Tropical and Subtropical Agroecosystems

NUTRITIVE VALUE OF IMPORTANT RANGE FORAGE SPECIES FOR CAMELS IN MARSABIT DISTRICT, KENYA

[VALOR NUTRITIVO DE ESPECIES FORRAJERAS DE IMPORTANCIA PARA CAMELLOS EN EL DISTRITO DE MARSABIT, KENYA]

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SUMMARY

A study carried out in the semi-arid rangelands of Marsabit during dry and wet seasons assessed the content and seasonal variation of crude protein (CP) and fibre of important forage species for camels. Using a semi-structured questionnaire, herders were interviewed and the important forage species consumed by camels identified. The respondents were mainly men and boys responsible for camel herding in the area. The identified forage species were verified through direct field observation of grazing camels. A total of 109 forages were sampled and analysed for CP, Ash and fibre. Camels preferred dwarf shrubs during the wet season, herbaceous and grass species in the dry season. The mean CP and Neutral Detergent Fibre (NDF) contents of preferred forages were 13.9±5.0% and 53.6±13.7% of dry matter (DM) respectively. Fibre content of the forages declined while CP increased from dry to wet season. Shrubs were lower in NDF (51.0±12.6%) and ash (15.5±7.2%) and higher in DM (50.0±18.2%) and CP (14.7±4.9%) compared to grasses (NDF = 60.4±14.3%, ash = 18.5±5.2%, DM = 49.7±17.8%, CP = 12.0±5.0%). It was concluded that the combination of forage species selected by the camels across sites and seasons was adequate in terms of CP.

Key words: Nutritive value, range forages, camels, Kenya

RESUMEN

Se evaluó la variación estacional en el contenido de proteína cruda (PC) y fibra de especies forrajeras de importancia para camellos en la región semi árida de Marsabit, Kenya. Se empleó un cuestionario semi estructurado para entrevistar a los pastores e identificar las especies forrajeras de importancia. Los encuestados fueron principalmente hombres y jóvenes responsables de las manadas de camellos del área. Las especies identificadas en la encuesta fueron verificadas mediante observación directa de camellos pastando en el área. Se tomaron muestras de un total de 109 especies y se analizó su contenido de PC, ceniza y fibra. Los camellos mostraron preferencia hacia arbustivas durante la época de lluvias y herbáceas y pastos durante la estación seca. El contenido de promedio de PC y fibra detergente neutro (FDN) de los forrajes preferidos fue de 13.9±5.0% y 53.6±13.7% respectivamente. El contenido de fibra declinó mientras el PC se incrementó al pasar de la estación seca a la estación lluviosa. Las arbustivas tuvieron un menor contenido de FDN (51.0±12.6%) y ceniza (15.5±7.2%) y mayor contenido de material seca (50.0±18.2%) y PC (14.7±4.9%) comparedas con los pastos (FDN = 60.4±14.3%, cenizas = 18.5±5.2%, MS = 49.7±17.8%, PC = 12.0±5.0%). Se concluyó que la combinación de forrajes seleccionada por los camellos en las áreas de pastoreo y en las dos estaciones fue adecuada en cuanto a su contenido de PC.

Palabras clave: valor nutritivo, forrajes de agostadero, camellos, Kenya.

INTRODUCTION

In the arid and semi-arid zones of the world, it is inevitable for livestock to be well adapted to the harsh grazing conditions (Abbas *et al*., 1995). Camels are able to survive in such environments due to their unique morphology and physiology. The physiology of camels enables them to survive on very fibrous and low protein diets (Heller *et al*., 1986; Lechner-Doll *et al*., 1990). They reportedly retain such feed material for longer periods in the rumen and thus utilize these better than cattle, sheep and goats (Mousa *et al*., 1983). The height of camels allows them to utilize feed resources inaccessible to other livestock species (Field, 1979). The cleft upper lip enables camels to select diets better than other livestock species (Rutagwenda *et al*., 1990). Due to these adaptive features, camels are important in the subsistence of pastoral peoples inhabiting the harsh areas through provision of particularly milk and some blood (Field

and Simpkin, 1984). Despite the socio-economic importance of the camel in the arid and semi-arid rangelands of the world, efforts to improve its productivity have lagged behind other livestock species (Bahgat, 1991).

