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The names and affiliations of all authors are provided below, following the references.

Changes in morphological and qualitative composition of ruminant pastures during the rainy season in Kenya

I Tura¹, M Githui², F Kemboi³, R Kenana⁴, NKW Olekaikai⁵, C Ndung'u⁶, J Kiprop⁷, P Tarus⁸, P Kamau⁹, E Owiro¹⁰

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ABSTRACT

Beef cattle production in Kenya is predominantly dependent on natural forages that grow naturally during two main rain seasons, i.e., long rains in March, April, and May, and short rains in October, November, and December. The type, quality, and quantity of forages fed to beef animals are crucial in determining the growth rate, productivity, and overall health of the cattle. This study evaluated the morphological availability, diversity of plants, as well as nutritional composition of forages available to ruminants in a ranching system in Kenya during the rainy season. Forages include Rhodes grass (*Chloris gayana*), *Brachiaria* grass, Kikuyu grass (*Pennisetum clandestinum*), African couch grass *Digitaria abyssinica*, goose grass (*Eleusine indica*), grey love grass (*Eragrostis cilianensis*), woolly finger grass (*Digitaria eriantha*) and legumes such green leaf desmodium (*Desmodium intortum*), silver leaf desmodium (*Desmodium uncinatum*), Kenya white clover (*Trifolium semi-pilosum*), *Sesban* (*Sesbania sesban*) were evaluated for their proximate composition, including dry matter, crude protein, crude fiber, energy, and crude fat. The study was conducted over six days under free range on a ranch in Kenya. The results showed that *Eragrostis cilianensis* (29%) and *Digitaria abyssinica* (28.3%) had the highest crude protein (CP) content, followed by *Pennisetum clandestinum* (15.8%), while *Digitaria eriantha* had the highest crude fiber content (79.7%). *Trifolium semi-pilosum* (24.9%) and *Sesbania sesban* (24.4%) had the highest CP. *Sesbania sesban* (11.5 MJ/Kg-1 DM) and *Trifolium semi-pilosum* (11.1 MJ/Kg-1 DM) legumes had the highest metabolizable energy (ME). Hairly hood grass (*Hyparrhenia hirta*) had the lowest ME (6.3 MJ/Kg-1 DM). *Sesbania sesban* had the highest crude fat content (3.4%). The study concludes that *Eragrostis cilianensis*, *Digitaria abyssinica*, and *Pennisetum clandestinum* are suitable forages for beef cattle production under ranching conditions in Kenya due to their high crude protein content. However, a balanced grass and legume mixture is recommended to ensure optimal growth and health of the cattle. Further research is required to determine the mineral and vitamin composition of these selected forages and their potential impact on cattle production.

Keywords: Beef cattle, Forages, Proximate composition, Ranching conditions, Kenya

Introduction

The beef industry in Kenya plays a crucial role in the Country's economy, providing a significant source of food, income, and employment for both rural and urban communities (Khanal *et al.*, 2022) [1]. Cattle farming in Kenya is diverse, ranging from large-scale commercial operations to smallholder systems. This industry has experienced notable growth over the years due to increased demand for beef products and favorable climatic conditions for livestock production. Kenya is home to several beef cattle breeds, with each breed adapted to different ecological zones. Some prominent beef cattle breeds found in the Country include the Boran, Sahiwal, Ankole, and Zebu (Yadav *et al.*, 2023) [2]. These breeds are known for their adaptability to harsh environments, resistance to diseases, and ability to utilize low-quality forage efficiently.

The beef industry in Kenya utilizes different production systems based on factors such as land availability, resource availability, and market demands. These systems include extensive grazing systems, ranching systems, and feedlot systems. Extensive grazing systems involve free-range grazing on natural pastures, while ranching systems involve managed grazing on large tracts of land (Msuya, 2022) [3]. Feedlot systems, on the other hand, focus on intensive feeding and are commonly used in commercial operations to maximize animal growth and meat production. In most of the production systems for beef cattle in Kenya, the feeding regime is pasture-based (Kahi *et al.*, 2006) [4]. Improved beef breeds, such as improved Boran and crosses between improved Boran and exotic breeds, are also kept in these ranches to maximize profits (Rewe *et al.*, 2010) [5]. Forage availability is affected by various factors such as seasonality of the year (Sunya, 2006). A lack of enough feed for all the animals can have adverse effects on the animals' welfare, which includes malnutri

Corresponding Author: F Kemboi

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O Box 3840 -20100, Nakuru, Rift Valley, Kenya.

tion leading to mortalities in the herds, especially in pastoral production systems (Santos, 2019). These forages, including legumes, can have varying levels of nutrients depending on the climatic conditions, which influence factors such as rainfall availability (Rini 2016; Brandao, 2018). During dry seasons, for instance, the crude protein levels decrease as compared to seasons of abundant rainfall (Brandao, 2018; Yani, 2004). The dry season increases quantities of dead material in the plants, and the palatability of the feed decreases as drought persists (Brandao, 2018). The levels of nutrients affect the ability of the grasses and shrubs to meet the nutritional requirements of the animals for their various body needs (Caballero *et al.*, 2022) [6].

It also affects the availability or limited availability of minerals especially the major minerals like Calcium, phosphorus, and magnesium, and trace minerals like Manganese and Zinc, which are crucial for beef animals for various body functions in maintenance, health promotion, and growth (Khalil, 2016; Jones, 2013; Lopi, 2016). The minerals are also affected by climatic conditions and soil characteristics, among other factors (Khan, 2005). Variations in feed nutrients and availability of the forages depending on the seasons of the year influence the ability of beef cattle to gain weight (Fernandes *et al.*, 2022) [7]. In beef production, weight gain is one of the most important fac-

tors as it affects the weight of the animal (Garber *et al.*, 2022) [8], which in turn affects the returns. The objective of this study was to determine the levels of nutrients found in forages and their availability to beef cattle in various seasons. This study focuses on the plant variety, nutritional value, and seasonal availability of ruminant pastures during the rainy season rather than the animal performance or feeding behavior.

