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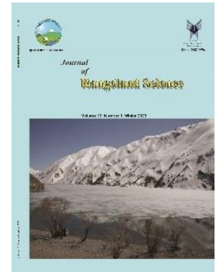

Research and Full Length Article:

The Influence of Cattle Grazing on Plant Species Composition in a Mesic Montane Region of Southern Africa

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Abstract. This study investigated the effect of grazing on plant community structure. Two adjacent areas: one grazed for five years and non-grazed were sampled in March-April 2020. On each area, three sampling sites were selected. Quadrats of 1×1m were placed at 5m intervals along 50m transects (198~ 40 transects in total). Plants were identified and percentage cover was estimated following Braun-Blanquet method. Indicator values were calculated for each species. T-test compared the means between sites. Multi-response permutation procedures compared plant species composition between sites. Species richness (t=3.44, $p<0.01$) and evenness (t=-8.06, $p<0.01$) were significantly higher in non-grazed sites than grazed ones. Diversity showed the opposite trend ($p<0.01$). Mean cover differed ($p<0.05$) at species level. Density was significantly higher (t=6.93, $p<0.01$) in non-grazed sites than in grazed ones. Mean grass species richness was significantly higher (t= 2.97, $p<0.01$) in grazed sites than non-grazed ones while for herbs it was opposite (t=-5.94, $p<0.01$). 18 grass species were perennial while 1 was annual. *Sporobolus pyramidalis* (Low palatability, Increaser II) was found exclusively in the non-grazed areas, 7 others including *Paspalum scrobiculatum* (Moderate palatability, Increaser II) and *Eragrostis curvula* (Moderate palatability, Increaser II) were found in the grazed sites only and 11 were common to both sites. These include *Themeda triandra* (high palatability, Decreaser), *Panicum natalense* (low palatability, Decreaser), *Eustachys paspaloides* (high palatability, Decreaser) and *Melinis repens*. (Low palatability, Increaser II), *Eragrostis racemosa* (moderate palatability, Increaser II) and mean cover of *P. natalense* (t=-2.07, $p<0.05$), *M. repens* (t=-5.68, $p<0.01$) and *E. racemosa* (t=-7.54, $p<0.01$) was significantly higher in grazed areas than in non-grazed ones. *Themeda triandra* (t=13.0, $p<0.01$) and *E. paspaloides* (t=2.12, $p<0.05$) had significantly higher mean cover in non-grazed sites than in grazed ones. Our results indicate that grazing has negative impact on highly palatable species. We suggest long term monitoring of vegetation change.

Key words: Conservation, Eswatini, Functional groups, Non-grazed, Palatable

Introduction

Grazing is among the key environmental factors that determine plant community structure in rangeland ecosystems (Davis and Goetz, 1990). Although there have been several studies investigating the impact of cattle grazing elsewhere (e.g. Humphrey and Patterson, 2000; Hayes and Holl, 2003; Loeser *et al., 2*006 and Peco *et al., 2*006), little is known about its influence on plant community composition and distribution in a mesic landscape of Eswatini. Grazing by cattle can affect grassland community dynamics through consumption, mechanical disturbance, seed dispersal and altered soil fertility due deposition of nutrients from the dung and urine (Peco *et al., 2*006). This can negatively affect plant community structure by consumption of leaves, roots, fruits and mechanical damage by trampling on whole plant (Crawley, 1997). Cattle overgrazing can also lead to physical and chemical changes in soil properties (Peco *et al., 2*006) by resulting in heterogeneous availability of nutrients and their cycling (Haynes and Willams, 1993). This will influence plant species composition and distribution in both space and time such as increase in unpalatable/undesirable vegetation (Louhachi *et al., 2*009) and loss of vegetation cover (Zhao *et al.,* 2011).

Grazing also negatively impact soil bulk density and texture (Jones, 2000). In both wet and dry soils, disturbance can result from trampling (Shanker and Singh, 1996) which can increase soil heterogeneity resulting in micro-sites for species co-existence (Grubb, 1977). This can lead to high species diversity. Conversely, grazing disturbance can also lead to increased soil erosion which reduces species diversity (Milchunas *et al.,* 1988) in rangeland suitable for grazing.

The impacts of grazing on the ecosystem vary with intensity (Rosenthal *et al., 2*012). Low grazing intensity can result in high habitat diversity by enhancing pre-existing environmental gradients and resulting in various disturbance patterns on various spatial scales (Rosenthal *et al., 2*012).

Conversely, high-intensity grazing damages the porosity of the soil and leads to consumption of most herbaceous plants (Peco *et al., 2*006) in all soils and any condition. The degradation of grazing on the soil is dependent on the soil type, accretion of plant material and soil moisture (Chiavegato *et al., 2*015; Roesch *et al., 2*019). The vulnerability of the soil to trampling degradation is dependent on soil moisture (Roesch *et al*., 2019). Dry soils are more resistant to degradation from cattle trampling than wet ones because stress transfer to deep soil layers is minimized and as a result the upper subsoil suffers more damage (Batey, 2009; Herbin *et al., 2*011).

Wet clay soils are more vulnerable to degradation by trampling than sandy ones. In wet soils, the damage from trampling on surface and subsurface layers results from pugging (Ferrero and Lipiec, 2000). Pugging results in compaction of the soil as it breaks down large soil aggregates which reduces pore space thereby increasing bulk density (Qasim *et al., 2*017). This reduces water and air circulation in the soil and hampers plant root growth (Greenwood and Mckenzie, 2001). Furthermore, pugging can also result in sealing the soil surface and increasing the risk of water erosion (Roesch *et al.*, 2019).

