ANALYSIS OF SEASONAL VARIATION IN DIETARY COMPOSITION AND BEHAVIOUR OF WILD CHACMA BABOONS (*PAPIO URSINUS*) IN TWO HABITATS OF DIFFERENT HUMAN INFLUENCE AROUND WINDHOEK, CENTRAL NAMIBIA

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ABSTRACT

Diet composition of an organism gives a holistic picture of what an organism forages on in its environment to maximize energy intake for all its essential activities that contribute to survival and successful reproduction. Chacma baboons have the ability to modify their broad omnivorous diet and behavior under changing environmental and climatic conditions. However, the ever-increasing environmental and anthropogenic pressures on baboon populations are likely to affect both the diet composition and foraging behavior of these animals. Moreover, Namibia being one of the driest countries in the Sub Saharan Africa, and coupled with accelerated anthropogenic changes, baboon populations, especially those thriving in and around the city of Windhoek are facing constant threats of habitat destruction and fragmentation due to the rapid expansion of the city and are under pressure to adapt to these changes in order to survive. With limited research carried out on primates in the central highlands of Namibia, this study was carried out in an effort to bridge the knowledge gap and obtain insight into the influence humans have on the ecology of these primates around the city of Windhoek. The study investigated the activity budget and diet of the baboons using data collected from two contrasting habitats (Dobra and farm Krumhuk) that are influenced by human activities. A total of 166 baboons were observed during 2 seasons (wet & dry) at two sites using a focal animal method. Forty-nine (49) scat samples were collected between the seasons, separated in the laboratory, weighed, and placed into four categories (fruits and seeds, roots, stems, and leaves, invertebrates, and others). Results showed that baboons consumed plant materials more than any other food type and that they maintained their diet profile across the seasons. Furthermore, their behavior was found to be reactional to seasonal changes. The study further confirmed the broad diet and selectivity that exists in the so-called “generalist diet” of these well-documented old-world monkeys while also providing an alternative method to enhance scat analysis techniques in the laboratory. The study noted that the human-disposed food waste, stable and constant water supply, preserved wild flora and minimal disturbance regimes around human settlements, all contribute to increased contact with humans.

Keywords: Activity budget, dry season, wet season, raiding

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LIST OF ABBREVIATIONS AND/ OR ACRONYMYS

%- percent

°C- degree Celsius

DAD - Dobra Afternoon Dry season

DAW- Dobra Afternoon Wet season

DD - Dobra dry season

DMD - Dobra Morning Dry season

DMW- Dobra Morning Wet season

DW- Dobra wet season

KAD - Krumhuk Afternoon Dry season

KAW - Krumhuk Afternoon Wet season

KD - Krumhuk dry season

KMD - Krumhuk Morning Dry season

KMW - Krumhuk Morning Wet season

KW – Krumhuk wet season

T - Test statistic

α - Alpha

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DEDICATIONS

This thesis is dedicated to my daughter, Mukuve Elizabeth Konkenda, for always giving me that extra motivation to see my studies through.

DECLARATIONS

I, Bernhard Mukuve, hereby declare that this study is my own work and is a true reflection of my research, and that this work, or any part thereof has not been submitted for a degree at any other institution.

I, Bernhard Mukuve, grant The University of Namibia the right to reproduce this thesis in whole or in part, in any manner or format, which The University of Namibia may deem fit.

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Name of Student	Signature	Date

CHAPTER 1: INTRODUCTION

1.1 Orientation of the study

Diet selection provides insights on how species maximize energy gain to enhance their survival (Harry, Carter, Rowcliffe, *et al.*, 2012). Generalists such as baboons (genus *Papio*) are constantly juggling how much time to spend consuming a particular food type because the length of time it takes individuals to forage and satisfy their daily nutritional needs is a critical component of their time budget (Marshall *et al.*, 2015). Among mammals, baboons (genus *Papio*) are one of the most generalist taxa: characterized by non-seasonal breeding, they are behaviorally, ecologically and socially flexible and occupy diverse habitats throughout sub-Saharan Africa (Dolotovskaya and Heymann, 2020; Patterson, Strum and Silk, 2021). Baboons' adaptive generality includes the capacity to combine a variety of plant foods in their diet to meet their nutritional and energy requirements as well as the ability to choose from a constantly shifting mosaic of options (Norton *et al.*, 1987). With intensifying changes in global climatic conditions activity budgets may shift as a direct coping mechanism to climatic stresses (e.g., thermoregulatory demands) or as an indirect response to food availability changes due to seasonality (Leith *et al.*, 2020; Chowdhury, Brown and Swedell, 2021). In colder seasons, some primates (Japanese macaques, *Macaca fuscata*) extend their feeding period, which likely helps them obtain energy for thermoregulation (Agetsuma and Nakagawa, 1998). As a way of coping with seasonal food shortages, changes in feeding and foraging periods, as well as the diet itself, may occur (Chowdhury, Brown and Swedell, 2021). Dry seasons may entail longer foraging periods, reducing time available for other crucial activities such as resting and socializing, thus imposing both ecological and social costs (Lambert and Rothman, 2015; Schreier, Schlaht and Swedell, 2019; Watts, 2020). However, variation is minimal throughout the year (DeVore and Hall, 1965). Studies on dietary composition have revealed that generalists such as baboons may still show high levels of selectivity by concentrating on specific parts of the plants to consume in order to maximize energy gains (Marshall *et al.*, 2015). For instance (Clymer, 2006) reported that younger and small sized baboons preferred eating fresher leaves that were found on the top most part of Protea shrubs as compared to larger bodied baboons that preferred older leaves found at the base of the plant as they have a higher carbohydrate to protein ratio. Furthermore, the status and rank of individuals in a troop may lead to variation their diet (Lewis and O'Riain, 2017). Generalized feeding behaviour gives baboons an advantage over more specialized animals when faced with environmental changes, including anthropogenic perturbations (DeVore and Hall, 1965). Nevertheless, such perturbations may place constraints even on this species, if resource availability and diversity falls to a level below which searching costs are too large to maintain intake requirement, or if nutritional value of available foods becomes too low (Agetsuma and Nakagawa, 1998; Garcia *et al.*, 2011; van Doorn and O'Riain, 2020; Chowdhury, Brown and Swedell, 2021).

1.2 Statement of the problem

The expansion of human settlements in central Namibia has caused notable habitat change, influencing natural food availability both in space and time, thus facilitating potential shifts in diet selection in opportunistic feeders like the chacma baboons (*Papio ursinus*) (Leith *et al.*, 2020). The increased contact with humans may lead to increased raiding of human settlements and thereby obtaining human-derived food which may potentially alter diet selection by chacma baboons (Kaplan *et al.*, 2011; Fehlmann *et al.*, 2017). This potential diet shift has not been investigated around the city of Windhoek, at a time when rural-urban migration has increased, thereby potentially leading to an increase in human baboon conflicts. Frequent drought periods further reduce availability of natural wild food for baboons. This has led to reported intense raiding of human settlements by baboons in search for food especially during the dry season in drought years. Hence the aim of the study was to investigate seasonality in dietary composition and activity budget of chacma baboons in two habitats that vary in the extent to which baboons raid these habitats around human settlements in central Namibia.

1.3 Research objectives

a) To determine and compare the diet composition of chacma baboons across the wet and dry season and between Dobra and Krumhuk.

b) To determine and compare the activity budget of chacma baboons across the wet and dry season and between Dobra and Krumhuk.

c) To determine and compare the raiding intensity of chacma baboons across the wet and dry season and between Dobra and Krumhuk.

1.4 Research hypotheses

a) There is no significant variation in the diet components consumed by chacma baboons across the wet and dry seasons at Dobra and Krumhuk.

b) Chacma baboons will display similar behavioral activities during the wet and dry season at Dobra and Krumhuk study sites.

c) There is no significant difference in the raiding intensity of chacma baboons across the wet and dry season at Dobra and Krumhuk.

1.5 Significance of the study

Presence of human-derived food (unnatural food source) in the diet and shifts in activity budget or behavioral patterns of chacma baboons will help explain the extent to which the ecology of the chacma baboons has been influenced by the human encroachment in their natural habitat. Furthermore, it could contribute to documenting the extent to which diet and activity budget of chacma baboon may shift seasonally. The information will facilitate management of the baboons to avert potential impacts of baboons as urban pests to city planners, the Ministry of Environment, Forestry and Tourism and researchers at large.

1.6 Limitation of the study

Identification of some food samples (from seeds only) to species level might be difficult due to limited taxonomic expertise and as well as food items that are completely digested.

CHAPTER 2: LITERATURE REVIEW

Semi-arid environments pose unique challenges for wildlife, influencing their diet and activity patterns (Brain, 1990). In Namibia, semi-arid baboons (*Papio* spp) are a significant primate species that adapt to these harsh conditions and may give some insight on how they cope with these conditions on a day to day basis (Hamilton and William, 1984, Brain, 1990). The distinction between generalists and specialists can be drawn in a variety of ways, including dietary breadth or diversity, degree of behavioral flexibility during foraging, and degree of over diet overlap with sympatric competitors, and baboons appear to be true generalists along almost any axis (Post, 1982). Baboons are known to consume relatively broad food types, with the primary diet composition consisting of fruits, leaves, and invertebrates that are consumed all year and peak in the summer months (Moolman and Breytenbach, 1973; Bronikowski and Altmann, 1996; Schreier, 2010). Moolman and Breytenbach (1973) described baboons to be 90% herbivorous, while DeVore and Hall, (1965) put them at 98% herbivorous in Kenya and 90% herbivorous in the Cape regions. They are known to eat 94 species of plants in the Cape Region and 180 species in Mikumi National Park, Tanzania (DeVore and Hall, 1965; Norton *et al.*, 1987). Insects are a very minor dietary item but given the opportunity can become a principle food source while meat eating is a learned behavior, being frequent is some groups and rare or lacking in others (DeVore and Hall, 1965). The most notable aspect of baboon diet is its eclecticism and variety; no edible plants parts seem to be left out, and it is almost easier to tally what they do not eat than to list the foods they do (DeVore and Hall, 1965). Baboons are selective feeders who seem to be optimizing their diet by choosing from a variety of available food in a constantly changing floral environment (Norton *et al.*, 1987). While characteristics that prevent the extraction of nutrients, such as fiber, phenolic content, and roughness of exterior surfaces, have been demonstrated to correlate negatively with food selection, protein concentration is frequently positively connected with food choice (Whiten *et al.*, 1991; Barton and Whiten, 1994). Compared to low land gorillas (*Gorilla gorilla gorilla*) or Malaysian leaf monkeys (*P. melalophos and P. rubicunda*), baboons have been reported to use food with a higher protein food content and lower fiber content as well as differences in condensed tannin levels (Barton *et al.*, 1993). Given the variation in nutrients, digestion inhibitors, toxins, and cellulose content of the many different plants that are available in various developmental states, as well as the various requirements to mechanically process food, it would be surprising if selection in baboon feeding did not occur (Norton *et al.*, 1987; Barton *et al.*, 1993; Barton and Whiten, 1994).

