



**RESEARCH ARTICLE**

**FORAGE AVAILABILITY AND QUALITY FOR THE IMPALA (*AEPYCEROS MELAMPUS* (BRIAN) KATHRYH) OF IMPALA SANCTUARY, KENYA**

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**ABSTRACT**

Forage availability and grazing pattern for the impala (*Aepyceros melampus* (Brian) Kathryh) in three ecosystems of the Impala sanctuary, Kenya was assessed during the wet and dry seasons. The grazing behavior of the impalas was observed to identify the preferred forage species and patterns grazing between seasons and ecosystems. Preferred grass species were sampled to determine percentage dry matter, neutral detergent fiber, acid detergent fibers, and Crude protein. Data was subjected to Analysis of Variance using SAS version 9.0. The results showed that impala sanctuary had 37 different grass species but *Cynodon dactylon*, *Eragrostis curvula*, *Digitaria scalarum*, *Eleusine indica*, *Pennisetum setaceum* and *Hyparrhenia filipendula* were most grazed on by the Impala. Grassland ecosystem had significantly high forage availability during the wet season, but in the dry season the marshes ecosystem was the one with the most nutritious forages. Grazing patterns varied with seasons, with most impalas preferring to graze in the grassland during the wet season and in the marshes during the dry season. The study suggests management practices that favor dominance of species that are most foraged in order to increase forage availability for the impalas in the sanctuary.

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**INTRODUCTION**

African Savanna ecosystems have many species of large mammalian herbivores than any other known ecosystem. This is due to a combination of precipitation, soil fertility and habitat heterogeneity which promote establishment of a variety of forage resources for the herbivores (Smith, 1999; Otieno *et al.*, 2005). Herbivores can be divided into three general groups: browsers, grazers and mixed or intermediate, feeders (Hofmann, 1989). The Impalas are categorized as intermediate feeders because they feed on a combination of grasses and herbs species and alter their diets throughout the year (McNaughton and Georgiadis, 1986; Skinner and Chimimba, 2005). Impala switches between forage types, and plant parts, in response to fluctuating environmental factors such as change in rainfall (Van Rooyen, 1992; Skinner and Chimimba, 2005). The co-existence of many herbivores within the same ecosystem has been attributed to the fact that different grazers specialize on forage at different grazing heights (Wilkins *et al.*, 2000) and the differences in feeding patterns (McNaughton and Georgiadis 1986; Hofmann, 1989). The main grazers in the Impala sanctuary are the impalas (*Aepyceros melampus* (Brian) Kathryh), zebras (*Equus quagga*, Alistair), hippos (*Hippopotamus amphibious* (Aurelius) and the sitatunga (*Tragelaphus spekeii* L.). The Impalas are known to exhibit diet flexibility by combining both browsing and grazing (Meissner *et al.*, 2003) and also make large change in percentages of browse and graze consumed seasonally (Mon, 1980; Meissner *et al.*, 1996). In the Impala sanctuary grasses constitute upto 90% of impala diet during the rainy season, but

only 33% during the dry season (Meissner *et al.*, 1996). Impala and zebra diets are also believed to differ markedly between localities depending on changes in local vegetation. For instance, Tanzanian impala populations eat over 90% grass (Lamprey, 1992) whereas the Zimbabwean populations have diet dominated by browse (Smithers *et al.*, 1987).

Several studies have attempted to evaluate and compare forage quality of the grazers of savanna in different ecosystems under different conditions. For example, (Belsky *et al.*, 1993) compared forage quality under trees and in open field. He found high forage quality under Acacia trees. This was probably due to high soil nutrient concentrations under tree canopies (Belsky *et al.*, 1993). Studies in Namibia showed that the number of large trees has reduced by 50% over the last 36 years due to the pressure from wild animals while the extent of shrub land dramatically increased (Fulco *et al.*, 2007)

The Impala Sanctuary in Kisumu, Kenya, is a closed ecosystem and there is no cross-habitat movement amongst the grazers of the sanctuary, therefore grazing patterns are restricted within and these ultimately have an impact on the forage availability and preference. The quality of forage has a major impact on animal production and health, making it an important consideration for savannas management and conservation (Van Saun, 2006). Information on the availability and quality of the preferred forage species and seasonal changes in the grazing pattern is important for designing appropriate management strategies, however such information is lacking for the Impala sanctuary. The objectives of this study were (i) to determine the preferred forage species and

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their seasonal availability, (ii) to determine the quality of the preferred forage species and (iii) to assess changes in grazing patterns of the impala during the wet and dry seasons.

