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Habitat Use and Diet Composition of the Common Eland (*Tragelaphus oryx*) in Ngorongoro Conservation Area, Tanzania

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Abstract

Ngorongoro Conservation Area (NCA) is renowned worldwide for its multiple land use where pastoralism and wildlife conservation co-exist. Thus, the NCA must meet a delicate balance of competing needs between livestock and wildlife. Currently the NCA is conducting resettlement program to facilitate pastoralists who are willing to move and resettle outside of the conservation area in order to reduce the number of people and livestocks in NCA. The common eland (*Tragelaphus oryx*) are among the large herbivore species found in the NCA that might be affected by possible competition between livestock and wildlife. The information on this species including habitat utilization and feeding ecology is limited. This study therefore, investigated the factors influencing habitat use and diet composition of the common eland (*Tragelaphus oryx*) in NCA. Data were collected along 82 pre-established transects using direct field survey. The study therefore assessed habitat use, distribution patterns, diet composition and conservation threats facing the common eland in NCA, The results indicated that the grassland habitat was mainly used by elands (> 85% in both dry and wet seasons), while other habitats were least used (< 15%). Eland diet composition varied significantly among plant species, with the animals most frequently feeding on *Themeda triandra* but rarely on *Vachellia tortilis* and *Hibiscus aponeurus*. The study concludes with recommendations for enhancement of grassland habitat management and reduced anthropogenic activities to enhance eland conservation in NCA.

Keywords: *Tragelaphus oryx*, Habitat utilization, Food composition, Herbivore, Conservation of elands, Ngorongoro Conservation Area.

Introduction

The common eland (*Tragelaphus oryx*), formerly *Taurotragus oryx*, is among the rare African antelopes which include, sable antelope (*Hippotragus niger*), common tsessebe (*Damaliscus lunatus*), roan antelope (*Hippotragus equinus*), fringed-eared oryx (*Oryx beisa callotis*), gerenuk (*Litocranius walleri*) and lesser kudu (*Tragelaphus imberbis*). It is the second largest African antelope after the giant eland (*Tragelaphus derbianus*) (Hillman 2008). The common eland occurs in eastern and southern Africa (Hillman 1987, Skinner and Chimimba 2005); and inhabits in heterogeneous habitats that contain more shrubs and is frequently

seen in grassland, woodland, and sub-desert bush habitats (IUCN 2008). The species is extensively domesticated in various countries, such as Kenya, Zimbabwe and South Africa, and provides high-value and delicious bushmeat (Buijs et al. 2016). The recent population status of the common eland in the East African region is estimated to be around 136,000 individuals, with a population density of 0.05 km^{-2}, of which Tanzania is the stronghold range state (East 1999, IUCN 2008) Populations are considered stable in some countries including, Tanzania, Botswana, Zimbabwe, South Africa, Malawi and Namibia (IUCN 2008). Elands are social animals living in herds of 20–70 individuals (IUCN SSC 2016). Although the the International Union for Conservation of Nature (IUCN) has categorised the species as "Least Concern" (LC), like other ungulates, in the Ngorongoro Conservation Area (NCA), their numbers have been reported to decrease in the period of 1964–1980 and 1986–2005 due to habitat loss and poaching (Campbell and Borner 1995, Atwood and Estes 2006).

Common elands are highly adaptable ruminants, formerly inhabiting large proportions of landscapes with succulent plants as well as grasslands (Skinner and Chimimba 2005). Mattiello et al. (2004) reveals that habitat use and, spatial distribution of African wild ungulates overlap among species and varies according to the abundance of their preferred habitats which are characterised by vegetation heterogeneity of savannah woodland, forest, shrubs and grassland. Their range is somewhat extended into distinctive type of vegetation such as trees and shrubs. Common elands are generally absent from true deserts, dense forests, and in entirely open grasslands and they are occasionally present in grasslands with substantial herb cover.