Baboons are highly social primates known for their diverse behaviors and activities (Bronikowski and Altmann, 1996; Gustison, le Roux and Bergman, 2012). While the specific activity budgets can vary among different baboon species, it is important to note that the activity budgets can vary depending on environmental factors, food availability, and social dynamics within a baboon population (Post, 1982; King and Cowlishaw, 2009). For instance chacma baboons found in the Cape Region show less fluctuations in their activity budget throughout the year due to the more stable climate they find themselves in as compared to those found in more seasonally marked areas (DeVore and Hall, 1965). Activity budget is mainly categorized into five main categories; foraging, resting, moving, socializing and reproduction, but not limited to these as behavioral scholars may redefine them depending on the objectives of their studies (Whiten, Byrne and Henzi, 1987; Dunbar, 1992; Hill *et al.*, 2003). Chacma baboons are known to spend a significant amount of time foraging, with an emphasis on plant material like fruits, leaves, and bulbs (Altmann and Muruthi, 1988; Segal, 2008). They also allocate a relatively high proportion of time to social interactions, including grooming, playing, and maintaining hierarchical relationships within their troop (Lewis and O'Riain, 2017). Olive baboons (*Papio anubis*) exhibit similar patterns to Chacma baboons, with a considerable amount of time spent foraging. They are opportunistic feeders and consume a wide variety of foods, including fruits, seeds, leaves, and small vertebrates. Social interactions, such as grooming and establishing dominance, are also important components of their activity budget (Byrne *et al.*, 1993) . Yellow baboons (*Papio cynocephalus*) also allocate a significant amount of time to foraging, similar to other baboon species. They have a diverse diet that includes fruits, seeds, leaves, and insects (Segal, 2008). Social interactions, including grooming and affiliative behaviors, are integral to their social structure and occupy a considerable portion of their activity budget (Rasmussen, 1985). Whilst Guinea baboons (*Papio papio)* have a relatively higher proportion of time allocated to social interactions compared to some other baboon species (Kerstin *et al.*, 2008). They engage in grooming, playing, and maintaining social relationships within their troop. Foraging is also a significant activity for them, as they consume fruits, leaves, seeds, and invertebrates (Galat-Luong, Galat, and Hagell, 2006).

Chacma baboons habitats in Southern Africa in general have been spatially separated, fragmented, and reduced in size as a result of considerable land use change, and is considered to be single greatest threat to the survival of primates as well as a primary driver of human-baboon conflict (Hoffman and Riain, 2011; Slater, Barrett and Brown, 2018; van

Doorn and O’Riain, 2020). A few monkey species can, however, adapt to human-altered settings and even thrive there; Vervets (*Cercopithecus aethiops*) and some macaques (*Macaca* spp.) are examples of species that are particularly capable at residing close to human populations (Fehlmann *et al.*, 2017) . Land use change can potentially influence the diet of chacma baboons as it can add provisions or drastically reduce food resources (van Doorn and O’Riain, 2020). Furthermore, availability of food resources for wild animals including chacma baboons vary with season; for example, fruits are not available year-round and so are above ground parts of some herbaceous plants. Segal (2008) reported that in the dry season, fecal examination revealed that chacma baboons in the Suikerbosrand Nature Reserve consumed less plant matter which accounted for 29% of their diet as compared to the early and late wet season where plant matter accounted for 61% of their diet. Fruits and seeds accounted for 48% of their diet in the dry season and rising to 55% in the early and late wet season. Chowdhury, Brown and Swedell (2021) found that time spent foraging across seasons did not change significantly but maintaining a consistent number of hours spent eating between seasons was only possible at the expense of other activities. Baboons in the Cape Peninsula that foraged in a least altered environment spent more time eating in the winter than they did in the summer due to their home range containing more natural habitats than suburban regions and scavenged less on processed food (Lewis, West and O’Riain, 2018; Li *et al.*, 2019). Baboons that foraged in less disturbed areas may have needed to spend more time feeding in the winter to maintain their energy intake levels due to the lower input of high-energy anthropogenic sources to their diet (Lewis and Riain, 2017; Chowdhury, Brown and Swedell, 2021). The greater reliance on human-derived foods by baboons in heavily encroached areas may have provided them with a larger energetic buffer, allowing them to reduce their eating time in the winter. The reduced feeding time is supported by the observation that baboons living close to human settlements increased their reliance on anthropogenic foods from summer to winter (Kaplan *et al.*, 2011; Leith *et al.*, 2020). Due to the high caloric value and digestibility of chromogenic foods, baboons that eat them can significantly shorten their feeding period and lengthen their resting time, while baboons that eat non-human sources have longer feeding time (van Doorn and O'Riain, 2020). Provisioned yellow baboons in Amboseli, Kenya, for example, fed just 20% of the time and rested 50% of the time, whereas non-provisioned baboons fed 60% of the time and rested 10% of the time (Altmann and Muruthi, 1988). The baboons in Tokai section of Table Mountain National Park studied by Chowdhury, Brown and Swedell, (2021) revealed seasonal changes in the food items they ate, which is consistent with our knowledge of baboons being flexible feeders. Grass and forbs, pinecones, underground storage organs, nuts and seeds, and other subterranean plant parts were the primary foods of all studied troops. Baboons sighted closer to suburbs in the Cape peninsula significantly increased their time spent eating grasses and weeds during the rainy winter season, when these foods are more abundant, to the point where they formed about half of the diet during this season (Fehlmann *et al.*, 2017). Baboons that have access to human processed food spent more time eating subsurface storage organs such as sedge bulbs, corms and herb roots in the winter, as compared to those that were found in natural habitats that spent more time doing so in the summer (Riain and Swedell, 2010; Lewis and O'Riain, 2017). They appeared to be able to eat whatever was more readily available to them in each season, and this diet adaptability may be significant in allowing them to cope with seasonal obstacles (DeVore and Hall, 1965; Chowdhury, Brown and Swedell, 2021).

A detailed analysis between provisioned troops and those in natural habitats in the Masai Mara and Amboseli National Parks in Kenya revealed that, despite daily variations in food consumption, nutritional intake was adjusted to maintain the same nutrient balance from day to day, possibly preventing nutrient deficits (Leith *et al.*, 2020). Regardless, it appears that the availability of varied foods throughout the year allowed the baboons to switch between food sources without incurring significant costs associated with seasonally reduced supply of favorite foods (Karere *et al.*, 2020). This was indicated for yellow baboons at Amboseli as well (Barton *et al.*, 1993). The capacity to follow seasonal food availability presumably allows baboons to maintain a reasonably consistent energy intake throughout the year, keeping them from suffering the deleterious effects of energetic stress, and this may explain the minimal seasonal difference in energy intake across the seasons (Blumenthal *et al.*, 2012; Lewis, West and O'Riain, 2018; Schreier, Schlaht and Swedell, 2019; Morand, 2020; Chowdhury, Brown and Swedell, 2021).

Baboons being generalists in all aspects of the words means that the selective nature and flexibility in their foraging gives them a unique dynamic to explore and contextualize in every habitat they are found in. This study sought to shed some light on the extent of diet selectivity that may make the baboons in the central areas of Namibia different from the rest as they are exposed to a different mosaic of floristic environment which influences their diet foraging activities in general.

CHAPTER 3: MATERIALS AND METHODS

3.1. Description of Study area.

The study was carried out at Farm Krumhuk and Dobra, both located on the outskirts of the city of Windhoek with a distance of 64.1 km between them on the northern and southern exists of the city in the Khomas region as shown in Figure 1. The area of Windhoek is characterized by the mountainous terrains and mica dominated rocks. Windhoek is located in the tree and shrub savanna, also known as the acacia savanna which is dominated by *Vachellia* and *Senegalia* species as well as a variety of grass species (Westinga *et al.*, 2020). The Khomas region is regarded to be semi-arid area as it receives variable precipitation amounts with rain fall being the dominant form of precipitation (Kaseke *et al.*, 2016). The rainfall in the region ranges from 250 mm-400 mm with most of it falling at the back end of the country's rainy season (January-March) (Wingate, Phinn and Kuhn, 2019). Temperatures range from 2°C to 32°C, with some winter days reaching well below freezing point due to the cold fronts generated by the cold Benguela currents affecting Atlantic Ocean on the west coast of Namibia (Kaseke *et al.*, 2016). The Khomas region is one of the highest areas above sea level in Namibia with Windhoek sitting on the Khomas highland plateau at around 1700 m above sea level (Diener *et al.*, 2013).

The study was conducted in two contrasting habitats in terms of human influence on baboon activities and availability of anthropogenic food. The sites were selected based on popular reports involving human baboon conflict. Preliminary visits were undertaken to various areas to determine the frequency of baboon sightings and the response of baboons to human presence to ascertain the viability of sites to be selected for this study. Initially four sites were considered but after preliminary investigations were done only two sites were regarded to be viable sites that offered the maximum chance of seeing baboon on any given day on which data was to be collected since there was no provision of GPS tagging to track the whereabouts of the baboons at any given time of the day.

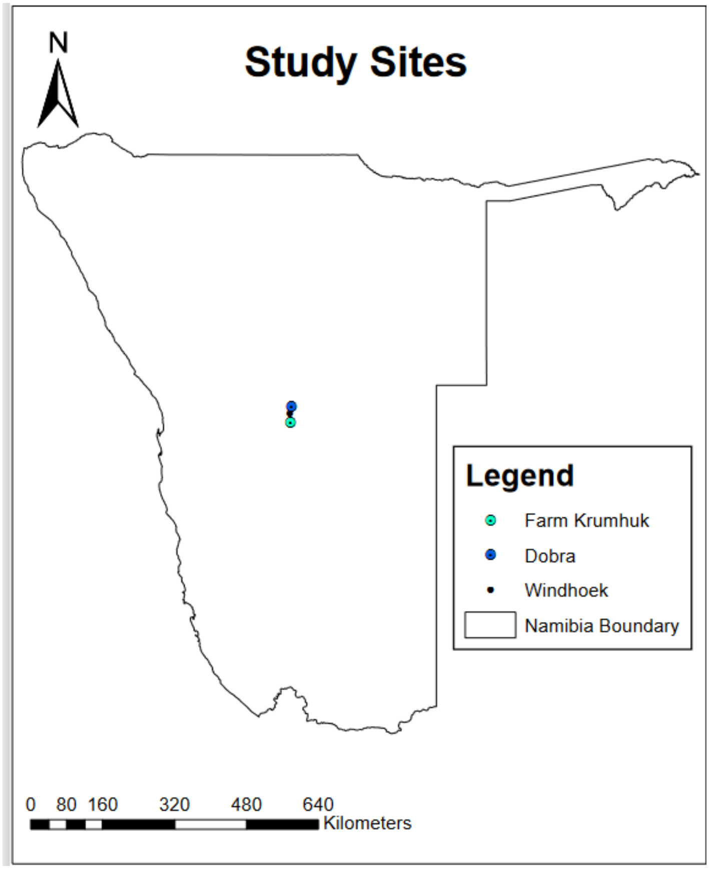

Figure 1: A map of Namibia showing the study areas (Farm Krumhuk, Dobra, Khomas Region).