Compared to other livestock, it has been found that sheep have relatively less impact on the soil degradation through compaction as a result of their low body weight ratio to soil contact area (Cox and Amador, 2018). Conversely, Cox and Amador (2018), found that compaction by horses is more detrimental to the soil than that of cattle. Grazing by cattle also has positive impacts on the ecosystem. Cattle can act as dispersal agents of seeds in space thus leading to improved connectivity in isolated plant populations. Seed dispersal helps to increase the probability of germination and establishment due to reduced competition between the parent plants and seedlings (Rosethal *et al.*, 2012). In mesic regions cattle (heavy) grazing may play a critical role in enhancing species richness by mitigating the concomitant impacts of higher levels of biomass accumulation (Hayes and Holl, 2003).

Information on the influence of grazing on plant communities is vital for informing strategies on planning grazing regimes for optimizing resource allocation for livestock production (Ormerod, 2003; Ruiz-Jaen and Aide, 2005; Atsbha *et al.*, 2020). Such information can also be important in the conservation of local biodiversity, restoration (Montalvo *et al*,. 1993; Mekuria and Veldkamp, 2012; Atsbha *et al.*, 2020) and reducing fire hazards (Perevolotsky and Haimov, 1992). This is especially relevant in Eswatini where fire breaks are maintained by cattle grazing in some of the forestry plantations such as our current study site. Therefore, a quantitative study must be conducted on the impact of grazing on plant communities to establish its impact to inform future management plans on the conservation of plant communities and sustain their ecosystem functions.

In this study, we assessed the effect of grazing by cattle on plant community structure in a mesic montane zone in Eswatini. Our hypothesis was that plant community composition will differ between grazed and non-grazed areas in terms of species composition and diversity. We predicted that the grazed area would have higher species diversity and density than the non-grazed one. The specific objectives were: 1) To determine the effect of grazing on species composition of herbaceous plants 2) To investigate the effect of grazing on species diversity of herbaceous plants and 3) To determine the effect of grazing on the abundance of plant functional groups.

Materials and Methods

Study area

The study was conducted, in Bhunya within the forestry plantations in the highveld region of Eswatini (Fig. 1). The plantations are in the Highveld and Middleveld of Eswatini covering approximately 55 000 hectares (https://montigny.co.sz). The main plantation species are *Pinus patula*, *P. taeda*, *P. elliottii* and *Eucalyptus grandis*. To reduce the accumulation of plant biomass in the fire breaks the company uses both fire and cattle grazing. Grazing by cattle started in 2015 and its impact on plant species composition has not been investigated. Bhunya is located in the Manzini region which has a mean rainfall of approximately 881 mm/annum (https://weatherspark.com/y/96812/Average-Weather-in-Bhunya-Swaziland-Year-Round).

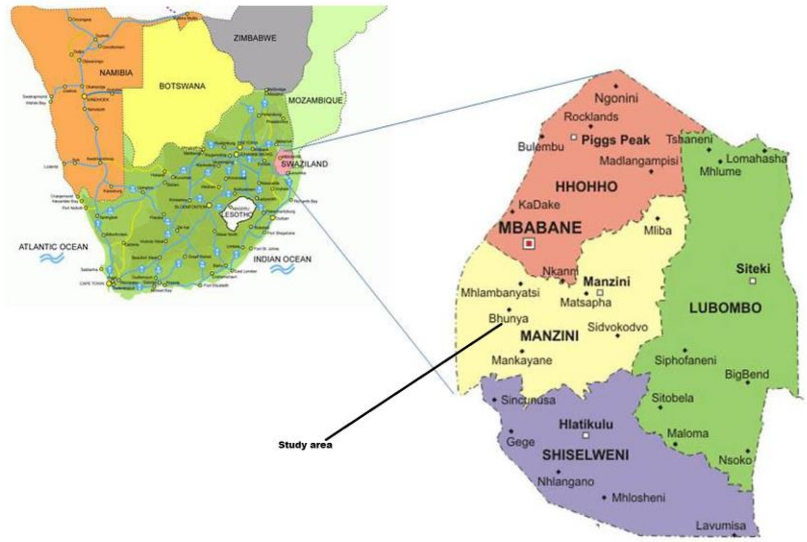

Fig. 1. Location of Bhunya in Eswatini. (Source: https://www.google.com/search?q=map+of+Bhunya+eswatini&tbm=isch&chips=q:map+of+bhunya+eswatini)

The temperature of Bhunya typically varies from 6^{o}C to 25^{o}C and is rarely below 3^{o}C or above 30^{o}C. The warm season lasts for 3.5 months, from early December to late March with an average daily high temperature above 24^{o}C, while the cool season lasts for 1.8 months from early June to late July, with an average daily high temperature below 20^{o}C (https://weatherspark.com/y/96812/Average-Weather-in-Bhunya-Swaziland-Year-Round).

Eswatini experiences subtropical climate with summer rainfall (October-March). In the high veld where our study site falls, mean annual rainfall ranges between minimum of 850mm and maximum of 1 450mm (Loffler and Loffler, 2005). The soils in the high veld of Eswatini where this study is conducted are the grey clay and grey sandy loam, the white sand and the yellow loam (Loffler and Loffler, 2005).