Coppock *et al*. (1986) observed that the dromedary was, by preference, a browser of trees and shrubs and sometimes hard-thorny and bitter plants that grew naturally in the desert and other semi-arid areas. Camels browsed selectively, preferring the more nutritious browse materials, with high moisture and electrolyte contents (Newman, 1975; Field, 1995). Field (1979), Coppock *et al*. (1986) and Rutagwenda *et al*. (1990) reported that on thorn bush savannah pasture, camels spent more than 80% of their feeding time on highly digestible dicotyledonous plants. Wangoi (1984) and Field (1995) observed that the browse selected by Rendille camels was predominantly comprised of dwarf shrubs, shrubs and trees. However, they also noted seasonal variations such that trees, shrubs and dwarf shrubs dominated camel diet in wet season but the percentage of trees and shrubs noticeably declined during the dry season when most of these species shed the leaves. Rutagwenda *et al*. (1990) further reported that during the wet season, Rendille camels successfully selected for dicotyledons while in the dry season, more than 90% of feeding time was spent on monocotyledons. Wangoi (1984) reported that grass species made a small component of camel diet.

The nutritive value and seasonal variations of most forage species selected by camels in the Rendille area have not been determined (Field, 1995). Seasonal changes in the diets selected by camels would result in changes in the diet quality (Kayongo *et al*., 1978), which directly affect camel performance and the subsequent well being of the pastoral people. This paper reports the seasonal variation of CP and fibre fractions of important forage species utilized by grazing camels in the Rendille area.

MATERIALS AND METHODS

The Rendille pastoralists occupy Laisamis and Loyangalani administrative divisions of Marsabit district between 2º and 3º north and 37º and 38º east. The area comprises of sedimentary plains about 350m **a**bove **s**ea **l**evel (masl) (Bake, 1983). To the East of Rendille area is mount Marsabit (1865masl) while to the west and north are Mt.Kulal (2335masl) and Hurri hills (1685masl) respectively. All these landforms are of volcanic origin. To the southern side are the metamorphic basement rock mountain ranges of Nyiru (2752masl), Ol Donyo Mara (2067masl) and Ndoto (2637masl) while to the south west are the Matthew's ranges (3170masl). The area receives mean annual precipitation of 250mm on the plains and 800mm on the foot slopes of the mountains (Schwartz *et al*., 1991) and follows a bimodal pattern. Long rains are received in March/April whilst short rains come in October through December. The mean monthly temperatures vary from 27-29ºC with mean minimum and maximum daily temperatures of 20ºC and 35ºC respectively.

The study was conducted in Ngurunit, Korr and Kargi administrative locations all of which are located in western Marsabit district. Ngurunit is located on the mountain slopes while Korr and Kargi are on the plains. Soils in Kargi area are of volcanic origin while those in Ngurunit and Korr are metamorphic in nature (Bake and Kekem, 1984). Vegetation in the area is mainly shrubs interspersed with annual grasses and trees with the bush being thicker in Ngurunit area and sparse towards Kargi. The study covered an area of 30km radii from the settlements.

A semi-structured questionnaire was designed, pre-tested and administered through a language translator on semi-settled Rendille camel herders in Ngurunit, Korr and Kargi during dry and wet seasons. The respondents were mainly boys and men who were directly involved in camel management and a few women. They numbered 33, 28 and 30 in Kargi, Korr and Ngurunit respectively. Individuals interviewed in the dry season were re-interviewed during the wet season to capture seasonal variations. Five to eight respondents were selected at random from 4 to 5 randomly selected *manyattas* in the three study sites.

Identification of preferred forages

During the administration of questionnaire, the respondents were asked to identify five forage species preferred by camels during the dry and during wet periods. The identification was followed by verification through direct field observation of grazing camels. Thirty (30) different camels were observed per season per site (5 – 6 camels per day) in a period of 5 – 7 consecutive days. The observations were carried out by two people with each person observing 2 - 3 camels daily, between 10.00am and 12.00 noon. Each camel was observed for a total of 15 minutes, recording the number of bites made by the camel on various forage species. Bites made on particular forage species by different camels were tallied to get the site totals. The species were ranked on the basis of proportion of bites to the total bite counts for every site and season.