## MATERIALS AND METHODS

### Study Area

The study was conducted in Impala Sanctuary (00° 37' S and 34° 12' E) in Kisumu County- Kenya. It is located at an altitude of 1,149 meters above sea level and situated about 2km west of Kisumu city centre. The sanctuary measures about 0.34 km<sup>2</sup> and is predominantly grassland and shrubland. It is home to a herd of impala as well as many reptiles and birds (Kenya Wildlife Service, 2012). There are also several caged baboons and leopards that enhance the tourism potential of the sanctuary. The area experiences warm-hot humid type of climate with an annual precipitation of 300-900 mm per annum and an annual mean diurnal temperature of 27°C. The soils are predominantly black cotton clays (Kenya Wildlife Service, 2012).

### Identification and selection of the preferred forage species for study

The sanctuary was divided into 3 study ecosystems: grassland, shrubland and marshes. Quadrats of 1m x 1m were set up randomly in the in grassland and marshes ecosystem, while in the shrub land 5m x 5m quadrats placed at an interval of 5m. All the grass species in each quadrat were identified and coded with the help of a hand book on Primer on grass identification and uses in Kenya, (Muyekho *et al.*, 2004) and Family taxonomic key of Poaceae (family graminæ) Barkworth *et al.*, (2007). Plant species diversity in the three ecosystems was calculated using the Shannon – weaver diversity index (Magurran, 1988). Identification of the preferred forage species for the impalas was done by direct observation of the grazing impala as described by Meissner *et al.*, (1996), Meissner *et al.*, (2003). The frequency of grazing by the impalas on the forage species was monitored in the morning and evening, four times a week at five different points' in the months of March to June (rainy season) and December to February (dry season). Data on the frequency of grazing was used to identify the most preferred forage species with the species most frequently grazed on being the most preferred.

### Determination of quality of preferred forage species

Preferred forage species in each ecosystem were sampled by harvesting the forage from the ground level to the leafy part in each quadrat replicated five times and the total fresh weight taken. Dry matter yield (DM) for the species collected was determined by the difference between fresh sample weight and weight of samples dried in the oven at 70 °C for 48 hours. All the samples of each of the collected species was ground into powder and analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF) and total nitrogen in the laboratory using the procedure as described by (Kjeldahl, 1965-modified by Okalebo *et al.*, 2002). The concentration of the nitrogen in the plant sample was calculated using the formula described by (Kjeldahl, 1965). The (CP) of the plant sample was calculated from the total nitrogen as described by Kjeldahl, (1965) using the formula, % CP = % N \* 6.25.

### Assessment of change in grazing patterns

The impalas grazing patterns in the three ecosystems was monitored in the morning and evening four times a week and the frequency of grazing each ecosystem noted, for the wet and

dry seasons respectively. The data on percentage frequency of grazing on nutrient analysis was used to describe the change in grazing behavior of the impalas in the two seasons.

### Data Analysis

Data obtained from dry matter analysis, neutral detergent fibre (NDF), acid detergent fibre (ADF), Crude protein (CP), was subjected to two and three way Analysis of Variances (ANOVA) using computer software package SAS version 9.0 to determine the differences in seasonal variation in forage availability and quality in the three ecosystems. A correlation coefficient analysis was done to compare to assess the relationship between the various nutrient variables within the species.

## RESULTS

Grassland ecosystem was more diverse with the highest species diversity index of 1.60; followed by shrubland ecosystem with 1.03 and then marshes ecosystem with 0.92. Grassland ecosystem recorded the highest species richness at 37 species, shrubland 13 species and marshes 9 species. The species evenness was also greater in the grassland (0.89) and marshes (0.84) and lowest in the Marshes (0.45). Figure 1 shows the percentage frequency of grazing on most preferred forage species in the sanctuary. *Cynodon dactylon* ((L.)Pers), *Eragrostis curvula* (Schrad.) Nees, *Digitaria scalarum* (Schweinf.), *Eleusine indica* (L.) Gaertn, *Pennisetum setaceum* (Forsk) Chiov and *Hyparrhenia filipendula* (Hochst.) Stapf were the most preferred species across the three ecosystems in the sanctuary.