Vegetation Sampling

Two adjacent areas were studied to determine the effect of grazing on herbaceous plant species composition. One area (site) has a history of being grazed since 2015 while the other portion was a non-grazed with no history of grazing. In our study a site refers to an area either grazed or non-grazed where transects and quadrats were placed for vegetation sampling. At the time of sampling (March-April 2020), it had experienced five years of continuous grazing. Three sites were sampled in each treatment, and there were three transects in each site. The length of transects was 50m to ensure that it falls within the range of the sites Our reconnaissance study showed that transects longer that 50m encroached into nearby woody forests. As a results the 50m transect was used so that a uniform area in both sites is sampled.

The transects were 50m long and spaced 10m apart to cover a wider and a good representation of the sampling sites. Along each transect, 1m × 1m quadrats were placed at 5m intervals. The 5m intervals were meant to minimize spatial variation of underlying co-founding environmental factors such as soil nutrients, moisture and pH which could influence plant species composition in the sampled areas (Hayes and Holl, 2003). In each quadrat plant species were identified and percentage cover estimated following the Braun-Blanquet cover/abundance scale (Table 1). Plant identification followed Outshoorn (2014) for grasses, while Manning (2009) was used to identify herbs. Our study area was characterized by grassland bordered by forest plantations. Common plant species in this area include *Themeda triandra*, *Paspalum notatum*, *Melinis repens* and *Panicum natalense*.

Table 1. Braun-Blanquet plant percentage cover/abundance scale (Mueller-Dombois and Ellenberg, 1974)

Level	Description
5	75-100% plot cover
4	50-75% plot cover
3	25-50% plot cover
2B	15-25% plot cover
2A	5-15% plot cover
2M	1-5% plot cover, over 50 individuals
1	1-5% plot cover, 6-50 individuals
+	less than 1% plot cover, 3-5 individuals
R	less than 1% plot cover, 1-2 individuals

Data Analysis

We computed species richness; mean percentage cover, Shannon-Weiner species diversity index, evenness and species density (number of individual/ha) for each site. Their means were compared for statistical significance with T-test with unequal variances. Prior to statistical comparisons with T-test, we tested for normality using Kolmogorov-Smirnov test and homogeneity of variance through Levene's test. All the data met the requirements of normality and homogeneity of variance. We also used Multi-response permutation procedures in PC-ORD 6 to compare species composition between grazed and non-grazed sites and visualized in two dimensions in non-metric multidimensional scaling (McCune and Grace, 2000). Indicator species analysis was conducted to calculate indicator values (IVs) for species in non-grazed and grazed sites (Dufrêne and Legendre, 1997). The significance of maximum IVs of species against random data was assessed using Monte Carlo test (Dufrêne and Legendre, 1997). We also calculated the difference between each species frequency between non-grazed and grazed areas (Scott-Shaw and Morris, 2015). Species were also compared in terms of their life form (annual/perennial and grass/herb), grazing value (palatability) and grazing status following Oudtshoorn (2014). Grazing status was divided into four classes of Decreaser, Increaser I, II and III (Oudtshoorn, 2014). The classes are described based on Oudtshoorn (2014) as follows:

1. "Decreasers: Grasses that are abundant in good veld, but decrease in number when the soil veld is overgrazed or undergrazed.''
2. "Increaser I: Grasses that are abundant in underutilized veld."
3. "Increaser II: Grasses that are abundant in overgrazed veld. They increase due to the disturbing effect of overgrazing and mostly include pioneer and subclimax species."
4. "Increaser III: Grasses that are commonly found in overgrazed veld. They are usually unpalatable climax grasses and are strong competitors that increase in value when palatable grasses are weakened by overgrazing."

Results

Richness

A total of 129 species were recorded from both grazed and non-grazed sites. 102 herbs and 27 grass species were identified from both treatments, (grazed and non-grazed sites). Of these 129 species, 104 were found in non-grazed sites, while there were 53 species identified in grazed sites. T-test analysis showed that species richness was significantly (t=3.44, $p<0.01$) higher in non-grazed sites than grazed ones (Fig. 2).

Vegetation cover

Mean plant cover was higher in the non-grazed area (54.4±13.0%) than in grazed one (34.0±17.0%) (Fig. 3). However, this difference was not statistically (t= 0.51, $p>0.05$) significant.

Diversity

Species diversity was significantly ($p<0.01$) higher in the grazed site (0.93) compared to the non-grazed site (0.66) (Fig. 4).

Evenness

Plant community evenness was significantly higher (t=-8.06, $p<0.01$) in non-grazed sites (0.87) than in grazed ones (0.49) (Fig. 5).

Species Density

Density was significantly higher (t=6.93, $p<0.01$) in the non-grazed site (55.0) as compared to the grazed one (35.0) (Fig. 6).

Species composition

Some species were found only on each of the treatments while others occurred in both (Table 2). Some plant species were found in both the grazed and the non-grazed sites. These species were *Acanthospermum glabratun* (Herb), *Oxalis semiloba* (Herb), *Panicum natalense* (Decreaser), *Themeda triandra* (Decreaser), *Eustachys paspaloides* (Decreaser), *Cenchrus ciliaris* (Decreaser), *Brachiaria serrata* (Decreaser), *Loudetia simplex* (Increaser I and II), *Eragrostis chloromelas* (Increaser II), *Eragrostis capensis* (Increaser II), *Melinis repens* (Increaser II), *Eragrostis racemosa* (Increaser II) and *Paspalum notatum* (Exotic) (Table 2).

