ACTIVITY TIME BUDGET AND FORAGING PATTERNS OF ROTHSCHILD'S GIRAFFES (*Giraffa camelopardalis rothschildi*) IN LAKE NAKURU NATIONAL PARK, KENYA

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UNIVERSITY OF NAIROBI

DECLARATION

This thesis is my original work and has not been submitted for awarding a degree in any other University.

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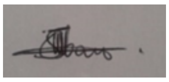

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I dedicate this thesis to my family for holistic support throughout my education.

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ACRONYMS

ADF	Acid Detergent Fiber
AFFEW	African Fund for Endangered Wildlife
ASAL	Arid and Semi-Arid Lands
GCF	Giraffe Conservation Foundation
GPS	Geographical Positioning System
IUCN	International Union for Conservation of Nature
IVGP	In Vitro Gas Production
KWS	Kenya Wildlife Service
LNNP	Lake Nakuru National Park
NACOSTI	National Commission for Science and Technology
UNESCO	United Nations Educational, Scientific and Cultural Organization

ABSTRACT

Animal behavioral studies are essential to efficiently manage them and their preferred habitats for the mutual benefit of both. However, very few studies have been conducted on Rothschild's giraffes' ethology in Africa, and especially in Kenya. The objective of this study was to assess the seasonal diurnal activity time budget and foraging patterns of free-ranging Rothschild's giraffes in Lake Nakuru National Park (LNNP), Kenya. The species is under the IUCN Red List, due to a variety of threats and the continued rapid population decline globally. Scan sampling method was used to assess how Rothschild's giraffes allocate time to various activities of the day. Descriptive data analysis was performed and results presented in bar graphs, and line graphs. Independent t test was performed to compare giraffes' activities and food preference in different seasons, dry and wet seasons. All statistical tests were considered significant at a 95% confidence limit if type 1 error (alpha) is less than 5% (0.05). Foraging was the principal activity in both dry and wet seasons being allocated 53% and 57% of their time respectively. Resting and movement accounted for 18 and 26%, in dry and wet seasons respectively. Although *Vachellia xanthophloea, Maytenus senegalensis*, *Solanum incanum* contributed to the bulk of giraffes' diet in both seasons, the most preferred woody species was *Vachellia xanthophloea* in the dry and wet season (67% and 72%) respectively. Other notable plant species that giraffes fed on included *Maerua triphylla*, *Vachellia gerrardii,* and *Grewia similis* during the dry season and *Maerua triphylla*, *Vachellia abyssinica,* and *Rhus natalensis* during the wet season. The most preferred browsing height was about 3.5 meters (level 5) (49% in the dry season and 46% in the wet season) while 1 meter (level 2) was the least preferred (7% in the dry season and 4% in the wet season). At 3 and 3.5 meters (level 4 and 5) giraffes fed on more plant species including *Vachellia xanthophloea, Maytenus senegalensis, Maerua triphylla, Vachellia abyssinica,* and *Rhus natalensis.* This study concluded that seasonality does not influence the diurnal activity time budget of Rothschild's giraffes in LNNP while the hypothesis that Rothschild's giraffes' foraging habits vary significantly between the dry and wet seasons was not entirely supported. Giraffes forage and move around when temperatures are low and rest when temperatures are high to conserve energy. The choice of browse species to feed on is an adaptive strategy to survive recurrent droughts, a common occurrence in the study area which is generally Arid and Semi-arid. Giraffes prefer to forage below 4 meters (3.0-3.5), which is within the average body height of an adult giraffe. Planting perennial woody species will promote uniform use of resources in the park, increase the diversity of plant species foraged by giraffes and reduce browsing pressure in acacia woodlands.

CHAPTER 1: INTRODUCTION

1.1 Background

Giraffes (*Giraffa camelopardalis*) are the world's tallest mammals, each having its distinctive skin pattern (Estes, 1991). As big herbivores, they use large segments of the ecosystem to obtain the resources necessary for survival and reproduction (du Toit and Yetman, 2005). Giraffes require particular daily nutrients to thrive and maintain their physical health (Deacon, 2015). They can adjust the amount of time they spend foraging and non-foraging behaviors like resting, moving, and drinking water, as well as how they select plants to forage on, to meet particular criteria (Deacon, 2015). Giraffes, like other animal species, have an activity time budget that reflects physiological traits and ecological relationships (Blake et al., 2012; Norris et al., 2010; Tobler et al., 2009). It is affected by seasonality, spatial patterns, resource availability, and abundance. Variation in the number, availability and accessibility of these resources is primarily due to seasonality and severe climatic conditions such as periodic droughts, predation, and changes in the vegetation types within a habitat (Fennessy, 2009). Giraffes, like other herbivores, have a variety of competing demands, including food, water, resting areas, soil licks, and restricted resources that change in time and geography. These factors affect how they utilize their habitat (Beyer et al., 2010).

Giraffes live in a variety of habitats including savanna, grasslands, and open woodlands as they traverse extensive sections of their home range, where they, like other browsers, utilize a variety of flora types (Obari, 2014). Giraffes prefer savanna woodlands dominated by Acacia species in Sub-Saharan Africa. These are defined by evenly spaced trees with open canopies that allow for the growth of herbaceous species, which provide an abundance of food for giraffes. They do, however, provide limited resources, particularly in enclosed ecosystems in arid and semi-arid regions (ASAL), which are characterized by severe dry and wet seasons even under normal conditions (Staver et al., 2011). Vachellia (*Vachellia xanthophloea* (Benth.) P.J.H. Hurter, *Vachellia abyssinica* (Hochst. ex. Benth.) Kyal and Boatwr, *Vachellia gerrardii* (Benth.) P.J.H. Hurter, and *Vachellia hockii* (De Wild.) Seigler and Ebinger), sausage tree (*Kigelia africana)* (Lam.) Benth), Baobab (*Adansonia digitata*) (L.), and Torchwoods (*Commiphora wightii)* (Arn. Bhandari**)** are the predominant tree species present in these areas (Muller et al., 2016). Among these trees, studies have shown that Acacias are the preferred browse species by giraffes (Ciofolo and Le Pendu, 2002; Mahenya, 2016; O'Connor et al., 2015). During the dry season, giraffes congregate in locations near rivers to ensure a constant supply of food and water. Giraffes however, do not require daily water consumption because they feed on succulent plant species such as *Vachellia xanthophloea*, *Vachellia karroo* (Hayne) Banfi and Galasso, *Combretum molle* (R.Br. ex G.Don, *Combretum erythrophyllum (*Burch.) Sond., *Vachellia nilotica* (L.) P.J.H.Hurter and Mabb, and *Grewia similis* (K.Schum.) (Fennessy, 2004; Leuthold and Leuthold, 1978). They tend to lick the soil on termite mounds, searching for nutrients (Ciofolo and Le Pendu, 2002).

Giraffes are considered as Vulnerable species under the IUCN Red List and have decreased by over 40% in the last three decades (Muller et al., 2019). Subsequently, the IUCN Giraffe and Okapi specialized group re-categorized Rothschild’s giraffe as Nearly Threatened due to their fast decline over the last three decades and loss of the majority of their native habitats (Fennessy et al., 2018). Rothschild’s giraffes are the most endangered of the giraffe subspecies found in Kenya, with an estimated population size of 478 individuals in the country (Fennessy et al., 2016) and only 89 individuals in Lake Nakuru National Park (LNNP) (Muller, 2018). Rothschild’s giraffes are found only in Uganda and Kenya and are believed to have become extinct in Sudan (Fennessy et al., 2016). The Kenya Wildlife Service (KWS) relocated several Rothschild’s giraffes from free-ranging areas into enclosed areas such as LNNP, Ruma National Park, Mwea Game Reserve, and Nasalot Game Reserve in 1979 (KWS, 2002). The relocation was carried out to save the species from extinction as a result of habitat fragmentation for agricultural production, settlements, infrastructure development, and urbanization (Umbertoh, 2007).

As Fennessy, (2009), notes, habitat fragmentation, encroachment on the savannah and other animal habitats (dispersal areas), as well as other threats such as poaching and predation, have resulted in a dramatic fall in the African giraffe population. At the moment, the habitats of Rothschild’s giraffes have fallen by 37% in Sub-Saharan Africa and 75% in Kenya (O’Connor et al., 2019). This decline is mostly due to habitat loss caused by human activity and habitat degradation caused by the change of climate (O’Connor et al., 2019).

Despite widespread worry over the loss of prime giraffe habitats in Kenya, the elements that significantly influence Rothschild’s giraffe activity patterns and forage selection are not well known (O’Connor et al., 2019). This knowledge is critical for the development, management, and maintenance of national parks and game reserves as critical ecosystems for their conservation. It is also crucial for monitoring changes in habitat and resource availability through time, as well as the causes that contribute to these changes (Borghi et al., 2011). Understanding the abundance and accessibility of giraffe-favored plant species, as well as the distribution and availability of other scarce resources within a protected area, is critical for their effective management. The information aids in the development of conservation plans and decision-making about the redistribution of resources required by giraffes in their habitats. It is also critical for building habitat suitability maps for giraffes in Kenya and Sub-Saharan Africa, which will guide future giraffe introductions and conservation resource allocation (Fennessy et al., 2016).

The purpose of this study was to ascertain the ethology of Rothschild's giraffes found in LNNP. The park is located in Kenya's ASAL, where droughts, among other dangers, not only affect the availability of plant species for feeding but also their distribution and abundance. The park has a high lion density of 30 lions per $100km^2$, which poses a threat to Rothschild's giraffe population through predation and may influence their habitat use (Muller, 2018).

1.2 Statement of the problem

Ethology is the study of animal behavior and is a major determinant of whether individuals or groups of animals will survive and reproduce. The population trend of giraffes in LNNP has been declining with a variation in recovery. Between 1998 and 2003 the population declined from 153 to 62 (Brenneman et al., 2009) and then increased to 89 (Muller, 2018). Studying the behavior of any animal is therefore essential to efficiently manage them and their preferred habitats for the mutual benefit of both. However, very few studies have been conducted on Rothschild's giraffes' ethology in Africa, especially in Kenya. Seeber et al., (2012), did a behavioral inventory of giraffes *(Giraffa camelopardalis)* in Southern Africa. The major outcome of this study was an ethogram that listed 65 different behavioral patterns. Deacon, (2015), studied the spatial ecology of giraffes in South Africa, focusing on the activity time budget of the giraffes. Fleming et al. (2006) researched on whether giraffes in Kruger National Park, South Africa are pollinators or flower predators of *Senegalia nigrescens* (Oliv.) P.J.H. Hurter (synonym *Acacia nigrescens)*. The findings of this study showed that the giraffes were flower predators of *Senegalia nigrescens* significantly reducing fruit development at heights accessible to giraffes (Fleming et al., 2006). Obari, (2009), studied factors affecting habitat use of Masai giraffes in Nairobi National Park, Kenya, and focused on giraffes' daily time budget. Adolfsson, (2009), studied behavior patterns and utilization of shade in Masai in Masai Mara National Reserve in Kenya. The study's most significant finding was that adult giraffes spent more than a third of their day foraging. Sembe, (2015) assessed the activity patterns of Rothschild's giraffes at Nairobi's Giraffe Center sanctuary. The results indicated that the most popular activity was browsing (51.4%), followed by a mix of walking and browsing (26.8%), and finally walking (21.7%). Giraffes in sanctuaries live in a controlled habitat with restricted movement, predator protection, and access to water and food. The purpose of this study was to evaluate the ethology of Rothschild's giraffes in Kenya's LNNP by focusing on assessing the seasonal diurnal activity time budget and foraging patterns of free-ranging Rothschild's giraffes in Kenya's LNNP.

1.3 Justification

The dramatic global drop in giraffe population (40%) over the previous three decades portends the species' extinction if dangers are not thoroughly identified and addressed (Muller et al., 2016). Rothschild's giraffes numbered 89 in LNNP in 2018 (Muller, 2018), an increase of 27 giraffes since 2009 (Muller, 2018). This study will contribute to the KWS National Giraffe Recovery and Action Plan in Kenya (2018-2022) report, which urged, among other things, that serious efforts be made to improve the current understanding of giraffe ecology in Kenya through the use of evidence-based information. This national park is home to the biggest population of Rothschild's giraffes and hence plays a critical role in giraffe subspecies conservation. This can be achieved mainly by maintaining natural habitat and resource allocation to support the nearly threatened species, given that it is one of only four viable populations in Kenya. Information on giraffe activity time budget and forage plant species preference is vital in assisting wildlife managers design conservation strategies, reducing mortalities and losses of genetic variability, as well as preventing environmental degradation and biodiversity loss (Gandiwa and Zisadza, 2010).

Studying plant species preference of the giraffes in LNNP, in time and space will address the food shortage concerns including the decline in *Vachellia xanthophloea* species, and is most likely going to enhance the survival of Rothschild's giraffes. Additionally, the study is likely to shed light on Brenneman et al., (2009) hypothesis that there is a correlation between climatic events and a decline in alternate browse species, driving giraffes to eat more Acacia species. The research on the effects of habitat type variation and seasonal variability provides wildlife managers with the knowledge to help them make habitat conservation decisions and improve the equitable distribution and availability of resources for giraffes and other wild animals throughout the year. Variations in environmental parameters such as water availability, forage availability, and tree density, among others, have been linked to habitat occupancy in tropical savannas, particularly for migratory species such as giraffes (Anderson et al., 2016; Hopcraft et al., 2014). Variation in the availability of resources continues to affect the population and distribution of giraffes in their natural environments. Thus, it is critical to understand Rothschild's giraffes' seasonal activity time budget in order to advise wildlife managers and conservationists about the giraffes' resource requirements.

1.4 Objectives

1.4.1 Broad objective

To evaluate activity time budget and foraging patterns of Rothschild's Giraffes in Lake Nakuru National Park, Kenya

1.4.2 Specific objectives

1) To evaluate the seasonal activity time budget of Rothschild's giraffes in LNNP
2) To determine seasonal foraging patterns of Rothschild's giraffes in LNNP

1.5 Hypothesis

1. Rothschild's giraffes allocate significantly different amounts of time to different daily activities in dry and wet seasons.
2. Rothschild's giraffes' foraging habits vary significantly between the dry and wet seasons.

CHAPTER 2: LITERATURE REVIEW

2.1 Rothschild's giraffe

Rothschild's giraffes have distinct chestnut-colored patches that darken with age and are encircled by white lines, while the undersides and a portion of the legs from the knees downward are spotless. According to the International Union for Conservation of Nature's (IUCN) Red List assessment for giraffes, they are members of the mammalian order Artiodactyla, the family Giraffidae, the genera Giraffa, and the species *Giraffa camelopardalis* (Muller et al., 2018). *Giraffa camelopardalis* is classified into nine subspecies: Angolan giraffe, Kordofan giraffe, Masai giraffe, Nubian giraffe, Reticulated giraffe, Rothschild's giraffe, South African giraffe, Thornicroft's giraffe, and West African giraffe (Winter et al., 2018; Wube et al., 2018). Rothschild's giraffes *(Giraffa camelopardalis rothschildi),* which Lord Rothschild initially described in Kenya, Uganda, and Sudan, are thought to be similar to the Nubian giraffe *(Giraffa camelopardalis camelopardalis),* and attempts have been made to incorporate it into the Nubian giraffe subspecies (Fennessy et al., 2016). The giraffes are referred to in this article as Rothschild's giraffes because no consensus exists over their status on the IUCN Red List (Muller, 2019). Giraffes are non-territorial and gregarious animals that live in loose, open herds of between ten and twenty individuals. These herds are composed of males, females, and calves (Jolly, 2003; Shorrocks, 2016). Females create stable nursery groups within an area to care for their calves, whereas young males who are self-sufficient form bachelor herds.

2.2 Activity time budget of Rothschild's giraffes

The activity time budget of an animal is an essential function of an animal's life to survive or thrive (Adolfsson, 2009). The location of browsing, the selection of specific browse items, and the amount of time given to foraging and other activities are choices that are influenced by a variety of internal and external factors (Pellew, 1984a). Knowledge about these factors and how they influence these choices is central to all management decisions. The study of the activity time budget of an animal is an important area of study within the broader area of ethology. Such studies are mainly based on field observations aimed at identifying how and when various activities are performed.

Researchers generally observed that giraffes in Southern Africa's Mokolodi Nature Reserve spent 36% of their time foraging, 20% moving, and 16% resting (Blomqvist and Renberg, 2007). They spent the remainder of their time looking around, moving, lying down, galloping, and licking soil (Blomqvist and Renberg, 2007). Giraffes spend most of their time ruminating while resting as well as walking (Blomqvist and Renberg, 2007). Giraffes spend less than 5% of their time resting on average (Blomqvist and Renberg, 2007). In a similar study, Obari, (2009) while studying habitat use of Masai giraffe at the Athi-Kapiti ecosystem, Kenya, observed that giraffes spent about 78% of their time foraging, 7.0% standing, 6.0% walking, 5.0% lying down, 3.0% chewing cud and about 1.0% drinking water. These findings are similar to those of Sembe, (2015), who studied the time budget of Rothschild's giraffes in the Giraffe Center Sanctuary, Nairobi. Although the time allocated for the same activities in the different sections of the Sanctuary studied differed, the general observations were that foraging and foraging while walking were the highest consumers of time (51.4 and 26.8 %) while movement was least common (21.7%) (Sembe, 2015). Similar observations were observed in a research on giraffes' spatial ecology, diet selection, and habitat preference, in South Africa's Kalahari. Foraging was responsible for 53% of the animals' daily time budget (Deacon, 2015). Additionally, Maasai giraffe in Arusha National Park allocated 38.6% of their time to foraging, ruminating 26.6%, resting 19.6%, and moving 8.7% and 4.1% to vigilance (Mahenya, 2016). Although all these studies were undertaken in different ecosystems, their findings are very close in terms of time allocated to various daily activities with browsing being the activity allocated most time, and resting and walking the least time.

Intrinsic and extrinsic factors determine how time is allocated to activities by an animal. Intrinsic factors include age, reproductive status, and mass; external determinants include group size, the availability and quality of plant species on which they feed, and the season. (Hamel and Côté, 2008; Shi et al., 2003). Time allocated to a given activity can be hard to predict because it is highly variable (Deacon, 2015). Studying any animal's activity time budget generates valuable information necessary for a better understanding of how they interact with their environment which is highly influenced by biotic and abiotic factors including resource distributions and availability, changes in season, time of day, and presence of predators.

