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Forage Availability and the Effects of Dry Season Patch Burning on Diet and Habitat Selection by the Common Eland in Eland Sanctuary Park, Zimbabwe

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ABSTRACT

Common elands are also kept in small fenced areas where they utilise different habitats in search of forage when scarce. Ecologists need to understand forage availability and determine how dry season patch burning can influence diet selection of the common elands in protected areas and this prompted the study in the Eland Sanctuary Park. Two sites were selected: i.e. burnt and unburnt. The burning exercise was done on the 16th of June, 2023 and the area was left for two weeks for regrowth. Forty random sample plots were set on the 1st of July, 2023, consisting of twenty-four in unburnt and sixteen in burnt site each of size 25m x 25m. Data collection was done from the 1st to 10th of July, 2023, recording number of plant species utilised and eland spoors in each plot. Plant species selectivity was determined using preference ratios and frequencies of acceptance which was calculated at species level. Mann-Whitney U-test was used to determine the significant differences in common eland spoor density between burnt and unburnt areas at $p = 0.05$ after the Kolmogorov-Smirnov normality test at $p = 0.005$ ($N = 24$, $P = 0.070$). Results showed that *Macaranga capensis, Pinus patula,* and *Sclerocarya birrea* had a high preference ratio in the unburnt area, while, *Laodetia simplex, Cymbopogon plurinodis,* and *Themeda triandra* had a high acceptance rate after burning. However, there was no strong correlation between spoor abundance and number of plants utilised in both burnt and unburnt areas. Ecologists should acknowledge dry season patch burning at intervals to facilitate regrowth and retain forage palatability for the common eland.

INTRODUCTION

Forage utilisation by herbivores in relation to availability vary in different geographic regions due to local area vegetation composition and type of forage available (Furstenburg, 2018). The variable nature of environments such as semi-arid savannahs and subtropical grasslands create challenges for the conservation of wildlife, particularly in fenced, insular protected areas (Parrini *et al*, 2019). Large mammalian herbivores inhabiting these spatially and temporally heterogeneous environments with periods of seasonal scarcity face the challenge of securing adequate forage (Wilmshurst *et al*, 1999). However, mixed feeders like the common eland (*Tragelaphus oryx*) can switch between browsing and grazing in response to seasonal variation in the abundance and quality of forage (Parrini *et al*, 2019).

Common elands are highly mobile in dry season and this is related to forage scarcity (Hillman, 2008). The common eland moves around in search of habitats that meets their forage requirements and at times move out of their environments. During dry season, common elands mostly browse while switching to grazing only on new growth grasses after the early rains in the Southern of Africa (Buys, 1987). However, it has been reported by Furstenburg (2018) that in East Africa, annual diet of common eland contains up to 50% of monocotyledons, while Watson & Owen-smith (2001) and Harris (2010) reported that throughout the year common elands can switch from browsing to grazing depending on the availability of local food.

Common elands are highly mobile in dry season and this is related to forage scarcity (Hillman, 2008). In Eland Sanctuary Park, Zimbabwe, in dry season elands have been observed moving out of the park. Dube (2020) mentioned that the common eland moving into the communal area in search of food during dry season expose the animals to poaching. One strategy to meet this challenge is to make use of fire through patch burning to provide high-quality nutritional grass that can sustain individuals during dry season. Through burning, protected area managers alter both herbivores' foraging behaviour and habitat choices as fire clears long, dry, low-nutritious grass hence facilitating new growth (Mahakata & Mapaure, 2022). Stoklasová & Hejcmanová (2019) pointed out that new grass growth after a fire has high protein levels and thus attracts common elands and other herbivores (Watson & Owen-smith, 2000). Grass biomass decreases whereas forage quality increases when the area is burnt (Anderson *et al*, 2020).

Habitat suitability assessment conducted by Dube (2020) in the Eland Sanctuary Park to determine food availability recommended supplementary feeding to keep common elands within the reserve during dry season by maintaining the species' required quality forage. Use of fire through patch burning is known to maintain the quality of the forage (Lemon, 1968). Therefore, this habitat manipulative criteria can be used as a method to supplement forage during dry season in a reserve. Sprouting grass has a higher content of protein, calcium and phosphorus (Wagner, 2008) hence attracts selective feeders like the common eland.