We also compared mean cover/abundance of species that were found in all the treatments. We found that the mean cover of seven species was significantly different ($p<0.05$, noted with *) between the two treatments. Of the seven species, five had a higher average cover in the grazed sites compared to the non-grazed sites (Table 3). These were *Acanthospermum glabratun* (t=-2.88, $p<0.01$), *Panicum natalense* (t=-2.07, $p<0.05$), *Melinis repens* (t=-5.68, $p<0.01$), *Eragrostis racemosa* (t=-7.54, $p<0.01$) and *Paspalum notatum* (t=-4.07, $p<0.01$). However, two of the seven species being *Themeda triandra* (t=13.0, $p<0.01$) and *Eustachys paspaloides* (t=2.12, $p<0.05$) had significantly higher average cover in the non-grazed sites. The other species did not show significant differences ($p>0.05$) in their average cover between the grazed and the non-grazed sites (Table 3).

Fig. 2. Means of species richness

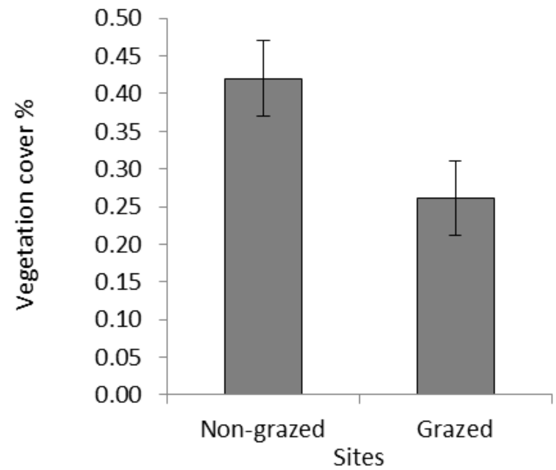

Fig. 3. Mean vegetation cover.

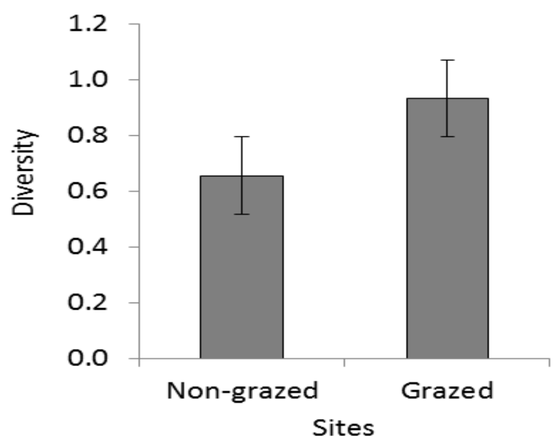

Fig. 4. Means of diversity.

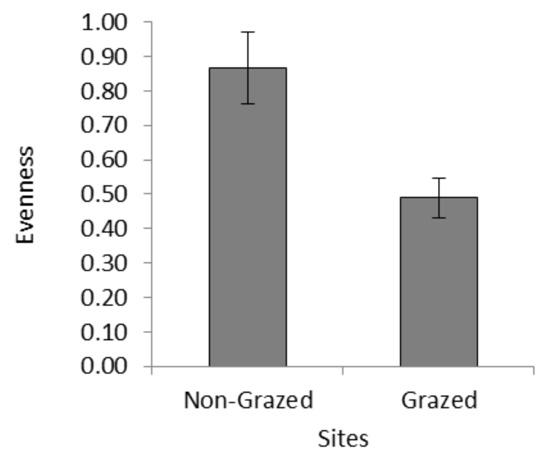

Fig.5. Means of evenness.

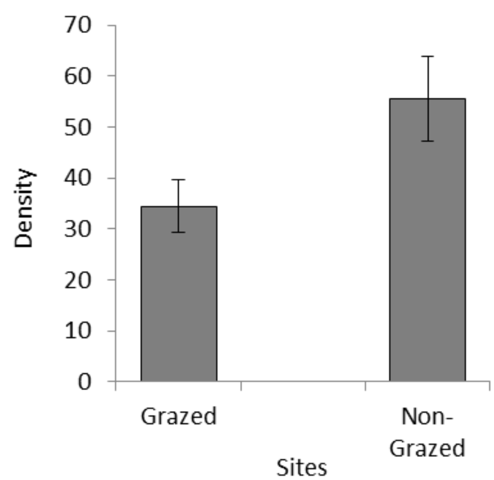

Fig. 6. Means of species density

Figs 2-6 Mean comparison of species composition and diversity between the grazed and non-grazed sites in Bhunya, Eswatini.

Table 2. Plant species that are unique to grazed and non-grazed sites and those that are common in both treatments in Bhunya, Eswatini

Grazed only	Non-grazed only	Common species
Paspalum scrobiculatum	*Ruellia cordata*	*Acanthospermum glabratum*
Eragrostis curvula	*Berkheya echinacea*	*Oxalis semiloba*
Hyperthelia dissoluta	*Ocimum obavotum*	*Panicum natalense*
Rendlia altera	*Thunbergia atriplicifolia*	*Themeda triandra*
Sporobolous africanus	*Dietes iridiodes*	*Eustachys paspaloides*
Agrostis lachnantha	*Nemesia denticulata*	*Cenchrus ciliaris*
Eragrostis lehmanniana	*Sporobolus pyramidalis*	*Brachiaria serrata*
Hyperthelia dissoluta	*Vigna vexillata*	*Loudetia simplex*
	Thunbergia natalensis	*Eragrostis chloromelas*

