three to four camels were randomly selected from each type of the 10 experimental camels. Two pedometers were tied on the front legs of the camel above the elbow pad. The pedometers were protected by a wooden box and tied in the safest place to prevent damage when a camel occasionally rolls itself on the ground. After each 12-hour observation, the pedometers were removed from the camel and readings recorded. The pedometers were previously calibrated by driving the camels to a known distance. From the readings an adjustment factor was calculated. This factor was used to relate the

pedometer readings to the actual distance walked by the camel during 12-hour foraging period.

Statistical Analysis

A factorial experimental design was used that compared two camel types (milking, non-milking) and two moisture levels (dry, wet). The individual camels and seasons were nested in animal type and moisture levels, respectively. Repeated measurements were made for 10 camels over 6 seasons. Analysis of variance was done using Statpack FCTCVR local statistical computing package. LSD procedure was employed to compare individual means (Cochran and Cox 1957).

Results and Discussion

Activity Time Budget

Foraging Time

Foraging time spent (%) by milking and non-milking camels was different ($P < .05$) in three of the six seasons (Fig. 4.1). Milking camels spent more time foraging than non-milking camels in the long, hot, dry winter (5.2 and 4.6 hrs, respectively; Fig 4.1, Appendix Table 2). The increased feed demand to satisfy lactation apparently caused the milking camels to allocate their time towards gathering feed. This foraging behavior could have accounted for the weight loss of milking camels in winter; but at the same time, helped them to continue to produce sufficient milk for their calves.

Milking camels spent less ($P < .05$) time foraging than non-milking camels in two of the three wet season (Fig. 4.1). The time allocated

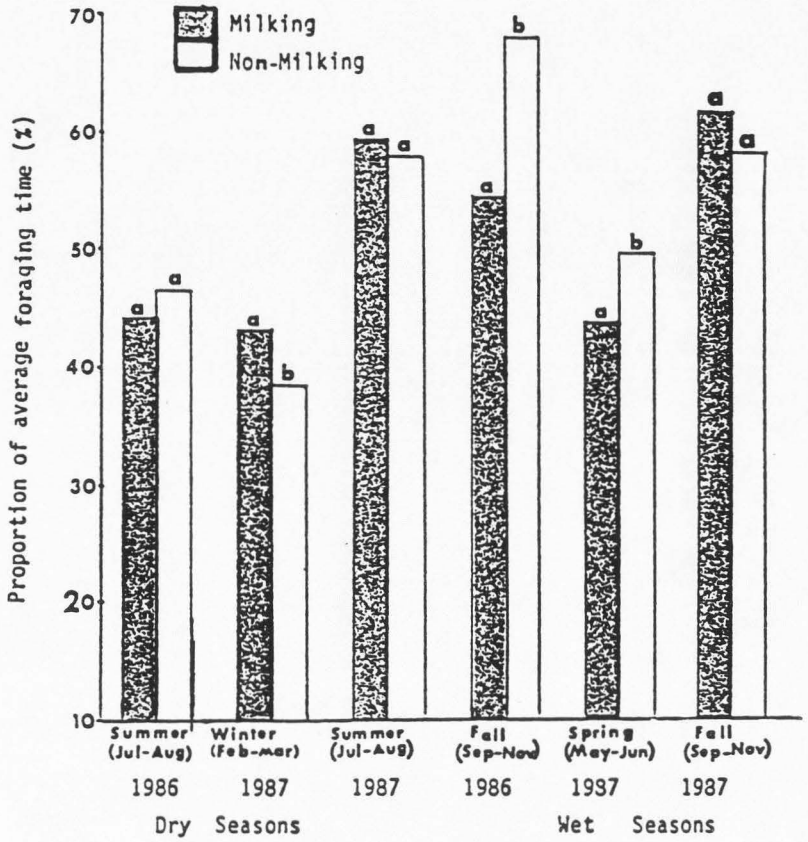

Figure 4.1. Proportion of average foraging time (%) spent in each season by milking and non-milking camels. Different letters above bars for the same seasons indicate significant difference ($P < .05$).

for foraging in fall 1986 by milking and non-milking camels was 6.5 and 8.1 hours, respectively. In spring 1987, milking camels spent 5.2 hours foraging while non-milking camels spent 6 hours (Appendix Table 3). This may be due to the fact that milking camels stayed with their calves longer since forage availability was not a limiting factor. Forage abundance, high moisture content of the forage, breeding male disturbance, frequent rainfall and high humidity were factors that probably lowered the feeding time of spring season for all types of camels (Table 4.1).

The camels rose from sitting or lying and stretched, extending their hind legs. They usually stood for 5 to 15 minutes and ruminated after rising. The calves also rose with their mothers, but returned to sitting since they were tied. The camels started foraging at about 5-6 a.m. Milking camels foraged close to their calves while dry camels moved further away from the bedding ground. Camel activities for 12-hour observation period broken down into morning (6-10 a.m.), midday (10 a.m. to 2 pm.) and evening (2 to 6 p.m) are presented in Figure 4.2 and Appendix Table 4 as pooled averages obtained from all observations.

About 7 a.m. in the dry seasons and 9 a.m. in the wet seasons calves were released and the camels milked. Calves foraged with their mothers after milking throughout the day and suckled at about 3 hour intervals. The camels searched for their calves if they were not with them. They nursed the calves as the day progressed. The camels always tried to have their calves by side while foraging or resting. Camels called their calves continuously while foraging till the calves came to view. Then the camels stopped calling and stood waiting for their

Table 4.1. Camel activities (time in hours), distance travelled and weather conditions in different seasons.

Season		DT (km)	Time Spent (hours) F	RR	RI	BC	W	C	%RH
Dry Summer (J-A)	1986	---	5.44	0.33^{ab}	0.06^{a}	1.15^{b}	4.89^{b}	27.54^{a}	66.08^{b}
Winter (F-M)	1987	5.74	4.90	0.80^{b}	2.39^{b}	0.02^{a}	3.51^{a}	31.24^{b}	48.20^{a}
Summer (J-A)	1987	5.66	6.95	0.03^{a}	0.06^{a}	0.06^{a}	4.83^{b}	27.85^{a}	64.36^{b}
Wet Fall (S-N)	1986	---	7.31	0.14^{a}	0.23^{a}	0.00	4.21	30.03	61.32^{a}
Spring (M-J)	1987	6.24	5.60	1.11^{b}	1.15^{b}	0.01	4.04	29.26	80.10^{c}
Fall (S-N)	1987	6.00	7.17	0.48^{a}	0.43^{a}	0.02	3.94	29.96	68.00^{b}
Dry Seasons		5.70^{a}	5.76	0.39	0.84	0.40^{a}	4.41	28.88^{a}	59.55^{a}
Wet Seasons		6.12^{b}	6.69	0.58	0.60	0.01^{b}	4.06	29.75^{b}	69.81^{b}

[a] Columns with at least one common letter or no letter superscript are not significantly different ($P>.05$) from each other.

M=Milking camels
NM=Non-milking camels
DT=Distance travelled
F=Foraging time
RR=Rest rumination time
RI=Rest idling time
BC=Bone chewing time
W=Walking (include scratching).
°C=Degree Centigrade
RH=Relative humidity

calves to come to them. They either nursed or foraged upon reaching their mothers.

At about 6 p.m. the camels were herded to a bedding ground close to the camp. If the bedding ground was not reached by dark, the camel herd was driven, forming several walking lines following a leader, the remaining distance to the camp. Some camels continued foraging around the bedding ground after dark. Foraging usually stopped at about 7 p.m. All camels came together in groups, sat, and started chewing their cuds. Some camels slept stretching their long neck parallel to the ground.

The total time spent on foraging was the actual time spent on biting, chewing and swallowing. Camels foraged more intensively in the morning and evening in the dry seasons; but, milking camels increased foraging time from morning to evening while non-milking camels foraging time decreased from morning to evening in the wet seasons. However, foraging times are not different statistically (Fig. 4.2, Appendix Table 4).

During wet seasons camels foraged selectively among plant species and within plant parts. They ate more young twigs, flowers and pods or fruits. In late morning and late evening they ate avidly and were not easily distracted from the plants. Sometimes camels sniffed the forage plant species before grabbing them.

In the dry season, however, camels nibbled leaves from matured twigs, extended their long neck inside bushes to get protected tender inner growth or concentrated on evergreen species.

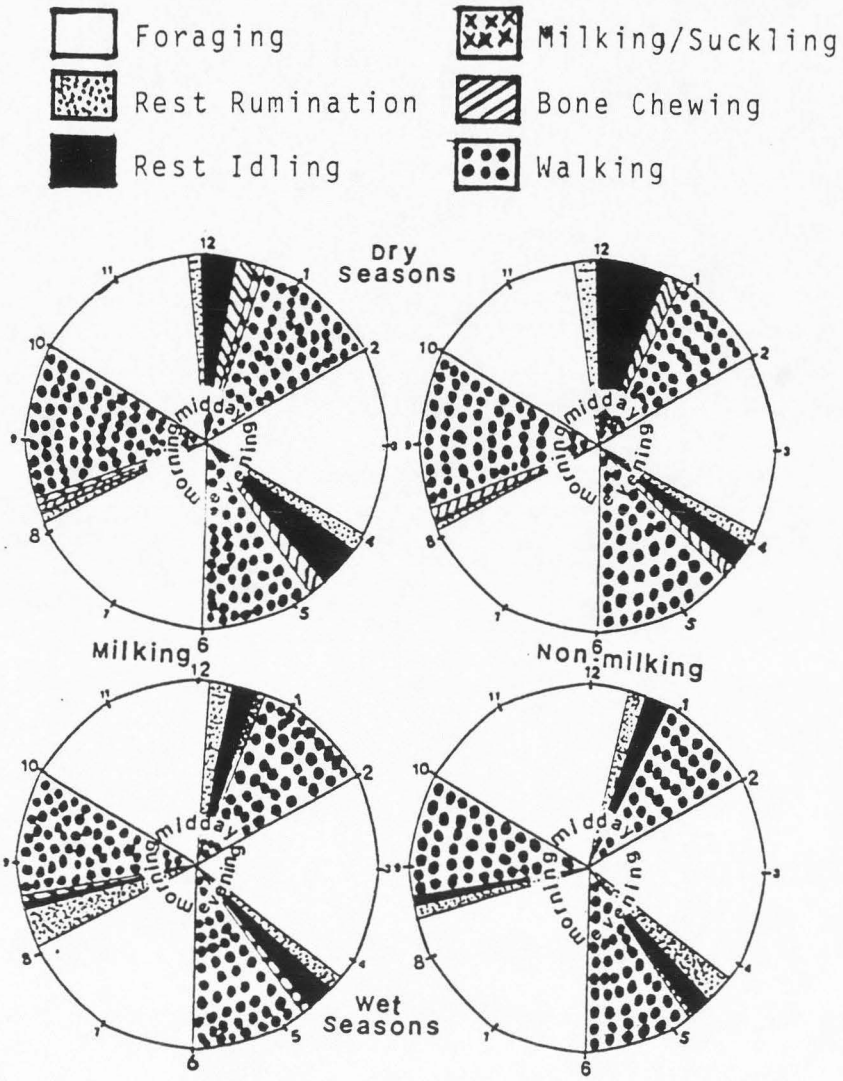

Figure 4.2. Average length of time spent in three periods of the day in different activities by milking and non-milking camels in dry and wet seasons.

In summer 1986, 1987 and Fall 1987, there were no differences ($P>.05$) between milking and dry camels in the time they spent feeding (Fig. 4.1, Appendix Tables 2 and 3). Herding could be a major factor; because camels were always driven to where forage availability and quality was expected to be superb.

Within dry or wet seasons, no difference ($P>.05$) was detected between milking and non-milking camels on time allocation for foraging (Table 4.2). Both camel types spent less time feeding in the dry seasons than in the wet seasons. However, between seasons, non-milking camels foraged for significantly more time ($P<.05$)in the wet seasons than in the dry seasons while no significant difference was detected for milking camels (Table 4.2). Milking camels were observed gathering sparsely available green forage in the dry seasons. This may have been to compensate energy lost for milk production in the dry seasons. In the wet seasons, they spent more time nursing their calves and ruminating.

Variety of forage species seemed quite important for the camels' diets. They ate almost every plant species encountered but consumed different amounts. Both milking and dry camels depended on hardwood and herbaceous shrubs more than grasses. Camels continuously foraged many different trees, shrubs, vines, grasses, forbs and succulents. More grass species were consumed in the dry seasons by non-milking camels than milking ones. Certain plants were regrazed during all seasons while others were foraged one season or another. These results are discussed in detail in Chapter V.

Table 4.2. Milking and non-milking camel activities (time in hours), distance travelled and weather conditions in different seasons.

Season	Camel Type	DT (km)	Time Spent (hours) F	RR	RI	BC	W	C	%RH
Dry	M	5.43	5.86[ab]	0.34	0.84	0.46	4.30	29.05	60.40
	NM	5.97	5.66[a]	0.44	0.83	0.49	4.52	28.71	58.69
Wet	M	6.16	6.38[bc]	0.72	0.53	0.01	4.17	29.69	72.70
	NM	6.14	7.01[c]	0.44	0.68	0.01	3.96	29.81	67.34
All	M	5.79	6.12	0.53	0.69	0.24	4.24	29.37	66.34
	NM	6.06	6.34	0.44	0.76	0.24	4.24	29.26	63.02

[a] Columns with at least one common letter or no letter superscript are not significantly different ($P>.05$) from each other.

DT = Distance travelled
F = Foraging
RR = Rest rumination
RI = Rest idling
BC = Bone chewing
W = Walking (including scratching, rolling, rubbing)
C = Degree Celcius
RH = Relative Humidity

Milking and non-milking camels spent 6.12 hours and 6.34 hours foraging, respectively during the 12-hour observation period (Table 4.2). Lactating camels spent more time foraging in winter (long hot dry season) than dry camels, perhaps to compensate energy lost to milk production. Thus, the hypothesis that foraging behavior of milking and dry camels does not change in different seasons is rejected for winter (Fig. 4.1, Appendix Table 2).

Camels spent less time foraging when forage dry matter availability started deteriorating in summer 1986. The air temperature increased and forage abundance and quality decreased. Following summer 1986 (short dry season), the fall season became a drought followed by winter (long dry season) (Table 4.3). In these seasons bite size was reduced as a result of reduced dry matter availability and, therefore, camel conditions deteriorated.

Camels spent less time foraging in spring 1987 than in fall 1986 or 1987 wet seasons. Several reasons contributed to this reduced foraging time in the best forage production season of the year: 1) frequent daytime rainfall, 2) high moisture content of the vegetation which caused more water intake, 3) large bite size because of high proportion of leaves, young tender twigs, and overall lush growth of plants, 4) herding of camels, and 5) disturbance and foraging interruptions by breeding males.

Deterioration of camel condition was apparent in fall (drought) and the camels continued losing weight throughout the winter (long, hot dry season). This was mainly because of low forage dry matter availability which, in turn, resulted in small bite size. Camel

Table 4.3. Forage availability, bite size, and camel condition ratings in different seasons of the year as they occur naturally based on ocular estimation during 1986-1987 study period.

Moisture	Season	Forage Availability	Bite Size	Camel Condition
Dry	Summer (Jul-Aug), 1986	medium	medium	good
Wet (drought)	Fall (Oct-Nov), 1986	low	small	deteriorating
Dry	Winter (Feb-Mar), 1987	lowest	smallest	poor
Wet	Spring (May-Jun), 1987	highest	biggest	recovering
Dry	Summer (Jul-Aug), 1987	high	big	good
Wet	Fall (Oct-Nov), 1987	highest	biggest	good

stomachs never bulged out at the end of the day in these seasons as it did in spring and fall 1987 wet seasons. Based on information obtained from experienced camelmen and my actual observation of camel conditions during the two year study period, it was obvious that camels went to bed with half empty stomachs in those dry seasons and continued losing weight until the following spring rainy season (Table 4.3).

Recovery of camel weight in spring, even though time spent foraging was as low as in the dry seasons (Table 4.1) may have been due to high availability and quality of forage and bigger bite sizes. During this period camels were herded in the best foraging areas. Therefore, I did not find that camels spent extended length of time foraging in dry season (Table 4.1 and 4.2). As a matter of fact, camels spent less time foraging in the dry seasons than in the wet seasons. This is in contrast to some authors (reviewed by Wilson 1984) who stated camels spent more on poor forage (dry seasons) than on good forage (wet seasons).

Camels ordinarily forage in groups on the same shrub, tree or mixed species growing together but still exercise a great deal of individuality. There was a leader that other camels followed in every group. In foraging, each camel followed the action of the other camels, listening to the camel-bell usually hanging on a leader or troublesome camel. The composition of various foraging groups constantly changed through mingling simply by moving from one group to another. The only constant group was the calves accompanying each other behind their mothers.

Three major groups were observed while foraging: 1) a group of nursing camels foraged together the first 8 months of lactation, 2) a pregnant or mature non-milking group foraged together, and 3) all camels foraged together after about 8 months of lactation. The young immature camels foraged either with the non-milking or milking herd. These different foraging groups were observed even though the camel herd was kept together by herders every day. The milking camels never became a separate herd from the non-milking herd in Ceeldeer District as usually happens in most Somali camel pastoral areas in the country.

The camels never passed up the opportunity to rub or roll themselves whenever they came near grounds or trees that provide a rubbing surface. Rolling on dusty grounds attracted several camels at a time. Scratching on dry branches of trees with their long neck or use of thick bushes to remove ticks from their rear were frequently observed. Breeding males also rubbed their neck on bushes, often destroying the plants. This behavior was exhibited when a rutting male saw or smelt a rival from a nearby herd.

Once every 10 to 15 days the owners rubbed their camels with acaricides to control ticks. This tick control treatment was done by hand on individual camels. Sometimes camels were tied to a tree; ofttimes the camel stood without being restrained.

Flies such as riibi (Muscidae family, genus Stomoxys-stablefly), soor (Tabanidae family--horsefly) and gilmi (not identified) and red-billed oxpecher's (Buphagus sp.) were quite bothersome to camels. The camels swung their heads around to knock away flies and birds from their sides and walked a short distance in an effort to get away from

them. In the case of soor flies, camels stopped foraging and attentively listened for a fly that was about to attack. The soor produces a loud buzzing sound when moving from one animal or tree to another.

Nighttime Foraging

The length of nighttime foraging was affected by daytime elevated temperature and long intervals of watering (in winter) or high moisture content of the forage in spring. Night time foraging occurred with several hundred meter circumference of bedding ground.

During my study I observed camels foraging in moonlight. I was told by experienced camelmen that hungry camels browse during moonless nights, but I did not observe this in my study. Camels foraged at night in the long dry winter for several reasons: 1) insufficient forage availability, 2) movement of camels to new location, 3) when camels were lost and 4) when they were thirsty. All these cases were observed in my winter study which was preceded by a short summer dry season followed by drought in the fall season. The few camels observed foraging at night rested during the day more than other camels.

Generally, camels did not forage at night when plenty of food was available or during the first few weeks of lactation. Since forage availability was not a limiting factor during the study period, except in winter, camels rarely foraged at night.

Some camels foraged at night during spring (major rainy season) when water content of the forage plants was high. Camels were perhaps ingesting more water in the day and, therefore, continued foraging at

night. Night time foraging in the spring was shorter than that time spent browsing in winter dry season. Lactating and pregnant camels were among the ones most often observed foraging at night.

During the first week of the month when moonlight was present, camels continued foraging up to 9 p.m. and rested till morning. During the middle weeks of the month, camels usually foraged about 2 hours after moonrise and continued to forage for several hours. At the last week of the month when there was no moonlight camels did not forage. However, some camels rose as early as 4 a.m. and started foraging while still dark.

Rest Rumination Time

Significant difference was detected for the amount of time allocated by all camels for rest rumination within the dry seasons or wet seasons (Table 4.1). Among the dry seasons camels spend more ($P<.05$) time ruminating in winter 1987 (0.80 hrs) than either in summer 1986 (0.33 hrs) or in summer 1987 (0.03 hrs). Similarly, among the wet-seasons, the animals spent more ($P<.05$) time in this activity in spring 1987 (1.11 hrs) than either in fall 1986 (0.14) or in fall 1987 (0.48 hrs). Time spent in rest rumination was not different ($P > .05$) between summer or fall seasons.

All types of camels ruminated during rest periods while standing, sitting or lying down. Milking camels also ruminated when nursing or milking. Occasionally the camels ruminated while walking from one group to another or following the herd in the direction of foraging. Milking camels spent more time in rumination in the evening while non-

milking camels did so in midday in the dry season; overall, milking camels ruminated less than non-milking ones (Appendix Table 4). In the wet seasons, milking camels spent slightly more time than non-milking camels in rest rumination. But the time milking camels spent ruminating in the morning was more than either in midday or evening in the wet seasons. Rumination time decreased from morning to evening for milking camels perhaps to compensate for time lost by milking or suckling. The time ruminating increased for dry camels (Appendix Table 4).

Time spent by milking and non-milking camels in rest rumination during the day were 0.53 and 0.44 hours, respectively. Analysis of variance did not indicate the differences were significant (Table 4.2). However, significant differences were detected in winter and spring seasons for the time allocated in rest rumination, rest idling and bone chewing (Table 4.1) perhaps for the reasons discussed earlier.

Rest Idling Time

The amount of time camels spent was different within dry or wet seasons. They rested idle more ($P < .05$) time in winter 1987 (2.39 hrs) than the summer 1986 or 1987 (0.06 hrs) dry seasons (Table 4.1). Similarly, camels spent more time idling in spring 1987 (1.15 hrs) than fall 1986 or 1987 (0.23 and 0.43 hrs, respectively) (Table 4.1).

Rest idling includes all the time spent by camels in lying, sitting or standing. Overall time spent in rest idling for all season by milking camels and non-milking camels were 0.69 and 0.76 hours,

respectively (Table 4.2). This represented more time than the camels spent in rest rumination (0.53 and 0.44 hours).

Both camel types spent more ($P < .05$) time in rest rumination and rest idling in winter (0.80 and 2.39 hours) and in spring (1.11 and 1.15 hours) than any other season (Table 4.1). More of the rest rumination or rest idling time was spent sitting than lying or standing. When rest idling, the camels spent most of their time sitting with their necks either upright or completely outstretched with the head on the ground and eyes closed. This was observed in the hot dry winter season when camels were thirsty. It started a few days before watering. Most of the time calves sat beside their mothers. Sometimes calves lay down as a group separately, or played around their sitting mothers.

Bone Chewing Time

Camels were observed picking up bones, snails or licking soils. Bone chewing time included total time spent on these activities. Camels chewed bones more in the dry seasons than in the wet seasons. Overall, both types of camels spent about the same time in chewing bones in the dry or wet seasons (Table 4.2). The amount of time allocated in this activity by all camels was more ($P < .05$) in the dry seasons (0.40 hrs) than in the wet season (0.01 hrs) (Table 4.1). Camels allocated more time chewing bones in summer 1986 (1.15 hrs) than in any other season (Table 4.1). In summer 1986, camels foraged in Xarar--Transitional zone--where shrub vegetation cover and composition were lower than Carroguduud--Central Ridge or Buur--West (Figs. 3.1 and

3.3, Chapter III). Bones were not provided to the camels. They were just picked up as the animal found them. Camels challenged and chased each other for the randomly found bone. Most of the time, bones were chewed at midday or evening in both dry and wet seasons (Fig. 4.2, Appendix Table 4).

Both camel types spent more time chewing bones at midday than other periods in the dry seasons. In the wet seasons they rarely consumed bones or licked soils (Appendix Table 4). The camels may have obtained adequate mineral nutrients from the lush forage they consumed which were primarily browse species. For camels feeding on browse, minerals other than salt are generally adequate (Wilson 1984). In the dry season, however, most minerals may be deficient and since minerals were not provided to the study camels, they chewed bones randomly found on the foraging areas more than they did in the wet seasons (Tables 4.1 and 4.2). Phosphorous rather than sodium was deficient in the study areas (see Chapter VI).

Walking (Including Scratching and Rolling) Time

Time spent in walking and to lesser extent rubbing, rolling and scratching, was the total actual time spent on these activities while the camels were foraging. It included the time spent walking from one place to another, from one plant species to another, or circling a tree or shrubs when browsing. Movement for body comfort such as rubbing against trees, rolling on the ground, scratching with its own body parts were also included. Walking from one place to another included travelling from one group to another, to foraging areas, and back to

the bedding ground. The average time spent in these activities in all seasons was 4.24 hours for both camels (Table 4.2).

The amount of time spent walking (to lesser extent scratching, rolling, rubbing) by both types of camels was about the same for all seasons. The smallest time spent walking (3.96 hrs) in wet seasons and the largest one (4.52 hrs) in dry seasons were demonstrated by non-milking camels. Milking camels time allocation for walking lay within the non-milking time range in different seasons. No significant differences were detected for overall dry and wet season (Tables 4.2).

In dry seasons, camels spent significantly less time walking between plants in winter (3.51 hrs) than summer ($P < .05$) seasons (Table 4.1). In wet seasons, however, there was no difference in the amount of time spent on these activities (Table 4.1).

Milking camels walking time decreased from morning to evening in both dry and wet seasons. On the other hand, non-milking camels spent less time walking in midday and more time in the cooler morning and evening hours for both dry and wet seasons (Appendix Table 4).

Comparing the time spent travelling in different periods of the day, both types of camels allocated more time in the morning than either in midday or evening (Appendix Table 4). Overall, camels spent more time on walking in the dry seasons than in the wet seasons (Table 4.1). However, camels spent less ($P < .05$) time walking in winter than any other season (Table 4.1).

Distance Travelled

The average overall distance walked by camels during the 12-hour camel-day was 5.79 and 6.06 km for milking and non-milking camels, respectively (Table 4.2). Milking camels travelled slightly less in the dry seasons and slightly more in the wet-seasons than non-milking camels.

Comparing the distance travelled by all camels in the dry and wet seasons, camels spent less ($P < .05$) time walking in the dry seasons than in the wet seasons (Table 4.1). Thus, the hypothesis that camels exhibit no change in the daily distance travelled for foraging in different seasons is rejected for cumulative dry and wet seasons (Table 4.1). Plenty of diverse green, lush forage species were available in the wet seasons. The choice of selecting the most liked plant species was high. Thus, the camels had the opportunity to sample variety of forage plants in different vegetation community. The distance travelled from plant to plant or from one group of animals to another was, therefore, more in the wet season than in the dry season. Green forage availability was reduced in the dry seasons. Camels sometimes spent hours on a single green plant encountered before they moved to another plant. Within dry or wet seasons no significant difference was detected for the distance travelled between milking and non-milking camels (Table 4.2).