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In the Eland Sanctuary Park, management fires are used as a strategy mainly for peripheral burning to control fires from encroaching into the protected area. Use of a combination of peripheral burning with low-intensity patch burning has been agreed as a strategy to keep a balance between natural fire regimes and biodiversity (Yarnell *et al*, 2016). Parrini *et al*. (2019) mentioned the selection of grasses versus browse in the seasonal diet of eland as site-specific and dependent on the availability of protein-rich and fibre-deficient forage (Watson & Owen-Smith, 2001). Given the challenge for a large herbivore to acquire sufficient nutrition from a variable and generally poor food source, habitat selection of common eland in connection to forage quality and post-fire effect has been debated for the last century.

Therefore, the objectives of the study were: 1). to determine dry season plant species utilised by common elands, 2). to identify potential dietary changes as a result of manipulative burning during dry season and 3). to determine influence of management fires on habitat selection through comparing spoor density between burnt and unburnt areas in Eland Sanctuary Park. The study provides insight into how fires can be used to facilitate dry season regrowth.

MATERIALS AND METHODS

Study area

The study was conducted in the Eland Sanctuary Park (Figure 1), located at the north western side of the Chimanimani Town at altitude 1470m above sea level. It is 18km^2 in size and partially fenced.

Eland Sanctuary Park is surrounded by various land-uses such as timber plantations, urban settlements, indigenous forest farms and communal settlements. Climate of the area is generally considered humid tropical to temperate with temperatures ranging between of 18−23^{0}C in summer (November-April) while 8−15^{0}C in winter season (May-August). Rainfall ranges between 1200 and 2000mm per year. Due to favourable temperatures and winter rains, grass regrowth during dry season after fires

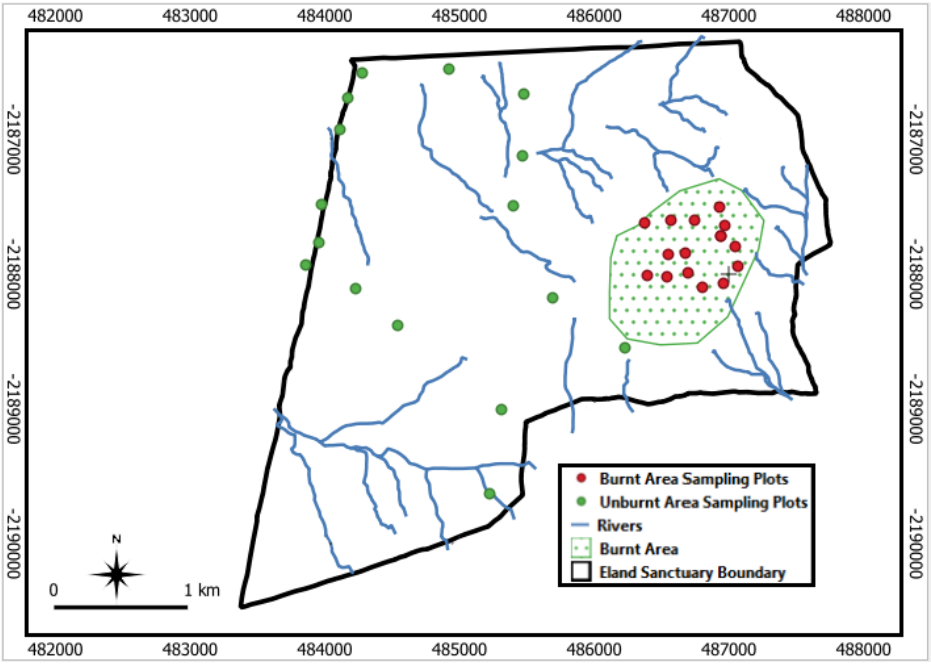

Figure 1: Map of Eland Sanctuary showing sampled plots in burnt and unburnt blocks