Table 3. Comparison of mean cover in species that were found in both grazed and non-grazed sites in Bhunya, Eswatini

Common Species	Vegetation cover	
	Non-grazed	Grazed
*Acanthospermum glabratun**	0.02±0.01	0.60±0.32
Oxalis semiloba	0.02±0.01	0.07±0.01
*Panicum natalense**	1.40±0.10	3.33±1.30
*Themeda triandra**	39.2±7.00	0.45±0.32
*Eustachys paspaloides**	1.30±0.43	0.34±0.43
Cenchrus ciliaris	1.04±0.32	0.90±0.0
Brachiaria serrata	1.14±0.0	0.40±0.70
Loudetia simplex	0.80±0.0	0.15±0.70
Eragrostis chloromelas	2.68±1.13	2.60±1.62
Eragrostis capensis	0.55±0.32	0.60±0.0
*Melinis repens**	0.30±0.01	5.54±2.70
*Eragrostis racemosa**	0.53±0.80	6.5±1.20
*Paspalum notatum**	2.34±1.60	8.18±1.62

Functional Groups

The mean number of grass species was significantly higher (t= 2.97, $p<0.01$) in the grazed site (3.12) compared to the non-grazed site (2.5). Conversely, the mean number of herbs was significantly higher (t=-5.94, $p<0.01$) in the non-grazed site (5.3) compared to grazed one (3.5) (Fig. 7).

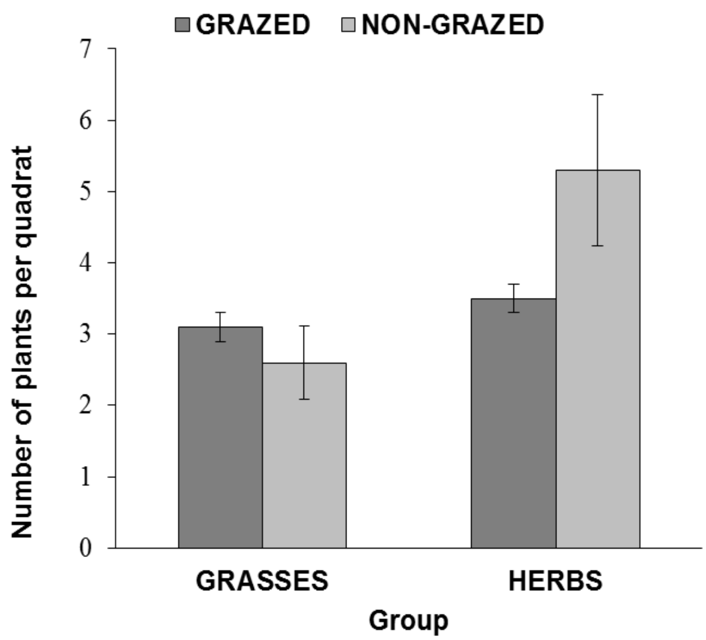

Fig. 7. Comparison of species richness in morphological groups between grazed and non-grazed sites in Bhunya, Eswatini

Life form

In terms of life form, 18 grass species were perennial while only one was annual (Table 4). Of these *Sporobolus pyramidalis* (Low palatability, Increaser II) was found exclusively in the non-grazed area, 7 others including *Paspalum scrobiculatum* (Low palatability, Increaser II), *Eragrostis curvula* (Moderate palatability, Increaser II) and *Hyperthelia dissoluta* (Moderate palatability, Increaser I) were found in the grazed sites only and 11 were common in both treatments (Table 4). Species that were common in all treatments include *Panicum natalense* (Low palatability, Decreaser), *Themeda triandra* (Highly palatable, Decreaser), *Eustachys paspaloides* (Highly palatable, Decreaser) and *Cenchrus ciliaris* (Highly palatable, Decreaser) (Table 4).

Indicator species and their frequency

There was a differential response in species frequency as a result of grazing. Some grass species such as *Eragrostis capensis* (Average palatability, Increaser II), *Themeda triandra* (Highly palatable, Decreaser), *Eustachys paspaloides* (Highly palatable, Decreaser), *Cenchrus ciliaris* (Highly palatable, Decreaser) and herbs such as *Rabdosiella calycina*, *Tephrosia macropoda* and *Berkheya speciosa* decreased in frequency in response to grazing (Table 5). Conversely, other grass species such as *Panicum natalense*, *Eragrostis chloromelas* and *Melinis repens* increased in frequency in grazed sites. In terms of the herbs, only *Oxalis semiloba* had an increase in frequency as a result of grazing (Table 5).

Table 4. Life forms, grazing value/palatability and grazing status of grass species found in grazed and non-grazed sites in Bhunya, Eswatini.