Common eland have been reported as water-dependent, but can also survive and thrive in arid regions, such as the central Kalahari Game Reserve in Botswana where there is scarce of surface water (Pallas 1766). Thus, it is likely that elands are able to meet much of their water requirements from their diet, although they will drink regularly when surface water can be accessible (Estes and Small 1999). Common eland distribution like other mammals form social groups during foraging, migration and other daily activities and group size is considered a fundamental attribute of the social organization of such species (Pratt and Anderson 1982). A study of the diet of the common eland has suggested that they are herbivorous, they browse more during the dry season and graze during the wet season where grasses are more common and then they are classified as mixed feeders (Buys and Dott 1991, Gagnon and Chew 2000). Being a mixed feeder could be a survival strategy for the common eland as it has been observed that diet accessibility for many mammals varies according to variety of food available seasonally and hence this reduces foraging competition with other herbivores (Dice 1952).

The information on habitat use and diet composition for the common elands is limited, and only few studies have been conducted on common eland in NCA. The present study therefore aimed at assessing habitat use and diet composition of common eland in NCA which are essential for determining eland ranges for effective planning and implementation of the species management and conservation. The specific objectives of this study therefore were; (i) to evaluate the habitat use of common elands in NCA, and (ii) to determine the diet composition of common elands in the area.

Materials and Methods

Study area

The study was conducted in Ngorongoro Conservation Area (NCA), Tanzania. The NCA was established in 1959, NCA was designated with triple objectives of conserving natural resources, safeguarding the interest of indigenous and promoting tourism. Ngorongoro Conservation Area is located in Northern Tanzania at 340 52'–350 58' E, 20 30'–3 0 38' S Figure 1, covering an area of 8,292 km^2 (Niboye 2010). Rainfall ranges from 400 to 600 mm per annum in lowland areas, while highland areas range above 1200 mm (Niboye 2010). The

vegetation of the area consists of montane forest, grassland in the highlands and semi-arid woodlands around escarpments and plains (Niboye 2010).

The main features of NCA include, the Crater and the Ndutu Plains that support migratory wildlife species of the Greater Serengeti-Mara Ecosystem. The NCA together with Serengeti National Park and other conservation areas of the Serengeti ecosystem support the greatest concentration of wildlife left on earth, (IUCN 2008). The short grass plains of NCA are the wet-season grazing grounds for majority of the Serengeti's migratory herds, which approximately comprises of 1.5 million wildebeest, 470,000 gazelles, and 260,000 zebra (UNESCO World Heritage Centre and IUCN 2010). The protected area is a prominent World Heritage Site (Oates and Rees 2013) and famous tourist destination due to its unbroken crater and abundant wildlife species, cultural and pre-human history attractions (Niboye 2010). It hosts several large herbivores, including common eland, wildebeest (*Connochaetes taurinus*), zebra (*Equus quagga*), waterbuck (*Kobus ellipsiprymnus*), Thomson's gazelle (*Eudorcas thomsonii*), eastern black rhinoceros (Diceros bicornis), common hippopotamus (*Hippopotamus amphibius*), buffalo (*Cyncerus caffer*), elephant (*Loxodonta africana*), spotted hyaena (*Crocuta crocuta*), leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), and lion (*P. leo*) (Höner et al. 2002).

