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Forage preference of the greater kudu *(Tragelaphus strepsiceros)* in a miombo woodland adjacent to Umfurudzi Park, Zimbabwe

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Abstract: Understanding the diet of herbivores is a crucial factor for the management of wild animals in natural ecosystems. The aim of this study was to establish the forage selection by the greater kudu *(Tragelaphus strepsiceros)* in different seasons in Garura communal area management programme for indigenous resources (CAMPFIRE) project adjacent to Umfurudzi Park, Zimbabwe. The direct observation method was used to collect data on the woody species foraged by the greater kudu, where field observations were conducted to determine woody species consumed by the greater kudu at the feeding sites across two seasons, dry (September to October 2015) and wet season (December 2015 to January 2016). A total of 17 out of 38 woody species were recorded as being preferred by the greater kudu. There was no significant difference in the diversity, acceptance and availability of forage by greater kudu across seasons. The main five commonly utilized woody species across both seasons were *Ficus coronata, Savanna*

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PUBLIC INTEREST STATEMENT

Though the diet of large herbivores has been extensively studied, understanding the feeding ecology of introduced free-ranging greater kudu *(Tragelaphus strepsiceros)* under the Communal Areas Management Programme for Indegenous Resources (CAMPFIRE) is important for monitoring and making appropriate habitat management decisions under potential competing land use options. This study established the forage selection by introduced greater kudu in Garura communal area adjacent to Umfurudzi Park, Zimbabwe. It was found that the greater kudu is adaptable to a broad range of habitats as evidenced by the wide spectrum of woody plant species selection. While introductions and re-introductions of herbirvores to areas they formally occupied are on-going under species restoration programs, it is important to carryout habitat suitability assessment as per the International Union for Conservation of Nature (IUCN) recommendations before and after such introductions. This is so as significant habitat changes could have taken palce with a huge bearing on introduced species survival and health.

dwababerry, Dalbergia nyassae, Gymnosporia senegalensis and *Bauhinia petersiana*. Results revealed that seasonality did not have any influence on forage selection on woody species in the study area.

Subjects: Animal Behaviour; Animal Ecology; Biodiversity & Conservation

Keywords: abundance; acceptability; availability; browsing; foraging behaviour; herbivores; woody species

1. Introduction

The greater kudu (*Tragelaphus strepsiceros)* is one of the largest antelopes of the world and of great economic value. The greater kudu are browsing ruminants found through much of Eastern and Southern Africa even outside of conservation areas (Skinner & Smithers, 1990). The greater kudu mainly browse on woody plant leaves and forbs plus some fraction of grass material (Owen-Smith, 1993, 1979). This implies that some herbivores, like the greater kudu, do not feed on plants at random, but display marked food preferences (Colebrook, Black, Purser, Collins, & Rossiter, 1990). Feed preferences can be attributed to relative spatial and temporal availability of particular plants (Belovsky and Schmitz, 1991).

Bergström (1992) suggested that there is an active interaction between browsers and woody plants, in that woody plants respond to browsing and have an impact on foraging or feeding behaviour. Browsers have been shown to choose plants with high growth rates over plants with slow growth rates (Danell, Huss-Danell, & Bergstrom, 1985). Selection of diet items may sometimes be a function of quality and other times a function of quantity (Shipley, Illius, Danell, Hobbs, & Spalinger, 1999). Foraging behaviour is an important ecological process that describes the relation between plant communities and herbivores. This foraging behaviour is influenced by various plant characteristics such as plant availability, plant chemical composition and plant defense; as well as animal factors including body size, digestive physiology, and experience (Pellew, 1984; Owen-Smith & Cooper, 1987). Further, Rooney et al. (2000) states that the degree of ungulate browsing on a woody species clearly depends on their inherent preferences, which in turn may vary in response to local differences in plant abundance and palatability.

The feeding strategy of herbivores is continually modified as the availability and nutritional quality of food items varies seasonally and between and amongst species (Owen-Smith, 1994; Senft et al., 1987). The diet assessment of herbivores is, thus, important for the understanding of resource requirements and provides insight into herbivore impacts on an ecosystem as well as animal populations (Parker & Bernard, 2006; Tanentzap et al., 2009).

