



Rothschild Giraffe Forage Plant Diversity and Distribution in Rimoi National Reserve, Kenya

*Cheruiyot Philip, Koskey Joseph Arusay, Kimanzi Johnstone Kithiki

*Department of Wildlife Management, University of Eldoret, Eldoret, Kenya

*Corresponding author: phillippbett@gmail.com

Abstract

The study was conducted in Rimoi National Reserve situated in Elgeyo Marakwet County, Kenya. Data collection was done between January and April 2023. This study examines the forage vegetation diversity and its distribution patterns for the introduced Rothschild giraffes in Rimoi Reserve, focusing on the ecological conservation of the habitat for better interactions with the available vegetation and other herbivores. Specific objectives were a) to determine the distribution of forage plants preferred by Rothschild Giraffe in the reserve, and b) to assess the diversity of the preferred forage plants by Rothschild Giraffe in the reserve. Over the course of the study, 16 tree species were identified as part of the giraffes' diet, with significant consumption of *Balanites aegyptica*, which constituted nearly half of their intake. The distribution of giraffe forages across upland and riverine areas within the reserve showed a significant difference ($t= 2.302$, $df= 30$, $p=0.028$), suggesting that forage availability in the reserve is skewed towards the upland area (64.73%). The diversity analysis using and richness using rarefaction curves revealed that the Riverine area had the highest plant diversity, providing a variety of plants beneficial for giraffes, while the upland area exhibited the lowest diversity ($t= 7.325$, $df= 31$, $p=0.001$). The study recommends active habitat management by the reserve to promote the growth of key forage species, regular monitoring of plant distribution and dietary patterns, and conflict mitigation strategies to reduce competition for resources among herbivores. Implementing these strategies can enhance the conservation of Rothschild giraffes and maintain a balanced ecosystem in the Rimoi National Reserve.

Keywords: Giraffe Forage, Rimoi Reserve, Giraffe Ecology

Introduction

Africa is the cradle and birthplace of the three-giraffe subspecies. Rothschild giraffe (*Giraffa camelopardalis-rothschildi*-Lydekker) is an herbivorous, browsing ruminant and a member of the Bovidae family. It serves as a flagship species in an ecosystem and has significant conservation importance. Although giraffe populations have declined in East Africa over the last three decades, little is known about this species (Muller et al., 2016). Mega herbivore extinction has been attributed to several factors, including community composition, alterations in ecosystem structure and function, and the encroachment of shrubs and woody plants (Bakker et al., 2016; Chritz et al., 2016; Doughty et al., 2016). Giraffe feeding and survival ranges have continued to shrink due to land fragmentation across Africa (Muller et al., 2018).

The giraffe population at Rimoi National Reserve was reintroduced in 2016 and remains small within a wide conservation area. Managing the species in diversified ecosystems, particularly their introduction into new ecosystems, is of great concern, given the limited information on how the species acclimatizes to new ecosystems and which forage plant species it selects. According to Gordon et al. (2016), giraffes mainly browse on woody plant parts and forbs and feed selectively. The success of giraffe translocations has shown that giraffes can adapt to different ecosystems.

Extrinsic and intrinsic factors can easily influence giraffe ecology and population dynamics. Extrinsic factors include precipitation, human disturbance, habitat disturbance, and competition for resources and mates, while intrinsic factors include the allele effect, density-dependent processes and stress. Poaching, predation, habitat fragmentation, irregular recruitment and forage availability can significantly influence giraffe population dynamics (Obari, 2012; Dagg & Foster, 1972). Understanding ecological processes in giraffe habitats is critical as this determines the population, density, and distribution of giraffes in any protected area (Obari, 2014).

Rothschild giraffes, as mega herbivores, play a pivotal role in maintaining the ecological balance within their habitats. Their browsing habits help shape vegetation structure by selectively feeding on certain forage plant species, preventing the over-dominance of particular species and promoting plant diversity (Gordon et al, 2016).

Determining the distribution and assessing the diversity of Rothschild giraffe forage plants in the reserve is crucial for the successful conservation of the Rothschild giraffe introduced into an ecosystem. According to Sands et al.