Extremes travelled by individual camels in each season were 4.34 and 7.78 km (Appendix Table 7). Much of this distance was walking to various plant species, from one group to another and from one place to another within home foraging area.

When camels were taken to water or when they were moved from one foraging area to another, they could travel from 50 to 100 km a day. But camels were not observed to move more than 8 km when foraging within their home area. My result agrees with the foraging distance travelled by camels in Afar area (Ethiopia) by Gebremariam (1987). I believe the 50 km distance travelled by foraging camels reported by Schmidt-Nielsen (1964), McKnight (1969), Gauthier-Pilters and Dagg (1981) and others should be viewed as a distance travelled by camels when they are moving from watering or moving to another location away from home ranging areas and not the distance covered foraging in their home range.

Effects of Weather Conditions on Foraging Activities

Average daily temperature ranged from 27.5°C to 31.2°C in dry seasons and from 29.2°C to 30°C in wet seasons. Average relative humidity varied from 48.2% to 66.1% among dry seasons and from 61.3% to 80.1% in wet seasons (Table 4.1). The highest temperature and lowest relative humidity occurred in winter (long hot dry season--December to March) and in fall (short, rainy season--September to November, but below normal rainfall in 1986). In the camel areas further inland (from Xarar--Transitional zone to Carroguduud--Central Ridge to Buur-West, Fig. 3.1, Chapter III) temperatures were higher and relative humidity was lower.

Relative humidity was higher in spring (major rainy season-April to June) than in any other season. Camels foraged less but spent more time in rest rumination and idling in spring than fall wet seasons

(Table 4.1). Camel activities, whether dry or wet seasons, were correlated more by relative humidity than temperature. In winter 1987, relative humidity was lower (48.2%) and temperature was higher (31.24°C) than in other dry seasons. At this time, camels spent less time foraging, more time in rest rumination and idling and walked less (Table 4.1). On the other hand, in spring 1987, relative humidity was the highest (80.10%) and temperature was high (29.26°C) compared to other wet seasons. Then camels demonstrated similar behavioral time budget except for walking as in winter dry season. Experienced camelmen believe that camels do not like extremes of temperature and humidity. Camels foraged less when hot and dry and when humid and hot. Camelmen also argued that camels forage less time when high air and plant moisture are coupled with high temperature.

All three wet seasons were significantly different in relative humidity (Table 4.1). This is probably related to rainfall variability among wet seasons in Central Somali climate.

Temperature is known to have a strong effect on voluntary forage intake, behavior and on overall metabolism of most ruminant animals. Feed intake of lactating dairy cows started declining at 25-27°C with sharp decline occurring above 30°C due to continuous heat stress (NRC 1981). Dwyer (1961) pointed out that when the temperature exceeded an average of 30°C for the day, time spent on grazing by range cows was lower than when average temperature was lower. Voluntary dry matter intake by foraging animals may decline rapidly because of direct effect of heat which suppresses foraging activities. The general principles

of heat stress seem applicable to all animal species, to some extent, depending on their behavioral and physiological adjustment.

Camel foraging activities seemed influenced by high temperature and low or high relative humidity more in dry winter and wet spring seasons than other seasons (Table 4.1). Thus the hypothesis that temperature and relative humidity do not affect foraging behavior of camels is rejected. Camels, however, can adapt to high temperatures (Schmidt-Nielsen et al. 1956a, Schmidt-Nielsen 1959, 1964, Yagil et al. 1979).

This study suggests that relative humidity may influence the foraging behavior of camels more than temperature. Because in winter relative humidity was lower (48.2%) and temperature was higher (31.24°C) than in other dry seasons; and in spring relative humidity was highest (80.1%) and temperature was still high (29.26°C) but lowest in the wet seasons. In both season foraging behavior of camels was affected in the same manner but different from other seasons.

Other Behavioral Activities

Suckling/Milking Activities

The number of nursing periods during the day varied for each calf. In general, the nursing interval was shorter (about 2 hours) for the first 2 months when the calves were young. After they started foraging the time interval between nursing lengthened to about 3 hours. Camels nursed their calves four times each day (morning, noon, afternoon, evening). They were milked usually in the morning and evening. An average of 0.2 hours was spent suckling or milking during a camel day

in both dry and wet season (Appendix Tables 5 and 6). Equal time was spent in different periods of the camel-day in all seasons.

Suckling was generally initiated by the calf. The mother called the calf to suckle occasionally. There were times the calf tried to nurse but the mother refused either by walking away or not letting down her milk. This was specifically true when the camel was foraging or chewing bones in the dry seasons. When suckling or milking, the camel usually ruminated. Sometimes it stood still with or without closing its eyes. Prior to milk let down, the camel generally defecated and stretched its hind legs backward to give space for the nursing calf or milking men or women. The camel nursed its own calf or foster calf only. It never allowed other calves to suckle. If the camel would not stand immediately for its calf, the calf made pity noises and moved back and forth in front of her or under her neck. The calf often stretched its neck to reach the udder while holding the camel hump against the stomach of the mother. The calf changed teats every few seconds, in a fairly regular sequence, during the entire nursing period. The suckling camels often remained behind to nurse their calves while the rest of the herd moved on.

Behavior of Calves

Teeth had appeared three nights after birth on several calves examined. At about three weeks of age, calves started licking soil and eating termite mounds. For the first month or two, the neck is shorter than the front legs. In order to reach the ground, calves stretched

their front legs wide to taste soil or herbaceous vegetation. They often sniffed the same plant species their mothers were eating.

After about two months of age, the calves were able to forage with the herd. They assumed foraging activities that resembled those of their mothers. Up to four months of age, calves were spending less time foraging than resting, generally lying down on one side of their body with their heads up. Sometimes they sat upright and stretched their neck on the ground with their head on the ground and closed their eyes. They were easily disturbed and were up and down frequently. They sought their mothers when they woke up. The mothers also called them to nurse.

The calves were not watered for the first year. When camels were driven to water, they remained in the bedding ground near the camp. After the herd disappeared a few hours later, the calves were released to forage. They continued foraging while calling their mothers frequently. Sometimes they followed other camel herds nearby and became lost.

Defecation and Urination

Counts were made to determine the number of defecations and urinations that occurred during the camel day for each animal observed. Camels defecated and urinated when standing, walking or foraging. An average number in all seasons for milking and non-milking camels were 14.04 and 14.70 defecations and 6.50 and 6.97 urinations during the camel day (Appendix Table 5).

Between dry and wet seasons, the number of defecations were almost the same for both types of camels. But, the number of urinations in the dry seasons were smaller than those in the wet seasons (Appendix Tables 5 and 6).

In both dry and wet seasons, milking camels urinated fewer times than dry camels. Camels defecated twice as often as they urinated. Defecation and urination intervals were less for both camel types in the wet seasons than in the dry seasons. Thus, number of defecations and urinations increased in the wet seasons when forage was plentiful and water content of the plant species was high (Appendix Tables 5 and 6).

Large quantities of defecation occurred while the camels were resting; prior to foraging in the morning and in the evening after camels were brought back to the camp. Most of the time they urinated on their thighs (habeed) without stretching their hind legs apart. Sometimes camels opened their hind legs, stained with urine, and urinated on the ground.

Behavior During Rainfall

Camels foraged quietly preceding a rain or when it started sprinkling. When a light shower fell camels continued foraging tranquilly with minimum movement from plant to plant or from group to group. As soon as the heavy drops of rain began falling, the camels moved slowly with the wind without foraging. If the rain continued, the camels stopped, either sat or stood idling without rumination. They continued in these positions facing away from the wind,

individually or in clusters. If the rain continued longer, the camels shivered and urinated frequently. During rain, defecation was rare. Camels seldom lay down when it was raining or when the soil was saturated with water.

As soon as the rain stopped camels moved to the nearest plant, shook their bodies, and started browsing. It was difficult for the camels to walk in muddy soil. They easily lose balance and, therefore, their movement was limited. In this muddy situation, it was almost impossible to bring the camel herd to bedding ground near the camp. Thus, they were brought together in a place where surface water drained out adjacent to a thick bush or between shrub plant communities to spend the night. Clusters of calves were tied in the bedding area in dense shrubs for protection from the wind. Camels sat close to one another in groups. Individuals making up each group faced the same direction and ruminated the whole night.

Conclusion

In the dry seasons, especially in winter, milking camels foraged more, travelled shorter distances and rested less than non-milking camels. The increased feed demand to satisfy lactation apparently caused the milking camels to allocate their time towards gathering feed. This foraging behavior may account for the weight loss of lactating camels; but, at the same time, help them to continue sufficient milk production for their calves and people in this critical winter season.

In the wet seasons, milking camels spent less time foraging in fall 1986 and spring 1987 than non-milking camels. This could be due to the fact that milking camels stayed with their calves longer since forage availability was not a limiting factor.

In summer 1986, 1987 and fall 1987, the amount of time spent on foraging by both types of camels was the same. Herding could be a major factor because camels were always driven to where good forage was available.

Comparing overall wet and dry seasons, milking camels spent about equal time foraging while non-milking camels spent more time in wet seasons than in dry season. Lactating camels gathered more sparsely available green forage in the dry seasons.

Camels spent more time chewing bones in summer 1986 than in any other season. They were foraged in Xarar (Transitional zone) where shrub species cover and composition were lower than either Carroguduud (Central Ridge) or Buur (West). Insufficient browse species availability coupled with dry season mineral deficiencies due to dormant vegetation probably caused the camels to chew bones. Bones were usually chewed at midday or evening in all seasons.

Camels had the opportunity to sample a variety of forage species in different plant communities in the wet season. Thus, they travelled greater distances in the wet seasons than in the dry seasons. Green forage availability was limited and camels spent hours on a single green plant before moving to another plant in the dry seasons.

Foraging activities of camels were affected by both temperature and relative humidity. Low and high relative humidity together with

hot temperature reduced foraging time, increased rest rumination time and rest idling time in winter and spring seasons. This finding was supported by opinions of experienced camelmen who believed that camels do not like extremes of weather conditions; camels forage less when hot and humid or dry.

Many factors contributed to the low foraging time in either winter (long, hot dry season) or spring (major rainy season). Factors influencing foraging behavior in winter included: hot temperature, low relative humidity, long interval of watering, low forage availability and lignification of available forage even evergreen ones. In spring, foraging time was lowered because of abundance of forage plants, higher water content of the forage, frequent daytime rainfall, high moisture in the air and frequent disturbance from breeding males.

In this study, camels spent more time foraging in the wet seasons than in the dry season. The amount of time camels allocated for foraging was more dependent on forage availability than forage quality. The quality of forage consumed in the dry seasons was not different than that consumed in the wet seasons.

CHAPTER V

COMPOSITION OF CAMEL DIETS IN CEELDHEER DISTRICT

Camels have a reputation for adaptability to harsh arid and semi-arid rangelands. This adaptability may be due in part, to unique dietary selection. Other factors include drought resistance, spreading behavior when foraging and travelling long distance when moving from one foraging area to another (Mares 1954, McKnight 1969, Dahl and Hjort 1979, Shalash 1979, Knoess 1979, Farid et al. 1979, Gauthier-Pilters and Dagg 1981, Morton 1984, McDowell 1984, Yagil and Etzion 1985, Hjort 1988). Almost all authors agree that camels make minimal impact on desert vegetation because of their free movement while foraging. Camels take few bites, especially in the wet seasons, from each plant species regardless of its quality and quantity. In the dry season, they use a variety of sparsely located green plants without generally damaging them. However, camels may repeatedly browse some plant species season after season and may eventually kill them (McKnight 1969, Gauthier-Pilters and Dagg 1981). In Ceeldheer District, Central Somalia, where my study was conducted, camels browsed certain evergreen shrubs and trees heavily such as Cadaba longifolia (Rugumbay) and Balanites rotundifolia (Shillan) among others.

Camels utilize a diversity of vegetation in various ecosystems (Coughenour et al. 1985). They select green forage plants which have better nutritional value (Pratt and Gwynne 1977). Trees and shrubs are

converted to milk more efficiently by camels than any other domestic livestock (Coughenour et al. 1985). Besides trees and shrubs, camels also consume herbaceous vegetation (Mares 1954). When browse species shed their leaves and cease growth of new twigs in the dry seasons or droughts periods, camels eat grasses and other herbaceous species in Eastern Africa (Field 1979) and in Northwest Africa (Gauthier-Pilters 1979).

Camels browse forage species not within reach of other domestic livestock. They can browse trees up to 3 to 5 meters high (Richards 1979, Gauthier-Pilters and Dagg 1981). Due to their long neck, adaptive features of their mouth (slit upper lip, small tongue, hard upper gum and obliquely protruding lower teeth among others) camels browse thorny shrubs, trees, young twigs hidden inside hedged bushes and nibble leaves from spiny stems (El-Amin 1979, Gauthier-Pilters and Dagg 1981, Wilson 1984).

Few investigations have examined the diets of camels. Field (1979) reported camel diets of 77% woody plants, 11% grasses and 1% vines. Newman (1979) found that in Australia 70% and 90% of camels diets came from shrubs and forbs in winter and summer respectively. Prior to the present study, no work has been done to examine the diets of free ranging but herded camels in Central Rangeland of Somalia.

The objective of this study was to determine botanical composition of camel diets in different seasons and to evaluate foraging strategy of milking and non-milking camels.

Methods

Foliage cover and composition of herbaceous and shrubby vegetation were determined by the line transect method (Canfield 1942, revised by Pieper 1978). A 100-m fiber tape transect was used. For herbaceous vegetation, species point interceptions at 0.5 m interval were recorded. The canopy interception of woody plants of each species within the reach of a camel (2.5 m) was recorded in centimeters on the same transect. One 100-m tape transect measurement was taken from each site a camel was observed. A total of 10 transects were taken at each location where 10 camels were herded. The total number of point interceptions for herbaceous and canopy contact on shrub species of all 10 transects were summed and the total amount was divided by 10 (number of transects). The average value was used to compute percent foliage cover and species composition.

Specimens of unknown plant species were collected, pressed well, labelled and brought to the National Range Agency and Faculty of Agriculture Herbariums (Somalia) for identification. Somali names of all plant species were recorded in the field. Scientific names are from Kuchar and Herlocker (1985) and Kuchar (1986).

Percent of individual plant species and its proportion (%) in camel diet was calculated from bite counts taken in the field. From the cover data, species composition (%) was determined. Percentages of all plant species in camel diets of similar physical characteristics (thorny, spiny, fleshy) or lifeform (evergreen, deciduous, grass, vines, forbs, succulents) were subjectively put together to form a

forage class. Nine such forage classes were identified. Number of individual plant species comprising each forage class was used to determine percent of each class in the study area. Sorensen's species presence or absence similarity index (Sorensen 1948) was used to determine forage class similarities in different season within respective location and percent diet similarities for milking and non-milking camels on a seasonal basis.

The major forage classes and their definitions are as follows:

1. Deciduous non-spiny (non-thorny) -- woody shrubs and trees without thorns or spines which shed their leaves in the dry season (eg. Cordia sp., Commiphora sp., Dalbergia sp., Grewia sp., etc.).
2. Deciduous spiny (thorny) -- woody shrubs and trees, with thorns or spines, which also shed their leaves in the dry season (e.g. Acacia sp., Commiphora sp., Dichrostacys sp., etc.).
3. Evergreen non-spiny (non-thorny) -- woody shrubs and trees, without spines or thorns, which produce and lose leaves continuously throughout the year (e.g. Boscia sp., Boswellia sp., Cordia sp., Cadaba sp., Maerua sp., Combretum sp., Terminalia sp., Albizia sp., etc.). They stay green throughout the year.
4. Evergreen spiny (thorny) -- woody shrubs and trees, with spines or thorns, which are green throughout the year by producing and losing leaves continuously all year round (e.g. Balanites sp., Terminalia sp., Ximenia sp., and Zyziphus sp.).

5. Suffrutescents -- plant species in which many of the branches die after flowering, leaving a persistent woody base; or plants in which stems are woody at the base and the upper portion die back at the end of the wet seasons leaving a persistent base (e.g. Crotalaria sp., Indiofera sp., etc.).
6. Grasses -- members of Graminae (Poaceae) family (e.g. Aristida sp., Brachiaria sp., Cenchrus sp., Heteropogon sp., etc.).
7. Vines -- plant species with long slender stem that trail or creep on the ground or climb by winding themselves for support or holding fast with tendrils or claspers (e.g. Iphionopsis sp., Merremia sp., Pentatropis sp., Rhynchosia sp., etc.).
8. Forbs -- Herbaceous plants other than grasses (e.g. Blepharis sp., Commelina sp., etc.).
9. Succulents -- plants with thick fleshy and juicy tissues e.g. Kleina sp., Capitanya sp., etc.

For statistical analysis, in addition to the analysis of variance described in Chapter IV, correlation and regression analysis for species composition in each forage class and its proportion in camel diets was done using minitab (Ryan et al. 1981).

Results

Forage Availability

The number of plant species consumed by camels during each season is illustrated in Table 5.1. Their scientific and local Somali names are listed in Appendix Table 8. The composion of the top ten plants

Table 5.1. Number of plant species consumed by camels in different seasons and locations.

Seasons	Camel type	Location	Woody shrub/tree species	Suffrut-escent species	Forb species	Vine species	Succulent species	Grass species	Total species
Summer '86	M	Xarar	17	2	0	3	1	2	25
(dry)	NM		16	3	0	5	1	2	27
Fall '86	M	Xarar/	20	3	0	3	3	2	31
(wet)	NM	Carroguduud	29	4	0	4	1	2	40
Winter '87	M	Buur	19	3	0	2	0	6	30
(dry)	NM		17	5	0	3	0	6	31
Spring '87	M	Xarar	30	1	0	7	0	1	39
(wet)	NM		33	1	0	6	0	0	40
Summer '87	M	Carroguduud	26	5	4	4	0	3	42
(dry)	NM		25	6	5	4	0	4	44
Fall '87	M	Buur	38	7	6	3	0	4	58
(wet)	NM		37	6	6	3	0	5	57

M = Milking NM = Non-milking

most liked by camels and their proportion in camel diets and vegetation cover are also presented in Table 5.2 Appendix Tables 9 and 10.

Woody shrub and tree plants, which comprise deciduous and evergreen species, are clearly the dominant component of the available forage on a seasonal basis. The largest number of woody plants were eaten in fall 1987 in Buur (West) foraging area (see Chapter III, Fig. 3.1). Rainfall was below normal in fall of 1986. Less forage was, therefore, available for the camels than spring or fall, 1987, wet seasons. On the other hand, more forage was available for the animal in summer, 1987 dry season than in the summer 1986 or winter 1987 dry season. Rainfall was good in the preceding spring season and enough moisture was available in the soil for continuous plant growth in the summer of 1987 dry season.

Suffrutescent plants, vines, and grasses were consumed in all season but in much less numbers than woody species. Woody shrubs and trees were dominant plant species in all foraging areas except in some sites of Xarar (Transitional zone) where camels foraged in summer 1986. Forbs were consumed only in summer and fall, 1987.

The most abundant plant species in the deciduous non-spiny (non-thorny) forage class in dry seasons were Cordia somalensis, Crotalaria sp. and Dalbergia uarandensis. These species comprise a large proportion of camels diets. Relatively low abundant species such as Cassia ellisae were substantially consumed by camels. On the other hand, species like Solanum jubae with fairly high abundance did not contribute much to the animals' diets. Substantial amounts of forage also came from these forage plants in the wet seasons. Large amount

Table 5.2. Composition (%) and diet (%) of the most liked plant species by milking and non-milking camels in cummulative dry or wet seasons.

		Dry Seasons[1]			Wet Seasons			
Forage class	Species[2]	%comp.[3]	M %diet	NM %diet	%comp	M %diet	NM %diet	Total # of Seasons Consumed
Deciduous	Allophyllus sp.	0.16	0.33	0.07	0.81	1.50	1.55	3
nonspiny	Cassia ellisae	0.73	0.40	2.46	0.58	0.67	0.03	5
(nonthorny)	Commiphora chiovendance	----	----	----	1.85	0.81	4.74	1
	C. gurreh	----	----	----	2.02	3.83	2.42	1
	Commiphora sp.(Dulwayn*)----		----	----	0.48	0.24	1.04	1
	Commiphora sp.(Jawdher*)----		----	----	0.41	0.09	0.63	1
	Commiphora sp.(Xagar*)	----	----	----	1.50	8.86	4.46	3
	Cordia ovalis	----	----	----	0.59	1.19	0.44	1
	C. somalensis	5.15	1.67	1.08	4.39	2.18	2.15	4
	Crotalaria sp.	5.81	6.44	6.15	0.18	----	----	2
	Dalbergia uarandensis	5.36	1.42	0.88	2.87	0.09	1.33	5
	(Dhuusacarmeed*)	0.37	0.46	0.02	2.87	4.97	8.92	3
	Euphorbia matabelensis	----	----	----	7.61	4.11	4.28	2
	Grewia bicolor	0.16	0.90	0.04	0.91	2.20	0.34	2
	G. pennicillata	----	----	----	4.76	4.94	4.34	1
	G. tembensis	1.75	0.54	0.33	2.83	1.59	1.68	5
	G. villosa	0.49	0.42	0.01	2.20	0.73	0.52	5
	Sessamothamnus buseanus	----	----	----	1.09	0.32	1.04	1
	Solanum jubae	3.73	0.49	0.01	3.36	0.01	1.22	2

Deciduous spiny (thorny)	Acacia edgeworthii	0.52	0.01	0.18	2.02	3.43	1.08	5
	A. horrida	8.72	5.02	2.61	4.88	1.34	8.03	6
	A. mellifera	1.21	0.63	0.98	1.32	1.08	2.39	4
	A. nilotica	11.65	10.41	7.31	5.78	4.16	6.16	6
	A. reficiens	2.09	6.05	4.35	1.55	0.13	0.43	6
	A. senegal	4.20	2.97	1.22	1.28	0.19	0.19	6
	Commiphora sp.	----	----	----	5.37	1.59	3.12	1
	Dichrostachys kirkii	17.89	17.05	19.18	12.10	1.33	7.48	5
Evergreen nonspiny (nonthorny)	Albizia anthelmintica	T	0.08	0.15	1.23	1.69	1.50	4
	A. obbiaddensis	----	----	----	9.40	10.12	5.76	1
	Boswellia microphylla	----	----	----	1.16	0.87	0.95	1
	Cadaba longifolia	0.24	0.63	0.12	T	0.59	1.06	4
	Combretum contractum	0.40	1.69	0.13	----	----	----	1
	Maerua crassifolia	0.47	2.72	1.75	0.33	1.11	1.65	5
	Sterculia rhyncocarpa	----	----	----	2.18	1.28	1.12	2
	Terminalia polycarpa	6.82	5.57	3.66	8.84	0.88	0.67	5
Evergreen spiny (thorny)	Balanites rotundifolia	2.00	4.54	6.27	0.18	----	0.04	3
	Terminalia spinosa	5.38	1.94	2.48	10.26	18.09	4.09	3
	Ximenia sp.	0.81	0.24	0.33	1.46	0.08	0.22	4
Suffrut-escents	(Caanoxaraarshe*)	4.60	1.30	1.52	0.60	----	----	2
	Crotalaria dumosa	5.02	0.74	0.06	1.47	----	0.97	3
	Indigofera intricata	8.21	12.53	18.07	6.18	2.68	----	3

Grasses	Brachiaria sp.	0.10	0.06	0.01	1.08	----	----	1
	Cenchrus ciliaris	6.17	1.67	3.60	6.97	0.17	0.25	6
	Heteropogon contortus	13.77	3.50	6.04	14.29	0.87	0.03	3
	Leptothrium senegalense	12.04	0.54	1.21	7.44	0.01	0.05	2
Vines	Pentatropis spiralis	0.79	1.51	1.30	1.49	0.23	0.31	6
	Rhynchosia velutina	0.89	0.72	0.61	0.28	0.20	0.39	6

M = Milking Camels NM = Nonmilking Camels

[1]Percentage of the above species in total camel diets on a season basis:

dry seasons	- summer	1986	- milking camels	= 96.41%	, nonmilking camels	= 98.84%
	- winter	1987	- " "	= 92.02%	, " "	= 88.53%
	- summer	1987	- " "	= 95.27%	, " "	= 95.98%
				$\bar{X}$ 94.57%		$\bar{X}$ 94.45%
Wet seasons	- fall	1986	- milking camels	= 97.18%	, nonmilking camels	= 92.52%
	- spring	1987	- " "	= 90.16%	, " "	= 93.77%
	- fall	1987	- " "	= 83.75%	, " "	= 81.76%
				$\bar{X}$ 90.36%		$\bar{X}$ 89.35%

[2]These plant species fell between 1 to 10 ranking scores at least in one season.

*Somali local names were used where the plant was not properly identified.

[3]Percent composition were separately calculated for woody shrubs and trees (deciduous, evergreen) and herbaceous species (suffrutescents, grasses, vines).

of wet season camel diets were, however, from Allophyllus sp., several Commiphora and Grewia sp. and Euphorbia matabelensis. Perhaps the most important forage species in deciduous non-spiny class are those consumed in both dry and wet seasons (Table 5.2, Appendix Tables 9 and 10).

Acacia species were the favorite deciduous spiny (thorny) forage class for camels in all seasons. Most of the acacia plants either stayed green longer in the dry seasons or greened up long before the onset of rainy seasons. Dichrostachys kirkii was also an important forage species in camel diets.

Evergreen non-spiny forage class such as Terminalia polycarpa, Maerua crassifolia and Combretum contractum constituted a large portion of the animal's diets in the dry seasons. Albizia anthelmintica, A. obbiadensis and Sterculia rhyncocarpa were important wet season forage plants.

Among evergreen spiny plant species, Balanites rotundifolia and Terminalia spinosa were major forage plants in camel diets for both dry and wet seasons.

Indigofera intricata (suffrutescent), Cenchrus ciliaris and Heteropogon contortus (grasses) were some of the herbaceous species eaten in large amounts during dry seasons. Vines such as Pentatropis spiralis and Rhynchosia velutina were consumed in all seasons despite their low abundance in all foraging areas.

