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Seasonal botanical characteristics of the diets of Grant's (*Gazella granti* Brooke) and Thomson's (*Gazella Thomsoni* Guenther) in the dryland habitats of south-central, Kenya

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Understanding of dietary requirements of different wildlife populations is critical in wildlife habitat conservation especially in Sub-Saharan Africa where wildlife contributes much to the National GDP of many countries. This study was conducted to determine the seasonal (wet/dry) diet profiles of Thomson's and Grant's gazelles (Gazella Thomson and Gazella granti) in the Athi-Kapiti savannah ecosystem of south-central Kenya. Diet composition was determined using the micro histological faecal analysis technique. Plant species in the diets were categorized into grasses, forbs and browse. Botanical compositions for diet selection by the two gazelles were generally influenced by season. Forage classes were significantly ($P<0.05$) associated with the two gazelles. Grant's gazelle was a mixed feeder in the wet season and a browser in the dry season, whereas Thomson's gazelle was a grazer during wet season and a browser in the dry season. The two gazelles had diverse diets in the wet season with Thomson's gazelle having diverse diets in both seasons than Grant's gazelle. The degree of dietary overlap between the two gazelles was highest during the dry season with a significant ($P<0.05$) Spearman's rank-order correlation coefficient; $R_n = 0.92$. The results indicate that the two species are competitors during the dry season and complimentary feeders during the wet season. This implies that Wildlife Managers manning the conservation areas in the region need to consider the optimal stocking rates of the two gazelles during the dry season. The shift in dietary diversifications between the two species should be investigated further. The degrees of dietary overlap within the forage and forbs classes were highest throughout the two seasons. Therefore, key browse plants such as the Acacia spp, Grewia spp. and *Balanities glabra* and forbs such as *Hibiscus parvifolius* should be spared during bush control activities.

Key words: Grant's gazelle, Thomson's gazelle, herbivore diet, conservation management, Kenya.

INTRODUCTION

Kenyan rangelands cover nearly 70% of the country and are a home for thousands of pastoralists and agro-pastoralists and a wide range of domestic and wild herbivores. The rangelands play an important role in livestock production and wildlife conservation in Kenya, both of which are critical to Kenya's economy as they are key to supporting livelihoods and generating foreign exchange earnings through trade and tourism (GoK, 2002, 2003). Most of the south-eastern Kenya is rangelands which are mainly used for livestock production, wildlife conservation, and cultivation in the wetter areas. The rangelands provide habitat for countless mammals, birds, amphibians, and insects. Of these different types of animal species, Gazelles are the most common types of antelopes (AWF, Grant's and Thomson's gazelle's fact files). The different species of antelopes that inhabit the region include Thomson's gazelle (*Gazella Thomson*), Grant's gazelle (*Gazella granti*), gerenuk (*Litocranius wallen*), eland (*Taurotragus oryx*), greater kudu (*Tragelaphus strepsiceros*), lesser kudu (*Tragelaphus imberbis*) and the klipspringer (*Oreotragus oreotragus*) among others. Thomson's and Grant's gazelles' are the most common and conspicuous gazelle's species to the tourists visiting wildlife conservation areas in the region. They are often seen grazing together.

In late 1990s, the population of Thomson's and Grant's gazelles in Kenya was estimated to have declined by 64 and 58%, respectively (Boun and Blench, 1999; GoK, 1996). There has been a lot of concern as to what could be the underlying cause for the drop in their numbers. However, this trend is not unique for Kenya's wildlife. Land degradation and habitat loss to settlements, infrastructural development and encroaching cultivation among others are some of the leading causes of declining wildlife numbers inside as well as outside African parks (Western et al., 2009). In addition, climatic variation has placed further pressure on pastures, browse and habitat space for the wild animals including the two types of gazelles utilizing the rangelands. A significant change in habitat affecting the pastures is recognised to cause adjustments in the feeding habits of herbivores (Lamoot and Hoffmann, 2004). For efficient utilization of the shrinking rangeland through optimal allocation of the forage resource to the different species, knowledge of the feeding habits and habitat preference of the animal, and the prevailing climatic conditions of the area is essential (Hanley, 1982).

