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# Terrain encountered along the browsing path of *Tragelaphus strepsiceros* in the Musina Nature Reserve, Limpopo Province

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**Despite the wide distribution of the *Tragelaphus strepsiceros* (greater kudu) in the mopane woodland, there is still limited information on the influence of terrain on the browsing path of the greater kudu. There is also a lack of information on terrain associated with the browsing paths of male and female greater kudu. This study was conducted at Musina Nature Reserve from June 2012 to December 2013. Backtracking, which is a post-browsing method, was used to capture the movement of browsing greater kudu. This method entails the direct and indirect observation of the greater kudu at the point of browsing along a browsing path. The different terrains on which the greater kudu moved while browsing are taken as a percentage of the total browsing path. Areas frequented by male and female greater kudu were compared using t-test (Paired Two Sample for Means) and Spearman Correlation Coefficient analysis. Results indicated that the browsing greater kudu highly frequented the plains (72%) and flat areas (95%), particularly during the late wet season. During the pre-rain flush season, the browsing greater kudu spent most of the time (59%) walking on soil substrate. The eastern (50%) and northern (50%) aspects of hills were equally frequented during the late wet season. There were no significant gender differences on the preferred terrain. It is concluded that the browsing path of the greater kudu is largely influenced by the availability of browse, safety and conducive local weather conditions.**

**Keywords: browse; browsing path; greater kudu; season; terrain**

## INTRODUCTION

Habitat for mammals and other organisms is disappearing quickly from the Earth's surface due to human interference. Human exploitation and management may have a short- or long-term influence on the vegetation of a particular area, which may be of a direct or indirect nature. This interference by humans particularly affects the distribution patterns of large mammals as they wander in search of preferred habitats, which are found in patchy habitats of protected areas (Fetene *et al*., 2011). In addition, intra- and inter-competition amongst fauna and flora may influence particular vegetation types and guide it in such a way that it determines the availability of various browse to the animals that occur in the particular area (Owen-Smith *et al*., 2010). The area over which an animal searches for browse should be based on its browse requirements, which are determined by metabolic body size, the basic productivity of the habitat in terms of these browses, and the number of group companions with which it shares its browsing area (Butler, 2017).

Fetene *et al*. (2011) indicated that there is a need to identify the specific climate, browse habits and geographic features that different animals require. Seasonal changes in the environment affect the availability and quality of forage (Owen-Smith, 2008). Consequently, an animal's use of certain areas change in response to resource availability and quality (Hooimeijer *et al*., 2005). Pekin *et al.* (2014) found that ungulates are ecologically separated in response to vegetation structure and topography. As suggested by Powell and Mitchell (2012), it is important to recognise the possibility of seasonal variation in home range size and location, and those habitats are not themselves resources, but certain components of habitats. This implies that browse component is relevant and not necessarily the habitat as a whole (Morgan, 2010).

Fine-scaled within-patch richness is determined by the quality and quantity of resource components (browse and shelter) within a habitat patch. In contrast, coarse-scaled resource richness depends on the spatial arrangement of habitat patches, i.e. how closely-spaced patches are within an animal's home range (Fabricius, 1994). Home range is the area traversed by an animal in its activities of browsing, mating and caring for young (Powell and Mitchell, 2012). Plant community classified by ecologists in terms of species composition or physiognomy may be perceived differently by the animals browsing in it (Butler, 2017). According to Burkepile *et al.* (2013), habitat selection by an ungulate is governed, amongst others, by the browse plants the animal selects along a browsing path, which according to Dörgeloh (2001) is also influenced by habitat structure. However, D'Ammando (2016) is of the opinion that browsing path selection is governed by diet selection, which for ungulates is governed by body size, digestive systems and mouth structure. From the animal's perspective, the browse component of the habitat may be defined in terms of vegetation included in the browsing path (Bjørneraas *et al*., 2012).