occur. Wildlife is not abundant, but includes species such as eland, bushbuck and common duiker. Miombo woodlands occupies the slope areas, montane woodland the central parts while montane grasslands are found on higher grounds in the eastern side of the park. Dominant tree species include *Uapaca kirkiana, Brachystegia spiciformis, Julbernardia globiflora* and *protea spp*. The grass species found are *Hyperhania* species, *Loudetia simplex* (russet grass) and *Themeda trianda* (rooi grass) dominating the montane grasslands. The grasses are mostly sourveld species which provide very low nutrient values for grazers and becomes unpalatable during dry season as they mature and dry.

Sampling Design

The survey was conducted in two selected sites (Burnt and unburnt) of the Eland Sanctuary Park. The sites share similar variables like soil types, water availability and vegetation types. The vegetation at both sites is classified as montane habitats consisting of grasslands, shrubs and woodlands. A management fire was applied on an experimental basis in the eastern side of the park on 16 June, 2023, burning 2km^2. The rest of the Eland Sanctuary Park was left unburnt to act as the control site. The burnt area was left for two weeks before setting plots, during which grass regrowth was observed.

Data Collection

Random plots sites coordinates were then generated using QGIS-Software tool. The coordinates were entered into a Handheld Global Positioning System (GPS) device

Etrex-10 and then navigate to the point. Each point was used as the North-East corner and plots of 25m x 25m were set. The plots were pegged on the ground with four plastic pegs using a 50m tape measure. Three researchers were involved in day time data collection done from the 1st of July, 2023 to the 10th of July, 2023. Sixteen randomly selected plots were set in the burnt site and 24 plots of similar size, in unburnt site for sampling purposes. It was assumed that plots were rightly placed within the preferred common eland feeding sites. In each plot, the following were recorded; plant species available, name and number of plants species consumed, number of bites for each species and number of common eland spoors. The plant species name was recorded where evidence of a fresh bite sign was observed. Plants in each plot were identified to the species level. Field identification guides was used for species identification (Field guide to trees of Southern Africa (Wyk & Wyk, 1997), Identification guide to Southern African grasses (Fish *et al*, 2015), Handbook on weed identification (Naidu, 2012), (Herbaceous plants Gowanus field guide (Gruberg *et al.* 2020). Plants were categorized into different forage types according to Vleix *et al.* (2011): grasses, herbaceous forbs, shrubs (height between 30cm and 3m), trees (height >3m), creepers, seedlings (woody species less than 30cm in height) and woody forbs and shrublets or dwarf shrub (Gill, 2012).

Data Analysis

Plant Species Utilisation by the Common Eland

A list of all plants consumed by the common eland were listed and preference ratios (PRs) for each habitat (Burnt and unburnt) was calculated based on frequency of acceptance of the plant species using the formula adopted from (Viljoen, 1989);

Preference Ratio (PR)=(% Utilisation (U))/(% Availability (A))

Where % Utilasation (U) = (Number of utilised plants of a given species per plot/Total number of utilised plants of all species within the same area) x 100.

And, % Availability = (Number of available plants of a given species per plot/Total number of available plants of all species within the same site) x 100.

Frequency of acceptance of plant species in burnt and unburnt sites to determine plant species selectivity by the common eland was calculated using a formula adopted from (Owen-Smith & Cooper, 1987b):

Frequency of acceptance=(Number of plots in which a plant species had been recorded as eaten)/(Total number of plots in which it had been recorded present

Dietary Contribution of Plant Species

The dietary contribution of each plant species in the dry season was calculated using a formula adopted from (O'Shaughnessy *et al*., 2014):

Dietary contribution=(Number of bites recorded for each plant species)/(Total number of bites recorded across all the plant species)

As adopted from Ammando (2016), dietary contribution was compared for grass and browse species between burnt and unburnt sites utilised by the common eland in the study area.