Among the forage speices listed in Table 5.2 and Appendix Table 9 and 10, only a few species constituted the bulk of the camel diets in one season or another. For instance, Crotalaria sp. in summer of

1986, Dhuusacarmeed (unidentified) in spring of 1987, Euphorbia matabelensis in fall of 1987 (deciduous non-spiny); Acacia nilotica in fall of 1986 and in winter of 1987, A. reficiens in winter of 1987, Dichrostachys kirkii in summer of 1987 (deciduous spiny); Albizia obbiadensis in fall of 1987, Terminalia polycarpa in summer of 1986 (evergreen non-spiny); Balanites rotundifolia in winter of 1987, Terminalia spinosa in fall of 1986 (evergreen spiny); Indigofera intricata in summer of 1986 (suffrutescents); and Cenchrus ciliaris and Heteropogon contortus (grasses) in summer of 1986 and in winter of 1987 comprised from 10% to more than 50% of the total camel diets in, at least, one dry or wet season. All of these species were consumed by camels during at least two to all six seasons in which observations were made.

Forage Similarities Between Seasons in the Same Location

Camels foraged in Xarar (Transitional zone) in summer 1986, dry seasons and in spring 1987, wet season. In these seasons, camels foraged in different sites within the Xarar. The summer foraging site was open grassland with few scattered woody shrubs and trees. The vegetation cover was 5.6% woody species, 10.4% suffrutescent species, 14.4% grass species and 0.9% vine species. In the spring, camels foraged in thick isolated shrub site with 31.0% woody species cover, but only 0.3% suffrutescent plants, 2.2% grasses and 4.2% vine cover (Table 5.3). The forage species similarity in these two different sites of the same foraging area was zero for suffrutescent species, but

Table 5.3. Diet similarity[1] (%) for milking and non-milking camels within season and location based on species presence in diet.

Dry seasons	Camel type	Location	Woody shrub/tree species	Suffrut-escent species	Vine species	Grass species
Summer '86	M	Xarar	84.8	80.0	75.0	100.0
	NM		(5.6)*	(10.4)	(0.9)	(14.4)
Winter '87	M	Buur	83.3	75.0	80.0	100.0
	NM		(43.7)	(9.5)	(0.7)	(17.8)
Summer '87	M	Carroguduud	94.1	90.9	66.7	57.1
	NM		(38.8)	(5.4)	(2.7)	(10.0)
Wet seasons						
Fall '86	M	Xarar/	73.5	57.1	57.1	50.0
	NM	Carroguduud	(42.4)	(10.3)	(5.6)	(24.6)
Spring '87	M	Xarar	82.5	100.0	76.9	0.0
	NM		(31.0)	(0.3)	(4.2)	(2.2)
Fall '87	M	Buur	90.7	93.3	100.0	88.9
	NM		(24.6)	(2.8)	(2.4)	(17.1)
Dry seasons	M					
	NM		87.4	81.9	73.9	85.7
Wet seasons	M					
	NM		82.2	83.5	78.0	46.3
All seasons	M		84.8	82.7	75.9	66.0

*Numbers in brackets are percent cover for forage classes.

$$^{1}\text{Similarity} = \frac{2\sum^{C} MNM}{\sum^{A} M + \sum^{B} NM}$$

Where: A = Total number of forage plants in milking (M) camels' diets.
B = Total number of forage plants in non-milking(NM) camels' diets.
C = Total number of forage plants common in the diets of both camel types (MNM).

more than 60% for woody shrub/tree plants, vines and grasses based on species presence in camel diet (Appendix Table 11).

In fall 1986 and summer 1987, camels foraged between the Xarar (Transitional zone) and the Carroguduud (Central Ridge). These two foraging areas are adjacent to each other. They cover a large piece of grazing land from the coastal plains to the inland dense bush areas. All forage species are present. Camels moved back and forth in fall and summer seasons. Suffrutescent species, grasses, and vines were more abundant in the Xarar (Transitional zone) than in the Carroguduud (Central Ridge). Vegetation similarity as estimated by modified Sorenson's similarity index in the camel's diets was 75.9% for woody plants, 75% for grasses, 54.5% for suffrutescents and 88.9% for vines (Appendix Table 11).

Camels foraged in the Buur (West) areas in winter and fall, 1987, seasons. Vegetation similarity of the diets between these two seasons in the Buur area was 35.5% woody species, 15.4% suffrutescent, 66.7% vines and 72.7% grasses (Appendix Table 11). Woody plants in the winter foraging area were dominated by Acacias, while Commiphora occupied most of the Fall grazing areas. Camels ate a broader range of woody plant species in this foraging area than they did in the other two areas (Appendix Tables 11 and 12).

Camels consistently ate a broader range of plants species in Buur foraging areas than they did in Xarar or Carroguduud locations. However, little difference was noted between milking and non-milking camels for the number of plant species consumed in each foraging area.

This may be because they were always herded together and directed to the best foraging sites in any location.

Diet Similarity of Camels

Diet similarity for milking and non-milking camels in dry and wet season, based on species presence in different foraging areas, is presented in Table 5.3. Values of 87.4% and 82.2% for woody shrubs and trees, 81.9% and 83.5% for suffrutescents, 73.9% and 78.0% for vines and 85.7% and 46.3% for grasses were obtained for overall dry and wet seasons, respectively. Both types of camels consumed almost the same kinds of plants one season to another. For instance, in summer of 1986 in the Xarar area 84.8% of the diets of both types of camels were the same (Table 5.3). In the dry seasons, camels selectively consumed green grasses hidden inside bushes. Camel diet similarity was greater between adjacent foraging areas (e.g. Xarar and Carroguddud) than those far apart (e.g. Xarar and Buur) (Appendix Table 12).

Camels took advantage of sparsely available green forage in the dry seasons (Mares 1954, Pratt and Gwynne 1977, Farid et al. 1979, Field 1979, Bosticco 1981, Gauthier-Pilters and Dagg 1981, Coughenour et al. 1985). Dry camels shifted more to grass consumption than milking animals. Largely ignored grass-species became an important dietary component in winter, long hot dry season, for both types of camels (14% for milking, 22% for non-milking) (Fig. 5.1, Appendix Table 13). Similar findings were reported by Field (1979) in Eastern Africa and by Gauthier-Pilters and Dagg (1981) in Northwest Africa.

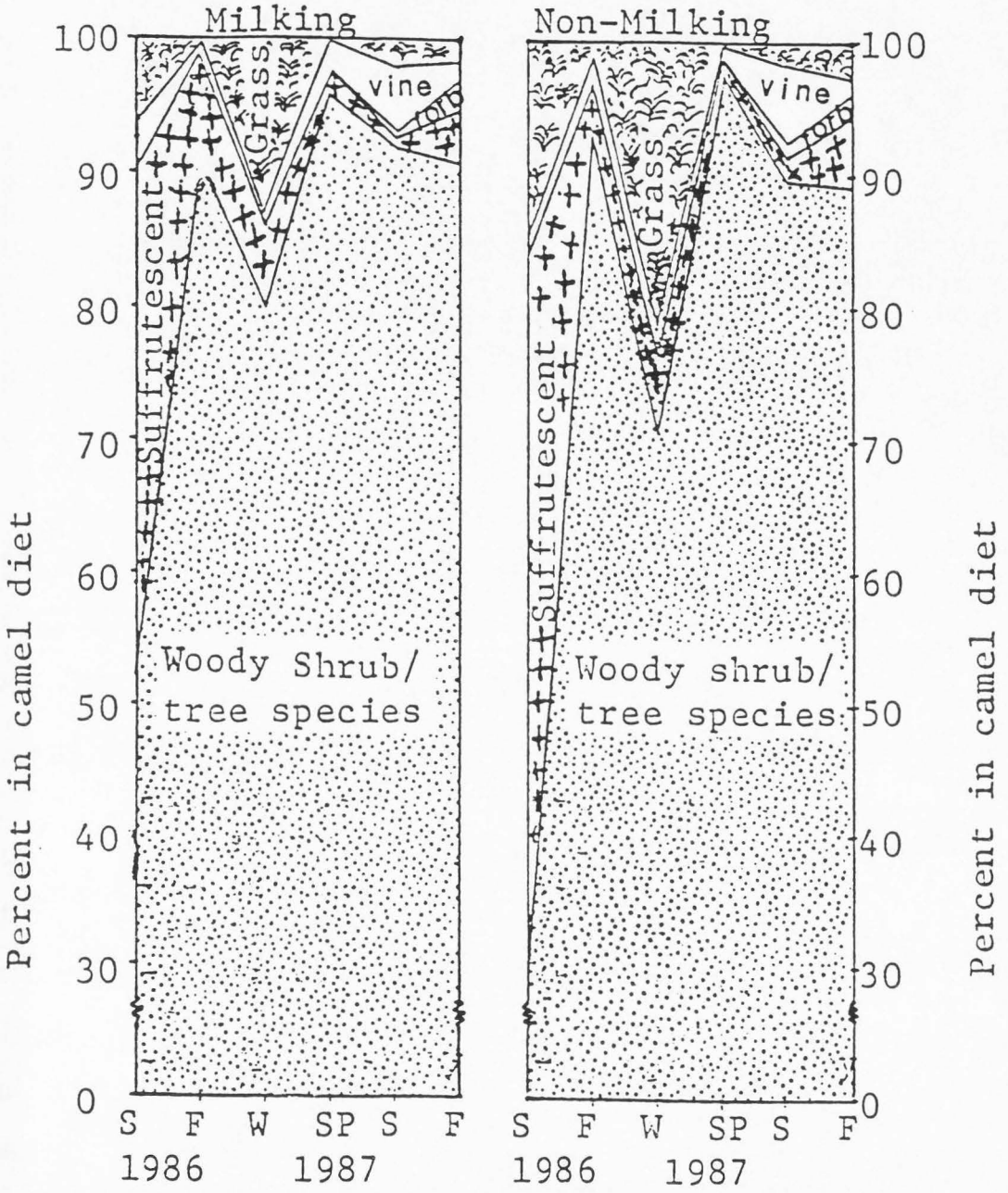

Figure 5.1. Dietary selection (%) by camels during dry and wet seasons (Dry: Summer '86, Winter '87, Summer '87; Wet: Fall '86, Spring '87, Fall '87).

Dietary Selection of Camels

Camels selected for large but variable amounts of woody shrub/tree species and for a lesser amount of suffrutescents, grasses and vines in all seasons except in the summer 1986 (suffrutescents) and in winter (grasses). Forbs and succulents were eaten the least (Fig. 5.1, Appendix Table 13).

In the summer 1986, non-milking camels consumed more suffrutescent plants than shrubs and trees. Milking camels also ate larger amount of suffrutescents but less than the amount they took from sparsely available evergreen shrubs and trees (Appendix Table 13).

In winter 1987, both camel types consumed relatively large amounts of grasses but non-milking camels ate more than milking camels. Of all forage classes forbs and succulents were the least abundant and were present in camel diets in the lowest amounts (Appendix Table 13).

Camel diets consisted of 80.85% shrubs and trees, 10.69% suffrutescents, 5.79% grasses, 2.17% vines, 0.45% forbs and 0.04% succulents (Appendix Table 13). Milking camels consumed more shrubs, trees, vines, forbs and succulents and less suffrutescents and grasses than non-milking camels. The increased feed demand to satisfy lactation may have caused the milking camels to consume more green plants (evergreen shrubs, trees, etc.) than relatively dry suffrutescents and grasses. This foraging behavior may help account for the weight loss of camels in winter.

In the dry seasons, milking camels ate less ($P<.05$) suffrutescent plants than non-milking camels (Fig. 5.2, Appendix Table 14). No difference ($P>.05$) was found for the remaining forage classes between

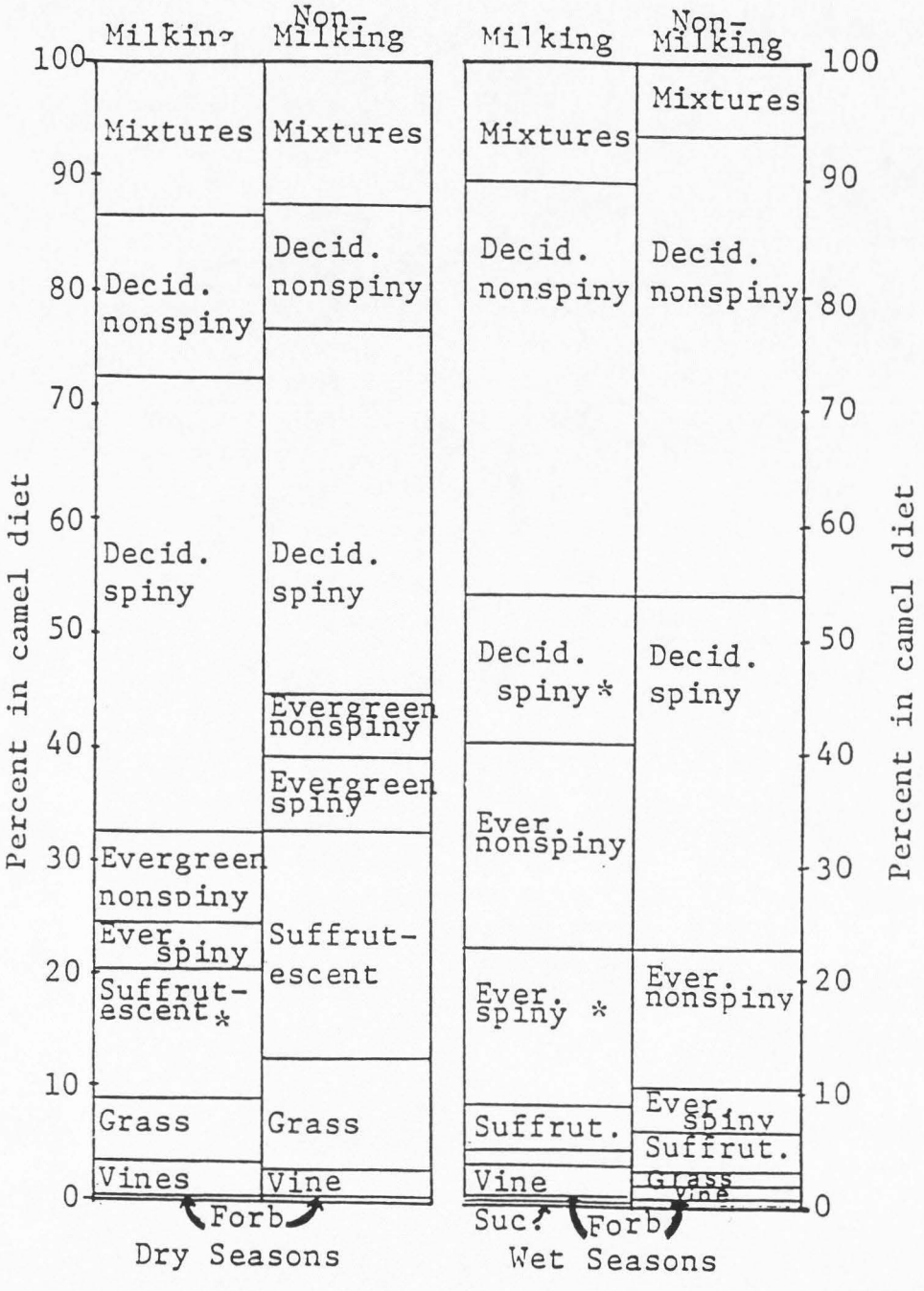

Figure 5.2. Dietary selection (%) by camels in dry and wet seasons. *Indicates statistical significance (P<.05).

the two camel types. However, milking camels consumed more deciduous non-spiny and spiny plants which stayed green late in the dry season and vines. Lactating camels ate less grasses than non-milking camels.

In the wet seasons, milking camels ate less ($P<.05$) deciduous spiny plants, more evergreen spiny species and more succulents than non-milking camels (Fig. 5.2, Appendix Table 14). Camels selected less grass in the wet seasons than in the dry seasons. The increase of grasses in dry season camel diets was due to camels selectivity of relatively abundant green grasses under shrubs and trees.

Overall, milking camels consumed less ($P<.05$) deciduous spiny plants and significantly more evergreen non-spiny species than non-milking camels (Fig. 5.3, Appendix Table 15). No differences were detected among the remaining forage classes for the camels.

Camels selected different diets in dry seasons than in wet seasons (Fig. 5.4, Appendix Table 16). Deciduous non-spiny plants, evergreen non-spiny species, evergreen spiny plants and succulents were consumed significantly less in the dry seasons than in wet seasons. Deciduous spiny plants, suffrutescent species and grasses were eaten by camels significantly more in the dry seasons than wet seasons. There was no significant difference detected for the amount of vines and forbs consumed ($P>.05$). These results indicate that camels consume whatever is available to them but not in the same proportion as availability. Forage quantity seems more limiting than quality (see Chapter VI) specially in the dry seasons.

Species composition and its proportion in camel diets were correlated (Appendix Tables 17 to 24). The proportion of a species in

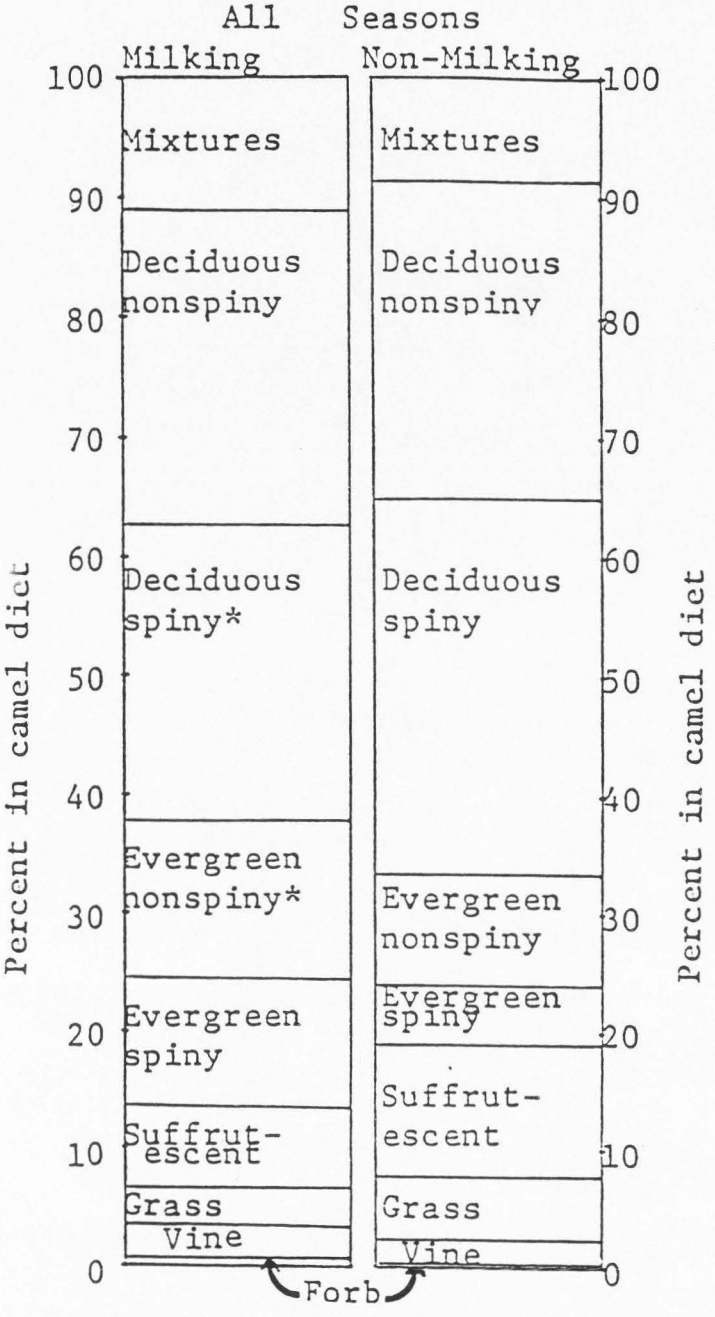

Figure 5.3. Dietary selection (%) by camels in all seasons.
* Indicates statistical significance (P<.05).

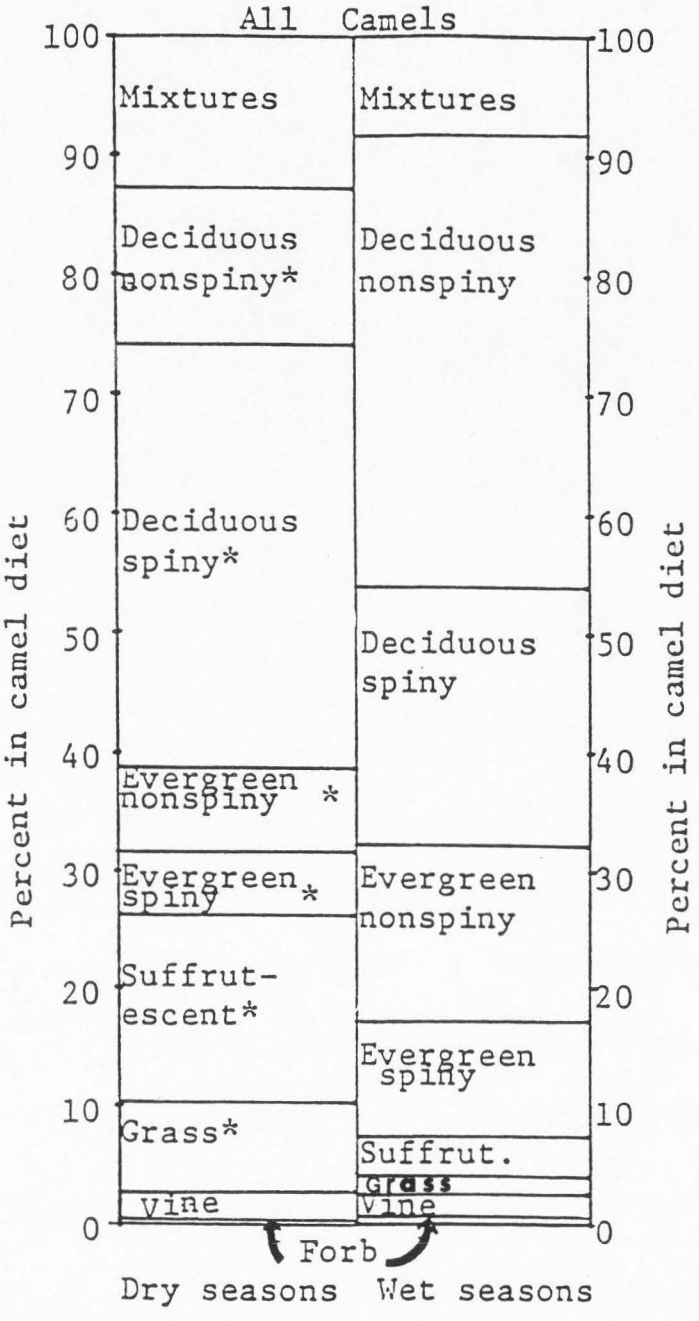

Figure 5.4. Dietary selection (%) by camels in dry and wet seasons. *Indicates statistical significance (P<.05).

camel diets increased as the composition of plant species in the community increased for both lactating (r = 0.798) and non-milking animals (r = 0.888) in the dry seasons (Appendix Table 17 and 18). As the percent species composition of the forage base increased, green material availability usually increased. This, in turn, increased the proportion of species in camel diets. In the wet seasons, however, significant correlation between species composition and its presence in camel diet was not detected for milking (r = 0.507) or dry (0.633) camels (Appendix Tables 19 and 20).

For all seasons, percent species composition of the plant community and its presence in milking camels' diet was not statistically significant (r = 0.618) (Appendix Table 21). For non-milking camels, however, the proportion of species in camel diets significantly increased (r = 0.744) as its composition increased (Appendix Table 22). This indicates that milking camels were more selective than dry ones.

For all camels, percent of plant species in diets increased significantly (r = 0.856) with increase in composition in the community in the dry season (Appendix Table 23). In the wet season, however, no statistical significance was detected (r = 0.598); but the proportion of individual species in diets increased as its composition increased (Appendix Table 24).

In general, as the species composition in the plant community increased, the amount of green plant species in camel diets also increased. Exceptions are grasses in all seasons and deciduous shrubs and trees in most dry seasons. Grasses were abundant in all seasons

but camels were reluctant to eat them. On the other hand, most of deciduous shrubs and trees (spiny or non-spiny) stayed green until the middle of dry seasons or greened up late in the dry season, weeks or months before the rainy season started. Thus, their presence in camel diets was greater than any other vegetation types in this study. This study shows that deciduous shrubs and trees are the major components of camel diet in both dry (42.7% - 53.5%) and wet (49.0% - 71.0%) seasons. Evergreen shrubs and trees comprised 12.1% to 12.8% of diets in the dry seasons and 16.4% to 32.3% in the wet seasons. Thus deciduous shrubs and trees are the most preferred plants by camels in all seasons in Ceeldheer District ranges.

Discussion

Like other animals, camels display a great innate sensitivity to changing foraging conditions (Arnold and Dudzinski 1978). They were able to adjust their forage selections according to changes in its availability through time and remembered where good pasture was available (Gauthier-Pilters and Dagg 1981, Morton 1984). Species like Indigofera intricata was a crucial dietary element (45.5%) in summer, 1986, dry season in the Xarar foraging area. Camels were attracted also by flowers and fruits (pods) even though they represented a very small fraction of the diet in the dry seasons. They were observed eating leaves and pods shed by deciduous shrubs and trees.

Animal's dietary habits (Emlen 1966) or grazing selectivity (Westoby 1974, and others) have been theoretically considered to be an optimization process involving time and efforts in relation to energy

harvested or optimization of total nutrient balance. Even though the original work on these theories was based on insects and small mammals, Zahorik and Houpt (1977) and Jarman and Sinclair (1979) considered domestic and wild ungulates, respectively, the most efficient feeders in any given environment. Based on these theories, Van Soest (1982) classified camels as "feeders" preferring browse to grasses. Camels are more efficient users of woody shrub and tree species than any other domestic livestock (Coughenour et al. 1985). Whether the optimization theories are applicable to camels and other domestic animals is difficult to prove because of man's intervention. Domestic livestock, including camels, are controlled by man through herding and moving them from one place to another in search of better pastures.

A relatively small number of plants comprised the bulk of the camel diets. Only eleven species; Indigofera intricata (45.5%) in summer, 1986; Acacia nilotica (20.3%), A. reficiens (15.4%), Balanites rotundifolia (16.2%) in winter, 1987; Dichrostachys kirkii (53.93%), Crotalaria sp (18.89%) in summer, 1987; Terminalia spinosa (20.7%), Acacia horrida (11.67%) in fall, 1986; Dhuusacarmeed (unidentified, 20.77%), Grewia pennicillata (13.91%) in spring, 1987; and Albizia obbiadensis (23.82%) in fall, 1987; were the major camel diet components. In the dry seasons, more than 50% of the camel diet came from one or few plant species. Similarly, very few plant species comprised more than 20% of the camel diet in the wet seasons (Appendix Tables 9 and 10). Gauthier-Pilters and Dagg (1981) reported similar observations in which very few plants were the source of camel food in one or two seasons in Northwest Africa.