Thomson's and Grant's gazelles' often graze together and although outwardly similar, they differ fundamentally and are distinguishable using their morphology. Ecologically, the two gazelles have very different feeding characteristics. The two species select slightly different forage plants. Knowledge of the similarities and differences in diets of the two species of animals is thus important in making crucial grazing management decisions. Unfortunately, studies on common range-use by the two gazelles are old and far from complete (Estes, 1967; Field, 1975; Mugambi, 1982; Stelfox and Hudson, 1986; Stewart and Hofmann, 1972). Published studies addressing the problem of competition and ecological separation among other East African herbivores are common and include those of Casebeer and Koss (1970), Field et al. (1973) and Ng'ethe and Box (1976). More recent studies do not compare the feeding characteristics of the two gazelles (Kilonzo et al., 2005; Mugambi 1982; Spinage et al., 1980). This study aimed to evaluate the seasonal dietary botanical composition, diversity and overlaps between Thomson's and Grant's gazelles' with the hope that the findings would help in suggesting some management decisions affecting the two gazelles in the South-eastern rangelands of the country and in other areas with similar ecological characteristics.

MATERIALS AND METHODS

Study area

The study was carried out within the Athi-Kapiti ecosystem, about 80 km south of Nairobi along the Nairobi–Namanga highway between latitude 2°0' south and longitude 36°45' east. The study area falls under ecological zone IV characterized by low and erratic rainfall of bimodal distribution. Average annual precipitation ranges between 300 and 800 mm (Pratt and Gwynne, 1977). The long rains occur between March and May, while the short rains normally occur between October and December. Elevation varies from 600 to 2500 m above sea level. The vegetation consists primarily of scattered tree and open grasslands (Pratt and Gwynne, 1977). Open grasslands predominate in the Athi-Kapiti plains while Bush and woodland are found mostly in the central hills. *Themeda triandra*, *Pennisetum mezianum*, *Chloris* spp. and *Sporobolus* spp. are the dominant grass species (Rattray, 1960). *Balanites aegyptiaca, Acacia merifella* and *Acacia drepanolobium* are the dominant tree species on the plains. The drainage lines are dominated by *Acacia* species, specifically *A. seyal*, *A. xanthophloea* and *A. Paoli* (Croze, 1978; McDowell et al., 1983). The main economic activity of the area is livestock production and wildlife conservation in national parks, game reserves, and game ranches established in the area.

Determination of diet composition

Botanical composition of the gazelles' diets was determined by use of the faecal microhistological technique as described by Sparks and Malecheck (1968). The sampling period straddled a wet and a dry season. The samples of faeces were collected once per month. Wet season samples were taken from March through June and dry season from July through September. On the day of sampling, the researchers scouted the study area looking for fresh pellet piles of either type of gazelle. From each pellet pile, two pellets were picked. A total of ten pellet piles per gazelle species were identified. A total of 20 pellets were therefore collected per each sampling day. The pellets were stored in paper sacks, then air-dried for three days and oven-dried at 60°C for 24 h. Pellets from each type of

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gazelle and month per season were thoroughly mixed to make one composite sample. From each composite sample three sub-samples were taken for analysis. The pellets were then ground in a Wiley mill through a 1 mm screen. Handling and slide preparation of plant reference and faecal material as well as calculation for frequency, particle density, relative density, and percent dry-weight followed the procedures outlined by Cavender and Hansen (1970), Hansen et al. (1984) and Sparks and Malecheck (1968). Differences in amounts of forage classes identified in the diets of the two animal species were evaluated and statistical differences were accepted at the 5% level of significance.