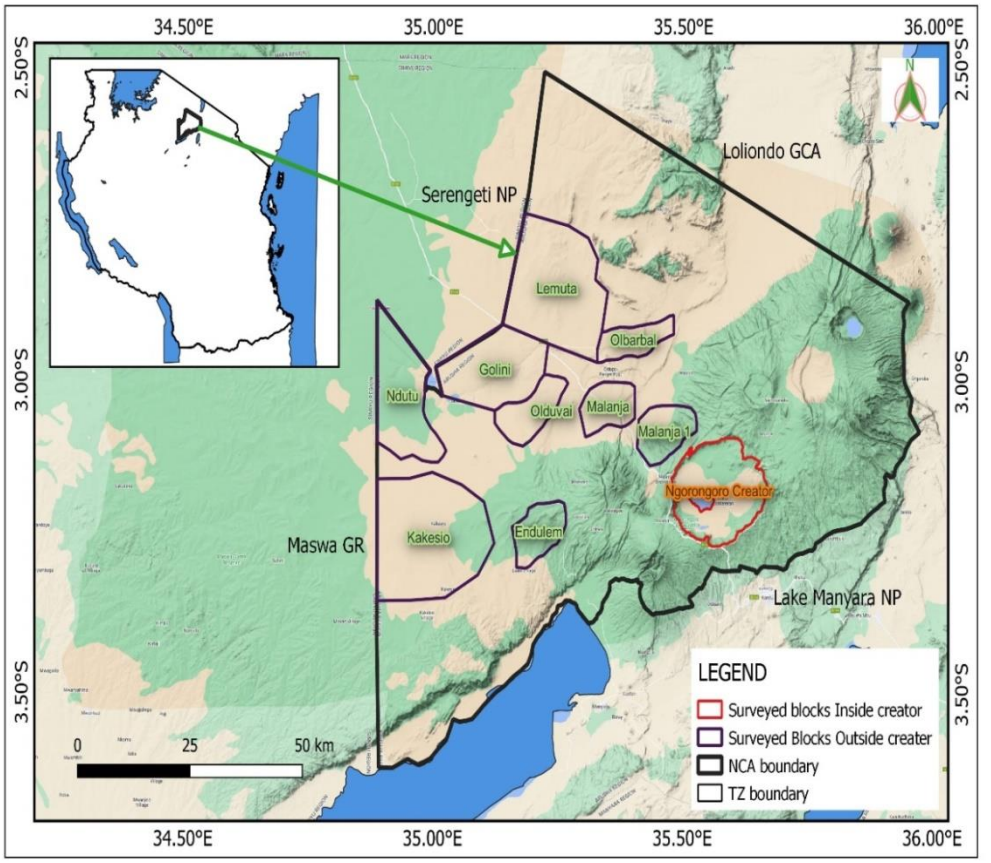

Figure 1: Map of Ngorongoro Conservation Area showing sampled areas in the study sites in Tanzania.

Study design

The study site was subdivided into ten survey zones, namely Crater, Golini, Ndutu, Olbalbal, Olduvai, Kakesio, Endulen-Esirwa, Malanja A, Malanja B and Lemuta based on known eland sightings in NCA. Overall, the survey covered the total area of 3,521 km² which is equivalent to 42.5% of the entire NCA with a total of 82 transects with the length of 12 km each transect and width of 2.5 km from one transect to another. Transects for habitat use crossed different habitat types where systematic eland counts were conducted. Vegetation plots of 1 hactare within the transects were systematically established whenever eland groups were sighted in each zone for determining eland diet composition. Diet use sampling was done along transects early in the morning (06:00 to 11:30 am) and late evening (05:00 to 6:30 pm) in both wet (April) and dry (September) seasons, in 2020 and 2021, when a foraging group of common eland was located, the observers waited from a distance of 100 m for at least 30 minutes without disturbing the foraging common elands then, signs through visual marks of fresh tuffs of grasses with fresh bites and fresh hoof prints were also used in locating the feeding point (Magome et al. 2007). A 1 hectare plot where eland groups foraging were established (Bukombe et al. 2015). In this quadrat, four sampling plots each 1 m^2 at each corner of the 1 ha was placed, and then 50 m x 50 m were established at the centre of 1 hactare, making a total of eight 8 sample plots of 1 m^2 (Figure 2). The distribution of transects ensured a good representation of the heterogeneous habitats in the study area.