*Tragelaphus strepsiceros* Pallas, 1766, commonly known as the greater kudu (IUCN SSC Antelope Specialist Group, 2016), is one of the valued antelope in game reserves in South Africa's mopane woodland (Curlewis, 2014). The greater kudu is widely distributed in southern and eastern Africa (Skinner & Chimimba, 2005), attracting many tourists, and is treasured in the dried meat industry and for trophy hunting (Bonsma & Du Toit, 2010). Despite the wide distribution of the greater kudu in the mopane woodland and its economic value, there is still limited information on the influence of terrain and season on the browsing path of the greater kudu in the mopane woodland. In addition, there is a lack of information that distinguishes the terrains that are associated with the browsing paths of male and female greater kudu, which is critical to any management plan. This deficiency in the current knowledge is based on the understanding of the distribution, browsing requirements and conservation of the greater kudu within its natural habitat. This study closes the current gap by investigating the influence of terrain (topography, substrate, aspect and slope) on the browsing paths of the greater kudu in the mopane woodland during different seasons. The results of this study are of great importance for game farmers, ranchers and reserve managers in the extensive mopane woodland, by enabling them to better understand the influence of terrain on the browsing paths of the greater kudu during different seasons. This information is essential for effective management of the greater kudu within its home range.

## METHODOLOGY

### Study area

This study was conducted in the Musina Nature Reserve, northern Limpopo Province, South Africa. The reserve is situated 5 km south-east of the town of Musina between 22° 22′ S; 30° 02′ E and 22° 26′ S; 30° 04′ E, and covers 4 976 hectares. The altitude of the reserve ranges from 400 to 750 m above sea level. Rainfall in Musina typically starts in late September to early October and reaches its maximum in November, December, January and February. The average rainfall is 331 mm per annum and typically ranges from 300 to 400 mm per annum. The mean annual temperature ranges from 16 °C in winter to a maximum of 45 °C in summer. The annual average maximum temperature is 30 °C. The relative humidity of the area is very low, ranging from 12% in September to 28% in February (Musina Weather Data, 1981–2014).

The geology is underlain by the Archaen Beit Bridge Complex, which consists of gneisses and meta-sediments. Soils range from deep red/brown clays at the bottom of slopes to freely drained sandy soils at the top of slopes. The soil has a high sodium content and is alkalinic in nature (Mucina & Rutherford, 2006).

The grass and herbaceous layers are poorly developed. The grass layer is dominated by *Schmidtia pappophoroides* but other grasses such as *Cenchrus ciliaris*, *Stipagrostis uniplumis*, *Enneapogon cenchroides* and *Aristida congesta* are also found in the reserve. The forbs are characterised by *Indogofera*, *Abutilon*, *Monechma*, *Barleria*, *Monsonia*, *Hibiscus*, *Ocimum*, *Tephrosia* and *Melhania* species (Curlewis, 2014). The Musina Nature Reserve is located within the Musina Mopane Bushveld and Limpopo Ridge Bushveld of the mopane bioregion. The Musina Mopane Bushveld vegetation unit is the most widespread in South Africa. It is characterised by open woodland, mid-dense to closed shrubland dominated by *C. mopane* on clayey lowlands and *C. apiculatum* on the hills. Other tree and shrub species found include *Commiphora edulis*, *Grewia* species, *Terminalia* species, *Vachellia* species, *Senegalia* species, *Boscia albitrunca*, *Sclerocarya birrea* and *Dichrostachys cinerea* (Rutherford *et al*., 2006).

The Limpopo Ridge Bushveld on the other hand is characterised by moderately open savanna. Plant species such as *Kirkia acuminata* are prominent on some ridges and often occur together with large individuals of *Adansonia digitata*, which occur on shallow calcareous gravel. Shrubs such as *Catophractes alexandri* are dominant on the calci-silicate soils. However, the tree and shrub component in this vegetation unit is dominated by *C. mopane*, *Commiphora mollis*, *Commiphora glandulosa*, *Commiphora tenuipetiolata*, *Maerua parvifolia* and *Terminalia prunioides* (Rutherford *et al*., 2006).