Site	Species	Life form	Grazing Value/Palatable	Grazing status	Mean±SE abundance
Non-grazed only					
	Sporobolus pyramidalis	Perennial	Low grazing value/Low palatability	Increaser II	0.3±0.2
Grazed only					
	Paspalum scrobiculatum	Perennial	Average grazing value/Moderate palatability	Increaser II	0.8±0.2
	Eragrostis curvula	Perennial	Average grazing value/Moderate palatability	Increaser II	0.3±0.1
	Hyperthelia dissoluta	Perennial	Average grazing value/Moderate palatability	Increaser I	0.2±0.1
	Rendlia altera	Perennial	Low grazing value/Low palatability	Increaser III	0.5±0.2
	Sporobolus africanus	Perennial	Low grazing value/Low palatability	Increaser III	0.1±0.1
	Agrostis lachnantha	Annual	Average grazing value/Moderate palatability	Increaser II	0.03±0.03
	Eragrostis lehmanniana	Perennial	Average grazing value/Moderate palatability	Increaser II	0.05±0.05
Common in both sites					
	Panicum natalense	Perennial	Low grazing value/Low palatability	Decreaser	2.3±0.4
	Themeda triandra	Perennial	High grazing value/Highly Palatable	Decreaser	20.0±2.0
	Eustachys paspaloides	Perennial	High grazing value/Highly palatable	Decreaser	0.8±0.2
	Cenchrus ciliaris	Perennial	High grazing value/Highly palatable	Decreaser	1.0±0.2
	Brachiaria serrata	Perennial	Average grazing value/Moderate palatability	Decreaser	0.7±0.4
	Loudetia simplex	Perennial	Average grazing value/Moderate palatability	Increaser I and II	0.5±0.4
	Melenis repens	Perennial	Low grazing value/Low palatability	Increaser II	3.0±0.4
	Paspalum notatum	Perennial	Average grazing value/Moderate palatability	Exotic grass	5.2±0.7
	Eragrostis capensis	Perennial	Average grazing value/Moderate palatability	Increaser II	0.6±0.2
	Eragrostis chloromelas	Perennial	Average grazing value/Moderate palatability	Increaser II	3.0±0.6
	Eragrostis racemosa	Perennial	Average/Moderate palatability	Increaser II	4.0±0.4

Table 5. Indicator value (IV>=10%), mean frequency (percentage occurrence in 198 plots) of species that were abundant in non-grazed and grazed sites in Bhunya, Eswatini

Species	IV	*P*-value	Morphology	(% Frequency)		
				Non-grazed	Grazed	Difference
Grazed						
Acanthospermum glabratum	40.9	0.01**	Herb	5	41	36
Oxalis semiloba	16.2	0.07ns	Herb	11	17	6
Panicum natalense	28.5	0.01**	Grass	8	31	23
Eragrostis chloromelas	23.7	0.01**	Grass	18	27	9
Eragrostis capensis	11.3	0.01**	Grass	10	0	-10
Melinis repens	36.1	0.01**	Grass	1	38	37
Eragrostis racemosa	50.1	0.01**	Grass	8	52	44
Paspalum notatum	51.5	0.01**	Grass	14	55	41
Paspalum scrobiculatum	11.3	0.01**	Grass	7	13	6
Non-grazed						
Themeda triandra	97.0	0.01**	Grass	100	16	-84
Rabdosiella calycina	10.8	0.03*	Herb	10	0	-10
Tephrosia macropoda	12.8	0.01**	Herb	11	0	-11
Berkheya speciosa	16.6	0.01**	Herb	19	7	-12
Scabiosa columbaria	13.0	0.01**	Herb	9	0	-9
Ruellia cordata	19.7	0.01**	Herb	22	6	-16
Ocimum obavotum	49.2	0.01**	Herb	66	7	-59
Thunbergia atriplicifolia	10.8	0.01**	Herb	5	0	-5
Streptocarpus dunnii	10.8	0.01**	Herb	5	0	-5
Dietes iridiodes	13.5	0.01**	Herb	7	0	-7
Hibiscus dongolensis	13.2	0.01**	Herb	11	0	-11
Eustachys paspaloides	19.9	0.14ns	Grass	39	18	-21
Cenchrus ciliaris	10.0	0.35ns	Grass	26	7	-19

Multi-response permutation procedures showed that there was a significant (T= -42.31, $p<0.01$) difference in terms of plant species composition between grazed and non-grazed sites. The plots between the two sites were separated from each other in ordination space (Fig. 8).

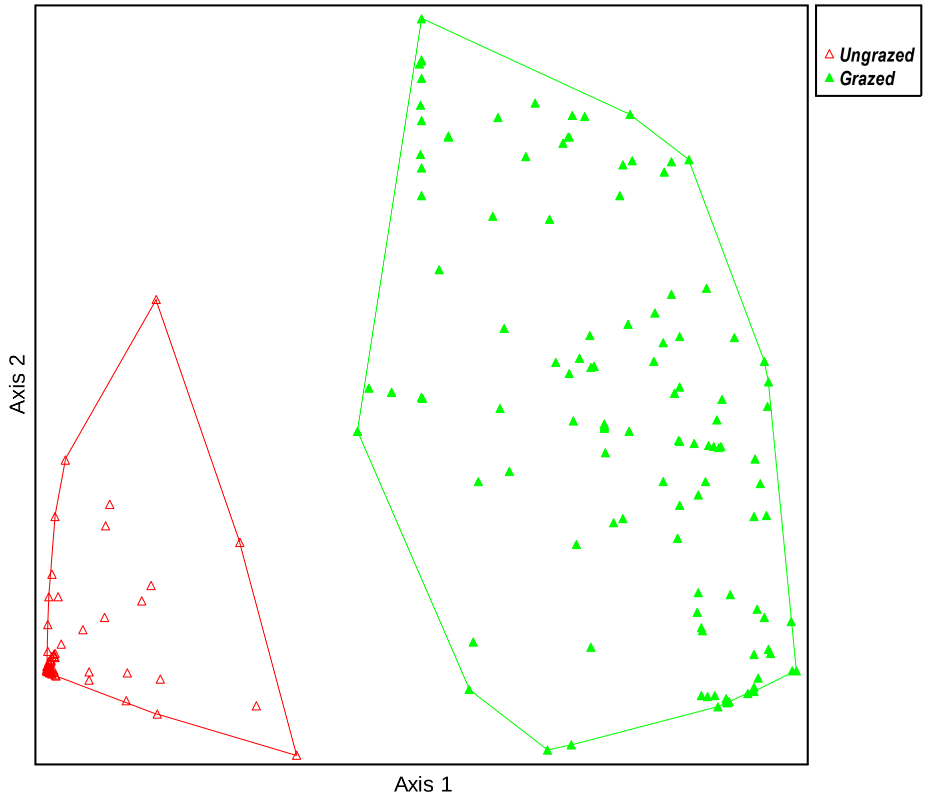

Fig. 8. A non-metric multidimensional scaling ordination of plant species abundance data from grazed and non-grazed sites in Bhunya, Eswatini.

