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Nutritional Quality of Dominant Herbaceous Forages: A Comparative Study of Burnt and Unburnt Areas of Kikulula Ranch, Tanzania

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ABSTRACT

Herbaceous plants are the primary forage of livestock on rangelands and, hence, are important for the sustainability of ranches. Herbaceous plants are susceptible to fires that may affect forage quality either positively or negatively. This study aimed to evaluate the forage quality of the dominant herbaceous plants in burnt and unburnt areas of Kikulula Ranch (located between 1.5° and 1.8° S and 31.2° and 31.5° E), focusing on crude protein (CP), acid detergent fibre (ADF) and neutral detergent fibre (NDF). Importance value index of common herbaceous plants and nutrient quality of the three most abundant forage species were computed by standard methods. *Themeda triandra*, *Loudetia kagerensis* and *Desmodium uncinatum* were the most common fodder species. CP levels in *Themeda triandra* and *Desmodium uncinatum* were significantly higher ($p < 0.05$) in burnt areas than in unburnt areas, indicating that burning promotes protein synthesis and growth. Alternatively, in *Themeda triandra*, NDF levels were higher in unburnt areas ($p < 0.05$), indicating reduced forage consumption and digestibility for livestock. On the other hand, ADF levels did not differ significantly between burnt and unburnt areas ($p > 0.05$). In *Desmodium uncinatum*, NDF and ADF contents were not different between the burnt and unburnt areas ($p > 0.05$). Furthermore, in *Loudetia kagerensis,* the levels of CP, NDF and ADF did not differ between burnt and unburnt parts ($p > 0.05$). Hence, the study recommends *Themeda triandra* and *Desmodium uncinatum* as quality forages with high crude protein, particularly in rangelands susceptible to frequent fires.

Keywords: Acid detergent fibre, crude protein, fires, herbaceous plants, neutral detergent fibre

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INTRODUCTION

In Tanzania, the livestock sector contributes to the country's agricultural gross domestic product (GDP) by 7.4% (World Bank, 2024). The real undisclosed cattle operation depends on good ranch management. Animal feeding is an important component of ranch management, which is principally constituted by herbaceous plants (grasses, herbs and forbs). Cattle fodder value is associated with parameters such as nutritional content, biomass output, palatability, growth habit (annual or perennial) and tolerance to grazing pressure (Foran et al. 1978). However, fodder plants' quantity and quality are affected by environmental and management factors such as fire, soil degradation, antinutritional components, mycotoxins and technological constraints (Akintan, 2025; Baris, 2023; Ndah et al., 2017; Thornton et al., 2014; Thapa et al., 2022). Fire has received much attention for its effects on feed availability among these factors. It has been associated with the reduction of quantity and quality of animal feed, affects nutrient cycling and interferes with ecosystem functioning (Reid et al., 2023; Thapa et al., 2022). However, other studies suggest that fire leads to increased nutrient storage and production of higher quality feed (Debyle, 1989; Ranglack et al., 2015; Vera-Velez et al., 2023). Additionally, controlled burning is often used in the management of rangelands and ranches to promote new pastures, eliminate unwanted plants, and manage pests and diseases (Eloy et al., 2019; Israr et al., 2024; Pandit et al., 2021). Little is known of the effect of fire on the nutritional value of the food, and results are variable; therefore, further work is required.

Many plants are adapted to fire and tend to resprout from the base after even severe burns. Pyrophytes or fire-tolerant plants survive with subterranean storage organs or regenerate quickly after fire or possess seeds that require heat or smoke for germination (Gold et al., 2023; Hoffmann et al., 2003; Stephan et al., 2010). Normally, species such as *Panicum maximum*, *Hyparrhenia hirta* and *Chrysopogon plumulosus* are fire-sensitive (Jacobs & Schloeder, 2002; Nepolo & Mapaure, 2012; Ryan & Williams, 2011). Other species like *Themeda triandra*, *Monechma divaricatum*, *Pupalia lappacea* and *Melhania damarana* are fire-adapted and tend to thrive in abundance after fire (Jacobs & Schloeder, 2002; Nepolo & Mapaure, 2012).