Green plant species were selectively eaten by the study camels throughout the year. The steady weight loss of camels in the dry season or drought periods could be due to limited browse species availability and not because of quality. Woody shrubs and trees consumed by camels in the dry season contained green leaves. Thus camels were selectively feeding on green deciduous and evergreen shrubs and trees and perhaps, satisfied most of their nutrient requirements but could not obtain sufficient energy.

Shrubs and trees were the major species selected by camels throughout the season. The optimal foraging model of Owen-Smith and Novellie (1982) for foraging ungulates predicts that animals widen the range of acceptable plant species as food resource decline. The results obtained in my research with camels agrees with this prediction. Camels expanded the range of acceptable plant species in the dry season. Fewer plant species were available for selection in the dry season than in the wet seasons (Table 5.1). However, camels included more grasses and suffrutescents in their diet. These species were largely ignored in the wet seasons. Some deciduous shrubs and trees which stayed green late in the dry season or started greening up long before the beginning of rainy season increased the range of acceptable plant species in the dry season. In addition, camels were always herded where forage availability was superb.

Owen-Smith and Novellie (1982) found that availability of acceptable plant species was as important a limitation to the selection process as was diet quality. The number of plant species consumed by camels in the dry seasons was not much less than those selected in the

wet seasons (Table 5.1). Camels widen their dietary acceptance range in the dry seasons apparently to compensate the declining forage abundance by eating more grasses, litter, leaves, vines and lignified twigs. Some plant species consumed rarely in the wet season were eaten in the dry season. Most of these plant species were deciduous shrubs and trees which stayed green late in the dry seasons.

The climbing vines (Pentatropis spiralis, Rhynchosia velutina, Merremia sp.) were important dietary components during most of the year. All parts of these vines were eaten including large amounts of stems and substantial quantities of fruits. Acacia nilotica, A. senegal, A. horrida, A. reficiens (all thorny deciduous shrubs and trees); Rhynchosia velutina, Pentatropis spiralis (vines); and Cenchrus cilaris (grass) were continuously consumed throughout the year.

The proportion of forage species in camel diets varied according to its proportional composition in the habitat. Rate of harvest is considered to have an important influence on the feeding preference of large herbivore (Malechek and Balph 1987). For browsing ruminants this rate is reduced by structural plant features such as spinescense, thorniness, and twiggy growth form (Owen-Smith 1982). Such features impede access to edible plant parts within the feeding height range of any particular browsers. However, it was found in this study that structurally defended plants such as Acacias, Balanites, etc., were relatively preferred forage plants of camels. Whether this preference is due to camels ability to harvest these plants for their quality or whether they simply acquired adaptability mechanisms to overcome structural defense of forage plants needs more investigation.

Certainly, leaves and new shoots of browse species are nutritious. Pellew (1984) found that thorned browse plants used by giraffes were particularly nutritious. Camel's consumed a higher percentage (39.5% milking, 31.1% non-milking) of leaves and young spiny or thorny twigs of deciduous shrubs and trees in the dry seasons than any other forage class (Appendix Table 14). Number and size of bites taken from non-spiny (non-thorny) deciduous or evergreen plant species were relatively greater in the wet seasons than in the dry seasons.

There was no evidence whether spinescense, thorniness or other anatomical defense structures of plants reduce leaf and shoot losses to camels. But the type of thorns or spines, certainly, lower eating rates (Gauthier-Pilters and Dagg 1981). For example, leaves of Acacia melliferia, A. reficiens, A. senegal, Terminalia spinosa, among others, which possess small hooked thorns, were nibbled more than other Acacia sp. and Balanites sp. with long pointed thorns and spines. Camels took matured twigs with thorns or spines carefully and chewed slowly with an open mouth (Gauthier-Pilters and Dagg 1981). Such plants were highly favored as forage species by camels in this study.

The ultimate diet selection in a particular situation is a function of many interacting and poorly understood plant and animal related factors (Heady 1964). The physical characteristics of a plant (spinescense, thorniness, awns, dense pubescence, etc.) did not seem to impair the consumption of that plant by camels. Deciduous spiny (thorny) shrubs and trees were equally utilized (if not more) by camels than other forage species in the dry seasons (Appendix Tables 8 to 13). The acceptance of plant species by camels was not affected by these

features in relation to bite dimensions of the animal but was influenced by seasons and diet availability. Due to the camels anatomical mouth structure (slit upper lip, small tongue, horny mouth) they easily nibbled leaves from thorns or spines or matured twigs (Wilson 1957, El-Amin 1979, Gauthier-Pilters and Dagg 1981).

Camels had exclusive access to upper canopies of many shrubs and trees unreachable to other domestic livestock (Richards 1979). They selectively fed on young shoots, pods and flowers on top of the canopy with the neck stretched vertically upward as well as protruded their long neck inside thick shrubs or between branches of dense shrub and browsed inner tender shoots. They were able to crop unbrowsed plant parts not available to other livestock or even young camels. To feed on these relatively abundant plant parts was perhaps more beneficial for the camels than to search for new shoots within the feeding height range for other domestic animals herded together with them in the dry season. They could conserve energy that would have been lost in search of rarely available forage.

Camels also ate herbaceous layer forage consumed by cattle, goats and sheep (Field 1979, Gauthier-Pilters and Dagg 1981). Grasses, vines, forbs and succulents were consumed by camels one time or another even though they comprise a small percentage of the camel diet. Availability of greener grass plants protected by shrubs increased diet acceptance range of camels in dry seasons specifically in winter when woody plant foliage cover was in short supply.

Camels prefer certain plant species (McKnight 1969, Gauthier-Pilters and Dagg 1981) and if they browse year after year they could

kill them. Cadaba longifolia (an evergreen non-spiny shrub) and Balanites rotundifolia (an evergreen spiny) were among those species severely browsed in the Xarar and Buur foraging areas of Ceeldheer District.

Each time a camel filled its mouth it straightened up when foraging herbaceous vegetation. When eating shrubs or trees it simply stopped browsing, chewed and swallowed. Several bites of either a mixture of plants, or exclusively of trees, shrubs, grasses, vines, forbs or succulents made a mouthful. Gauthier-Pilters and Dagg (1981) suggested that bite size was constant throughout the browsing or grazing period. Size of bites in this study, however, varied with moisture content and growth stage of the plant, season of the year, accessibility of the plant parts, anatomical defense structures and the preference of the animal.

Camel preference for plant species varied with seasons and was often correlate with the moisture content of the plant. The water content of the plant species consumed in the dry seasons was slightly less than the moisture content of the same species consumed in the wet season (see Chapter III, Table 3.2). Some plants were eaten year round while others constituted most of the diet in one or two seasons (Appendix Tables 9 and 10).

Camels recognized poisonous plants growing in regularly foraged areas. Camels and other livestock avoided the Uvaria denhardtiana (Murug) shrub due to its poisonous effect. Surprisingly, the fruits of this plant are eaten by man and were not considered poisonous.

Other plants such as Cassia truncatta (Jallelo) were avoided by camels during certain times of the year.

Conclusion

Camels on natural range ate a variety of mixed vegetation. The dietary acceptance range was widened in the dry seasons apparently to compensate, to some extent, for declining forage availability. In dry seasons, animals included large amounts of lignified mature twigs, grasses, suffrutescents and vines in their diet. They also consumed leaf litter, forbs and succulents.

The diets of milking and non-milking camels were similar on a seasonal basis, probably because they were herded together and foraged on the same location at any given season. Milking camels consumed more green forage than non-milking camels in the dry seasons apparently to satisfy lactation requirements. Normally, as the species composition increased the availability of its green material also increased in the dry season. This increased the species proportion in camel diets. Deciduous shrubs and trees were the major components of the animal's diet (>80%) in all season.

Forage plant species consumption was not affected by physical defense structures or by leaf size in relation to bite dimensions of the animal at any given time. These structures (spinescense, thorniness, awns, pubescence, etc.) did not prevent feeding on the plant species. Small leafed deciduous spiny (thorny) plants were equally utilized (if not more) as large leafed deciduous or evergreen

plants. Bite size was, however, influenced by growth stage of plants which was, in turn, affected by season.

Camels were more efficient feeders on woody shrubs and trees than other domestic livestock foraging on the same areas. Due to their anatomical mouth structure, long neck, and heights, camels browsed top layers of vegetation canopy unreachable to other animals. Because of their feeding behavior on shrubs and trees, camels would be considered browsers in most habitats. However, they could survive on grasses and other herbaceous plant species even though they are primarily browsers.

Camels were extremely flexible and opportunistic in their diet selection and foraging behavior in Ceeldheer District. They selected different plants and plant parts in different seasons. Therefore, they could be used as biological bush control animals in some vegetation types.

CHAPTER VI

NUTRIENT CONTENTS OF CAMEL DIETS IN CEELDHEER DISTRICT

Camel production is the main economic enterprise for Somalis in general, and for the pastoralists living in Ceeldheer District in particular. Camels are well adapted the arid and semi-arid environments. There has been a growing realization of the importance of camels as a source of food in drought stricken regions of Africa (Gauthier-Pilters and Dagg 1981, Yagil 1982, Yagil and Etzion 1985, Coughenour et al. 1985).

Camels freely select a diet of a great diversity of plant species in their natural range. Shrubs and trees are the major dietary components for the camels but they also eat herbaceous vegetation (Gauthier-Pilters and Dagg 1981, Wilson 1984, see also Chapter V).

Nutritional fluctuations with regard to quantity and quality exist in different seasons of the year. To my knowledge, however, no attempt has been made prior to the present study to investigate the quality of forage free ranging camels eat on Somali rangelands. Such information is critically needed for the planning and implementation of development programs in Somalia. Availability of information on the quality of camel diets is also important for successful formulation of range and animal management strategies to increase animal production and alleviate human starvation in arid and semi-arid regions of developing

world. The objective of this study was, therefore, to assess nutritive contents of major plant species consumed by freely ranging but herded camels on native pastures.

Methods

Three to four of the 10 study animals were randomly selected to observe camel bites. Major plant species consumed by camels were collected for chemical analysis. Simulated camel bites of about 100-300g were hand clipped from several plants of each species. The samples were put in paper bags, weighed using a spring scale, and partially air dried. The samples were labelled and transported to the Faculty of Agriculture, Somali National University. They were oven-dried at 60°C for 48 hours. The dry plant samples were ground through a stainless steel (1.1 mm) mesh and stored in moisture-free, air-tight plastic bags. In January 1988, ground plant materials were brought to Utah State University (USU) for nutritive quality analysis.

In forage quality analysis, emphasis was given to the major forage species in dry seasons. A few plant species consumed only in the wet seasons were also analysed for their nutrient contents.

Forage was analyzed for dry matter, crude protein, in-vitro dry matter digestibility, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), and minerals such as calcium (Ca), phosphorus (P), postassium (K) and sodium (Na).

Dry matter was determined by standard methods of Harris (1970). Crude protein determination was made by the peroxymonosulfuric acid method (Hach et al. 1985). A regression equation was developed from

the standard solution (0.25 g sample material). Crude protein content was corrected to the standard and then expressed on dry matter basis. In-vitro dry matter digestibility (IVDMD) was determined by a cellulase enzyme method (McLeod and Minson 1978). Filter paper (Whatman 541) was used during filtration of the residue. Percent IVDMD was calculated and expressed on dry matter basis. The fibers (NDF, ADF, ADL) were determined by using Goering and Van Soest (1970) forage fiber analysis method.

For mineral analysis, ground plant material of individual species from different seasons were mixed according to wet or dry seasons samples. The samples were sent to the Soil, Plant and Water Testing Laboratory at Utah State Univesity. A pooled sample was taken from each species. Calcium, phosphorous, potassium, and sodium were determined using Inductively Coupled Argon Plasma (ICP or ICAP) method (Chapman and Pratt, 1961).

For statistical analysis, comparisons were made of moisture levels (dry vs. wet) with individual season effect nested within moisture levels. The LSD procedure was used to compare individual means (Cochran and Cox 1957).

Results

Crude Protein

Crude protein content of individual plant species consumed by camels varied from about 10 to 31% in the dry seasons and about 11 to 48% in the wet seasons (Table 6.1). Levels of crude protein were lower in the dry seasons than in the wet seasons. Summer of 1987 was

Table 6.1. Camel diets (%) of major forage species and their nutrient contents (%) in dry and wet seasons.

Forage class	Species[a]	Dry Season: % diets[a]							Wet Season: % diets[b]							Total # of seasons consumed
		% M	% NM	% CP	% IVDMD	% NDF	% ADF	% ADL	% M	% NM	% CP	% IVDMD	% NDF	% ADF	% ADL	
Deciduous nonspiny (nonthorny)	*Allophyllus sp.*[10]	0.98	0.21	10.13	27.18	70.41	68.19	19.83	----	----	----	-----	-----	-----	----	3
	Cassia ellisae[22]	0.46	3.39	10.17	29.23	70.60	54.07	13.50	1.01	0.04	18.19	40.71	65.29	53.31	13.43	5
	Cordia somalensis[11]	5.07	3.17	16.41	26.29	60.85	55.18	25.89	3.29	2.92	27.67	39.09	63.31	53.70	26.58	4
	Crotalaria sp.[10]	19.33	18.46	19.60	36.08	66.53	54.77	15.27	----	----	----	----	----	----	----	2
	Dalbergia warandensis[21]	2.14	1.32	17.52	27.82	75.34	57.65	13.66	----	3.71	19.88	31.54	75.81	58.16	15.33	5
	(Dhuusacarmad[a]*)*[21]	0.69	0.04	17.70	37.95	67.13	47.49	15.66	14.89	26.65	28.76	38.38	63.45	48.76	17.65	3
	Euphorbia matabelensis[02]	---A[4]	----	----	----	----	----	----	6.16	14.38	19.47	32.21	69.65	58.79	14.44	2
	Grewia bicolor[10]	2.69	0.13	16.25	33.97	64.13	48.88	10.73	----	----	----	----	----	----	----	2
	G. tembensis[22]	0.81	0.36	16.54	30.23	71.13	49.86	14.57	1.91	2.41	17.42	29.55	73.56	53.04	15.42	5
	G. villosa[21]	0.63	0.02	12.35	33.78	68.28	48.27	14.61	0.07	0.02	25.23	43.04	68.01	45.15	16.63	5
	Helinus integrifolia[13]	0.09	0.23	14.42	29.75	73.20	56.13	14.10	0.73	0.83	20.22	35.27	69.09	54.77	14.15	4
	Solanum jubae[11]	1.48	0.04	23.26	32.25	59.15	46.20	14.67	----	2.63	30.70	38.72	66.97	52.60	15.36	2
Deciduous spiny (thorny)	*Acacia edgeworthii*[13]	----	0.55	13.89	33.44	69.99	56.82	17.46	3.43	1.63	26.38	36.60	73.89	62.97	20.44	5
	A. horrida[13]	5.14	4.11	14.55	30.13	71.17	56.43	15.55	1.35	8.03	22.56	30.08	60.83	55.82	20.37	6
	A. mellifera[22]	0.95	1.47	25.95	38.96	63.56	49.19	12.72	1.52	3.59	33.46	45.91	56.80	44.64	16.57	4
	A. nilotica[32]	10.41	7.31	13.32	36.66	61.40	47.56	18.16	6.13	9.24	18.97	39.34	56.29	42.68	13.61	6
	A. nubica[11]	0.11	----	30.94	48.60	56.77	41.26	12.81	----	2.61	29.92	50.63	54.90	40.58	15.38	3
	A. reficiens[11]	18.11	12.69	17.09	31.34	63.29	46.99	15.32	0.37	0.15	13.63	31.64	66.59	51.28	19.59	6
	A. senegal[30]	2.97	3.77	24.20	38.28	68.65	55.63	15.79	----	----	----	----	----	----	----	6
	A. seyal[20]	0.96	0.59	12.35	34.41	65.94	53.04	17.23	----	----	----	----	----	----	----	4
	Dichrostachys kirkii[21]	25.58	28.78	21.63	33.58	70.02	57.06	18.30	3.92	4.24	29.10	34.06	70.08	50.66	24.68	5
Evergreen nonspiny (nonthorny)	*Albizia anthelmintica*[12]	0.01	0.41	29.16	51.68	49.56	34.18	8.74	2.54	2.25	36.17	46.16	61.58	46.12	10.59	4
	A. obbiadensis[01]	----	----	----	----	----	----	----	30.36	17.28	30.36	27.77	67.52	59.00	13.12	1
	Boscia coriacea[10]	----	0.37	20.93	37.55	65.55	40.01	8.81	----	----	----	----	----	----	----	1
	Cadaba longifolia[11]	0.53	0.05	20.80	43.14	64.05	38.97	9.21	0.76	3.19	30.21	40.88	65.01	43.23	12.40	4
	Maerua crassifolia[23]	4.09	2.64	25.97	64.11	42.19	27.34	8.26	1.11	1.65	48.30	63.93	56.06	34.24	9.87	5
	M. macrocarpa[11]	1.29	1.33	20.54	67.81	37.73	25.91	7.56	0.21	0.10	30.47	59.76	46.59	32.32	9.32	2
	(Ikigad[a]*)*[11]	0.21	1.49	10.55	48.03	53.45	34.44	9.99	----	0.32	21.81	47.41	59.01	40.84	14.73	2
	Terminalia polycarpa[22]	8.35	5.49	12.75	46.25	57.85	41.17	10.43	1.31	1.01	23.88	36.62	63.62	51.21	12.25	5
Evergreen spiny (thorny)	*Balanites rotundifolia*[11]	13.61	18.79	22.23	39.72	61.53	45.67	11.62	----	0.13	23.81	36.75	61.76	51.15	14.98	3
	Terminalia spinosa[12]	5.82	7.44	10.79	20.61	70.86	60.16	16.26	27.14	6.13	18.90	37.55	54.55	48.74	19.74	3
	Ximania sp.[12]	0.71	1.00	15.75	24.07	67.12	63.19	23.54	0.06	0.32	14.47	22.50	71.70	62.64	23.52	4

Suffrut-	*Asparagus africanus*[11]	0.06	0.08	12.19	36.83	68.62	55.70	12.10	0.01	0.17	20.61	34.97	75.05	56.95	11.77	2
escents	(Caanoxaraarche*)[10]	3.91	4.56	12.08	38.80	61.15	56.78	11.96	----	----	----	----	----	----	----	2
	Crotalaria dumosa[21]	0.76	0.41	13.32	31.14	71.06	57.24	12.87	----	2.91	20.26	23.66	80.15	65.65	15.11	3
	Hildebrandtia sepalosa[12]	0.06	0.14	16.95	29.86	72.27	56.96	15.03	0.79	0.94	20.01	32.83	71.13	55.23	15.42	3
	Indigofera intricata[21]	18.79	26.80	13.03	36.09	61.85	49.01	12.09	8.08	----	21.15	44.56	54.11	42.23	11.53	3
	I. ruspollii[10]	0.56	0.17	17.12	25.53	74.23	69.59	15.32	----	----	----	----	----	----	----	1
	I. schimperi[11]	0.29	0.22	18.83	45.85	58.96	47.45	12.33	0.82	0.59	19.69	38.76	67.33	54.61	11.56	2
	Kelleronia sp.[11]	0.14	0.09	23.31	47.78	36.64	30.95	7.35	0.52	0.02	20.34	61.52	50.59	33.91	9.47	2
	Psilotricum tomentosum[02]	----	----	----	----	----	----	----	0.24	0.39	19.42	36.75	66.40	44.02	12.46	3
Grasses	*Aristida adscensionis*[20]	0.84	1.00	10.67	30.08	83.93	48.75	8.14	----	----	----	----	----	----	----	2
	A. sieberiana[11]	1.30	2.12	9.46	26.73	80.06	51.22	9.34	1.47	1.83	11.41	26.16	82.89	49.00	10.78	2
	Cenchrus ciliaris[32]	1.67	3.60	11.69	34.76	82.30	51.71	10.57	0.22	0.38	13.85	33.42	83.49	54.68	8.20	6
	Heteropogon contortus[20]	5.25	8.33	8.66	29.53	81.27	52.82	9.43	----	----	----	----	----	----	----	3
	Leptothrium senegalense[11]	1.61	3.63	9.37	23.29	81.21	52.13	10.94	0.02	0.14	11.80	32.26	83.01	51.09	10.07	2
Vines	(Dabanaylood*)[20]	0.01	1.10	16.07	32.52	69.40	53.98	12.21	0.01	0.29	21.57	44.92	64.13	52.85	15.26	3
	Iphionopsis rotundifolia[22]	0.90	0.45	17.09	37.65	65.22	49.54	13.56	0.12	0.17	22.05	39.56	67.28	50.78	12.22	4
	Merremia sp.[12]	0.24	0.62	21.39	44.15	59.10	45.37	13.50	0.64	0.32	33.34	58.21	44.48	35.89	11.71	4
	Pentatropis spiralis[22]	1.06	0.91	17.36	36.58	63.88	48.97	9.32	0.04	0.46	26.36	39.47	58.36	41.36	12.47	6
	Rhynchosia velutina[21]	2.27	1.94	19.47	30.02	66.62	52.98	15.57	0.16	0.08	27.19	40.58	71.30	50.56	12.17	6

[a] *Forage species in these columns comprise 98.8%, 94.4% and 89.2% of the total camel diets in summer of 1986, winter of 1987 and summer of 1987 dry seasons, respectively.*

[b] *Forage species in these columns comprise 79.5%, 46.5% and 55.4% of the total camel diets in fall of 1986, spring of 1987 and fall of 1987 wet seasons, respectively.*

[c] *Indicates the number of seasons included in nutritional analysis of each plant species; for example, 10 indicates that the species was eaten 1 dry season and it was not consumed in wet seasons; 22 indicates that the plant was eaten 2 dry seasons and 2 wet seasons.*

**Somali names were given for unidentified plants.*

***Dash-lines indicate that the plant was not consumed or chemically analysed.*

exceptional because the preceeding spring rainfall was above normal and allowed vegetation growth to continue in the following summer seasons.

Overall, crude protein contents of major forage species in camel diets were 16.34% in the dry seasons and 24.11% in wet seasons. Crude protein levels for the dry and wet season for forage classes were not different (P>.05) (Table 6.2).

Dominant plant species preferrred by the camels such as Crotalaria sp., Cordia somalensis, Dalbergia uarandensis, Grewria bicolor, several Acacia sp. (Acacia horrida, A. nilotica, A. reficiens), Dichrostachys kirkii, Terminalia polycarpa, Balanites rotundifolia, Terminalia spinosa, Indigofera intricata etc., were relatively high in crude protein in the dry seasons (Table 6.1). Some plant species with high crude protein contents (Maerua crassifolia, Pentatropis spiralis, Rhynchosia velutina were important forage plants for camels in almost all seasons despite their low abundance in plant communities. On the other hand, high crude protein plants such as Solanum jubae which were relatively abundant in the vegetation community in most foraging areas did not contribute much to the camel diets. Many of the dry season forage species were also eaten in a large amount in the wet seasons. However, Albizia obbiadensis, Dhuusacarmeed (unidentified sp.) etc., high in crude protein were important forage species in the wet seasons.

Camels selected green leaves, unbrowsed shoots from the tops of trees and high shrubs, young twigs protected inside bushy plants, partially green grasses, and other herbaceous and vine plants which were hidden from desication of the hot sun rays during the dry seasons.

Table 6.2. Seasonal nutritive contents of major forage species in camel diets during 1986-1987 study period.

Seasons	# Of species	Nutrient contents (%) CP	IVDMD	NDF	ADF	ADL
Dry Summer 1986	19	13.44	32.10	69.25	52.94	15.34
" Winter 1987	25	14.89	35.32	67.88	49.93	11.39
" Summer 1987*	27	20.68	39.38	63.42	47.88	13.44
$\bar{X}$		16.34	35.60	66.85	50.25	13.39
Wet Fall 1986**	26	23.87	39.29	64.27	49.21	15.19
" Spring 1987	18	27.39	41.28	64.73	49.38	15.02
" Fall 1987	21	21.02	37.06	66.91	50.76	13.89
$\bar{X}$		24.11	39.21	65.30	49.78	14.70

*Was exceptionally wet season instead of regular short dry season
**Was a short drought (rainfall was below "normal")

Crude protein content was, obviously, high during wet seasons. New shoot growth which comprised the bulk of the camel diets in the wet seasons was relatively higher in crude protein than lignified old green leaves and twigs which dominated camel diets in the dry seasons. High crude protein levels have been reported for old green leaves of several Acacia species (Pellew 1980). Acacia species were important forage plants for camels in both dry and wet seasons apparently because of their dominance and relatively high crude protein contents.

Crude protein levels of plant species consumed by camels were lower in summer of 1986 than in any other season (Table 6.2). At this time, camels were herded in the Xarar (Transitional Zone) where browse species were low in abundance (see Chapter V). Suffrutescent species such as Indigofera intricata and others became the main source of camel diets in this foraging area. In dry seasons, camels selectively ate flushing leaves from deciduous and evergreen shrubs and trees.

Fiber

Camel diets were high in fiber and lignin contents. Fiber values of major forage species were almost the same between dry and wet seasons (Table 6.1 and 6.2). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) levels were slightly higher while acid detergent lignin (ADL) level was slightly lower, in overall average of forage classes in dry seasons than in wet seasons even though statistically not significant ($P>.05$) (Table 6.2). Plant species comprising the bulk of the camel diets in dry and wet seasons (listed in the preceeding section) contained relatively low fiber values. Higher components of

CWC and lower lignin levels were present in grasses than in other plant species. Trees, shrubs, suffrutescents and vines generally contained similar fiber contents.

Camels selected apparently less lignified plant parts of browse species specifically in the dry seasons. They avoided highly lignified twigs and gathered sparsely available green leaves of shrubs and trees. In the wet seasons, however, camels selected new shoots already lignified in the tropical climate. Air and oven-drying at 60°C may have artificially elevated "lignin" levels (Goering and Van Soest 1970, Grant and Campbell 1978, Van Soest 1982, Piccaglia and Galletti 1987, Burritt et al. 1988). Green and relatively young twigs constituted the major portion of the shoot consumed by the camels.