Materials and methods

Site description

The study was conducted at the Beef Research Institute, Lanet, Nakuru County, Kenya (Figure 1). The station is located at latitude 0° N 18° S and longitude 36° W 09° E, 1920m above sea level. The area has a bimodal rainfall pattern with long rains being experienced from March to June and short rains in October, November, and December. Annual rainfall is often below 800 mm and unreliable both in quantity and distribution. The Research Center is located at the interface of agroecological zones 3 and 4 (Wasike *et al.* 2007). Temperatures range between 8 and 30 °C. Soils are deep sandy loam with good water-holding capacity, with a pH range of 5.5 to 6.5.

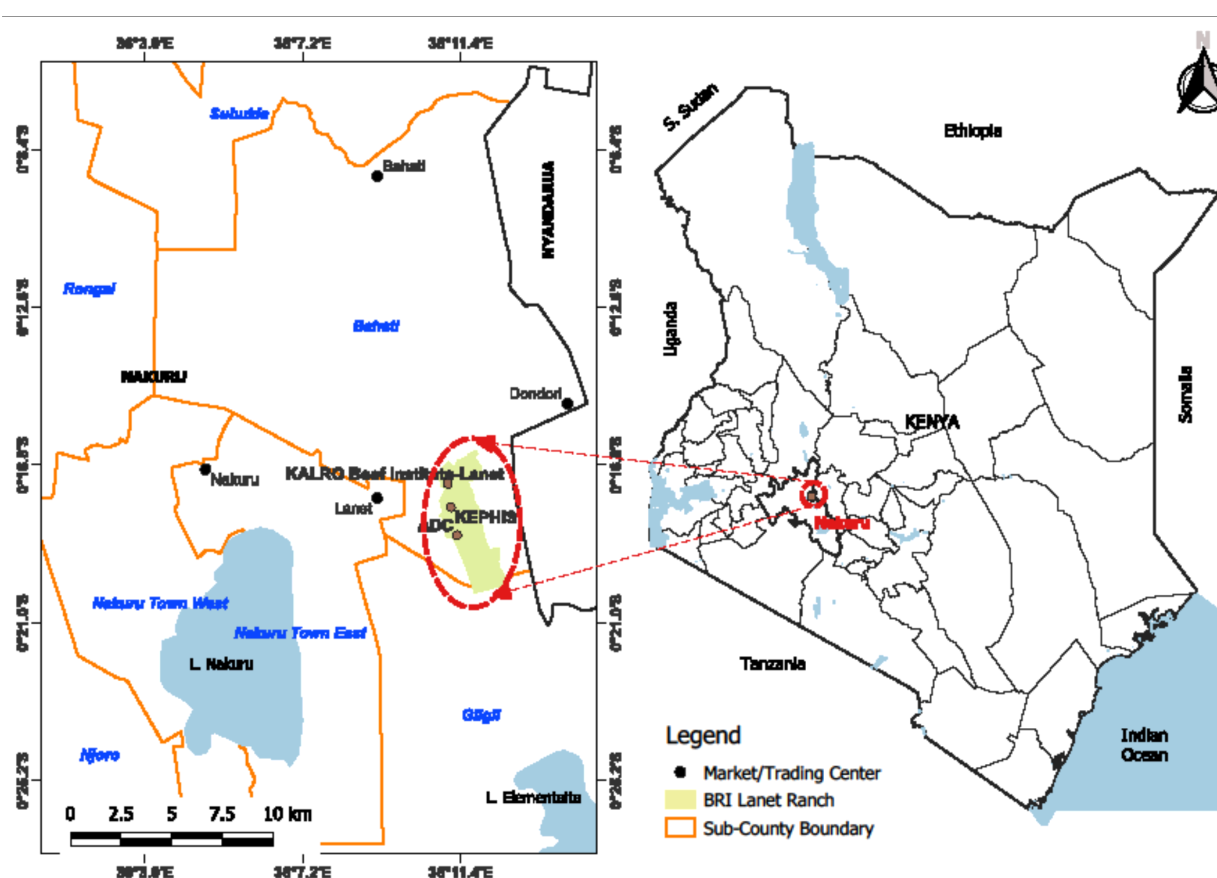


Figure 1. Map of Lanet, in Nakuru County, study site

Experimental animals, feeding regimes, and management

This research focused on thirty beef cattle, which included improved Boran, Boran-Sahiwal crosses, and Small East African Zebu breeds. The animals were between 24 and 30 months of age, clinically healthy, and kept under standard extensive ranch farming conditions. The ranch has a variety of highly nutritious natural forages. The animals were between twenty-four and thirty months old. The animals grazed from 0800 hours to 1700 hours daily. Animals were provided with water daily *ad libitum*. The study was conducted during the rainy season when most forage species were available and at the right nutrient levels.

Grazing observation and sampling methods for preferred forages for beef animals

During forage sample collection, the visual evaluation of the plant's morphological stage (for example, vegetative, flowering, or seed-setting) was performed and noted to enhance understanding and interpretation of the plant's preference and nutritional value as forage. The most preferred forage species were determined after conducting grazing behavior observations (Plate 1 & 2) for 6 days during the peak of the rainy season. A total of 30 clinically healthy beef cattle (Boran, Boran-Sahiwal crosses, and Small East African Zebu) aged 24 to 30 months were selected across six free-grazing herds maintained under ranching conditions. Each day, up to five different animals that were not part of the previous day's observations were randomly selected

for the morning grazing session from 9:00 a.m. to 11:00 a.m., the peak grazing period.

For each animal, one trained observer was assigned for the entire duration of 15 minutes. Foraging activity was assessed using feeding behavior recorded based on tongue-grasp bites, typical of cattle grazing behavior, as animals used their tongues to curl and tear forage. Notably, a “bite” was defined not by head position as in small ruminants, but rather by eye-visible curling and grasping of forage with the tongue and swallowing. “Bite” was marked with species and specific plant portions consumed (leaf, stem, flower, etc). With every dis-

tinct bite, the observer collected a specimen from the specific plant to represent the actual plant material consumed. The sample's volume was estimated by a hand-circle technique, which relates to the average size of the observed bites. This approximate process ensured consistency in representing the animals' dietary choices.