2.2.1 Effects of time of the day on activity patterns of giraffes

Different times of the day and changes in weather patterns affect how an animal species devotes its time during the day to various tasks (Jeugd and Prins, 2000). For example, giraffes in Tanzania's Lake Manyara National Park spend an average of 35% of their time foraging between 0700 and 1900 hours, with time spent foraging in the mornings and late afternoons nearly twice as high as time spent foraging during the midday hours (Jeugd and Prins, 2000). Giraffes in the Free State of South Africa were found to spend over half of their nighttime resting, with peak resting times occurring close after midnight and alternating with foraging (Theron, 2005). Giraffes spent approximately 31% of their nighttime foraging, with the majority occurring in the early evening and early morning hours, and substantially decreasing around midnight (Theron, 2005). Between 1100 and 1400 hours, when temperatures were extreme, giraffes were observed to spend more time resting (Theron, 2005). The lengths of foraging were found to be essentially stable throughout the day, with an increase of roughly 20% in the early morning and late afternoon (Theron, 2005). Adolfsson, (2009) reported that mature giraffes spent more than a third of their day feeding; females 36 percent and males 39 percent, with the most intense foraging times occurring three hours post-dawn and pre-dusk. At midday and early afternoon, when ambient temperatures were high, the least foraging time was seen. During this period, giraffes engaged in less-energy consuming activities such as ruminating and resting. Giraffes, like other animals, feed more frequently in the evening hours and early hours of the day than in the midnight, as Deacon, (2015), notes.

2.2.2 Effect of seasonality on the activity time budget

Seasonality has a considerable effect on how animal species allocate their time to various activities (Theron, 2005). Theron, (2005) reported a significant difference in giraffes' movement between seasons, with giraffes moving more during the dry season when food scarcity is common than during the wet season, when food availability is enhanced (Theron, 2005). Similarly, Deacon, (2015) observed that giraffes spent longer foraging and looking for browse species during the dry season in South Africa's Khamab Kalahari Nature Reserve. In both the dry and wet seasons, giraffes' primary activity was foraging, whereas less energy-consuming activities such as socializing and resting were more prevalent in the dry season than in the rainy season as an energy-saving technique (Mahenya, 2016). Seasonality, in general, dictates how giraffes arrange their time during the day. However, the overall trend from many studies indicates that foraging is a primary activity that consumes the majority of time during both seasons. As energy-saving tactics, socializing and resting which are energy-saving activities are more prevalent during the dry season than during the wet season.

2.2.3 Effects of habitat variation on the activity time budget

The term "habitat" refers to an area that contains a mixture of essential resources, such as cover, food, and water, as well as environmental factors, such as rainfall and the competition and predation risks that promote individual species' occupancy (O'Neil et al., 2001). Animals utilize a variety of habitats for a variety of purposes, including grazing and browsing, watering, resting, breeding, and protection from harsh weather (Godvik et al., 2009). The varying terrain and forage selection processes affect herbivores' habitat utilization (Pettorelli et al., 2003).

Giraffes possess unique daily nutritional and environmental needs to survive and sustain their physical conditions. Giraffes can manage the following behavioral elements to attain certain provisions: (1) foraging habitat selection; (2) forage selection criteria; and (3) the relative quantity of time spent on feeding and other activities (Deacon, 2015). Environmental variables such as water sources, forage availability, longitude, latitude, and tree density, on the other hand, influence giraffes' choice to occupy a habitat, place where they will live, and mobility, and particularly their habitat utilization (Anderson et al., 2016; Deacon and Smit, 2017; Fennessy, 2009) as well as predation.

Animals utilize diverse habitats for a variety of purposes, including browsing, watering, resting, and evading adverse weather and predators (Godvik et al., 2009). Giraffes choose environment and activity selections to satisfy their body growth and reproduction requirements (Pellew, 1984a). As Zisadza-Gandiwa et al., (2013) observed vegetation structure and composition play a critical role in herbivore habitat selection. The abundance of preferred plant species within a vegetation type affects the length of time giraffes spend in various habitat types. Giraffes in South Africa's Khamab Kalahari Nature Reserve were observed roaming more extensively in elongated home ranges during dry seasons to fulfill their daily intake of food and thus nutritional requirements, whereas, during the wet season, when food was plentiful, giraffes regularly visited the location that best met their preference (Deacon and Smit, 2017). Additionally, observations revealed that giraffes favored plains with *Vachellia karroo* trees in full bloom during the wet season and rocky slopes with evergreen vegetation during the dry season. Munyaka and Gandiwa, (2018) noticed that during the dry season, giraffes preferred riparian zones and browsed on plants such as *Combretum erythrophyllum* and *Combretum molle*. Giraffes changed to areas containing plant species such as *Flueggea virosa* (Roxb. ex Willd.) Voigt; Hort. Suburb. Calcutt. during the wet season. Williams and Williams, (2018) observed that giraffes prioritize regions with abundant forage before selecting on openness. They foraged in homogeneous areas dominated by acacia, primarily *Vachellia gerrardii*, which was the preferred plant species. They did, however, choose less wooded microhabitats, particularly during the dry season, to avoid predation.

While vegetation structure and composition have a substantial role in giraffe habitat selection, the openness of vegetation, which minimizes predation risk, also plays a role. For example, Brand, (2007) noticed that giraffes utilized a variety of habitat types in Etosha National Park, Namibia, including wide treeless plains, *Vachellia nebrownii* (Burtt Davy) Seigler and Ebinger. shrub savannah, and *Catophractes alexandri* (D.Don) shrub savannah. In the wet season, mixed broadleaf forest was favored, whereas *Vachellia nebrownii* thickets were preferred in the dry season. Mixed broadleaf vegetation accounted for around 50% of woody species, including *Colophospermum mopane* (J.Kirk ex Benth.) J.Léonard, Bull. Jard. Bot. Brux., *Combretum imberbe* (Wawra; Sitzb. Acad. Wien, Math.-Nat.), and *Terminalia prunioides* (M.A.Lawson.), all of which served as forage species for giraffes. *Vachellia nebrownii* grew in an open habitat, which made predator detection easy for giraffes. *Colophospermum mopane*-dominated habitats were avoided due to their low visibility, which increased giraffes' vulnerability to predation. Additionally, this species was avoided when an alternate food source was available.

Giraffes are water independent; they can go extended periods without drinking and drink as much as 47 liters of water a day while water is available (Bothma et al., 2010). For example, Deacon, (2015) noticed that giraffes in South Africa preferred to water during the day at natural watering places every two to three days during the summer and every four to five days during the winter. Waterholes are critical for managing animal behavior and impacting the functioning of ecosystems (Bothma et al., 2010). For example, during the dry season in South Africa's Kwaggafontein Nature Reserve, drinking stations were discovered to be focal places for animals and a strategic location for predators to readily capture their prey (Bothma et al., 2010).

Numerous researches have established licking soil as a feeding behavior in giraffes' daily activity time budget. Obari, (2014) discovered that Masai giraffes were spotted at natural salt licks during particular periods of the year in Southern Kenya's Amboseli, Athi-Kapiti plains, and Tsavo environments, licking salt as a mineral supplement to their diet. Giraffes in South Africa's Kruger National Park were often observed licking the ground when their diets lacked sufficient phosphorus and calcium (Furstenburg, 2003). Soil licking, along with other non-foraging eating behaviors such as osteophagy, was uncommon but detected in nutrient-deficient habitats (Fennessy et al., 2019). Giraffes have been documented looking for salts by licking termite mounds (Ciofolo and Le Pendu, 2002). Soil licks supplement nutrient-deficient diets and have the extra benefit of binding toxins and counteracting the effects of endo-parasites in herbivores (Starks and Slabach, 2012).

High predation risk also affects the feeding location and behavior of herbivores (Ford et al., 2014). Giraffes can run up to 55 kilometers per hour when evading predators (Carnaby, 2006). Due to their fear of predators, giraffes devote some time to vigilance. For instance, female giraffes tracked in Kruger National Park were observed halting their browse more frequently to look for predators to increase their safety (Cameron and du Toit, 2005). This behavior was also seen to be influenced by feeding heights, with giraffes browsing more frequently at lower and higher neck angles, allowing them optimal visibility while eating (Cameron and du Toit, 2005). Predators were observed to play a substantial impact in the decline of the giraffe population in Khamab Kalahari Reserve. Giraffe calf mortality was high in this wildlife reserve, with over half of them dying before reaching the age of one year (Bercovitch and Berry, 2010). Determining how habitat variation affects activity patterns aids in determining the distribution and availability of resources for Rothschild's giraffes. This knowledge informs critical conservation and management decisions, such as giraffe translocation from one park to another and even resource distribution inside the park.

2.3 Plant species preference by giraffes

This section gives a general introduction to foraging theory and preference, seasonality effects on plant species preference, and foraging heights. This research acknowledges new changes made to plant species and makes use of the latest scientific names of the plant species, more specifically genus Acacia that has been revised to genus Vachelia and Senegalia (Kyalangalilwa et al., 2013; WFO, 2022).

Foraging theory is concerned with the decisions made by animal species when it comes to food acquisition, namely where they look for food when they forage, what foods they take, and the feeding duration (Owen-Smith et al., 2010). Preference for a plant species by an animal refers to the chance of an animal selecting a certain plant species when presented with comparable options (Johnson, 1980). The goal of plant species selection is to maximize nutritional intake and digestible energy while minimizing the chemical and mechanical defenses of the plant (Skarpe et al., 2000). An animal is said to prefer a particular type of plant species if it consumes it first or in a larger quantity than other equally available plant species. Determining how giraffes balance their time during the day between foraging activities and plant species choices enables seasonal comparisons of plant species availability (Croft, 2009). Dietary studies of herbivores are critical for understanding trophic connections because they shed light on the potential competition with other herbivores while also showing the potential influence of herbivores on an ecosystem (Bookhout, 1996).

The majority of giraffes spend extended periods in places with dense populations of acacia trees. (Kimuyu et al., 2021; Viljoen, 2013). Studies by Parker and Bernard, 2005) on the giraffes' diet and ecological role in South Africa showed that woody species, shrubs, and grass species constituted their diet, *Vachellia karroo* (43%) and *Rhus longispina* (Eckl. and Zeyh.) Moffett; Bothalia (17%) being the most important species giraffes' diet. *Acacia mearnsii* (De.Wild) and *Acacia cyclops (*A. Cunn. ex G. Don) also formed part of the giraffes' diet although they are alien species in South Africa (Parker and Bernard, 2005). Brand, (2007) on the other hand studied the giraffes' evolutionary ecology in Etosha National Park, Namibia. Results showed that among the plant species foraged on by giraffes, *Vachellia nebrownii* was the most essential browsed species making up 50.5% of the observation. *Terminalia prunioides* and *Combretum imberbe* were also highly foraged in some months. O'Connor et al., (2015) studied giraffes and camels' foraging ecologies in northern Kenya, specifically the impacts of habitat structure and competition. Results showed that giraffes mainly preferred Acacia species, *Senegalia mellifera* (Vahl) Seigler and Ebinger, *Vachellia drepanolobium* (Harms ex Sjöstedt) P.J.H.Hurter, *Vachellia etbaica* (Schweinf.) Kyal. and Boatwr., and *Boscia albitrunca* (Burch.) Gilg and Gilg-Ben) being the most preferred. Giraffes selected *Vachellia erioloba* (E.Mey.) P.J.H.Hurter and *Vachellia haematoxylon* (Willd.) Seigler and Ebinger, in Auob riverbed, Kgalagadi Transfrontier Park, as their most preferred species (Viljoen, 2013).

Giraffes were observed feeding mostly on Vachellia and Combretum tree species that were prevalent in Southern Kenya (Obari, 2014). According to Deacon, (2015), *Vachellia erioloba, Ziziphus mucronata* (Willd.), *Boscia albitrunca*, and *Senegalia mellifera* are considered important food resources in the Kalahari region of South Africa and are preferred by giraffes. Mahenya et al., (2016) investigated whether the choices to forage by Maasai giraffes varied according to habitat, patch, and tree species in a Tanzanian savannah. Giraffes liked Acacia and Dodonaea shrub habitat, *Vachellia xanthophloea* being the most preferred species. Williams and Williams, (2018) reported that 60 percent of the diet of Rothschild's giraffes at Lake Mburo National Park, Uganda, was *Vachellia gerrardii*, whereas all acacia species accounted for 80 percent of the giraffes' total diet.

Generally, the findings show that acacia tree species are highly preferred, and other species are fed on to compensate for inadequate quantity or quality of browse from Vachellia trees either with the seasonal difference or vegetation variations. In addition, giraffes demonstrate differing preferences among Vachellia tree species in a given area and across various regions in Africa. Thus, for effective management of giraffes' habitats replanting of acacia species should be considered.

2.3.1 The effect of seasonality on giraffes' plant species preferences

Seasonality affects giraffes' forage species preferences. Parker and Bernard, (2005) observed that *Vachellia karroo,* a deciduous tree species, was the preferred plant species by giraffes during the wet season while *Rhus longispina,* an evergreen tree species, had the highest preference during the dry season in Eastern Cape, South Africa. The choice for *Rhus longispina* was found to be influenced by the reduced number of deciduous tree species hence the shift of preference for the evergreen tree species available year-round. In this reserve, ever-green tree species provide quality and quantity plant species for giraffes in the dry season. As influenced by seasonality, tree phenology has been reported to play a role in food selection by giraffes, particularly flowers, pods or fruit, and new leaves production (Brand, 2007). The study also found out that, during the wet season, giraffes showed a preference for *Combretum imberbe, Terminalia prunioides,* and *Cataphractus alexandria,* while *Vachellia tortilis* (Forssk.) Galasso and Banfi, during the dry season, was the most grazed species. The ability of *Terminalia prunoides* and *Catophractes alexandri* to produce flowers and new leaves only during periods of heavy rain promoted their selection during the wet season, whereas several plant species, notably Acacia, flower only during the middle of the dry season. Obari, (2009) reported that giraffes in Nairobi National Park favored *Vachellia drepanolobium* during wet seasons and *Balanites glabra* (Mildbr. and Schltr.) during dry seasons. Obari, (2014) reported that perennial plants such as *Vachellia* tortilis ((Forssk.) Galasso and Banfi., *Commiphora Africana* ((Rich.) Engl. DC., Monogr. Phan., *Vachellia drepanolobium,* and *Commiphora campestris* (Engl.) that were available to giraffes throughout the year were favored during the dry and wet seasons. Gordon et al., (2016) while examining the diet of South African giraffe in Sanbona Wildlife Reserve, discovered that *Vachellia karroo*, a common species in the area, was the most preferred forage species in autumn and spring, while in winter *Schotia afra* (L.) Thunb.) was the most preferred species. Similarly, due to the availability of river tributaries, giraffes were observed seasonal migrating between catchments with tree species other than *Vachellia karroo* (Gordon et al., 2016).

Contrary to previous research indicating a preference for Acacia, giraffes had a seasonal preference for other plant species in Umfurudzi Park, Northern Zimbabwe, despite the park's presence of *Vachellia karroo* (Munyaka and Gandiwa, 2018). This study discovered that giraffes preferred six woody species over *Vachellia karroo* in different seasons (Munyaka and Gandiwa, 2018). In the dry season, these species included *Ziziphus mucronata, Combretum apiculatum* (Sond.), *Piliostigma thonningii* (Schum.) Milne-Redh., *Vangueria infausta* (Burch.), and *Pseudolachnostylis maprouneifolia* (Pax), whereas in the wet season, *Combretum erythrophyllum, Combretum hereroense* (Schinz.), *Flueggea virosa, Olea africana* (Wall. ex G.Don) Cif., *Combretum imberbe,* and *Ziziphus mucronata* (Munyaka and Gandiwa, 2018). Despite its low density, *Vachellia karroo* was seen to be selected in both dry and wet seasons. *Vachellia karroo* was chosen for its ability to produce fruits during the dry season and leaves during the wet season (Munyaka and Gandiwa, 2018).

2.3.2 Effects of forage availability on giraffes' foraging levels

The height of an adult giraffe varies between 4.0m -5.5m (Jolly, 2003). These heights give them the advantage to feed at elevations that are not easily reachable by other ungulates. Differences in browsing heights are a type of resource partitioning; browsing at a high level minimizes browsing pressure on vegetation where sexes and groups foraging heights coincide (Obari, 2009). Another factor that forces giraffes to feed at higher levels is a heavy browsing pressure on lower heights by other herbivores (Blomqvist and Renberg, 2007). Giraffes forage at heights where they compete with one another, allowing them to browse in savannas that are rich in nutrients and those with poor nutrient levels (Mahenya, 2016).

Woolnough and du Toit, (2001) evaluated vertical zonation of browse quality in tree canopies subjected to a size-structured guild of herbivores in various South African Savanna settings. Giraffes were observed to browse on *Senegalia nigrescens* and *Boscia albitrunca* species at a height of 2.5 meters, which was inaccessible to smaller browsers (Woolnough and du Toit, 2001). The giraffes also preferred to browse at canopy heights with higher leaf mass per browse shoot (Woolnough and du Toit, 2001). Giraffes' foraging efficiency increases as they ascend the canopy; browsing at elevations above the reach of smaller herbivores provides them with a nutritional advantage while reducing competition. In addition, at a higher canopy level, more photosynthate is produced in response to increased light intensity (Woolnough and du Toit, 2001). Small herbivores selectively pick and remove individual leaves, but large herbivores bite and remove entire shoots. Since the little selective bites diminish the total forage quality of each giraffe browse unit (GBU), giraffes prefer to feed at a higher canopy level with intact GBUs (Woolnough and du Toit, 2001).

Blomqvist and Renberg, (2007) discovered considerable disparities in feeding heights between male and female giraffes, with male giraffes foraging at greater elevations than female giraffes. The study classified foraging levels as follows: first, below the knees; second, from the knees to the belly; third, from the belly to the back; fourth, from the back to the middle of the neck; fifth, from the middle of the neck to the head; and sixth, above the head (Blomqvist and Renberg, 2007). Male giraffes favored level five (between 3 and 4 meters) for browsing, accounting for 49 percent of browsing records, whereas females chose level four (between 2 and 3 meters) for browsing, accounting for 40.4 percent of browsing data. Only 3% of total foraging on trees below 2 meters was recorded (Blomqvist and Renberg, 2007).

Obari, (2014) observed that giraffes browsed mostly at heights of 5 meters and could reach 6 meters. Williams and Williams, (2018) observed giraffes fed mostly on levels between 4 to 5 meters tall Acacia trees. The studies showed a clear preference for foraging at levels above 3 meters from the ground. Additionally, foraging heights in giraffes were viewed as a resource partitioning strategy, with high-level browsing intended to alleviate browsing pressure on vegetation where the feeding levels of the sexes overlap, hence lowering competition.