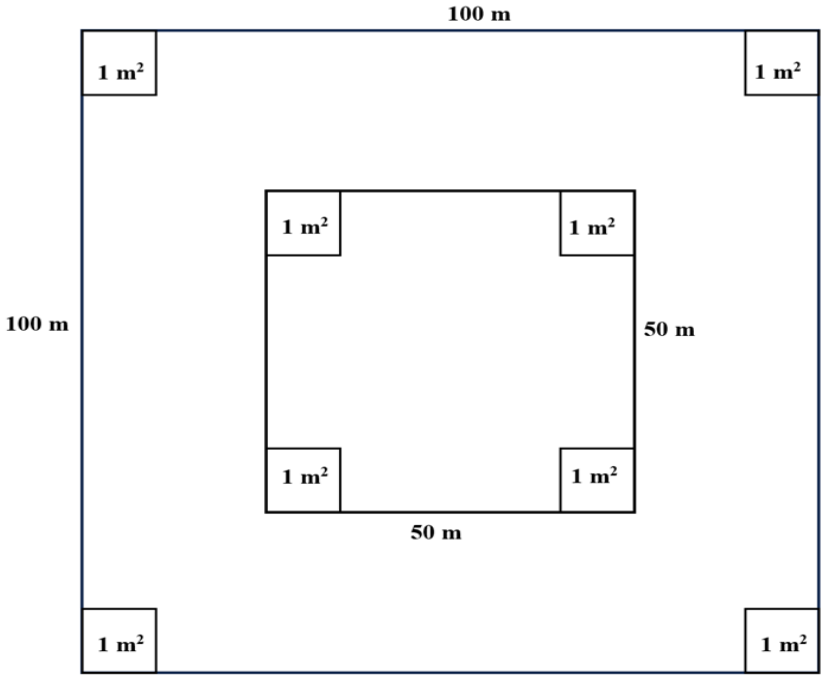

Figure 2: An area of 1 ha with a total of 8 sample plots for studying diet composition of common eland in Ngorongoro Conservation Area, Tanzania.

Data on habitat use

The habitats where elands occurred were characterized according to Pratt and Gwynne (1977) and Reed et al. (2009). The common assumption of the presence of an animal at a given location suggests its preference on habitat use and forage resources availability (Jonsen et al. 2006, Godvik et al. 2009, Owen-Smith et al. 2010). Also, different habitats do fulfil different life history

objectives and therefore preference is likely to be behavioural specific and likewise, activity patterns and habitat use may vary diurnally and seasonally.

Habitat classification was based on vegetation heterogeneity and type of plant species composition existing at a given geographical location. Data including GPS coordinates, plant species composition and vegetation type (e.g., grassland, woodland, forest, wooded grassland and shrubland) from locations where elands were sighted were collected for describing eland habitat use. Furthermore, the existing land-cover classes for NCA database were applied for mapping eland habitat uses.

Data on diet composition

Elands were searched early in the morning (06:00 am to 11:30 am) and late evening (05:00 to 06:00 pm). When a group of common elands was sighted feeding; the observers waited at a distance of 100 m for 30 minutes, then a 1 ha (100 x 100 m) plot was established. In this plot, four sampling plots each 1 m^2 at each corner of the 1 ha was placed, and then 50 x 50 m was established at the centre of 1 ha, and other four sample plots each 1 m^2 were placed at each corner of the 50 x 50 m making a total of eight 8 sample plots of 1 m^2 (Bukombe et al. 2015). Signs through visual mark of fresh tuffs of grasses with fresh bites and fresh hoof prints were also used in locating the feeding point (Magome et al. 2007) (Figure 2). At each sampling point, the following were noted: time, GPS coordinates, vegetation type and plant species composition. Any grazed/browsed plant species were collected and described using guide books known as Flora of Tropical East Africa (Beentje 2003).

Data analyses

Eland habitat use

Eland habitat use was computed and mapped using ArcGIS Software Version 10.3, while R statistical software version 4.1. was used to quantify autocorrelation between seasonal eland habitat uses in heterogeneous vegetation at 5% level of significance. The data collected included, GPS coordinates (eastings and northings), vegetation type (grassland, woodland, shrubland), eland numbers and number of groups. The parameters recorded into excel spreadsheet were converted into GIS shapefiles and overlaid into Ngorongoro Conservation Area vegetation land cover data base to illustrate seasonal common eland habitat use in different vegetation types (Esri 2006).

Eland diet composition

To assess diet composition for eland in the study area, Generalized Linear Model was fitted whereby the number of elands recorded was used as a response variable, while plant species which the eland fed on were used as explanatory variables. The GLM was run under a Poisson distribution, as the response variable was a count data. The model was checked for over-dispersion by using *dispersion test function* from *AER Package* (Kleiber and Zeileis 2008) in R 4.1.2 (R Core Team 2021). If dispersion was observed to be significant, the negative binomial distribution was implemented by using *glm.nb function* from *MASS Package* (Venables and Ripley 2002). After the model was fitted, type three Wald chi-square was applied for model selection using *ANOVA* from *CAR Package* (Fox and Weisberg 2019) in R 4.1.2 (R Core Team 2021). The variable was considered significant if the *p*-value was less than 0.05.