Dobra (22°25'00.6"S 17°05'51.8"E)

Dobra is a Catholic Boarding school, also known as Saint Joseph High School, located on the outskirts, about 37.9 km north of Windhoek. The school has a population of four hundred (400) students and within the school compound there is a Catholic Parish (Saint Mary) representing three areas of human concentration at any given time, the parish, student hostels and the school grounds. The school is also close to a small settlement that attracts large troops of baboons. The school has been in existence for 140 years, making Dobra the study area that represented the site with more human contact and increased presence of anthropogenic food to the baboon. It was predicted that Dobra represented at least the third generation of baboon descendants as the life expectancy of chacma baboons is around 45 years (Segal, 2008). Dobra has a blend of well-preserved natural flora and some exotic plants planted for ornamental reasons but predominantly the natural flora still exists in the school compound. The school has waste disposal sites and a number of waste bins around the school ground that represented baboon hotspots for baboon sighting.

Figure 2: Satellite image of Dobra (Adopted from google maps)

Farm Krumhuk (22°44'37.1"S 17°04'22.8"E)

Krumhuk is an organic and a game farm that cultivates various range of vegetables and produces a range of diary and game products. The farm is renowned for its organic produce such Maize, butternuts, green pepper, carrots, eggplants, beetroot, but the farm also hosts a variety of recreational and educational activities such as game drives, hunting and research activities. The farm is about 8,000 ha in size with five water points of which two are natural water points and three are artificial. These water points served as observational points for data collection throughout the study.

Figure 3: Farm Krumhuk (adapted from google maps)

3.2 Seasons

The seasons were characterized mainly based on precipitation but not limited to rainfall only. The rainy season in the Windhoek area is predominantly between the months of January and April (Mapani et al, 2023), but surface water persists until the month of June as shown in Figure 4. The wet season comprised of the months where there was rainfall and the months when natural reservoirs still had water in them, and hence the data collection months for the wet season ranged from March 2022 to June 2022. The dry season was marked by the period when the natural reservoirs dried up and the dry season data was collected in the months of August 2022 to September 2022.

Figure 4: Natural water reservoirs at Dobra on the 9th of June 2022.

Figure 4 shows the presence of water in the natural reservoirs in the month June way after the rain has stopped falling.

Figure 5: Natural water reservoirs at Dobra on the 1st of August 2022.

Figure 5 shows the dried out natural water reservoir at the beginning of August when the dry season data collection commenced.

3.4 Scat collection

Scat samples were collected to determine the main components of the diet of the baboons over the course of the investigation as they gave a clear overview of what the baboons were consuming throughout their day. Scats in the wet season were collected from the month of March 2022 to June 2022 while the dry season scats were collected between August 2022 to September 2022. A total of 51 scat samples were collected at random across the two seasons, Dobra Wet season (DW)= 15, Dobra Dry season (DD) = 15, Krumhuk Wet season (KW) = 6 and Krumhuk Dry season (KD) = 15. The scats were collected at opportunistically upon encounter within the vicinity of the sampling sites but mainly at water points where the density and encounter rate of the scats was higher compared to open areas within the sites. The scats were collected using latex gloves and put in Ziplock bags with all the relevant information recorded, such as date, location and season. However, only fresh scat samples were collected as they represented the best view of the gut contents before further degradation and decomposition took place to give the most realist representation of the true gut content of the baboons. Fresh scat samples were characterized by a soft, moist consistency on the outside and accompanied by a strong odor. The samples were stored in the -30°C freezer at the University of Namibia until the time for analysis.

3.5 Sample analysis

The scat samples were removed from the freezer and thawed for 30 minutes. Each scat sample was placed in a 500ml beaker and mixed with boiled water and stirred until it formed a consistent mixture with the water. The mixture was sieved through a 3mm sieve, and the residue was placed on a drying board to air dry for 48 hours. Thereafter, the dried samples were placed a Petri dish and sorted into four food groups (roots; stems and leaves; fruits and seeds; invertebrates and others) under a dissecting microscope at 15X magnifications. The sorted food types were weighed using the (A&D HR-251A) analytical balance to determine their mass which was measured in grams and recorded to the nearest 4 decimal places. Boiled water was used as a method of separation as it proved to offer a higher separating power compared to ethanol. Soaking scats in various concentrations of ethanol for 24 hours to separate samples has been used commonly as a scat analysis technique predominantly in carnivore diet studies (Bencini *et al.*, 2001; Segal, 2008; Ogara *et al.*, 2010; Smith *et al.*, 2018). Food items in scats were classified as presented in Table 1.

Table 1: Categories of food types and their characteristics in the scat samples. The category of other mainly consisted of non-nutritional parts. Descriptions are adopted from Segal (2008).

Food type	**Characteristics**
Roots stems and leaves	The material in this category varies greatly. The color can be green, but it was more commonly yellow or brown. Leaves and grasses appeared undigested and preserved live material characteristics such as shape, texture, and, in some cases, color. The stems are woody or pulpy and range in color from light brown to almost white. All underground plant structures, including bulbs and corms, were regarded as roots. The texture of roots varied from woody or pulpy to a mix of wire-like or hair-like fibers. They were typically light in color.
Fruits and seeds	Most seeds passed through the digestive tract unchanged but sometimes slightly damaged during mastication and appeared open. Pieces of the seed coat fragments were tough and were identified by their grainy texture and sharp edges and were usually light or dark brown in color. Most fruits came out altered, but their outer skins remained unchanged and preserved some of their live characteristics. Some fruits that were eaten in their dry state, like *Vachellia erioloba* pods came out whitish in color and their once fleshy insides were observed floating on top of the scat-water mixture.
Invertebrates	Most invertebrates were broken into many pieces especially the remnants of insects like larger beetles and grasshoppers, but they could still be identified by their hair

	like structures on their exoskeletons and brittle texture and some pieces of the bodies that remained unchanged. Smaller invertebrates like some small beetles passed through the digestive tract unchanged.
Others	This category contained items that did not fit into any of the preceding categories. Sand, slab, and pieces of plastics or unrecognizable items were among the non-nutritional materials that were classified in this group.

Figures 6-12 illustrate some aspects the processing of scat samples collected from the study sites.

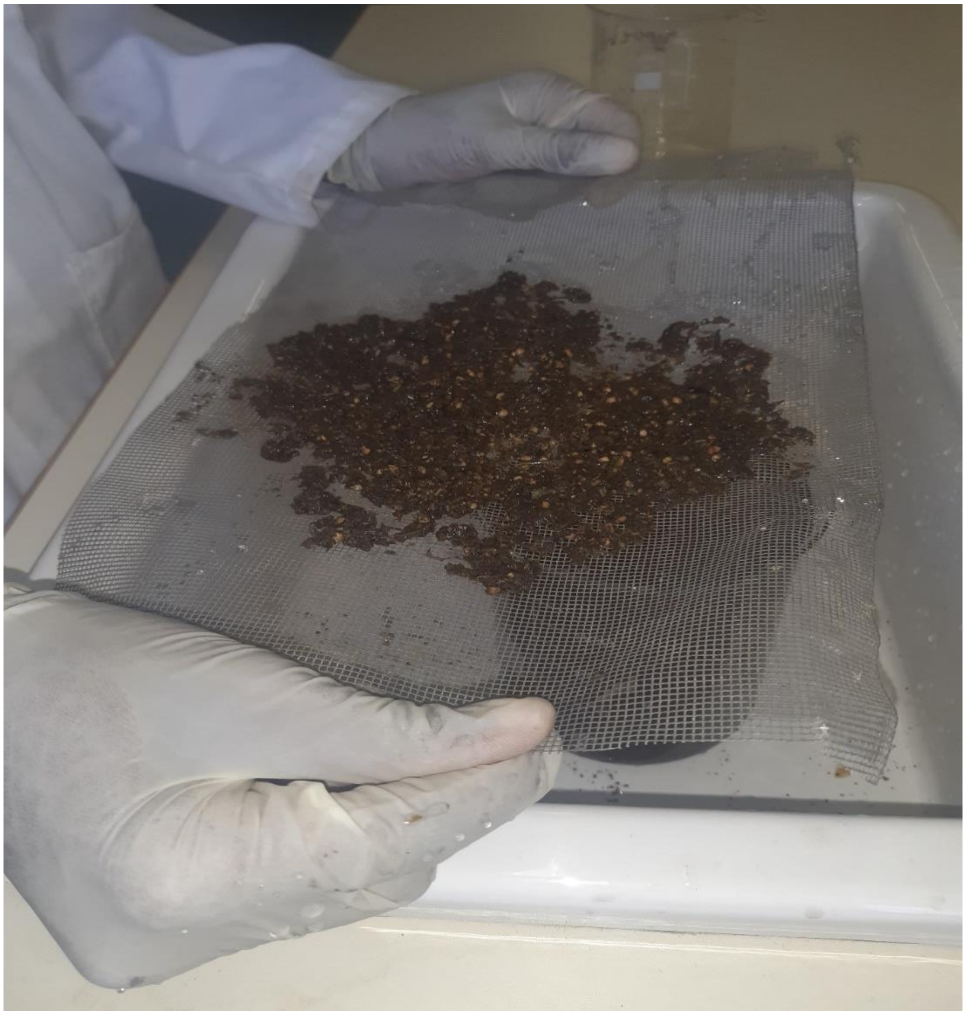

Figure 6: Sieved scat sample.

Figure 7: Scat sample on a drying board

Figure 8: Illustration of the sorting process.