(2012), conservation achieves its highest level of success when research results are effectively translated into management applications. This study, conducted within Rimoi National Reserve, aims to achieve this by providing empirical data that can inform and enhance giraffe management practices in a region that has experienced significant anthropogenic disturbances. The study focuses on the detailed counting and observation of forage plant resources available to giraffes in the reserve. This methodological approach is essential in an ecosystem impacted by human activities, as it allows for an understanding of how forage vegetation outlook affects giraffe behaviour and habitat use. By understanding these impacts, the study contributes to developing strategies that mitigate negative effects, thereby promoting sustainable conservation and management of giraffe populations. Furthermore, the study enhances the relationship between giraffe management practices and wildlife scientific research (Gavlin 2018). Conducting this survey provided the necessary information and a more accurate assessment of the giraffe population and factors affecting its conservation. The relative importance of factors affecting giraffe vital rates and habitat use can be determined (Johnson 1980, Stiver et al. 2010).

Limitations of the Study

Collecting sufficient data in order to find reliable results during research is faced with drawbacks that limit the capacity to collect, analyze and present the results. Accessibility of some sampling sites in the study area was not guaranteed due to ruggedness, making the process tedious. Secondly, Rimoi National Reserve is under the care of the Kenyan government (i.e. Kenya Wildlife Service, and Kenya Forest Service) and the County government. All these offices were a requirement that needed getting permits in order to have access to the reserve. It involves time-consuming procedures to obtain the permits. Finally, research needs sufficient funds, and the process of obtaining data in Rimoi National Reserve was financially demanding. Data collection could have been done throughout the year for a seasonal comparison for better management and conservation decisions.

Materials and Methods

Study Area

This study was conducted in Rimoi National Reserve, located in the floor of Great Rift Valley of Kenya. Regionally, it is situated in the Rimoi and Tambach divisions of Keiyo District, Elgeyo Marakwet County. Elgeyo Marakwet County covers a total area of 3029.9 km², which constitutes 0.4 percent of the country's total area. It extends from latitude 0° 20' to 1° 30' to the North and longitude 35° 0' to 35° 45' to the East. It borders West Pokot County to the North, Baringo County to the East, Trans Nzoia County to the Northwest and Uasin Gishu County to the West. The county has an elongated shape and is wedged in between the Uasin Gishu Plateau on the West and the Kerio River on the East (Figure 1). The Kerio River has its source in the southern highlands of the county and drains into Lake Turkana (Elgeyo Marakwet County Government Integrated Development Plan, 2013). The reserve lies along the Kerio Valley and is bordered by the Elgeyo Escarpment to the east. It is approximately 15 kilometres from Iten town, accessible via the Iten-Kabarnet road through Biretwo trading centre. The reserve also borders Lake Kammarok and the Kerio River, adding to its ecological diversity. It is a relatively small reserve, covering 66 km², and is protected by the Kenya Wildlife Service. Rimoi National Reserve provides ample space to support a wide variety of wildlife populations (Kariuki et al., 2018).

since there is no fencing done long the river. Further, there is grazing of animals in this area. The upland area is near the electric-fenced section stretching towards the centre of the reserve and deemed to be the main conservation area for wildlife survival.

From the time Rothschild giraffes were introduced in the reserve, there have been areas where they were spotted foraging within the two zones. A transect using the existing road networks that runs longitudinally in the middle of the two zones (upland and riverine) was established within the reserve. To quantify forage availability, systematic vegetation sampling was conducted (Lee et al., 2016). Six points along the road transect that lie approximately 2km apart and 100m perpendicular to the road transect were established systematically in each of the two zones (Figure 4).