Giraffes have also been observed feeding below their maximum foraging height in several investigations (Gordon et al., 2016; Leuthold and Leuthold, 1978; Obari, 2014). Gordon et al., (2016) found giraffes eating on forage less than 1.5 meters in height, mainly *Salsola aphylla* (L.fil.,Suppl) and *Vachellia karroo,* while Obari, (2014) reported giraffes feeding at plant heights of between 1 and 2 meters. Foraging at lower levels was associated with two factors, namely: low browse availability at mean foraging height, hence not satisfying all giraffes' dietary requirements or selection of preferred food plants.

Herbivore habitat utilization studies are beneficial because they provide a starting point for determining the resources and habitat on which management decisions should be made. From this literature review, several aspects that influence giraffes' ecology are explained from different ecosystems and regions. It is vital to understand habitats preferred by Rothschild's giraffes in LNNP to comprehend the seasonal and spatial variability and provide insight into potential competition with other herbivores while informing management decisions.

2.4 Knowledge gap

While numerous research on giraffes in Africa have highlighted substantial challenges to their population, there is still a knowledge gap on the extent to which seasons and habitat variation affect giraffe activity time budgets and feed selection in LNNP. Similarly, few studies on giraffes' activity time budgets in various environments, including LNNP, have been conducted. While this is true, these parameters vary considerably between ecosystems. Giraffe foraging patterns have been studied in several localities and subspecies, with varying results. No comparable research has been conducted to ascertain Rothschild's giraffe's foraging patterns in LNNP. As a result, this research focuses on giraffes' plant species preferences and foraging levels in Lake Nakuru National Park. Moreover, area-specific evidence is required to infer a species' successful management and conservation efforts.

CHAPTER 3: METHODOLOGY

3.1 Study Area

As shown in Figure 1 below, the study was carried out within LNNP which is one of the 39 National Parks of Kenya, located in the Rift Valley, Nakuru County and covers 188 Km^2. It lies between 0^0 18’S and 0^0 30’ S latitudes and 36^0 03’ E and 36^0 07’ E longitudes. It is located about 1759 m above sea level (KWS, 2011), approximately 156 kilometers north of Nairobi and 3 kilometers south of Nakuru’s core business district. Menengai crater borders the park to the North, Bahati escarpment to the South, and Mau escarpment to the west (KWS, 2011).

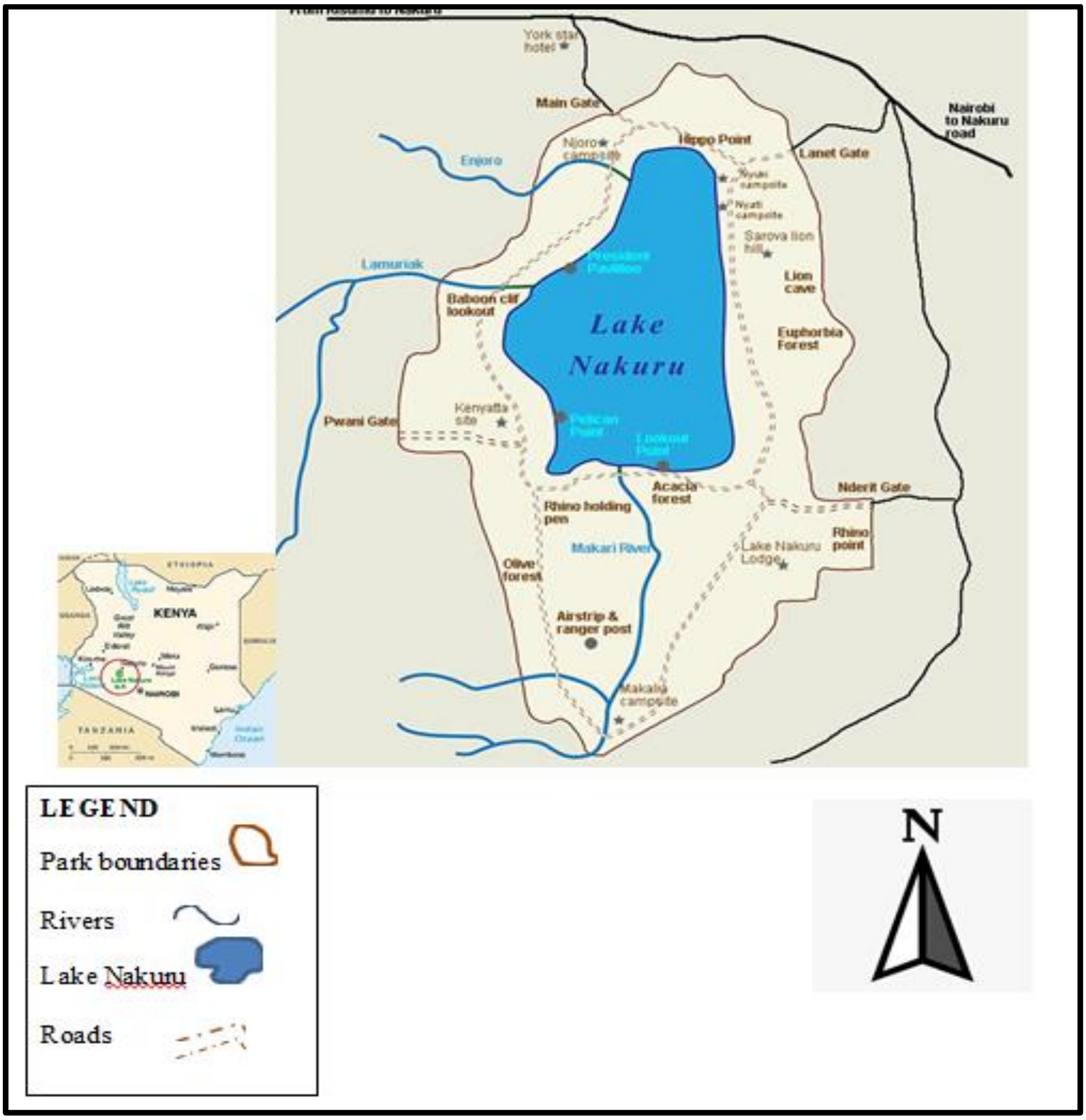


Figure 1: Map of the study area

The park was established as a conservation area in 1957, elevated to the status of a National Park in 1968 (KWS, 2010), and declared a Ramsar Site (No. 476) in 1990 under the Ramsar Convention on Wetlands of International Importance (UNESCO, 1999). It is recognized as a significant habitat for Flamingos and other birds. The geological features of LNNP are defined by four important landscapes: the Rift valley bottom, which contains Lake Nakuru, the escarpments on the lake's western and eastern shores, and the fault lines that run north-south. The lake occupies an area of 40 km^2 however its surface area varies according to the seasons. Makalia, Nderit, Njoro, Naishi, and Larmudiac are its five seasonal inlet rivers. Additionally, the lake receives water from the Baharini springs. However, because the lake lacks outlets, it maintains an alkaline pH of 10.4 on average (KWS, 2011).

3.1.1 Climate of the park

The park is classified as a dry, sub-humid to semi-arid area meaning that it is neither too wet nor too dry. The average annual rainfall in the park and its surrounding is around 750 mm, almost equally distributed between two wet seasons, namely, November-December (short rains) and March-May (long rains). From June to December, conditions in the park are sunny with the occasional showers, especially in the afternoons. Temperatures rise to about 25°C in the afternoon, but in the evenings and mornings, they oscillate around 9°C. January and February are the driest and warmest months of the year and temperatures can rise above 28°C. The average daily minimum and maximum temperatures are 8.2°C and 25.6°C, respectively. March to May is a wet season, but it rarely rains all day. Mean annual evaporation is 1800 mm, while mean annual radiation is 490 Langleys (KWS, 2011).

3.1.2 Major habitat types within the park

As shown in Figure 2, there are five broad habitat types in the park, namely: springs and open water, shorelines, open grasslands, woodlands, and forests. The open water, shorelines, and springs are dominated by zooplanktons such as *Brachionus dimidiatus* (Bryce.) and *Brachionus plicatilis* (Mueller.). Acacia woodlands are the most extensive and scattered in the park and are linked with high water table areas and plains. They make up the woodland habitats. They are dominated by woody species like *Vachellia seyal* ((Del.) P.J.H.Hurter, *Verchellia hockii, Verchellia xanthophloea*, *Verchellia gerrardii,* and *Verchellia abyssinica*. Short bushes include *Achyranthes aspera* (L), *Solanum incanum* (Ruiz and Pav.), and *Urtica massaica* (Mildbr.); while the shrub layer is dominated by *Grewia similis*, *Rhus natalensis* (Bernh. ex Krauss**)**, *Senecio lyratipartitus* (Forssk.), *Cassia bicapsularis* (L.), and *Vernonia auriculifera* (Hiern, Cat. Afr. Pl. (Welw.) (Mutangah, 1994).

Bushed woodlands, which alternate with acacia woodland, are the park's second-largest ecosystem. The main shrub species is *Tarchonanthus camphoratus* (Houtt. ex DC., Prod.), the main grass species are *Cynodon dactylon (*Caro and Sánchez) Romero Zarco, Lagascalia and *Sporobolus spicatus* (Vahl) Kunth , the main tree species are *Vachellia xanthophloea* and *Vachellia gerardii*, and the key shrubs are *Psiadia punctulata* (DC.) Oliv. and Hiern ex Vatke,*Grewia similis, Aspilia mossambicensis* (Oliv.) Wild, and *Ocimum basilicum* (Willd.) Benth) (Mutangah, 1994).

Open grasslands within the park are mainly found in the sedimentary plains to the North and South of the lake. The grasslands comprise *Chloris gayana* (Kunth.), and *Hyparrhenia hirta* (Troupin, Fl. Garamba), dotted with short bushes of *Lippia ukambensis* ((Vatke) Verdc), and *Lantana trifolia* (L.). The habitat is dotted with trees and shrubs, including *Vachellia xanthophloea*, *Vachellia gerrardii*, *Vachellia hockii* for trees, and *Maerua triphylla* (A.Rich.), *Maytenus senegalensis*, *Cordia ovalis* (R.Br., Salt., Voy. Abyss. Append., *Tarchonanthus camphoratus*, *Rhus natalensis*, and *Dodonaea angustifolia* (L.fil., Suppl.) for shrubs (Mutangah, 1994).

The most common grass species along the alkaline lake shores are, *Sporobolus spicatus* and *Typha species* (KWS, 2011). The main forests in the park are the Euphorbia forest dominated by *Euphorbia candelabrum* (Trémaux and Kotschy) species; the Olive forest on the South-western side comprising *Olea*, *Teclea*, and *Juniperus* species and finally, Acacia forest which is dominated by *Vachellia xanthophloea*, especially on the high water table patches (KWS, 2011).

In terms of fauna, the park is home to around 400 bird species and 70 mammal species. The main mammalian species found on the lake's shoreline include Hippopotamus, Waterbuck, Thompson's gazelles, Bohor reedbuck, Impala, Burchell's zebras, and Warthogs. Woodlands mainly host Giraffes *(Giraffa camelopardalis rothschildi)*, buffalos, black and white Rhino, Leopards, Lions, Baboons, Bush backs, and Colobus monkeys. Bushlands provide habitats for Elands, Steinboks, Impala, and Dikdiks (Mutangah, 1994; KWS, 2002). Among other birds, the park is famous internationally for its large population of the lesser (*Phoenicopterus minor)* and greater flamingos *(Phoenicopterus ruber* (McClanahan et al., 1996; Ogutu et al., 2017).

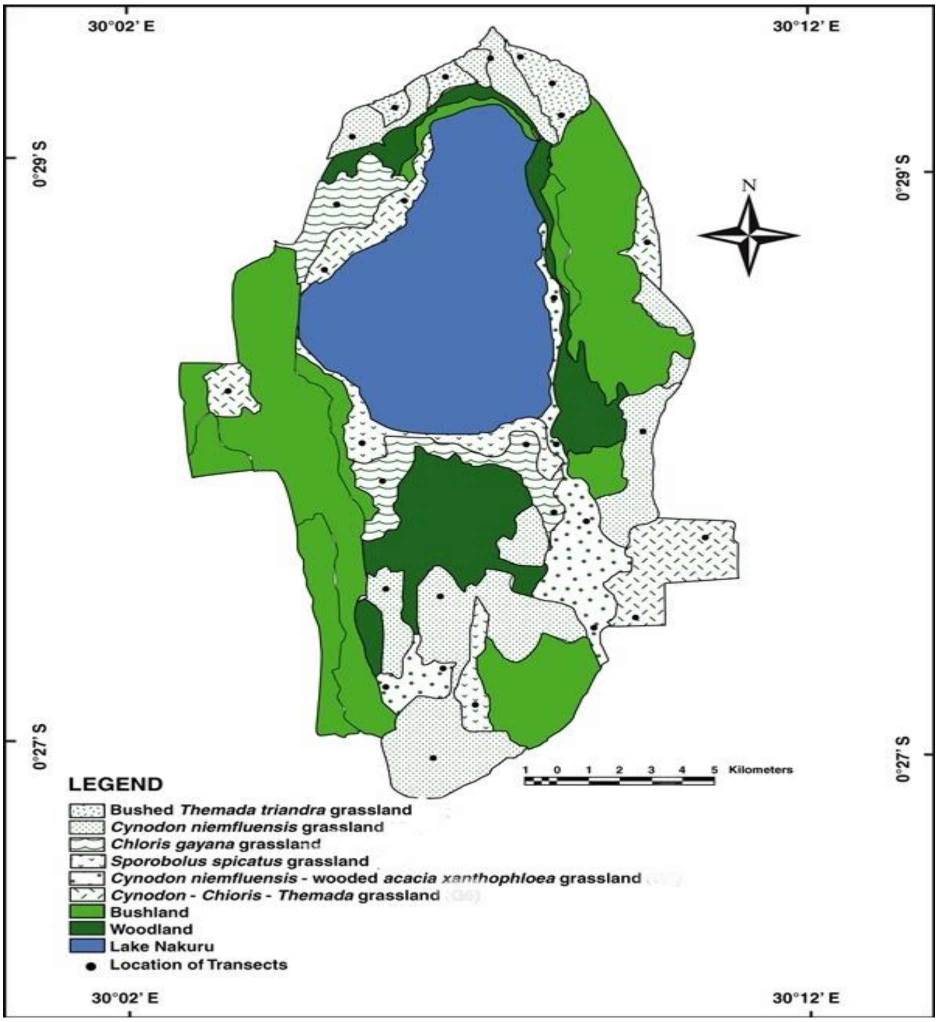


Figure 2: Map showing the vegetation types found in the park (Ng'weno et al., 2010)

3.2 Assessment of Rothschild's giraffes' diurnal activities

The study was conducted during the dry and wet seasons of 2019 with each data collection period lasting 3 days. Dry season data were collected in 6 days from 14^{th} to 16^{th} February 2019 and 20^{th} to 22^{nd} February 2019, while the wet season data were also collected in 6 days from 31^{st} May to 2^{nd} June and from 10^{th} to 12^{th} July 2019. The park was divided into 3 blocks and each block was assigned a letter (A, B, and C). Roads that cut across each block were used as sampling lines. Each block had heterogeneous vegetation the main vegetation types being, acacia woodland, open grassland, and bushed woodland. Each morning one tower (a group of 5-25 giraffes) was randomly selected from any of the three blocks. The giraffes were the sampling units. This means that on day one the first tower was selected from any of the 3 blocks, on day two the second tower was selected from the remaining 2 blocks, and on day 3 the third tower was selected from the remaining block. The first tower that was sighted as one drove through the selected block, was observed that day. This process was repeated in the subsequent observations.

The Scan sampling method described by Altmann, (1974) was used to assess how Rothschild's giraffes allocate time to various activities of the day. The activities assessed in this study were moving (running and walking), resting (lying down, standing, and social interactions), foraging, licking soil, and drinking water. At the beginning of the observation, date, time, season, weather, habitat type, tower size, and location (GPS) were recorded. Each adult giraffe in the tower was identified by capturing its skin pattern in a digital camera and then analyzing the images using a pattern recognizing software known as WILD-ID. Observations were made from the top of a pick-up vehicle approximately 50-100 m away, to minimize disturbance to the animals. A pair of binoculars was used for observations and a standard digital stopwatch was used to track time.

Assessment of the giraffe's activities was conducted by a team of 7 people working in tandem. The 7 people were trained on data collection during a pre-visit, to ensure that data was harmonized to reduce error. Three members of the team tracked the giraffes' behavioral activities, 2 captured the images of the giraffes for WILD-ID identification and 2 identified the plant species browsed by giraffes and estimated the feeding heights during the observation period. Plant species preference by giraffes (the percentage use of each species relative to all foraging observations) was also documented. Each day was divided into 4 observation 'windows', 2 in the morning (0800-0900 and 1100-1200) and 2 in the afternoon (1400-1500 and 1700-1800). A total of 8 scans were conducted in an hour. Each scan lasted five minutes with a 20 minutes break after 4 scans. Data were recorded on prepared data sheets (Appendix 1 and 2). The giraffes were scanned in the same order during the subsequent scans within each hour. The same procedure was replicated in the subsequent scans, and observation hours.

The plant species selected by each giraffe were taxonomically identified by comparison method; comparing the unknown plant species with named species, photographs, illustrations or descriptions and the general browsing height was estimated and recorded. A foraging activity was defined as when an individual giraffe took a bite at a leaf or twig of a particular plant species during a given scan. A resting activity was defined as when a giraffe was lying down or standing, and movement activity was when a giraffe was walking or running. Finally, a watering activity was when a giraffe was drinking water. Feeding heights were visually estimated using Deacon, (2015) classification, with the lowest level being below the knees (1m), the second being from the knees to the belly (1-2m), the third being from the belly to the back (2-3m), the fourth being from the back to the middle of the neck (3-3.5m), the fifth being from the middle of the neck to the head (3.5-4.0m), and the sixth being above the head (>4.0m). The plant species preference was calculated as follows

Species preference = Individual plant species foraged ÷ total plant species foraged × 100.

3.3 Data analysis

Data analysis entailed calculations of means, percentages, and frequency distributions. Means of frequencies of each activity in each hour and each season were grouped and percentages of time allocated to each activity during each observation hour were derived. A browse species' preference by giraffes was calculated from the totals of foraging records for each species forage in each season and habitat type and expressed as a percentage of all foraging records in that season and habitat type. Percentage of occurrence of the various activities per hour and per season, percentage of occurrence of a plant species in the foraging records in each season, standard errors, and standard deviation were calculated and presented as descriptive statistics. Independent t test was performed to test whether there were significant differences in activity patterns between the two seasons, dry and wet season. The differences in means of each forage species in the 2 seasons was also tested using the independent t test. All statistical tests were considered significant at a 95% confidence limit if type 1 error (alpha) is less than 5% (0.05) *(Zar, 1996).* All statistical analyses were conducted using STATA version 12.0. Line graphs and bar charts were drawn for result visualization. GPS coordinates were used to plot a map showing the seasonal spatial distribution of key activity areas of Rothschild's giraffes in LNNP.