Common Eland Spoor Density in Burnt and Unburnt Sites

Mann-Whitney U-test was used to determine for significance differences in common eland spoor density between burnt and unburnt area at $p = 0.05$. Data was first tested for normality using the Kolmogorov-Smirnov at $p = 0.005$ and was not normal ($N = 24$, $P = 0.070$). Spoor density was calculated at plot level using a derived formula for each plot;

Spoor Density/plot=(Number of spoors)/(Plot size (m^2))

RESULTS

Plant Species Utilisation and Preference Ratios

List of all plants (Grasses, trees, shrubs and forbs) consumed/ utilised by the common eland in burnt and unburnt areas of the Eland Sanctuary Park were presented in table form and ranked based on their Preference Ratios. Frequency of acceptance of grasses (acceptance ≥0.75) was high in the burnt site than the unburnt site (Fig 2.) with *Laodetia simplex, Cymbopogon plurinodis, Themeda triandra* and *Setaria sphacelata* as the highly preferred species (Table 2). Trees and shrubs had high frequency of acceptance ratio in the unburnt site than the burnt site with *Macaranga capensis, Pinus patula, Alysicarpus monilifer* and *Sclerocarya birrea* as the highly preferred species. Forbs, shrublets and woody forbs were highly accepted in the

Table 1: Dry season plant species utilisation and preference ratios by the common eland in the Eland Sanctuary Park

Species name	Number present	Number utilisation	% Utilisation (U)	% Availability (A)	Preference Ratio (U/A)
Macaranga capensis	11	9	0.0382	0.0051	7.466
Pinus patula	92	73	0.3104	0.0428	7.241
Alysicarpus monilifer	1200	936	3.9809	0.5593	7.118
Sclerocarya birrea	18	14	0.0595	0.0083	7.097
Grewia spp	25	19	0.0808	0.0116	6.935
Burkea africana	29	21	0.0893	0.0135	6.608
Mimosa pudica	1151	817	3.4748	0.5364	6.477
Canthium inerme	31	22	0.0935	0.0144	6.476

Acacia spp	17	12	0.0510	0.0079	6.441
Ammania baccifera	900	632	2.6879	0.4194	6.408
Physalis peruviana	19	13	0.0552	0.0088	6.243
Bidens pilosa	3683	2416	10.2756	1.7166	5.986
Combretum spp	28	18	0.0765	0.0130	5.866
Mystroxylon aethiopicum	39	24	0.1020	0.0181	5.615
Ziziphus mucronata	17	10	0.0425	0.0079	5.368
Deodenum spp	1014	581	2.4710	0.4726	5.23
Prunus africana	15	8	0.0340	0.0069	4.867
Vitis acerifolia	945	455	1.9351	0.4404	4.394
Atriplex elegans	1257	557	2.3690	0.5858	4.043
Long leaved alyce clover	7763	3431	14.5925	3.6183	4.033
Cocculus hirsutus	879	347	1.47584	0.4096	3.602
Plumbago zeylanica	683	236	1.00374	0.3183	3.153
Rumex dentatus	954	328	1.3950	0.4446	3.137
Khaki weed	351	113	0.4806	0.1635	2.938
Chloris barbata	1031	312	1.3269	0.4805	2.761
Cassia pumila	3913	974	4.1425	1.8238	2.271
Alloteropsis semialata	9257	2030	8.6338	4.3146	2.001
Brachiaria ramosa	5918	1173	4.9889	2.7583	1.809
Ageratum conyzoides	353	67	0.2849	0.1645	1.732
Amaranthus palmeri	3183	595	2.5306	1.4835	1.706
Aristida spp	5609	1021	4.3424	2.614	1.661
Tridax procumbens	4199	737	3.1345	1.9571	1.602
Laodetia simplex	9131	1569	6.6731	4.2559	1.579
Blumea wightiana	1352	230	0.9782	0.6301	1.552
Abelmoschus moschatus	5108	744	3.1643	2.3808	1.33
Andropogon appendiculutus	3089	353	1.5013	1.4397	1.043
Setaria sphacelata	9101	912	3.8788	4.2419	0.914
Tristachya leucothrix	5554	443	1.8841	2.5886	0.728
Themeda triandra	10255	542	2.3052	4.7798	0.482
Cyperus brevifolius	3732	165	0.7017	1.7394	0.403
Lolium multiforum	3512	83	0.3530	1.6369	0.216
Harpochloa falx	8943	211	0.8974	4.1682	0.215
Digitaria eriantha	5789	63	0.2679	2.6982	0.099
Cymbopogon plurinodis	7994	83	0.3530	3.7259	0.095
Imperata cylindrica	3096	27	0.1148	1.4430	0.08
Eragrostis curvula	4657	32	0.1361	2.1706	0.063
Semialata eckoniana	3354	15	0.0637	1.5632	0.041
Hyparrhenia spp	8462	25	0.1063	3.9441	0.027
Melinis nerviglumis	9026	14	0.0595	4.2069	0.014