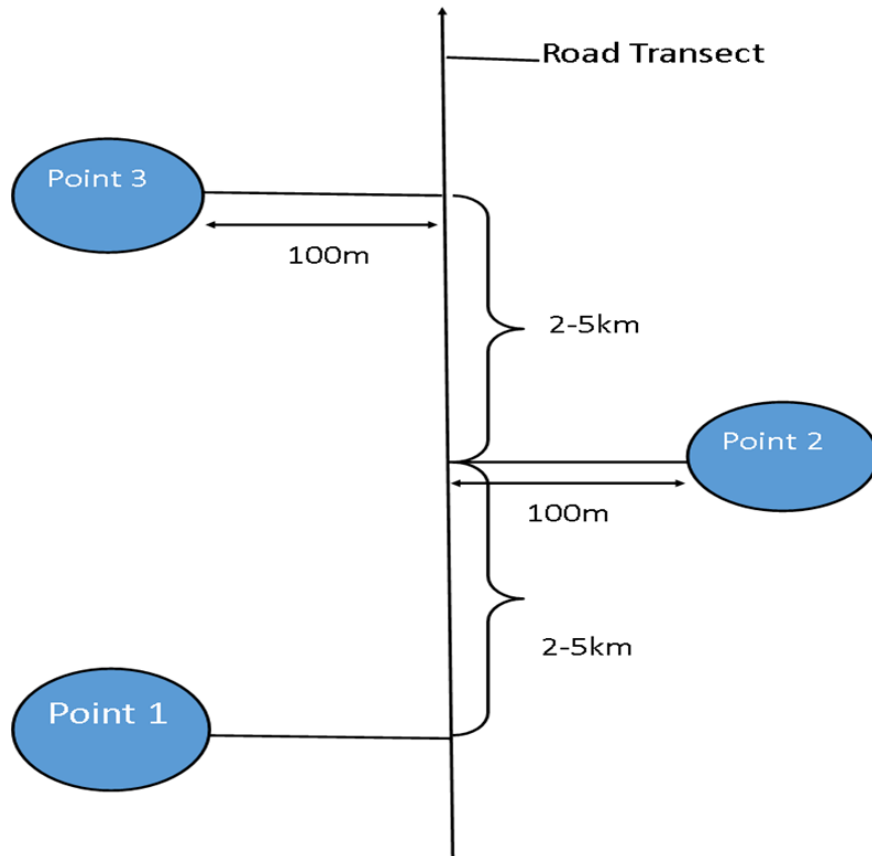


Figure 4: Vegetation sample points and transect in Rimoi National Reserve

At each point, four plots of 20×10 m were established to the North, East, South, and West (Lindgren & Sullivan, 2001) as illustrated in Figure 5. On the plots, a detailed inventory of plant species was conducted. Dominant plant species were identified and recorded, along with their relative abundance. Forage plant species were identified in the field in situ by a botanist, while those that were not identified, plant specimens (Plant parts having a mature 6-inch stem, leaves, flowers and fruit) were pressed in a plant press. The pressed plant parts were coded and recorded in a field notebook for further identification. This approach ensured that the reserve in totality was covered and the plant survey representation was adequate. By using this method, the survey aimed to capture the heterogeneity of the reserve's vegetation (Veldhuis et al., 2019).

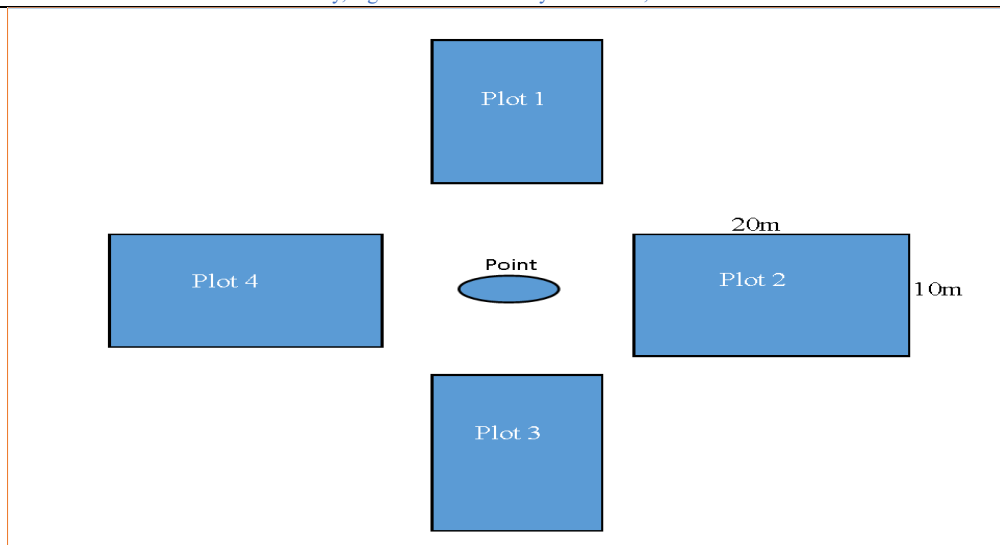


Figure 5: Vegetation Sample Plots within each sampling point

Data Analysis

The SPSS statistical software version 26 was used to perform an independent sample t-test for mean differences in plant species distribution across the reserve at 5% significance level. A t-test was used to determine if plants were differently diverse and the distribution was skewed to part of the reserve. Data obtained for the number of plants in each habitat was first tested for normality and transformed using the square root method since it was count data. Means are presented \pm SE. Species richness was compared between the two sampling zones using rarefaction curves to standardize for differences in sampling effort. Rarefaction curve was generated in R (Version 2.5-7) using the vegan package (Oksanen et al, 2020). A diversity t-test was used to test for differences between di Shannon wiener s.