The reserve has a diverse range of antelope, which includes eland (*Taurotragus oryx*), greater kudu (*Tragelaphus strepsiceros*), gemsbok (*Oryx gazella*), nyala (*Tragelaphus angasii*), sable antelope (*Hippotragus niger*), blue wildebeest (*Connochaetes taurinus*), common duiker (*Sylvicapra grimmia*), gemsbok (*Oryx gazella*), impala (*Aepyceros melampus*), klipspringer (*Oreotragus oreotragus*) and steenbok (*Raphicerus campestris*) (Curlewis, 2014).

### Survey procedures

The survey took place at Musina Nature Reserve from June 2012 to December 2013, following backtracking, which is a post-browsing method. This method entails the direct and indirect observation of greater kudu at the point of browsing along a browsing path. The total browsed sites were 332, which were observed at 149 points. The different terrains on which the greater kudu moved while browsing are taken as a percentage of the total browsing path. A browsing path is defined as the terrain the animal utilised while browsing. Due to the major impact seasonality has on vegetation composition, and hence potentially on the diet of the greater kudu in the Musina area, seasons were grouped according to the following months: wet season (November to February); late wet season (March to April); dry season (May to August); and pre-rain flush season (September to October).

The number of observation points in each habitat type or terrain does not necessarily reflect the degree of importance that each habitat type or terrain holds for the greater kudu. For example, as one of the browsing paths followed by the greater kudu, wet drainage lines are under-represented in this study as they cover a small area. Wet drainage lines are also a source of drinking water where all the animals congregate, making it difficult to determine which animal browsed on the vegetation.

### Terrain classification

The following features related to terrain were documented: topography, substrate, aspect and slopes of the browsing path. The topographical characteristics of the area were recorded as: dry drainage line (a channel where water flows for a short period after a significant rainfall event, but otherwise dry during the rest of the year); wet drainage line (a rivulet where water flows and/or contains water for the most part of the year either above or below the surface); slope (any slope away from the horizontal); plain (flat savanna area); kloof (an area between two steep slopes); and plateau (the top flat area of slopes of any degree).

The substrate was classified as: soil (soil particles <2 mm in diameter), gravel (>2 mm to <30 mm), stony soil (stones up to <100 mm in diameter, soil <2 mm in diameter with stones lying on top of the soil or mixed with small areas of soil in between), and rocky soil (soil <2 mm in diameter mixed with rocks >100 mm in diameter).

The aspect of the terrain on which the greater kudu browsed was recorded for the four major magnetic directions, using a compass. The slope of the terrain was classified as: no slope (flat area), gentle slope <10°, moderate slope 11–25°, and steep slope >26°. The aspects frequented by male and female greater kudu were not distinguished during the observation.

### Data analysis

Collected data were analysed using descriptive and inferential statistics from Excel 2013. The different terrains on which the greater kudu moved while browsing are taken as a percentage of the total browsing path. A browsing path is defined as the terrain the animal utilised while browsing. The t-test (Paired Two Sample for Means) and Spearman Correlation Coefficient analysis were used to compare the areas frequented by male and female greater kudu when browsing during different seasons. Significant difference was accepted when $p \leq 0.05$.

## RESULTS

### Topography of browsing paths

This study showed that during the pre-rain flush season, the greater kudu frequented the dry drainage lines (38%) and plains (38%) the most while browsing, followed by the slopes (21%) and wet drainage line (3%). However, during the wet season, the greater kudu frequented plains (44%) the most, followed by the dry drainage line (33%). Less frequented areas during the wet season include the plateaus (15%) and slopes (7%). Throughout the late wet season, the greater kudu were found most of the time on the plains (72%), while the dry drainage lines and slopes were visited by the greater kudu equally at 14% of the time. In the dry season, the greater kudu patronised the plains (55%) the most. The less visited areas during the dry season included the dry drainage lines (21%) and slopes (18%), while the least frequented areas were the plateaus (6%) (Table 1).

The comparison of the browsing paths of male and female greater kudu showed that both males (45%) and females (47%) frequented the plains the most, followed by dry drainage lines at 28%, respectively, for both genders. The kloof and wet drainage line areas were avoided by both male and female greater kudu (Table 1). Despite the variation in the topography frequented by males and females during browsing, the difference was not statistically significant at $p \leq 0.05$ ($t = 0.975$) and proves to be positively correlated ($r = 0.921$) (Table 1).