CHAPTER 4: RESULTS

4.1 Rothschild's giraffes' diurnal activities in the dry and wet season

Figure 3 and 4 below shows the diurnal activity time budget of Rothschild's giraffes during the dry and wet season. The key activities that giraffes were involved in were foraging, moving, and resting. During the dry season, foraging was allocated most of the time (53%). During morning to midmorning, the giraffes allocated over 50% of their time to foraging, while resting and movement time ranged between 18 and 26%. However, the time spent foraging declined progressively from morning (63%) to midmorning (52%) and about 38% during the afternoon. Foraging gradually increased in the evening hours to 48%. Percentage time spent moving increased from morning to midmorning (18 - 26%), then decreased in the afternoon to 16% before gradually increasing again to 26% at the close of the day. A steady increase in resting time was observed from morning (19%), to mid-morning (22%) and afternoon (46%) then decreased to 26% at the end of the day. No time was allocated to the watering activity.

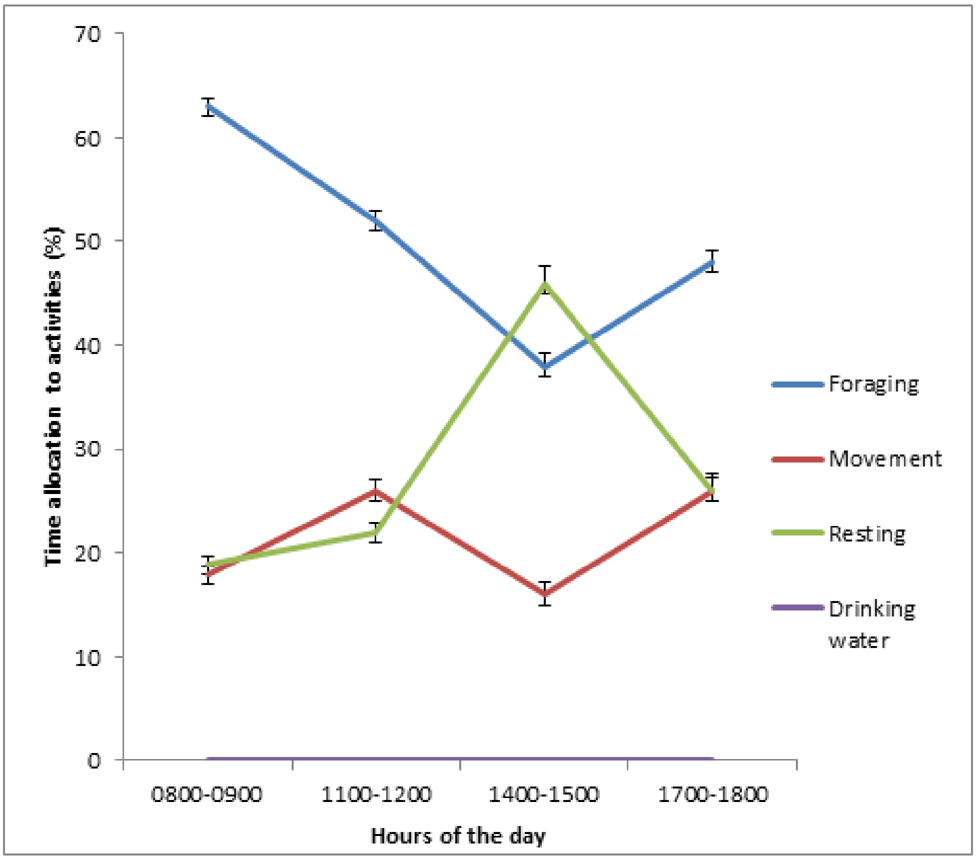


Figure 3: Diurnal activity time budget of Rothschild's giraffes during the dry season

Foraging was the main activity of giraffes during the wet season accounting for about 57% of their time every day. On any given day, time spent foraging remained over 50% while resting and movement time ranged between 14 and 33%. The percentage time allocated to foraging decreased gradually from morning to evening, i.e. 64% in the morning, 59% in the midmorning, 53% in the afternoon, and 52% in the evening. The time spent moving between morning and midmorning was more or less the same (18%) but decreased in the afternoon to 14%. The movement however increased steadily to 30% by evening. Resting time, on the other hand, increased gradually from morning to mid-morning to afternoon (17%, 23%, and 33%, respectively) then reduced to 17% at the close of the day. Time spent drinking water was negligible and was only recorded in the morning (1%) and evening (1%) during the wet season.

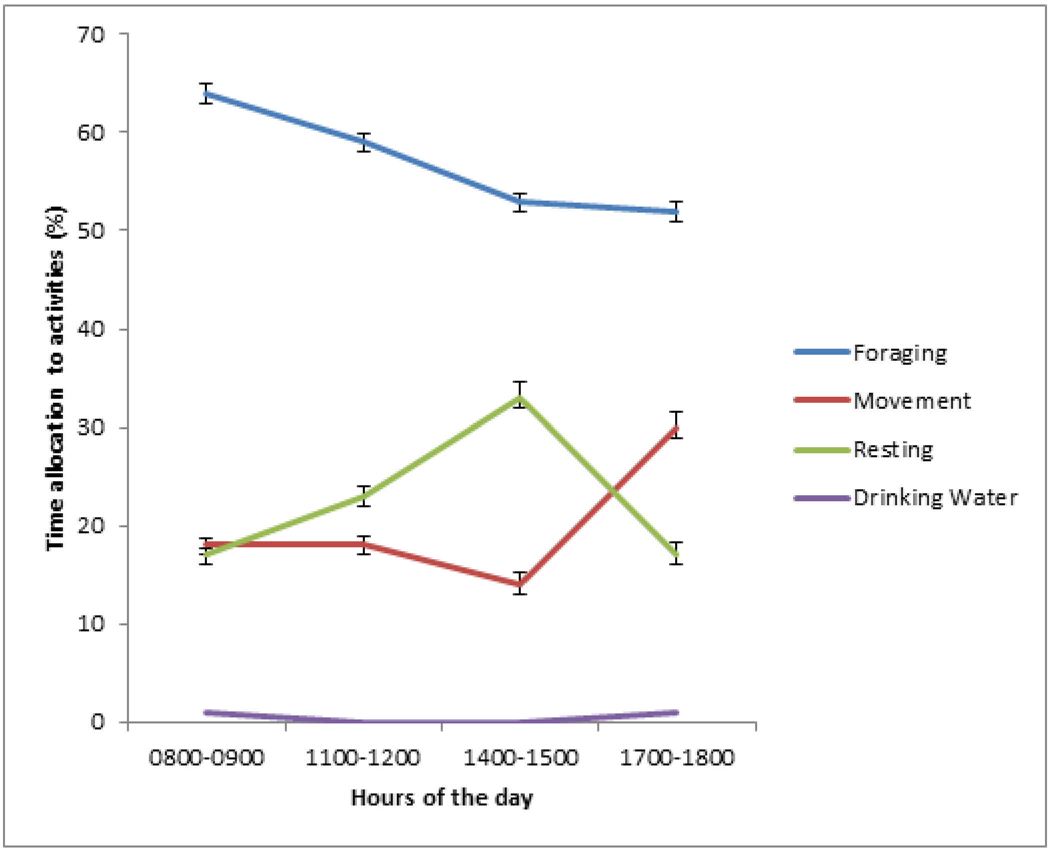


Figure 4: Diurnal activity time budget of Rothschild giraffes during the wet season

The time giraffes spent foraging increased insignificantly from dry to wet season (53% to 57%) $t(280)= -1.7957$, $p=0.07$. Movement and resting duration increased from dry to wet season 22% to 20% and 25% to 22% respectively, although the difference was insignificant $t(280)= 0.6848$, $p=0.49$ and $t(280)= 1.3911$, $p=0.16$.When foraging was highest (during morning hours) movement and resting were at the lowest, while when resting was at the highest (afternoon hours), foraging and movement were at the lowest in both seasons. In both seasons, the percentage time allocated to resting was highest in the afternoon but was higher in the dry season.

4.2 Rothschild's giraffes' diurnal activities in different habitat types

Figure 5 and 6 shows the habitat types used by Rothschild's giraffes for various activities during different periods of the day in both dry and wet seasons of the study. Giraffes spend most of their time in the acacia woodland during both dry (60%) and wet seasons (63%).

Generally, giraffes spent most of their morning, mid-morning, and afternoon hours in the acacia woodlands and most hours in open grasslands towards the close of the day in the dry season. A steep increase in the time spent by giraffes in the acacia woodland was observed from morning (50%) to mid-morning (68.6%) to afternoon (88%). However, the trend was followed by a sharp decline of 45% towards the close of the day as the giraffes moved to the open grasslands. Therefore, when one habitat type was utilized more, the others were less utilized or avoided. Bushed woodland was utilized more early in the morning (42.9%) but rapidly declined (2.9%) by mid-morning. This habitat was avoided in the afternoon. However, it was used a little in the evening (5%). The time spent in the open grassland gradually increased from morning (7%) to mid-morning (28.6%) and then declined in the afternoon (11.8%). The trend then increased rapidly in the evening (50%).

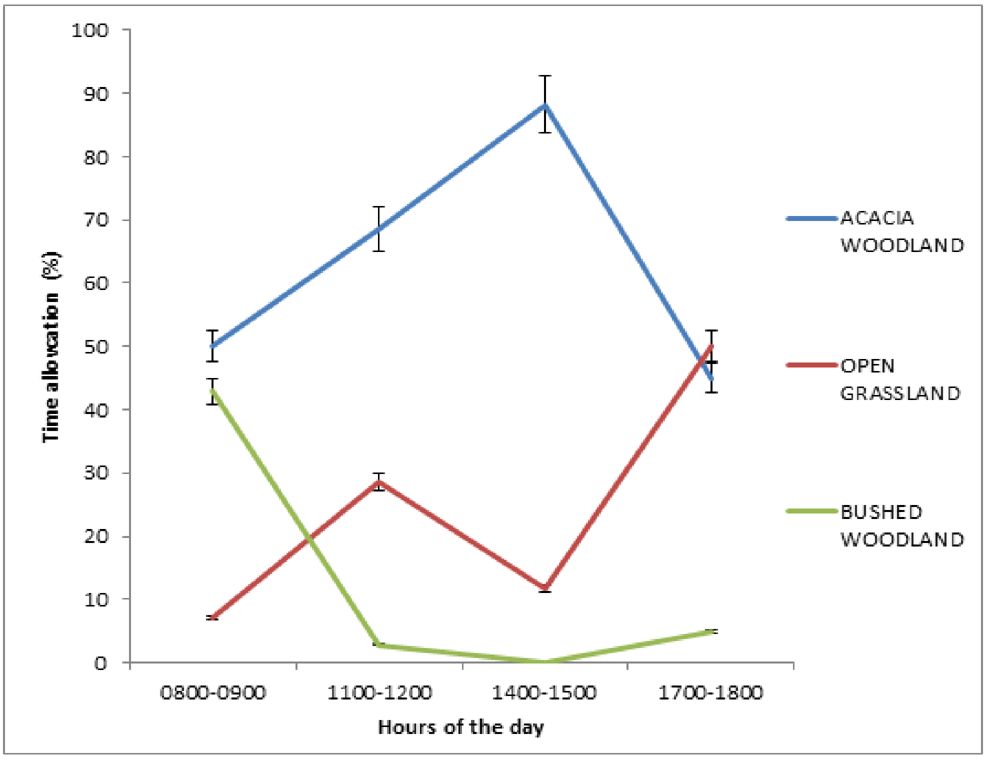


Figure 5: Habitats preferred by Rothschild's giraffes for various activities at different times of the day during the dry season

During the wet season, giraffes spent more than 50% of their time in the acacia woodland on any given day. An increase in percentage time spent in acacia woodland was observed from morning (59.5%) to mid-morning (83.3%). Though still more preferred habitat type than the bushed woodland and open grasslands, the utilization of this habitat type declined in the afternoon into evening to 58.5% and 55.1%, respectively. When time spent in acacia woodland was highest (83.3% in the mid-morning hours), time spent in the open grassland (13.9%) and bushed woodland (2.8%) was lowest. A gradual decline in time spent in bushed woodland was observed from morning (11.9%) to mid-morning (2.8%) which was followed by a steep increase towards the afternoon (17%) and the close of the day (28.6%). A gradual decline in time spent in open grassland was recorded from morning (28.6%) to mid-morning (13.9%) followed by a gradual increase into the afternoon (24.4%) and later a decline to the close of the day (16%) when it was least preferred. While the percentage time spent in acacia woodland declined steadily from midmorning, into the afternoon and evening, with an increase in time spent in bushed woodland was observed in the same period of the day.

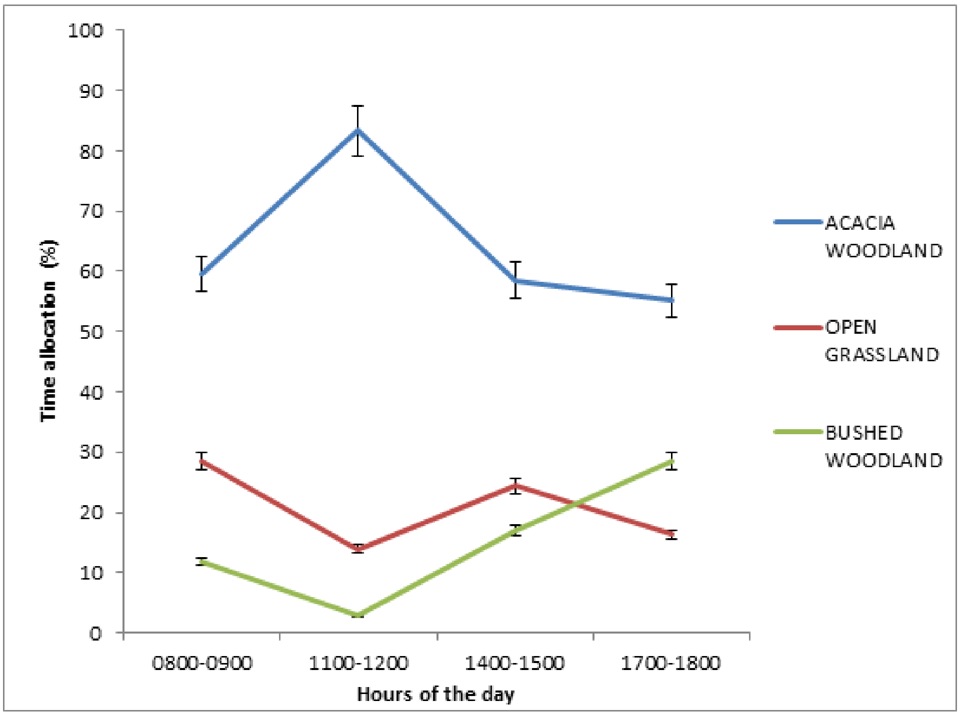


Figure 6: Habitats preferred by Rothschild's giraffes for various activities at different times of the day during the wet season

Generally, during both dry and wet seasons, when the percentage time spent in acacia woodland was highest, the percentage time spent in open grassland and bushed woodland was lowest. In both seasons, giraffes spent more time in the acacia woodland from morning to evening, except in the dry season when the time spent in acacia woodland was slightly lower than in open grassland in the evening.

Figure 7 shows the seasonal spatial distribution of the key activities of Rothschild's giraffes in the national park. Surprisingly, the giraffes only utilized the southern part of the park in both dry and wet seasons.

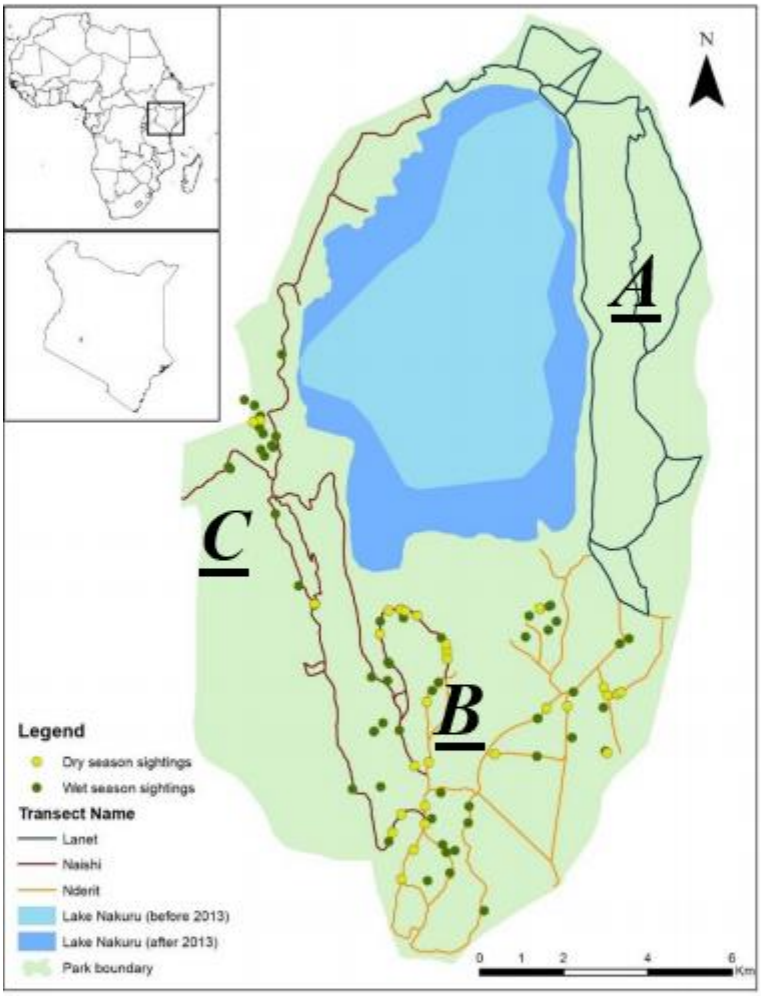


Figure 7: Seasonal spatial distribution of key activity areas of Rothschild's giraffes

4.3 Forage plant species preference by Rothschild's giraffes during dry and wet seasons

The giraffes foraged on a total of 8 woody plant species namely, *Vachellia xanthophloea* (67%), *Maytenus senegalensis* (19%), *Solanum incanum* (9%), *Maerua triphylla* (2%), *Vachellia gerrardii* (1%), *Vachellia abyssinica* (1%), *Rhus natalensis* (1%) and *Grewia similis* (0.5%). Figure 8 below presents the relative preference of these tree species by Rothschild's giraffes for forage during the dry and wet season. *Vachellia xanthophloea*, *Maytenus senegalensis,* and *Solanum incanum* contributed the bulk of the giraffe's browse diet component in both seasons.