Sampling of preferred species

The ranking lists of preferred forage species were used as a guide to determine which species were to be sampled for analysis. Where the camels ate 10 or less species during the observation per site per season, they

were all selected for sampling. However, where the list had more than 10 species, a combination of forage species taking 90 - 100% of camels' grazing time were chosen for sampling starting from the highest scorer. Sampling targeted plant parts eaten by the camels during the field observation. Forage species perceived as important by herders were also sampled, regardless of whether they were eaten during field observation or not. Plant parts selected for sampling were mostly the leaves and soft stems. A total of 55 forage species were sampled in the three sites during the dry season of which 36 were observed being eaten by the camels. In the wet season, 54 forage species were sampled and of these, camels were observed eating 29. Wet weight of all the forage samples was taken after harvesting and the samples packed in polythene bags for laboratory analysis.

Laboratory analysis

Dry matter content of the samples was determined at both 60°C and 105°C. The samples were dried at 60°C for two days, weighed, ground and then stored for analysis. The second DM was determined by drying the ground samples at 105°C overnight as recommended by Abdouli *et al*. (1992). Crude protein analysis was done using the Kjeldal procedure described in the AOAC (1995). Fibre components were analysed according to the procedure of Van Soest (1963). Ash was determined according to the AOAC (1995).

RESULTS

Forage preference

Table 1 show the forage species selected by camels per site and their relative contribution to the daily diet of camels in dry and wet seasons. Dwarf shrubs recorded the highest percent of bite counts especially in Kargi and Korr during the wet season while in the dry season, herbaceous and grass species were eaten more by the camels. In Ngurunit, shrubs had the highest percent of bite counts in both dry and wet seasons. Forage species, *Indigofera spinosa* and *Duosperma eremophilum* were grazed in significant amounts during both dry and wet seasons in all the study sites. *Heliotropium studineri* and *Cordia sinensis* were grazed during dry and wet seasons in Korr and Ngurunit respectively. The rest of the forage species were either eaten during dry or wet season in some of the sites.

Crude protein and fibre composition

Tables 2 and 3 shows the DM, CP and fibre contents of the forage species selected by camels during dry and wet seasons respectively. The preferred forage species had an overall mean DM of 60.8±17.8% and 40.0±9.1% during dry and wet seasons respectively. The overall average CP content of these forages was 12.1±4.7% and 16.2±4.4% of DM in dry and wet seasons respectively. The mean CP for shrubs was 13.2±4.7% compared to 9.3±3.8% for grasses, herbs and climbers during the dry season. In the wet season, average CP for shrubs was 16.6±4.5% in comparison with 15.5±4.2% for grasses, herbs and climbers. The CP thus increased from dry to wet season and was higher in shrubs than other forage categories. The average NDF of preferred forages was 55.9±13.9% and 50.7±13.0% during dry and wet seasons respectively. Shrubs had a mean NDF content of 51.0±12.6% compared to 60.4±14.3% for grasses, herbs and climbers (Tables 2 and 3). The NDF declined from dry to wet seasons and was higher in grasses and herbs than in shrubs. Ash content of the forages (Tables 2 and 3) averaged 15.3±6.4% and 17.7±7.2% during dry and wet seasons respectively.

Daily CP and NDF intake for the camels

To estimate the amount of nutrients available to the camels daily, computations were done for an average camel (450kg live weight consuming 2% of live weight feed – Field, 1993) and the results are shown in Table 4. These were computed from the list of preferred forages, their bite counts and nutrient content. The CP available to the camels in the study area daily was higher during wet (mean = 1.4kg) than dry season (mean = 1.1kg). It was highest in Ngurunit during wet season and lowest in Kargi during the dry season. The average NDF available to the camels on daily basis was 5.1kg in dry and 4.7kg in the wet season. Fibre content of the diet declined from Kargi through Ngurunit.