Results

Vegetation Distribution

From the six points in each of the two RNR zones used in data sampling, a total of n=1151 vegetation samples were obtained. These were from sixteen different species of plants that were identified to be found in RNR during the early months of the year when the research was done.

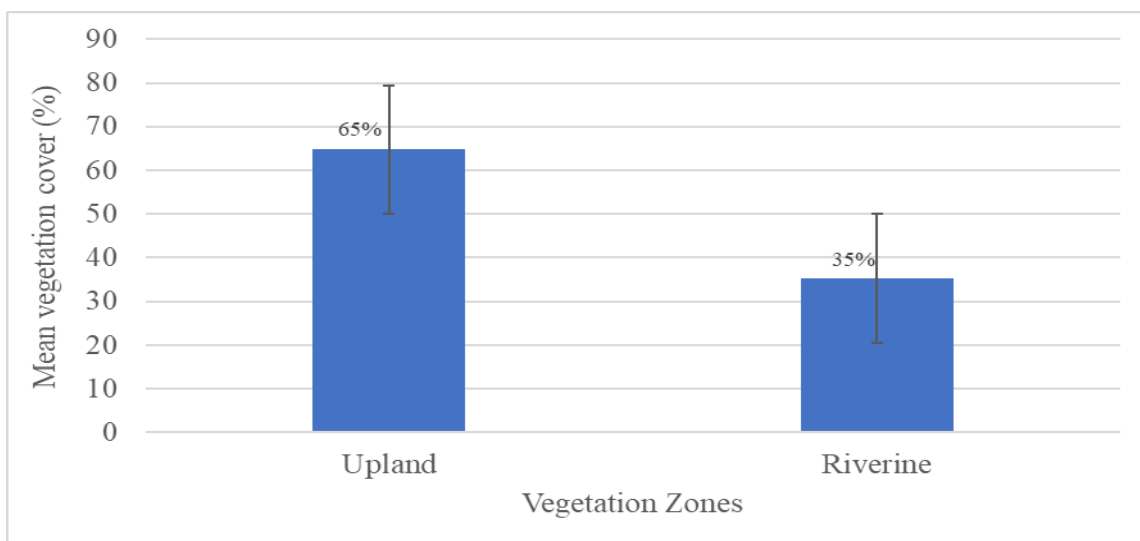


Figure 6: The mean difference of forage vegetation in Rimoi National Reserve

From the independent sample T-test, the mean \pm SE vegetation cover for the upland zone ($65\% \pm 8.72$) is significantly higher ($t= 2.302$, $df= 30$, $p=0.028$) than in the riverine zone ($35\% \pm 2.94$). Further, giraffe forage availability in this zone (Upland area) is plentiful.

Forage Plant Species Richness and Diversity

Preferred forage species show that all vegetation species are well represented and that they all appear heterogeneous in abundance but with a difference in species richness between the two areas ($t= 7.325$, $df= 31$, $p=0.001$).