After six days, all the bite samples were pooled by species across animals and days, and the twenty most frequently selected forage species were identified and sampled for laboratory analysis to determine their proximate composition.



Plate 1. Steers in group grazing



Plate 2: Forage collection and sorting

Sample preparation

Upon collection, the different forage species were tagged and given laboratory ID codes to ease tracking during analysis. Each sample was mechanically shredded into smaller sections (roughly 2-3 cm) to assist with consistent drying. The samples were then oven-dried at a temperature of 60 °C for 48 hours, which is a universally accepted time and temperature for drying out moisture without damaging essential nutrients, especially proteins. The dried samples were put through a Wiley mill after which they were sieved with a one-millimeter mesh to obtain an identical particle size adequate for proximate and mineral analysis. Uniformly stored material was placed in airtight jars that were properly labeled until further analysis.

Laboratory analysis: proximate, tannins, and minerals assay of samples

Proximate analysis of preferred browses by grazing cattle in the free-range system under ranching conditions was analyzed to determine their dry matter (DM), crude protein (CP), ether extract (EE), metabolizable energy (ME), and ash according to the standard methods of AOAC (2006). The CP was calculated as $(N \times 6.25)$. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed according to the procedure described by Van Soest *et al.* (1994). Minerals (macro and microelements) were determined using atomic absorption spectrophotometry (AAS).

Statistical analysis

Data collected on proximate, and minerals were subjected to analysis of variance (ANOVA) in a completely randomized design (CRD) using the General Linear Model procedure of the Statistical Analysis System (SAS 2002) version 9.0. Significant means were separated us-

ing Tukey's HSD (Tukey's Honestly Significant Difference Test) at 5% significance.

The model used for statistical analysis was:

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$$

where:

Y_{ij} = is the j^{th} observation of the i^{th} treatment

μ = is the population mean

τ_i = is the effect of browse inclusion level

ε_{ij} = is the random error term

Results and discussion

Results

Frequency table of sampled forage materials

The Forages and grasses for beef under the free-range grazing system are presented in Table 1. The table provides information on the scientific names, common names, plant types, parts eaten, and availability of various plant species. The availability of these plants varies depending on the rainy and dry seasons. During the rainy season, many of the plants are highly available, while during the dry season, their availability decreases. Some plants, such as *Themeda triandra* and *Trifolium semi-pilosum*, are highly available during the rains but rarely available during the dry season. On the other hand, plants like *Sesbania sesban* and *Digitaria milaniana* are available in riverine and riparian areas during the dry season. Overall, the availability of these plants is influenced by the climate and specific ecological conditions.

Bottom of Form **Table 1:** Common forages and grasses for beef under a free-range grazing system

Scientific name	Common name	Plant type	Parts eaten	Availability			Trend over the last 10-year period
				Rainy	Dry		
<i>Themeda triandra</i>	Red oat grass	Tufted perennial grass	Leaf blade, stem, tillers, inflorescence, and seeds	Highly available during the rains	Low availability of the parts is dry, stemmy as standing biomass	All parts are standing biomass, fallen and destroyed by insects, not available	Heavy grazing & encroachment by woody species & herbaceous plants have reduced the grazing capacity of this species
<i>Trifolium semipilosum</i>	Kenya white clover	Perennial herb stoloniferous	Leaves, stem, and flowers	Highly available during the rains	Rarely available	Disappear and sparsely available	Heavy use & disturbance have reduced the species in the botanical composition
<i>Sesbania sesban</i>	<i>Sesban</i>	Perennial legume	Leaves, young twigs, fruits, and flowers	Highly available during the rains	Available, in riverine & riparian areas during the dry season	Dry and rarely available, only in riverine and riparian areas	Found mostly in riverine and riparian areas
<i>Setaria sphacelata</i>	Common <i>Nandi setaria</i>	Tufted perennial grass	The leaves, stem, tillers, & inflorescence	Bushed grassland & rarely on open grassland	On bushed grassland & riverine areas	Disappears from the botanical composition	Reduced presence in the botanical composition due to heavy grazing
<i>Cynodon dactylon</i>	Common star grass	Spreading perennial, both stoloniferous & rhizomatous grass	Leaf blade, stem, tillers, inflorescence, and seeds	Highly available	Available	Dries and forms standing biomass and litter	Over the years it has increased in botanical composition
<i>Indigofera arrecta</i>	Bengal Indigo, Natal Indigo, or Java Indigo	Branched, stout, woody perennial legume herb/shrub	Twig leaves, flowers, and young fruits	Highly available	Available	Dry and loose leaves	Increased over the years with bush encroachment
<i>Desmodium intortum</i>	Green leaf desmodium	A large trailing and scrambling perennial legume	Leaves, stems, twigs, and fruits	Available and restricted to bushed grassland	Available & restricted to bushed grassland	Dries and disappears from the bushed grassland	Found only on restricted spots in bushed grassland areas
<i>Desmodium uncinatum</i>	Silver leaf desmodium	Evergreen trailing perennial legume	Leaves, stems, twigs, and fruits	Available and restricted to bushed grassland	Available & restricted to bushed grassland	Dries and disappears from the bushed grassland	Found only in restricted spots in bushed grassland areas
<i>Glycine wightii</i>	perennial soybean	Legume perennial Climber, with a woody stem base	Leaves and stems, pods, twigs	Highly available	Available	Dries and rarely available	Restricted to bushland & bushed grassland where bush encroachment occurs
<i>Aristida adoensis</i>	Mountain needle grass	A tufted perennial grass	Harsh foliage not relished by livestock	Highly available in the early rains period	Dry and harsh, affecting livestock grazing	Dries and disappears	Increases with heavy grazing & bush encroachment
<i>Brachiaria brizantha</i>	Common signal grass	Tufted perennial grass	Leaves, blade tillers, inflorescence, and seeds	Highly available with good to medium grazing	Available but dries	Dries and disappears	Reduces in the botanical composition in terms of its volume
<i>Pennisetum clandestinum</i>	Kikuyu grass	A low matted (sod grass) spreading perennial by stolons & rhizomes	Leaves, stem, tillers, inflorescence	Highly available, desirable grass of high grazing value & use	Available but dries	Dry and remains underground in form of rhizomes	Constantly found in the grassland & bush grassland. Increases with disturbance
<i>Hyparrhenia hirta</i>	Hairy hood grass	Tufted perennial, medium to tall size of medium grazing value	Leaves, stem, tillers, and inflorescence but with age become stemmy and harsh	Highly available, medium grazing value during the early rains period	Available but stemmy and tough	Dry standing stemmy biomass and litter	Reduced in terms of volume in the botanical composition due to bush encroachment