The feeding ecology of free-ranging greater kudu has been researched extensively in some non miombo woodland ecosystem and in protected areas, including research into diet selection (Codron et al., 2007; De Garine-Wichatitsky, Fritz, Gordon, & Illius, 2004; Hooimeijer et al., 2005; Owen-Smith, 1994; Owen-Smith & Cooper, 1987). However, limited knowledge exists on the foraging of greater kudu in miombo woodlands and in community managed protected areas. Since the greater kudu were introduced in Garura communal area management programme for indigenous resources (CAMPFIRE) project adjacent to Umfurudzi Park, Zimbabwe in 2011 there is a dearth of information on how the species utilises its habitat. This study therefore aimed to establish the forage selection by the greater kudu in different seasons in Garura CAMPFIRE project adjacent to Umfurudzi Park, Zimbabwe.

2. Materials and methods

2.1. Study area

Garura CAMPFIRE Project area which is 50 ha in extent lies in the Maramba District of Mashonaland East Province and it is also an ecotourism project dominated by miombo woodland. The study area is adjacent to Umfurudzi Park, Zimbabwe. The study area is found in Natural Region IV at an altitude range of 940 to 960 m. The area receives erratic rainfall ranging from 450 to 900 mm annually (Chimanikire, Chikwari, Manyevere, & Mutawarira, 2005). Maximum temperatures are recorded in summer ranging from 24°C to 30°C and minimum temperatures are recorded during winter ranging from 19°C to 23°C.

Red soils which are shallow to moderately shallow on middle to upslope positions are common. The vegetation is dominated by *Bauhinia thonningii* and *Diospyros kirkii*, with *Terminalia sericia, Parinari curatellifolia* and *Ficus capensis* also being part of the vegetation classification of the area (Muposhi et al. 2016). Also the area contains *Brachystegia boehmii* and *Julbernardia globiflora* as part of its vegetation, thus classifying it as a miombo woodland (White 1983). Large herbivores in the study area include eland (*Taurotragus oryx*), greater kudu and giraffe (*Giraffa camelopardalis*) (Munyaka & Gandiwa 2018).

2.2. Data collection

The study population consists of 12 greater kudu individuals which were observed for foraging records. Forage availability and acceptability were used as indices of forage preference. To determine the forage preference of the greater kudu, the direct observation method was used to collect data on foraging (Mills 1992). Since the greater kudu is mainly active during the early morning and late afternoon, data was collected during these day periods. Four hour sessions were undertaken for observations of greater kudu in the day sessions, such that 2 hours were completed during the morning (06:00–08:00 hrs) and 2 hours in the afternoon (14:30–16:30 hrs). Feeding animals were observed from a distance of 50–300 m to avoid disturbing them, with the aid of 10 × 40 Nikon binoculars and a stop watch to observe the feeding time. A greater kudu was recorded as foraging when it was bitting twigs, stripping and picking leaves from a woody species. A focal animal was randomly selected from the feeding herd and each animal was observed for a maximum of 15 minutes after which a new observation was done. If a greater kudu started browsing on a different tree, it was recorded as a new observation and time would be reset.

A feeding record was defined as each instance in which one plant was consumed by 1 animal during a particular scan. Therefore, if 10 greater kudu were foraging on the same tree during a scan, there would be 10 feeding records for that species for a scan. After records were made and the greater kudu had left, the feeding site was visited to verify the browsed species. A total of 60 (20 m × 20 m) plots were established in order to collect an inventory of plant species present in areas where greater kudu foraged. Woody species composition in the plots was recorded taking note of both the browsed and non- browsed species.

Data collection was conducted between October 2015 and January 2016. Observations were grouped into two seasons: dry season (September and October) and wet season (December and January). The selected woody species were used to establish forage preference of the greater kudu.

2.3. Data analysis

Data were first tested for normality using the Shapiro-Wilk test and data conformed to the normality assumptions. Preference was quantified by calculating preference indices (acceptability and availability) of the species in the diet of greater kudu. Based on the woody species selected by the greater kudu, acceptability and availability was determined using the following approaches as described by Magome, Cain Iii, Owen-Smith, and Henley (2008); availability: number of plots in

which the woody species was present divided by the total number of plots *(n)*; and *a*cceptability: number of plots in which the woody species was eaten divided by the number of plots in which the species was present. To test for any variations in the forage indices of woody species across seasons, independent samples *t*-test was performed using the Statistical Package for Social Sciences version 16.0 for Windows (SPSS Inc, Chicago, USA).