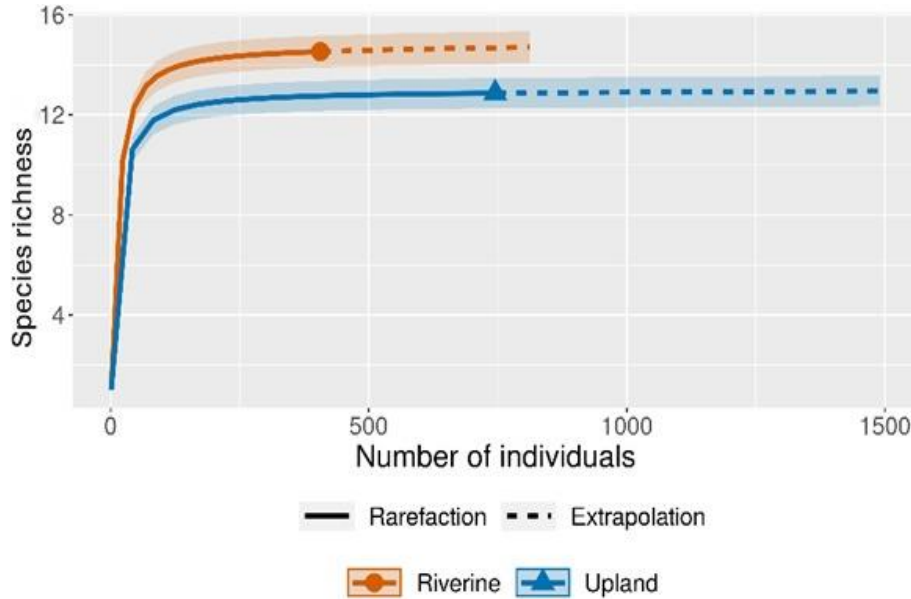


Figure 7: Rarefaction Curves for Herbivore Forage Species Richness in Rimoi National Reserve

The difference in the heights of curves along the Y-axis shows that riverine area is higher than upland area hence rich in species. This shows the differences in evenness and richness, riverine exhibiting the highest value. Upland Area has a lower species richness when compared to the riverine area. This could mean that a few species are found and might have a few plant species dominating the area. Further, there is less evenness of species present as compared to the Riverine area. The Shannon values of the study area, as shown in Table 1, ranged from 2.50 – 2.99 as per Shannon-Weiner ratings. This means that the vegetation diversity within the reserve is moderate (Baliton. et al, 2020)

Table 1: Diversity and Evenness Indices in Rimoi National Reserve

	Upland Area	Riverine Area
Diversity (H)	2.55	2.68
Evenness (E)	0.39	0.45

Discussion

Plant species Distribution

The high preference of *Balanite aegyptica* by Rothschild giraffe explains its frequent consumption despite it being one of the least available in the area. Other species like *Capparis tomentosa* and *Acacia senegal* are also relatively common in their diet. Studies on the Serengeti show that giraffes can select forages from a large array of vegetation, and a few forage plants will make up their diet. Further, forages are affected by the quality of nutrients in a plant. Both studies indicate that giraffes often consume abundant species, but the best and most nutritious forages form much of the diet (Valery, 2015. Skarpe, 2008).



Studies show that species such as *Balanite aegyptica*, *Acacia senegal* and *Capparis tomentosa*, despite having high preference indices, are much less available. Birkett (2002) research on the effects of forage plant availability on giraffe foraging in the Rimoi national reserve found that giraffes exhibit strong preferences for certain forage plant species despite their low abundance. This is consistent with our findings, where giraffes seek out scarce but preferred forage plant species like *Balanite aegyptica*, highlighting the critical balance between availability and preference. This scarcity underscores their higher preference index, as giraffes actively seek out these less common species.

The distribution of plant species across the areas shows significant differences. The upland area exhibits the highest number of vegetation, indicating a high cover of plants in the habitat. Riverine area gives a slightly lower percentage plant cover, indicating a relatively lower plant population. Vegetation cover might be brought about by the difference in the location of the areas and the time at which data was collected, whereby the riverine area is at the lower part of the reserve near the Kerio River and has no fence, thus it is under human manipulation and encroachment. The distribution of vegetation does not guarantee a variety of plant species since it can be dominated by one type of vegetation. The dominance of *Acacia totilis* and *Acacia melifera* suggests it is a key species for maintaining giraffe populations, although its low preference indicates that efforts to increase the availability of highly preferred species could enhance giraffe dietary satisfaction and health. The differences in these areas suggest that these regions could support a larger giraffe population by providing a wide range of forage options.