Results

Habitat use

A total of 4,116 individual elands were recorded in the study area in both dry and wet season. Across habitats, majority of observations were made in grassland, The results indicate that in the wet season grassland was the most preferred habitat by the eland (85.4%) followed by shrubland and woodland (6.2%) and forest (2.1%). In the dry season, elands preferred grassland, by 90.0% and, shrubland (10.0%), while forest and woodland did not register any elands (Figures 3–6). However, there was no significance difference in habitat use of the common eland between wet and dry seasons ($Df = 3$, $F = 4.17$, $p = 0.741$) (Figure 4).

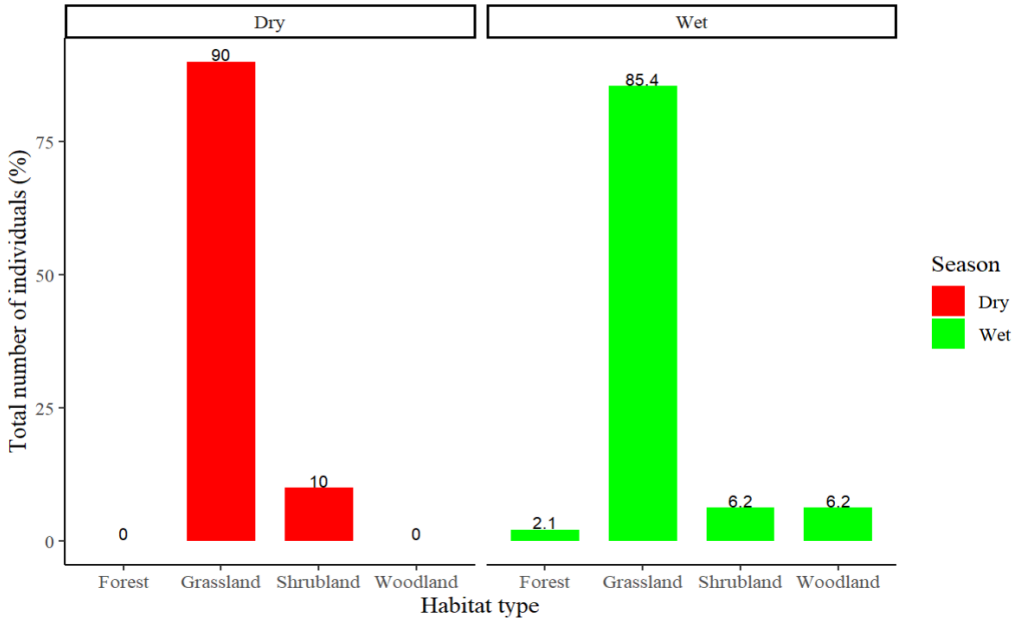

Figure 3: Common eland habitat use in different vegetation types of the Ngorongoro Conservation Area, Tanzania.