The nutritive values of other forages, perceived as important by the respondents are presented in Table 5.

Table 1. Preferred forage species in different sites and their contribution to the camel diet in dry and wet seasons.

Site	Growth form	Forage species	Bite count %	
			Dry season	Wet season
Kargi	Shrubs	*Cordia sinensis*	**1.4(1.4)	0
		Acacia mellifera	0	2.8
		Acacia reficiens	0	2.6 **(5.4)**
	Dwarf shrubs	*Ficus species*	28.0	0
		Indigofera spinosa	15.5	79.9
		Crotolaria deseticola	1.6	0
		Sericocomopsis hilderbrandtii	0.6	0
		Duosperma eremophilum	0	8.1
		Indigofera cliffordiana	0 **(45.7)**	6.5 **(94.5)**
	Herbs	*Blepharis linariifolia*	**0.4(0.4)**	0
		Heliotropium species	0	**0.2(0.2)**
	Grasses	*Dactyloteniun bogdanii*	22.9	0
		Digitaria velutina	12.6	0
		Aristida adscensiosis	8.9	0
		Sporobolus spicatus	8.2 **(52.6)**	0
Korr	Shrubs	*Cadaba mirabilis*	2.0	0
		Maerua classifolia	1.7	0
		Cadaba farinosa	0.6	**(2.6)**
		Balanites orbicularis	0.6 **(4.9)**	0
	Dwarf shrubs	*Indigofera spinosa*	23.3	42.3
		Duosperma eremophilum	22.0	13.0
		Indigofera cliffordiana	0.8	5.2
		Cadaba glandulosa	0.3	0
		Sericocomopsis hilderbrandtii	0 **(46.4)**	9.5 **(70.0)**
	Herbs	*Heliotropium studineri*	34.2	4.1
		Portulacea oleracea	12.5	0
		Heliotropium species	0	16.0
		Blepharis linariifolia	0	3.5
		Indigofera hochstetteri	0 **(46.7)**	2.2 **(25.8)**
	Grasses	*Dactyloteniun bogdanii*	0	**(0.01)**
	Climbers	*Maerua oblongifolia*	**(2.4)**	0
Ngurunit	Shrubs	*Lawsonia inermis*	13.8	0
		**Lkerpei*	10.9	0
		Cordia sinensis	10.0	3.1
		Balanites aegyptiaca	7.7	0
		Boscia coriacea	6.8	0.1
		Maerua species	6.5	0
		Craibia inurentii	2.2	0
		Tapinanthus sansibarensis	1.8	0
		Cadaba farinosa	1.2	0
		Salvadora persica	0.9	0
		Justicia exigua	0	46.9
		Opilia campestris	0	5.2
		Commiphora boiviniana	0	4.9
		Grewia tenax	0	4.3
		Momordica trifoliolata	0	1.5
		Maerua classifolia	0 **(61.8)**	0.8 **(66.8)**
	Dwarf shrubs	*Indigofera spinosa*	16.8	1.8
		Duosperma eremophilum	11.5	27.4
		Cadaba glandulosa	1.1 **(29.4)**	0 **(29.2)**
	Herbs	*Barlaria proxima*	**(4.8)**	0
	Climbers	*Maerua oblongifolia*	**(4.0)**	0
		Combretum molle	0	**(3.9)**

*Botanical name unavailable; ** in brackets and bolded – growth form totals

Table 2. Variation of chemical composition of preferred forage species with site during dry season.