Fire stimulates biological processes and growth of plants and thus may variably affect the nutrient levels in plant tissues such as crude protein (CP), neutral detergent fibre (NDF) and acid detergent fibre (ADF) (Thapa et al., 2022). CP, ADF and NDF reflect forage nitrogen content, digestibility and the amount consumed by grazing animals, respectively. In Nepal, the burning of plant tissues in grasses and post-fire regrowth resulted in increased CP. However, NDF and ADF increased in mature grasses, which in turn decreased digestibility (Thapa et al., 2022). But other studies have been inconsistent on nutritional susceptibility to fires. For example, frequent fire was associated with high abundance of herbaceous, low-crude-protein species in North America (Harrison et al., 2021). Additionally, Snobl et al. (2022) reported that large wildfires increased the amount and quality of feed in the elk habitat in the United States. Species from routinely burnt locations had crude protein levels up to 45.7% (Harrison et al., 2021). However, in Zambia, Namukonde et al. (2023) reported no significant differences in crude protein, neutral detergent fibre and acid detergent fibre between burnt and unburnt grass species. The variable outcome here reflects the unpredictability and situation-dependent effect of fire on the nutritional value of feed. Fire effects can vary with plant type and environment. The effect of fire on the quality of feed under different climatic conditions needs to be studied.

The Kikulula Ranch in the Kagera Region has reported fires and soil degradation (Nzunda et al., 2013). However, limited investigative studies have been conducted to ascertain the quality of herbaceous plants in the degraded region. This study is therefore on the right track in light of burning occurring in areas of the ranch.

The study was undertaken to: (i) identify the dominant species of herbaceous fodder and (ii) determine the nutritional quality of the dominant species of the burnt and unburnt areas of the ranch. The results will add to the existing knowledge on the effects of fire on the nutritional value of fodder and provide useful information for the development of proper ranch management techniques for the sustainability of animal production.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Kikulula Ranch, Karagwe District in Kagera region in north-western Tanzania. It is one of six ranches established in this area for raising livestock. Kikulula spans an area of 12,700 ha and is situated between 1.5° and 1.8° S latitude and 31.2° and 31.5° E longitude (Figure 1). Kikulula is a bimodal rainfall sub-humid grassland with an annual average rainfall of between 750 and 1,250 millimetres (Tanzania Meteorological Agency [TMA], 2023). Rain falls from October to January, and from March to June. Average annual temperature is about 21 ºC, and temperature varies from 15 ºC to 28 ºC (The United Republic of Tanzania, 2019).

The soil is mainly sandstone in the steep hills and clay loam in the flat areas (Merumba et al., 2020). The Kikulula grazing land comprises a great variety of vegetation types: trees, bushes, shrubs, herbs and grasses. The Kikulula Ranch was selected because it has been less scientifically studied than the other ranches in the country. Furthermore, the nutritional value of forage plants in fire-prone environments is complex and unpredictable and not suitable for comparison. Kikulula Ranch has two fire seasons, a long season from June to September and a short season from January to February (unpublished data 2023). Grasslands burn every year either from controlled fires or wildfires, but bushlands and isolated hills rarely burn.