3. Results

A total of 38 woody species were recorded from the feeding sites of greater kudu in the study area during the study period. Of these species, greater kudu were observed to have selected about 17 and 16 woody species for the dry and wet season respectively. Diversity of the selected woody species was similar across the seasons, i.e., dry season (1.40 ± 0.78) and wet season (1.54 ± 0.78) (t test, df = 58, t value = −0.67, P = 0.500).

Most trees in the *Fabaceae* family were not acceptable or preferred species by the greater kudu during the study period. The availability (dry season (0.41 ± 0.16) and wet season (0.46 ± 0.22) (t = −1.00, df = 58, P = 0.320)) and acceptance (dry season (0.36 ± 0.21) and wet season (0.40 ± 0.21) (t = −0.69, df = 58, P = 0.500) of woody species foraged by greater kudu between the dry and the wet season were not significantly different.

During the dry season, *Dalbergia melanoxylon, Ficus coronata, Savanna dwababerry, Dalbergia nyassae* and *Gymnosporia senegalensis* were the top 5 woody species that were highly preferred (Table 1). These species showed the highest acceptance frequencies thus these were highly preferred. In the wet season, the top 5 most accepted species were *Flacourtia indica, Dichrostachys cinerea, Gymnosporia senegalensis, Savanna dwababerry* and *Bauhinia petersiana* with *Flacourtia indica* appearing to be highly preferred. Generally most of the woody species were commonly utilized across all seasons. The top five commonly utilized species across both seasons were *Ficus coronata, Savanna dwababerry, Dalbergia Nnyassae, Gymnosporia senegalensis* and *Bauhinia petersiana*. Some species were uniquely utilized in either one of the seasons. For example, *Trichilia emetica* and *Combretum paniculatum* were only accepted in the dry season while *Grewia monticola* was only accepted in the wet season.

4. Discussion

Our results showed a non-significant difference in species diversity across the seasons in the study area. High disturbance as a result of browsing and herbivore trampling has been reported to negatively influence species diversity (Mukaru & Mapaure, 2012). Further, our results showed that during the dry season, unarmed woody plants such as *Dalbergia melanoxylon, Ficus coronata, Savanna dwababerry, Dalbergia nyassae* and *Gymnosporia senegalensis* were mostly preferred species for forage. This corroborated with the results of a study by Owen-Smith and Cooper (1987), where unarmed plants (without thorns) such as *Combretum* species became utilized relatively more than the *Acacias* and other prickly species as the dry season advanced.

In the dry season, *Acacia tortilis* and *Acacia nigrescens* which were the most abundant food source in the area were not part of the highly accepted species. Bryant and Kuropat (1980) attributed the non preference of such species to their ability to produce secondary chemical compounds for defence which deterred kudus. The low acceptability of the *Acacia* species might also be due to the species having less forage material as *Acacia* species lose their leaves in the dry season. Our study findings collaborate with those of Arnold (1981) who revealed that herbivores select diets based on the concentration of nutrients relative to toxins rather than on their abundance.

Tree species in the *Apocynaceae* family were non-browsed by greater kudu in this study, and according to Van Wyk and Gericke (2000) trees in this family have been described to have a low acceptability, probably due to the strong resinous smell that is released when their leaves are browsed. The selection of *C. mopane* browse by greater kudu, particularly during the dry season, is

Table 1. Seasonal availability and acceptance of woody species selected by the Great Kudu in Garura CAMPFIRE project area