Site	Growth form	Forage species	DM %	CP %	Ash %	NDF %	[a]ADF %	[b]ADL %
	Shrubs	*Cordia quercifolia*	57.0	13.2	7.4	47.8	42.0	23.4
		Ficus species	26.5	11.4	19.1	47.2	31.8	8.1
		Sericocomopsis hilderbrandtii	59.7	9.6	13.1	64.7	43.4	10.8
		Indigofera spinosa	71.0	8.1	17.6	69.4	53.4	17.6
		Crotolaria deserticola	83.9	7.1	10.8	64.9	50.7	8.4
	Grasses	*Sporobolus spicatus*	57.6	7.1	22.2	74.4	41.0	7.0
Kargi		*Dactylotenium bogdanii*	58.3	6.7	19.0	63.1	38.1	6.2
		Aristida adsensionis	84.7	5.9	22.2	75.7	50.2	6.6
		Digitaria velutina	-	4.2	11.6	76.2	47.4	7.1
	Herbs	*Blepharis linariifolia*	70.6	7.2	25.6	81.8	59.3	16.8
	Shrubs	*Balanites orbicularis*	46.8	25.6	6.9	52.4	32.3	11.3
		Cadaba mirabilis	59.8	18.4	31.3	48.5	30.9	12.7
		Maerua classifolia	56.3	17.1	23.2	35.6	22.6	11.4
		Cadaba farinosa	64.8	15.2	7.0	80.4	59.5	24.9
Korr		*Duosperma eremophilum*	78.1	12.6	18.7	46.9	30.0	14.6
		Indigofera spinosa	82.7	11.5	7.6	46.2	24.8	19.6
		Indigofera cliffordiana	82.8	9.2	8.1	49.6	32.9	21.7
		Cadaba glandulosa	57.5	15.8	20.4	47.5	31.1	14.0
	Herbs	*Heliotropium studineri*	34.6	13.3	19.0	44.9	33.8	9.0
		Portulacea oleracea	31.5	9.3	16.6	56.0	38.2	6.8
	Climbers	*Maerua oblongifolia*	56.2	15.0	11.3	65.9	45.6	16.7
		Craibia inurentii	53.3	22.6	14.1	49.7	32.6	12.0
		Tapinanthus sansibarensis	57.3	18.7	8.4	54.4	30.5	15.4
		Cordia quercifolia	32.1	16.1	17.5	60.4	51.6	22.3
		Cadaba glandulosa	87.9	14.7	17.7	51.0	31.3	15.0
		Boscia coreacea	68.7	14.5	18.1	54.7	34.7	12.9
		Cadaba farinosa	61.2	14.3	7.3	73.1	45.7	20.0
Ngurunit	Shrubs	*Balanites aegyptiaca*	50.1	11.9	7.5	60.9	41.5	19.4
		Salvadora persica	31.3	11.3	16.4	33.4	16.4	4.4
		Maerua species	42.1	10.7	27.4	32.0	19.3	12.7
		Duosperma eremophilum	75.1	9.3	19.5	50.7	31.2	24.4
		Indigofera spinosa	78.9	8.8	7.6	68.5	51.0	20.0
		Lawsonia inermis	42.9	7.8	8.1	46.1	35.1	16.5
		**Lkerpei*	87.4	7.2	14.2	23.5	16.4	7.7
	Herbs	*Barlaria proxima*	85.2	9.6	12.3	60.5	44.4	19.3
	Climbers	*Maerua oblongifolia*	55.8	14.5	17.0	54.2	32.9	16.7

* Botanical name unavailable; [a]ADF - Acid Detergent Fibre; [b]ADL – Acid Detergent Lignin ; - imply missing data

Table 3. Variation of chemical composition of preferred forage species with site during wet season.