Determination of diet diversity and overlaps

Diet diversity was calculated using the Shannon-Wiener index (Shannon 1948). The index gives an estimate of the variety and evenness of the components in the diet (Hurtubia, 1973). Overall similarity of diets for shared forage was calculated using Morisita similarity index (Morisita, 1959) as modified by Horn (1966). Overlap within each individual forage category (grasses, forbs and shrubs) was also calculated. The Spearman's rank-order correlation coefficients (Snedecor and Cochran, 1973) were used to compare food habits between the two gazelles. Differences in the variables used were evaluated using the *t*-test and statistical differences were accepted at the 5% level of significance.

RESULTS

Botanical composition of the diets

Data on Table 1 show plant species recorded in the diets of the Thomson's and Grant's gazelle during the wet and dry seasons. Certain species were prevalent in the diets throughout the two seasons, while others were prevalent only during one of the seasons. Commonly shared forage plants were similar while others differed in the diets throughout the two seasons.

Wet season diet composition

A total of 23 plant species were identified in the diets of Grant's gazelle during this season. The most abundant plant species in the diets were *Acacia* spp. mainly *A. mellifera* and *A*. *drepanalobium* contributing about 35% of the total diet of the Grant gazelle. Other abundant species include the *Hibiscus parvifolius* (13%), *Grewia* spp (9%) and *Pennisetum straminium* (7%). Twenty one (21) plant species were identified in the diet of Thomson's gazelle. Of these plants, the most abundant in the diet were the grass species namely the *Digitaria* spp. and *Cynodon* spp. each contributing an equal percentage of about 15% of the diet followed closely by *Pennisetum mezianum* and *P*. *straminium* equally contributing about 14% of the diet.

Relative proportion of each forage classes in Grant's gazelle diets were 61% browse, 24.3% grass and 14.7% forbs. For Thomson's gazelle, the proportions were 76.8% grass, 14.7% browse and 8.5% forbs (Figure 1). Forage classes were significantly associated with the two gazelles (*P<0.05*) when frequency of occurrence was analyzed. Grass, browse and forbs use were significantly different between the two types of the gazelles during the season. Thomson's gazelle relied largely on grasses while the Grant's gazelle on browse. Forbs were the least contributor to the diets of the two gazelles.

Wet season diet diversity and overlap

In the wet season, Thomson's gazelle had a Shannon-Wiener diversity index of 1.07, whereas Grant's gazelle had 1.01. This showed that Thomson's gazelle diets were more diverse during the wet season even though the number of plants species was less by 2 of that of Grant's gazelle. This meant that the proportions of the individual plants relied by the Grant's gazelle were higher than those of Thomson's gazelle. Overall diet similarity was 26.4% among common (15) forage species comprising Thomson's and Grant's gazelles' diets. Though the overall diet similarity was low, overlap within each forage class was higher with browse having 46.2%, followed by forbs 42.3% and grasses 31.8% (Figure 2). The Spearman's rank-order correlation coefficient was 0.24 and was not significantly different (P>0.05) implying that there was no strong link in the order in which the two species selected the common forage plants during the season. This showed that the two animal species do not compete with each other during the wet season.

Dry season diet composition

Twenty four (24) plant species were identified in the diets of Grant's gazelle while 18 were identified in the diets of Thomson's gazelles. Grant's gazelle consumed in abundantly *Grewia* spp, *Hibiscus parvifolius*, *Acacia* spp, *Balanities glabra* and *Themeda triandra* plant species each contributing about 38, 16, 9, 8 and 6% respectively. Relative proportion of each forage class were 58.6% browse, 22% forbs and 19.4% grass in Grant's gazelle diets. Relative proportions in Thomson gazelle diets were 65% browse, 19.8% forbs and 15.2% grass (Figure 3). Browse and forbs use were significantly different (P<0.05) between Grant's and Thomson's gazelles' during the wet season. Grant's gazelle relied largely more on browse and forbs than Thomson's gazelle. Grasses were the least contributor to the diets of the two gazelles.