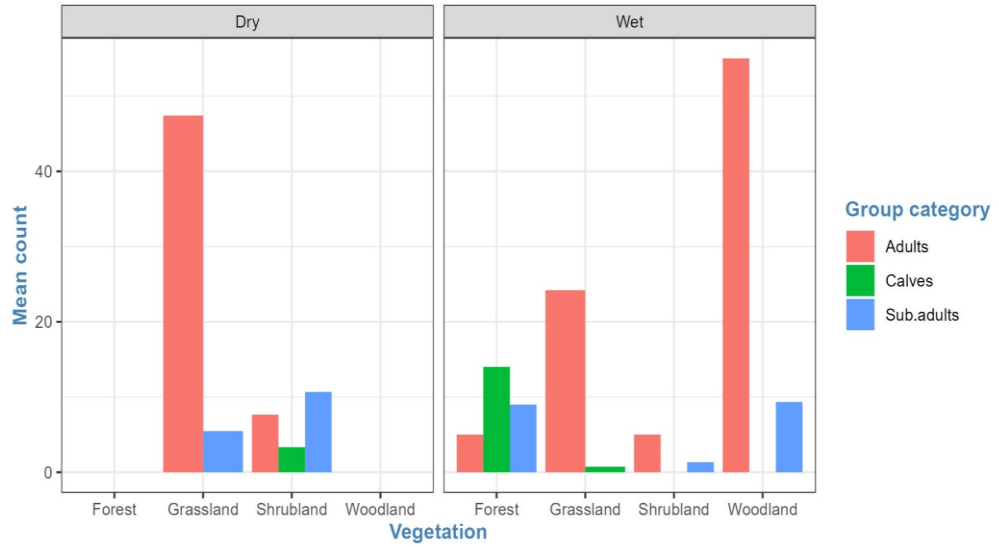

Figure 4: Mean counts of the common eland different vegetation types of the Ngorongoro Conservation Area, Tanzania.

Values	Df	Sum Sq	Mean Sq	F Value	Pr(>F)
Vegetation	3	6215	2072	0.419	0.741
Residuals	74	367578	4967		

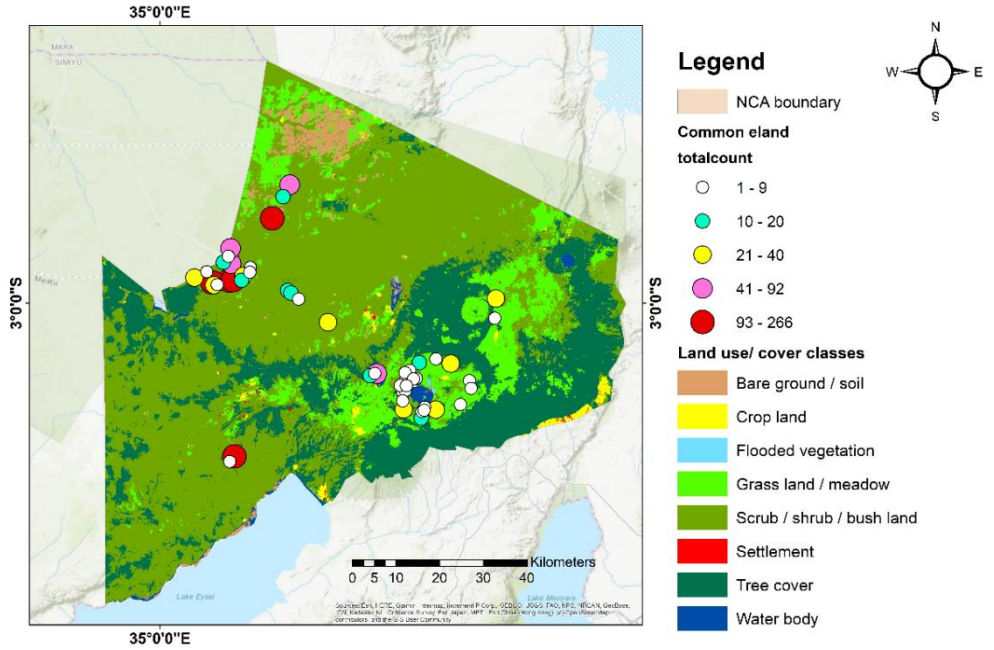

Figure 5: Common eland habitat use in the wet season in Ngorongoro Conservation Area, Tanzania.