Table 2: Dry season plant species utilisation and preference ratio by the common eland after patch burning in the Eland Sanctuary Park

Species name	**Number present**	**Number utilisation**	**% Utilisation (U)**	**% Availability (A)**	**Preference Ratio (U/A)**
Laodetia simplex	657	502	8.5461	1.6011	5.337
Cymbopogon plurinodis	113	83	1.4130	0.2753	5.131
Themeda triandra	466	319	5.4307	1.1356	4.782

Setaria sphacelata	1532	912	15.5260	3.7335	4.158
Eragrostis curvula	59	32	0.5447	0.1437	3.789
Andropogon appendiculutus	700	353	6.0095	1.7059	3.523
Tristachya leucothrix	887	443	7.5417	2.1616	3.489
Alloteropsis semialata	4486	2030	34.5590	10.9326	3.161
Bidens pilosa	561	245	4.1709	1.3671	3.051
Imperata cylindrica	69	27	0.4596	0.1681	2.733
Deodenum spp	342	122	2.0769	0.8334	2.492
Atriplex elegans	345	118	2.0088	0.8407	2.389
Harpochloa falx	711	211	3.5921	1.7327	2.073
Alysicarpus monilifer	81	23	0.3915	0.1974	1.984
Tridax procumbens	226	59	1.0044	0.5507	1.824
Aristida spp	142	30	0.5107	0.3411	1.497
Digitaria eriantha	325	63	1.0725	0.7920	1.354
Melinis nerviglumis	81	14	0.2383	0.1974	1.207
Amaranthus palmeri	618	82	1.3959	1.5061	0.927
Hyparrhenia spp	193	25	0.4256	0.4703	0.905
Long leaved alyce clover	109	14	0.2383	0.2656	0.898
Semialata eckoniana	120	15	0.2553	0.2924	0.873
Abelmoschus moschatus	1430	72	1.2257	3.4849	0.352
Brachiaria ramosa	2420	80	1.3619	5.8976	0.231

unburnt site than the burnt site. Grasses had very low dietary contribution on the unburnt site (0.43%) whereas shrublets and woody forbs; trees, shrubs and seedlings had a high dietary contribution on the unburnt site (38.4% and 34.2% respectively). In burnt sites, grasses constituted the dominant food item (86.1%) after regrowth.

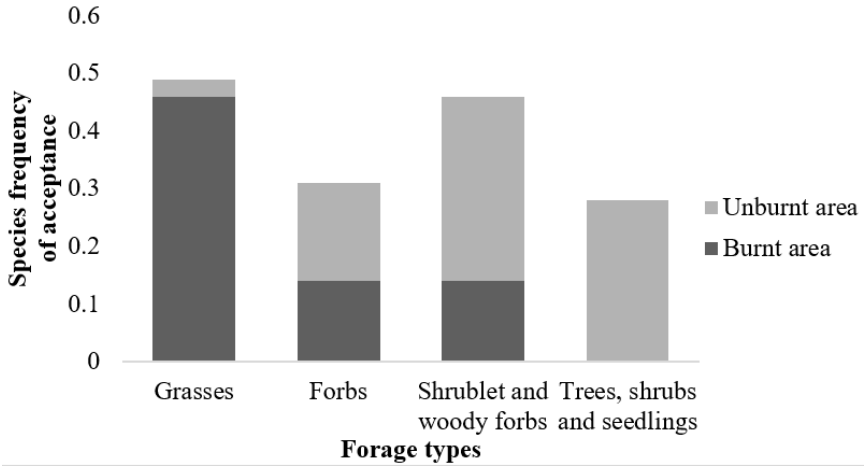

Figure 2: Site-based frequency of acceptance of plant species based on forage types in dry season