Dry season diet diversity and overlap

Grant's gazelle had a Shannon-Wiener diversity index of 0.947, whereas Thomson's gazelle had 0.959. Grant's gazelle had a slightly less diverse diet than Thomson gazelle. This implies that the two types of gazelles relied more less on the same number of forage species for their diets though there could be slight differences in the proportions of individual plants foraged. Overall diet similarity index was 46% among the 15 common forage

Table 1. Mean relative density (%) of individual forage plant species in Grant's and Thomson's gazelles' diets during wet and dry season.

Forage species/classes	Wet season		Dry season	
	G. gazelle	***T. gazelle***	***G. gazelle***	***T. gazelle***
Grasses				
Bracharia spp.	3.1	0.4	0.6	0
Cynodon spp.	5.8	15.3	0.5	0
Digitaria spp.	2.0	15.4	0.9	3.3
Enterpogon macrostachyus	0	8.6	0	0.7
Eragrostis spp.	0.8	0.4	0.6	0
E*ustachyus paspaloides*	0.4	1.6	0	0
Hyparrhenia spp.	0	0.4	0	0
Lantana trifolia	0.7	0	0	0
Lintonia nutans	0	0.6	2.2	0
Panicum spp.	0	2.0	0.5	0.5
Pennisetum mezianum	0.5	13.9	1.8	0.8
Pennisetum straminium	7.2	13.9	5.9	2.0
Setaria spp.	0	0.6	0	0
Sporobolus spp.	0.7	1.7	0	0
Themeda triandra	3.1	2.0	6.4	7.9
Sub-total	24.3	76.8	19.4	15.2
Forbs				
Barleria spp.	0.7	1.9	0.6	1.8
Commelina spp.	0	2.0	0	0
Hibiscus parvifolius	12.8	4.6	16.2	13.9
Indigofera spp.	0.5	0	0	0
Ipomoea spp.	0.7	0	0.4	0
Monechmna debile	0	0	0.4	0
Sida spp*.*	0	0	0.9	0
Solanum incanum	0	0	0.9	0
Hermania spp*.*	0	0	0.6	0.9
Ochna inermis	0	0	2.0	3.2
Sub-total	14.7	8.5	22.0	19.8
Browse				
Acacia spp*	35.2	10.5	9.0	18.8
Asparagus spp	0.5	1.9	0	0.6
Aspilia mossambiscensis	2.8	0	0	2.1
Balanities glabra	4.6	1.4	7.5	10.8
Boscia spp.	0	0	0.9	0
Cadaba farinose	4.1	0.9	0.6	0.5
Commiphora spp	3.4	0	2.0	4.5
Duosperma spp	0.7	0	0.6	0.6
Grewia spp	9.2	0	38.0	27.1
Soricocomopsis spp	0.5	0	0	0
Sub-total	61.0	14.7	58.6	65.0
Total	100.0	100.0	100.0	100.0

species comprising the diets of the two species of gazelles. However, there were over 40% diet overlaps within each individual forage category with forbs having 49% followed by browse (46%) and grass (42%) (Figure