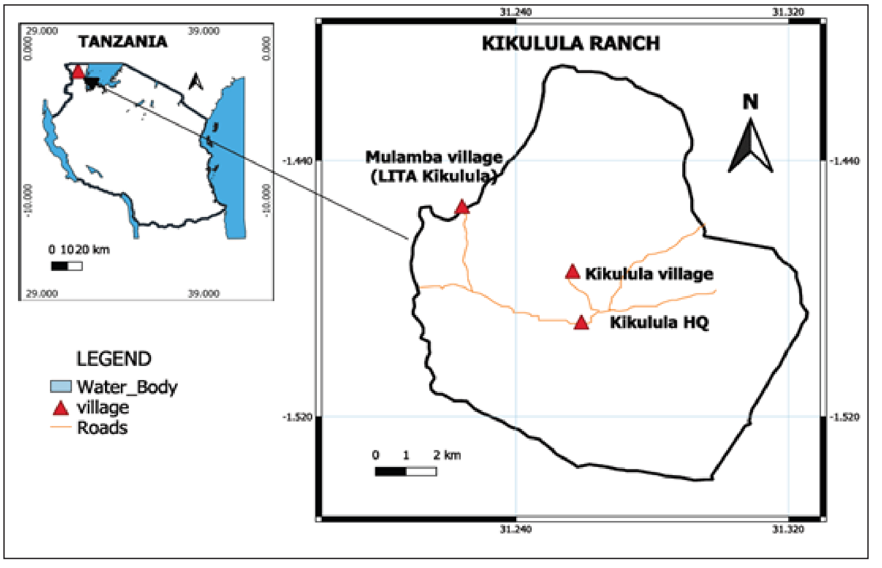

Figure 1. Map Showing Location of Kikulula Ranch in Kagera Region, Tanzania
Source: Field Data using QGIS software Prizren version 3.34 (QGIS Project, 2023)

Study Design

The design used in the study was a two-group simple randomised design under a completely randomised design (Kothari, 2004). The areas were chosen deliberately and were categorised into burnt and unburnt areas. Dominance of the herbaceous species was determined by laying down seven transect lines of 300 metres each and 50 metres apart in each site of hills, plains and bush lowland, giving a total of 21 transects. The quadrat and counting procedures were utilised where a 1 m^2 Daubenmire cover frame was randomly thrown every 10 metres along each transect line according to Caratti (2006). In each quadrat, herbaceous plants were identified carefully to the species level with emphasis on important morphological characters. The herbaceous species were listed in a notebook, with their frequencies of recurrence. Correspondingly, the percentage cover of each item was approximated to calculate the percentage dominance of the plants.

Data Collection

Herbaceous plants were recorded for abundance at species level. The data were collected during the rainy season before the blooming of the herbaceous plants when the nutrient levels are generally high (Kilcher, 1981; Sangu & Nahonyo, 2021). Proximate analysis of the three most abundant forage plant species was done by collecting thirty samples per species, fifteen in the burnt area and the other fifteen in the unburnt area, to give a total of ninety samples for the three species. We targeted the upper leaves most likely to be consumed by animals. Fresh top leaves and grass stems were randomly collected from the herbaceous plants along a 300-metre transect line according to the methodology recommended by Geisseler et al. (2017). About 250 g was collected for each of fresh top leaves and grass stems.

Data Processing and Analysis

Importance Value Index of Herbaceous Plant Species in Kikulula Ranch+

The importance value index (IVI) for herbaceous species was calculated as per Phillips (1959) as given in Equation 1:

$$\text{IVI} = \text{Relative Density} + \text{Relative Frequency} + \text{Relative Dominance} \qquad [1]$$

Crude Protein, Neutral Detergent Fibre and Acid Detergent Fibre in Herbaceous Forage Species in Burnt and Unburnt Areas

The collected samples of leaves and stems of dominant herbaceous forages were packed in paper bags and sent to the Sokoine University of Agriculture laboratory for analysis. The forage samples were air-dried for 24 hours to reduce moisture and prevent loss of nutrients, then oven-dried and chemically analysed in duplicate.

Crude Protein Content

The forage was analysed for CP content by the micro Kjeldahl method. This involved digestion of 1 g ground forage sub-sample in sulfuric acid (H_2SO_4). The samples were oven-dried at 55 °C for 8 hours and analysed for CP according to the 21st edition of the international protocols formulated by the Association of Official Analytical Chemists (Latimer, 2023). Nitrogen was determined in duplicate by distillation and titration of ammonia (NH_3) with a standard solution in the distillation unit model K-300 (Silva et al., 2016). Crude protein was then calculated from the nitrogen level obtained from the ammonia according to Equations 2 and 3.