In-vitro Dry Matter Digestibility (IVDMD)

IVDMD of forage species in camel diets range from 32.10% to 39.38% in the dry seasons and from 37.06% to 41.28% in the wet seasons (Tables 6.1 and 6.2). These IVDMD values are lower than the digestibility values reported in the literature for forage plants, not necessarily specific to camel diets (Le Houerou 1980b, Malechek 1984). Coppock et al. (1986) reported low IVDMD of camel diets (48% in wet, 25% in dry seasons) in Turkana, Kenya. Oven-drying may have also depressed IVDMP (Grant and Campbell 1978). Digestibility was inversely correlated to fiber contents. As CWC increased, digestibility decreased in most forage species in camel diet (Table 6.1). The lower digestibility of camel diets could, in part, be due to high lignin component in the

diets. Use of enzymes only without rumen fluid of the camels may have also contributed to the low IVDMD.

Evergreen shrubs and trees relatively high in digestibility, some suffrutescents, and vines were the major components of camel diets. Grass species were less digestible than other forage plants.

Minerals

Adequate amounts of calcium (Ca), potassium (K), and sodium (Na) were available in most major forage species camels consumed. Phosphorous (P) was, however, deficient (Tables 6.3 and 6.4). Potassium and phosphorous percentages were significantly lower ($P<.05$) in the dry seasons than in the wet seasons on average of all plants species analyzed. No differences ($P>.05$) was detected for calcium and sodium levels between the two seasons. Calcium and phosphorus ratios (Ca:P) were extremely low, about 26.7 in the dry seasons and about 15.1 in the wet periods for all plants consumed by camels.

Discussion

One of the many criteria used to make judgements on the value of plant species consumed by foraging animals is its nutritive content (i.e. species chemical composition and its digestibility). Nutrition fractions such as crude protein and fibers are widely believed to influence acceptability of forage plants to consumers. The degree of acceptance of any plant species or plant parts is said to be linked to many interrelated plant-animal- and environmental factors (Heady 1964, Arnold and Hill 1972, Le Houerou 1980a).

Table 6.3. Mineral contents in major forage plant species in camel diets for dry and wet seasons.

Forage class	Species	Dry Seasons % Ca	% P	% K	% Na	Wet seasons % Ca	% P	% K	% Na	Total # of seasons consumed
Deciduous	*Allophyllus sp.*	*0.96*	*0.10*	*1.49*	*0.07*	---*	---	---	---	*3*
nonspiny	*Cassia ellisae*	*1.04*	*0.06*	*1.04*	*0.12*	*1.36*	*0.10*	*1.37*	*0.09*	*5*
(nonthorny)	*Cordia somalensis*	*2.53*	*0.10*	*1.98*	*0.90*	*2.20*	*0.19*	*1.85*	*1.34*	*4*
	Crotalaria sp.	*2.07*	*0.08*	*0.96*	*0.12*	---	---	---	---	*2*
	Dalbergia uarandensis	*1.12*	*0.07*	*0.98*	*0.12*	*0.90*	*0.09*	*1.29*	*0.11*	*5*
	(Dhuusacarmeed)*	*2.19*	*0.07*	*0.71*	*0.33*	*1.72*	*0.15*	*2.67*	*0.14*	*3*
	Euphorbia matabelensis	---	---	---	---	*0.79*	*0.11*	*1.51*	*0.05*	*2*
	Grewia bicolor	*2.60*	*0.08*	*1.68*	*0.07*	---	---	---	---	*2*
	G. tembensis	*3.34*	*0.06*	*1.23*	*0.09*	*3.43*	*0.06*	*1.11*	*0.04*	*5*
	G. villosa	*2.68*	*0.06*	*1.46*	*0.22*	*2.35*	*0.16*	*2.16*	*0.06*	*5*
	Helinus integrifolia	*1.01*	*0.05*	*1.10*	*0.21*	*1.29*	*0.08*	*1.27*	*0.12*	*4*
	Solanum jubae	*1.66*	*0.17*	*3.15*	*0.03*	*1.69*	*0.14*	*2.13*	*0.05*	*2*
Deciduous	*Acacia edgeworthii*	*1.90*	*0.06*	*0.82*	*0.09*	*1.22*	*0.10*	*1.39*	*0.04*	*5*
spiny	*A. horrida*	*1.63*	*0.09*	*0.82*	*0.42*	*0.97*	*0.12*	*1.31*	*0.06*	*6*
(thorny)	*A. mellifera*	*1.24*	*0.10*	*1.15*	*0.18*	*1.76*	*0.14*	*1.30*	*0.05*	*4*
	A. nilotica	*1.17*	*0.05*	*0.87*	*0.04*	*0.91*	*0.09*	*1.02*	*0.03*	*6*
	A. nubica	*2.23*	*0.13*	*1.26*	*0.09*	*2.41*	*0.10*	*1.78*	*0.15*	*3*
	A. reficiens	*1.51*	*0.06*	*0.86*	*0.12*	*1.74*	*0.06*	*0.87*	*0.06*	*6*
	A. Senegal	*1.35*	*0.12*	*1.12*	*0.08*	---	---	---	---	*6*

	Acacia seyal	1.75	0.05	0.67	0.29	----	----	----	----	4
	Dichrostachys kirkii	1.04	0.09	1.15	0.15	1.13	0.09	1.09	0.08	5
Evergreen	*Albizia anthelmintica*	2.73	0.08	1.18	0.02	1.34	0.10	1.24	0.07	4
nonspiny	*A. obbiadensis*	----	----	----	----	1.00	0.05	0.93	0.07	1
(nonthorny)	*Boscia coriacea*	1.53	0.03	1.43	0.02	----	----	----	----	1
	Cadaba longifolia	1.42	0.06	2.70	0.54	1.08	0.07	3.38	0.08	4
	Maerua crassifolia	4.20	0.06	3.19	0.21	1.81	0.91	3.38	0.07	5
	M. macrocarpa	2.56	0.04	3.84	0.79	3.45	0.35	4.15	1.09	2
	(Magad)*	3.39	0.04	0.39	0.51	2.22	0.10	0.56	0.06	2
	Terminalia polycarpa	2.17	0.05	0.75	0.18	1.47	0.05	0.87	0.06	5
Evergreen	*Balanites rotundifolia*	1.38	0.04	1.47	0.07	1.36	0.05	1.52	0.03	3
spiny	*Terminalia spinosa*	0.94	0.05	0.84	0.10	1.23	0.08	1.08	0.05	3
thorny	*Ximenia sp.*	0.34	0.11	1.75	0.06	1.26	0.09	1.70	0.10	4
Suffrut-	*Asparagus africanus*	1.15	0.05	0.78	0.19	0.73	0.08	1.43	0.19	2
escents	*(Caanoxaraarshe*)*	1.31	0.05	0.94	0.10	----	----	----	----	2
	Crotalaria dumosa	1.24	0.06	0.63	0.04	0.73	0.06	0.78	0.03	3
	Hildebrandtia sepalosa	1.24	0.13	2.26	0.22	1.25	0.06	2.75	0.20	3
	Indigofera intricata	4.25	0.05	0.67	0.08	6.28	0.08	1.10	0.10	3
	I. ruspollii	2.47	0.05	0.34	0.06	----	----	----	----	1
	I. schimperi	4.19	0.05	1.83	0.08	2.43	0.05	1.58	0.03	2
	Kelleronia sp.	5.26	0.08	2.24	0.04	5.70	0.08	1.84	0.03	2
	Psilothricum tomentosum	----	----	----	----	2.54	0.08	3.10	0.17	3

Grasses	*Aristida adscensionis*	*0.48*	*0.05*	*0.67*	*0.06*	----	----	----	----	*2*
	A. sieberiana	*0.49*	*0.03*	*0.23*	*0.31*	*0.34*	*0.06*	*0.97*	*0.02*	*2*
	Cenchrus ciliaris	*0.67*	*0.06*	*0.84*	*0.36*	*0.85*	*0.07*	*1.51*	*0.24*	*6*
	Heteropogon contortus	*0.70*	*0.02*	*0.54*	*0.20*	*0.77*	*0.07*	*1.09*	*0.35*	*3*
	Leptothrium senegalense	*0.38*	*0.04*	*0.37*	*0.15*	*0.40*	*0.07*	*1.14*	*0.02*	*2*
Vines	*(Dabanaylood*)*	*2.12*	*0.07*	*0.99*	*0.32*	*2.78*	*0.11*	*1.64*	*0.10*	*3*
	Iphionopsis rotundifolia	*1.32*	*0.06*	*0.76*	*2.93*	*0.88*	*0.11*	*1.64*	*0.10*	*3*
	Merremia sp.	*2.11*	*0.09*	*1.73*	*0.25*	*3.89*	*0.14*	*2.75*	*0.05*	*4*
	Pentatropis spiralis	*3.08*	*0.06*	*1.37*	*0.93*	*3.06*	*0.07*	*1.72*	*0.31*	*6*
	Rhynchosia velutina	*1.43*	*0.08*	*1.35*	*0.06*	*1.99*	*0.19*	*2.07*	*0.04*	*6*

**Plant species were not eaten by camels in those particular seasons or not analysed for nutritive contents.*

(*)Somali name of plants since it was not identified.

Table 6.4. Mineral contents (%) of major forage species in camel diets for overall average of dry and wet seasons.

Mineral	Dry seasons	Wet seasons
Calcium (Ca)	1.87	1.83
Phosphorous (P)	0.07[a]	0.12[b]
Potassium (K)	1.26[a]	1.67[b]
Sodium (Na)	0.26	0.15
Ca:P	26.71	15.15

[a]Rows with different letters superscript are significantly different ($P \leq .05$) from each other

The crude protein content of the camel diets was lower in the dry season than in the wet seasons. It was, however, high for all seasons in all forage species (Table 6.1). This was apparently due to the ability of camels to select green leaves and relatively young tender twigs with high crude protein contents in dry seasons.

Loss of weight in camels was not because of lack of crude protein but apparently because of low energy in the diet during the dry season. Crude protein requirements for camels is not known. However, crude protein contents of camel diets revealed in this study are more than the protein requirements of cattle (NRC 1984), sheep (NRC 1968, 1975) or goats (NRC 1981). Whether this crude protein value is completely and effectively digestible needs further investigation. Variation in true digestibility of crude protein in different browse species has been reported not to relate to their crude protein content in other studies (Walker 1979). Coppock et al. (1986), however, found that camel diets in Turkana were high in digesetible nitrogen in dry periods.

If camels were assumed to have similar requirements for crude protein as other domestic livestock, certainly, the protein contents of the study camel diets exceed their requirements in all seasons for almost all plant species comprising their diets. Crude protein levels obtained in this study are similar to those reported for browse species in Africa (Rose-Innes and Mabey 1964, Wilson 1977, Lamprey et al. 1980, Lawton 1980, Le Houerou 1980b, Pellew 1980, Walker 1980, Hashi and Cianci 1985). Thus, crude protein may not be a limiting factor for camels in the dry season. They have access to variety of forage

species, primarily browse, and they can selectively browse or graze green parts of plants heavily armed with spines and not available to other livestock.

Camels included stems as well as leaf tissues in their diets. Through selective foraging, they were apparently able to maintain high dietary protein levels in their diets throughout the year. Effective crude protein concentration could be, therefore, assumed high in camel diets. If so, camels seemed to secure their protein requirements in all seasons. High temperature (29-31°on average) and low or high relative humidity (48-80% on average) probably reduced the time camels spent on effective foraging in winter and spring seasons (see Chapter IV), but did not affect the ability of camels to get quality protein in the forage consumed. Other studies showed that heat stress did not appreciably change the protein requirements of other domestic animals (NRC 1981).

Camels consumed high fiber content diets. Energy intake probably barely exceeded the maintenance threshold of the camel. The weight loss of camels observed in the field during dry seasons could support this intuitive judgement of energy deficiency in dry seasons and drought periods such as the one occurred in fall, 1986. In Turkana ecosystems, camel diets were found deficient in digestible energy (Coppock et al. 1986).

Studies on small ruminants indicate that goats ate less fiberous, highly digestible, nutritious diets to maintain a rapid rumen turnover. A high rate of feed passage was necessary for their survival because

of their small body size and rumen capacity (Van Soest 1982, Coppock et al. 1986).

In my study, there appeared relatively little change of CWC and lignin levels in forage species consumed by camels between dry and wet seasons (Tables 6.1 and 6.2). The low contents of CWC in browse species, suffrutescents and vines compared to grasses might help camels gradually lose weight because of relatively high energy content of browse species with respect to grasses. Maloiy (1972) reported that cattle grazing in the same areas with camels, but exclusively dependent on grasses, quickly lost weight as the dry season advanced. In my study, camels usually neglected grass consumption in most seasons perhaps because of their inefficiency in digesting low quality grass culms and dry leaves.

During all seasons camels generally consumed diets containing slightly more lignin (ADL) than herbaceous or vine species. High fiber and lignin contents in camel diets was apparently due to their preference of browse plants in all seasons. Short et al. (1974) stated that plants with high fiber contents were low-quality forage for small ruminants. For camels it might not be so, because they have a big body size and large rumen volume which allows longer retention of forage particles in the rumen than goats and sheep. Emmanuel's (1980) study supports that camels are more efficient in crude fiber digestion than sheep.

IVDMD values for dry and wet seasons were generally low ($P>.05$). High lignin content, possible presence of secondary polyphenolic compounds such as tannins and the <u>in vitro</u> procedure in which only an

enzyme was used without rumen fluid may have contributed to low values of IVDMD of forage species in camel diet.

High lignin levels in trees and shrubs which constituted the major portion of camel diets probably depressed the IDVMD. Wilson (1969, 1977) reported that browse plants were generally higher in lignin than herbaceous species. Van Soest (1982) indicated that lignification is the most important factor influencing forage quality. He stated that lignin restricts the extent of digestion. Meneely and Schemnitz (1981) found low dry matter digestibility (33-52%) for several temperate browse species in the United States. Wilson (1977) and McLeod (1973) reported low digestibility for tropical shrubs and trees in Australia. Though no relationships between dry mater digestibility and the level of browse consumption was found, Malechek and Leinweber (1972) reported low digestibility for goat's diets. Range forage digestibility seldom exceeds 55-65% (Malechek 1984). Le Houerou (1980b) found digestibility of 56% for legumes and 55% for grasses. Wilson and Harrington (1980) obtained reduced value of <u>in vitro</u> digestibility in assessing browse forage quality. Thus, the digestibility of forage species in camel diets may not be as low as the IDVMD indicated in this study.

Maximizing the intake of nutrients (Westoby 1974) and at the same time minimizing ingestion of secondary plant metabolites (Freeland and Jansen 1974, Bryant et al. 1985, 1987) were considered the most important base in herbivore diet selection processes. The presence in browse species of secondary polyphenolic compounds such as tannins reduced protein digestibility (Robbins et al. 1987a) of deer consuming tanniferous forages but did not depress plant cell wall digestion

(Robbins et al. 1987b). Tannins have been found to lower digestibility of organic matter and protein (Donnelly and Anthony 1969, Bohra 1980, Van Soest 1982) and plant cell wall digestion in domestic sheep (Barry and Manley 1984, Barry et al. 1986). However, no tannin effect was found on cell wall or NDF digestion in deer (Robbins et al. 1987b). Plants with a relatively high condensed tannin content may be acceptable to browsers such as camels if they tolerate its toxicity. Thus, camels may not necessarily select their diets according to levels of either nutrients or secondary metabolites but according to the balance between the two. In the Australian desert, Whittaker (1970) reported that camels feed on eucalyptus leaves high in essential oils and phenols. Williams (1963) indicated that camels eat a diversity of vegetation perhaps to dilute the toxicity of some forage species they consume.

The in vitro procedure and the use of enzyme digestion alone without rumen fluid of the animal studied can reduce the IVDMD of forage species. If ingestion inhibiting secondary compounds were present in the simulated samples, microorganisms tolerant of these compounds would have been absent since rumen fluid of the concerned animal was not used. Wilson and Harrington (1980) found that the in vitro digestibility of tropical trees and shrubs was of limited value in assessing forage quality because of the variation in in vitro method. Thus the value of in vitro digestibility for assessing quality was much reduced. In vitro procedure was reported to underestimate digestibility of shrub diets (Sidahmed et al. 1981). They, however, indicated reasonably accurate estimation of digestibility of diets

containing shrubs when the donor animals were fed shrub-containing diets.

Forage digestibility is a potential indicator of dietary energy requirements of ruminants (Rittenhouse et al. 1971). The digestibility levels reported in the present study for dry and wet seasons may not be exceptionally low. However, camel weight loss during dry seasons (Chapters IV and V) and the adequate crude protein contents in their diets show that camels, especially milking camels, were not able to meet their energy requirements. Deficiencies of dietary energy due to insufficient forage availability were apparently a serious limitation to livestock production during dry or drought periods, not only in Ceeldheer District but throughout Somalia.

Protein catabolism may alleviate, to some extent, energy deficiency. But trees and shrubs which dominate camel diets are relatively high in fiber content and are accompanied by low dietary energy content and may reduce rumen turnover and lower rate of passage (Van Soest 1982). Heat stress also may increase suspected dietary energy deficiency by increasing maintenance energy requirements for thermoregulation and by depressing feed intake (NRC 1981). Camels might not spend much energy for thermoregulation because of their ability to regulate their body temperature (Schmidt-Neilsen et al. 1956b, MacFarlane et al. 1963) and consumption of fat deposited in their hump. The hump of the camels grows big when plenty of forage is available in the wet seasons and almost disappears in the dry seasons when forage is in critical condition.

The impact of environment upon a deficiency of dietary energy was not measured in this study. However, given the consistently high ambient temperature coupled with either low or high relative humidity in Ceeldheer District, heat stress probably reduces camel performance in the dry seasons or drought periods when energy requirements are not met due to insufficient forage availability and mineral deficiencies.

The mineral requirement of camels is not known. Attempts were made to find mineral contents of major elements in camel diets. Calcium (Ca), potassium (K) and sodium (Na) were found adequate for other livestock in most plant species camels consumed. However, phosphorous (P) was extremely low. Results from other studies on these elements for specific plant parts such as new shoots, leaves, twigs or seeds in Africa were similar to my results except for phosphorous (Lawton 1980, Le Houerou 1980a, Walker 1980, Hashi and Cianci 1985). Lower phosphorous percentages were obtained in this study than those sources cited above.

Plant species in camel diets in Ceeldheer District contained sufficient Ca, K, and Na for most domestic animals but were deficient in P in all seasons. Mineral content of camel diets is more than enough for cattle (NRC 1984), for tropical animals (McDowell et al. 1983), and for llamas and sheep (Espinoza et al. 1982). If the mineral requirements of camels were considered similar to the requirements of those animals, only P is deficient for camels. Browse species which comprise the bulk of camel diets are rich in minerals. The major problem is the imbalance of Ca:P ratio. This ratio is extremely low in both dry (26.7) and in wet (15.1) seasons. It is much lower than

that reported by Le Houerou (1980b) of 11.2:1. The Ca:P ratio is far below the 2:1 ratio generally recommended for domestic livestock production (McDowell et al. 1983). The study camels chewed bones when they found them, giving a circumstantial indication of phosphorous deficient diet (McDowell 1985). Phosphorous supplement may, therefore, be apparently necessary for maximum production of camels and other domestic animals in Ceeldheer District. Practically no mineral supplements are provided or available in the district.

Conclusion

The forage species camels consumed (trees, shrubs, suffrutescents, vines, grasses) appear to be rich in crude protein and the major mineral elements (Ca, K, Na) with the exception of phosphorous. Cell wall constituents (i.e. NDF) and lignin level (ADL) are high. A high level of fiber contents in camel diets apparently be tolerated due to the big body size and large volume of rumen which allows the camels to retain fibrous diets for a long time in the rumen.

Leaves, lignified but relatively young twigs, and stems are regular components of camel diets most of the year (Chapter V). Due to the camel's ability to select highly nutritious plants and plant parts, effective crude protein concentration could be assumed to be high. They secure their protein requirements by maximizing crude protein intake.

Crude protein intake seems far in excess of maintenance requirements throughout the year, if camel protein requirements are assumed similar to other domestic livestock requirements. However,

digestible energy seems deficient in dry and drought periods. In order to satisfy their dietary needs, camels widen their dietary acceptance range in all seasons.

Low dietary energy intake and inadequate phosphorous availability accompanied with extremely low Ca:P ratios may be responsible for the weight loss of camels as the dry season progresses and during drought periods, especially in lactating camels.

To understand nutritional constraints for camels and other domestic livestock in Somalia, a great deal of research is certainly needed. In order to maintain maximum sustainable livestock production, successful programs must be established to reduce and eventually eliminate feed shortage and nutrient deficiencies in the dry seasons and recurrent drought periods.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

Somali pastoralist management systems are controlled by the quantity of forage and water availability. These are predictable by seasons but are erratic in distribution, amounts and intensity of annual rainfall. The unreliability of rainfall in time and space within wet seasons, coupled with periodical droughts, caused the Somali livestock herders to develop migratory movement from place to place in search of better forage for their livestock.

The great attention they pay to productivity in selecting breeding stock is part of their traditional management. Their traditional system, however, is under increasing pressure from within and outside. Their foraging lands are largely unsuitable for farming due to the sandy nature of the soil. However, a substantial amount has been cleared for shifting cultivation. Farming and intensive livestock raising do not seem appropriate at present and will lead to deterioration of the successfully existing pastoralists-vegetation-animal equilibrium. It is important to identify successful means of improving and, at the same time, preserving camel pastoralism as the base for future development. This can be achieved through integrated research that elaborates on my findings for the Ceeldeer District and accounts for the customs, lifestyle, internal logic--both social and economic--of the pastoral systems.

Camels are primarily browsers in the study area. Clearing of woody shrubs and trees (which comprise more than 80% of the camel diets) for shifting cultivation is increasing at a rapid pace in Ceeldheer District. These browse species serve as dry or drought period natural forage reserves. The negative effects of removing these forage species are most obvious near villages where camel forage plants have been cut. Sand dunes have increased in and near the denuded areas. If vegetation clearance continues at the rate of the past 10 years, the best camel range will be gone in a matter of a few decades. The most useful animals, camels, will no longer sustain themselves in numbers sufficient to support the human population.

The undesirable vegetation clearance could be stopped through education and mass awareness of the benefits of conserving the natural resource the people depend upon. Agropastoralism based on well formulated and ecologically sound management objectives should be designed, and implemented to eventually halt degradation of rangelands and, at the same time, lead to maximum sustainable vegetation-animal production.

Hot, dry and long winter seasons are the bottleneck of animal production in Somalia. Dry season forage reserves are needed to overcome forage deficiency in late dry seasons or drought periods. Camels, specifically the milking ones, lose weight due to increased feed demand to satisfy lactation. Milking camels allocated more time towards gathering insufficiently and sparsely available green forage than non-milking camels. Additional forage is needed to compensate for

the energy lost in milk production in the dry seasons and drought periods.

Camels spent less time foraging, more time in rest, rumination, and idling in winter (dry) and spring (major hot, humid rainy season) than in any other seasons. Among factors which contributed to low foraging time were insufficient forage availability, long interval between watering, lignification of available evergreen forage plants and heat stress caused by hot temperature and low relative humidity. In spring, reduction in foraging time of camels was not because of lack of sufficient forage but high moisture content of the lush green plants, high relative humidity and temperature, and disturbance by breeding males.

Heat stress reduced the time camels spent on foraging, increased rest rumination and rest idling. High ambient temperature occurred daily in Ceeldheer District. Interactions of high temperature and probably low or high relative humidity increased the effect of heat stress on the animal. Foraging time was reduced in the winter dry season due to high temperature and perhaps low relative humidity. In spring, foraging time was reduced because of high temperature and high relative humidity. In these two contrasting seasons, few camels foraged at night. But the majority of the herd did not compensate for the reduced quantity of forage available or heat stress during dry seasons by increasing the foraging time during cool hours of the night.

Camels spent more time foraging and travelling in the wet seasons when forage was abundant and higher in quality than in the dry seasons. The ability to select the most preferred species was high in the rainy

periods. Continuation of this study, specifically on the relationship of time spent in foraging in relation to seasonal forage availability and forage quality could relate to systems for better camel performance. The relationships of weight loss or gain of camels and forage quality; of milk production and weight loss as influenced by dry and wet seasons; of environment and camel milk production within and between seasons; of rainfall, forage production and camel performance; and of daily, weekly or monthly watering to milk production and weight gain or loss of camels are all suitable topics for studies under controlled conditions.

Camels chose their diet from a variety of range vegetation primarily of browse species. They were more selective in the wet seasons than dry seasons. Dietary acceptance range of camels increased in the dry seasons to compensate for the declining choice of available forage species. Grasses which were almost ignored in the wet seasons were included in the dry season diets. Lignified mature twigs, old leaf-litter, suffrutescents, vines and dry forbs were consumed in a large amount.

The diets of milking an dry camels were similar in all seasons. Milking camels consumed more green plants in the dry seasons than non-milking camels even though they are herded and foraged together at any given time. The availability of green materials in camel diets increased as the percent browse composition in the plant community increased.

Browse plant species such as high shrubs and trees were the major components of camel diets throughout the year. Most of the dry season

camel diets consisted of spinescent or thorny browse species. These physical defense structures of forage plants did not prevent feeding on the plant. Small leaved deciduous or evergreen shrubs and trees were equally utilized as large leaved ones.

Camels were flexible in their diet selection and foraging behavior in different seasons. Studies on diet selection of camels to learn more about whether camels are more efficient feeders than, for example, goats, and less destructive of range plants than small ruminants or cattle need to follow my research. Additional studies to further assess how much of the browse plant species are available for camel use and the influence of physical defense structures (spinescence, thorniness, etc.) on forage intake of the animal would be helpful.

Camels have a nutritional advantage over other domestic animals herded together due to their ability of selectively browsing high shrub and tree canopies unreachable to small ruminants. Developing ways to increase the available overhead green materials during dry seasons or drought periods of nutritional stress could enhance camel production.

Plant species such as Rhynchosia velutina, Pentatropis spiralis (vines); Indigofera sp. (suffretuescent sp.); and Acacia sp. (shrub/tree) are important in camel diets throughout the year. For instance, all portions of vine plants were consumed including large amounts of stem. Substantial quantities of lignified twigs with little or no leaves of browse species were also eaten in the dry seasons. Research into exploiting camel forage species as cultivated plants may merit consideration.

Crude protein was not deficient in camel diets at any season when measured against published requirements for other livestock. However it is not known whether the crude protein content in camel diets is digestible protein for the animal. Studies should be done to determine the requirement for camels.