Species	Family	Dry season		Wet season	
		Availability[a]	Acceptability[b]	Availability[a]	Acceptability[b]
Dalbergia melanoxylon	Fabaceae	0.03	1	0.13	0.25
Ficus coronata	Moraceae	0.27	1	0.23	0.95
Savanna dwababerry	Annonaceae	0.37	0.73	0.17	0.84
Dalbegia nyassae	Fabaceae	0.37	0.73	0.1	1
Gymnosporia senegalensis	Celastraceae	0.43	0.58	0.07	2
Ximenia caffra	Olacaceae	0.5	0.53	0.3	0.5
Bauhinia petersiana	Fabaceae	0.6	0.5	0.17	0.86
Trichilia emetica	Meliaceae	0.2	0.5	-	-
Burkea africana	Caesalpiniaceae	0.3	0.44	0.17	0.8
Diospyros mespiliformis	Ebenaceae	0.23	0.43	0.17	0.2
Acacia tortilis	Fabaceae	0.67	0.4	0.4	0.83
Flacourtia indica	Salicaceae	0.43	0.31	0.1	0.96
Colophospermum mopane	Fabaceae	0.53	0.25	0.2	1
Combretum paniculatum	Combretaceae	0.13	0.25	-	-
Dichrostachys cinerea	Fabaceae	0.5	0.2	0.17	0.92
Acacia nigrescens	Fabaceae	0.63	0.16	0.7	0.29
Grewia monticola	Malvaceae	-	-	0.17	0.2
Julbernardia globiflora	Fabaceae	-	-	-	-
Terminalia stenostachya	Combretaceae	-	-	-	-
Diplorhynchus condylocarpon	Apocynaceae	-	-	-	-
Tamarindus indica	Fabaceae	-	-	-	-
Brachystegia boehemii	Fabaceae	-	-	-	-
Bolusanthus speciosus	Fabaceae	-	-	-	-
Terminalia sericea	Combretaceae	-	-	-	-
Catunaregum taylorii	Rubiaceae	-	-	-	-
Bauhinia toementsa	Fabaceae	-	-	-	-
Strychnos innocua	Loganiaceae	-	-	-	-
Diospyros senensis	Ebenaceae	-	-	-	-
Combretum paniculatum	Combretaceae	-	-	-	-
Commiphora mossambiscensis	Balanitaceae	-	-	-	-
Pseudolachnostylis maproumeifolia	Phyllanthaceae	-	-	-	-
Albizia amara	Fabaceae	-	-	-	-
Lecaniodiscus fraxinifolous	Sapindaceae	-	-	-	-
Lonchocarpus capassa	Fabaceae	-	-	-	-
Xeromphis obovata	Rubiaceae	-	-	-	-
Euphobia cooperi	Euphorbiaceae	-	-	-	-
Hexalobus monopetalus	Annonaceae	-	-	-	-
Antdesma venosum	Euphorbiaceae	-	-	-	-

[a]Number of plots in which the woody species was present divided by the total number of plots *(n)*

[b]Number of plots in which the woody species was eaten divided by the number of plots in which the species was present.
- denotes not applicable or not available

mainly due to the availability of this forage, when most other savanna species are leafless (Kos et al., 2012). The nutritional value of mopane browse also causes it to be habitually selected by greater kudu during the dry period (Hooimeijer et al., 2005), when concentrations of secondary metabolites such as tannins and phenols are relatively low in leaf tissues (Kohi et al., 2010; Wessels et al., 2007).

Some woody species were utilized only in the dry season such as *Trichillia emetica* and *Combretum paniculatum*. In a study carried out by Owen-Smith and Cooper (1989) on greater kudu, it was noted that kudus increased their use of evergreen plants during the course of the dry season in the Nylsvley Nature Reserve, Limpopo Province. This might also have been the case on these two woody species as they are also evergreen woody species that were only foraged on during the dry season. Kok and Opperman (1980) explains that deciduous plants shed their leaves in the dry season and forage resources become scarce, therefore browsers may alter their food preferences. They go on to state that the less palatable, evergreen species that were not utilized during the wet season increase in importance as food reserve during the dry season. Therefore in this study, a shortage of foliage retained on woody plants in the dry season might have led the Greater kudu to revert to *Trichilia emetica* and *Combretum paniculatum* for forage species. In the wet season, *Combretum paniculatum* was not accepted for forage by the greater kudu, according to Owen-Smith (1993) species in the Combretaceae family commonly show high contents of total polyphenols in their foliage during the wet season. This might have contributed to the avoidance of this species in the wet season.

5. Conclusion

The greater kudu in Garura CAMPFIRE area selected a wide spectrum of woody species. Unarmed woody plants were the mostly preferred as they were readily available. Greater kudu can uniquely utilize some woody species only in any one of the seasons as revealed in this study. Species availability has no greater influence on the acceptability of woody species by greater kudu. In this study, seasonality did not have any influence on forage selection as the acceptance of woody species did not vary significantly across the seasons. We recommend for continued monitoring of the species habitat utilisation and vegetation changes in the study area.

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Competing Interest
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