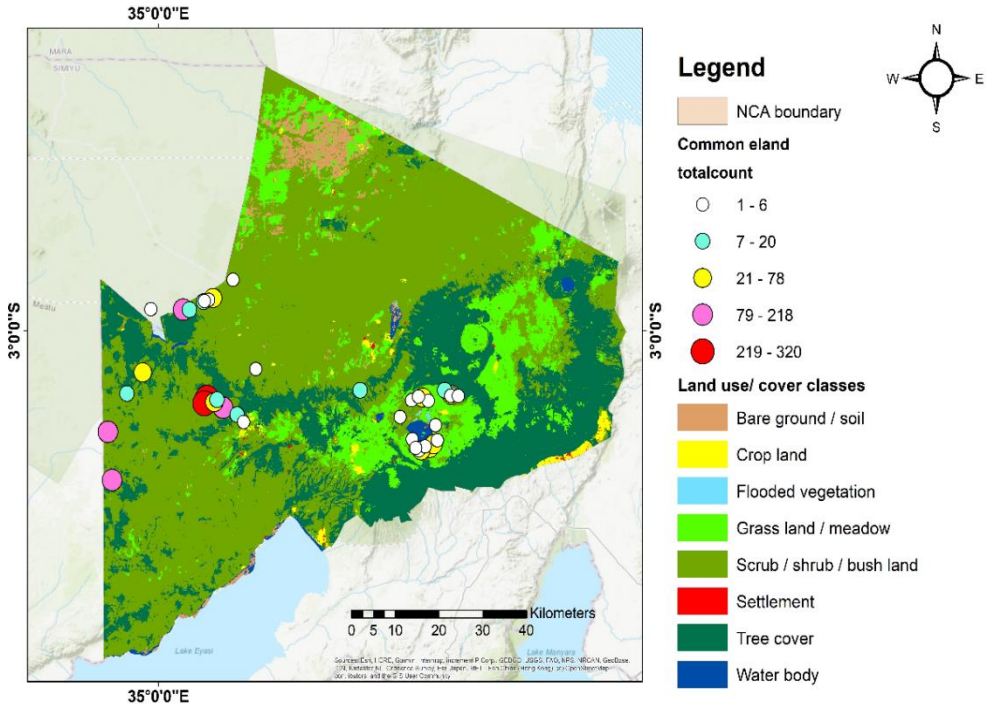

Figure 6: Common eland habitat uses in the dry season in Ngorongoro Conservation Area, Tanzania.

Eland diet composition

Diet composition for common eland constituted of 13 plant species with five browsed species and eight grazed species and had different influence in eland distribution. Results shows that most of the species making eland diet composition were preffered positively with percentage preference ranging from 15% to 60% reflected by 11 plant species. Examining figure 7 it indicates that only two plant species (*Vachelis tortilis* and *Hibiscus aponerus*) showed a negative preference. The level of preference for most grazed species influenced the distribution pattern of the common eland in NCA.

Since the Poisson model showed significant over-dispersion (z = 2.3, p = 0.012), the model was fitted under negative binomial distribution. The model showed that eland diet varied significantly between plant species (χ^2 = 43.8, df = 14, $p < 0.001$), with the animals feeding frequently on *Themeda triandra*, *Chloris pycnothrix*, *Cynodon dactylon*, *Vachellia drepanolobium*, *Vachellia brevispica*, *Trifolium Subterraneum*, *Solanum incanum*, *Eleusine jagaerii*, and *Amaranthus hybridus* but rarely on *Vachellia tortilis* and *Hibiscus aponeurus* (Figure 7).