$$\text{Kjeldahl nitrogen (\%)} = \frac{(V_A - V_B) \times M \times 14.01}{W \times 10} \qquad [2]$$

where:
V_A = Volume (mL) of standardised acid (for sample)
V_B = Volume of standardised acid (for blank reagent)
M = Molarity of standard hydrochloric acid (HCl)
14.01 = Atomic weight of nitrogen
W = Weight of test portion
10 = Factor for conversion mg/g to percentage

$$CP = \text{Total nitrogen } (\%) \times 6.25 \quad [3]$$

Where:
6.25 is a factor for usable protein

Neutral Detergent Fibre

The NDF was analysed by the Automated Fibre Analysis with the Ankom 200 Fibre Analyser according to the method of Van Soest et al. (1991). Dried and ground samples of forage (1 g) were placed in a crucible at room temperature, and 100 mL of neutral detergent solution, 0.5 g of sodium sulfate (Na_2SO_4) and a few drops of octanol ($C_8H_{18}O$) were added. The mixture was then heated to the boil and allowed to reflux for 60 minutes. Then the mixture was filtered and washed three times with water and acetone. Samples were dried at 105 °C for 8 hours, cooled in desiccators and weighed. Results were calculated with Equation 4. Samples were dried in an oven at 55 °C for 8 hours and thereafter analysed for neutral detergent fibre (Latimer, 2023).

$$NDF\ (\%) = \frac{W_2 - W_1}{W_3} \times 100 \quad [4]$$

Where:
W_1 = Weight of the empty crucible (g)
W_2 = Weight of crucible + dried NDF residues (g)
W_3 = Weight of oven-dry weight of the sample (g)

Acid Detergent Fibre

The acid detergent fibre content was measured by Ankom 200 Fibre Analyser. Duplicate sub-samples (1 g air-dried ground forage) were added to a beaker containing 100 mL of an acid-detergent solution with a few drops of $C_8H_{18}O$ (Troyer et al., 2020). The mixtures were boiled and refluxed for 60 minutes, filtered and washed with boiling water and acetone. Then the samples were dried at 105 °C for 8 hours and cooled. The weight of the dried sample was calculated from Equation 5.

$$ADF\ (\%) = \frac{W_3 - W_1}{W_2} \times 100 \quad [5]$$

where:
W_1 = Weight of the empty crucible (g)
W_2 = Initial dry weight of the test sample (g)
W_3 = Final dry weight of the crucible with the fibre residue after the acid detergent extraction process (digestion and drying) (g)

Burnt and Unburnt Parts of Kikulula Ranch

The status of fire in Kikulula Ranch was derived from prescribed fires and wildfires and from physical characteristics of the landscape. Fire hotspots were extracted from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor with a spatial resolution of 1 kilometre (Giglio et al., 2018).

Statistical Analysis

Statistical analysis was performed by descriptive analysis and equality of means using R version 4.4.2.

RESULTS AND DISCUSSION

Burnt and Unburnt Parts of Kikulula Ranch

Figure 2 shows fire hotspots, which occurred in large plains and hills with no lowland barriers to impede fire spread. These regions are hilly, and the lowlands or depressions between