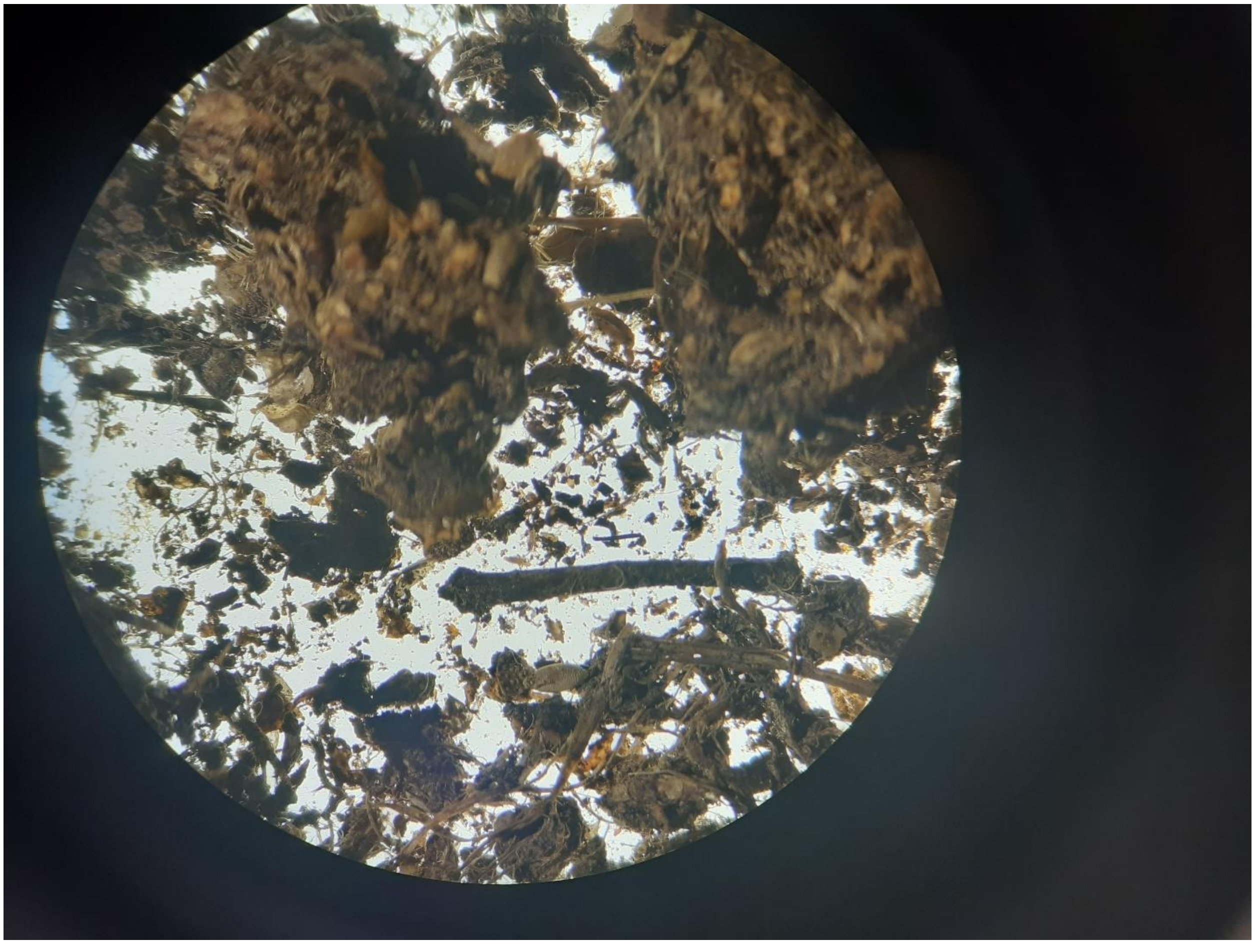

Figure 9: Sample view under a dissecting microscope (15X magnification)

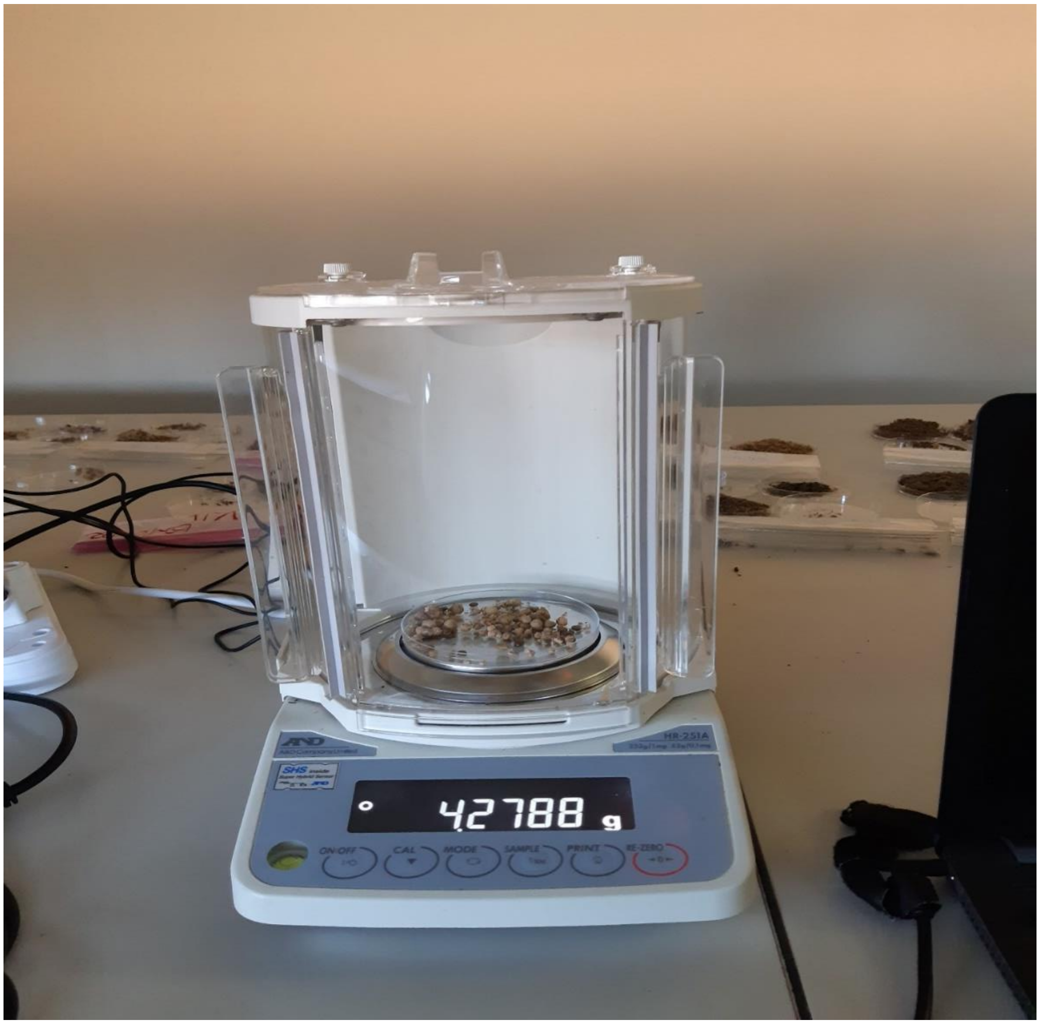

Figure 10: Illustration of the weighing process of the food types.

Figure 11: Sorted scat sample into the four food categories (roots, stems and leaves, fruits and seeds, invertebrates and others).

Figure 12: Sorted scat samples.

3.5 Behavior data collection.

Focal animal sampling technique was used to obtain behavior data (Byrne *et al.*, 1993; Robert, Bryne and Andrew, 1996; Segal, 2008; Gustison, le Roux and Bergman, 2012; Marshall *et al.*, 2013; Bosholn and Anciães, 2018). Behavioral data in the wet season were collected from the month of March 2022 to June 2022 while the dry season behavioral data were collected between August 2022 to September 2022. Fifteen (15) minutes observations were carried out on an individual baboon using a pair of binoculars and behavioral observation were recorded 15 times for every individual at a one-minute interval. Only the dominant behavior was recorded as described in Table 2 and by this it means if a baboon spent 30 seconds or more grooming and the remaining seconds moving, than grooming was recorded as the dominant behavior in that one-minute interval. When an individual did not spend more than 30 seconds performing the same behavior the instantaneous sampling rule was applied (behavior that occurs in the beginning of the interval will be recorded) (Bosholn and Anciães, 2022). The instantaneous sampling rule was rarely applied as baboon behavior in adults is not erratic but highly synchronized with the entire troop (King and Cowlishaw, 2009) and it was very common to observe one distinct behavior in every one-minute interval. If a focal animal disappeared before the 15 minutes elapsed, the observation was stopped at whatever time interval the focal animal was no longer visible and the data was still kept on record. Only adult baboons in the troop were observed. A five-minute waiting interval was allowed between any two-consecutive observations. When a troop was spotted, the total number of visible individuals were counted first before observations were carried to avoid observing the same baboon twice or more and observations were done either from left to right across the troop or vice versa to ensure that baboons moving into focus from either side were spotted, hence limiting the chances of pseudo-replication. Behavioral observations were carried out in two sessions per day, in the morning (08:00 -12:00) and in the afternoon (13:00- 17:00) across the wet and dry seasons. Baboons responded differently to the presence of people, as those at Dobra were not wary of people on foot and were warier of men than women while those at Krumhuk were warier of everyone on foot and were comfortable with vehicles, hence the data at Krumhuk was collected from inside the car but both observations were done from a distance that ensured that their natural behavior was not altered. When feeding behaviour was noted especially when the baboons were feeding on fruits from a plant such fruits were collected and identified to species level using a field guide trees and shrubs of Namibia (Table 12 in Appendix) A total of 166 individual adult baboons (≈2490 minutes of observations) were observed across the two seasons (Dobra Morning Wet season (DMW) = 33, Dobra Afternoon Wet season (DAW) = 13, Dobra Morning Dry season (DMD) = 27, Dobra Afternoon Dry season (DAD) = 15, Krumhuk Morning Wet season (KMW) = 12, Krumhuk Afternoon Wet season (KAW) = 33, Krumhuk Morning Dry season (KMD) =25 and Krumhuk Afternoon Dry season (KAD) = 20).

Table 2: Descriptions of Behaviors which chacma baboons displayed in the field

Behavior	**Descriptive characteristics**
Feeding	Recorded when focal baboon was observed consuming food items by placing them in its mouth.
Foraging	Recorded when focal baboon was observed looking for food for instance turning over stones to look for food whether invertebrates or trying to dig out underground parts of a plant.
Raiding	Recorded when focal baboon was observed handling any human-derived food items, for instance going through a waste bin searching for food or consuming human human-derived food items.
Playing	This when the focal baboon was observed displaying playful behavior.
Moving	The display of locomotive behavior usually moving from one place to another.
Grooming	This was recorded when the focal animal was involved in a grooming (removing parasites or insects from one's body) act, whether the focal baboon was being groomed, grooming itself or was the one grooming another individual.
Relaxing	This was the display of inactivity, especially when the baboons were just resting.
Vigilance	When the focal baboon was actively looking out for danger usually with their heads raised and scanning their surroundings
Fighting	This was recorded when a focal animal was involved in a physical confrontation with another baboon, usually over food items.