### Substrates of browsing paths

During the pre-rain flush season, the greater kudu were observed most of the time walking on the soil substrate (59%), followed by gravel (21%), and less frequently on the rocky (14%) as well as stony substrates (7%), while browsing. Similarly, during the wet season, the browsing greater kudu spent most of the time walking on the soil (44%), followed by gravel (37%), but less were observed walking on rocky soil (11%) and stony soil (7%). During the late wet season, the browsing greater kudu were observed the most walking on soil substrate (57%), followed by gravel (27%). They were less frequently observed walking on stony soil (14%) and never observed walking on rocky soil substrate during the late wet season. However, during the dry season, the browsing greater kudu were observed the most walking on soil substrate (36%), followed by gravel and stony soil substrates at 30%, respectively, and the least on rocky soil substrate (3%) (Table 2).

The male greater kudu was observed walking on the gravel substrate the most (38%) when browsing, followed by soil substrate (35%). However, female browsing greater kudu were observed walking on soil substrate most frequently (42%), followed by gravel substrate (31%). Both male and female browsing greater kudu avoided walking on rocky substrate. Despite the variation in the substrate frequented by male and female greater kudu during browsing, the difference was not statistically significantly at $p \leq 0.05$ ($t = 0.975$) and proves to be positively correlated ($r = 0.922$) (Table 1).

### Aspect of browsing paths

During the pre-rain flush season, browsing greater kudu frequented the southern aspect (39%) the most, followed by the western aspect (33%), eastern aspect (22%), and northern aspect (6%). The aspect that the greater kudu visited the most while browsing during the wet season was the east (39%), followed by the south (28%), north (22%), and west (11%). The browsing greater kudu were observed during the late wet season to equally split their visits between the eastern (50%) and northern (50%) aspects, but avoided the southern and western aspects. However, during the dry season, the aspect frequented the most by the browsing greater kudu was the south (47%), followed by the north (32%), west (16%) and east (5%) (Table 3).

### Slope of browsing paths

During the pre-rain flush season, the greater kudu browsed mostly in areas where there was no slope or flat (48%), followed by areas having a gentle slope (28%) and areas containing a moderate slope (14%). The steep slope areas (10%) were the least frequented during browsing. During the wet season, browsing greater kudu frequented no slope areas the most (59%), followed by areas containing gentle slopes (30%) and moderate slopes (11%). The steep slope areas were avoided by the browsing greater kudu. In the late wet season, the browsing kudu visited mostly the plains (95%) and gentle slopes the least (5%). The moderate and steep slopes were avoided by the browsing kudu during the late wet season. During the dry season, the browsing greater kudu were observed frequenting the no slope areas the most (61%), followed by areas having a gentle slope (36%) and steep slope (3%) (Table 4).

The no slope (flat) areas were the most preferred browsing area for both males (52%) and females (56%). The gentle slopes showed to be the second preferred areas by browsing male and female greater kudu. Despite the variation in the substrate frequented by male and female greater kudu during browsing, the difference was not statistically significant at $p \leq 0.05$ ($t = 0.996$) and proves to be positively correlated ($r = 0.927$) (Table 4).

**Table 1.** Topography frequented by browsing greater kudu in the Musina Nature Reserve, Limpopo Province, South Africa.

| | Topography (%) | | | | | |
|---|---|---|---|---|---|---|
| Season | Dry drainage line | Plateau | Slope | Plain | Kloof | Wet drainage line |
| Pre-rain flush | 37.9 | 0 | 20.7 | 37.9 | 0 | 3.4 |
| Wet | 33.3 | 14.8 | 7.4 | 44.4 | 0 | 0 |
| Late wet | 14.3 | 0 | 14.3 | 71.7 | 0 | 0 |
| Dry | 21.2 | 6.1 | 18.2 | 54.5 | 0 | 0 |
| Gender | | | | | | |
| Male | 27.6 | 10.3 | 17.2 | 44.8 | 0 | 0 |
| Female | 27.8 | 5.6 | 16.7 | 47.2 | 0 | 2.8 |
| *t*-test = 0.975 | | | | Pearson = 0.921 | | |

## DISCUSSION

The greater kudu inhabit a static home range which is shared by various individuals of both genders (Hensman, 2013). Furthermore, the core of the home range is fixed and permanent, but the total area and size varies with vegetation condition and season (Furstenburg, 2010). The influences of terrain (topography, substrate, aspect and slope) and season on the greater kudu browsing path are discussed below.