Site	Growth form	Forage species	DM %	CP %	Ash %	NDF %	[a]ADF %	[b]ADL %
	Shrubs	*Acacia mellifera*	33.0	27.8	6.8	63.7	44.8	13.9
		Acacia reficiens	56.7	17.9	7.5	40.2	26.2	14.7
Kargi		*Duosperma eremophilum*	36.4	14.4	24.3	49.2	32.0	12.1
		Indigofera cliffordiana	52.1	13.1	13.0	64.9	39.7	11.4
		Indigofera spinosa	52.1	11.3	10.1	58.9	43.6	14.9
	Herbs	*Heliotropium species*	46.6	10.6	14.9	81.3	43.7	12.4
	Shrubs	*Cadaba glandulosa*	49.0	20.6	16.8	45.6	29.8	13.6
		Cadaba farinosa	48.3	18.2	8.1	60.6	40.9	21.1
		Sericocomopsis hilderbrandtii	38.2	16.0	16.3	63.7	27.4	4.0
		Duosperma eremophilum	33.9	14.9	21.4	50.3	26.8	8.4
		Indigofera cliffordiana	32.9	13.9	19.0	48.9	36.8	8.8
Korr		*Indigofera spinosa*	27.9	12.7	22.9	55.7	45.1	8.9
	Grasses	*Dactylotenium bogdanii*	39.7	8.3	16.0	76.3	41.1	7.9
		Heliotropium studineri	26.7	20.8	29.0	41.7	31.6	12.9
		Portulacea oleracea	28.7	19.5	22.3	44.1	28.1	15.7
	Herbs	*Blepharis linariifolia*	37.8	16.5	21.7	46.3	27.5	4.8
		Indigofera hochstetteri	38.0	15.8	24.6	52.2	32.0	7.1
		Heliotropium species	44.0	14.6	17.2	47.5	34.4	7.4
	Shrubs	*Opilia campestris*	31.9	24.4	28.1	28.9	16.7	8.4
		Grewia tenax	29.9	23.4	17.3	38.8	22.4	8.0
		Commiphora boiviniana	25.7	19.3	14.2	50.5	36.9	13.9
		Maerua species	29.5	16.5	35.6	19.4	7.9	3.3
Ngurunit		*Momordica trifoliolata*	35.6	15.4	10.6	38.1	24.2	7.9
		Justicia exigua	43.0	13.9	9.3	51.1	30.9	14.2
		Cordia sinensis	41.2	13.8	18.9	56.6	43.3	18.9
		Duosperma eremophilum	45.8	12.4	25.2	43.4	25.0	9.2
		Indigofera spinosa	55.2	11.3	12.7	57.8	44.6	14.9
	Climbers	*Combretum molle*	48.8	17.6	11.3	44.6	30.1	8.5

[a]ADF - Acid Detergent Fibre; [b]ADL – Acid Detergent Lignin

Table 4. Calculated percent of CP, NDF and the daily CP and NDF intake for a 450kg camel consuming 2% of live weight dry matter.

Site	Dry season		Wet season	
	CP	NDF	CP	NDF
Kargi	8.1% (0.7kg)	66.5% (6.0kg)	15.9% (1.4kg)	59.7% (5.4kg)
Korr	15.4% (1.4kg)	52.2% (4.7kg)	16.0% (1.4kg)	52.7% (4.7kg)
Ngurunit	12.8% (1.2kg)	51.5% (4.6kg)	16.8% (1.5kg)	42.9% (3.9kg)

Table 5. Chemical composition of other forage species perceived as important by the respondents.