(continued on next page)

Scientific name	Common name	Plant type	Parts eaten	Availability			Trend over the last 10-year period
				Rainy	Dry		
<i>Sporobolus pyramidalis</i>	Pyramid drop seed grass	Tufted perennial of low or medium grazing value, not quite commonly palatable	Leaves, stem, tillers, and inflorescence but with age not quite commonly palatable	Highly available	Available	Dries and disappears with devastating drought	Constantly available in the grassland.
<i>Chloris gayana</i>	Rhodes grass	A tufted stoloniferous perennial with long stolons forming rapidly spreading colonies	Leaves, stem, tillers, and inflorescence	Highly available, desirable grass of high grazing value and use	available	Dries and some varieties (Rongai) are drought-resistant types	Restricted to the grassland and bush grassland but disappears with heavy grazing use and bush encroachment
<i>Digitaria scalarum</i>	African couch grass	Rhizomatous perennial, produces surface runners; it is of medium to high grazing value and used with nutritious grazing	Leaves, stem, tillers, and inflorescence	Highly available it is medium to high grazing value and used with nutritious grazing	Available but dries only found on shed and bushed grassland	Dries and disappears	Constantly found on the grassland and bushed grassland
<i>Eleusine indica</i>	Goose grass	An annual with tough leaves & strong roots; a weed of arable land, roadsides, waste places	Leaves but not palatable, unattached by cattle probably because of its tough leaves	Available	Available	Dries and disappears	Restricted to disturbed areas roadsides & waste places
<i>Eragrostis cilianensis</i>	Grey love grass	Annual grass found in grassland and bush grassland and arable land of medium grazing value	Provides useful grazing from Leaves, stems, tillers, & inflorescences	Available	Available but restricted to moist areas	Dries and disappears	Constantly available in the grassland & bush grassland
<i>Digitaria milanijana</i>	Wooly finger grass	Rhizomatous or tufted perennial medium to tall grass becoming stoloniferous, found on seasonally moist grassland and bushland	Excellent grazing value or use especially in arid and semi-arid lands from Leaves, stems, tillers, and inflorescences	Highly available	Moderately available in the dry season	Dries and disappears with devastating droughts	Always restricted in bushland grassland and sparsely on open grassland

The wet season morphological stages of the investigated forage species are in Table 2. These stages notably affected the palatability and selection preferences by cattle of the species, especially those in

early vegetative or booting stages which tend to have greater digestibility as well as crude protein.

Table 2. Morphological Characteristics of Common Forages and Grasses During the Rainy Season

Scientific Name	Morphological Stage During Observation	Vegetative Features (Rainy Season)
<i>Themeda triandra</i>	Flowering and seed-setting stage; low leaf-to-stem ratio	Tall stems, dry and fibrous; seeds maturing; reduced palatability
<i>Trifolium semi-pilosum</i>	Early flowering stage; high leaf density	Prolific leafy growth; soft stems and active nodulation
<i>Sesbania sesban</i>	Vegetative & early pod formation	Young green leaves, soft twigs, and developing flower buds
<i>Setaria sphacelata</i>	Boot to heading stage	Dense tillering, elongated leaves, emerging inflorescence
<i>Cynodon dactylon</i>	Active vegetative growth; pre-boot stage	Short dense mat, leafy runners, high shoot density
<i>Indigofera arrecta</i>	Vegetative stage	Green compound leaves, young twigs, early lateral branching
<i>Desmodium intortum</i>	Late vegetative stage	Sprawling stems, well-developed leaves, some flower buds
<i>Desmodium uncinatum</i>	Vegetative stage	High leaf biomass, soft stems, early signs of flowering
<i>Glycine wightii</i>	Vegetative and twining stage	Long vines, expanded leaves, thickened stems
<i>Aristida adscensionis</i>	Seed-setting stage	Dry seed heads; tough, unpalatable stems
<i>Brachiaria brizantha</i>	Early heading stage	Robust tillers, elongated leaves, good leaf-to-stem ratio
<i>Pennisetum clandestinum</i>	Actively tillering; vegetative stage	Dense ground cover, soft lush leaves, rhizome spread
<i>Hyparrhenia hirta</i>	Advanced flowering& senescence	Stemmy with rough texture; dry leaf tips; reduced palatability
<i>Sporobolus pyramidalis</i>	Mid-flowering stage	Narrow leaves; erect stems with emerging seed heads
<i>Chloris gayana</i>	Early flowering stage	Long leaves, green stems, good biomass, and emerging inflorescences
<i>Digitaria scalarum</i>	Active vegetative growth	Dense green mats; leafy runners; highly palatable
<i>Eleusine indica</i>	Vegetative and tillering stage	Broad leaves; low rosette growth form; high tiller density
<i>Eragrostis cilianensis</i>	Vegetative stage	Compact twigs; lush, thick foliage; developing tillers
<i>Digitaria milanjiana</i>	Booting to flowering stage	Soft leaves; tall shoots; developing seed heads

Alongside the availability and parts used, the morphological composition of the forages (Table 2) was also studied and recorded for the rainy season. Most of the grasses were between the vegetative and early reproductive stages, for example, *Chloris gayana*, *Digitaria abyssinica*, and *Pennisetum clandestinum*. These exhibited high leaf-to-stem ratios and significant amounts of green biomass. The legumes, for instance, *Trifolium semi-pilosum* and *Sesbania sesban*, were also actively growing, displaying extensive branching, significant leaf expansion, and developing flower buds. These morphological traits are key factors describing the forage's palatability and nutrient concentration, especially in protein and energy. Cattle preference was noted to be strongly associated with forages dominated by leaves, which were largely at the pre-flowering stage. These are more likely to provide better digestibility and crude protein compared to older, senescent plants.