During the dry season, the order of forage plant species preference was *Vachellia xanthophloea* (72%), *Maytenus senegalensis* (12%), *Solanum incanum* (11%), *Maerua triphylla* (2%), *Vachellia gerrardii* (2%), and *Grewia similis* (1%). During the wet season, *Vachellia* *xanthophloea* (63%) was the most preferred, followed by *Maytenus senegalensis* (23%), *Solanum incanum* (8%), while *Maerua triphylla*, *Vachellia abyssinica*, and *Rhus natalensis* were least at 2%.

Grewia similis and *Vachellia gerrardii* were only browsed in the dry season, while *Vachellia abyssinica* and *Rhus natalensis* were only utilized in the wet season. In comparison, there was an insignificant reduction in preference for *Vachellia xanthophloea* (72% to 63%) $t(280)=1.0216$, $p=0.31$ and *Solanum incanum* (11% to 8%) $t(280)= 0.7997$, p=0.42 between the dry and wet seasons. Giraffes only browsed on *Grewia similis* and *Vachellia gerrardii* during the dry seasons at 1 and 2%, respectively. On the other hand, *Vachellia abyssinica* and *Rhus natalensis* were only browsed during the wet season at 2% each. Preference for *Maytenus senegalensis* increased significantly from 12% in dry to 23% in the wet season $t(280)= -2.9076$, $p=0.004$. Preference for *Maerua triphylla* was virtually the same (2%) during the dry and wet seasons.

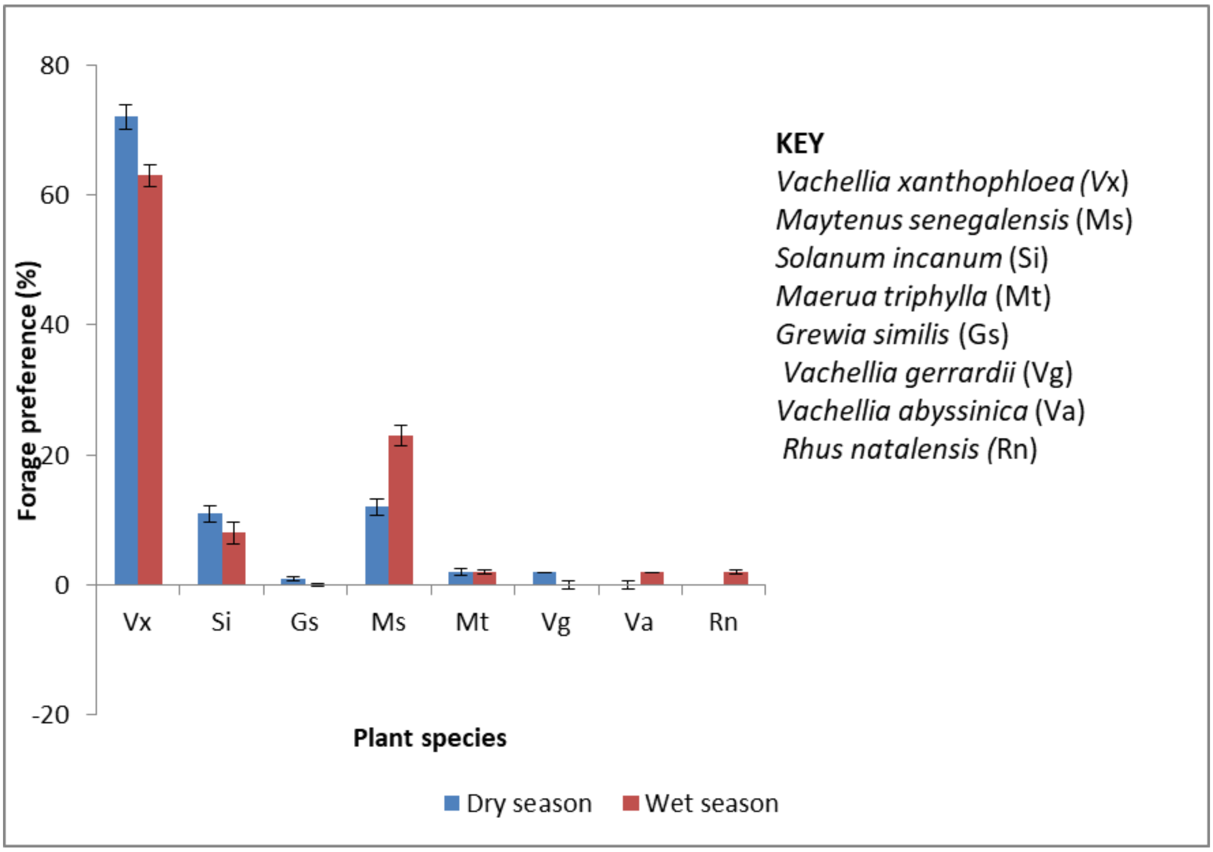


Figure 8: Percentage browse species preference by Rothschild's giraffes during the dry and wet seasons

4.4 Effect of foraging height on species preference

Figure 9 presents the relationship between the browsing heights and seasons. On Average, 3.5 m (level 5) was the most preferred browsing height at 49 and 46% during the dry and wet seasons, respectively, while 1 m (level 2) was the least preferred height at 7 and 4% during the dry and wet season, respectively. Browsing at heights greater than 4 meters (level 6) was second least preferred and decreased by 5% during the wet season than dry season while foraging at 2 and 3 meters (level 3 and level 4) increased by 6% during the wet season (9% to 15%) and 5% (25% to 30%), respectively.

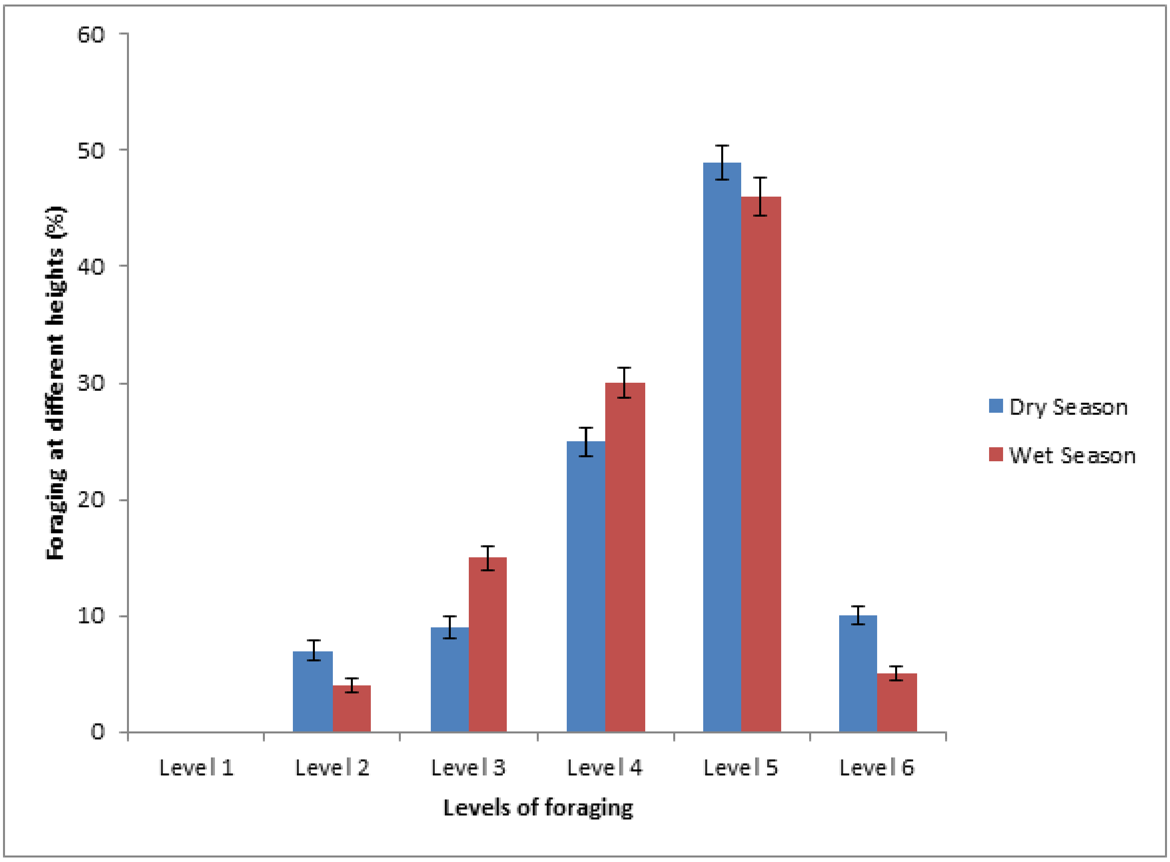


Figure 9: Giraffes' percentage preference of foraging at different heights in dry and wet seasons

Figure 10 below shows the relative preference of various browse species at different foraging heights and during the dry and wet seasons.

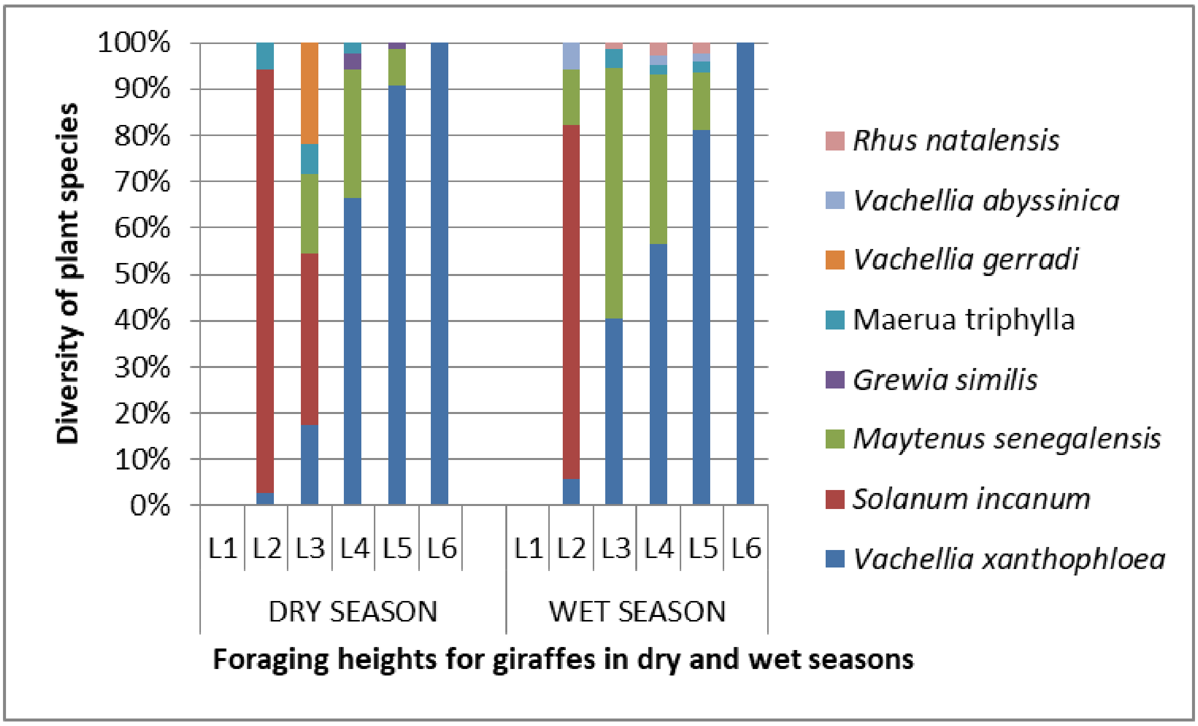


Figure 10: Browse species preference in relation to foraging heights in dry and wet seasons

Solanum incanum was the most browsed plant species at 1 meter (level 2) browsing height, while *Vachellia xanthophloea* was the only browsed species at level 6 foraging height. The highest number of plant species foraged during both seasons was recorded between levels 2 and 3. Around level 3 (2 m) foraging height, *Vachellia xanthophloea*, *Solanum incanum*, *Maytenus senegalensis*, *Maerua triphylla*, and *Vachellia gerrardii* were the most dominant species. The number of species foraged at this height, however, decreased as foraging height increased in both seasons. During the wet season, an increase in foraging heights from 1 m to 3.5 m (level 2 to level 5) led to an increase in the number of plant species that giraffes browsed, from 4 to 5 species. Between levels 4 and 5, *Vachellia xanthophloea*, *Maytenus senegalensis*, *Maerua triphylla*, *Vachellia abyssinica*, and *Rhus natalensis* were the most dominant forage species.

CHAPTER 5: DISCUSSION

5.1 Rothschild's giraffes' diurnal activity time budget during the dry and wet season in Lake Nakuru National Park

The results of this study support the hypothesis that seasons did not affect tdiurnal activity time budget of Rothschild's giraffes in Lake Nakuru National Park. Foraging was the principal activity for the giraffes followed by movement, and resting while drinking water took the shortest time in both seasons. Giraffes spend most of their time foraging, as observed in the current and other previous studies across Africa (Blomqvist and Renberg, 2007; Deacon, 2015; Jeugd and Prins, 2000; Mahenya et al., 2016; Obari, 2009). However, in Nairobi National Park, giraffes spend more time feeding (78%) (Obari, 2009) as opposed to 55% in this study. This is an indication that food shortage is a problem giraffes are facing in LNNP. Giraffes, like other animals, strive to balance between spending a long time (using more energy) searching for high-quality forage plant species or allocating short time (using less energy) to readily available forage species that are of low quality which are two contrasting strategies (Martin and Hine, 2015). The higher percentage time allocation on foraging during the wet season than to dry season could be because the dry season is not only characterized by scarcity of available forage and high temperatures but also the low quality of forage, which has low digestibility (Dagg, 2014; Fennessy, 2004). During the dry season the temperature of the study area ranged between 18-19^{0}C in the morning hours and 26-30^{0}C in the afternoon hours, while during the wet season temperatures in the morning hours ranged between 14-18^{0}C and in the afternoon hours 17-24^{0}C. Giraffes allocate more time to move during the dry season when high-quality forage is scarce, in search of patches with high-quality forage. During periods, when temperatures are high, animals reduce foraging time to avoid overheating (Owen-Smith, 2008). This reduces foraging time in this season. This is also supported by the fact that giraffes foraged for longer periods in the morning and evening, when temperatures are relatively low, just like average temperatures during the wet season. There is a strong negative relation between feeding time and temperature for ungulates (Belovsky, 1978).

Percentage time allocated to foraging during the dry season was highest in the morning and midmorning. The least foraging time was recorded in the afternoon. This scenario could be attributed to high temperatures in the afternoon that forced giraffes to reduce their foraging activities to save on high energy consumption during this period. Similar results were reported in Kenya by Adolfsson, (2009), in South Africa by Deacon, (2015), Obari, (2014), and in

Tanzania Pellew, (1984b). In Serengeti National Park Tanzania, the highest feeding records of giraffes were in the early morning and evening and least at noon (Pellew, 1984b). Obari, (2014) found out that giraffes spent the longest duration in foraging during early mornings and late afternoons (1500 hours). Adolfsson, (2009) in Maasai Mara Kenya recorded the peak foraging hours to be in the late afternoon (1530 hours) and morning hours and the shortest time recorded at noon. Deacon, (2015) indicated giraffes foraged more in the morning from 1100-1200 hours and in the afternoon from 1400-1500 hours. The observations by these researchers indicate that giraffes in other regions, just like those in LNNP prefer to forage in morning hours and the evening as a strategy to reduce energy loss from the high temperatures at noon (Adolfsson, 2009); (Deacon, 2015); (Obari, 2014); (Pellew, 1984b).

During the wet season, the shortest time allocated to feeding was recorded in the evening. In this season, the temperatures were generally low throughout the day, thus did not affect foraging in the afternoon. Continuous foraging throughout the day in the wet season led to low foraging time allocation in the evening, due to adequate forage consumption from the morning. The duration of time spent on foraging and other energy-consuming activities alongside browse choice are some of the behavioral factors involved in maintaining a positive energy balance essential to all mammals (Pellew, 1984a). Therefore, forage availability and quality are among the factors that affect giraffes' foraging time.

In both dry and wet seasons, movement and resting time remained relatively low throughout the day, except during the afternoon period of the dry season when resting was highest. In arid and semi-arid lands like LNNP, giraffes face a tradeoff between energy acquisition and conservation, which are primary goals for survival. During the dry season when forage was inadequate and patchily distributed, giraffes in LNNP spent more time moving around when temperatures were low searching for forage and resting when temperatures were high to conserve energy. These observations are similar to those made by Ciofolo and Le Pendu, (2002) and Mahenya, (2016). Reduced percentage time allocated to foraging and movement when temperatures are high alongside browse choice helps giraffes maintain a positive energy balance. This strategy sets an energy-saving mode for the giraffes and minimizes energy-consuming activities during periods when temperatures are high in favor of less energy-consuming activities such as standing, observations that are similar to those made by Adolfsson, (2009).

In both dry and wet seasons, giraffes foraged mainly on riverine *Vachelia xanthophloea* vegetation, which is succulent throughout, reducing the need to drink water. This observation is supported by their physiological adaptations that conserve water coupled with foraging on moisture-rich trees and shrubs (Fennessy, 2004). Similarly, Wyatt, (1969) observed that giraffes, especially in arid and semi-arid habitats, are water independent and obtain about 73.6% of their water needs from succulent browse, enabling them to go for a long time without drinking water. The results from this study are also similar to those made by Ciofolo and Le Pendu, (2002) in Niger and Obari, (2009) in Kenya. In all these studies, giraffes allocated less than 1% of their time to drinking water in the entire study period. During this study, water pans had completely dried up during the dry season with high levels of siltation. However, with water availability, giraffes have been observed to drink water freely, mainly in the dry seasons when the forage has low water content (Gaylard et al., 2003).

5.2 Rothschild's giraffes' diurnal activity time budget in different habitat types

Giraffes preferred to forage mostly in the acacia woodland during the dry and wet seasons and more so in the morning and mid-morning hours. Preference for this habitat was attributed to the high availability of the preferred forage species mainly *Vachellia xanthophloea* and secondly, giraffes actively forage during this period. In congruence with observations by Deacon and Smit, (2017) abundance of the principal forage species influences the percentage of time spent by giraffes in the different vegetation types. Giraffes spend most of their afternoon hours in the acacia woodland. Acacia woodlands are characterized by tall *Vachellia xanthophloea* trees that provide shade from the large canopy during the afternoon when temperatures are extremely high, while bushed woodland and open grasslands have few tall trees. Complete avoidance of bushed woodland in the afternoon hours of the dry season when temperatures were high can partially be attributed to the lack of ample shade for giraffes. The bushed woodland habitat is characterized by fewer *Vachellia xanthophloea* trees with large canopies to provide shade compared to the other habitat types. Similar results were made by Valeix et al., (2008), where giraffes in Hangwe National Park avoided areas with minimal shade in hotter periods of the day when solar radiations were at the maximum. Further, other herbivores, just like the giraffes were also observed to move to more open areas when wind intensity was higher for evapotranspiration-related heat loss (Valeix et al., 2008).