Spoor Density of the Common Eland between Burnt and Unburnt Areas of the Eland Sanctuary

The common eland preferred burnt areas (Mean spoor density = 158.125) than unburnt areas (Mean spoor density of 43.333). There was significant difference on number of spoors recorded between the two sites (Burnt and unburnt) at p-value (0.000).

Test of $n_1 = n_2$ vs $n_1 \neq n_2$ is significant at 0.000. The test is significant at 0.000 (adjusted for ties). However, there was no strong correlation between spoor density and number

Table 3: Mann-Whitney U-test for spoor abundance in burnt and unburnt areas

	Mann-Whitney U-test for spoor abundance in burnt and unburnt areas					
	n	**Median**	**n_1-n_2**	**95% CI**	**w**	**p-value**
Burnt	16	17	13	(8.000, 16.000)	493.0	0.00
Unburnt	24	4				

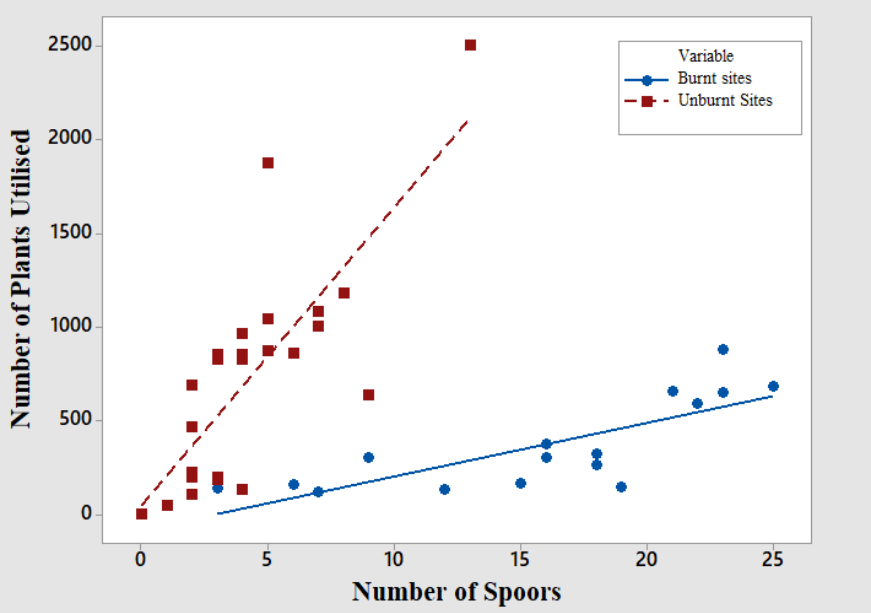

Figure 3: Correlation between common eland spoor abundance and number of plants utilised in burnt and unburnt habitats

of plants utilised in each site (Figure 2).

Results showed weak correlation between number of spoors and plants utilised in unburnt habitat while a relatively weak correlation in burnt habitat. Therefore, common eland habitat selection could not be directly linked to forage utilisation in both unburnt and burnt habitats

DISCUSSION

Common Eland Plant Species Utilisation in Eland Sanctuary Reserve

The common eland demonstrated differences in species utilisation during dry season, preferring trees and forbs to grass species. They increased their use of dry grassland on the burnt site, where green grass regrowth was available. *Macaranga capensis, Sclerocarya birrea* and *Pinus patula* (an exotic tree encroaching from the nearby plantations) were the most utilised woody species with highest preference ratios to other plants. Browsing during dry season contributed 88.1% of all species utilised while grazing contributed only 12.9% in unburnt areas. Grass species of *Cymbopogon plurinodis, Themeda triandra* and *Laodetia simplex* were also utilised by common eland during dry season but with low utilisation. The diet of the common eland in dry season was dominated by trees, seedlings and shrubs whereas mature grasses were less preferred. In contrary, Furstenburg (2018) have shown that grasses always form more dietary intake of the common eland at any time of the year. However, most grass species become sour and unpalatable in dry season. D'Ammando (2016) suggests that habitat selection by the ruminants for grazing or browsing is determined by forage quality than the quantity.