Discussion

The main aim of this study was to assess the impact of cattle grazing on herbaceous plant community structure. Grazing can result in changes to the soil chemical properties (Peco *et al.*, 2006) by adding mineral nutrients through dung and urine (Bargett *et al.*, 2001). These would increase site regeneration and soil heterogeneity thereby creating opportunities for plant species co-existence (Grubb, 1977). However, high-intensity grazing damages the porosity of the soil and causes the consumption of most of the herbaceous plants reducing species diversity (Peco *et al.*, 2006). Trampling by herbivores also has negative effects on plant diversity as it minimizes soil aeration and moisture and increases salinization which excludes intolerant species (Bardgett *et al.*, 2001).

In our study, it was found that species richness and diversity were significantly higher in the non-grazed sites than in the grazed ones consistent with our hypothesis. This shows that grazing reduced the number of plant species in our study area. The grass species in both grazed and non-grazed areas were mainly perennial species with only one annual species in the grazed site. These perennial species are vital for soil conservation as protected the soil from surface runoff (De Groot, Field-Juma and Hall, 1992). In terms of desirability, grass species in the grazed sites were dominated by species of average or less palatability while in non-grazed sites highly palatable species were dominant. This contrasting species composition between grazed and non-grazed sites is due to cattle grazing preferentially selecting against highly palatable species resulting in the dominance of the unpalatable ones in grazed sites (Rutherford *et al.*, 2012). Some of the unpalatable species that were found in grazed sites were *Paspalum scrobiculatum* (Increaser II), *Eragrostis curvula* (Increaser II), *Hyperthelia dissolute* (Increaser I) and *Rendlia altera* (Increaser III). In the non-grazed sites the highly palatable species are dominant due the absence of grazing pressure. Some of the highly palatable species that were dominant in non-grazed were Themeda triandra (Decreaser), *Eustachys paspaloides* (Decreaser), *Panicum natalense* (Decreaser) and *Brachiaria serrata* (Decreaser). The effect of grazing on plant species composition and distribution could be due to physical destruction, compaction of the soil making it hard for plants roots to penetrate, seed dispersal and elevated soil nutrients content resulting from dung input (Peco *et al., 2*006). This is consistent with findings by Hillel, (1992), who found that cattle grazing destroys the soil porosity and results in the extinction of some herbaceous plants mostly through excessive consumption and destruction. Our findings were also consistent with Pettit *et al.* (1995), who found that species richness and diversity were significantly lower in grazed areas than non-grazed ones. This was explained by native perennial species being replaced by fewer exotic annual species (Pettit *et al.*, 1995). Exotic species are able to survive in disturbed sites like grazed areas due to life history strategies such as seed dormancy, short life cycle and early flowering (Grime, 1979). Hiernax (1998) also supports the findings of our study as they observed higher species richness in non-grazed areas than the grazed ones. This could be due to increased litter accumulation, enriched soil organic matter and nutrients that promote plant growth resulting in species richness (Hiernax, 1998). In our study, the results suggest that the lower species richness and diversity in grazed areas than in non-grazed could be due to grazing pressure which results in overgrazing and trampling (Angassa and Oba, *2*010). Overgrazing can negatively affect plant species diversity due to indirect effects on seedling germination and establishment as a result of depletion of biomass at the soil surface (Desalew, 2008). Depletion of litter layer on the soil surface will expose seeds and seedlings to direct sunlight which increases the rate of evapotranspiration. Furthermore, depleted litter layer will lead to seedlings being grazed before they can be recruited into the next growth stages.

We found that plant density was significantly higher in the non-grazed sites than the grazed ones consistent with Fleishner (1994), who found that plant density was lower in grazed areas than in non-grazed ones. In terms of morphological groups, the density of herb species was significantly higher in the non-grazed sites compared to the grazed sites while the density of grasses was higher on the grazed than in the non-grazed one. This was consistent with findings by Pettit *et al.* (1995) in southwestern Australia who found that the density of herbs was significantly lower in grazed sites than the non-grazed ones. In our study, the following herbs decreased in mean frequency in response to grazing: *Rabdosiella calycina, Tephrosia macropoda* and *Ocimum obavotum* (Table 4). This decrease could also be an indicator of a disturbed grazing site in which herbs are grazed on since the palatable grasses such as *Themeda Triandra* species are depleted (Rutherford *et al., 2*012; Atsbha *et al., 2*020; Schmiedel *et al., 2*020). Cattle grazing can negatively affect ecosystem functioning by removing species that belong to important functional groups (Pettit *et al.,* 1995; Rutherford *et al.*, *2*012; Atsbha *et al., 2*020). For instance, the loss of functional groups that are important in nutrient cycling such as legumes may have negative impact on nutrient cycling in grazed areas (Pettit *et al.* 1995). Likewise, the loss of palatable species may result in poor grazing conditions in the landscape (Atsbha *et al.,* 2020).