All the six preferred grass species showed an increase in DM values from the wet season to the dry season with significant differences (P<0.05) amongst the species in each season. *Hyparrhenia filipendula* recorded the highest DM values in the two seasons and *E. curvula* recorded the lowest values of DM. There was a significant (P<0.05) difference in the NDF and ADF content between the two seasons with the dry season having higher values in all the six grass species. *P. setaceum* and *H. filipendula* had the highest NDF and ADF values in both the wet and dry season. *C. dactylon* and *E. indica* recorded the lowest values. The values of CP for the six grass species were higher during the wet season than during dry season. *Cynodon dactylon* and *D. scalarum* had significantly (p<0.05) the highest CP in the two seasons. *P. setaceum* and *H. filipendula* had the lowest but were not significantly different (P<0.05) from those of *E. indica* and *E. curvula*.

The Impalas grazed more in the grassland ecosystem during the wet season than in the shrub land, while in the dry season most of the grazing occurred in the marshes. The shrubland ecosystem was the least grazed amongst the three ecosystems Figure 2. DM % did not differ significantly between the ecosystems but was slightly higher during the dry season than the wet season. The marshes ecosystem showed significantly (P<0.05) higher NDF and CP values than other ecosystems in both the two season (Figure 2). There was no significant difference (P<0.05) in the ADF values for grassland and marshes ecosystems although the two ecosystems greatly varied with the shrubland ecosystem (Table 1).

## DISCUSSION

Grassland had the highest species diversity and richness, followed by shrubland and then marshes. This results could be

attributed to the fact that grassland is open and there is high primary productivity (Sankara *et al.*, 2004) thus can support more species. The marshes ecosystem is water logged during the wet seasons and thus does not favor the growth of most of the grass species which are not adapted to such an ecosystem (Muyekho *et al.*, 2004). The shrubland ecosystem is usually well shaded with the shrubs canopy; therefore fewer grass species can grow under the canopy created by the shrubs (Belsky, 1994; Manuel and Molles, 2003).

The study showed that Dry matter % increased with plant maturity towards the dry season. The result are in agreement with findings of Undersander *et al.*, (2001); Van Saun, (2006) who reported that as the plant matures, the moisture content is replaced by the structural fibrous component hence the high DM %. . In the current study NDF was high NDF during the dry seasons. This is in agreement the finding by Linn *et al.*, (1999); Undersander *et al.*,(2001) who reported that as the plant matures plant tissues becomes more fibrous and the cell wall production increases leading to increase in NDF content. *H.filipendula* and *P.Setaceum* had high values of NDF compared to the other four species; and these can be attributed to the fact that these grasses are stemmy and thus more fibrous (Linn *et al.*, 1999; Undersander *et al.*, 2001).

According to a study by Undersander *et al.*,(2001), a grass forage with NDF of <60% would be considered to be of high quality, in this study all the grass forage tested apart from *P.Setaceum*, and *H.filipendula* which had values >60%. The high NDF for *P.Setaceum*, and *H.filipendula* could be attributed to the low leaf to stem ratio which is one of the factors that affect forage quality (Undersander *et al.*, 2001). In the dry season ADF values of <35% were recorded for most of the grass species except for *P. setaceum*. This results are comparable to finding by Linn *et al.*, (1999) and Van Saun, (2006) who recommended ADF value for a good feed to be <35% for either legume or grass forage. The dry season exhibits higher levels of ADF because as the plant matures the poorly digestible cell wall components namely, cellulose, lignin and other resistant substances that make up ADF increase in content (Barry and Garry, 2005).

Crude protein varied significantly (p<0.05) across the two seasons with the forage species having a higher % CP values during the wet season than the dry season and this could be attributed to the high NDF as reported in the present study and that of Undersander *et al.*,(2001). In the present study *C.dactylon* and *D.Scalarum* had significantly (P<0.05) high CP values across the two seasons and this could be attributed to the higher leaf to stem ratio compared to the other grasses (Undersander *et al.*, 2001).