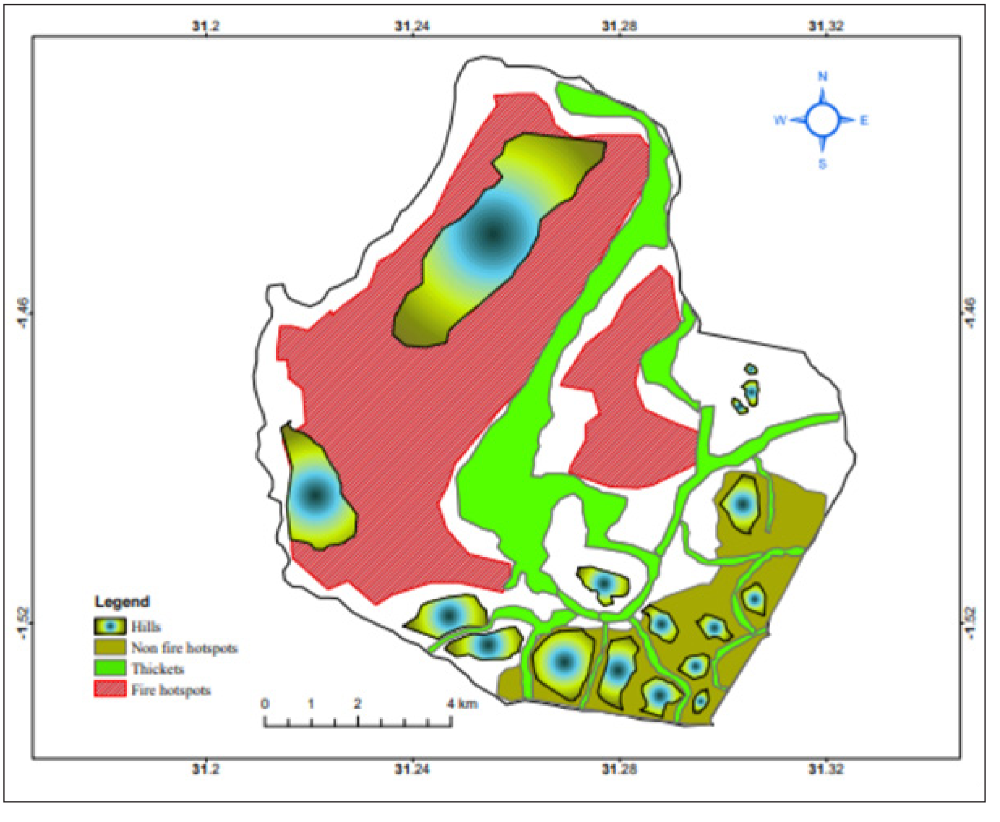

Figure 2. Fire hotspots and non-fire hotspots in Kikulula Ranch (Created by Researchers of this Study)

hills are overgrown with thickets and bushes, which serve as a natural barrier for fire spread over the landscape. By contrast, the non-fire hotspots were plains and hills embedded in a fragmented landscape where lowlands with thickets served as efficient fire barriers.

Composition of Herbaceous Species in Kikulula Ranch

Table 1 shows importance value indices of herbaceous plants in Kikulula Ranch. The results indicated that the three most important forage plants were grasses, *Themeda triandra*, *Loudetia kagerensis* and a leguminous herb, *Desmodium uncinatum*. Results revealed that the herbaceous plant species with an IVI of 56.23 are widely distributed in Kikulula Ranch and well adapted to the prevailing environmental conditions. This is consistent with the results of Sarwatt and Mollel (2006) and Bloesch (2008), who reported *Themeda triandra*, *Setaria sphacelata*, *Cenchrus ciliaris*, *Panicum* spp., *Pennisetum purpureum*, *Loudetia* spp., *Centrosema pubescens*, *Neonotonia wightii* and *Desmodium intortum* in other highlands of the Kagera region.

Table 1
Importance Value Index of herbaceous species in Kikulula Ranch

Herbaceous Species	IVI Percentage
Themeda triandra	16.01
Loudetia kagerensis	7.29
Urochloa mosambiensis	6.29
Cyanodon dactylon	3.85
Abutilon angulatum	3.57
Panicum maximum	3.38
Brachiaria brizantha	3.3
Hyparrhenia rufa	2.48
Desmodium uncinatum	2.44
Sporobolus pyramidalis	2.17
Sporobolus africanus	1.96
Setaria pumila	1.8
Eragrostis tenuifolia	1.7
IVI % of ten herbaceous species	56.23
IVI% of other 115 herbaceous species	35.58

Note. Importance Value Indices were calculated for all recorded herbaceous species, along with the ten most abundant species, at Kikulula Ranch

T. triandra and *L. kagerensis* were ecologically important with their dominance and spreading in different conditions in burnt and unburnt areas with IVI of 23.01 %. The species appear to be well adapted to Kikulula Ranch, perhaps due to a dense network of rhizomes and rapid re-colonisation of burnt areas (Hagl et al., 2021; Hodgson et al., 2024). They have long light awns that aid in dispersal by wind and escape from fire by smoke (Ghebrehiwot et al., 2012; Zahed & Bączek-Kwinta, 2023). Thus, *L. kagerensis* is well suited to the fire-prone hilly habitats of Kikulula Ranch. *L. kagerensis* is a species of montane, fire-resistant, drought-resistant, and grazing-resistant (National Park Service, 2021). *L. kagerensis* is fire-resistant; it bounces back quickly from fire and thrives in fire-prone ecosystems. The spikelets are lightweight and lanceolate and are easily dispersed by wind and smoke, which, due to the open panicle and flexible branches, promote germination and rapid regrowth (Ripley et al., 2015). Its leaves are narrow and slender in blade, and glaucous and pubescent on the surface to reduce water loss, thus giving it a better chance to survive in nutrient-poor soils. Several studies have reported the dominance of *L. kagerensis* in poor soils of the hilly fire-prone ecosystems of tropical Africa (Kyagaba, 1997).