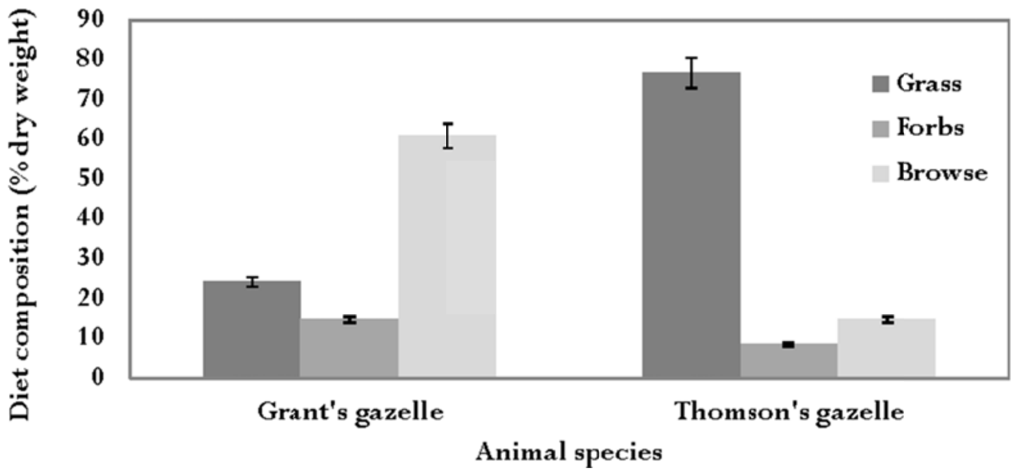

Figure 1. Dry weight percentage of total diet each forage class contributes to Thomson's and Grants gazelle diet during wet season.

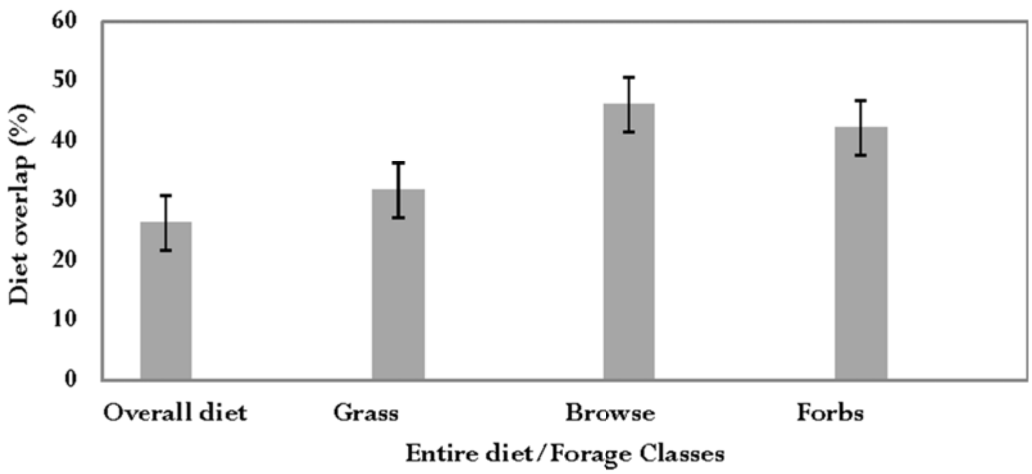

Figure 2. Percent overlap of overall diet and each forage class for Thomson's and Grant's gazelles during wet season.

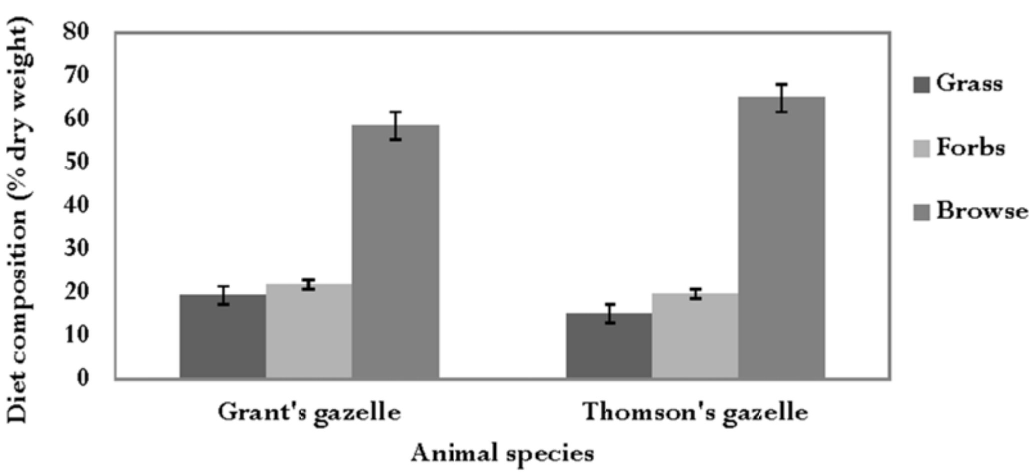

Figure 3. Dry weight percentage of total diet each forage class contribute to Thomson and Grants gazelles during dry seasons.