### Topography

The greater kudu select browsing paths where sought-after tree species are the most common (Butler, 2017). This study found that the greater kudu frequented plains the most during all seasons, which was followed by dry drainage lines and slopes. A similar pattern was also observed for both male and female greater kudu (Table 1). The findings of this study compare favourably with Kelso (1987), who also described the plain area as being mostly preferred by the greater kudu. Habitat selection patterns for the browsing kudu were much the same throughout the year, with a high preference for plains (open savanna, mesocline savanna or open woodland). The results of this study are therefore fairly consistent with the study by Furstenburg (2010), which also showed that the greater kudu preferred open woodland.

Though greater kudu frequented plain the most, the environmental conditions in the area, especially vegetation and climate, can influence them to occupy other topographical areas during a particular season (Butler, 2017). For instance, greater kudu are highly sensitive to cold and sudden temperature changes. As a result, they turn to move away from lower lying areas up the catena to warmer hill slopes during cold winter nights (Furstenburg, 2010). Similarly, the plateaus were frequented during the dry and wet seasons, while the wet drainage lines were frequented the least during the pre-rain flush season. The kloof was not frequented at all by the browsing greater kudu. A possible reason for the high visit frequency of the plains and dry drainage lines could be the availability of palatable forage in those areas. In addition, trees that grow in the plain areas provide shade to herbivores, which thus attract them to frequent such areas (Treydte *et al*., 2010). As indicated by Valeix *et al*. (2007), during hot days, shade reduces ambient temperature, which enable animals to avoid elevated heat loads.

It is suggested from this study that the kloofs were avoided primarily due to the cost:benefit ratio involved in obtaining browsable plants and safety issues related to loose substrates. This implies that the areas frequented by the greater kudu are mostly related to the available browse at the various topographical areas in combination with other factors such as safety and local weather conditions.

### Substrate

This study found that throughout the seasons, the substrate frequented by the browsing greater kudu is mostly soil, followed by gravel, stony soil and lastly rocky soil (Table 2). This pattern seems to be in relation to the frequented browse source in each site. Soil areas provide more suitable conditions for the growth of a rich and diverse flora as opposed to rocky and stony soils. Consequently, the greater kudu are sparsely distributed in rocky outcrops (Furstenburg, 2010) due to insufficient browsing sources. However, their lesser frequency on rocky soil areas, particularly during pre-rain flush and wet seasons, could possibly be due to the availability of forbs. The substrate mostly crossed while browsing

**Table 2.** Substrate frequented by browsing greater kudu in the Musina Nature Reserve, Limpopo Province, South Africa.

| | Substrate (%) | | | |
|---|---|---|---|---|
| Season | Soil | Gravel | Stony soil | Rocky soil |
| Pre-rain flush | 58.6 | 20.7 | 6.9 | 13.8 |
| Wet | 44.4 | 37 | 7.4 | 11.1 |
| Late wet | 57.1 | 28.6 | 14.3 | 0 |
| Dry | 36.4 | 30.3 | 30.3 | 3 |
| Gender | | | | |
| Male | 34.5 | 37.9 | 20.7 | 6.9 |
| Female | 41.7 | 30.9 | 22.2 | 5.6 |
| *t*-test = 0.975 | | | Pearson = 0.922 | |

**Table 3.** Aspects frequented by browsing greater kudu in the Musina Nature Reserve, Limpopo Province, South Africa.

| Season | Aspects (%) | | | |
|---|---|---|---|---|
| | East | West | North | South |
| Pre-rain flush | 22.2 | 33.3 | 5.6 | 38.9 |
| Wet | 38.9 | 11.1 | 22.2 | 27.8 |
| Late wet | 50 | 0 | 50 | 0 |
| Dry | 5.3 | 15.8 | 31.6 | 47.4 |

Note: The aspects frequented by male and female greater kudu were not distinguished during the observation.