Camel foraging activities and weight loss in dry seasons may suggest a deficiency of digestible energy. Since forage availability was low in the dry seasons, digestible energy could be assumed to be deficient. The declining camel condition in the dry winter supports the apparent insufficient dietary energy intake of camels in late dry seasons and in drought periods. Because crude protein levels in camel diets are high in the dry season, weight loss of the animal is probably due to a deficiency in digestible energy and some minerals. Mineral analysis indicated acute shortage of phosphorous and extremely low Ca:P ratios in both dry (26.7:1) and wet (15.1:1) for major plant species comprising the camel diets. In the wet seasons when plenty of lush green forage is available dietary energy intake is high and camels quickly gain weight. Research is necessary to determine how the crude protein levels reported in this study are related to digestible protein. Phosphorous deficiency indicated in this study is probably real because of sandy soils which are typically low in phosphorous and quick maturation of leaves and stems of forage plants. Determining energy and mineral supplementation levels necessary for optimum animal production would aid management.

The advantage of free-ranging, one-humped camels over other domestic livestock resides mainly in their ability to convert woody

trees and shrubs efficiently to milk and meat production in arid lands of Africa (Coughenour et al. 1985). The free movement of camels minimizes the risk of localized over-browsing and degradation of rangeland particularly in Somalia.

Camel ranching as advocated by some "neo-camelists" (Battiata 1988) may negate the animals' main values as users of scattered woody plants further from watering sources and may not be better or good as goats in confinement. Sedenterization of camels may lead to irreversible destruction of the pastoral-vegetation-animal coexistance that has been successfully sustained for centuries. More importantly, free movement of camels offers reliable sources of sustenance in a drought-susceptible environment. Successful means of improving and, at the same time, preserving camel pastoralism as the base for future development must be identified.

It is also important to do long term studies similar to the present one on animal behavior and nutritional needs to better measure the response of vegetation and animals to highly variable weather conditions characteristic to the Somali climate. To achieve all these studies, a well designed research program should be established. This will help obtain optimum range vegetation use for maximum sustainable animal production to alleviate shortage of protein and energy for developing nations in arid and semi-arid regions of the world, specifically in Africa.

LITERATURE CITED

Abokor, A. C. 1987. The camel in Somali oral tradition. (Translated by A. A. Xange). SOMAC/SIAS. Uppsala, Sweden. 95 pp.

Arnold, G. W., and J. L. Hill. 1972. Chemical factors affecting selection of food plants by ruminants. pp. 71-101. In: J. B. Harborne (ed.) Phytochemical Ecology. Academic Press, New York.

Arnold, G. W., and M. L. Dudzinski. 1978. Ethiology of free-ranging domestic animals. Elsevier/North-Holland Inc., New York. 198 pp.

Barry, T. N., and T. R. Manley. 1984. The role of condensed tannins in the nutritional value of Lotus pedunculatus for sheep. 2. Quantitative digestion of carbohydrates and proteins. Brit. J. of Nutr., 51:493-504.

Barry, T. N., T. R. Manley, and S. J. Duncan. 1986. The role of condensed tannins in nutritional value of Lotus pedunculatus for sheep. 4. Sites of carbohydrates and protein digestion as influenced by dietary reactive tannin concentration. Brit. J. of Nutr., 55:123-137.

Battiata, M. 1988. Camels plod to new glory: African experts praise their big, soft feet. The Washington Post. Thursday, June 2, 1988.

Behnke, R. H. 1988. Range enclosures in Central Somalia. Pastoral Development Network Paper No. 25b. ODI, London, UK. 28 pp.

Bohra, H. C. 1980. Nutrient utilization of Prosopsis cineraria (Khejri) leaves by desert sheep and goats. Ann. Arid Zone, 19:73-81.

Bosticco, C. 1981. Osservazzione sui cicli sexuale e reproductivo di Camelus dromedarius (Tesi de Laurea). Universitat degli Studi di Turino, Faculta di Medicina Vet., Italy. 120 pp.

Box, T. W. 1968. Range resources of Somalia. J. Range Manage. 21(6):388-392.

Bryant, J. P., G. D. Wieland, T. B. Clausen, and P. S. Kuropat. 1985. Interaction of snowhare and felt leaf willow in Alaska. Ecology 66:1564-1573.

Bryant, J. P., F. S. Chapin III, P. B. Reichardt, and T. B. Clausen. 1987. Response of winter chemical defense in Alaska paper birch and green alder to manipulation of plant carbon/nutrient balance. Oecologia (Bert) 72:510-514.

Bulliet, R. W. 1975. The camel and the wheel. Harvard Univ. Press, Cambridge, Massachusetts. 326 pp.

Burritt, E. H. J. A. Pfister, and J. C. Malechek. 1988. Effects of drying method on nutritive composition of esophageal fistula forage samples: influence of maturity. J. Range Manage. 41(4):346-349.

Canfield, R. H. 1942. Measurement of grazing use by the line interception method. J. For. 142:192-194.

Chapman, H. D., and P. E. Pratt. 1961. Methods of analysis for soils, plants and water. Univ. of California. 61 pp.

Cochran, W. G., and G. M. Cox. 1957. Experimental designs. John Wiley and Sons Inc. New York. 611 pp.

Coppock, D. L., D. M. Swift, and J. E. Ellis. 1986. Seasonal nutritional characteristics of livestock diets in a nomadic pastoral ecosystem. J. Appl. Ecol. 23(2):585-595.

Coughenour, M. G., J. E. Ellis, D. M. Swift, D. L. Coppick, K. Galvin, T. C. McCabe, and T. C. Hart. 1985. Energy extyraction and use in a nomadic pastoral ecosystem. Sci. (230(4726):619-625.

Dahl, G., and A. Hjort. 1979. Dromedary pastoralism in Africa and Arabia. p. 447-458. In: IFS provisional rep. No. 6. Khartoum, Sudan.

Donnelly, E. D. and W. B. Anthony. 1969. Relationships of tannin, dry matter digestibility and crude protein in Sericea leopedza. Crop. Sci. 9:361-362.

Dwyer, D. D. 1961. Activities and grazing preferences of cows with calves in Northern Osage County, Oklahaoma. Okla. Agric. Exp. Sta. Bull. B-588. 61 pp.

El-Amin, F. M. 1979. The dromedary camel of the Sudan. pp. 35-53. In: IFS Provisional Rep. No. 6. Khatoum, Sudan.

Elmi, A. A. 1984. Observation on the browsing and grazing behavior of camels. Camel Forum Working Paper No. 7:115-136. SOMAC, Mogadishu, Somalia.

Elmi, A. A. 1985. Importance, traditional management and research needs of camels in Somalia. pp. 115-122. In: L. D. White and J. A. Tiedeman (eds.) Prov. Int'l. Rangeland Symp, SRM. Salt Lake City, Utah.

Emlen, J. M. 1966. The role of time and energy in food preference. Amer. Nat. 100:611-617.

Emmanuel, B. 1980. Comparative biochemical studies between the camel and other ruminants. pp. 246-321. In: IFS Provisional Rep. No. 6. Khartoum, Sudan.

Espinoza, J. E., L. R. McDowell, J. Rodriquez, J. K. Looseli, J. H. Conrad, and F. G. Martin. 1982. Mineral status of llamas and sheep in the Bolivian Altiplano. J. of Nutr. 112(2):2281-2292.

Evans, J. O. 1979. Camel husbandry to increase the productivity of rangelands. pp. 241-250. In: IFS Prov. Rep. No. 6. Khartoum, Sudan.

Farid, M. F. A., S. M. Shawket, and M. H. A. Abdelrahman. 1979. Observation on the nutrition of camels and sheep under stress. pp. 125-170. In: IFS Prov. Rep. No. 6. Khartoum, Sudan.

Field, C. R. 1978. The food habits of camels in Northern Kenya. Integrated Project in Aridlands, Tech. Rep. No. E-16 UNEP/UNESCO.

Field, C. R. 1979. Camel growth and milk production in Marsabit District, Northern Kenya. pp. 215-240. In: IFS Prov. Rep. No. 6. Khartoum, Sudan.

Freeland, W. J., and D. H. Jansen. 1974. Strategies of herbivory by mammals: The role of plant secondary compounds. Amer. Nat. 108:169-289.

Gauthier-Pilters, H. 1979. Some ecological aspects of the camel in Western Sahara. pp. 387-398. In: IFS Prov. Rep. No. 6. Khartoum, Sudan.

Gauthier-Pilters, H., and A. I. Dagg. 1981. The camel: its evolution, ecology, behavior and relationship to man. University of Chicago Press, Chicago. 208 pp.

Gebremariam, A. 1987. Livestock production and its socio-economic importance among the Afar in Northeast Ethiopia. Camel Forum Working Paper No. 16:1-44. SOMAC, Mogadishu, Somalia.

Goering, H. K., and P. J. Van Soest. 1970. Forage fiber analysis USDA Agr. Handbook. Washington, D.C. 379 pp.

Grant, S. A., and D. R. Campbell. 1978. Seasonal variation in in vitro digestibility and structural carbohydrate contents of some commonly grazed plants of blanket bog. J. Brit. Grass. Soc. 33:167-173.

Hach, C. C., S. V. Brayton, and A. B. Kopelove. 1985. A powerful Kjeldahl nitrogen method using peroxymonsulfuric acid. J. of Agr. and Food Chem. 33:1117-1123.

Harris, L. E. 1970. Nutrition techniques for domestic and wild animals. Utah State Univ., Utah. 226 pp.

Hashi, A. M., and D. Cianci. 1985. Chemical compositon of some range forage in Somalia. Bulletino Scientifico della Fucolta di Zootecnia e Med. Vet. (UNS). VI:109-116.

Heady, H. F. 1964. Palatability of herbage and animal preference. J. Range Manage. 17:76-82.

Hemming, C. F. 1972. Survey of the Northern rangelands: Ecological and grazing survey of the Mudug Region. Somali Democratic Republic. UNDP/FAO/SF/SOM/70/512, FAO, Rome. 15 pp.

Herlocker, D. R., and A. M. Ahmed. 1985. Intrim report on range ecology and management of Ceeldheer District, CRDP Tech. Rep. No. 8:1-37. Mogadishu, Somalia.

Herlocker, D. R.,and A. M. Ahmed. 1986. The vegetation of the coastal plain, Central Somalia. Somali J. Range Sci. 1:34-58.

Herlocker, D. R., A. M. Ahmed, and T. L. Thurow. 1987. Response of vegetation of Acacia reficiens, Dichrostachys sp. shrubland range site to land use intensity, Ceeldheer District, Central Somalia. Somali Journal of Range Sci. 2(1):10-24.

Herlocker, D. R., A. M. Ahmed, and T. L. Thurow. 1988. Response of vegetation of the Acacia nilotica / Dichrostachys kirkii shrubland range site to land use intensity, Ceeldheer District, Somalia. Somali J. Range Sci. 3(1):1-11.

Hjort, A., and M. A. Hussein. 1986. Camel herd dynamics in Southern Somalia: Longterm develompent and milk production implications. Camel Forum Working Paper No. 13:1-32. SOMAC, Mogadishu, Somalia.

Hjort, A. 1988. Camel in development: Sustainable production in African drylands. SIAS, Sweden. 165 pp.

Holt, R. M. 1985. Agropastoralism and desertification in Ceeldheer District, Central Somalia. CRDP Tech. Rep. No. 3:1-129. Mogadishu, Somalia.

Hussein, M. A. 1984. Traditional systems of camel management and husbandry. Camel Forum Working Paper No. 7:37-41. SOMAC, Mogadishu, Somalia.

Hussein, M. A. 1987. Traditional practices of camel husbandry and management in Somalia. Camel Forum Working Paper No. 19:1-15. SOMAC. Mogadishu, Somalia.

Hutchinson, P. 1986. The climate of Somalia in relation to forage production. Somali National University, Mogadishu, Somalia. 9 pp.

Jarman, P. J., and A. R. E. Sinclair. 1979. Feeding strategy and pattern of resources partitioning in ungulates. pp. 130-163. In: A. R. E. Sinclair and M. Morton-Griffiths (eds.) Sarengeti: Dynamics of an ecosystem. Chicago Univ. Press, Chicago.

Knoess, K. H. 1976. Assignment report on animal production, in the middle Awash Valley, Development of Awash Valley, Phase IV, UNDP/FAO Eth/75/001. FAO. Rome.

Knoess, K. H. 1979. Milk production of dromedary. pp. 201-214. In: IFS Prov. Rep. No. 6. Khartoum, Sudan.

Kuchar, P., and D. R. Herlocker. 1985. Somali plant names in Ceeldheer and Buulo Burte Districts. CRDP Tech. Rep. No. 10:1-128. Mogadishu, Somalia.

Kuchar, P. 1986. The plants of Somalia. An overview and checklist. CRDP Tech. Rep. No. 16:1-291. Mogadishu, Somalia.

Lamprey, H. F., D. J. Herlocker, and C. R. Field. 1980. Report on the state of knowledge of browse in East Africa. pp. 33-54. In: H. N. Le Houerou (ed.) Browse in Africa: The current State of Knowledge. ILCA, Addis Ababa, Ethiopia.

Lawton, R. M. 1980. Browse in Miombo woodland. pp. 25-31. In: H. N. Le Houerou (ed.), Browse in Africa: The current state of knowledge. ILCA, Addis Ababa, Ethiopia.

Le Houerou, H. N. 1980a. Browse in Northern Africa. pp. 55-82. In: H. N. Le Hourerou (ed.). Browse in Africa. The current state of knowledge. ILCA, Addis Ababa, Ethiopia.

Le Houerou, H. N. 1980b. Chemical composition and nutritive value of browse in tropical West Africa. pp. 261-289. In: H. N. Le Houerou (ed.). Browse in Africa: The current state of knowledge. ILCA, Addis Ababa, Ethiopia.

MacFarlane, W. V., R. J. H. Morris, and B. Howard. 1963. Turnover and distribution of water in desert camels, sheep, cattle and kangaroos. Nature 197:270-271.

Malechek, J. C., and C. L. Leinweber. 1972. Chemical composition and in vitro digestibility of forage consumed by goats on lightly and heavily stocked ranges. J. Anim. Sci. 35:1014-1019.

Malechek, J. C. 1984. Impact of grazing intensity and specialized grazing systems on livestock response. pp. 1129-1158. In: NRC/NAS Developing Strategies for Range Manage. Westview Press, Boulder, CO.

Malechek, J. C., and D. F. Balph. 1987. Diet selection by grazing and browsing livestock. pp. 121-132. In: J. B. Hacker and J. H. Temouth (eds.). The Nutrition of Herbivores. Academic Press, Sydney.

Maloiy, G. M. D. 1972. Comparative studies on digestion and fermentation rate in the fore-stomach of the one humped camel and zebu streer. Res. in Vet. Sci. 13:476-481.

Mares, R. G. 1954. Animal husbandry, animal industry and animal diseases in Somaliland Protectorate. Part I. The Brit. Vet. Jour. 110:411-481.

McDowell, L. R., J. H. Conrad, G. L. Ellis, and J. K. Loosli. 1983. Minerals for grzing ruminants in tropical regions. USAID Bulletin, Washington, D. C. 86 pp.

McDowell, R. E. 1984. Livestock nutrition in Subsaharan Africa: an overview. pp. 43-59. In: J. R. Simpson and P. Evangelou (eds.). Livestock Development in Subsaharan Africa. Westview Press, Boulder, Co.

McDowell, L. R. 1985. Nutrition of grazing ruminants in warm climate. Acadmic Press, Inc. 443 pp.

McKnight, T. L. 1969. The camel in Australia. Melbourne Univ. Pres, Australia. 154 pp.

McLeod, M. N. 1973. The digestibility and nitrogen, protein and ash contents of leaves of some Australian trees and shrubs. Aust. J. Exp. Agr. Anim. Husb. 13:245-250.

McLeod, M. N., and D. J. Minson. 1978. The accuracy of the pepsin-cellulase technique for estimating the dry matter digestibility in vitro of grasses and legumes. Anim. Feed Sci. and Tech. 3:277-287.

Meneely, S. C., and S. D. Schemnitz. 1981. Chemical comosition and in vitro digestibility of deer browse three years after a wildfire. The Southwest Nat. 26:365-374.

Morton, R. H. 1984. Camels for meat and milk production in Subsaharan Africa. J. Dairy Sci. 67:1548-1553.

Mukasa-Mugerwa, E. 1981. The camel (Camelus dromedarius): A bibliographical Review. ILCA Monograph. Addis Ababa, Ethiopia. 147 pp.

Newman, D. M. R. 1979. The feeding habits of old and new world camels as related to their future role productive ruminants. pp. 171-200. In: IFS Prov. Rep. No. 6. Khartoum, Sudan.

NRC. 1968. Nutrient requirements of sheep, No. 5. National Academy Press, Washington, D. C. 64 pp.

NRC. 1975. Nutrient requirements of goats, No. 15. National Academy Press, Washington, D. C. 91 pp.

NRC. 1981. Effects of environment on nutrients of domestic animals. National Academy Press, Washington, D. C. 152 pp.

NRC. 1984. Nutrient requirements of cattle. National Academy Press, Washington, D. C. 90 pp.

Ohri, S. P., and B. K. Joshi. 1961. Composition of camel milk. Indian Vet. Jour. 38:604-607.

Owen-Smith, R. N. 1982. Factors influencing the composition of plant products by large herbivores. pp. 359-404. In: B. J. Huntly and B. H. Walker (eds.) Ecology of Tropical Savanas. Springer-Verlag, Berlin.

Owen-Smith, R. N., and P. Novellie. 1982. What should a clever ungulate eat? Amer. Nat. 19:151-178.

Pellew, R. A. 1980. The production and consumption of Acacia browse and its potential for animal protein production. pp. 223-231. In: H. N. LeHouerou (ed.) Browse in Africa: The Current State of Knowledge. ILCA, Addis Ababa, Ethiopia.

Pellew, R. A. 1984. Food consumption and energy budget of the giraffe. J. Appl. Ecol. 21:141-159.

Piccaglia, R., and G. C. Galletti. 1987. Effects of sample drying on the determination of fiber and water soluble carbohydrates of maize silage. Grass and Forage Science (42):319-321.

Pichi-Sermolli, R. E. C. 1957. Una carta geobotanica del'Africa Orietale (Eritrea, Ethiopia, Somalia) Webbia, Vol. XIII, No. 1.

Pieper, R. D. 1978. Measurement techniques for herbaceous and shrubby vegetation. New Mexico State Univ., Las Cruces, NM. 148 pp.

Pratt, D. J., and M. D. Gwynne. 1977. Rangeland management and ecology in East Africa. Hodder and Stoughton, London, UK. 310 pp.

Pratt, D. J. 1984. Ecology and livestock. pp. 21-41. In: Livestock Development in Subsaharan Africa. Westview Press, Boulder, Co.

Richards, D. 1979. Study of the pathology of dromedary in Borarna Awraja (Ethiopia) I.E.M.U.T., France. 221 pp.

Rittenhouse, L. R., C. L. Streeter, and D. C. Clanton. 1971. Estimating digestible energy from digestible dry and organic matter in diets of grazing cattle. J. Range Mange. 24:73-75.

RMR. 1979. Static range resource Vol.I, part 2 maps. Central Range Survey. Somali Democratic Rep.

Robbins, C. T., T. A. Hanley, A. E. Hagerman, O. Hjeljord, D. L. Baker, C. C. Schwartz, and W. W. Mantz. 1987a. Role of tannins in defending plants against ruminants: reduction in protein availability. Ecology 68(1):98-107.

Robbins, C. T., S. Mole. A. E. Hagerman, and T. A. Hanely. 1987b. Role of tannins defending plants against ruminants? Ecology 68(6):1606-1615.

Rose-Innes, R., and G. L. Mabey. 1964. Studies on browse plants in Ghana I. Chemical composition: Emp. J. Exp. Agric 32(126):114-124.

Ryan, T. A., Jr., B. L. Joiner, and B. F. Ryan. 1981. Minitab reference manual. The Pennsylvania State Univ., University Park, PA. 154 pp.

Schmidt-Nielsen, B., K. Schmidt-Nielsen, T. R. Houpt, and S. A. Jarnum. 1956a. The question of water storage in the stomach of the camel. Mammalia 20:1-15.

Schmidt-Nielsen, B., K. Schmidt-Nielsen, T. R. Houpt, and S. A. Jarnum. 1956b. Water balance of the camel. Am. J. of Physiol. 185:185-195.

Schmidt-Nielsen, K. 1959. The physiology of the camel. Sci. Amer. 200:140-142, 144, 146-148, 150-151.

Schmidt-Nielsen, K. 1964. Desert animals: Adaptation and environment. Oxford Univ. Press, Oxford, UK. 277 pp.

Schwartz, H. T. 1979. The role of the camel as a transport animal in the pastoral economy of the Rendille of Marsavit District, Kenya. pp. 459-470. In: IFS Prov. Rep. No. 6. Khartoum, Sudan.

Shalash, M. R. 1979. Utilization of camel meat and milk in human nourishment. pp. 285-306. In: IFS Prov. Rep. No. 6. Khartoum, Sudan.

Sidahmed, A. E., J. G. Morris, L. J. Koong, and S. R. Radosevich. 1981. Contribution of mixyures of tree chaparral shrubs to the protein and energy requirements of Spanish goats. J. Anim. Sci. 53:1391-1400.

Short, L. H., R. M. Blair, and C. A. Segelquist. 1974. Fiber composition and forage digestibility by small ruminants. J. Wild. Manage. 38(2):197-209.

SOMAC/SAREC. 1983. The Somali camel research project-proposal of 1983/84 and 1984/85 years. Camel Forum Working Paper No. 1:1-31. Mogadishu, Somalia.

Sorensen, T. 1948. A method of establishing groups of equal magnitude in plant sociology based on simmilarity of species content. Det Kong. Panske Vidensk. Selsk. Biol. Skr. 5(4):1-34.

UNESCO. 1979. Map of the world distribution of arid regions with explanatory notes. UNESCO, Paris. 54 pp.

UNSO. 1984. Inventory of sand movement in Somalia. UNSO/DES/SOM/80/001. 100 pp.

Van Soest, P. J. 1982. Nutritional ecology of the ruminant. O and B Books, Corvallis, Or. 374 pp.

Walker, B. M. 1979. Management principles for semiarid ecosystem. pp. 379-388. In: B. H. Walker (ed.). Managment of Semiarid Ecosystems. Elsevier, Amsterdam.

Walker, B. H. 1980. A review of browse and its role in livestock production in Southern Africa. pp. 7-24. In: H. N. Le Hourerou (ed.). Browse in Africa: The current state of knowledge. ILCA, Addis Abab, Ethiopis.

Westoby, M. 1974. The analysis of diet-selection by large generalist herbivores. Am. Nat. 108:290-304.

Whittaker, R. H. 1970. The biochemical ecology of higher plants. pp. 43-70. In: E. Sondheimer and J. B. Simeone (eds.). Chemical Ecology, New York.

Williams, V. J. 1963. Rumen function in the camels. Nature 197:1221.

Wilson, P. N. 1957. Studies of the browsing and reproductive behavior of East African dwarf goats. The East African Agric. Journal. Kampala, Uganda. 138-147.

Wilson, A. D. 1969. A review of browse in the nutrition of grazing animal. J. Range Manage. 22:23-28.

Wilson, A. D. 1977. The digestibility and voluntary intake of the leaves of trees and shrubs by sheep and goats. Aust. J. Agric. Res. 58:501-508.

Wilson, A. D., and G. N. Harrington. 1980. Nutritive value of Australian browse plants. P. 291-297. In: H. N. Le Houerou (ed.). Browse in Africa: The current state of knowledge. ILCA, Addis Ababa, Ethiopia.

Wilson, R. T. 1984. The camel. Longman, London, 223 pp.

Wilson, R. T., and D. Bourzat. 1986. Towards collaborative research on the one-humped camel in Africa. Group document No. 11. ILCA, Addis Ababa, Ethiopia. 65 pp. plus appendices.

Yagil, R., Z. Etzion, and J. Ganami. 1979. Camel thyroid metabolism: The effect of season and dehydration. Vet. Bull. 69(6):3625.

Yagil, R. 1982. Camels and camel milk. FAO Animal Production and Health Paper No. 26. FAO, Rome. 69 pp.

Yagil, R, and Z. Etzion. 1985. Survival and production in the desert camel. pp. 373-379. In: E. E. Whitehead, C. F. Hutchinson, B. N. Timmermann and R. G. Varady (eds.). Arid Lands today and tomorrow. Proc. Int'l. Res. Dev. Conf. Oct. 20-25, 1985. Tucson, Arizona.

Zahorik, D. M., and K. Houpt. 1977. The concept of nutritonal wisdom: applicability of laboratory learning models to large herbivores. pp. 45-67. In: L. M. Barker, M. R. Best and M. Domjan (eds.). Learning mechanisms in food selection. Baylor Univ. Press, Dallas, Texas.

APPENDIX

Table A.1. Dominant plant species on the major three physiognomic regions of Ceeldheer District where camels forage during observation periods.

Forage Class	Xarar Transitional	% Comp.[1]	Carroqduuud Central Ridge	% Comp.	Buur West	% Comp.
Trees and Shrubs	Terminalia polycarpa	20.46	Acacia horrida	7.04	Acacia horrida	19.11
	Terminalia spinosa	16.15	Dichrostachys kirkii	24.02	Dichrostachys kirkii	29.65
	Cordia sp	15.44	Crotalaria sp.	17.43	Acacia nilotica	14.23
	Acacia nilotica	10.82	Euphorbia matabelensis	13.06	Solanum jubae	6.26
	Acacia senegal	8.15	Dalbergia uarandensis	13.11	Acacia reficiens	5.69
	Commiphora sp	5.25	Ximenia sp	2.31	Commiphora incisa	3.56
	Grewia sp	6.51	Acacia nilotica	9.91	Balanites rotundifolia	5.61
	Acacia edgeworthii	1.57	Acacia senegal	3.98	Acacia mellifera	2.89
	Cassia ellisae	0.63	Solanum jubae	3.17	Dalbergia uarandensis	2.97
	Allophylus sp.	0.50	Commiphora incisa	1.40	Cassia ellisae	1.56
	Sterculia rhynococarpa	6.55	Acacia mellifera	0.73	Euphorbia matabelensis	1.32
	Albizia anthelmintica	3.03			Acacia edgeworthii	4.57
Suffrutescent	Indigofera intricata	23.6	Crotalaria dumosa	10.31	Indigofera ruspollii	13.14
			*Helichrysum sp (caanoxaraarshe)	2.0	Crotalaria dumosa	4.44
			Indigoera ruspollii	10.76	*Helichysum sp (caanoxaraarshe)	11.77
					Psilothricum tomentosium	2.05
Grasses	Heteropogon contortus	26.11	Aristida adscensionis	10.29	Aristida adscensionis	21.33
	Cenchrus ciliaris	6.73	Cenchruss ciliaris	7.33	Leptothruim senegalense	21.00
	Aristida adscenscionis	8.55	Leptothrium senegalese	15.13	Aristida sieberiana	5.12
	Leptothruim senegaleses	9.47	Heteropogon contortus	12.79	Heteropogan contortus	2.39
Vines	Iphionopsis rotundifolia	0.31	Merremia sp	2.34		
			Pentatropis spiralis	1.40		
			Rhynchosia velutina	2.50		

*Not sure whether the genus is correct, so Somali name of the plant is used in brackets for proper identification.
[1]Percent composition of herbaceous species (suffrutescents, grasses, vines) were calculated differently from trees and shrubs.