Site	Season	Growth form	Forage species	DM %	CP %	Ash %	NDF %	ADF %	ADL %
			Cadaba mirabilis	32.2	20.7	26.8	33.1	22.6	14.8
			Salsola dendroides	51.9	14.8	39.1	41.9	15.5	7.4
			Boscia coreacea	58.3	14.6	12.8	49.7	29.4	-
		Shrubs	*Maerua classifolia*	48.2	13.9	11.7	57.2	37.3	22.0
			Cadaba farinosa	69.4	13.6	8.4	66.9	44.2	23.1
	Dry		*Salvadora persica*	28.4	11.9	22.7	39.9	21.5	5.23
			Barlaria proxima	67.4	10.4	11.8	42.2	37.1	16.4
			Cadaba glandulosa	62.8	5.8	23.0	43.5	29.2	14.5
		Grasses	*Neuracanthus species*	77.2	8.9	20.8	64.9	47.4	17.0
		Climber	*Maerua oblongifolia*	62.0	12.5	10.1	63.3	42.1	14.0
		Shrubs	*Boscia coreacea*	42.5	24.7	9.9	44.1	27.9	8.0
Kargi			*Cadaba mirabilis*	38.8	21.8	23.4	38.5	24.9	12.7
			Cadaba glandulosa	76.2	19.5	22.3	36.2	22.8	15.4
			Maerua classifolia	42.6	18.4	27.5	35.1	18.1	7.1
			Cordia sinensis	49.4	18.1	14.4	57.1	51.4	23.9
			Salsola dendroides	30.9	17.2	36.4	44.1	14.4	7.8
	Wet		*Barlaria proxima*	46.4	16.3	15.7	58.4	36.4	14.2
			Ficus sp.	29.6	13.9	21.0	55.8	37.5	12.9
			Lycium europaem	43.4	12.9	7.8	72.6	51.3	22.3
			Salvadora persica	34.5	10.7	33.4	40.5	20.8	5.9
		Grasses	*Dactylotenium bogdanii*	20.3	11.6	18.2	66.8	39.2	5.7
			Sporoborus spicatus	53.9	9.6	11.0	39.2	18.5	10.2
		Climbers	*Maerua oblongifolia*	39.7	15.0	15.7	52.6	33.8	13.0
		Shrubs	*Cadaba ruspoli*	65.1	18.8	14.6	49.0	30.6	15.0
	Dry		*Ficus sp.*	66.9	14.4	11.0	67.6	50.1	13.8
			Salvadora persica	37.3	-	49.5	32.0	15.4	3.9
			Boscia coreacea	58.8	17.4	13.9	48.5	29.2	15.2
		Shrubs	*Ficus sp.*	20.4	19.4	21.1	56.8	37.4	9.3
Korr			*Cassia/Crotolaria sp.*	39.2	18.4	8.3	54.2	39.2	8.1
	Wet		*Maerua classifolia*	47.7	17.7	21.3	41.4	24.7	8.5
			Salsola dendroides	30.9	13.4	22.3	55.2	27.4	5.21
			Salvadora persica	28.9	10.0	43.1	31.9	19.9	5.3
		Herbs	*Heliotropium studineri*	26.7	20.8	29.0	41.7	31.6	12.9
		Trees	*Acacia tortilis*	46.6	14.7	10.5	52.2	42.5	18.7
			Ormacarpum trichocarpum	33.9	12.1	16.6	52.5	32.0	12.3
	Dry	Shrubs	*Dobera glabra*	48.2	10.2	14.2	64.9	35.3	13.1
			Tarenna graveolena	80.2	9.0	8.1	45.2	32.9	14.3
		Herbs	*Heliotropium studineri*	61.2	11.7	13.9	53.7	38.3	7.1
Ngurunit		Shrubs	*Sclerocarpus africanus*	31.0	15.8	19.2	41.2	24.6	-
			Ficus sp.	31.6	15.2	22.5	45.9	27.3	7.6
	Wet		*Kedrostis gijef*	25.3	13.9	40.3	42.8	24.4	7.18
			Commiphora paolii	29.8	13.5	14.9	53.1	28.4	9.4
			Balanites aegyptica	48.7	12.1	9.2	46.7	28.0	16.3
			Salvadora persica	31.3	10.5	41.6	32.8	11.7	3.9

- imply missing data

DISCUSSION

The camels showed preference for dwarf shrubs especially in Kargi and Korr during the wet season while in the dry season, they selected more of herbaceous and grass species in addition to the dwarf shrubs (Table 1). Compared with grasses, shrubs and dwarf shrubs were lower in fibre and ash, and higher in DM and CP. These attributes made the shrubs and dwarf shrubs more palatable, in harmony with El Shaer and Gihad (1994) and were thus preferred by the grazing camels. These findings were consistent with

the reports of Wangoi (1984), Rutagwenda *et al*. (1990) and Field (1995). Wangoi (1984) observed that camels preferred a diet predominated by browse, at 96% of total in wet season. The percentage of browse in the diet however declined in the dry season as the forage species shed off the leaves. Field (1995) also reported that dwarf shrubs constituted the most important plant species in the diet of camels. In Ngurunit, camels mostly browsed on shrubs in both dry and wet seasons, possibly because shrubs dominated the vegetation.