**Table 4.** Slopes frequented by browsing greater kudu in the Musina Nature Reserve, Limpopo Province, South Africa.

| | Slope (%) | | | |
|---|---|---|---|---|
| Season | No slope | Gentle | Moderate | Steep |
| Pre-rain flush | 48.3 | 27.6 | 13.8 | 10.3 |
| Wet | 59.3 | 29.6 | 11.1 | 0 |
| Late wet | 94.7 | 5.3 | 0 | 0 |
| Dry | 60.6 | 36.4 | 0 | 3 |
| Gender | | | | |
| Males | 51.7 | 41.4 | 0 | 6.9 |
| Females | 55.6 | 30.6 | 11.1 | 2.8 |
| *t*-test = 0.996 | | | Pearson = 0.927 | |

by males and females was soil. No major differences were found between male and female substrate usage. However, the males traversed into gravel more often than soil while browsing. This corroborates with the findings by Perrin (1999) that mature males may leave their home ranges but return later. The females are in cohesive social units and stick with the family group within the same home range (Furstenburg, 2010).

### Aspect

The greater kudu tend to move between the aspects of slopes to the opposite sides of on-blowing winds and also avoid cold weather (Furstenburg, 2010). As a result, the eastern aspect was frequented mostly by greater kudu while browsing, especially during wet and late wet seasons. The western and southern aspects were avoided during the late wet season. However, during the dry season, greater kudu frequented mostly the southern aspect. Other research also found that the majority of greater kudu herds seen in the early morning were on east facing slopes (Perrin, 1999). This could be a way of getting much needed energy from the sun during sunrise while browsing. In addition, the high preference for the southern aspect during the dry season could be for the greater kudu to get the last rays of sun before sunset. No comparison was made for the aspects frequented while browsing with regard to the male and female greater kudu as the restricted data on either sexes would have no meaningful interpretation.

### Slopes

As also indicated by Kelso (1987), flat areas are preferred by the greater kudu. The flat areas were frequented mostly by the greater kudu, followed by gentle slopes (Table 4). The greater kudu only browsed along the steep slopes during the pre-rain flush and dry season. This implies that the flat and gentle slopes are the areas that provide the browse for the greater kudu during most seasons, which is the main reason those areas are highly preferred. However, browsing along the steep slopes during the pre-rain and dry seasons could be when the greater kudu move erratically in search of nutritious buds and flowers that become available during this period of very limited and low nutritious browse. However, steep hillsides appear to be frequented by the greater kudu, especially in association with thicket (Pekin *et al*., 2014). The tendency of both male and female greater kudu to frequent more flat areas and less steep or mountainous areas is possibly due to browse selection and for safety measures. Energy expenditure during movement in steep or mountainous areas could be another reason that the greater kudu frequent flat areas the most during browsing.

## CONCLUSION

This study found that the greater kudu prefers areas such as plain or flat, soil, east and south aspects when browsing. It seems that the browsing paths of kudu were largely influenced by the availability of browse in the area they frequented and were familiar with, commonly referred to as their home range. Because kudu spend most of their lives in their home-range, they have intimate knowledge of the localites of edible plants and which plant species to browse during the various seasons. The presence of a browse source could trigger the recognition of the availability of such a browse source, which possibly activates the greater kudu to search for the known location of these plants in the home range. This study revealed that the greater kudu select areas to browse in which the plants-of-choice were most abundant. In addition to browse availability, other factors such as safety and conducive local weather conditions, also seem to influence the greater kudu's preference for a particular terrain when browsing. This study therefore demonstrated that terrain has a major influence on browsers' distribution within their home range. These are important considerations to be taken into account during management intervention for the greater kudu within their home ranges. It further requires that research should be directed towards understanding the influence of terrain as one of the indicators of potential browse and wildlife distribution.

## DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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