Plant Species Richness and Diversity

The riverine zone has the highest plant species richness as compared to the upland zone. The high number of different vegetation types suggests a more heterogeneous area, and from its greater number of species present, the best area for herbivore forage selection. Further, with a high Evenness value, it offers a wide range of forage options for giraffes. Also, this zone has the highest plant diversity. The high H' value suggests a more even distribution of individuals among different species and a greater number of species present. Research in the RNR emphasized the importance of plant diversity for herbivore diet quality (Birkett, 2002). Similarly, our study shows that high plant diversity, as evidenced by the diversity rarefaction curves for the reserve. It is crucial to provide giraffes with a varied and nutritious diet, supporting their overall health and well-being. A study on the impact of herbivores on biodiversity (Gordon and Prins 2008) indicated that herbivores thrive better in habitats with high biodiversity. Our results support this by demonstrating that the Riverine area, with the highest diversity value, provides a diverse habitat that can sustain a healthy giraffe population. The Upland area shows the lowest diversity index, indicating that this area has the lowest plant diversity. This low diversity value suggests that a few species dominate the area, resulting in less evenness in distribution among the species present. Such dominance could be due to various ecological factors, such as soil type, water availability, or competition among species. A study by Western and Lindsay (1984) on East African rangelands highlighted the importance of maintaining plant diversity for the health of herbivore populations. Our diversity analysis, showing significant variability in forage plant species across different areas, underscores the need for conservation strategies to protect diverse habitats, thereby supporting robust giraffe populations. The areas, with their high species diversity values on the rarefaction curve, offer a wide range of forage options for giraffes. Management strategies should aim to preserve this diversity by protecting various plant species and their habitats. Ensuring the continued health of these ecosystems will support a robust giraffe population. The riverine area exhibited a better species diversity than the upland area, making it a better area for a giraffe fodder source. It is crucial to enhance species richness and evenness because it can further support the giraffe population by providing a stable and nutritious forage supply.

Conclusions and Recommendations

The preferred forage plant species are distributed throughout the reserve, with certain areas showing higher densities of specific species. Forage Plant species are diverse along the riverine areas, despite that there is no management control to keep the variety of vegetation in those areas.

Conducting regular monitoring of forage plant species distribution and herbivore dietary patterns to assess changes over time and adjust management strategies accordingly is crucial. Further research on the seasonal availability of forage plant resources, and their impact on herbivore foraging behaviour and competition needs to be done. Research needs to be done for the whole year to know the difference in seasons and have a clear picture of vegetation structure. By considering habitat enrichment techniques, such as planting additional forage species, can alleviate resource pressure and support diverse herbivore populations.



Acknowledgement

I thank the Elgeyo Marakwet County for granting me an opportunity to do the research work at Rimoi National Reserve. I appreciate the guidance of mentors, reviewers, collaborators, field assistants, and local community members who contributed valuable insights. This research did not receive any specific external funding