Open grasslands make it easy for giraffes to spot predators, hence the observed high preference of this habitat type during evening hours of the dry season. This behavior by giraffes along with other herbivores reduces the probability of predation. For instance, Valeix et al., (2009) and Owen-Smith, (2008) noted that giraffes and other herbivores moved to more open habitats when the risk of predation was high, e.g. the presence of lions in their vicinity.

Preference for acacia woodland in all the time sessions during the wet season could be an indicator that the other two habitats were used preferably to compensate for forage deficiencies. Deacon and Smit, (2017) also observed similar behavior by giraffes, whereby they preferred *Senegalia mellifera* and *Vachellia erioloba* woodland, which best met their daily preference. Giraffes in other regions have been observed to utilize different habitat types due to variations in resource availability (Frost, 1996; Leuthold and Leuthold, 1978; Saito and Idani, 2020). Animals deal with the inadequacy of high-quality plant species by moving from one habitat to the other (Frost, 1996). For instance, giraffes in Tsavo East National Park preferred habitats near rivers during the dry season and used deciduous woodlands in the rainy season (Leuthold and Leuthold, 1978). In Tanzania, giraffes were reported to move to Miombo woodland for resting after long foraging hours in the wooded grassland (Saito and Idani, 2020).

The northern part of the park was avoided by giraffes. Giraffes, just like other animals, select a habitat as an outcome of their characteristics (including movement, growth, reproduction), the landscape they inhabit, and the interactions among the animals and the habitat (Beest et al., 2016; Godvik et al., 2009; Thurfjell et al., 2017). The activity time budget of animals and their home range can be affected by the resources available including the presence of competitors, risk of predation among other factors (Knüsel et al., 2019; van Beest et al., 2011). In this study area, the northern part of the park is characterized by a cliff, which makes it difficult for the giraffes to utilize the area. This is escalated by the increased water levels of Lake Nakuru that have reduced the habitat available for giraffes in this part of the park. The narrow strip of the habitat left also increases giraffes' vulnerability to predation hence a likelihood of being avoided.

5.3 Rothschild's giraffes' forage species preference in dry and wet seasons

The results of forage species preference of giraffes explained here present a more general understanding of seasonal variation in forage preference in relation to availability in LNNP. It does not explain the foraging choices of giraffes in relation to availability, digestibility or nutrient value. The results of this study did not entirely support the hypothesis that Rothschild's giraffes' foraging habits vary significantly between the dry and wet seasons, as there was no significant difference in preference of *Acacia xanthophloea*, *Solanum incanum* and *Maerua triphylla* in dry and wet season. Giraffes browsed on eight species, with *Vachellia xanthophloea* (Vx*)* being the most preferred, followed by *Maytenus senegalensis* (Ms), *Solanum incanum* (Si), *Maerua triphylla* (Mt), *Grewia similis* (Gs), *Vachellia gerrardii* (Vg), *Vachellia abyssinica* (Va) and *Rhus natalensis* (Rn) in reducing preference. They did not only forage on leaves of *Vachellia xanthophloea* but also the barks causing debarking, an indication of the high preference of this species. These results are congruent with observations from other studies that reported acacia species to be the most browsed species by giraffes in different regions. For instance, Obari, (2009) observed that Acacia and Combretum plant species were preferred by giraffes, with the order of preference from the most preferred being *Vachellia drepanolobium*, *Vachellia xanthophloea*, *Vachellia gerrardii*, *Vachellia hockii*, *Cordia monoica* (Roxb.), *Senegalia mellifera,* and *Hibiscus micranthus* ((Franch.) Hochr.. Mahenya et al., (2016) reported that *Vachellia xanthophloea* made up to 75% of the giraffes' diet. Munyaka and Gandiwa, (2018) observed that giraffes mostly preferred *Vachellia karroo*. Williams and Williams, (2018) reported that *Vachellia gerrardii* was the most preferred species, followed by *Vachellia sieberiana* ((DC.) Kyal. and Boatwr., *Rhus natalensis, Vachellia hockii,* and *Senegalia polyacantha* (Willd.) Seigler and Ebinger, Phytologia being least preferred. Gordon et al., (2016) reported that *Vachellia karroo* was browsed significantly more than *Schotia afra* and *Euclea undulate* by giraffes. O'Connor et al., (2015) observed that the food species with highest number of feeding observations for giraffes were *Senegalia mellifera, Vachellia drepanolobium, Vachellia etbaica,* and *Boscia albitrunca.*

Deacon, (2015) observed that the order of plant species preference for giraffes in the Kalahari region of South Africa was *Vachellia erioloba*, *Senegalia mellifera*, *Ziziphus mucronata,* and *Boscia albitrunca* in order of reducing preference. Milewski and Madden, (2006) recorded that giraffes in Game Ranching Limited in Kenya spent the longest period feeding on *Vachellia drepanolobium*, *Vachellia seyal,* and *Balanites glabra*. Viljoen, (2013) reported that 80% of the diet of giraffes consists of *Vachellia haematoxylon*. Acacia species were seen to have the most nutritive value among 14 woody species in Zambezi National Park in Zimbabwe, with high In Vitro Gas Production (IVGP), low Acid Detergent Fiber (ADF), and low Condensed Tannin (CT) concentration hence preferred by giraffes (Mandinyenya et al., 2019). All these observations confirm the results from this study with regards to the high preference of acacia species by giraffes. Excessive preference for *Vachellia xanthophloea* by giraffes in LNNP was also seen from the debarking of the species which threatens the plant species, ecosystem, and the herbivores that utilize it. This is now made worse by the increasing water levels of Lake Nakuru which have also submerged a part of the habitat occupied by the *Vachellia xanthophloea* species. This is a threat to giraffes in this park since they cannot move to other regions as it is enclosed.

Contradictory results from Berry and Bercovitch, (2017) showed that giraffes' most frequently eaten species were *Sesbania greenwayi* (J.B.Gillett), *Capparis tomentosa* (Lam.), *Combretum obovatum* (F.Hoffm.), and *Trichilia emetic* (Forssk.) Vahl). Nevertheless, Vachellia species including *Vachellia gerrardii, Vachellia sieberiana, Vachellia kirkii* (Oliv.) Kyal. and Boatwr., *Senegalia nigrescens,* and *Vachellia tortilis* were available in the giraffes' habitat in their study. Blomqvist and Renberg, (2007) observed that species such as *Spirostachys Africana* (Sond., Linnaea.), *Combretum imberbe, Peltophorum africanum* (Sond.), and *Ziziphus mucronata* are among giraffes' most preferred species in different habitats. *Vachellia tortilis* and *Senegalia erubescen*s (Welw. ex Oliv.) Kyal. and Boatwr were present in the giraffes' diet though in an insignificant percentage. These differences are mainly attributed to regional differences with different vegetation types and woody species. These points to the value of site specific forage preference data to inform management of giraffes in different localities.

Solanum incanum, was the third-most preferred species in the park despite being an invasive species. This shrub is considered a bush encroacher, toxic to livestock, a major threat to grazing, and a threat to native vegetation (Lusweti et al., 2011). This species' inclusion and preference could be a pointer that the woody species that form giraffes' diet in the park may be lacking important minerals and nutrients required by giraffes for survival. Other invasive/alien species that have been foraged by giraffes are *Tamarix ramosissima* (Kar. ex Boiss., Fl. Orient.), and *Atriplex nummularia* (Aellen, Bot. Jahrb. Syst.) in Little Karoo, South Africa (Gordon et al., 2016) and *Lantana camara* (Moldenke.) in Nairobi National Park (Obari, 2009). Foraging on the invasive species is a pointer to the possible positive impacts these species can have on the environment and wildlife species too, observations that were also made by Chapman, (2016). Similarly, Bonanno, (2016) reported that invasive species' potential benefits are unreported and that removing them indiscriminately may not be a suitable management action.

The transition from dry to wet season informed plant species preference and diversity in giraffes' diet. Some plant species such as *Grewia similis* and *Vachellia gerrardii* were preferred in the dry season only while *Rhus natalensis* and *Vachellia abyssinica* were preferred in the wet season only. This could indicate two possibilities, i.e., seasonal variations in palatability of plant species, whereby *Rhus natalensis* and *Vachellia abyssinica* were less palatable during the dry season hence did not make to be part of giraffes' diet, or that, giraffes fed on *Grewia similis* and *Vachellia gerrardii* due to inadequacy of the preferred species during the dry season. Therefore, the seasonal difference in the types of forage plant species in giraffes' diet was associated with differences in palatability, quality, and quantity of woody species in the study area. Preference of *Vachellia xanthophloea* as a browse species remained high in the dry and wet seasons, as the leaves remain green in both seasons because of its drought stress-resistant abilities. These results concur with those made by Oba et al., (2001). *Vachellia xanthophloea* is a riverine tree species; hence it remains green even in the dry season. Preference for *Maerua triphylla* remained more or less the same in the dry and wet season while preference for *Maytenus senegalensis* increased from dry to the wet season. This can be explained by the fact that *Maytenus senegalensis* is deciduous, thus reducing the amount of available browse for giraffes during the dry season, while it produces new leaves and flowers on the onset of rain (Dziba et al., 2003; Singh and Kushwaha, 2016). *Maerua triphylla* is a riverine plant species and is also known to occur in evergreen or deciduous woodland, making forage available in both dry and wet seasons (Mbuvi et al., 2019).

The increase in plant species' preference from dry season to wet season observed in this study is similar to previous studies elsewhere. For example, Parker and Bernard, (2005) observed a preference for deciduous plant species, *Vachellia karroo* in the wet season and an increased preference for evergreen species such as *Rhus longispina* in the dry season. Berry and Bercovitch, (2017) observed differences in plant species preference with the season, whereby in the dry season *Kigelia africana, Capparis tomentosa,* and *Trichelia emetica* (Vahl.) were most preferred, *Sesbania greenwayi, Combretum obovatum,* and *Markhamia zanzibarica* (Bojer ex DC.) K. Schum) were preferred in the wet season. Deacon, (2015) reported that in summer and autumn most preferred species were *Vachellia erioloba, Senegalia mellifera,* and *Ziziphus mucronata*, while in winter and spring, preference for *Boscia albitrunca* increased although, *Vachellia erioloba, Ziziphus mucronata,* and *Senegalia mellifera* had higher preference ratio in Kalahari region of South Africa. Seasonality affects forage availability as the phenology of different woody species varies with the season (Dziba et al., 2003). As observed in this and other similar studies, Parker and Bernard, (2005), giraffes tend to feed on evergreen woody species in the riverine vegetation during dry seasons when deciduous plants lose their leaves.

5.4 Preferred foraging heights for giraffes

In both seasons, giraffes preferred to forage at the height of 3.5 m from the ground, (level 5), while 1m (level 2) was the least preferred. This feeding separation reduces competition for forage with other browsers in all seasons. A decrease in foraging at level 6 (greater than 4 meters) from dry to wet season was also observed. This could be associated with the increased growth of new shoots and leaves at lower levels after rains. Further, the increase in foraging at levels of 2 and 3 (1 and 2 m from the ground) from dry to the wet season could also be associated with the new shoots' growth from the diverse plant species found at these levels. The most preferred foraging height was between 1.7 and 3.7 meters, which is the average body height of an adult giraffe. These heights are also comfortable for the forelegs. This is also confirmed by the high diversity of plant species giraffes browse at 2m (level 3) during the dry season (*Vachellia xanthophloea, Solanum incanum, Maytenus senegalensis*, *Maerua triphylla*, and *Vachellia gerrardii*) and level 4 and 5 (3 and 3.5 meters) in the wet season (*Vachellia xanthophloea, Maytenus senegalensis, Maerua triphylla, Vachellia abyssinica*, and *Rhus natalensis*). As shown in this study, strenuous feeding positions are avoided in the wet season when feed resources are plenty. Thus, the preference for foraging at levels above 4 meters declined from dry to the wet season, indicating that they forage at high levels as a means of niche separation and during periods of forage shortage.

These results further corroborate with other studies. For example, Blomqvist and Renberg, (2007) reported that over 80 % of the total browsing by giraffes was between 2 and 5 meters above the ground in Mokolodi Nature Reserve, Botswana. O'Connor et al., (2015) observed that the median individual average feeding height for giraffes was 2.93 meters. Woolnough and du Toit, (2001) observed that browsing of *Senegalia nigrescens* by giraffes had the highest browsing intensity at 2.5 meters. Similarly, Mahenya et al., (2016) observed that giraffes foraged at high levels where they only competed with themselves. These results indicate that competition between giraffes and other browsers is minimal in all seasons, holding other factors constant, e.g., variability in rainfall amounts.

Some other studies however, have reported different results; for instance, giraffes were observed to prefer feeding about or above 5 meters by Obari, (2009) in Nairobi National Park.

In other studies feeding preference of below 2 meters was noted, e.g., Gordon et al., (2016) observed that giraffes regularly fed on plants below 1.5 m. The different observations could be attributed to differences in vegetation types with variations in species composition of different heights.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Acacia woodland is the most preferred habitat by Rothschild's giraffes in LNNP. This habitat is characterized by a high diversity of the preferred plant species. Among these are the *Vachellia xanthophloea* trees which provide forage and large canopies for shade in the afternoon in periods of extreme temperatures, contributing to giraffes spending more time in this habitat type.

Seasonal changes do not affect the diurnal activity time budget of giraffes in LNNP however; foraging is the principal activity in both dry and wet seasons. Foraging was however higher in the wet season compared to the dry season.

Temperatures influence the activity time budget of giraffes. They were more active when temperatures were low, specifically in the morning, mid-morning, and evening periods. In agreement with this, giraffes preferred to rest when temperatures were high.

Food shortage continues to be a challenge to giraffes in LNNP. The scarcity of forage species during the dry season made giraffes increase movement in the midmorning and evening as they searched for food. Giraffes in LNNP are water-independent and well adapted to survive in arid and semi-arid lands. This is however enhanced by their preference for riverine vegetation that remains succulent in all seasons.

The risk of predation also informs where giraffes forage. The tradeoff between acquiring forage and the risk of predation made giraffes spend the least time in bushed woodland habitats. This habitat type offers good vegetation cover for predators thus increasing vulnerability to predation.

Seasonal changes inform variation in plant species preference by giraffes. Plant species that remained evergreen were utilized throughout the year. Among these were *Vachellia xanthophloea*, *Solanum incanum*, *Maerua triphylla*, and *Maytenus senegalensis*. Out of the eight preferred plant species in LNNP, *Vachellia xanthophloea* ranked highest in preference in

both seasons. Giraffes fed on both leaves and bark of this species, an indication of the value of this species in contributing to their diet and survival in this park.
Solanum incanum was the third-most preferred browse species despite being an invasive species. The preference of this species in both seasons could indicate a possible deficiency of certain nutrients or minerals in woody species browsed on in LNNP. Generally, the seasonal difference in forage species preference was attributed to differences in their quantity and quality as influenced by phenological changes.

Giraffes' most preferred foraging height is 3.5 meters above the ground regardless of seasonal differences. This is not only the average height of an adult giraffe but also offers niche separation thus reducing competition from other herbivores. In periods of inadequate forage, giraffes browse more at levels above their body height, which seems strenuous. However, with the growth of new shoots and leaves at lower levels, they adjust the foraging heights to maximize the new growth.

6.2 Recommendation

Management and conservation actions on replanting woody species in the park should be done in the three habitats mostly used by giraffes. These should comprise the different types of plant species utilized by giraffes in the park. This will increase the variation and diversity of giraffes' forage plant species in the park to better fulfill their dietary needs during different seasons of the year. In addition, this will reduce the possible over browsing of Acacia woodland. The replanting efforts need to be augmented with active management of the bushed woodland to reduce the chances of predation while promoting more redistribution of giraffes in the park.

Long foraging hours in Acacia woodland could lead to its overexploitation. Since this habitat type is used to supplement water needs, distribution of more water pans and maintenance of the existing ones will ensure that water is available for giraffes throughout the year. This will promote even utilization of the various habitat types, and reduce overexploitation of acacia woodland, which serves to supplement the water needs of giraffes in the park.

Lake Nakuru's water levels have increased, submerging a significant portion (approximated at 2 kilometers) of the park, further reducing the size of habitat utilized by giraffes over time. This needs to be addressed to prevent further loss of their habitats. In the event this further threatens their survival in this park, and considering the species is critically endangered, translocation is a plausible option to protect them.

To increase the home range of the giraffes and further reduce the challenge of food shortage, there is a need to consider the possible positive impacts of *Solanum incanum* as a food resource of giraffes in the park, despite being an invasive species.

Areas for further studies;

1. The nocturnal activity time budget of Rothschild's giraffes in LNNP in different seasons,
2. Nutritional value of preferred forage species and the seasonal difference because the park lies in the nutrient-poor savannas,
3. Nutritional value of invasive species to herbivores, especially *Solanum incanum* that is preferred by giraffes, and
4. The reason why giraffes de-bark *Vachellia xanthophloea* despite being observed since 2002.

Challenges

Poor road networks in the park that made movement a challenge during the wet season.

Insufficient funds to conduct the field work for a long period of time.

REFERENCES

Adolfsson, U. G. (2009). *Diurnal Behaviour and Utilization of Shade in Masai Giraffes (Giraffa camelopardalis tippelskirchi)* [Thesis]. Swedish University of Agricultural Sciences.

Altmann, J. (1974). Observational Study of Behavior: Sampling Methods. *Behaviour*, *49*(3–4), 227–266. https://doi.org/10.1163/156853974X00534

Anderson, T. M., White, S., Davis, B., Erhardt, R., Palmer, M., Swanson, A., Kosmala, M., & Packer, C. (2016). The spatial distribution of African savannah herbivores: Species associations and habitat occupancy in a landscape context. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1703), 20150314. https://doi.org/10.1098/rstb.2015.0314

Beest, F. M. van, McLoughlin, P. D., Mysterud, A., & Brook, R. K. (2016). Functional responses in habitat selection are density dependent in a large herbivore. *Ecography*, *39*(6), 515–523. https://doi.org/10.1111/ecog.01339

Belovsky, G. E. (1978). Diet optimization in a generalist herbivore: The moose. *Theoretical Population Biology*, *14*(1), 105–134. https://doi.org/10.1016/0040-5809 (78)90007-2

Bercovitch, F. B., & Berry, P. S. M. (2010). Ecological determinants of herd size in the Thornicroft's giraffe of Zambia. *African Journal of Ecology*, *48*(4), 962–971. https://doi.org/10.1111/j.1365-2028.2009.01198.x

Berry, P. S., & Bercovitch, F. B. (2017). Seasonal and geographical influences on the feeding ecology of giraffes in the Luangwa Valley, Zambia: 1973–2014. *African Journal of Ecology*, *55*(1), 80–90.