Indeed in our study, highly palatable species such as *T. triandra* and *Eustachys paspaloides* which are both decreasers, had lower abundance in grazed areas than in excloures. Conversely, we found an increase in the abundance of unpalatable species such as *Panicum natalense* and *Melinis repens* in response to grazing. This was consistent with the observation made by Mengistu *et al.* (2005) who in the hillsides of central and northern Ethiopia found that under continuous grazing conditions, palatable plant species (decreasers) died off leading to an increase in abundance in less palatable species (increasers). This could suggest that decreasing abundance of palatable species opens up spaces for colonization by the less palatable one that are avoided by cattle. However, it is expected that as the grazing pressure increases and the palatable grasses continue to be depleted, the abundance of less palatable grasses will also decrease. This is because in the absence of the preferred species they will serve as alternative grazing resource (Outshoorn, 2014).

While both perennial and annual herbs can be either desirable or not, generally perennial herbs species decrease in abundance in response to grazing while the annual ones increase (Loeser *et al.,* 2006). The native annual herbs are able completing their life cycle before the grazing pressure increases (Pettit *et al.,* 1995). Conversely, the perennial herbs are a vital resource contributing to persistent forage supply throughout the year (Lohman *et al.,* 2012; Siebert *et al.,* 2020). They grow slowly and are stress tolerant and are exposed to increased grazing pressure when the annual species have died off (Pettit *et al.,* 1995). Therefore, their reduction in abundance as in our study leads to poor grazing quality (Hiernax, 1998; Atsbha *et al.,* 2020).

The overall percentage cover of the two treatments which are the grazed and the non-grazed sites was not statistically significantly different. This is supported by Peco *et al.* (2006), who found no significant difference plant cover in non-grazed areas and grazed ones in Mediterranean region in Spain. However, this comes into contrast with other studies as they mostly found that the grazed areas had less cover compared to the non-grazed ones (Hays and Holl, 2003; Loeser *et al.,* 2006). In our study, plant cover was used as a proxy to abundance and this would suggest that grazing did not affect the abundance of plant species. It could also be an indication that plant cover at the site level is not a good indicator of the impact of grazing. This could be due to some species with disproportionately high mean cover in the grazed sites masking the impact of grazing on plant cover.

The foregoing assertion that plant cover may not be a good indicator of impact of grazing was supported by higher evenness in the non-grazed site than in the grazed one. This suggests that species in the grazed site were unequally distributed in terms of abundance (Legendre and Legendre, 2012). Species that had significantly higher mean cover in grazed sites were *Melinis repens*, a pioneer, unpalatable species found in disturbed sites, *Paspalum notatum*, an aggressive grass that invades disturbed sites including active pastures that is a threat to native species and *Panicum natalanse*, an unpalatable grass species (Outshoorn, 2014). These species indicate that the grazed site is disturbed and degraded. *Melinis repens* is an increaser II grass that increases in abundance in over-grazed areas while *Panicum natalanse* is a decreaser grass which decreases in abundance in overgrazed areas (Outshoorn, 2014). Therefore, high abundance of *M. repens* in grazed sites in our study could be an indicator that they are overgrazed. The high abundance of *P. natalanse* could be due to its unpalatability due to hard and rolled leaves leading its rare utilization by grazers (Outshoorn, 2014).

Other species such as *Themeda triandra* and *Eustachys paspaloides* had lower mean cover in grazed sites than non-grazed ones. These species are highly palatable and decreasers (Table 4) whose abundance reduces in response to grazing (Outshoorn, 2014). Therefore, their contrasting mean cover between the treatments shows that due to their palatability hence they were preferentially selected by cattle resulting in their lower abundance (Szaro, 1989; Gemedo *et al., 2*006; Rutherford *et al., 2*012). The increase in grazing releases plant competition resulting in a rapid increase in species that are either actively resistant to grazing or passively resistant ones through unpalatability (Hiernaux, 1998). In grazed areas, only species which are resistant to grazing persist, and there is low competition as few plants are resistant to grazing (Belovsky, 1978). It is for this reason that plants which can persist in the face of grazing are in higher abundance in grazed sites. Moreover, herbivores generally reduce competition by consuming the competitively dominant species (McNaughton, 1985).

Some species such as *Berkheya zeyheri* and *Thunbergia atriplicifolia* were exclusively found in non-grazed areas. These areas provide refuge niches for species that are intolerant of grazing while grazed sites promote the colonization of opportunistic species due to release of plant competition (Lavorel *et al.,* 1994; Bullock *et al.,* 1995). However, with increasing grazing pressure, refuge niches are minimized and cannot maintain their function of protecting grazing sensitive species (Hiernaux, 1998). In our case, this could imply that these species did not withstand the impact of grazing and were excluded from the grazed area.

Conclusion

Our study found that grazing reduced plant species diversity, richness, cover and density. In terms of grasses it was found that grazing had a negative impact on highly palatable and decreaser plant species. We recommend that the correct livestock stocking rates and rotational grazing should be used to minimize the deteriorating impact of grazing on vegetation in our study area. We also recommend for long-term studies on the effect of grazing intensity on plant species diversity in this study area. This will improve our understanding of the response of plant cover to grazing. Such studies should also investigate the impacts of grazing on soil nutrients and physical structure.

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