The high IVI of *D. uncinatum* in the leguminous herbs could be associated with its invasive nature and fast growth rate, which help it outcompete the native vegetation (Witt & Luke, 2017). It has allelopathic properties, with high nitrogen-fixing ability and tolerance to a range of environmental stresses (Hooper et al., 2015; Ngondya et al., 2017). *D. uncinatum* is a tropical American species introduced in the 1990s in Kikulula Ranch under the Kagera Livestock Development Programme to maximise milk yield (Komwihangilo et al., 2011). Witt and Luke (2017) studied the effects of the invasive species *D. uncinatum* on plant community structure, biodiversity and ecosystem function in East Africa. However, *D. uncinatum* is a high crude protein species (Heuzé et al., 2015). Thus, it is important to manage the grazing land in a sustainable way, increase the production of herbaceous forages with high nutritional value and control the invasion of this species by mechanical removal, burning and targeted grazing.

Nutrient Quality of *Themeda triandra* Forssk. in the Burnt and Unburnt Areas

Themeda triandra CP and NDF percentage values were significantly different between the burnt and unburnt areas (Table 2; t = 2.91, F = 55.2, $p < 0.05$; t = 2.96, F = 1.69, $p < 0.05$, respectively). The higher CP level in *Themeda triandra* in the burnt area shows that the plant is fire-tolerant and has a high rate of amino acid and protein synthesis for its growth. For example, seed culms of *T. triandra* were observed to remain standing and unburnt after hot fires (Snyman, 2013). Our results agree with Reid et al. (2023). Also, the low NDF value of *T. triandra* in the burnt area showed a decrease in digestible cell wall content in the young leaves after fires, which may limit vegetation intake by animals. These data also indicate that fire affects the cellulose and hemicellulose fractions of NDF. The low energy content of young leaves is due to low hemicelluloses, cellulose and lignin, which are components of the NDF (Bin et al., 2021). Fire tolerance in *T. triandra* may also be due to its ability to resprout from scars after burning. The increase in fibre content is due to the dead mass spots of growing forage plants (Erkovan et al., 2009). ADF levels in *T. triandra*, however, did not differ significantly between burnt and unburnt sites (t = 1.37, F = 3.73, p > 0.05). The ADF seems to be a problem with hemicellulose, which is a factor in the digestibility of forage, and is exacerbated by fires. Fire does not influence the lignin content in ADF significantly, and therefore similar values are found in burnt and unburnt areas. Lignin and fibres have a known defensive role and reduce the quality of digestible forage plants (Lee et al., 2017). The fibre contents of *Themeda triandra* are similar to those reported by Lunt and Morgan (1999) and Erkovan et al. (2009). The ADF contents in forage plants from the burnt and unburnt areas are consistent with the observations reported by Pule et al. (2023).

Table 2
Variation of selected forage qualities in Themeda triandra between burnt and unburnt areas

Nutrition Parameter (%)	Levene's Test for Equality of Variances		t-test for Equality of Means		Mean	
	F	**Sig**	**t-test (2-tailed)**	**Sig.**	**Burnt**	**Unburnt**
NDF	1.69	0.2	2.96	0.006	68.86 ± 0.39	71.71 ± 0.6
ADF	3.73	0.06	1.37	0.18	36.06 ± 0.49	37.32 ± 0.77
CP	55.2	4 e^{-8}	2.91	0.007	6.22 ± 0.06	5.41 ± 0.27