Table A.2. Seasonal foraging time (in hours) and bite rate for milking and non-milking camels in dry seasons.

Dry seasons	Camel Type	Distance Travelled (km)	Time Spent Hours	Time Spent %	Bite/hour
Summer (J-A) 1986	M	---	5.3[b]	44.2[b]	2141.2
	NM	---	5.6[b]	46.5[b]	2680.1
Winter (F-M) 1987	M	5.25	5.2[b]	43.1[b]	1842.2
	NM	6.23	4.6[a]	38.5[a]	2123.9
Summer (J-A) 1987	M	5.60	7.1[c]	59.3[c]	2081.4
	NM	5.71	6.8[c]	56.6[c]	2115.9

[a]Columns with at least one common letter superscript are not significantly different (P>.05) from each other.

Table A.3. Seasonal foraging time (in hours) and bite rate for milking and non-milking camels in wet seasons.

Wet Seasons	Camel Type	Distance Travelled (km)	Time Spent Hours	Time Spent %	Bite/Hour
Fall (S-N) 1986	M	---	6.5[c]	54.3[c]	2557.8
	NM	---	8.1[e]	67.9[e]	2010.0
Spring (A-M) 1987	M	6.51	5.2[a]	43.7[a]	2424.1
	NM	5.97	6.0[b]	49.6[b]	2358.7
Fall (S-N) 1987	M	5.81	7.4[d]	61.5[d]	2306.8
	NM	6.34	7.0[cd]	58.0[cd]	2125.7

[a]Columns with at least one common letter superscript are not significantly different (P>.05) from each other.

Table A.4. Average length of time spent in three periods of the day in different activities by milking and non-milking camels in dry and wet seasons (time in hours).

		Milking				Non-milking			
Season	Activities	Morning (6-10am)	Midday (10am-2pm)	Evening (2-6pm)	Over-all mean	Morning (6-10am)	Midday (10am-2pm)	Evening (2-6pm)	Over-all mean
Dry	Foraging	2.11	1.80	1.96	5.86	2.08	1.70	1.88	5.66
seasons	Rest rumination	0.07	0.12	0.19	0.38	0.06	0.23	0.17	0.46
"	Rest idling	0.02	0.39	0.45	0.86	0.01	0.78	0.24	1.03
"	Bone chewing	0.06	0.21	0.18	0.45	0.15	0.18	0.15	0.48
"	Suckling/Milking	0.07	0.07	0.07	0.21	0.00	0.00	0.00	0.00
"	Walking/Scratching/Roll.	1.67	1.41	1.15	4.23	1.70	1.11	1.56	4.37
Wet	Foraging	2.07	2.10	2.20	6.37	2.43	2.41	2.17	7.01
seasons	Rest rumination	0.42	0.25	0.18	0.88	0.13	0.18	0.31	0.61
"	Rest idling	0.06	0.25	0.26	0.57	0.10	0.32	0.29	0.71
"	Bone chewing	0.00	0.02	0.04	0.06	0.00	0.00	0.02	0.02
"	Suckling/Milking	0.07	0.06	0.07	0.20	0.00	0.00	0.00	0.00
"	Walking/Scratching/Roll.	1.38	1.32	1.25	3.95	1.34	1.09	1.21	3.64

No statistical significance ($P > .05$)

Table A.5. Time spent (in hours) on suckling/milking and number of defecations and urinations for milking and non-milking camels in different seasons.

Dry Season	Camel Type	Suckling/ Milking	Number of Defecation	Number of Urination
Summer 1986	Milking	0.24	9.60	2.80
	Non-milking	0.00	12.00	3.00
Winter 1987	Milking	0.20	8.20	7.00
	Non-milking	0.00	11.80	8.20
Summer 1987	Milking	0.18	23.60	6.60
	Non-milking	0.00	19.80	5.40
Wet Seasons				
Fall 1986	Milking	0.23	11.20	3.80
	Non-milking	0.00	13.80	8.00
Spring 1987	Milking	0.18	13.40	11.20
	Non-milking	0.00	17.40	9.80
Fall 1987	Milking	0.19	18.20	7.60
	Non-milking	0.00	13.40	7.40
All dry Seasons	Milking	0.20	13.80	5.47
	Non-milking	0.00	14.53	5.53
All wet Seasons	Milking	0.20	14.27	7.53
	Non-milking	0.00	14.87	8.40
All Seasons	Milking	0.20	14.04	6.50
	Non-milking	0.00	14.70	6.97

Table A.6. Number of defecations and urinations for all camels in different seasons.

Seasons	Number of Defecation	Number of Urination
Dry Seasons		
Summer 1986	10.80	2.90
Winter 1987	10.00	7.60
Summer 1987	21.70	6.00
Wet Seasons		
Fann 1986	12.50	5.90
Spring 1987	15.40	10.50
Fall 1987	15.80	7.50
All dry seasons	14.17	5.50
All wet seasons	14.57	7.97

Table A.7. Distance travelled (m) by milking and non-milking camels in different seasons of 1987.

Camel Type	Camel ID	Winter	Spring	Summer	Fall
Milking	1	5530	6790	6440	5390
	2	5250	6510	4200	5610
	3	5670	6510	6020	5810
	4	4340	7070	5740	6010
	5	5460	5670	5600	6230
	X	5250	6510	5600	5810
Non-milking	1	6230	4340	5910	6600
	2	6230	6020	5670	6590
	3	5190	6370	4990	5320
	4	5720	5910	5740	6550
	5	7780	7210	6240	6660
	X	6230	5970	5710	6344

Table A.8. Scientific and local Somali names of plant species camels consumed in each forage class.

Forage class	Family	Species	Somali Name
Deciduous nonspiny (nonthorny)	Anacardiaceae	Lannea cotoneastra	Wacanri
"	Boraginaceae	Cordia ovalis	Docol
"	"	C. somalensis	Deelaal
"	"	C. sp.	Hamir
"	Burseraceae	Commiphora chiovendence	Gabrar
"	"	C. gurreh	Gunray
"	"	C. horrida	Dililiqo
"	"	C. rostratr	Jinow
"	"	C. sp.	Xagar
"	"	C. sp.	Jawdheer
"	"	C. sp.	Dulwayn
"	Caesalpinaceae	Cassia ellisae	Jareer
"	Euphobiaceae	Euphobia Matabelensis	Dhiridhir
"	Malpighiaceae	Caucanthus edulis	Marmar*
"	Papilionaceae	Crotalaria sp.	Shalaboole
"	"	Dalbergia uarandensis	Dabakar
"	"	Ormocarpum muricatum	Reersoomagale
"	"	Tephrosia obbiadensis	Sararacadde
"	Pedaliaceae	Sesamothamnus busseanus	Saw
"	Rubiaceae	Coffea rhamnifolia	Diingaras
"	"	Gardia fiorii	Masaarjabis
"	Sapindaceae	Allophyllus sp	Laf
"	Solanceae	Solanum jubae	Caduur
"	Tiliaceae	Grewia bicolor	Dhamanaxaag
"	"	G. pennicillata	Hohob
"	"	G. tembensis	Dhammaag
"	"	G. villosa	Kabash
"	"	Triumfetta actinocarpa	Saalawayn
"	Verbenaceae	---------- ----------	Jacjacle
"	----------	---------- ----------	Hiirin
"	----------	---------- ----------	Dhuusacarmeed
"	----------	---------- ----------	Dhiinsoole
"	----------	---------- ----------	Gar.*
"	----------	---------- ----------	Geegcad
Deciduous spiny (thorny)	Burseraceae	Commiphora incisa	Raxanreeb
"	"	C. sp	Dhudhus
"	Caesalpinaceae	Caesalpina sp.	Qoodhi
"	Mimosaceae	Acacia edgeworthii	Jeerin
"	"	A. edgeworthii	Jirriq
"	"	A. horrida	Sarmaan
"	"	A. mellifera	Bilcil
"	"	A. nilotica	Maraa
"	"	A. nubica	Gumar
"	"	A. reficiens	Qansax
"	"	A. senegal	Cadaad
"	"	A. seyal	Jiiq
"	"	A. zyziphispina	Cadaadgari
"	"	Dichrostachys kirkii	Diigtaar
"	Solanaceae	Lycium shawii	Surur

Evergreen	Boraginaceae	Cordia sinensis	Mareer
nonspiny	Burseraceae	Boswellia microphylla	Muqle
(nonthorny)	Cappridaceae	Boscia coriacea	Dhagyar
"	"	Boscia minimifolia	Maygaag
"	"	Cadaba longifolia	Rugumbay
"	"	Maerua crassifolia	Qalaanqal
"	"	M. macrocarpa	Cadaybiil
"	Combretaceae	Combretum contractum	Sorog
"	"	Terminalia polycarpa	Hareeri
"	Mimosaceae	Albizia anthelmintica	Raydab
"	"	A. obbiadensis	Huyun
"	Rubiaceae	--------- ----------	Dogon
"	---------	--------- ----------	Magag
"	Sterculiaceae	Sterculia rhyncocarpa	Qanrar
Evergreen	Balanitaceae	Balanites rotundifolia	Shillan
spiny	Combretaceae	Terminalia spinosa	Xarar
(thorny)	Olacaceae	Ximenia sp.	Murcud
"	Rhamnaceae	Zyziphus hamur	Xamir
Suffrut-	Acanthaceae	Justicia flova	------
escents	Aizoaceae	Psilothricum tomentosum	Geeddaaf
"	Compositae	---------- ---------	Caanoxaraarshe
"	Convolvulaceae	Hildebrandtia sepalosa	Hiirincad
"	Cyclocheilaceae	Aseplum ereantherum	Sonkoreed
"	Lauranthaceae	Lauranthus sp.	Qadi
"	Liliaceae	Asparagus africanus	Arjeeg
"	Malvaceae	Pavonia sp.	Sariig*
"	Nyctaginaceae	Commicarpus sp.	Warankasiib
"	Papilionaceae	Crotalaria dumosa	Kumxidid
"	"	Indigofera intricata	Xajiin
"	"	I. ruspolli	Qurdhubaan
"	"	I. schimperi	Xajiinduureed
"	Zygophyllaceae	Kelleronia sp.	Canyogeel
"	Acanthaceae	Ruellia sp.	---------
Grasses	Gramineae	Afrotrichloris martinii	Cawsmullax
"	"	Aristida adscensionis	Mayr
"	"	A. sieberiana	Xalfo
"	"	Brachiaria sp.	Qaalmawaneeye
"	"	Cenchrus ciliaris	Garrow
"	"	-------- --------	Dooyo
"	"	Heteropogon contortus	Dhurbay
"	"	Leptothrium segalense	Rarmay
Vines	Compositae	Iphionopsis rotundifolia	Gagabo
"	---------	---------- ----------	Carmali
"	Convolvulaceae	Merremia sp.	Saaqasaaqe
"	Asclepiadaceae	Pentatropis spiralis	Geesariyood
"	Papilionaceae	Rhynchosia velutina	Xarkaxarkood
"	---------	--------- --------	Dabanaylood
"	---------	--------- --------	Saryan
"	---------	--------- --------	Qraduur

Forbs	Acanthaceae	Blepgaris linariifolia	Kaxar
"	Boraginaceae	Heliotropium cinerascens	Suntaar
"	Comelinaceae	Comelina sp.	Baar
"	Malvaceae	-------- ----------	Timafaaxis
"	Rubiaceae	-------- ----------	Kuruslafadhi
"	Verbenaceae	-------- ----------	Reexaan
"	----------	-------- ----------	Idaleef
"	----------	-------- ----------	Saqajaan*
Succulents	Compositae	Kleinia sp.	Wisil
"	Labiatae	Capitanya sp.	Carmadhurwa*
"	----------	--------- --	Haandawaco

---

*Informants were not sure whether the given names are the correct Somali names or not.

Table A.9. Percent in diet of the ten most liked plant species by milking (M) and non-milking (NM) camels in each forage class in one seasons or another based on actual bite counts.

Forage class	Species	Summer 1986		Winter 1987		Summer 1987		Fall 1986		Spring 1987		Fall 1987	
		M	NM	M	NM	M	NM	M	NM	M	NM	M	NM
Deciduous nonspiny (nonthorny)	Allophyllus sp.	0.98	0.21	----	----	----	----	----	0.57	4.49	4.14	----	----
	Cassia ellisae	0.76	1.61	0.16	5.17	0.27	0.60	1.99	0.06	----	----	0.02	0.02
	Commiphora chiovendanda	----	----	----	----	----	----	----	----	----	----	2.44	14.21
	C. gurreh	----	----	----	----	----	----	----	----	----	----	11.49	7.25
	Commiphora sp. (Dulwayn[4])	----	----	----	----	----	----	----	----	----	----	0.72	3.21
	Commiphora sp. (Javdhar[4])	----	----	----	----	----	----	----	----	----	----	0.27	1.89
	Commiphora sp. (Xagar[4])	----	----	----	----	----	----	17.23	0.33	6.54	9.96	2.82	3.15
	Cordia ovalis	----	----	----	----	----	----	----	----	3.57	1.31	----	----
	C. somalensis	5.02	3.17	----	----	----	0.06	3.29	2.92	3.24	3.53	----	----
	Crotalaria sp.	----	----	----	----	19.32	18.46	----	----	----	----	----	0.72
	Dalbergia uarandensis	----	----	0.26	0.29	4.01	2.35	----	3.71	0.18	----	0.09	0.24
	(Dhuusacarmeed[4])	0.90	0.01	----	----	0.48	0.06	0.02	0.11	14.89	26.65	----	----
	Euphorbia matabelensis	----	----	----	----	----	----	----	2.26	----	----	12.32	10.59
	Grevia bicolor	2.69	0.13	----	----	----	----	----	----	6.61	1.02	----	----
	G. pennicillata	---	----	----	----	----	----	----	----	14.79	13.03	----	----
	G. tembensis	1.37	0.40	----	----	0.25	0.59	0.96	0.24	3.34	4.08	0.43	0.73
	G. villosa	1.14	----	----	----	0.11	0.03	----	0.02	2.12	1.51	0.07	0.02
	Kensamothamnus buscanus	----	----	----	----	----	----	----	----	----	----	0.96	3.11
	Solanum jubae	----	----	----	----	1.48	0.04	----	2.63	----	----	0.03	1.02
	Subtotal	12.86	5.53	0.42	5.46	25.92	22.19	23.49	12.85	59.81	65.23	31.66	46.16
Deciduous spiny	Acacia edgeworthii	----	0.55	----	----	0.03	----	0.47	----	0.11	0.09	9.71	3.16
	A. horrida	0.27	0.04	5.14	4.11	9.65	3.63	2.78	20.55	1.19	2.52	0.05	1.03
	A. mellifere	----	----	1.41	2.56	0.48	0.38	1.38	6.46	1.66	0.71	----	----
	A. nilotica	5.66	2.52	23.97	16.63	1.61	2.77	10.59	16.66	0.22	----	1.66	1.82
	A. reficiens	----	0.07	18.11	12.69	0.04	0.29	0.37	0.15	----	0.07	0.03	1.07
	A. senegal	8.54	3.16	----	0.11	0.38	0.50	0.46	0.21	0.11	0.05	----	0.32
	Commiphora sp. (Dhudhus[4])	----	----	----	----	----	----	----	----	2.98	7.57	1.78	1.80
	Dichrostachys kirkii	----	----	0.44	0.41	50.72	57.14	----	18.16	0.08	----	3.92	4.24
	Subtotal	14.47	6.34	49.07	36.51	62.92	64.71	16.05	62.19	6.35	11.01	17.15	13.44
Evergreen nonspiny (nonthorny)	Albizia anthelmintica	----	----	0.22	----	0.01	0.44	0.67	3.60	4.40	0.90	----	----
	A. obbiadensis	----	----	----	----	----	----	----	----	----	----	30.36	17.28
	Boswellia microphylla	----	----	----	----	----	----	----	----	----	----	2.62	2.85
	Cadaba longifolia	0.53	0.05	0.42	0.32	----	----	0.66	3.19	1.02	----	----	----
	Combretum contractum	----	----	5.06	0.40	----	----	----	----	----	----	----	----
	Maerua crassifolia	----	----	7.77	5.09	0.40	0.16	1.52	4.47	1.48	0.45	0.33	0.03
	Sterculia rhynocoarpa	----	----	----	----	----	----	----	----	3.81	3.33	0.03	0.02
	Terminalia polycarpa	16.39	10.81	----	----	0.31	0.17	2.62	1.49	----	0.52	0.03	0.02
	Subtotal	16.92	10.86	13.47	5.81	0.72	0.77	5.47	12.75	10.71	5.20	33.37	20.20
Evergreen spiny (thorny)	Balanites rotundifolia	----	----	13.61	18.79	0.01	0.01	----	----	----	----	----	0.12
	Terminalia spinosa	5.82	7.44	----	----	----	----	41.37	0.03	12.90	12.23	----	----
	Ximenia sp.	----	----	----	----	0.71	1.00	----	0.64	0.13	0.02	0.11	----
	Subtotal	5.82	7.44	13.61	18.79	0.72	1.01	41.37	0.67	13.03	12.25	0.11	0.12

Suffrut-escents	(Caanoxaraarshe[4])	----	----	3.91	4.56	----	----	----	----	----	----	----	----
	Crotalaria dumosa	----	----	1.43	0.18	0.08	0.64	----	2.91	----	----	----	----
	Indigofera intricata	37.58	53.45	----	0.78	----	----	8.06	----	----	----	----	----
	Subtotal	37.58	53.45	5.34	5.52	0.08	0.64	8.06	2.91	----	----	----	----
Grasses	Brachiaria sp.	----	----	----	----	1.07	1.17	----	----	----	----	----	----
	Cenchrus ciliaris	0.70	0.78	3.65	9.29	0.65	0.74	0.07	----	0.02	----	0.43	0.76
	Heteropogon contortus	6.04	13.98	4.46	2.67	----	1.48	2.61	0.08	----	----	----	----
	Leptithrium senegalense	----	----	1.61	3.63	----	----	----	----	----	----	0.02	0.14
	Subtotal	6.74	14.76	9.72	15.59	0.65	2.22	2.68	0.08	0.02	----	0.45	0.90
Vines	Pentatropis spiralis	0.03	0.03	0.39	0.82	1.73	0.99	----	0.91	0.08	----	0.53	0.24
	Rhynchosia velutina	1.99	0.43	----	0.03	2.54	3.45	0.06	0.16	0.16	0.08	0.48	0.70
	Subtotal	2.02	0.46	0.39	0.85	4.27	4.44	0.06	1.07	0.24	0.08	1.01	0.94
	Total	96.41	98.84	92.02	88.53	95.27	95.98	97.18	92.52	90.16	93.77	83.75	81.76

M = Milking Camels NM = Nonmilking Camels

[4]Local Somali names were used where plants were not properly identified

		Diet(%)
Dry seasons-	milking camels	94.57
	-nonmilking camels	94.45
Wet seasons-	milking camels	90.36
	-nonmilking camels	89.35

Table A.10. Diet (%) and cover (%) of the 10 most like plant species by camels on a season basis based on bite counts by species (B) and foliage cover (C).

	Dry seasons						Wet seasons					
	Summer 1986		Winter 1987		Summer 1987		Fall 1986		Spring 1987		Fall 1987	
Species	B	C	B	C	B	C	B	C	B	C	B	C
Indigofera intricata	45.50	10.35	0.39	0.30	----	----	4.03	5.70	---	---	---	---
Acacia nilotica	4.09	0.69	20.30	7.26	2.16	4.48	13.63	5.83	0.11	0.24	1.74	0.17
Dichrostachys kirkii	---	---	0.43	15.12	53.93	10.86	9.09	0.36	0.04	T	4.08	1.52
Terminalia polycarpa	13.60	1.31	---	---	0.24	0.01	2.06	7.99	0.26	T	0.03	T
Acacia reficiens	0.04	T	15.40	2.90	0.17	0.26	0.26	1.01	0.04	T	0.55	T
Crotalaria sp.	---	---	---	---	18.89	7.88	---	---	---	---	0.36	T
Acacia senegal	5.85	0.52	0.06	0.24	0.44	1.84	0.34	1.08	0.08	T	0.16	T
Balanites rotundifolia	---	---	16.20	2.96	0.01	0.09	---	---	---	---	0.06	0.10
Acacia horrida	0.16	T	4.63	9.75	6.66	3.18	11.67	5.87	1.86	0.20	0.54	0.36
Heteropogon contortus	10.01	11.45	3.57	0.70	0.74	4.10	1.35	14.64	---	---	---	---
Maerua crassifolia	---	---	6.43	0.27	0.28	0.39	2.99	0.34	0.97	T	0.18	T
Dalbergia uarandesis	---	---	0.28	1.52	3.18	5.93	1.86	2.73	0.09	T	0.17	0.16
Terminalia spinosa	6.63	1.03	---	---	---	---	20.70	3.75	12.70	4.44	---	---
Rhynchosia velutina	1.21	0.30	0.02	T	2.99	0.87	0.11	1.35	0.12	0.03	0.59	0.10
Combretum contractum	---	---	2.73	0.62	---	---	---	---	---	---	---	---
Pentatropis spiris	0.03	0.05	0.61	0.61	1.36	0.76	0.46	1.88	0.04	T	0.39	1.09
Cordia somalensis	4.10	0.99	---	---	0.04	T	3.11	1.32	3.39	3.79	---	---
Grewia bicolor	1.41	0.03	---	---	---	---	---	---	3.82	0.91	---	---
"Caanoxaraarshe"	---	---	4.24	3.45	---	---	---	---	---	---	---	---
Solanum jubae	---	---	---	---	0.76	1.43	1.32	1.28	---	---	---	---
Cenchrus ciliaris	0.74	2.95	6.47	1.30	0.70	2.35	0.04	8.90	0.01	2.15	0.61	0.20
Brachiaria sp.	---	---	---	---	0.55	0.10	---	---	---	---	---	---
Grewia tembensis	0.89	0.33	---	---	0.42	0.06	0.60	1.03	3.73	2.09	0.58	0.13
Leptothrium senegalens	---	---	2.62	6.15	---	---	---	---	---	---	0.03	3.45
Aristida adscensionis	---	---	1.80	6.25	0.04	3.30	---	---	---	---	---	---
Ximenia sp.	---	---	---	---	0.86	1.05	0.32	1.29	0.03	0.18	0.06	0.02
"Dhuusacarmeed"	---	---	---	---	0.27	T	0.07	T	20.77	2.56	---	---
Albizia obbiadensis	---	---	---	---	---	---	---	---	---	---	23.82	6.84
Commiphora sp. (Xagar)	---	---	---	---	---	---	8.78	0.51	8.25	0.29	2.99	0.32
Grewia pennicillata	---	---	---	---	---	---	---	---	13.91	4.70	---	---
Euphorbia matabelensis	---	---	---	---	---	---	1.13	3.75	---	---	11.46	2.97
Commiphora gurreh	---	---	---	---	---	---	---	---	---	---	9.37	1.52
Acacia edgeworthii	0.28	0.10	---	---	0.02	T	0.24	0.73	0.10	0.15	6.44	1.14
Allphyllus sp.	0.60	0.03	---	---	---	---	0.29	T	4.32	0.80	---	---
Albizia anthelmintica	---	---	0.11	T	0.23	T	2.14	0.23	2.65	0.99	---	---
Boswellia micriphylla	---	---	---	---	---	---	---	---	---	---	2.75	0.87
Sterculia rhyncocarpa	---	---	---	---	---	---	---	---	3.57	2.16	0.03	T
Commiphora chiovendance	---	---	---	---	---	---	---	---	---	---	8.33	1.39
Cassia ellisae	1.19	0.04	2.67	0.80	0.44	T	1.03	0.36	---	---	0.02	T
Cordia ovalis	---	---	---	---	---	---	---	---	2.44	0.58	---	---
Commiphora sp.	---	---	---	---	---	---	---	---	5.28	2.46	1.79	1.90
Acacia edgeworthii	---	---	---	---	---	---	---	---	---	---	0.88	T
Acacia mellifera	---	---	1.99	1.47	0.43	0.33	3.92	0.96	1.19	0.29	---	---
Commiphora sp.	---	---	---	---	---	---	---	---	---	---	1.97	0.36
Cadaba longifolia	0.29	T	0.37	0.37	---	---	1.98	T	0.51	T	---	---
Sessamothamnus busseanus	---	---	---	---	---	---	---	---	---	---	2.04	0.76
Crotalaria dumosa	---	---	0.81	1.30	0.36	3.40	1.45	2.06	---	---	---	---

Table A.11. Plant species in camel diets similarity (%) in each forage class for dry and wet seasons in different location based on species presence in diet.

Season	Location	Woody shrub/tree species	Suffrut-escent species	Vine species	Grass species
Summer '86 Spring '87	Xarar	60.7	0.0	76.9	66.7
Fall '86 Summer '87	Xarar Carroguduud	75.9	54.5	88.9	75.0
Winter '87 Fall '87	Buur	35.5	15.4	66.7	72.7

Table A.12. Plant species in camel diet similarity (%) in each forage class for dry and wet seasons between different locations based on species presence in camel diet.

Dry seasons	Location	Woody shrub/tree species	Suffrut-escent species	Vine species	Grass species
Summer '86 Winter '87	Xarar Buur	35.0	37.5	75.0	50.0
Summer '86 Summer '87	Xarar Carroguduud	56.5	0.0	66.7	57.1
Winter '87 Summer '87	Buur Carroguduud	58.3	18.2	57.1	72.2
Wet seasons					
Spring '87 Fall '87	Xarar Buur	43.6	22.2	54.5	33.3
Fall '86 Spring '87	Xarar/Carro. Xarar	73.3	33.3	76.9	50.0
Fall '86 Fall '87	Xarar/Carro. Buur	52.8	30.8	75.0	25.0

Table A.13. Dietary selection (%) by milking and non-milking camels and foliage cover (%) of all species comprising each forage class on a season basis in different locations.