Figure 13-15 present some aspects of observation and recording of behavior of baboons

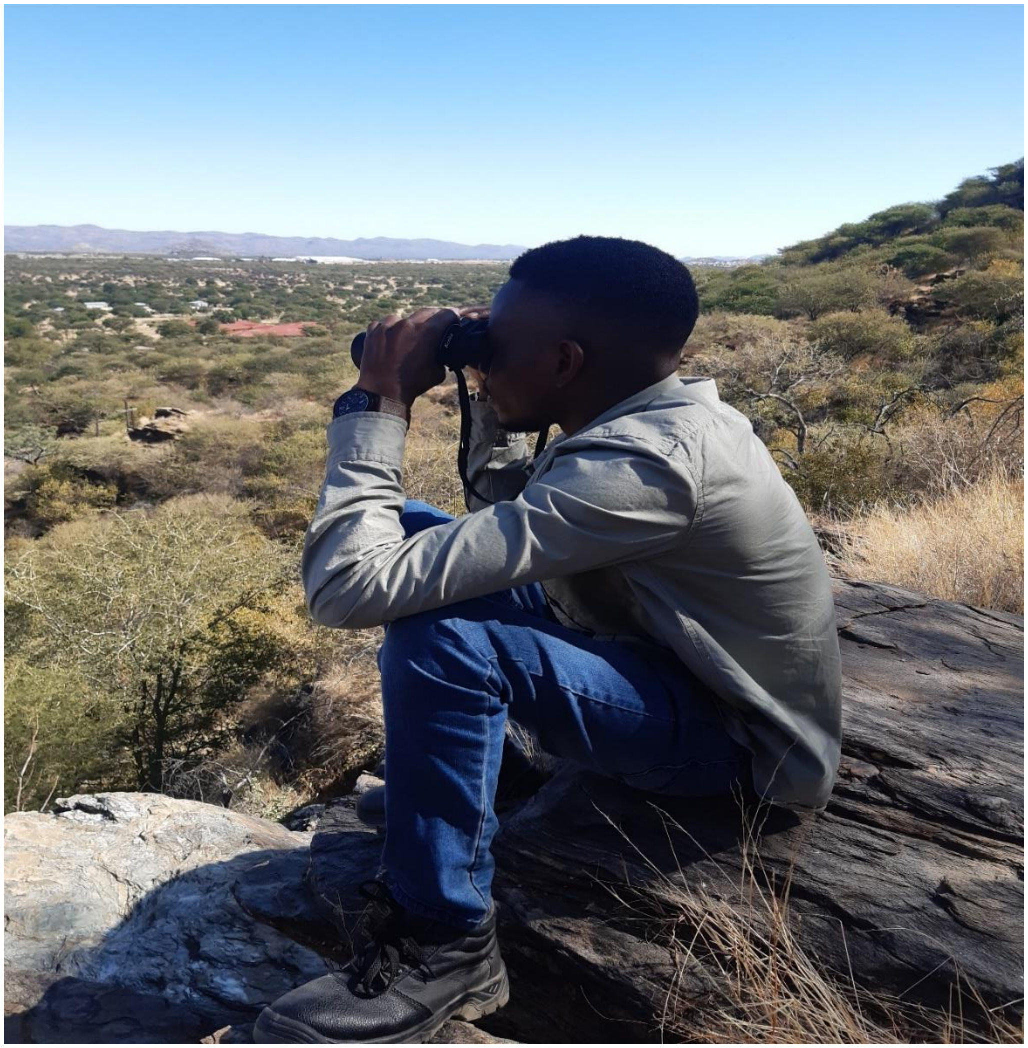

Figure 13: Focal animal observation using binoculars at Dobra.

Figure 14: A baboon troop at a waste disposal area at Dobra.

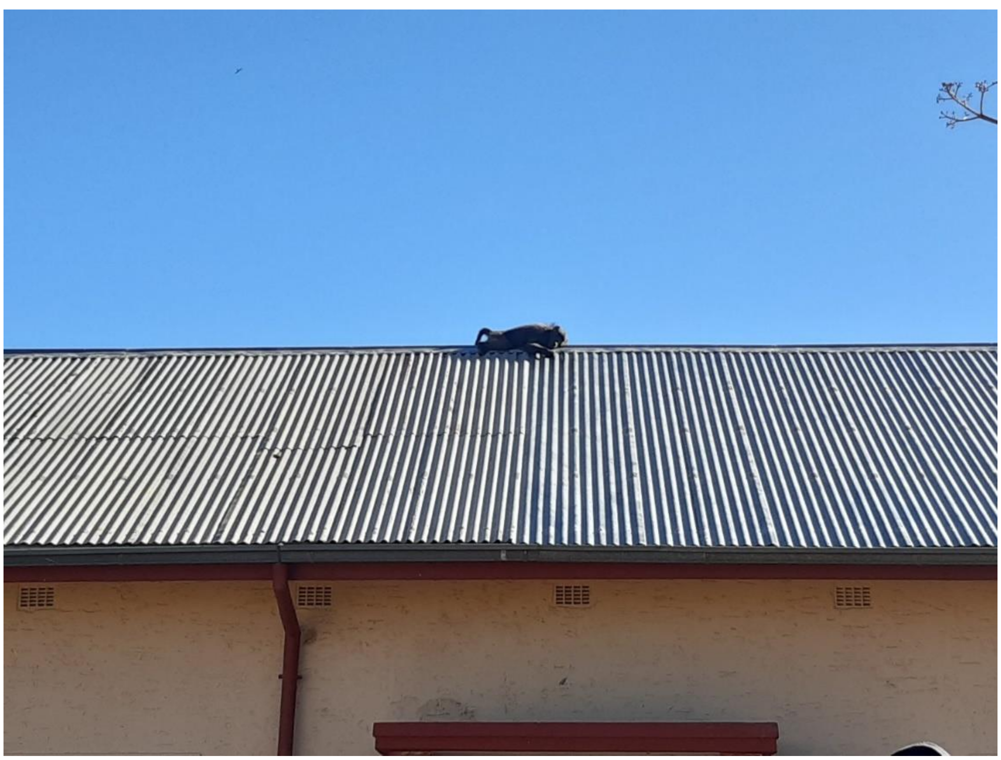

Figure 15: Relaxing baboon on top the roof at Dobra.

3.6 Data analysis

The data were analyzed using IBM SPSS version 28. Both the food type and behavior data did not conform to the normal distribution when tested using the Shapiro-Wilk test of normality. The distribution of mass across the four food types, seasons and sites ($P < 0.001$) and the distribution of time across behavior types, seasons, time of day, and sites ($P < 0.001$) (See Tables 5-12 in the Appendix section), hence non-parametric tests were used. The scat data had one dependent variable (mass) and three independent variables (food type, season and site) and the behavior data also had one dependent variable (time) and three independent variables (type of behavior, season and site). To analyze variation between groups, an analysis of variance in an experimental design consisting of three independent and one dependent variable a MANOVA was the most appropriate statistical test to use, but since the data did not meet the assumption of normality the non-parametric equivalent Kruskal-Wallis test was used to test each individual independent factor separately. The scat samples were collected at random in each season, hence a Kruskal-Wallis test was used to test the variation of the food mass across the independent factors (food type, season and sites). Pairwise comparison (Post Hoc) was used to identify where the differences were when the independent factor had more than two levels, for instance food type. The variation of the time spent performing each behavior between seasons and sites was analyzed using a Kruskal-Wallis test with time being the dependent variable while seasons and sites were the independent variables. The distribution of time across the various behaviors was analyzed using a pairwise Kruskal-Wallis test, with time being the dependent variable and behavior categories as the independent variable. The raiding data was similarly analyzed as done for the other behavior data. The only exception was that the “select cases filter” in SPSS was used to isolate the raiding data from the rest of the behavior data during the analysis process by selecting data, select cases, select if condition is satisfied, use mathematical expression to match your filter variable label and apply filter (Gupta, 1999). The statistical evaluations were made at a 95% confidence level.

CHAPTER 4: RESULTS

4.1 Diet composition of chacma baboons at Farm Krumhuk and Dobra.

The Kruskal-Wallis test revealed that there was no significant variation in the mass of the food consumed by the baboons between the wet and dry seasons ($H = 2.226$, $df = 1$, $p = 0.136$). Across the food type, baboons at both Dobra and Krumhuk consumed more roots, stems and leaves followed by fruits and seeds. However, invertebrates were the least food type consumed (Figure 16) In addition, the diet of the baboons at Krumhuk comprised of significantly higher mass of roots, stems and leaves as compared to those at Dobra, while those at Dobra consumed significantly more fruits and seeds compared to those at Krumhuk as revealed by the Kruskal-Wallis test ($H= 4.525$, $df = 1$, $p = 0.033$).

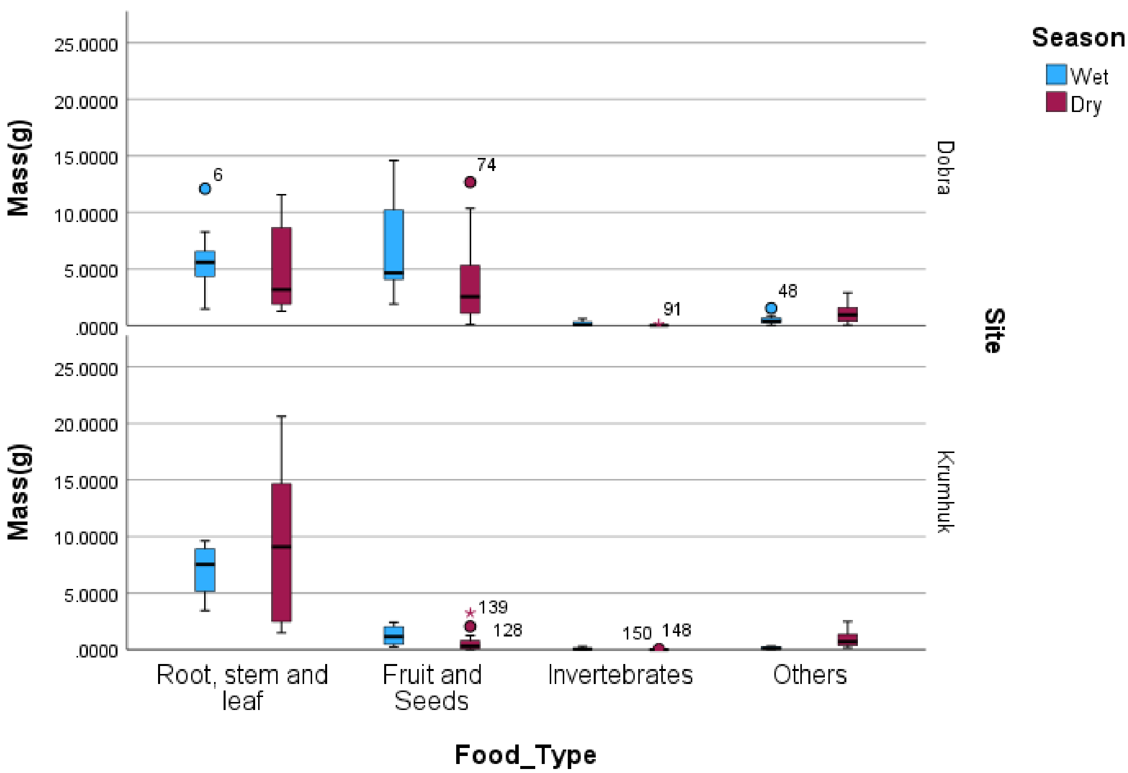

Figure 16: Box plots showing the distribution of mass(g) across seasons (Wet and Dry), food types, and site (Dobra and Krumhuk).