Note. Values of NDF, ADF and CP in *Themeda triandra*

Nutrient Quality of *Loudetia kagerensis* (K.Schum.) C.E.Hubb. ex Hutch. in Burnt and Unburnt Areas

The percentage levels of NDF, ADF and CP in *Loudetia kagerensis* revealed no significant differences between the burnt and unburnt areas (Table 3; t = 2.96, F = 0.12, $p > 0.05$; t = 1.37, F = 0.36, $p > 0.05$; t = 2.91, F = 0.47, $p > 0.05$, respectively). In both environments, *Loudetia kagerensis* had higher levels of NDF and ADF than CP (though not statistically significant), indicating a higher fibre content of the forage necessary for mechanical support but decreasing vegetation consumption and digestibility. A high ratio of carbohydrate (fibre) to nitrogenous compounds (protein) also indicates maturity of the plant. The results are in agreement with Kyagaba (1997), who recorded low values of nutrients for *L. kagerensis* but good growth in burnt environments. The similarity of nutritive values of *L. kagerensis* in burnt and unburnt areas may be due to inherent characteristics of the species. Heat Shock Proteins (HSPs) genes are reported to be linked to stable nutritional allocation (Mas-ud et al., 2025), as well as microRNAs such as miR156 (Kim et al., 2012). Field et al. (1973) reported low acceptability of *L. kagerensis* by Ankole cattle and buffaloes in southern Uganda. This indicates that *L. kagerensis* is a poor forage for livestock nutrition even in fire-managed ecosystems. However, it is a very hardy species and well adapted to fire-prone ecosystems. It plays important ecological roles such as stabilising soil on sloping hills.

Table 3
Variation of selected forage qualities in Loudetia kagerensis between burnt and unburnt areas

Nutrition Parameter (%)	Levene's Test for Equality of Variances		t-test for Equality of Means		Mean	
	F	Sig.	t-test (2-tailed)	Sig.	Burnt	Unburnt
NDF	0.12	0.73	2.96	0.4	73.57 ± 0.8	74.461 ± 0.66
ADF	0.36	0.55	1.37	0.29	37.5 ± 0.64	38.43 ± 0.58
CP	0.47	0.5	2.91	0.12	6.26 ± 0.25	5.68 ± 0.25

Note. Values of NDF, ADF and CP in *Loudetia kagerensis*

Nutrient Quality of *Desmodium uncinatum* (Jacq.) DC. *in* Burnt and Unburnt Areas

The mean CP of *D. uncinatum* was significantly higher in burnt than unburnt areas (Table 4; t = 2.6, F = 3.02, $p < 0.05$). This result shows that *Desmodium uncinatum* is fire-tolerant and biomass accumulation is due to active protein synthesis in the burnt areas. Likewise, at the genus level, similar results were recorded by Mligo (2019) in *Desmodium barbatum* that regenerated after frequent fires in Pugu Forest Reserve. Also, Carbone and Aguilar (2016) reported that in the burnt area of Argentina, *Desmodium uncinatum* had high total nitrogen. In this case, CP is an essential component of total nitrogen.

The study findings also support the observations of Mathenia (2011), Nichols et al. (2021), Thapa et al. (2022) and Haynes et al. (2023), who reported increased nutritive values of forage species after fire events. Moreover, there was no significant difference in the values of NDF and ADF in *Desmodium uncinatum* between burnt and unburnt areas, as shown in Table 4 (t = 1.11, F = 1.88, $p > 0.05$; t = 0.5, F = 9.29, $p > 0.05$, respectively). Moderate fire conditions are unlikely to have much effect on fibre formation of cellulose, hemicellulose and lignin in *D. uncinatum*. Hacker (1992) reported that *D. uncinatum* recovered from moderate fires, but was severely damaged by intense fires. This resilience can be attributed to the ability of fire to stimulate new growth in young herbaceous plants that are generally less fibrous (Thorvaldsson et al., 2007) but have active enzymes that synthesise amino acids and promote fast growth and development. The results of NDF and ADF of *D. uncinatum* are consistent with the results of Carbone and Aguilar (2016), who found that leaf biomass, which determines the fibre content, was not affected in the burnt areas.