References

- Bakker, E. S., Gill, J. L., Johnson, C. N., Vera, F. W. M., Sandom, C. J., Asner, G. P., & Svenning, J. C. (2016). Past and future polar bear status in a rapidly changing Arctic. *Ecology Letters*, 19(1), 1-8.
- Bálint Nobelmann, M., C., Chovanec, T., Evans, R., Hudcová, E., Jancsovszka, P., Moudrý, J., Pařízek, M., Schneider, C., Steininger, B., Ujj, A. (2020). Quality Standards for Teaching Social Farming -What future social farmers need to know to be successful. *Social Farming in Higher Education (SoFarEDU)*
- Birkett A., (2002). The impact of giraffe, rhino and elephant on the habitat of a black rhino sanctuary in Kenya.
- Chritz, K., Blumenthal, S., Cerling, T., Scott A. Blumenthal & Hans Klingel, (2016). Hippopotamus (H. amphibius) diet change indicates herbaceous plant encroachment following megaherbivore population collapse. *Sci Rep* 6, 32807 (2016). <https://doi.org/10.1038/srep32807>.
- Dagg, A. I., & Foster, J. B. (1972). *The giraffe: Its biology, behavior, and ecology*. Van Nostrand Reinhold.
- Doughty, C. E., Roman, J., Faurby, S., Wolf, A., Haque, A., Bakker, E. S., Malhi, Y., ... & others. (2016). Global nutrient transport in a world of giants. *Nature*, 528(7582), 547-550.
- Elgeyo Marakwet County Integrated Development Plan (CIDP) 2013.
- Galvin, K. A. (2018). Transitions: Pastoralists living with change. *Annual Review of Anthropology*, 47(1), 185-198.
- Gordon, I. J., & Illius, A. W. (2016). Foraging strategy and dietary preferences of giraffe. *Journal of Zoology*, 242(3), 365-374.
- Gordon, I. J., & Prins, H. H. T. (2008). *The Ecology of Browsing and Grazing*. (Ecological Studies; No. 195). Springer. <https://doi.org/10.1007/978-3-540-72422-3>
- Johnson, Douglas H. (1980). The Comparison of Usage and Availability Measurements for Evaluating Resource Preference. USGS Northern Prairie Wildlife Research Center. Paper 198.
- Kariuki, M. M., Ogutu, J. O., & Okeyo, D. M. (2018). Population dynamics and conservation status of giraffes in Rimoi National Reserve, Kenya. *Wildlife Research*, 45(4), 372-383.
- Lee, H. J., & Cho, I. (2016). Corporate Governance and Corporate Bond Liquidity. *Global Economic Review*, 45(2), 189-205
- Lindgren PMF, Sullivan TP (2001) Influence of alternative vegetation management treatments on conifer plantation attributes: abundance, species diversity, and structural diversity.
- Martinez-Freira, F., Matos, M., & Domingues, M. (2016). Vegetation and wildlife dynamics in an African savanna: A long-term perspective. *African Journal of Ecology*, 54(3), 249-261.
- Matana Levi (2022) Giraffe foraging ecology in the Tarangire Manyara ecosystem, Tanzania. <https://dspace.nm.aist.ac.tz/handle/20.500.12479/1505> Provided with love from The Nelson Mandela African Institution of Science and Technology
- Matana, J. M., Sitati, N. W., & Omondi, S. (2022). Impact of human activities on giraffe populations in Kenya: A review. *Kenya Journal of Agricultural Research*, 12(2), 45-52.
- Muller, Z., Bercovitch, F., Brand, R., Brown, D., Brown, M., Bolger, D., & Fennessy, J. (2016). Giraffa camelopardalis (amended version of 2016 assessment). *The IUCN Red List of Threatened Species 2016*.
- Muller, Z., Cuthill, I., & Harris, S. (2018). The impact of human activities on giraffe habitat uses and movements in the Tarangire-Manyara ecosystem. *Animal Conservation*, 21(4), 330-338.
- Ngare, P., Kariuki, M., & Njoroge, L. (2020). Community perceptions and attitudes towards giraffe conservation in Kenya. *Biodiversity and Conservation*, 29(5), 1221-1238.
- Obari, T. (2012). Factors influencing the conservation of Rothschild giraffe (Giraffa camelopardalis rothschildi) in Ruma National Park, Kenya. *PhD dissertation, University of Nairobi*.
- Obari, T. (2014). Effects of climate change on giraffe habitats and population dynamics in Kenya. *Journal of Environmental Management*, 146, 308-316.
- Oksanen, J., Blanchet, F. G., M. Friendly, M. & Kindt, R. (2020). Vegan community ecology package (version 2.5-7) {R package}
- Sands, P., & Peel, J. (2012). Principles of International Environmental Law (3rd ed.). Cambridge University Press.
- Shannon, C. E., & Weaver, W. (1948). *The mathematical theory of communication*. University of Illinois Press.
- Skarpe C., Hester A. J. The Ecology of Browsing and Grazing. Berlin, Germany: Springer; 2008. Plant traits, browsing and gazing herbivores, and vegetation dynamics; pp. 217–261.
- Stiver, J. R., Apa, A. D., Remington, T. E., & Gibson, R. M. (2010). Marking and age-determination techniques for greater sage-grouse. *Western North American Naturalist*, 70(1), 134-139.
- Thornton, P. K., Boone, R. B., & Galvin, K. A. (2014). Coping strategies in livestock-dependent households in east and southern Africa: A synthesis of four case studies. *Human Ecology*, 37(3), 381-400.
- Veldhuis, M. P., Ritchie, M. E., Ogutu, J. O., Morrison, T. A., Beale, C. M., Estes, A. B., ... & Shand, M. (2019). Cross-boundary human impacts compromise the Serengeti-Mara ecosystem. *Science*, 363(6434), 1424-1428.
- Valeri Mlingi (2015). Foraging by elephant, giraffe and impala during wet and dry season in rich and poor savanna, Tanzania.
- Western and Lindsay (1984) *Seasonal herd dynamics of a savanna elephant population Volume 22, pages 229-244*