The study showed that there were changes in the pattern of grazing between seasons and ecosystems (Figures 2). For instance the Impalas grazed more in the grassland during the wet seasons than in the shrublands; and towards the dry seasons they grazed more in the marshes and shrubland than grassland. This change in grazing behavior can be attributed to the adequate nutritious forage (Table) in the grassland during the wet season and the marshes during the dry season. The preference to grazing in the grassland during the wet season is comparable to a similar study by Cambell, (1992) who reported that most grazers prefer to graze on grounds which are accessible during wet seasons. The generally low grazing in the shrubland could be attributed to accessibility and the fact

that very few species of grasses can survive underneath the canopies of shrubs due to inadequate amount of light for photosynthesis. Some shrubs have allelopathic influence which hinders the establishment of other species around them (Sankara *et al.*, 2004).

**Conclusion and recommendations**

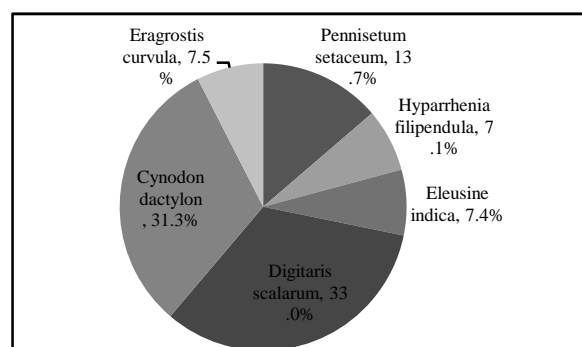
The sanctuary has thirty seven grass species across the three ecosystems but *Cynodon dactylon*, *Eragrostis curvula*, *Digitaris scalarum*, *Eleusine indica*, *Pennisetum setaceum* and *Hyparrhenia filipendula* were the most grazed on. Grazing patterns varied with seasons, with most impalas preferring to graze in the grassland during the wet season and in the marshes during the dry season. In order to increase forage availability, the management should either re-seed the sanctuary with the most preferred grass species and/or implement pasture management practices that favor dominance on the preferred species.

**Table 1** Comparison of Nutrient variables in the three ecosystems during wet and dry seasons

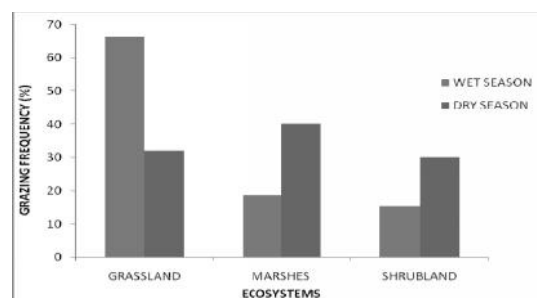
Nutritional components	Ecosystem	% mean of seasons at P<0.05		
		wet season	dry season	Average means
DM	Grassland	35.74±1.6	36.13±0.5	35.56±1.1a
	Marshes	34.99±1.2	35.99±0.6	35.49±0.9a
	Shrubland	35.40±1.0	36.10±0.6	35.23±0.8a
ADF	Grassland	32.40±1.8	34.22±2.2	33.31±2.0a
	Marshes	33.29±3.2	34.49±2.9	33.89±3.1a
	Shrubland	31.02±1.0	33.76±0.7	32.39±0.9b
NDF	Grassland	56.99±3.5	61.63±3.5	59.31±3.5b
	Marshes	59.77±3.0	64.36±3.3	62.06±3.2a
	Shrubland	53.04±0.7	60.63±0.8	56.84±0.8c
CP	Grassland	12.54±0.7	12.21±0.6	13.57±3.5a
	Marshes	13.88±3.6	13.25±3.3	12.35±0.7b
	Shrubland	12.36±0.5	11.36±0.9	LSD 2.3
				S.D 0.6

\*Column means with the same letters are not significantly different 5 % confidence limit. (±)- Shows the standard deviations

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**Figure1** Frequency of grazing by impalas on the most preferred grass species.