Beyer, H. L., Haydon, D. T., Morales, J. M., Frair, J. L., Hebblewhite, M., Mitchell, M., & Matthiopoulos, J. (2010). The interpretation of habitat preference metrics under use–availability designs. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1550), 2245–2254. https://doi.org/10.1098/rstb.2010.0083

Blake, J. G., Mosquera, D., Loiselle, B. A., Swing, K., Guerra, J., & Romo, D. (2012). Temporal activity patterns of terrestial mammals in lowland Rainforest of Eastern Ecuador. *Ecotropica*, *18*, 137–146.

Blomqvist, P.-A., & Renberg, L. (2007). Feeding behaviour of Giraffe (Giraffa camelopardalis) in Mokolodi Nature Reserve, Botswana [Dissertation, Uppsala University]. http://files.webb.uu.se/uploader/858/MFS-128blomqvist-peranders-renberg-linda.pdf

Bonanno, G. (2016). Alien species: To remove or not to remove? That is the question. *Environmental Science & Policy*, *59*, 67–73. https://doi.org/10.1016/j.envsci.2016.02.011

Bookhout, T. A. (1996). *Research and management techniques for wildlife and habitat*. (5th ed.). Allen Press.

Borghi, C., Campos, C., Giannoni, S., Campos, V., & Sillero, Z. (2011). *Updated distribution of the pink fairy armadillo Chlamyphorus truncatus (Xenarthra, Dasypodidae), the world's smallest armadillo. Edentata*(12), 14–19.

Bothma, J. D. P., Van Rooyen, N., & Du Toit, J. G. (2010). Antelope and other smaller herbivores. In *Bothma J du P & Du Toit JG (eds.) Game ranch management* (5th Edition). Van Schaik Publishers.

Brand, R. (2007). *Evolutionary ecology of giraffes (Giraffa camelopardalis) in Etosha National Park, Namibia* [Thesis, Newcastle University]. http://theses-test.ncl.ac.uk:8080/jspui/handle/10443.1/1461

Brenneman, R. A., Bagine, R. K., Brown, D. M., Ndetei, R., & Louis, E. E. (2009). Implications of closed ecosystem conservation management: The decline of Rothschild's giraffe (Giraffa camelopardalis rothschildi) in Lake Nakuru National

Park, Kenya. *African Journal of Ecology*, *47*(4), 711–719. https://doi.org/10.1111/j.1365-2028.2008.01029.x

Cameron, E., & du Toit, J. (2005). Social influence on vigilance behaviour in giraffes, Giraffa Camelopardalis. *Animal Behaviour*, *69*, 1337–1344. https://doi.org/10.1016/j.anbehav.2004.08.015

Carnaby, T. (2006). *Beat about the Bush: Mammals*. Jacana Media.

Chapman, P. M. (2016). Benefits of Invasive Species. *Marine Pollution Bulletin*, *1*(107), 1–2. https://doi.org/10.1016/j.marpolbul.2016.04.067

Ciofolo, I., & Le Pendu, Y. (2002). The Feeding Behaviour of Giraffe in Niger. *Mammalia*, *66*, 183–194. https://doi.org/10.1515/mamm.2002.66.2.183

Croft, D. (2009). Necks and networks: A preliminary study of population structure in the reticulated giraffe (Giraffa camelopardalis reticulata de Winston). *African Journal of Ecology*, *47*, 374–381. https://doi.org/10.1111/j.1365-2028.2008.00984.x

Dagg, A. I. (2014). *Giraffe: Biology, behaviour and conservation*. Cambridge University Press.

Deacon, F. (2015). The spatial ecology, habitat preference and diet selection of giraffe (giraffa camelopardalis giraffa) in the Kalahari region of South Africa [Thesis, University of the Free State]. http://scholar.ufs.ac.za/xmlui/handle/11660/1205

Deacon, F., & Smit, N. (2017). Spatial ecology and habitat use of giraffe (Giraffa camelopardalis) in South Africa. *Basic and Applied Ecology*, *21*, 55–65. https://doi.org/10.1016/j.baae.2017.04.003

du Toit, J. T., & Yetman, C. A. (2005). Effects of body size on the diurnal activity budgets of African browsing ruminants. *Oecologia*, *143*(2), 317–325. https://doi.org/10.1007/s00442-004-1789-7

Dziba, L. E., Scogings, P. F., Gordon, I. J., & Raats, J. G. (2003). Effects of season and breed on browse species intake rates and diet selection by goats in the False Thornveld of the Eastern Cape, South Africa. *Small Ruminant Research*, *47*(1), 17–30. https://doi.org/10.1016/S0921-4488 (02)00235-3

Estes, R. (1991). *The behavior guide to African mammals: Including hoofed mammals, carnivores, and primates*. Berkeley : University of California Press. http://archive.org/details/isbn_0520080858

Fennessy, J. (2009). Home range and seasonal movements of Giraffa camelopardalis angolensis in the northern Namib Desert. *African Journal of Ecology*, *47*(3), 318–327. https://doi.org/10.1111/j.1365-2028.2008.00963.x

Fennessy, J., Bidon, T., Reuss, F., Kumar, V., Elkan, P., Nilsson, M., Vamberger, M., Fritz, U., & Janke, A. (2016). Multi-locus Analyses Reveal Four Giraffe Species Instead of One. *Current Biology*, *26*, 2543–2549. https://doi.org/10.1016/j.cub.2016.07.036

Fennessy, J., Castles, M., Dadone, L., Fennessy, S., Ferguson, S., Miller, M., Morkel, P., & Bower, V. (2019). *A Journey of Giraffe. A practical guide to wild giraffe translocations*. Giraffe Conservation Foundation.

Fennessy, J., Fennessy, S., & Muneza, A. (2016). *Framework-Strategy-Conservation-and-Management-of-Giraffe_August-2016.pdf*. https://giraffeconservation.org/wp-content/uploads/2016/09/Framework-Strategy-Conservation-and-Management-of-Giraffe_August-2016.pdf

Fennessy, J. T. (2004). Ecology of desert-dwelling giraffe Giraffa camelopardalis angolensis in northwestern Namibia [Thesis, University of Sydney]. https://ses.library.usyd.edu.au/handle/2123/910

Fennessy, S., Fennessy, J., Muller, Z., Brown, M., & Marais, A. (2018). *Giraffa camelopardalis ssp. Rothschildi. The IUCN Red List of Threatened Species 2018:* https://doi.org/e.T174469A51140829.

Fleming, P. A., Hofmeyr, S. D., Nicolson, S. W., & Toit, J. T. du. (2006). Are giraffes pollinators or flower predators of Acacia nigrescens in Kruger National Park, South Africa? *Journal of Tropical Ecology*, *22*(3), 247–253. https://doi.org/10.1017/S0266467405003123

Ford, A. T., Goheen, J. R., Otieno, T. O., Bidner, L., Isbell, L. A., Palmer, T. M., Ward, D., Woodroffe, R., & Pringle, R. M. (2014). *Large carnivores make savanna tree communities less thorny*. 5.

Frost, P. (1996). *The Ecology of Miombo Woodlands*. 48.

Furstenburg, D. (2003). *Kameelperd, Giraffa camelopardalis*. 8–13.

Gandiwa, E., & Zisadza, P. (2010). Wildlife Management in Gonarezhou National Park, South-East Zimbabwe: Climate change and Implications of Management. *25*(1), 101–110.

Gaylard, A., Owen-Smith, N., & Jessica, R. (2003). Surface water availability: Implications for Heterogeinity and Ecosystem Processes. In *The Kruger Experience: Ecology And Management Of Savanna Heterogeneity*. Island Press.

Godvik, I. M. R., Loe, L. E., Vik, J. O., Veiberg, V., Langvatn, R., & Mysterud, A. (2009). Temporal scales, trade-offs, and functional responses in red deer habitat selection. *Ecology*, *90*(3), 699–710. https://doi.org/10.1890/08-0576.1

Gordon, C., Eichenberger, L., Vorster, P., Leslie, A., & Jacobs, S. (2016). Diet and seasonal dispersal of extralimital giraffe at Sanbona Wildlife Reserve, Little Karoo, South Africa. *Koedoe*, *58*. https://doi.org/10.4102/koedoe.v58i1.1346

Hamel, S., & Côté, S. D. (2008). Trade-offs in activity budget in an alpine ungulate: Contrasting lactating and nonlactating females. *Animal Behaviour*, *75*(1), 217–227. https://doi.org/10.1016/j.anbehav.2007.04.028

Hopcraft, J. G. C., Juan, M., Bever, H., Makus, B., & Ephraim, M. (2014). Competition, Predation and migration: Individual choice patterns of Serengeti Migrants captured by hierchical models. 84(3), 353–372.

Jeugd, H. P. van der, & Prins, H. H. T. (2000). Movements and group structure of giraffe (Giraffa camelopardalis) in Lake Manyara National Park, Tanzania. *Journal of Zoology*, *251*(1), 15–21. https://doi.org/10.1017/S0952836900005033

Johnson, D. H. (1980). The Comparison of Usage and Availability Measurements for Evaluating Resource Preference. *Ecology*, *61*(1), 65–71. https://doi.org/10.2307/1937156

Jolly, L. (2003). *Husbandry manual Giraffe.pdf*. http://www.australasianzookeeping.org/Husbandry%20Manuals/Husbandry%20manual%20Giraffe.pdf

Kimuyu, D. M., Kenfack, D., Musili, P. M., & Ang'ila, R. O. (2021). Fine-scale habitat heterogeneity influences browsing damage by elephant and giraffe. *Biotropica*, *53*(1), 86–96. https://doi.org/10.1111/btp.12848

Knüsel, M. A., Lee, D. E., König, B., & Bond, M. L. (2019). Correlates of home range sizes of giraffes, Giraffa camelopardalis. *Animal Behaviour*, *149*, 143–151. https://doi.org/10.1016/j.anbehav.2019.01.017

KWS, K. W. S. (2002). The Status of Rothschild's Giraffes (Giraffa camelopardalis rothschildi) in Lake Nakuru National Park. [Technical Report]. Kenya Wildlife Service, Nairobi, Kenya.

KWS, K. W. S. (2010). Lake Nakuru National Park.

KWS, K. W. S. (2011). Kenya Wildlife Service Lake Nakuru National Park Integrated Management Plan. Unpublished.

Kyalangalilwa, B., Boatwright, J. S., Daru, B. H., Maurin, O., & van der Bank, M. (2013). Phylogenetic position and revised classification of Acacia s.l. (Fabaceae:

Mimosoideae) in Africa, including new combinations in Vachellia and Senegalia. *Botanical Journal of the Linnean Society*, *172*(4), 500–523.
Leuthold, B. M., & Leuthold, W. (1978). Ecology of the giraffe in Tsavo East National Park, Kenya. *African Journal of Ecology*, *16*(1), 1–20. https://doi.org/10.1111/j.1365-2028.1978.tb00419.x
Lusweti, A., Wabuyele, E., Ssegawa, P., & Mauremootoo, J. R. (2011). Invasive plants of East Africa (Kenya, Uganda and Tanzania) (3.5 Key and Key Sheets Lucid v.). Makerere University. keys.lucidcentral.org/keys/v3/EAFRINET
Mahenya, O. (2016). *Browsing by giraffe in heterogenous savanna* [Dissertation]. Inland Norway University of Applied Sciences.
Mahenya, O., Mathisen, K. M., Andreassen, H. P., & Skarpe, C. (2016). Hierarchical foraging by giraffe in a heterogeneous savannah, Tanzania. *African Journal of Ecology*, *54*(2), 136–145. https://doi.org/10.1111/aje.12270
Mandinyenya, B., Monks, N., Mundy, P. J., Sebata, A., & Chirima, A. (2019). Habitat use by giraffe and greater kudu in the Zambezi National Park, Zimbabwe. *African Journal of Ecology*, *57*(2), 286–289.
Martin, E. M., & Hine, R. H. (2015). Optimal foraging theory. In E. Martin & R. Hine (Eds.), *A Dictionary of Biology*. Oxford University Press. https://www.oxfordreference.com/view/10.1093/acref/9780198714378.001.0001/acref-9780198714378-e-3109
Mbuvi, M. T. E., Kungu, J. B., Gachathi, F. N., Leley, C. W. N., & Muthini, J. M. (2019). Annonated checklist of plant species of Loita Forest (Entim e Naimina Enkiyio Forest or the forest of the lost child), Narok County, Kenya. *Int. J. Adv. Res. Biol. Sci*, *6*(3), 54–110.
McClanahan, Y., Young, A. P. at the L. C. C. T. P., Young, T. P., & McClanahan, S. C. Z. T. (1996). *East African Ecosystems and Their Conservation*. Oxford University Press.
Milewski, A. V., & Madden, D. (2006). Interactions between large African browsers and thorny Acacia on a wildlife ranch in Kenya. *African Journal of Ecology*, *44*(4), 515–522. https://doi.org/10.1111/j.1365-2028.2006.00665.x
Muller, Z. (2018). Population structure of giraffes is affected by management in the Great Rift Valley, Kenya. *PLoS ONE*, *13*(1). https://doi.org/10.1371/journal.pone.0189678
Muller, Z. (2019). Rothschild's giraffe Giraffa camelopardalis rothschildi (Linnaeus, 1758) in East Africa: A review of population trends, taxonomy and conservation status. *African Journal of Ecology*, *57*(1), 20–30. https://doi.org/10.1111/aje.12578
Muller, Z., Bercovitch, F. B., Brand, R., Brown, M. B., Brown, D., Bolger, D. T., Carter, K., Deacon, F., Doherty, J. B., Fennessy, J., Fennessy, S., Hussein, A., Lee, D. E., Marrais, A., Strauss, M., Tutchings, A., & Wube t. (2016). *The IUCN Red List of Threatened Species*. IUCN Red List of Threatened Species. https://www.iucnredlist.org/en
Muller, Z., Bercovitch, F., Brand, R., Brown, D., Brown, M., & Bolger, D. (2018). Giraffa camelopardalis (amended version of 2016 assessment). The IUCN Red List of Threatened Species. https ://doi. org/10.2305/iucn.uk.2016-3.rlts.t9194 a1362 66699.en.
Muller, Z., Cuthill, I. C., & Harris, S. (2019). Giraffe (Giraffa camelopardalis) social networks in areas of contrasting human activity and lion density. *Ethology*, *125*(10), 702–715. https://doi.org/10.1111/eth.12923
Munyaka, T. V., & Gandiwa, E. (2018). An Assessment of Forage Selection by Giraffe Introduced into Umfurudzi Park, Northern Zimbabwe [Research Article]. *Scientifica*. https://doi.org/10.1155/2018/9062868

Mutangah, J. G. (1994). The vegetation of Lake Nakuru National Park, Kenya: A synopsis of the vegetation types with annotated species list. *Journal of East African Natural History*, *83*(1), 71–96. https://doi.org/10.2982/0012-8317 (1994)83[71: TVOLNN] 2.0.CO; 2

Ng'weno, C. C., Mwasi, S. M., & Kairu, J. K. (2010). Distribution, density and impact of invasive plants in Lake Nakuru National Park, Kenya: Plant invasion in grasslands. *African Journal of Ecology*, *48*(4), 905–913. https://doi.org/10.1111/j.1365-2028.2009.01191.x

Norris, D., Michalski, F., & Peres, C. A. (2010). Habitat patch size modulates terrestrial mammal activity patterns in Amazonian forest fragments. *Journal of Mammalogy*, *91*(3), 551–560. https://doi.org/10.1644/09-MAMM-A-199.1

Oba, G., Nordal, I., Stenseth, N. C., Stave, J., Bjorå, C. S., Muthondeki, J. K., & Bii, W. K. A. (2001). Growth performance of exotic and indigenous tree species in saline soils in Turkana, Kenya. *Journal of Arid Environments*, *47*(4), 499–511. https://doi.org/10.1006/jare.2000.0734

Obari, T. (2014). Population ecology of Maasai giraffe (Giraffa camelopardalis tippelskirchi) in relation to climate variability in southern Kenya [Dissertation]. University of Nairobi.

Obari, T. O. (2009). Factors affecting habitat use by Masai giraffe (Giraffa camelopardalis tippelskirchi L) in Athi-Kapiti plains ecosystems, Kenya [Thesis]. University of Nairobi.

O'Connor, D. A., Butt, B., & Foufopoulos, J. B. (2015). Foraging ecologies of giraffe (Giraffa camelopardalis reticulata) and camels (Camelus dromedarius) in northern Kenya: Effects of habitat structure and possibilities for competition? *African Journal of Ecology*, *53*(2), 183–193.

O'Connor, D., Stacy-Dawes, J., Muneza, A., Fennessy, J., Gobush, K., Chase, M. J., Brown, M. B., Bracis, C., Elkan, P., Zaberirou, A. R. M., Rabeil, T., Rubenstein, D., Becker, M. S., Phillips, S., Stabach, J. A., Leimgruber, P., Glikman, J. A., Ruppert, K., Masiaine, S., & Mueller, T. (2019). Updated geographic range maps for giraffe, Giraffa spp., throughout sub-Saharan Africa, and implications of changing distributions for conservation. *Mammal Review*, *49*(4), 285–299. https://doi.org/10.1111/mam.12165

Ogutu, J. O., Kuloba, B., Piepho, H.-P., & Kanga, E. (2017). Wildlife Population Dynamics in Human-Dominated Landscapes under Community-Based Conservation: The Example of Nakuru Wildlife Conservancy, Kenya. *PLoS ONE*, *12*(1). https://doi.org/10.1371/journal.pone.0169730

O'Neil, T., Bettinger, K., Heyden, M., Marcot, B., Barrett, C., Mellen, T., Vander Haegen, M., Johnson, D., Doran, P., Wunder, L., & Boula, K. (2001). *Structural conditions and habitat elements of Oregon and Washington* (pp. 115–139).