Season/ Location	Camel types and (%) cover	Hardwood Shrub/tree	Suffrut-escents	Grass	Vine	Forbs	Succul.
Summer	milking	52.20	37.64	6.74	3.39	0.00	0.03
1986	non-Milking	30.55	53.53	14.61	1.14	0.00	0.01
Xarar	cover	5.55	10.35	14.40	0.97	0.00	T
Fall	milking	88.15	8.09	2.68	0.69	0.00	0.39
1986	non-milking	93.34	3.89	0.86	1.88	0.00	0.02
Xarar/Car.	Cover	42.40	10.34	24.63	5.61	0.00	0.48
Winter	milking	79.77	5.90	13.93	0.39	0.00	0.00
1987	non-milking	70.76	5.75	21.53	1.95	0.00	0.00
Buur	Cover	43.71	9.50	17.75	0.65	0.00	0.00
Spring	milking	95.90	1.54	0.02	2.54	0.00	0.00
1987	non-milking	97.58	1.26	0.00	1.16	0.00	0.00
Xarar	Cover	30.97	0.28	2.15	4.23	0.00	0.00
Summer	milking	92.02	0.64	1.79	4.93	0.54	0.00
1987	non-milking	89.69	1.65	2.28	5.42	0.96	0.00
Carrog.	Cover	38.80	5.40	10.00	2.65	3.35	0.00
Fall	milking	91.06	3.09	2.15	1.51	2.19	0.00
1987	non-milking	89.15	5.28	2.97	1.02	1.59	0.00
Buur	Cover	24.57	2.75	17.14	2.39	4.80	0.00
All season	milking	83.18	9.48	4.55	2.24	0.46	0.07
mean	non-milking	78.51	11.89	7.04	2.09	0.43	0.005
	Cover	31.00	6.44	14.35	2.75	1.36	0.08
	All camel average	80.85	10.69	5.79	2.17	0.45	0.04

Table A.14. Dietary selection (%) by milking and non-milking camels and composition (%) of all species comprising each forage class in dry and wet seasons.

Forage class	Dry seasons			Wet seasons		
		M	NM		M	NM
	%comp.	%diet	%diet	%comp.	%diet	%diet
Deciduous nonspiny (nonthorny)	15.4	14.0[a]	10.9[a]	21.6	35.8[b]	39.9[b]
Deciduous spiny (thorny)	28.8	39.5[a]	31.8[a]	17.8	13.2[b]	31.1[a]
Evergreen nonspiny (nonthorny)	4.9	8.1	5.7	11.9	17.2	12.7
Evergreen spiny (thorny)	4.9	4.7[a]	6.4[a]	5.8	14.9[b]	3.7[a]
Suffrutescents	17.2	11.4[a]	20.0[c]	8.8	3.7[a]	3.4[a]
Grasses	21.8	5.4	9.9	23.4	1.5	1.2
Vines	2.0	2.9	2.5	4.2	2.5	1.3
Forbs	4.9	0.2	0.3	6.1	0.8	0.5
Succulents	T	0.0[a]	0.0[a]	0.3	0.1[b]	0.0[a]
Mixtures	-	13.8	12.8	-	10.4	6.1

Rows with different letter superscript are significantly different ($P < .05$) from each other.

M = Milking camels NM = Non-milking camels

Table A.15. Dietary selection (%) by milking and non-milking camels and composition (%) of all species comprising each forage class.

Forage class	%comp.	Milking %diet	Non-milking %diet
Deciduous nonspiny (nonthorny)	18.8	26.3	26.3
Deciduous spiny (thorny)	22.7	24.6[a]	31.4[b]
Evergreen nonspiny(nonthorny)	8.8	13.3	9.4
Evergreen spiny (thorny)	5.4	10.5[a]	5.0[b]
Suffrutescents	12.6	7.0	11.2
Grasses	22.7	3.2	5.3
Vines	3.2	2.7	1.9
Forbs	5.9	0.6	0.4
Succulents	0.2	0.1	0.0
MIxtures	-	11.9	9.0

Rows with different letter superscript are significantly different ($P<.05$) from eachother.

Table A.16. Dietary selection (%) by all camels and composition (%) of all species comprising each forage class in dry and wet seasons.

	Dry seasons		Wet seasons	
Forage class	%comp.	%diet	%diet	%comp.
Deciduous nonspiny (nonthorny)	15.4	13.2[a]	37.8[b]	21.6
Deciduous spiny (thorny)	28.8	35.5[a]	21.9[b]	17.8
Evergreen nonspiny (nonthorny)	4.9	6.9[a]	15.0[b]	11.9
Evergreen spiny (thorny)	4.9	5.6[a]	9.5[b]	5.8
Suffrutescents	17.2	15.6[a]	3.5[b]	8.8
Grasses	21.8	7.6[a]	1.4[b]	23.4
Vines	2.0	2.6	1.9	4.2
Forbs	4.9	0.3	0.7	6.1
Succulents	T	0.0[a]	0.1[b]	0.3
Mixtures	-	12.7	8.3	-

Rows with different letter superscript are significantly different ($P<.05$) from each other.

Table A.17. Correlation of composition and diet for milking camels in dry seasons.

Forage class	%composition	%diet
Deciduous nonspiny (nonthorny)	15.4	14.0
Deciduous spiny (thorny)	28.8	39.5
Evergreen nonspiny (nonthorny)	4.9	8.1
Evergreen spiny (thorny)	4.9	4.7
Suffrutescents	17.2	11.4
Grasses	21.8	5.4
Vines	2.0	2.9
Forbs	5.0	0.2
Succulents	0.0	0.0

r = 0.798 regression equation: %diet = -1.19 + 0.968 %comp.

Table A.18. Correlation of composition and diet for non-milking camels in dry seasons.

Forage class	%composition	%diet
Deciduous nonspiny (nonthorny)	15.4	10.9
Deciduous spiny (thorny)	28.8	31.8
Evergreen nonspiny (nonthorny)	4.9	5.7
Evergreen spiny (thorny)	4.9	6.4
Suffrutescents	17.2	20.0
Grasses	21.8	9.9
Vines	2.0	2.5
Forbs	5.0	0.3
Succulents	0.0	0.0

r = 0.888 regression equation: %diet = -0.47 + 0.917 %comp.

Table A.19. Correlation of composition and diet for milking camels in wet seasons.

Forage class	%composition	%diet
Deciduous nonspiny (nonthorny)	21.6	35.8
Deciduous spiny (thorny)	17.8	13.2
Evergreen nonspiny (nonthorny)	11.9	17.2
Evergreen spiny (thorny)	5.8	14.9
Suffrutescents	8.8	3.7
Grasses	23.4	1.5
Vines	4.2	2.5
Forbs	6.1	0.8
Succulents	0.3	0.1

r = 0.507 regresion equation: %diet = 1.84 + 0.731 %comp.

Table A.20. Correlation of composition and diet for non-milking camels in wet seasons.

Forage class	%composition	%diet
Deciduous nonspiny (nonthorny)	21.6	39.9
Deciduous spiny (thorny)	17.8	31.1
Evergreen nonspiny (nonthorny)	11.9	12.7
Evergreen spiny (thorny)	5.8	3.7
Suffrutescents	8.8	3.4
Grasses	23.4	1.2
Vines	4.2	1.3
Forbs	6.1	0.5
Succulents	0.3	0.0

r = 0.633 regresion equation: %diet = -2.44 + 1.16 %comp.

Table A.21. Correlation of composition and diet for milking camels in all seasons.

Forage class	%composition	%diet
Deciduous nonspiny (nonthorny)	18.8	26.3
Deciduous spiny (thorny)	22.7	24.6
Evergreen nonspiny (nonthorny)	8.8	13.3
Evergreen spiny (thorny)	5.4	10.5
Suffrutescents	12.6	7.0
Grasses	22.8	3.2
Vines	3.2	2.7
Forbs	5.6	0.6
Succulents	0.2	0.1

r = 0.618 regression equation: %diet = 1.83 + 0.77 %comp.

Table A.22. Correlation of composition and diet for non-milking camels in all seasons.

Forage class	%composition	%diet
Deciduous nonspiny (nonthorny)	18.8	26.3
Deciduous spiny (thorny)	22.7	31.4
Evergreen nonspiny (nonthorny)	8.8	9.4
Evergreen spiny (thorny)	5.4	5.0
Suffrutescents	12.6	11.0
Grasses	22.8	5.3
Vines	3.2	1.9
Forbs	5.6	0.4
Succulents	0.2	0.0

r = 0.744 regression equation: %diet = -0.89 + 0.983 %comp.

Table A.23. Correlation of composition and diet for all camels in dry seasons.

Forage class	%composition	%diet
Deciduous nonspiny (nonthorny)	15.4	13.2
Deciduous spiny (thorny)	28.8	35.5
Evergreen nonspiny (nonthorny)	4.9	6.9
Evergreen spiny (thorny)	4.9	5.6
Suffrutescents	17.2	15.6
Grasses	21.8	7.6
Vines	2.0	2.6
Forbs	4.9	0.3
Succulents	T	0.0

r = 0.856 regression equation: %diet = -0.78 + 0.943 %comp.

Table A.24. Correlation of composition and diet for all camels in wet seasons.

Forage class	%composition	%diet
Deciduous nonspiny (nonthorny)	21.6	37.8
Deciduous spiny (thorny)	17.6	21.9
Evergreen nonspiny (nonthorny)	11.9	15.0
Evergreen spiny (thorny)	5.8	9.5
Suffrutescents	8.8	3.5
Grasses	23.4	1.4
Vines	4.2	1.9
Forbs	6.1	0.7
Succulents	0.3	0.1

r = 0.598 regression equation: %diet = -0.24 + 0.939 %comp.

Table A.25. Analysis of variance table for daily foraging time by milking and non-milking camels.

Sv	df	Ms	f
Type	1	9158789.40	0.691
Animal/type	8	13250684.00	
Moisture	1	167815310.00	1.722
Season/moisture	4	132314580.00	1.358
Error (b)	20	9743485.60	
Type x moisture	1	33573232.00	7.667*
Type x season/moisture	4	19865301.00	4.536*
Error (c)	20	4378996.00	
Total	59	20469863.00	

Table A.26. Analysis of variance table for time spent in rest rumination by milking and non-milking camels.

SV	df	MS	f
Type	1	1668667.30	0.841
Animal/type	8	1984890.70	
Moisture	1	7037005.10	1.678
Season/moisture	4	25871572.00	6.169**
Error (b)	20	4193978.60	
Type x Moisture	1	7076787.30	2.180
Type xSeason/moisture	4	1941952.70	0.598
Error (c)	20	3245941.70	
Total	59	4944306.60	

Table A.27. Analysis of variance table for time spent rest idling by milking and non-milking camels.

SV	df	MS	f
Type	1	958112.07	0.127
Animal/Type	8	7569265.40	
Moisture	1	10341802.00	2.797
Season/Moisture	4	132012690.00	3.571*
Error (b)	20	3697091.30	
Type x Moisture	1	1446464.30	0.101
Type X seasom/Moisture	4	4479558.70	0.314
Error (c)	20	14279686.00	

Table A.28. Analysis of variance table for time spent on suckling/milking by milking camels.

SV	df	MS	F
Type	1	7776720.00	67.913**
Animal/Type	8	114510.39	
Moisture	1	1653.75	0.063
Season/ Moisture	4	26493.13	1.016
Error (b)	20	26084.98	
Type x Moisture	1	1653.75	0.063
Type x Season/Moisture	4	26493.13	1.016
Error (c)	20	26084.98	
Total	59	168668.78	

Table A.29. Analysis of variance table for time spent on bone chewing by milking and non-milking camels.

SV	df	MS	F
Type	1	652709.40	0.312
Animal/Type	8	2091269.80	
Moisture	1	29872282.00	12.183**
Season/Moisture	4	27382554.00	11.168**
Error (b)	20	2451895.60	
Type x Moisture	1	587664.07	0.385
Type x Season/Moisture	4	1407241.50	0.922
Error (c)	20	1525750.00	
Total	59	4111100.20	

Table A.30. Analysis of variance table for time spent on walking (scratching, rubbing, rolling) by milking and non-milking camels.

SV	df	MS	F
Type	1	936.15	0.000
Animal/ Type	8	6713873.80	
Moisture	1	23825341.00	3.963
Season/Moisture	4	40781255.00	6.784**
Error (b)	20	6011703.40	
Type x Moisture	1	9101836.00	0.873
Type x Season/Moisture	4	22898252.00	2.196
Error (c)	20	10427399.00	
Total	59	11358291.00	

Table A.31. Analysis of variance table for temperature.

SV	df	MS	F
Type	1	0.19	0.260
Animal/Type	8	0.73	
Moisture	1	11.44	11.556**
Season/Moisture	4	21.97	22.192**
Error (b)	20	0.99	
Type x Moisture	1	0.77	0.481
Type x Season/Moisture	4	0.99	0.619
Error (c)	20	1.60	

Table A.32. Analysis of variance table for relative humidity.

SV	df	MS	F
type	1	265.34	4.046
Animal/ Type	8	40.87	
Moisture	1	1579.01	54.243**
Season/Moisture	4	939.59	32.277**
Error (b)	20	29.11	
Type x Moisture	1	39.05	0.528
Type x Season/Moisture	4	27.81	0.376
Error (c)	20	73.96	
Total	59	136.29	

Table A.33. Analysis of variance table for distance travelled by milking and non-milking camels.

SV	df	MS	F
Type	1	0.73	0.948
Animal/Type	8	0.77	
Moisture	1	2.13	5.462*
Season/Moisture	2	0.08	0.205
error (b)	12	0.39	
Type x Moisture	1	0.75	1.829
Type x Season/Moisture	2	1.19	2.902
error (c)	12	0.41	
Total	39	0.56	

Table A.34. Analysis of variance table for time spent on foraging in each period of the day (morning, midday, evening) by milking and non-milking camels.

SV	DF	MS	F
Moisture	1	0.85	1.25
Season/Moisture	4	0.68	
Type	1	0.04	0.364
Period	2	0.09	0.75
Type X Period	2	0.04	1.333
Moisture X Type	1	0.17	1.545
Moisture X Period	2	0.10	0.833
Moisture X Type X Period	2	0.03	1.000
Type X Season/Moisture	4	0.11	
Period X Season/Moisture	8	0.12	
Type X Period X Season/Moisture	8	0.03	
Total	35	0.17	

Table A.35. Analysis of variance table for time spent on rest rumination in each period of the day (morning, midday, evening) by milking and non-milking camels.

SV	DF	MS	F
Moisture	1	0.10	0.213
Season/Moisture	4	0.12	
Type	1	0.005	1.000
Period	2	0.006	0.022
Type X Period	2	0.04	0.571
Moisture X Type	1	0.02	4.000
Moisture X Period	2	0.02	0.333
Moisture X Type X Period	2	0.04	0.571
Type X Season/Moisture	4	0.005	
Period X Season/Moisture	8	0.060	
Type X Period X Season/Moisture	8	0.07	
Total	35	0.05	

Table A.36. Analysis of variance table for time spent on rest idling in each period of the day (morning, midday, evening) by milking and non-milking camels.

SV	DF	MS	F
Moisture	1	0.09	0.108
Season/Moisture	4	0.83	
Type	1	0.02	0.500
Period	2	0.47	2.136
Type X Period	2	0.08	0.727
Moisture X Type	1	0.003	0.075
Moisture X Period	2	0.10	0.455
Moisture X Type X Period	2	0.06	0.545
Type X Season/Moisture	4	0.04	
Period X Season/Moisture	8	0.22	
Type X Period X Season/Moisture	8	0.11	
Total	35	0.22	

Table A.37. Analysis of variance table for time spent on bone chewing in each period of the day (morning, midday, evening) by milking and non-milking camels.

SV	DF	MS	F
Moisture	1	0.18	1.125
Season/Moisture	4	0.16	
Type	1	0.00004	0.010
Period	2	0.009	3.000
type X Period	2	0.004	0.400
Moisture X Type	1	0.001	0.250
Moisture X Period	2	0.005	1.667
Moisture X Type X Period	2	0.002	0.200
Type X Season/Moisture	4	0.004	
Period X Season/Moisture	8	0.003	
Type X Period X Season/Moisture	8	0.01	
Total	35	0.03	

Table A.38. Analysis of variance table for time spent on suckling/milking in each period of the day (morning, midday, evening) by milking and non-milking camels.

SV	DF	MS	F
Moisture	1	0.00003	0.150
Season/Moisture	4	0.0002	
Type	1	0.042	60.000**
Period	2	0.00006	0.600
Type X Period	2	0.00006	0.600
Moisture X Type	1	0.00003	0.043
Moisture X Period	2	0.000008	0.080
Moisture X Type X Period	2	0.000008	0.080
Type X Season/Moisture	4	0.0007	
Period X Season/Moisture	8	0.0001	
Type X Period X Season/Moisture	8	0.0001	
Total	35	0.00131	

Table A.39. Analysis of variance table for time spent on walking, scratching and rolling in each period of the day (morning, midday, evening) by milking and non-milking camels.

SV	DF	MS	F
Moisture	1	0.26	0.909
Season/Moisture	4	0.22	
Type	1	0.011	0.122
Period	2	0.29	1.706
Type X Period	2	0.15	0.537
Moisture X Type	1	0.048	0.533
Moisture X Period	2	0.062	0.364
Moisture X Type X Period	2	0.053	0.189
Type X Season/Moisture	4	0.09	
Period X Season/Moisture	8	0.17	
Type X Period X Season/Moisture	8	0.28	
Total	35	0.18	

Table A.40. Analysis of variance table for the number of bites taken from deciduous non-spiny (non-thorny) forage plants by milking and non-milking camels in different seasons.

SV	Df	Ms	F
Type	1	148208.17	0.094
Animal/Type	8	1572967.20	
Moisture	1	262910110.00	89.839*
Season/Moisture	4	48110288.00	16.439*
Type X Moisture	1	1119846.80	0.383
Type X Season/Moisture	4	3979279.60	1.360
Error (b)	40	2926458.00	

Table A.41. Analysis of variance table for the number of bites taken from deciduous spiny (thorny) forage plants by milking and non-milking camels in different seasons.

SV	Df	Ms	F
Type	1	14866299.00	9.090*
Animal/Type	8	1635377.90	
Moisture	1	18295490.00	16.698*
Season/Moisture	4	105720900.00	96.490*
Type X Moisture	1	35420167.00	32.328*
Type X Season/Moisture	4	26771590.00	24.434*
Error (b)	40	1095666.70	
Total	59	1110951.90	

Table A.42. Analysis of variance table for the number of bites taken from evergreen non-spiny (non-thorny) forage plants by milking and non-milking camels in different seasons.

SV	Df	Ms	F
Type	1	3983526.70	2.828
Animal/Type	8	1408723.00	
Moisture	1	30121169.00	19.711*
Season/Moisture	4	15180999.00	9.935*
Type X Moisture	1	1281297.10	0.838
Type X Season/Moisture	4	3267861.60	2.139
Error (b)	40	1528104.20	
Total	59	307754.90	

Table A.43. Analysis of variance table for the number of bites taken from evergreen spiny (thorny) forage plants by milking and non-milking camels in different seasons.

SV	Df	Ms	F
Type	1	8305272.20	6.401*
Animal/Type	8	1297507.50	
Moisture	1	8108520.80	9.085*
Season/Moisture	4	10566791.00	11.840*
Type X Moisture	1	15690775.00	17.581*
Type X Season/Moisture	4	11238275.00	12.593*
Error (b)	40	892468.95	
Total	59	280345.15	

Table A.44. Analysis of variance table for the number of bites taken from suffrutescents forage plants by milking and non-milking camels in different seasons.

SV	Df	Ms	F
Type	1	5334201.70	3.633
Animal/Type	8	1468098.10	
Moisture	1	3145056.00	25.446*
Season/Moisture	4	43282258.00	35.019*
Type X Moisture	1	6543243.30	5.294*
Type X Season/Moisture	4	5642233.90	4.565*
Error (b)	40	1235972.00	
Total	59	508829.88	

Table A.45. Analysis of variance table for the number of bites taken from grass forage plants by milking and non-milking camels in different seasons.

SV	Df	Ms	F
Type	1	1391412.80	4.506
Animal/Type	8	308769.15	
Moisture	1	8632868.00	15.091*
Season/Moisture	4	1955156.30	3.418*
Type X Moisture	1	1840651.40	3.218
Type X Season/Moisture	4	560362.13	0.980
Error (b)	40	572064.54	
Total	59	801351.54	

Table A.46. Analysis of variance table for the number of bites taken from vine forage plants by milking and non-milking camels in different seasons.

SV	Df	Ms	F
Type	1	177997.07	1.459
Animal/Type	8	122016.32	
Moisture	1	278210.67	1.557
Season/Moisture	4	621640.17	3.479*
Type X Moisture	1	141135.00	0.790
Type X Season/Moisture	4	53928.93	0.302
Error (b)	40	178666.80	
Total	59	480282.83	

Table A.47. Analysis of variance table for the number of bites taken from forb forage plants by milking and non-milking camels in different seasons.

SV	Df	Ms	F
Type	1	4472.07	0.164
Animal/Type	8	27286.25	
Moisture	1	69496.08	3.571
Season/Moisture	4	177164.33	9.103*
Type X Moisture	1	20683.27	1.644
Type X Season/Moisture	4	12577.67	0.646
Error (b)	40	19463.15	
Total	59	31363.31	

Table A-48. Analysis of variance table for the number of bites taken from succulent forage plants by milking and non-milking camels in different seasons.

SV	Df	Ms	F
Type	1	1016.82	5.253
Animal/Type	8	193.58	
Moisture	1	1000.42	4.972*
Season/Moisture	1	874.02	4.344*
Type X Moisture	1	874.02	4.344*
Type X Season/Moisture	4	945.42	4.699*
Error (b)	40	201.21	
Total	59	353.66	

Table A-49. Analysis of variance table for crude protein contents of camel diets.

SV	Df	Ms	F
Moisture	1	301.446	3.727
Season/Moisture	4	80.883	
Forage Classes	6	167.262	12.292*
Forage Classes X Moisture	6	26.262	1.930
Forage Classes X Season X Moisture	24	13.207	
Total	41	51.529	

Table A-50. Analysis of variance table for *in vitro* dry matter digestibility in camel diets.

SV	Df	Ms	F
Moisture	1	4.301	0.038
Season/Moisture	4	112.850	
Forage Classes	6	375.690	6.401*
Forage Classes X Moisture	6	56.310	0.959
Forage Classes X Season X Moisture	24	58.689	
Total	41	108.689	

Table A-51. Analysis of variance table for neutral detergent fiber in camel diets.

SV	Df	Ms	F
Moisture	1	151.582	0.0986
Season/Moisture	4	153.660	
Forage Classes	6	120.051	0.556
Forage Classes X Moisture	6	164.311	0.760
Forage Classes X Season X Moisture	24	216.096	
Total	41	186.865	

Table A-52. Analysis of variance table for acid detergent fiber in camel diets.

SV	Df	Ms	F
Moisture	1	55.361	0.701
Season/Moisture	4	78.933	
Forage Classes	6	208.997	2.051
Forage Classes X Moisture	6	75.239	0.739
Forage Classes X Season X Moisture	24	101.879	
Total	41	110.283	

Table A-53. Analysis of variance table for acid detergent lignin in camel diets.

SV	Df	Ms	F
Moisture	1	9.287	0.515
Season/Moisture	4	18.024	
Forage Classes	6	86.092	9.773*
Forage Classes X Moisture	6	5.783	0.656
Forage Classes X Season X Moisture	24	8.809	
Total	41	20.586	

Table A-54. Analysis of variance table for calcium in camel diets.

SV	Df	Ms	F
Moisture	1	0.8192	0.379
Forage Classes	8	1.1266	0.521
Forage Classes X Moisture	8	2.1605	
Total	17	1.5951	

Table A-55. Analysis of variance table for phosphorous in camel diets.

SV	Df	Ms	F
Moisture	1	0.0089	5.933*
Forage Classes	8	0.0013	0.867
Forage Classes X Moisture	8	0.0015	
Total	17	0.0018	

Table A-56. Analysis of variance table for potassium in camel diets.

SV	Df	Ms	F
Moisture	1	0.9522	5.598*
Forage Classes	8	0.3813	2.242
Forage Classes X Moisture	8	0.1701	
Total	17	0.3155	

Table A-57. Analysis of variance table for sodium in camel diets.

SV	Df	Ms	F
Moisture	1	0.0544	2.789
Forage Classes	8	0.0681	3.492
Forage Classes X Moisture	8	0.0195	
Total	17	0.0444	

VITA

Ahmed A. Elmi

Candidate for the Degree of

Doctor of Philosophy

Dissertation: Management, Foraging Behavior, Diet Composition and Forage Quality of Free-Ranging but Herded Camels in Ceeldheer District, Central Somalia.

Major Field: Range Science

Biographical Information:

Personal Data: Born at Dire Dawa, Ethiopia, 1953, Somali; Married Khadra Y. Samatar, Aug. 15, 1976; four children, Mohamed, Farhiyo, Warsame and Deeqa.

Education: Attended and graduated from Muslim School, June 26, 1967; Lagahare Intermediate School, Aug. 21, 1969; obtained Ethiopian School Leaving Certificate (ESLC) from PMHI Secondary School, July, 1972, all in Dire Dawa; attended HSIU, College of Agriculture, Alemaya, 1972-1974; received Laurea in Scienza Agraria, SNU, Aug. 17, 1978; completed the requirements for the Master of Science degree in Range Management in Dec. 4, 1981, at the University of Arizona, Tucson; completed requirements for the Doctor of Philosophy degree from Utah State University in Range Management, 1989.

Professional Experience: Participated in illiteracy campaign, chairman of Public Relation Committee in Jigjiga, Ethiopia, 1974-1975; assistant lecturer, SNU, 1978-1979 and 1982-1983; head and lecturer, Department of Botany and Range Science, SNU; chairman of Foreign Relations and Agriculture Consultancy Committee, SNU, 1986-1987.

Seminars and Training: Certificate, Herbicide Use, two-week seminar, SNU, 1978; certificate, Root and Tuber Crops, IITA, Ibadan, Nigeria, May-July, 1983; certificate, Population Explosion, two-week seminar, Phoenix, Arizona, December 1984; certificate; Research Methodology and Planning, Mogadishu, September 17, 1986.