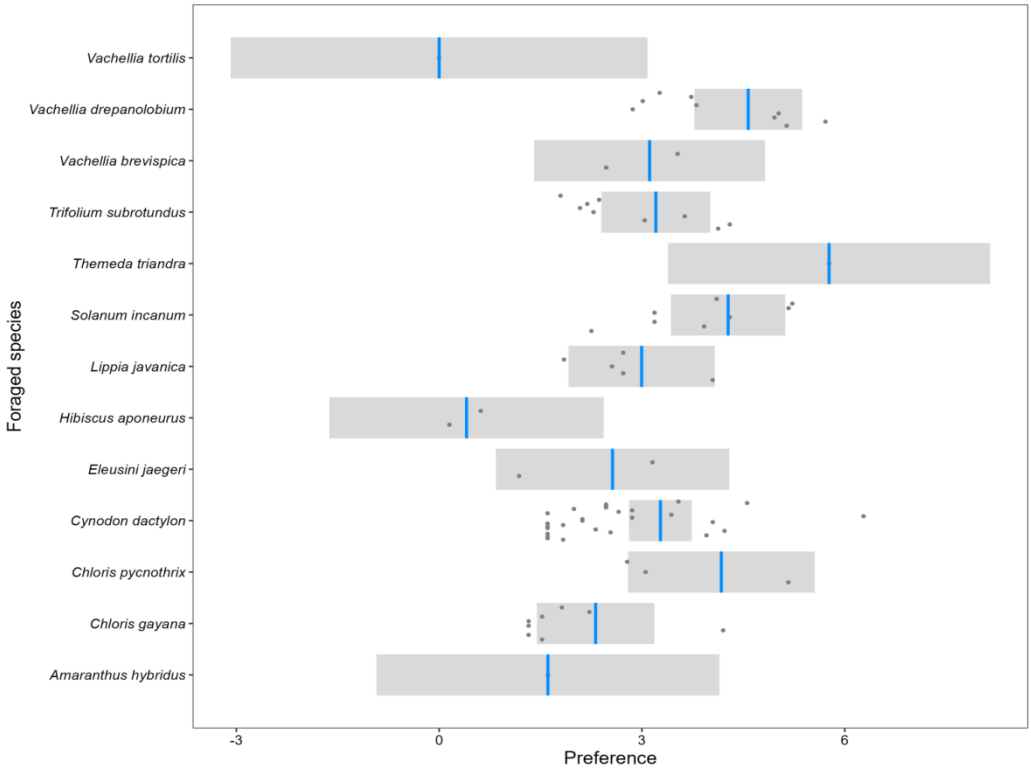

Figure 7: Diet composition for common eland in Ngorongoro Conservation Area, Tanzania.

Discussion

This study suggests that among the various vegetation types in the study area, elands preferred grasslands to other habitats in both the wet and dry seasons. Presumably the elands preferred plant species, such as *T. triandra* and *C. pycnothrix* which were mainly found on grassland habitat. This concurs with the findings of other studies elsewhere which have shown that the common eland frequently prefers feeding on grasses, such as *Setaria* sp. and *T. triandra* (Watson and Owen-Smith 2000). However, during the dry season in NCA, elands became less selective of habitats as they needed a large home range in order to obtain sufficient

forage. This suggests that eland habitat use has ecological correlation with dietary availability (Senft 1987, Redfern et al. 2003, Bukombe et al. 2017). Information on the seasonal use of habitat by eland in the NCA is fundamental for understanding connective ecological factors that contribute to habitat utilisation by large ungulates in NCA. Johnson (1980) proposed that habitat use is a hierarchical process by which species make decisions in utilising a certain habitat. However, areas with significant human activities such as human settlements, e.g., Kakesio, Olbalbal, and Nainokanoka despite having suitable eland habitat, only few elands were sighted compared to the core-conservation area as shown (Figure 3–4).

On diet composition, elands consumed varieties of plants though the rate of utilization differed from one plant species to another. The results indicated that elands feed more on certain plant species than those with diminutive palatability as eland prefer to feed mostly on grassland vegetation where most of the preferred plants species were grasses. This suggests that grassland was the main habitat for elands in NCA presumably because of diet supply. However, the study concludes with recommendations for enhancement of grassland habitat management which are of utmost significance for future conservation of common eland in the NCA.

Conclusion and Recommendations

Elands used mostly grassland habitats compared to other habitat types, presumably in response to forage resources availability of their choice especially *T. triandra* and *C. pycnothrix*. Thus, grassland habitat management in NCA would be an important management strategy for sustainable conservation of eland population in the area. During field surveys, it was observed that human activities influenced eland habitat use as the areas with significant human activities had few eland groups despite having suitable eland habitat and forage resources suggesting that elands are sensitive to human disturbances hence the need to control anthropogenic activities in eland range areas.

Elands appeared to forage on a variety of plant species and their diet influenced habitat use. The species consumed differed slightly between seasons and there was no evidence of significant shortage of forage even in the dry season. Based on the current findings from the study, the following recommendations are proposed:

(a) Undertake radio tracking of some eland groups using GPS collars for long-term monitoring of eland movements using, modelling distribution patterns to link individual elands to their home ranges.

(b) Undertake further studies on eland habitat use and diet composition for more detailed understanding of the feeding ecology of the species.

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