The diet of chacma baboons in the central parts of Namibia was found to consist of 63% roots, stems and leaves, 28% fruits and seed and 1% invertebrates (Figure 17) of which the majority of these plant parts were consumed in the wet season while fruits and seeds were similarly consumed across the two seasons (Figure 16).

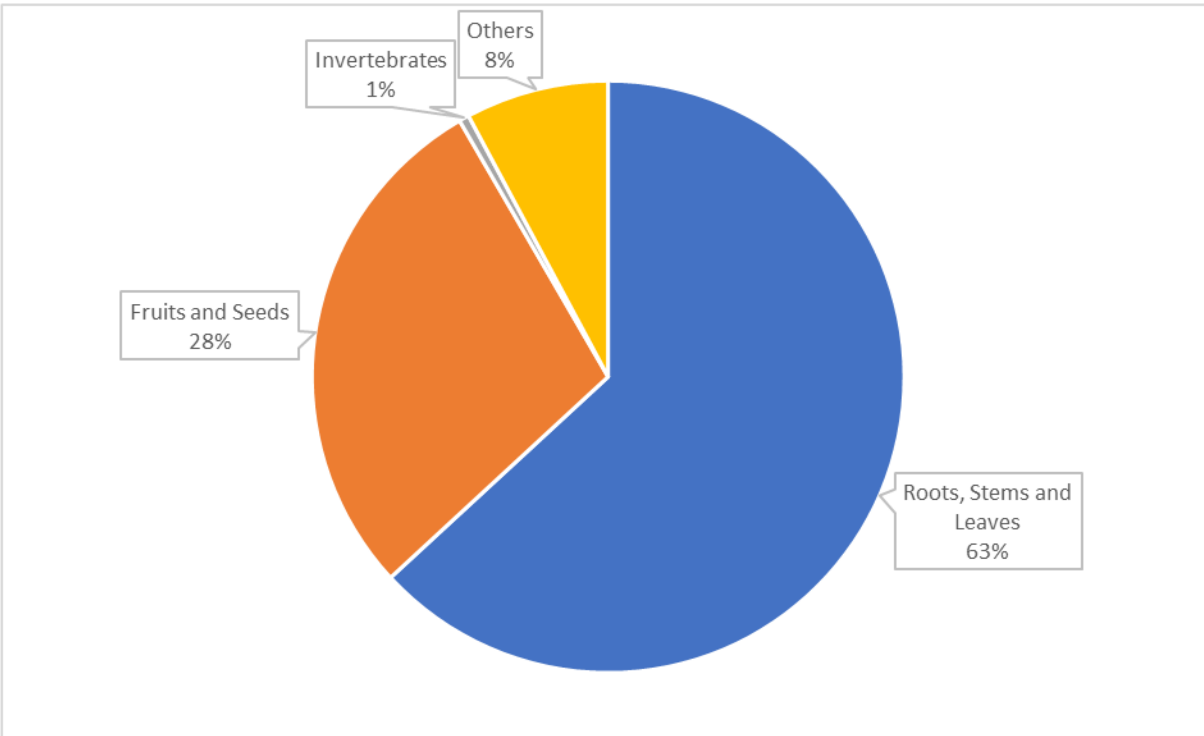

Figure 17: Overall diet composition of chacma baboon troops at farm Krumhuk and Dobra (Ratio of the mass of a food type to total mass of scats expressed as a percentage).

In Figure 17, scat samples revealed that the chacma baboons at Dobra and Krumhuk mainly consumed roots, stems and leaves followed by fruits and seeds. The overall percentage of invertebrates (1%) was the lowest among the diet of chacma baboons (Figure 17).

Furthermore, the diet of the chacma baboons significantly varied in the mass of the food which they consumed as shown in Table 3.

Table 3: Kruskal-Wallis Pairwise comparison of the mass of food types in scat content across the food type categories (root, stem and leaves; fruits and seeds; invertebrates and others).

Food type 1	**Food type 2**	**P-value**
invertebrates	others	<.001*
invertebrates	fruits and seeds	<.001*
invertebrates	roots, stems and leaves	<.001*
others	fruits and seeds	.003*
others	roots, stems and leaves	<.001*
fruit and seeds	roots, stems and leaves	.001*

* Significant at 5% level

Kruskal-Wallis Pairwise comparison in Table 3 shows that there was a significant variation in the mass of each of the food type consumed relative to the other groups. Roots, stems and leaves were utilized the most followed by fruits and seed lastly invertebrates.

4.2 Behavioral activities of Chacma baboons at Dobra and Krumhuk.

The medians of the time spent on each behavioral activity at Dobra and Krumhuk in the wet and dry season and the time of day morning and afternoon are shown in (Figure 18) below.

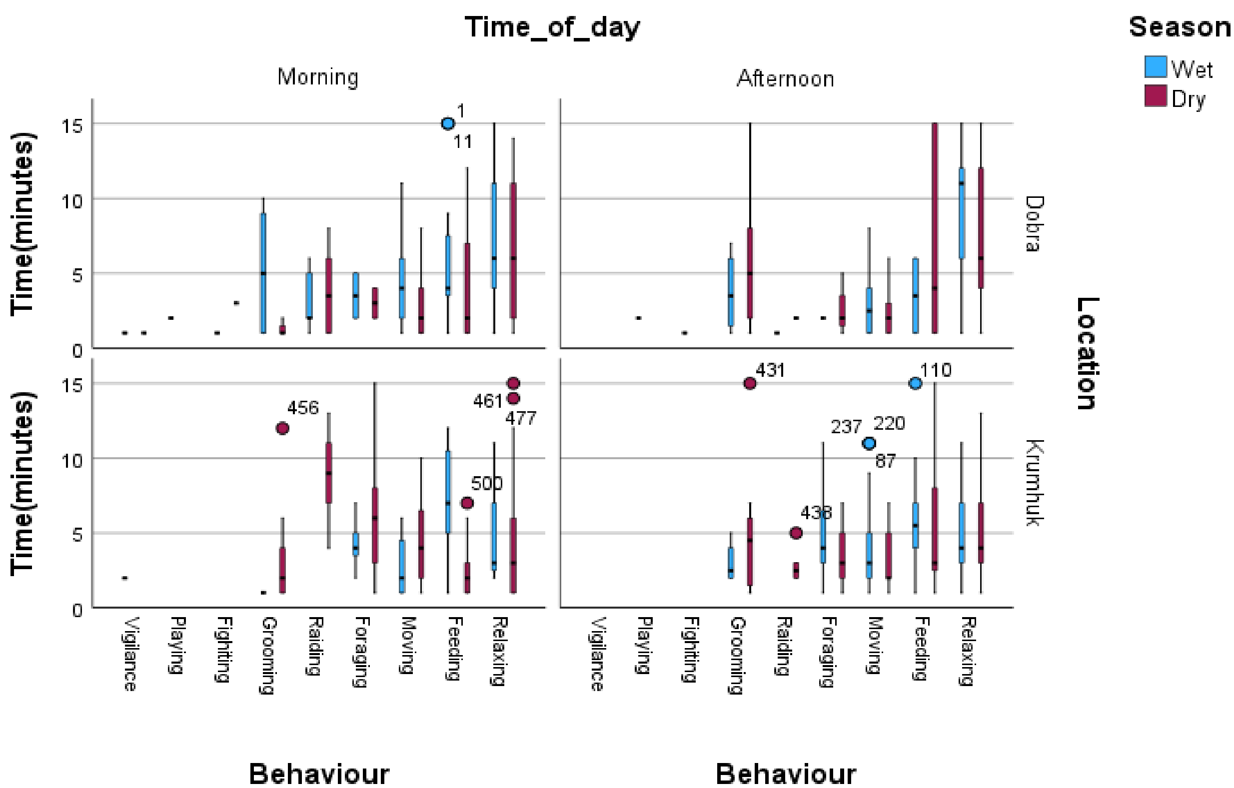

Figure 18: Box plots showing the time (median) spent on the different behaviors of chacma baboons across at time of the day (morning and afternoon), seasons (Wet and Dry), and site (Dobra and Krumhuk).

The Kruskal-Wallis test performed showed that there was a significant variation in the time the baboons spent performing their various behavioral activities (H = 25.161. df = 8, p = 0.001). Similarly, a significant variation was observed in the time the baboons spent performing their behavioral activities between the wet and dry seasons (H = 22.274, df =

1, $p < 0.001$), Morning and afternoon times of the day ($H = 17.707$, $df = 1$, $p < 0.001$), and Dobra and Krumhuk sites ($H = 14.583$, $df = 1$, $p < 0.001$). During the wet season, the behavior of the baboons at Dobra were mainly relaxing, moving and feeding in the morning while in the afternoon they were relaxing and moving (Figure 18). However, their main behavior at Krumhuk was feeding in the morning whereas in the afternoon they were feeding, moving, relaxing and foraging in the wet season. Overall, the baboons in Dobra performed their behavioral activities in the morning hours as compared to the afternoon hours while the opposite was the case for the baboons at Krumhuk. Moreover, Table 4 (Appendix section) shows the pairwise comparison for the nine behavioral activities. From Table 4 (Appendix section), significant differences occurred between the following pairs of behavior, being higher in the behavior mentioned first: playing and vigilance ($p = 0.039$), fighting and vigilance ($p = 0.024$), grooming and moving ($p = 0.003$), grooming and vigilance ($p = 0.005$), foraging and relaxing ($p = 0.017$), foraging and feeding ($p = 0.027$), foraging and moving ($p < 0.001$), foraging and vigilance ($p = 0.005$), raiding and vigilance ($p = 0.009$), relaxing and moving ($p = 0.048$), feeding and vigilance ($p = 0.011$), and moving and vigilance ($p = 0.021$).

4.3 Raiding behavior at Dobra and Krumhuk.

In the present study, raiding behavior was recorded when a focal baboon was observed handling any human-derived food items, for instance going through a waste bin searching for food or consuming human human-derived food items. The duration of raiding behavior of chacma baboons at Dobra and Krumhuk during the wet and dry season are presented in (Figure 19).