**Figure 2** Percentage frequency of grazing in the Wet and Dry seasons in the three ecosystems.

## References

- Barkworth, M.E., Capels, K.M. S., Long, L.K., 2007. Flora of North America Poaceae, part1 volume 24. Anderton and M.B. Peep, editors. Oxford University Press, New York, pg. 911.
- Barry, B. L. and Garry T. B. 2005. Ecological Societies of America Ecology, Hand book vol. 66, pg1-3.
- Belsky, A. J. 1994. Influence of trees on savanna productivity; tests of shade, nutrients and tree-grass competition. *Journals of Ecology*, 75 (4): 922 – 932.
- Belsky, A. J., Mwonga, S. M and Duxbury, J. M. 1993. Effects of widely spread trees and livestock grazing on understory environments in tropical savannah. *Agroforestry Systems*, 24:1-20.
- Cambell, G. A. 1992. Weighted averages ordination for interpreting seasonal and grazing influences upon arid zone pasture. Serengeti National Park Management Plan 1991-1995. Arusha: Tanzania National Parks.
- Fulco, L. Hans De K, and Harbert, H. T. P. 2007. Impacts of savanna trees on forage quality for a large African herbivore. *Oecologia*. 155 (3); 487 – 496.
- Hofmann, R. R. 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia* 78:443-457.
- Kenya Wildlife Service, 2012. Checklist of animals of impala sanctuary and feeds available for the animals- unpublished.
- Kjeldahl J. 1965. Method for Organic Nitrogen analysis. R B. Bradstreet. Published by Academic Press.
- Lamprey, H. F. 1992. Ecological separation of the large mammal species in the Tarangire Game reserve. *Journal of Ecology* (3) 272-275
- Linn, J. G and Martin, N. P. 1999. Forage quality test and interpretation. University of Minnesota.
- Magurran, A. E. (1988) Ecological diversity and its measurement. Princeton university press. pg 374-12.
- Manuel, C, and Molles, J. R. 2003. Ecology concept and Applications. *Journal of Ecology* (3) 372-373.
- McNaughton, S. J, Georgiadis, N. J 1986. Ecology of African grazing and browsing mammals. *Annu Rev EcolSyst* 17:39-66.
- Meissner, H. H., Pieterse, M. E., Grant, C. C., Ruiter de D., Julia Lee-Thorp, Codron D. and Jacqui Codron. 2003. Diets of impala from Kruger National Park: evidence from stable carbon.
- Meissner, H. H., Pieterse, E. & .Potgieter, J. H. J. 1996. Seasonal food selection and intake by male impala *Aepycerosmelampus* in two habitats. *South African Journal of Wildlife Research*.
- Mon, R. H. 1980. Observations on the feeding ecology of impala. *South African Journal of ecology*.
- Muyekho, F. N, Barrison, A. T Khan, Z. R. 2004. A Primer on Grass Identification and their uses in Kenya. Published by Development communication Ltd, Nairobi pg84.
- Okalebo, J. R., Gathua, K.W., Woomer, P. L., 2002. Laboratory methods of soil and plant analysis: A working manual. Second edition. pg1-34.
- Otieno, D. O., Schmidta, M. W. T, Kinyamario, J. J, Tenhunen, J. 2005. Responses of *Acacia fortilis* and *Acacia Xanthophloea* to seasonal changes in soil water availability in the savanna region of Kenya. *Journal of Arid environment* (62), pg 377-400.
- Sankara, M., Jayashree, R., Niall, P. H. 2004. Tree-grass coexistence in savanna revisited insights from an examination of assumption and mechanisms invoked in existing models. *Ecology letter* 7(6):480-490.
- Skinner, J. D, Chimimba, C. T. 2005. The mammals of the southern African subregion. Cambridge University Press, Cape Town
- Smith, R. L. 1999. Elements of Ecology. 3<sup>rd</sup> Edition. Island Press Washington D.C Pg 551 – 465.
- Smithers, R, Turner, M. G., Owen-Smith, Voigt, E., Hall, M. 1987. South African Association for the advance of sciences. Vol 83 Publisher S.A.A.A.S. 1987.
- Van Rooyen, A. F. 1992. Diets of impala and nyala in two game reserves in Natal, South Africa. *S Afr J Wildl Res* 22:98-101.
- Van Saun, R. J. 2006. Determining forage quality and Understanding feed analysis 3(8): pg18-26.
- Wilkins, P. W. Allen, D. K and Mytton, L. R. 2000. Differences in the nitrogen use efficiency of perennial ryegrass varieties under simulated rotational grazing and their effect on nitrogen recovery and herbage nitrogen content. *Journal of Grass and Forage science* 55:69-76.

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