Figure 4. Percentage overlap of overall diet and each forage class for Thomson's and Grant's gazelles during dry seasons.

4). The forb similarity index was high because of the high prevalence of *H. parvifolius* by the two types of gazelles. The Spearman's rank-order correlation coefficient was high (0.92), implying a strong link in the order the two species selected the common forage plants during the season. This indicates that the two types of gazelles most likely compete with each other for the same forage resources during the dry season.

DISCUSSION

Diet composition

Overall, diets of the two Gazelles varied with seasons in terms of individual species composition and forage class proportions. Browse dominated the Grant's gazelle diets during both seasons though slightly higher in the wet season. The forbs component was higher in dry season than in the wet season. According to our results, Grant's gazelles could be firmly classified as a mixed feeder in the wet season and as a browser in the dry season. Studies that classified Grant's gazelle as mixed feeder and agree with our findings include those of Hoffman (1973), Kilonzo et al. (2005), Lamprey (1963), Schenkel (1966) and Sommeratte and Hopcraft (1994). Studies that classify Grant's gazelle as a browser are few and include those of Kingdon (1982) and Spinage et al. (1980). The study reported *Cynodon* spp. and *Pennisetum straminium* as major grass species in the wet season while *Themeda triandra* and *Pennisetum straminium* common in dry season. The prevalence of the three perennial grasses in the diets of the Grant's gazelle is attributable to their palatability and higher frequency in the area particularly *Themeda triandra* (Kilonzo et al., 2005). *Acacia* spp. notably *A. merifella* and *A. drepanolobium* and *Grewia spp* formed the bulk of the browse component contributing about 35 and 38% in wet season and dry season, respectively. The three woody species remain green and retain their leaves throughout the year. The gazelles were observed foraging *Grewia* spp. more than the two Acacia species. *H. parvifolius* was the most prevalent forb in the diets of the gazelle throughout the two seasons though it was more prevalent in the dry season than in wet season. The forb has been reported as relatively frequent in the area (Kilonzo et al., 2005).

Grass dominated the Thomson's gazelle diets during wet season (77%) and browse (65%) during the dry season. The forb component is only significant in the dry season. Thomson's gazelle was thus predominantly a grazer during wet season and a browser in dry season. Thomson's gazelle is predominately a grazer preferring well-water short grass plains. The results on the diets of Thomson's gazelle agree with that of Hansen et al. (1985), who reported high proportion (>50%) of monocotyledonous plant species in the diets of the gazelle living in northern Serengeti. However, Kingdon (1982) and Spinage et al. (1980) classified Thomson's gazelle as mixed feeder. *Enterpogon macrostachyus*, *Digitaria* spp., *Pennisetum mezianum* and *P. straminium* were reported as forming the bulk of grass component in the wet season, while only *Themeda triandra* was the most important grass species in the gazelle diet in the dry season. The prevalence of certain grass species could be partly attributed to the fact that they are perennial and partly to the fact that they had a high relative frequency and greater standing biomass than other species as reported by Ego et al (2003) and Kilonzo et al (2005) who did their research work in the same region. Thomson's gazelle only turned to browse shrubs and forbs in the dry season when grass is unavailable. The current study reported *Grewia* spp., *Acacia* spp. and *Boscia* spp. as the most prevalent browse species contributing about 27, 19 and 11% of the entire diet respectively. *H. parvifolius* spp. was still the most prevalent forb in the diets of Thomson's gazelle throughout the two seasons.