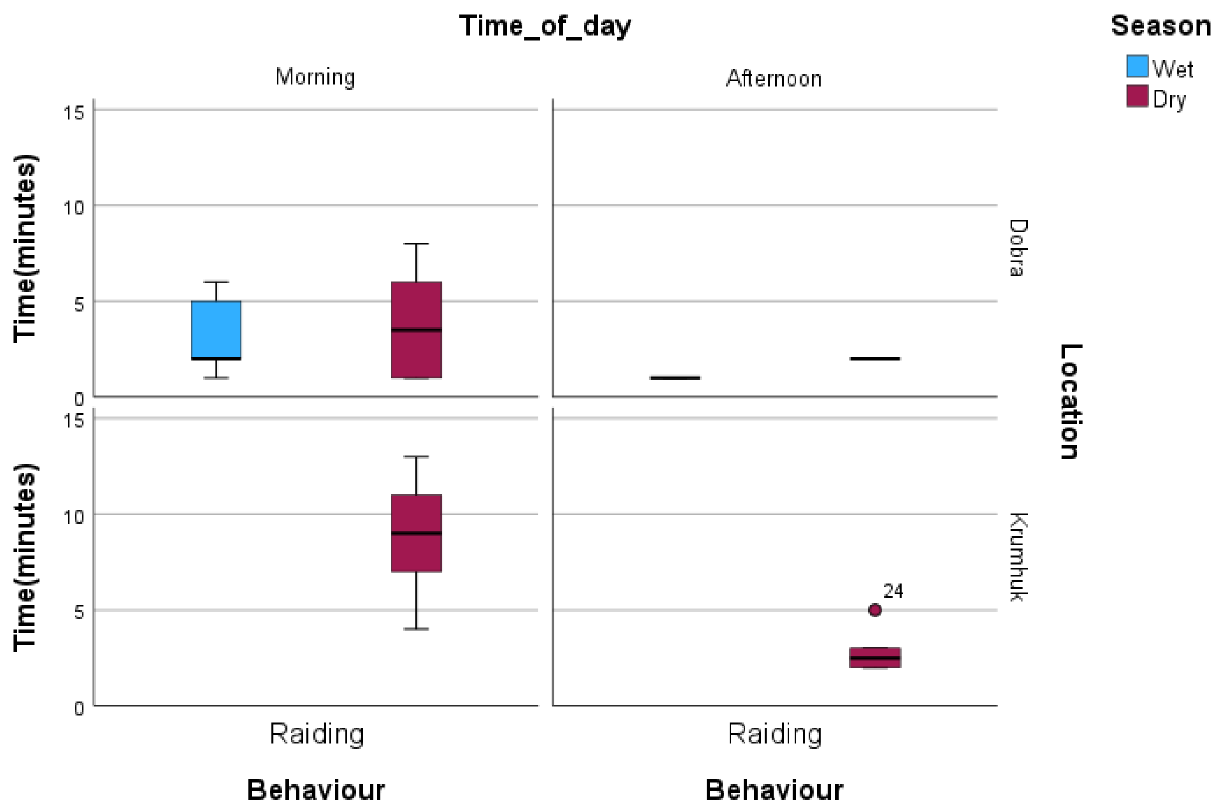

Figure 19: Box plots showing time (median) spent by chacma baboons raiding across times of the day (Morning and Afternoon), season (Wet and Dry), and sites (Dobra and Krumhuk).

The time spent by the baboons raiding at Dobra and Krumhuk was statistically the same across the wet and dry season and as well as between the two sites. The Kruskal-Wallis test performed showed that there was no significant variation in the time baboons spent raiding between the wet and dry seasons ($H= 0.525$, $df = 1$, $p = 0.469$), Dobra and Krumhuk sites ($H = 2.545$, $df = 1$, $p = 0.111$), and morning and afternoon times of the day ($H= 0.857$, $df = 1$, $p = 0.355$).

CHAPTER 5: DISCUSSION

Baboon behavior and diet have been well documented all around Africa, from the hamadryads in the horn of Africa to the chacmas in Southern Africa (Hamilton and William, 1985; Schreier, Schlaht and Swedell, 2019). These old-world monkeys have the ability to occupy and thrive in various environments ranging from rain forests of Uganda to the Namib desert (Elton and Dunn, 2020). The two ends of baboon diet that range in evergreen forests of central Africa to the hyper arid deserts of the Namib in terms of climate and vegetation cover have been well documented in several studies (Williams and Hamilton, 1986; Okecha and Newton-Fisher, 2006; Swedell, Hailemeskel and Schreier, 2008; Schreier, 2010; Anold, 2022) but this study focused on the middle of the curve in terms of climate and vegetation cover by zooming into chacma baboons occupying the semi-arid high lands of central Namibia. There are notable baboon studies in Namibia such as one on the diet analysis of the chacma baboons in the Kuiseb river canyon by Hamilton et al. (1978) and those under the long term studies in the Tsaobis Nature Park that have been under surveillance since the early 90s (Harry, Carter, Coulson, *et al.*, 2012). The Tsaobis baboon project uses the desert baboons as a model system in hyper arid conditions but mainly focusing on reproductive conflict, family ecology, and reproductive seasonality (Harry, Carter, Coulson, *et al.*, 2012; Marshall, Carter, Rowcliffe, *et al.*, 2012; Marshall *et al.*, 2013, 2015).

5.1 Diet

The differences observed in the percentages of the different food types (Figure 17) consumed by baboons can be attributed to both the nutritional ranks of the food items consumed and their availability in the environment across the seasons (Segal, 2008). Altmann (1998) showed that baboons preferred invertebrates because of their high content in fats and proteins, followed by fruits and seeds due to their high content in carbohydrates and finally the other parts of plant like roots and leaves. This results are in line with the results of the diet composition of the food types consumed by the troops of chacma baboons in the Suikerbosrand nature reserve in South Africa by (Segal, 2008). It is further noted that in this study, mass of the food types consumed by the chacma baboons at Krumhuk significantly differed from those at Dobra (Figure16). The results showed that the diet of the baboons at Krumhuk comprised of significantly higher mass of roots, stems and leaves as compared to those at Dobra, while those at Dobra consumed significantly more fruits and seeds compared to those at Krumhuk. These differences in their diet composition may reflect possible differences in the extent of their proximity and or interactions with humans and variations in the available sources of food (Segal, 2008). It is important to note that the relative availability of different food sources in the study sites were not quantified in this study hence this study cannot make direct comments on specific diet selection of baboons in these areas. For example, Segal (2008) showed that the baboon that spend majority of their time within the confines of Suikerbosrand nature reserve, mainly fed on plant parts like roots, stems and leaves and those on the periphery that had a higher number of maize seeds in their diet was a result of the maize they were raiding in the neighboring farms. The low utilization of invertebrates at both sites and between seasons could be due to various reasons. Although baboons are classified as omnivores their frugivory and folivory part of the diet significantly dominated their overall diet to the extent that Moolman and Breytenbach (1973) reported them to be 90% vegetarian in Loskop dam nature reserve in

South Africa while Devore and Hall (1965) placed them at 98% in Kenya. Although invertebrates are reported to be presumably one of the main sources of protein for baboons by David and Watts (2020), their handling time outweighs their energy returns in most cases. In this study it was observed during sorting of scats that the majority of the insects found in the scats especially those found whole were too small to have been targeted but rather consumed indirectly from eating other food sources like plant leaves. Devore and Hall (1965) concluded that invertebrates are a very minor diet item but given the opportunity can become a principle food choice.

On the other hand, chacma baboons select their diet not only based on the available food but also select that which maximizes energy or nutrition in terms of protein intake but also on their age, sex and reproductive status (Clymer, 2006). Clymer (2006) for instance also showed that adult females and juveniles were found to prefer higher protein food sources, whereas adult males preferred higher carbohydrate food sources. In a study on inter- and intra-habitat dietary variability of Chacma Baboons (*Papio ursinus*) in South African Savannas, Codron et al (2006) showed that chacma baboons adapt their dietary behavior to maximize protein intake, regardless of their environment.

Dobra has been in existence on the outskirts of Windhoek, as a substantial community, for over 140 years meaning it has seen at least 4 generation of baboons growing to maturity and bearing offspring. It was observed that the Dobra community kept a lot of the natural vegetation within their compounds hence provided a hot spot for fruit gathering for foraging baboons. Furthermore, ornamental plants have also been planted at and around Dobra which adds to the attraction of the baboons to the area and this is reflected in the constant and dominant fruit diet in the Dobra baboons compared to those at Krumhuk

(Figure 16). In addition, the baboons at Krumhuk faced a fair number of lethal deterrents such as gun fire from the farmers protecting their cash crops. The signs of conflict were evident in this troop as it has a few individuals with cut off limbs and tails. Such traumatic experiences confined these baboons to the periphery of the farm where nutritious food resources were fiercely competed for, hence the dominance of what is generally considered as low nutritious materials such as stems and leaves as compared to fruits and invertebrates in their diet. Krumhuk's rangeland management measures are also set up in such a way that they encourage herbaceous plants over woody plants to benefit their grazing cattle. Farm Krumhuk has also experienced recent fires which are a stimulant for palatable saplings and decreaser grasses (Anderies, Janssen and Walker, 2002). Shannon (2018) showed that after wildfires, baboons preferred to feed on germinating plants and fresh leaves of growing grasses due to their higher nutritional contend and abundance after a fire occurrence. This phenomenon is also supported by other primate species studied by Chapman and Chapman (2002) that showed that colobus monkeys (*Procolobus badius*) preferred young leaves over mature leaves because they contained more protein, were easier to digest, and had a higher protein to fiber ratio.

The study revealed that season did not significantly influence the types of food consumed at Dobra and Krumhuk (Figure 16). Yet it has been reported in chacma baboon populations in Suikerbosrand nature reserve in South Africa and the Ruaha National Park in Tanzania that diet shifted significantly with seasons (Pochron, 2005; Segal, 2008). Segal (2008) found that roots, stem and leaves increased in the baboon diet in the early rainy season due to the increasing levels of primary production. It is widely accepted that baboons are opportunistic foragers and are generalists (Codron *et al.*, 2006). Although seasonal variation in the consumption of the different food sources was not recorded in this study, others have reported variation due to the decrease in food sources and their associated variability across the wet and dry seasons. Such seasonal variation in available food resources has been reported by Kaplan *et al* (2011) where they found that there was a significant variation in seasonal diet and activity budget in baboons in the Cape Peninsula but also concluded these differences could have been exaggerated by the intensive raiding observed in these populations. Segal (2008) also showed that the baboon diet in the Suikerbosrand nature reserve varied between the seasons as they consumed fewer food type mainly restricted to plant matter and fruits and seed in the early and late wet season while consuming a wider range of food types in the dry season. In the present study, available food may have varied yet these baboons still found a way to show some level of consistency in what they consumed across the two seasons at the two study sites (Figure 16). Some of the contributing factors that may help explain this steady profile in these baboon's diet is the fact that their habitats are heavily dominated by *Vachillia* and *Senegalia* species that produce pods that persist across the two seasons. It was also observed that fruits of buffalo thorn (*Ziziphus mucronata)* were found in the scat samples in both seasons as one of the dominant fruits. Segal (2008)'s findings also showed that fruits of buffalo thorn persisted into all the seasons and were eaten at all of their stages of ripening. *Vachellia erioloba* pods were also one of the few fruits that persisted across the two seasons and were found to attract the baboons at both sites.