The high number of bite counts recorded for *Indigofera spinosa* and *Duosperma eremophilum* in all the three sites and seasons (Table 1) reflected the relative abundance of both dwarf shrubs on the ground. During the field observation, it was noted that among the preferred forage species, *Indigofera spinosa* was the most abundant. Forage species like *Lawsonia inermis* and *Cordia sinensis* in Ngurunit, *Heliotropium studineri* and *Portulacea oleracea* in Korr, *Ficus species* and *Dactyloteniun bogdanii* in Kargi recorded fairly high bite counts (Table 1) although they were not abundant on the ground. This suggests that the forage species were preferred and therefore sought after by the camels. This was in agreement with Osolo *et al*. (1994) who reported high preference for some plants that were not the most abundant in the study area. In addition, all these forage species were moderate in DM (mean = 43.3$\pm$13.3%), CP (mean = 12.1$\pm$3.7%) and ash (mean = 18.1$\pm$5.1%). El Shaer and Gihad (1994) observed that forage species with 14% ash had high palatability. While moderate moisture content makes feed more palatable and may increase DM intake, excessive moisture depresses DM intake of grazing animals (Linn, 2004).

The CP range in the present study (Tables 2 and 3) was higher than what had been reported for range forages in other countries by Animal Production Research Unit (APRU - 1978): 5.3 to 11.6% in Botswana, El Shaer and Gihad (1994): 6.2 to 13.2% in Egypt. El Shaer and Gihad (1994) reported an NDF range of 35 – 39% for forages selected by sheep and goats, which is narrow, compared to the range obtained in this study (Tables 2 and 3) for camel diets. The increase in CP from dry to wet season (Table 2 versus Table 3) was in agreement with Kayongo (1986), Field (1995) and Abbas *et al*. (1995). During a study on quality of forage selected by Zebu cattle in Ngurunit - Oltorot area of Marsabit district, Kayongo (1986) observed a declining trend in forage CP and a concomitant increase in the fibre fraction from wet to dry season. Field (1995) observed that the CP of forage species selected by camels peaked in the wet season. The author reported wet season CP content in the range of 15 - 16%, similar to results of this study. Abbas *et al*. (1995) reported a CP content of forages during dry season that was 73% lower than in the wet season. The increase in fibre content of forages from wet to dry season (Table 3 versus Table 2) was consistent with earlier reports by Van Soest (1982) and Wilson (1982) who noted that when forages matured (dry season), fibre content increased while protein level declined.

Protein requirements in ruminants include protein and or nitrogen requirements for the ruminal microbial population (Huston *et al*., 1981). The microbial requirements are met at 6 – 8 % CP while the animal requirements range from 7 – 20% CP in the diet depending upon species, sex and physiological state (Milford and Haydock, 1965; Huston *et al*., 1981). Kearl (1982) described 11 – 13% CP in the diet as adequate for maintenance and growth requirements of sheep and goats while 7 – 8% is enough to cover the requirements of ruminal micro-organisms. Camels selected adequate diets with the exception of Kargi during the dry season (Table 4). Across sites and seasons, the combination of forage species selected by the grazing camels had average CP content that was within the range recommended for microbial activities and milk production. Out of 64 forage species analysed, 84.4% had CP values above 8%. This confirmed an earlier observation by Abbas *et al*. (1995) that dromedaries on pasture select for protein rich forage species.

Neutral detergent fibre is the major determinant of overall forage quality and digestibility, and has a direct effect on animal performance (Linn, 2004). High NDF lower the voluntary DM intake of grazing animals (Van Soest and Jones, 1968; Kandil and El Shaer, 1990). The higher the NDF, the lower the neutral detergent solubles i.e. starches, sugars, fats, CP. El Shaer and Gihad (1994) described NDF range of 35 – 40% as within the normal range of nutritious fodders. The NDF of forages selected by camels (Table 4) was beyond this range in all sites and seasons. However, 50% of the selected forage species had NDF level of 50% or less, suggesting moderate level NDF for the selected diet. Unlike other ruminants however, camels have a higher capacity to utilize fibrous feed material by retaining it in the rumen for longer period, allowing for better digestion (Lechner-Doll *et al*., 1990). This mitigates the negative effects of high fibre content in camel diets.

CONCLUSIONS

Across sites, *Indigofera spinosa* and *Dusoperma* eremophilum were the most preferred forage species. In all sites and seasons, the combination of forage species selected by the grazing camels was adequate in terms of CP. The diet was however of medium quality with respect to NDF and DM.

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