Rhodes Grass (*Chloris gayana*) is a perennial tropical grass that thrives well in a variety of soil types. It has high productivity, good palatability, and is highly nutritious (Table 1). *Brachiaria* grasses are commonly used in free-range grazing systems due to their adaptability to different soil types and climates. They are known for their high productivity, drought tolerance, and good nutritional value. Kikuyu

grass (*Pennisetum clandestinum*) is a vigorous, perennial, and drought-resistant grass that is well-suited for free-range grazing. It establishes quickly and provides good ground cover.

Cenchrus ciliaris is a highly productive and drought-tolerant perennial grass. It has good forage quality and can withstand heavy grazing pressure. Star Grass (*Cynodon nlemfuensis*) is a warm-season perennial grass that is well-adapted to free-range grazing systems. It has good palatability, and regrowth ability, and can tolerate a range of soil conditions. *Panicum* grass is widely distributed and includes several species like Guinea grass (*Panicum maximum*). They are highly productive, palatable, and can be utilized for forage, especially for beef cattle in free-range grazing systems.

Chemical composition

The chemical composition of the browses and grasses is presented in Table 3.

The table provides information on the dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), fat, and metabolizable energy (ME) content of various plant species. These values are important indicators of the nutritional composition and quality of the forages.

Table 3. Proximate composition of most preferred forages

Scientific names	Common names	DM	CP	NDF	ADF	ADL	Fat	ME MJ. Kg ⁻¹ DM
<i>Themeda triandra</i>	Red oat grass	47.1 ^a	5.7 ⁿ	69.1 ^g	39.4 ^g	5.3 ^h	2.1 ^g	8.4 ^{ih}
<i>Trifolium semi-pilosum</i>	Kenya white clover	16.8 ^o	24.9 ^c	27.5 ^o	22.1 ^p	3.9 ^k	2.7 ^c	11.1 ^b
<i>Sesbania sesban</i>	<i>Sesban</i>	26.0 ⁱ	24.4 ^d	27.4 ^o	18.8 ^q	5.8 ^f	3.4 ^a	11.5 ^a
<i>Setaria sphacelata</i>	Common <i>Nandi setaria</i>	23.1 ^m	7.7 ^m	72.9 ^c	44.1 ^b	6.3 ^d	2.1 ^g	9.8 ^d

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Scientific names	Common names	DM	CP	NDF	ADF	ADL	Fat	ME MJ. Kg ⁻¹ DM
<i>Cynodon dactylon</i>	Common star grass	31.3 ^f	9.8 ^j	66.7 ^h	36.7 ^k	4.7 ^j	1.9 ^h	8.1 ^{ih}
<i>Indigofera arrecta</i>	Bengal indigo	35.0 ^d	24.7 ^c	24.8 ^p	31.7 ^o	6.0 ^e	2.2 ^{fg}	10.1 ^c
<i>Desmodium intortum</i>	Greenleaf desmodium	24.2 ^l	15.5 ^f	51.4 ^m	37.1 ⁱ	9.1 ^a	0.7 ^k	8.4 ^{ih}
<i>Desmodium uncinatum</i>	Silver leaf desmodium	25.7 ^j	15.1 ^g	52.2 ^l	40.0 ^f	4.8 ^j	2.4 ^d	7.4 ^k
<i>Glycine wightii</i>	Perennial soybean	33.3 ^e	17.1 ^e	50.7 ⁿ	37.4 ⁱ	7.9 ^c	2.4 ^d	9.1 ^e
<i>Aristida adscensionis</i>	Mountain needle grass	33.4 ^e	10.4 ⁱ	71.2 ^d	41.9 ^c	5.8 ^f	1.9 ^h	8.6 ^g
<i>Brachiaria brizantha</i>	Bread grass	29.6 ^g	10.4 ⁱ	66.8 ^h	39.4 ^g	5.6 ^g	2.1 ^g	8.1 ^{ih}
<i>Pennisetum clandestinum</i>	Kikuyu grass	20.1 ⁿ	15.1 ^g	65.3 ⁱ	35.1 ^l	4.3	2.7 ^c	9.7 ^d
<i>Hyparrhenia hirta</i>	Hairy hood grass	43 ^b	4.2 ^o	79.7 ^a	54.3 ^a	8.2 ^b	1.5 ⁱ	6.3 ^l
<i>Sporobolus pyramidalis</i>	Pyramid dropseed grass	41.4 ^c	7.6 ^m	68.5 ^g	38.5 ^h	5.1 ⁱ	1.3 ^j	8.9 ^f
<i>Chloris gayana</i>	Rhodes grass	24.9 ^j	9.1 ^k	75.1 ^b	43.0 ^c	6.2 ^e	2.2 ^{ef}	8.5 ^{gh}
<i>Digitalia scalarum</i>	African couch grass	15.6 ^p	28.3 ^b	63.9 ^k	33.5 ⁿ	3.8 ^k	3.1 ^b	10.0 ^c
<i>Eleusine indica</i>	Goose grass	27.3 ^h	10.9 ^h	64.4 ^j	34.1 ^m	4.1 ^l	2.8 ^c	9.1 ^e
<i>Eragrostis cilianensis</i>	Grey love grass	15.3 ^p	29.0 ^a	64.5 ^j	34.2 ^m	4.1 ^l	2.4 ^d	9.7 ^d
<i>Digitaria milanijana</i>	Woolly finger grass	31.3 ^f	8.1 ^l	69.7 ^e	40.3 ^c	5.4 ^h	2.3 ^d	8.6 ^g
SEM		0.1322	0.0518	0.0577	0.0382	0.0366	0.0367	0.0359
P		< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001

CP=crude protein, ME=Metabolisable energy, EE=Ether extract, DM=dry matter, ADF=Acid detergent fibre, NDF=Neutral detergent fiber, ADF= Acid detergent fiber.