Table 4
Variation of selected forage qualities in the Desmodium uncinatum between burnt and unburnt areas

Nutrition Parameter (%)	Levene's Test for Equality of Variances		t-test for Equality of Means		Mean	
	F	Sig.	t-test (2-tailed)	Sig.	Burnt	Unburnt
NDF	1.88	0.18	1.11	0.28	53.45 ± 0.46	54.31 ± 0.62
ADF	9.29	0.005	0.5	0.62	28.05 ± 0.39	27.52 ± 0.99
CP	3.02	0.093	2.6	0.02	19.25 ± 0.45	17.91 ± 0.25

Note. Values of NDF, ADF and CP in *Desmodium uncinatum*

CONCLUSION

In the study area, the dominant forage grasses were *Themeda triandra* and *Loudetia kagerensis,* while the dominant leguminous species was *Desmodium uncinatum*. These taxa are able to survive in burnt and unburnt habitats and highlight their resistance to numerous ecological stressors of ranching activities such as grazing, controlled burns, and wildfires. *Themeda triandra* and *Desmodium uncinatum* in burnt areas provided substantial crude protein. *Themeda triandra* in the burnt areas had low neutral detergent fibre, confirming high protein content but poor digestible cell wall energy. Levels of crude protein, neutral detergent fibre and acid detergent fibre of *Loudetia kagerensis* were, however, not different between burnt and unburnt areas. *Desmodium uncinatum* similarly revealed higher crude protein levels in burnt areas, but the neutral detergent fibre and acid detergent fibre levels were similar in both parts.

Controlled or prescribed burning is one option that can be employed on ranches to improve the quality of pastures (especially protein content in *Desmodium uncinatum* and *Themeda triandra*). However, fire reduces the neutral detergent fibre content of *Themeda triandra*, a measure of digestible cell wall components (cellulose, hemicellulose and lignin), and so reduces the energy-yielding capability of the forage. Fire did not affect levels of crude protein, acid detergent fibre and neutral detergent fibre in *Loudetia kagerensis* and neutral detergent fibre and acid detergent fibre levels in *Desmodium uncinatum*. Composition, palatability and quality of herbaceous species are key factors for the amount of vegetation consumed, herbivorous biomass and reproductive success (Herrero et al., 2015; Wold et al., 2023).

IMPLICATION OF THE STUDY

Based on the findings, this study has the following implications for the management of ranches and ecological sustainability: Fire is a useful tool in improving rangeland forages, especially *Themeda triandra* and *Desmodium uncinatum,* by increasing levels of crude protein. Strategic burning increases forage plant nutritional values. Burning increases protein content and decreases neutral detergent fibre content in *Themeda triandra*, so selective management of forage is needed. This is a trade-off with forage higher in protein but with less digestible cell wall energy. Fire responses are species-specific. Not all species respond the same to fire. Fire increases the nutritive value of *Themeda triandra* and *Desmodium uncinatum*. Conversely, the nutrient composition (crude protein, acid detergent fibre, neutral detergent fibre) of *Loudetia kagerensis* was similar between burnt and unburnt areas, suggesting that fire does not provide the same nutritional benefits to this grass species. The dominant species are very resilient, particularly *Themeda triandra*, *Loudetia kagerensis* and *Desmodium uncinatum* that can thrive in burnt and unburnt areas, despite grazing and fire. Dependable, consistent forage options for ranchers. Finally, the paper comments on better performance of livestock. The increased protein content of *Desmodium uncinatum* and *Themeda triandra* in burnt areas is likely to improve the health of livestock and thus increase biomass and reproductive success of herbivores grazing in burnt areas.

LIMITATION AND RECOMMENDATION FOR FUTURE RESEARCH

The nutritional composition of the herbaceous forage plants and other plant forms can be altered by edaphic variables, light, space and water (Lascano et al., 2001; Melo et al., 2022), but these aspects were not evaluated in the present study. Where high-protein, low-fibre forages are required, it is recommended that strategic burning is used to increase protein availability if the energy-yielding fibre (NDF) content of the overall diet is not reduced to a great extent.

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