Diet diversity and overlap

Seasonal diet diversity

Diet diversity indices were higher in the wet season and lower in dry season. Likewise, the indices were higher for Thomson's gazelle than Grant's gazelle in both seasons even though the numbers of plant species reported in their diets were less by 2 in the wet season and less by six in the dry season that of Grant's gazelle. What this meant was that Thomson's gazelle used higher proportions of the individual forage plants compared to the Grant's gazelle. Our results therefore indicate that the two gazelles tend to have wide and less variety of forage plants during wet and dry seasons' respectively. Larger species typically have greater diversity in species selection under normal conditions (Mackie, 1970; Schoener, 1971), but in our study Thomson's gazelle diets were more diverse than Grant's gazelle. Since diet diversity often increases under conditions of food resource shortages (Gullion, 1966), Thomson's gazelle probably selected more diverse diets because they were under dietary stress. Under more favourable conditions, Thomson's gazelle might have had a less diverse and more specialized diet than Grant's gazelle. Thomson's gazelle diets were more diverse in grass species in wet season and browse species in the dry season. This can be viewed as a resource utilization strategy whereby Thomson's gazelles make use of the grass when it is still growing and is high in nutrient content, before suddenly declining in quality as it matures. Unlike Thomson's gazelle, Grant's gazelle diets were more diverse only in browse species throughout the two seasons. Human disturbances currently being witnessed in the region might be the major cause in the change in the dietary diversity between the two types of gazelles. Harvesting or cutting of woody trees for charcoal burning can be very disastrous to the nutritional well being of the two types of gazelles.

Seasonal diet overlap

The seasonal overall diet similarity was highest (46%) during the dry season and lowest (26%) in the wet season. Though the overall diet similarity in wet season was low, the results also indicated higher similarities within browse and forbs categories. Our results indicate that the degree of overlap in the entire diets and within the three forage classes increased during the dry season. Dietary overlaps alone cannot tell whether the two species are competitors or complementarily feeders. The Spearman's rank-order correlation co-efficient technique was used to test whether there was any strong link in the order in which the two animal species selected the common forage plants during the two seasons. The Spearman's rank-order correlation co-efficient was highest (0.92) in the dry season and significantly different ($p<0.05$) unlike that of wet season (0.24). According to our results therefore, Thomson's and Grant's gazelles' are competitors during the dry season and complimentary feeders during the wet season. According to Schoener (1983), competition only occurs when the resources being shared are limited. This implies that there was limited forage available for the two species during the dry season and the two types of gazelles' are competing with each other for forage resources. During the wet season, the two types of gazelles were therefore ecologically separated and this demonstrates the feeding complimentary of these two species. This suggests that a combination of the Thomson's and Grant's gazelles' during the wet seasons provides a more efficient utilization of forage at the south-eastern dry lands of the country.

Conclusion and management implications

The botanical compositions for diet selection by the Grant's and Thomson's gazelles' were generally influenced by season. Certain species were prevalent in the diets throughout the two seasons, while others were prevalent only during a particular season. Commonly shared forage plants were similar while others were different in the diets throughout the two seasons. Grant's gazelle was a mixed feeder in the wet season and a browser in the dry season, whereas Thomson's gazelle was a grazer during wet season and a browser in the dry season. The two gazelles had diverse diets in the wet season with Thomson's gazelle having more diverse diets in both seasons than Grant's gazelle. Under normal conditions, Thomson's gazelle tend to have a less diverse diet compared to Grant's gazelle. This is an indication to the rangelands managers that the two gazelles are under nutritional stress and the problem needs some interventions. Human disturbances might be the main cause of this abnormality. The two species were competitors during the dry season and complimentary feeders during the wet season. The dry season conditions therefore may pose a threat to the survival of the two species in the area. This might have management implications to wildlife managers manning the conservation areas in terms of optimum stocking rates. Further study is needed to determine the sustainable stocking rates of the two species in the ecosystem. Dietary overlaps were higher within the browse forage and forb classes throughout the two seasons.

Therefore, any human activity interfering with the browse forage particularly the *Acacaia merifella*, *Grewia* spp and *Balanities glabra* and forbs like the *H. parviflora* should be stopped forthwith at any cost. We recommend a comparative study to characterise the nutritional requirements of the two types of gazelles in the study area. A census should also be conducted since the conservation of the two gazelles should be based on both their population status and habitat requirements.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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