Owen-Smith, N. (2008). Changing vulnerability to predation related to season and sex in an African ungulate assemblage. *Oikos*, *117*(4), 602–610. https://doi.org/10.1111/j.0030-1299.2008.16309.x

Owen-Smith, N. (2008). Effects of Temporal Variability in Resources on Foraging Behaviour. In H. H. T. Prins & F. Van Langevelde (Eds.), *Resource Ecology* (pp. 159–181). Springer Netherlands. https://doi.org/10.1007/978-1-4020-6850-8_14

Owen-Smith, N., Fryxell, J. M., & Merrill, E. H. (2010). Foraging theory upscaled: The behavioural ecology of herbivore movement. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1550), 2267–2278. https://doi.org/10.1098/rstb.2010.0095

Parker, D. M., & Bernard, R. T. F. (2005). The diet and ecological role of giraffe (Giraffa camelopardalis) introduced to the Eastern Cape, South Africa. *Journal of Zoology*, *267*(2), 203–210. https://doi.org/10.1017/S0952836905007399

Pellew, R. A. (1984a). Food Consumption and Energy Budgets of the Giraffe. *Journal of Applied Ecology*, *21*(1), 141–159. JSTOR. https://doi.org/10.2307/2403043

Pellew, R. A. (1984b). The feeding ecology of a selective browser, the giraffe (Giraffa camelopardalis tippelskirchi). *Journal of Zoology*, *202*(1), 57–81. https://doi.org/10.1111/j.1469-7998.1984.tb04288.x

Pettorelli, N., Gaillard, J.-M., Duncan, P., Maillard, D., Laere, G. V., & Delorme, D. (2003). Age and Density Modify the Effects of Habitat Quality on Survival and Movements of Roe Deer. *Ecology*, *84*(12), 3307–3316. https://doi.org/10.1890/02-0602

Saito, M., & Idani, G. (2020). Giraffe diurnal recumbent behavior and habitat utilization in Katavi National Park, Tanzania. *Journal of Zoology*, *312*(3), 183–192. https://doi.org/10.1111/jzo.12825

Seeber, P., Ciofolo, I., & Ganswindt, A. (2012). Behavioural inventory of the giraffe (Giraffa camelopardalis). *BMC Research Notes*, *5*, 1–8. https://doi.org/10.1186/1756-0500-5-650

Sembe, J. K. (2015). *Effects of the Rothschild giraffe on the biophysical and socio- economic environment: A case of Giraffe Center Sanctuary in Nairobi County* [THESI]. University of Nairobi.

Shi, J., Dunbar, R., Buckland, D., & Miller, D. (2003). *Daytime activity budgets of feral goats (Capra hircus) on the Isle of Rum: Influence of season, age, and sex. Canadian Journal of Zoology*. *81*, 803–815.

Shorrocks, B. (2016). *The Giraffe: Biology, Ecology, Evolution and Behaviour*. John Wiley & Sons.

Singh, K. P., & Kushwaha, C. P. (2016). Deciduousness in tropical trees and its potential as indicator of climate change: A review. *Ecological Indicators*, *69*, 699–706. https://doi.org/10.1016/j.ecolind.2016.04.011

Skarpe, C., Bergström, R., Bråten, A. L., & Danell, K. (2000). Browsing in a heterogeneons savanna. *Ecography*, *23*(5), 632–640. https://doi.org/10.1111/j.1600-0587.2000.tb00182.x

Starks, P. T. B., & Slabach, B. L. (2012). The Scoop on Eating Dirt. *Scientific American*, *306*(6), 30–32. https://doi.org/10.1038/scientificamerican0612-30

Staver, A., Archibald, S., & Levin, S. (2011). The Global Extent and Determinants of Savanna and Forest as Alternative Biome States. *Science (New York, N.Y.)*, *334*, 230–232. https://doi.org/10.1126/science.1210465

Theron, M. E. (2005). Voedingsgedrag van kameelperde (Giraffa camelopardalis) in die sentrale Vrystaat. http://scholar.ufs.ac.za/xmlui/handle/11660/1563

Thurfjell, H., Ciuti, S., & Boyce, M. S. (2017). Learning from the mistakes of others: How female elk (Cervus elaphus) adjust behaviour with age to avoid hunters. *PloS One*, *12*(6), e0178082.

Tobler, M. W., Carrillo-Percastegui, S. E., & Powell, G. (2009). Habitat use, activity patterns and use of mineral licks by five species of ungulate in south-eastern Peru. *Journal of Tropical Ecology*, *25*(3), 261–270. https://doi.org/10.1017/S0266467409005896

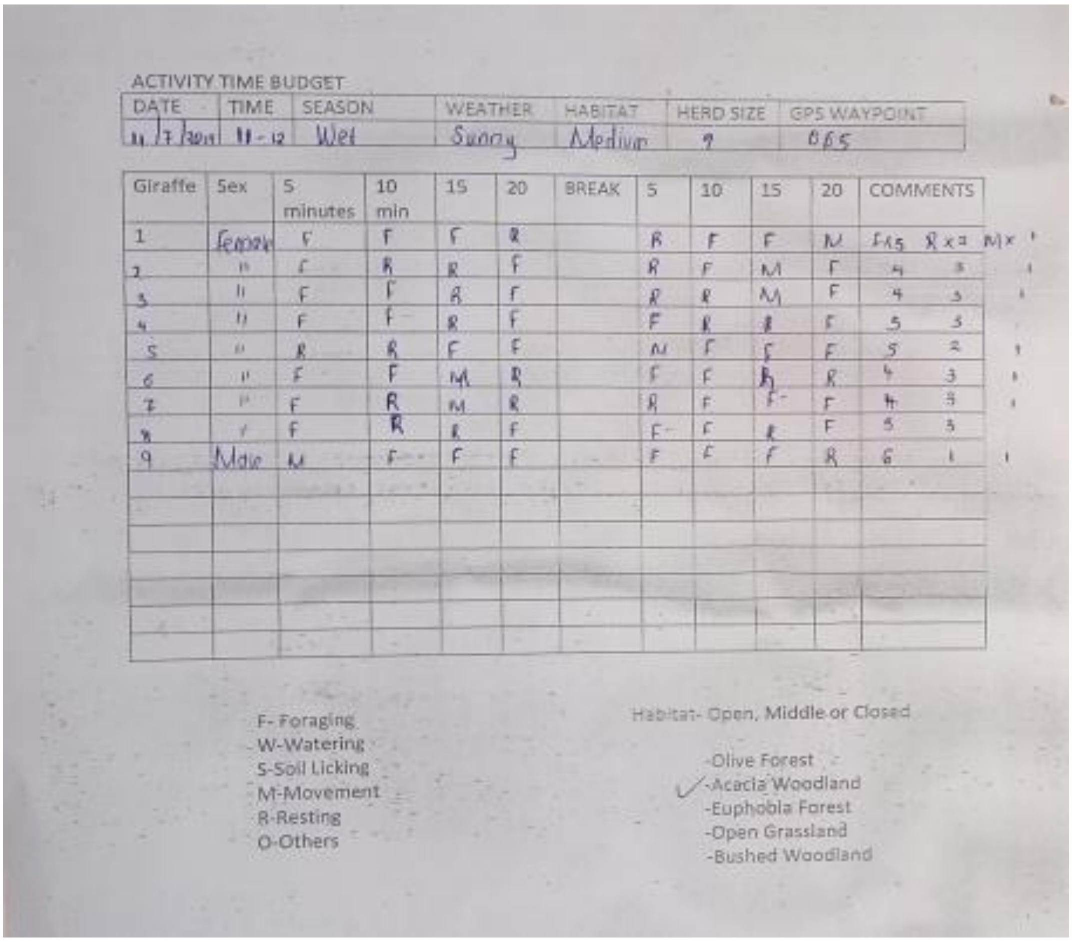
Umbertoh. (2007). Saving the Rothschild Giraffe from Extinction. AFEW Giraffe News, Issue No 9- 2007, pg 2. *AFEW Giraffe News*, *9*, 2.

UNESCO, U. W. H. C. (1999). *Lake Nakuru National Park*. UNESCO World Heritage Centre. https://whc.unesco.org/en/tentativelists/1344/

Valeix, M., Fritz, H., Loveridge, A. J., Davidson, Z., Hunt, J. E., Murindagomo, F., & Macdonald, D. W. (2009). Does the risk of encountering lions influence African

herbivore behaviour at waterholes? *Behavioral Ecology and Sociobiology*, *63*(10), 1483–1494. https://doi.org/10.1007/s00265-009-0760-3
Valeix, M., Fritz, H., Matsika, R., Matsvimbo, F., & Madzikanda, H. (2008). The role of water abundance, thermoregulation, perceived predation risk and interference competition in water access by African herbivores. *African Journal of Ecology*, *46*(3), 402–410. https://doi.org/10.1111/j.1365-2028.2007.00874.x
van Beest, F. M., Rivrud, I. M., Loe, L. E., Milner, J. M., & Mysterud, A. (2011). What determines variation in home range size across spatiotemporal scales in a large browsing herbivore? *Journal of Animal Ecology*, *80*(4), 771–785. https://doi.org/10.1111/j.1365-2656.2011.01829.x
Viljoen, S. (2013). Habitat use and diet preference of extralimital giraffes in the Kgalagadi Transfrontier Park. https://open.uct.ac.za/bitstream/handle/11427/14013/thesis_sci_2013_viljoen_giraffe_diet.pdf?sequence=1
WFO, W. F. O. (2022). The WFO Plant List | World Flora Online. https://wfoplantlist.org/plant-list
Williams, L., & Williams, L. A. (2018). The Rothschild's giraffe as a potential biological controller of invasive native Acacia species in Lake Mburo National Park, Uganda. https://nmbu.brage.unit.no/nmbu-xmlui/handle/11250/2565422
Winter, S., Fennessy, J., Fennessy, S., & Janke, A. (2018). Matrilineal population structure and distribution of the Angolan giraffe in the Namib Desert and beyond. *Ecological Genetics and Genomics*, *7–8*, 1–5. https://doi.org/10.1016/j.egg.2018.03.003
Woolnough, A., & du Toit, J. (2001). Vertical zonation of browse quality in tree canopies exposed to a size-structured guild of African browsing ungulates. *Oecologia*, *129*(4), 585–590. https://doi.org/10.1007/s004420100771
Wube, T., Doherty, J., Fennessy, J., & Marais, A. (2018). *Giraffa camelopardalis ssp. Camelopardalis. The IUCN Red List of Threatened Species. 2018:* https://doi.org/e.T88420707A88420710.
Wyatt, J. R. (1969). The feeding ecology of giraffe (giraffa camelopardalis linnaeus) in nairobi national park, and the effect of browsing on their main food plants. [Thesis, University of Nairobi]. http://erepository.uonbi.ac.ke/handle/11295/25719
Zar, J. H. (1996). Biostatistical Analysis, 3 edPrentice-Hall (3rd ed.). Pearson Education India.
Zisadza-Gandiwa, P., Parakasingwa, C., Mashapa, C., Muboko, N., & Gandiwa, E. (2013). Status of woody vegetation along riparian areas in Gonarezhou National Park, Zimbabwe. *Greener Journal of Agricultural Sciences*, *3*(7), 592–597. http://gjournals.org/GJAS

APPENDICES



ACTIVITY TIME BUDGET

DATE	TIME	SEASON	WEATHER	HABITAT	HERD SIZE	GPS WAYPOINT
11/7/2019	11-12	Wet	Sunny	Medium	9	065

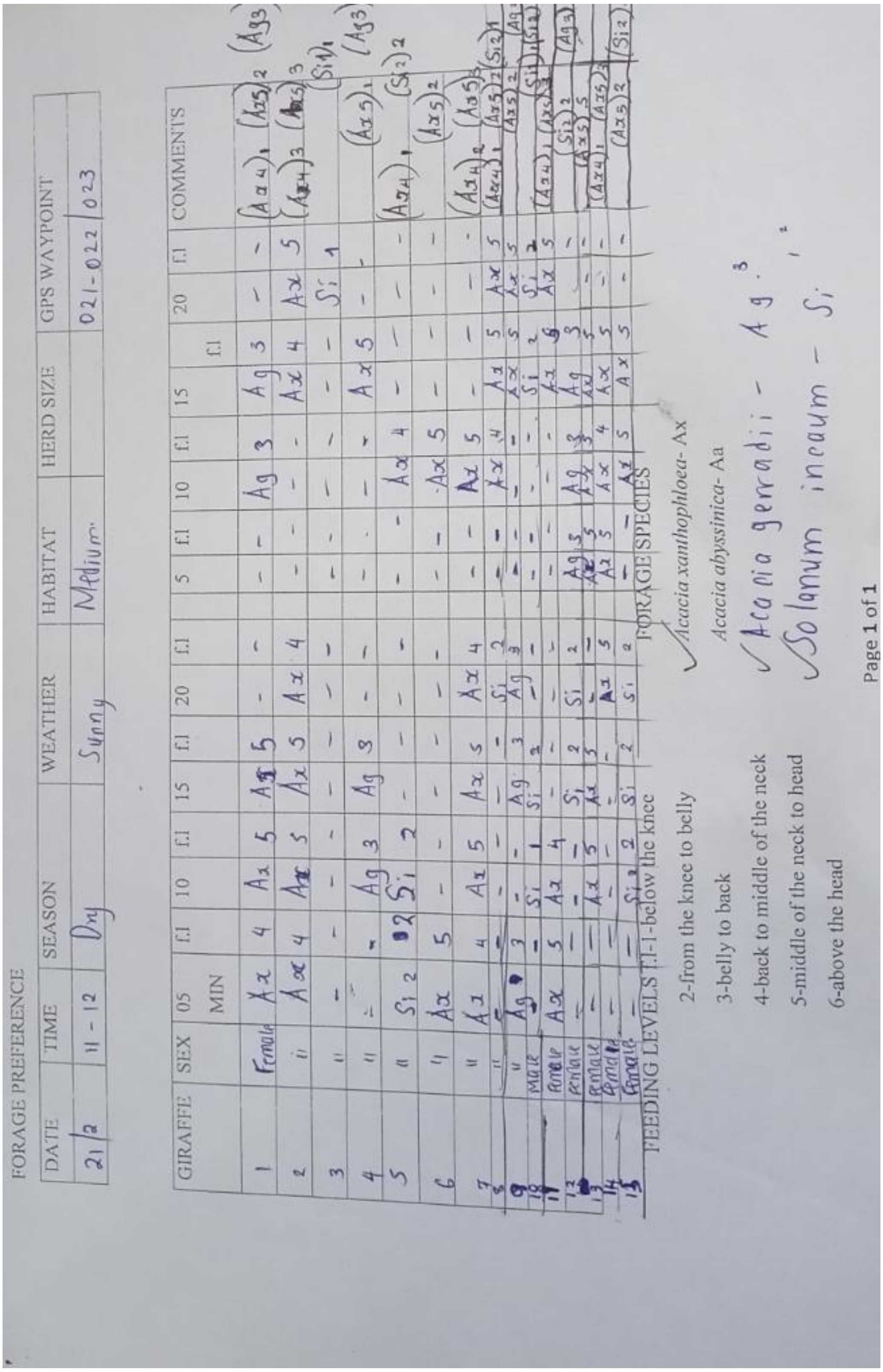
Giraffe	Sex	5 minutes	10 min	15	20	BREAK	5	10	15	20	COMMENTS
1	female	F	F	F	R		R	F	F	M	F×5 R×2 M×1
2	"	F	R	R	F		R	F	M	F	4 3 1
3	"	F	F	R	F		R	R	M	F	4 3 1
4	"	F	F	R	F		F	R	R	F	5 3
5	"	R	R	F	F		M	F	F	F	5 2 1
6	"	F	F	M	R		F	F	R	R	4 3 1
7	"	F	R	M	R		R	F	F	F	4 3 1
8	"	F	R	R	F		F	F	R	F	5 3
9	Male	M	F	F	F		F	F	F	R	6 1 1

F- Foraging
W-Watering
S-Soil Licking
M-Movement
R-Resting
O-Others

Habitat- Open, Middle or Closed

-Olive Forest
-Acacia Woodland
-Euphobia Forest
-Open Grassland
-Bushed Woodland

Appendix 1: Activity time budget data sheet



FORAGE PREFERENCE

DATE	TIME	SEASON	WEATHER	HABITAT	HERD SIZE	GPS WAYPOINT
21/2	11 - 12	Dry	Sunny	Medium		021-022/023

GIRAFFE	SEX	05 MIN	f.l	10	f.l	15	f.l	20	f.l		5	f.l	10	f.l	15	f.l	20	f.l	COMMENTS
1	Female	Ax	4	Ax	5	Ag	5	-	-		-	-	Ag	3	Ag	3	-	-	(Ax4)1 (Ax5)2 (Ag3)
2	"	Ax	4	Ax	5	Ax	5	Ax	4		-	-	-	-	Ax	4	Ax	5	(Ax4)3 (Ax5)3
3	"	-	-	-	-	-	-	-	-		-	-	-	-	-	-	Si	1	(Si1)1
4	"	-	-	Ag	3	Ag	3	-	-		-	-	-	-	Ax	5	-	-	(Ax5)1 (Ag3)
5	"	Si	2	Si	2	-	-	-	-		-	-	Ax	4	-	-	-	-	(Ax4)1 (Si2)2
6	"	Ax	5	-	-	-	-	-	-		-	-	Ax	5	-	-	-	-	(Ax5)2
7	"	Ax	4	Ax	5	Ax	5	Ax	4		-	-	Ax	5	-	-	-	-	(Ax4)2 (Ax5)3
8	"	-	-	-	-	-	-	Si	2		-	-	Ax	4	Ax	5	Ax	5	(Ax4)1 (Ax5)2 (Si2)1
9	"	Ag	3	-	-	Ag	3	Ag	3		-	-	-	-	Ax	5	Ax	5	(Ax5)2 (Ag3)
10	Male	-	-	Si	1	Si	2	-	-		-	-	-	-	Si	2	Si	2	(Si1)1 (Si2)
11	Female	Ax	5	Ax	4	-	-	-	-		-	-	-	-	Ax	6	Ax	5	(Ax4)1 (Ax5)3
12	Female	-	-	-	-	Si	2	Si	2		Ag	3	Ag	3	Ag	3	-	-	(Si2)2 (Ag3)
13	Female	-	-	Ax	5	Ax	5	-	-		Ax	5	Ax	3	Ax	5	-	-	(Ax5)5
14	Female	-	-	-	-	-	-	Ax	5		Ax	5	Ax	4	Ax	5	-	-	(Ax4)1 (Ax5)3
15	Female	-	-	Si	2	Si	2	Si	2		-	-	Ax	5	Ax	5	-	-	(Ax5)2 (Si2)

FEEDING LEVELS f.l-1-below the knee
2-from the knee to belly
3-belly to back
4-back to middle of the neck
5-middle of the neck to head
6-above the head

FORAGE SPECIES
✓ *Acacia xanthophloea*- Ax
Acacia abyssinica- Aa
✓ Acacia gerradii - Ag
✓ Solanum incaum - Si

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Appendix 2: Foraging patterns data sheet