Grey love grass (*Eragrostis cilianensis*) and African couch grass (*Digitalia scalarum*) had the highest crude protein content (28%) followed by *Pennisetum clandestinum* (15.8%), while Hairy hood grass (*Hyparrhenia hirta*) had the highest fiber fractions (NDF; 79.7%) (Table 3). The fat content ranged from 0.7% in *Desmodium intortum*

to 3.4% in *Sesbania sesban*. *Hyparrhenia hirta* had the lowest ME (6.3 MJ kg⁻¹ DM) content. Forages with higher fat content may have a higher energy density. The Mineral analysis of the most preferred forages is presented in Table 4.

Table 4. Mineral analysis of most preferred forages

Scientific names	Common name	Ca g/kg	P g/kg	Mg g/kg	Co mg/kg	Fe mg/kg	Zn mg/kg
<i>Themeda triandra</i>	Red oat grass	2.9 ⁿ	0.9 ^p	1.7 ^m	5.7 ^r	201.5 ^l	21.1 ^s
<i>Trifolium semi-pilosum</i>	Kenya white clover	10.1 ^d	3.3 ^e	3.1 ^f	12.1 ⁱ	121.3 ^r	28.1 ^p
<i>Sesbania sesban</i>	<i>Sesban</i>	15.9 ^a	3.3 ^e	3.5 ^c	18.4 ^a	288.3 ^g	41.1 ^h
<i>Setaria sphacelata</i>	Common Nandi setaria	3.2 ⁿ	2.4 ^j	2.0 ^k	7.1 ^o	232.6 ^j	30.3 ^m
<i>Cynodon dactylon</i>	Common star grass	4.4 ^j	2.2 ^l	1.8 ^l	8.2 ^m	133.3 ^p	44.3 ^g
<i>Indigofera arrecta</i>	Bengal indigo	15.4 ^b	2.8 ^g	10.1 ^a	11.0 ^j	306.9 ^e	36.4 ^k
<i>Desmodium intortum</i>	Greenleaf desmodium	10.2 ^d	3.1 ^f	3.2 ^d	14.3 ^e	301.3 ^f	37.1 ⁱ
<i>Desmodium uncinatum</i>	Silver leaf desmodium	8.5 ^e	2.2 ^l	2.5 ⁱ	10.1 ^k	126.3 ^q	23.8 ^r
<i>Glycine wightii</i>	Perennial soybean	14.8 ^c	2.5 ^j	3.1 ^d	12.3 ^h	143.7 ^m	33.2 ^l
<i>Aristida adscensionis</i>	Mountain needle grass	3.4 ^m	0.4 ^o	1.1 ^m	16.1 ^c	225.5 ^k	26.4 ^q
<i>Brachiaria brizantha</i>	Bread grass	4.6 ⁱ	2.2 ^l	3.1 ^d	13.1 ^g	401.3 ^a	36.6 ^j
<i>Pennisetum clandestinum</i>	Kikuyu grass	3.1 ⁿ	3.7 ^b	2.9 ^g	9.2 ^l	309.3 ^d	45.1 ^f
<i>Hyparrhenia hirta</i>	Hairy hood grass	6.5 ^f	3.4 ^d	2.1 ^j	16.3 ^b	348.1 ^c	51.2 ^d
<i>Sporobolus pyramidalis</i>	Pyramid dropseed grass	8.5 ^e	1.9 ^m	1.3 ⁿ	7.0 ^o	138.2 ⁿ	29.3 ⁿ
<i>Chloris gayana</i>	Rhodes grass	3.8 ^l	2.9 ^g	1.9 ^l	6.4 ^p	237.3 ⁱ	28.3 ^o
<i>Digitalia scalarum</i>	African couch grass	4.0 ^k	3.6 ^c	3.9 ^b	15.2 ^d	243.4 ^h	67.2 ^b
<i>Eleusine indica</i>	Goose grass	5.3 ^h	2.6 ⁱ	3.2 ^e	7.4 ⁿ	391.1 ^b	60.3 ^c
<i>Eragrostis cilianensis</i>	Grey love grass	2.3 ^o	1.2 ⁿ	0.9 ^o	6.1 ^q	126.8 ^q	77.5 ^a
<i>Digitaria milanijana</i>	Woolly finger grass	6.3 ^g	5.3 ^a	2.7 ^h	13.6 ^f	133.1 ^o	49.2 ^e
SEM		0.0333	0.0333	0.0323	0.0333	0.0333	0.0351

(continued on next page)

Scientific names	Common name	Ca g/kg	P g/kg	Mg g/kg	Co mg/kg	Fe mg/kg	Zn mg/kg
<i>P</i>		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

The preferred forages had varying levels of essential minerals, including calcium (Ca), phosphorus (P), magnesium (Mg), cobalt (Co), iron (Fe), and zinc (Zn). *Sesbania sesban* had the highest levels of Ca, Mg, Co, Fe, and Zn among the listed species (Table 4). On the other hand, *Eragrostis cilianensis* had the lowest levels of Ca, P, Mg, Co, and Fe. Mineral analysis is the measurement of mineral levels in forages and feeds and can help to determine whether supplementation is required and at what level. Therefore, understanding the mineral content of forages is important for proper feeding and optimal animal production. *Sesbania sesban* and *Indigofera arrecta* were high in calcium and phosphorus compared to other preferred forages found in the ranch.