Potential Dietary Changes as a Result of Manipulative Burning During Dry Season

Common eland demonstrated clear shifts in dietary use between burnt and unburnt sites. It moved from a

Figure 4: Elands grazing in burnt sites in the Eland Sanctuary

diet dominated by browse on the unburnt site to one relatively high in grasses after regrowth. The common eland concentrated foraging activities on the burnt site where green grass regrowth was available. The diet of the common eland in the Eland Sanctuary Park was dominated by grass species, such as *Cymbopogon plurinodis, Themeda triandra* and *Laodetia simplex* and browse species such as *Macaranga capensis, Sclerocarya birrea* and *Pinus patula* in the burnt area.

Changes in dietary use by eland is likely influenced by fire and season which affects palatability and freshness of plant species. Our study reviewed that patch burning to promote regrowth facilitates removal of dry season sour grasses with fresh leaves. Burning promoted selection of once unpalatable dry season grasses to regaining highest preference ratios by common eland. After burning, percentage of grasses utilised contributed 86.1 while browsing contributed only 13.9. Our findings agree to what was established by other researches which pointed out that common eland prefer utilising sprouting grasses after burning (Wagner 2008; Goodenough *et al*, 2022).

Common elands grazing on a burnt site and browsing on the unburnt site suggested that it selected the most available green species during the dry season. In a similar way, other studies have shown that the common eland selects woody plants offering the greatest number of green leaves in dry season and green grasses after a fire (Kerr *et al*, 1970; Mahakata & Mapaure, 2022). However, according to Kerr *et al*, (1970) common eland reverts to unpalatable plant species as soon as they produce new growth and they can quickly switch to browsing once the grass species become unpalatable.

Influence of Management Fires on Dry Season Habitat Selection by Common Eland in Eland Sanctuary

Our study revealed that common elands can utilise different habitats (i.e. burnt and unburnt) depending on availability of their requirements. There is evidence that common elands can quickly switch from browsing to grazing during dry season if new growth are available. We record a significant difference in spoor density between burnt and unburnt areas (p-value = 0.000). Presence of preferred species in an area can contribute to common eland habitat selection according to Wierik (2016). According to Harris (2010) common elands can utilise different habitats in search of food and easily tamed to a site. However, our results reports weak correlation between spoor density and number of plants utilisation. This suggest that common eland use of different sites does not necessarily reflect obvious forage utilisation although they were more attracted to burnt sites with fresh grasses. Accordingly, habitat manipulation through early dry season patch burning can be applied to bridge the forage quality from maturing plants as dry season sets and most grass species becomes unpalatable. Use of management fires to improve quality of grasses for common eland and other species in dry season as a way to supplement forage is important.

CONCLUSION

Common elands utilises trees, shrubs, seedlings and forbs mostly during dry season. *Macaranga capensis, Alysicarpus monilifer* and *Pinus patula* remain the most preferred forage for browsing. However, with use of management fires to facilitate new growth during dry season, common elands quickly switched to grazing. The most targeted species were *Laodetia simplex, Cymbopogon plurinodis, Themeda triandra* and *Setaria sphacelata*. During dry season, common eland concentration in burnt areas was high than in unburnt areas. The use of management fires as a way to facilitate new growth for dry season grazing by the common eland should be acknowledged by protected area managers in the Eland Sanctuary Park as a way to supplement dry season forage and retaining common elands within confines. Studies to establish burning intervals of blocks on rotational basis during dry season are recommended.

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