Discussion

The palatability and nutritional value of forage species are primarily driven by their morphological features observed during the rainy season (Table 2). During this period, most grasses and legumes were in the vegetative to early reproductive stages, a phase known to typically have high digestibility, crude protein, and energy levels. For instance, cattle prefer grazing on swards of *Digitaria scalarum*, *Cynodon dactylon*, and *Desmodium intortum* as they are highly leafy and show vigorous growth during this period. Mganga *et al.* (2021) [9] also observed that forages in the vegetative stage have greater nutrient concentration and ruminants' intake tends to be exacerbated because of softer tissues and low fiber fractions.

In contrast, *Themeda triandra* and *Hyparrhenia hirta* which are more advanced in the flowering or seed-setting stages showed signs of senescence such as a more fibrous stem and a lower leaf area ratio. These changes are likely to happen to reduce their palatability as well as cut down their nutritional value. These changes in vegetative morphology are known to reduce voluntary intake and digestibility among ruminants (Mganga *et al.*, 2021) [9]. The morphological maturity of grasses not only influences their chemical composition but also the grazing dynamics of cattle. Mature plants are more difficult to harvest because of higher levels of lignin and fiber, resulting in poorer nutrient availability.

Analysis of forage preferences and pastoral management for cattle can be informed by interpreting cattle beef species as their morphological development occurs, presenting the context for cattle grazing strategies aimed at maximizing forage quality and availability during the grazing season.

In Kenya, grasslands are mainly found in the arid and semi-arid regions, where they support pastoral livestock production systems. Grasslands in Kenya are threatened by land degradation, overgrazing, invasive species, climate change, and human population growth. Some of the common grass species in Kenya's rangelands are *Cenchrus ciliaris*, *Chloris roxburghiana*, *Enteropogon macrostachyus*, *Eragrostis superba*, *Pennisetum mezianum* and *Themeda triandra*. Some of the common legume species in Kenya are *Desmodium intortum*, *Desmodium uncinatum*, *Macroptilium atropurpureum*, *Stylosanthes guianensis* and *Trifolium semipilosum*. For beef cattle raised in free-range grazing systems to receive enough nutrition, high-quality forages and grasses must be readily available. The sustainability of the grazing system as well as the animal's health and productivity are directly impacted by the choice of forage species, making it an essential decision. Numerous investigations have been carried out to assess the effectiveness of diverse fodder species in the context of free-range grazing.

Panicum maximum also referred to as Guinea grass, is one of the fodder grasses that is most frequently utilized in free-range grazing systems. Herrero *et al.* (2021) [10] examined the performance and nutritional value of beef cattle feeding on Guinea grass. They discovered that the grass supported the cattle's notable weight gains by offering high levels of crude protein and minerals.

The high productivity, palatability, and nutritional value of Rhodes grass (*Chloris gayana*) are well-known, and they are crucial to the success of beef cattle grazing on the grass in semi-arid areas (Mapiye *et al.*, 2019) [11]. The results showed that the Rhodes grass supported adequate weight gains and body condition scores in the cattle, even during dry periods.

Due to their resilience to many soil types and climates, *Brachiaria* species, including *Brachiaria brizantha* and *Brachiaria decumbens*, are commonly utilized in free-range grazing systems. A study by Dias-Filho (2022) [12] evaluated the persistence and productivity of different *Brachiaria* cultivars in grazing environments. The findings highlighted the potential of *Brachiaria* species to provide high-quality forage for beef cattle while maintaining long-term productivity.

Legumes, in addition to grasses, are essential to free-range grazing systems because they increase soil fertility and produce high-quality feed. The potential of the perennial legume *Desmodium intortum* in mixed grass-legume pastures has been investigated. The effectiveness of beef cattle grazing on *Desmodium intortum* combined with *Panicum maximum* was assessed by Muir *et al.* (2022) [13]. Comparing mixed-forage pastures to grass-only pastures, they discovered that the mixed-forage system supported greater weight growth and better animal performance.

Grazing management practices, soil composition, and local climate should all be considered when choosing an appropriate forage species (Milazzo *et al.*, 2023) [14]. Incorporating several forage species can yield mutually beneficial outcomes, such as increased biodiversity, improved nutrient cycling, and enhanced resilience to environmental stresses (Mashece *et al.*, 2024) [15].

Several factors can affect the availability of forages and grasses. Environmental conditions, such as drying or wilting, can also impact availability and alter the composition of forages (Glasser *et al.*, 2013) [16]. Bushfires can cause the disappearance of some quality species. Nutrient availability, particularly nitrogen, plays a crucial role in the production and quality of forage grasses (Costa *et al.*, 2013). Biotic factors, including regeneration, shrub density, and herb density, can influence the availability of grasses for grazing (Ashokkumar *et al.*, 2021) [17]. In general, a combination of biotic and abiotic factors affects the availability of forages and grasses in various ecosystems, which might have an impact on the free-range grazing system in ranching situations.

Significant variations in the nutritional profiles of the most popular fodder species were found by proximate composition analysis. There were variations in moisture levels and possible consequences for the storage and preservation of fodder, as evidenced by the dry matter (DM) content, which varied from 15.3% in *Eragrostis cilianensis* to 47.1% in *Themeda triandra* (Muktiani *et al.*, 2020) [18].

Crude protein (CP) concentrations varied significantly, from 4.2% in *Hyparrhenia hirta* to 29.0% in *Eragrostis cilianensis*, highlighting the various protein sources available among the forages. Leguminous species, such as *Trifolium semi-pilosum* (Kenya white clover), *Sesbania sesban*, and *Indigofera arrecta* (Bengal indigo), exhibited relatively higher CP content, consistent with earlier findings on their potential as protein-rich supplements (Zahran *et al.*, 2021) [19].

Acid detergent fiber (ADF) and, neutral detergent fiber (NDF) fiber fractions showed a wide range, with *Hyparrhenia hirta* having the highest NDF (79.7%) and ADF (54.3%) values, while *Indigofera arrecta* had the lowest NDF (24.8%) and *Trifolium semi-pilosum* the lowest ADF (22.1%). These fiber levels can significantly affect intake and forage digestibility by ruminants (Baloyi *et al.*, 2018) [20]. According to Van Die, (2020) [21], forages supplying Crude protein (CP) > 12%, Total digestible nutrients (TDN) > 60%, and Neutral detergent fiber (NDF) < 50% are considered of very good quality for grass-fed cattle for beef production. *Hyparrhenia hirta* had the highest NDF and ADF values, indicating lower digestibility. On the contrary, legumes like *Sesbania sesban*, *Trifolium semi-pilosum*, and

Indigofera arrecta exhibited lower NDF and ADF levels, suggesting better digestibility. The metabolizable energy (ME) values ranged from 6.3 MJ/kg DM in *Hyparrhenia hirta* to 11.5 MJ/kg DM in *Sesbania sesban*, reflecting the potential energy density of these forages for livestock production systems (Bwalya *et al.*, 2022) [22]. An estimation of the energy available from the forages is given by the ME values (Benoit *et al.*, 2024) [23].

Legume plant species with higher CP content, such as *Trifolium semipilosum* and *Sesbania sesban* may be more suitable for inclusion in livestock diets to meet their protein requirements. On the other hand, plant species with higher fiber content, like *Themeda triandra*, may be less digestible and may require additional supplementation to meet the animal requirements.

The mineral compositions of the most popular fodder species varied significantly, as shown by mineral analysis, and these differences can have a major impact on the productivity and nutrition of cattle. These variations in nutrient content can have implications for livestock feed and forage selection. Minerals are essential nutrients required by livestock for various physiological functions, including growth, reproduction, and immunity (Palomares, 2022) [24]. These variations in nutrient content can have implications for livestock nutrition and forage selection. For instance, plant species with higher nutrient content, such as *Sesbania sesban*, may be more suitable for inclusion in livestock diets to meet their nutritional requirements. On the other hand, plant species with lower nutrient content, like *Eragrostis cilianensis*, may need to be supplemented with other feed sources to ensure adequate nutrient intake and improve animal performance.

Calcium (Ca) levels ranged from 2.3 g/kg in *Eragrostis cilianensis* to 15.9 g/kg in *Sesbania sesban*, demonstrating the potential of these forages to meet the calcium requirements of livestock, mainly during significant physiological stages (Muktiani *et al.*, 2020) [18]. Higher calcium levels were found in legume species such as *Sesbania sesban*, *Indigofera arrecta*, and *Glycine wightii*, which is in line with their function as calcium-rich supplements (Zahran *et al.*, 2021) [19]. The level of phosphorus (P) in the forages under study ranged from 0.4 g/kg in *Aristida adscensionis* to 5.3 g/kg in *Digitaria milanjiana*, indicating the variety of sources of this vital element. Sufficient quantities of phosphorus are essential for effective rumen functioning and general animal health (Baloyi *et al.*, 2018) [20]. Variations in the amounts of other important minerals, including magnesium, cobalt, iron, and zinc, were also found by the analysis. For example, the highest Mg content was shown by *Indigofera arrecta* (10.1 g/kg), while the highest Co level was found in *Sesbania sesban* (18.4 mg/kg). *Eragrostis cilianensis* exhibited the greatest Zn content (77.5 mg/kg), while *Brachiaria brizantha* and *Eleusine indica* displayed increased Fe concentrations (Bwalya *et al.*, 2022) [22]. These findings highlight the critical importance of understanding the mineral composition of forages and demonstrate how livestock production systems can effectively manage mineral shortages by supplementing and selecting forages carefully.

Conclusion and recommendations

The study provides a detailed profile of the morphological availability and nutrient composition of major forage species during the rainy season, which is vital for forage and pasture management under ranching conditions in Kenya. The study evaluated the preferred forages for beef cattle and their proximate composition under ranching conditions in Kenya. For beef grazing systems on the free range, a large range of forage grasses and legumes are suitable. The ideal choice of preferred forages is determined by variables such as the climate in the area, the state of the soil, and grazing management practices. The results indicate that Kikuyu grass, African couch grass, and grey love grass could be suitable forages for beef cattle production due to their high crude protein content. However, it is important to use a balanced forage mixture to ensure optimal growth and health of the cattle. The findings of this study can inform farmers and policymakers on the selection of suitable forages for beef cattle production under ranching con-

ditions in Kenya. It is recommended that livestock owners under ranching conditions should consider incorporating legume plant species with higher nutrient content, such as *Sesbania sesban* and Kenya white clover, into their forage and feed management practices. The productivity, nitrogen cycling, biodiversity, and resilience of the grazing system can all be improved by integrating a variety of complementary forage species.

Further research should be conducted to explore the potential benefits and limitations of using specific plant species with high nutrient content in livestock diets. Livestock owners under ranching conditions should regularly test the nutrient content of their forage and feed sources to ensure that they meet the nutritional requirements of their animals. Evaluation is to be done every ten (10) years to determine the forage availability as it can be affected by many factors such as overgrazing and burning.

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Contribution by authors

All the authors contributed equally to writing the manuscript. The final manuscript was read by all authors and consented to publication.

Conflict of interests

There is no conflict of interest.

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Authors

I Tura

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O Box 3840 -20100, Nakuru, Rift Valley, Kenya.

M Githui

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O Box 3840 -20100, Nakuru, Rift Valley, Kenya.

F Kemboi

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O Box 3840 -20100, Nakuru, Rift Valley, Kenya.

R Kenana

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O Box 3840 -20100, Nakuru, Rift Valley, Kenya.

NKW Olekaikai

Egerton University, Box 536-20115, Egerton, Njoro, Rift Valley, Kenya,

C Ndung'u

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O Box 3840 -20100, Nakuru, Rift Valley, Kenya.

J Kiprop

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O Box 3840 -20100, Nakuru, Rift Valley, Kenya.

P Tarus

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O Box 3840 -20100, Nakuru, Rift Valley, Kenya.

P Kamau

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O Box 3840 -20100, Nakuru, Rift Valley, Kenya.

E Owiro

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O Box 3840 -20100, Nakuru, Rift Valley, Kenya.