This study employed field techniques such as scat analysis which is a comprehensive passive method to study diet but also proved to be labour intensive (Ruppert, Kline and Rahman, 2019). For instance, in this study it was found that it took about three (3) days to process a single scat sample to ensure well sorted and discriminated portions of the food categories even though some parts of the diet still had to be grouped for instance root, stems and leaves. In this study we also did not identify the food types in the scats to species level but with the use of molecular techniques like eDNA the identification of food types both plants and animals could have been much faster and accurate using DNA barcodes (Beng and Corlett, 2020; Banerjee *et al.*, 2022). Profiling baboon diet to species level will give a more robust diet library that could be used to inform management strategies of these animals in our cities. The diet data in this study does not support the hypothesis of no significant variation in the diet components consumed by chacma baboons across the wet and dry seasons at Dobra and Krumhuk.

5.2 Behavior

Behavioral patterns are rarely influenced by one particular factor but rather a combination of several environmental factors, ecological interaction and socials organization inclusive of sex and reproductive status which lead to an appropriate responses, typically characterized by minimum energy expenditure and yields maximum survival chances (Marshall, Carter, Coulson, *et al.*, 2012; Marshall, Carter, Rowcliffe, *et al.*, 2012; Marshall *et al.*, 2015; Patterson, Strum and Silk, 2021). The observed significant variation (Figure18 in the results section and Table 4 in the Appendix section) in the time baboons spent performing their various behavioral activities across all nine behavioral classes, between sites and seasons may be due to various factors. There were clear patterns observed in the troops at Krumhuk and Dobra. One such possible factor relates to the different conditions these troops found themselves in. It was observed that the troops at Dobra were mostly active in the morning hours as there was high rate of encountering them in the morning hours. This may have been influenced by the fact that during the morning they spend a lot of their time around the school grounds monitoring the students and waiting to obtain food they left lying around, especially in the vicinity of the dining hall. The baboons at Dobra spent a larger portion of their time relaxing or inactive basking on the roof tops and up in the trees as compared to all the other recorded activities. This could be due to the fact that they had more access to human processed food than those at Krumhuk hence their energy needs could be satisfied with less foraging effort (Leith *et al.,* 2020). This was also evident in the generally low time spent foraging in the baboons at Dobra compared to those at Krumhuk that spend a lot of time looking for and handling their food. Baboons are known to alter their behavior by reducing or sacrificing other activities for instance social behaviors like grooming, playing to try and meet their energy needs by investing more time in foraging and feeding, which was a pattern that was observed in these troops (Marshall *et al.*, 2012).

The observed fighting could also be evidence that the baboons at Dobra had access to human processed food and may have led to frequent fighting as baboon are not known for sharing especially amongst male adults (Leith *et al.,* 2020). Furthermore, the manner these baboons responded to the presence of people was intriguing Baboons at both sites had a low time spend being vigilant as they spent close to zero time minutes being vigilant (see figure 18), although it has been shown that baboons assign a few individuals that act as guards while the troop feeds (Markham *et al.*, 2013).

The present study revealed that during the dry season when food sources are generally on a decline, baboons at Krumhuk spent a lot of time moving and searching for their food compared to those at Dobra that displayed the opposite. Chacma baboons at Dobra moved more during the wet season when food was plentiful but moved less in the dry season as they conserved their energy and took advantage of having more access to human food. This was also evident in the time of day these troops concentrated their feeding time. Gaynor, (1994) reported that baboon foraging strategies followed the central place foraging model where animals are expected to spend less time foraging when they travel less distances to their food sources, hence minimize energy spent. Such a foraging strategy was evident at Dobra as the nesting mountains were very close to the school which were all within a 1km radius as compared to the nesting mountains at Krumhuk which were at least 5km away. Lewis and O'Riain (2017) also reported that baboons that were living closer to human settlements and spend most of their time exploiting human derived food spend less time travelling and feeding. The baboons at Dobra fed more in the morning and relaxed and socialized in the afternoons. This may perhaps indicate that their energy needs were met earlier compared to those at Krumhuk, which generally had limited access to human food, hence fed more in the afternoons to ensure that they got enough energy before heading to their resting cliffs. Marshall, Carter, Rowcliffe, *et al.*(2012) showed that troop time budget is an emergent property of individual level decision making, and in an environment where animals satisfied their energy needs early the troops were found to spend less time foraging and vice versa.

Both troops at the Dobra and Krumhuk generally fed more during the wet season due to the high abundance of food and also relaxed due to a similar reason that less energy and time was required to find food and could afford to be more social. Chowdhury, Brown and Swedell (2021) found that troops in the Cape Peninsula’s time spent on feeding, moving and socializing all decreased from wet season when food was plentiful as more time was allocated to finding and handling food in the dry season.

Behavioral data in this study was recorded on an active bases, as in all behavior activities could only be recorded during the time of observations and were limited to the fifteen minutes each baboon was observed. The focal animal technique has its advantages as the researcher gets to see and associate specific behavior to specific individuals or even sex categories but it limits our understanding on the movements of these animals and does not give enough data on home range and distance traveled (Bosholn and Anciães, 2022). It can be supplemented by tracking techniques such as GPS tagging of individuals to track and identify troops and as well as remote sensing methods like the use of drones to properly follow and monitor individuals that may stray outside the viewing angle of a researcher using binoculars.

5.3 Raiding intensity

Baboons have been driven out of a significant portion of their historical range as a result of the conversion of natural land to agricultural and urban use (Warren, 2009; Pahad, 2010; van Doorn and O'Riain, 2020). However, the abundance of resources in the redeveloped areas still draws baboons back, leading to persistent levels of conflict across much of Africa, for instance chacma baboons have been raiding human-derived foods for more than 200 years in the city of Cape Town (Kaplan *et al.*, 2011; Fehlmann *et al.*, 2017; van Doorn and O'Riain, 2020). Raiding intensity is significantly influenced by the deterrent methods used to keep the raiding baboons away from a particular area (Fehlmann *et al.*, 2017). The present study found that there was no significant variation the time the baboons spent raiding across the seasons and between sites and the time of day (Figure 19). This uniform pattern of raiding activity across the seasons and sites could be due the opportunistic nature of the raiding behavior in baboons that they were able to avoid detection majority of the time. Most studies such as that by Pahad (2010) and Hill (2000) found that the frequency of raiding behavior did increase in the dry season as food availability lowered, and baboons raided specific crops from neighboring farms and the raiding behavior was found be significantly influenced by the proximity of the farms to the nature reserves and as well as the type of crops they grew as a high affinity for maize and beans was observed.

It seemed as if baboons at Dobra had a good understanding of their environment and the movement patterns of the learners around the school on a normal school day. The time baboons were found raiding the dormitories very much corresponded to the time the students were away from the dormitories. The focal sampling method, coupled with the fact that in this study sampling focused on the larger groups at a time to maximize data capturing, could have provided a loop hole in capturing these type of data. Van Doorn and O'Riain (2020) and Warren (2009) found that raiding was not always done in a group but fewer individuals especially males took the risk to raid human food especially when deterring measures were enforced. Segal (2008) concluded that raiding behavior was not necessarily the primary foraging method baboons would employ but rather an alternative mechanism to cope with increasing environmental pressures and low abundance of food during the dry season which could explain the very low occurrence of raiding behavior at Dobra and its absence at Krumhuk in the wet season. Farmers at Krumhuk protected their gardens very well with complete netting (fencing), had dogs on the farm and the employees were mostly present at the gardens resulting in an almost constant surveillance around the crops minimizing any chances of baboons raiding the gardens.

Many researchers have suggested that rising baboon-human conflict is caused by rapid urbanization, habitat destruction, environmental degradation and fragmentation (Kaplan *et al.*, 2011; Shannon, 2018; Slater, Barrett and Brown, 2018), but it is important to remember that humans have stabilized some of these areas where these animals would ordinarily not stay for very long. Roads serve as effective fire breakers, swimming pools provide as reliable water sources, and our refuse serves as a steady source of food (Nepstad *et al.*, 2001; Swedell, Hailemeskel and Schreier, 2008); the extent to which each of these influences these baboons may be examined to better understand these human baboon interactions. The focal animal method was good at capturing overall baboon behavior but also proved to generalize behavioral profiles of these baboons and maybe a complementary method is required which is more sensitive or could specifically target the raiding behavior.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study confirmed the current knowledge that chacma baboons have a broad omnivorous diet, feeding on both plant matter and invertebrates. Furthermore, as much as researchers thought chacma baboons are purely opportunistic generalist, as reported by other studies, this study also revealed that chacma baboons maintains their frugivory and folivory dominated diet profile, even when food resources varied across seasons. The diet of chacma baboons at Dobra and Krumhuk predominantly consisted of roots, stems and leave, fruits and seeds and invertebrates respectively. The diet of baboons remained the same across the wet and dry season but with variations between the sites, as baboons at Krumhuk fed more on roots, stems and leaves as compared to seeds and fruits and very little invertebrates, while those at Dobra fed more on fruits and seeds and invertebrates.

The baboon behavior was highly reactional to their environmental conditions, both at Krumhuk and Dobra. Variations were observed across seasons and site and as well as time of day at both study sites. The baboons at Krumhuk were more active in the afternoons while those at Dobra were more active in the morning time. Baboons at Dobra spent less time feeding and related behavior and more time resting and socializing whilst those at Krumhuk spent more time feeding and moving around and spent less time relaxing and socializing.

Baboon raiding intensity remained the same across season, time of day and as well sites. Raiding will continue to persist as a survival mechanism to cope with environmental pressures both natural and anthropogenic as baboons strive to survive in their habitats.

Anthropogenic derived food do not only present alternative food sources to these animals but also create stable environments for these animals to thrive.

6.2 Recommendations

The following recommendations are proposed for future research in order to (ultimately) better predict baboon behavior, their responses to environmental change, and the degree to which they interact (and compete) with humans;

1. Collect diet data using a method that will facilitate identification of contents of scats to species level where possible. It is important to document what baboons consumed and their respective diet composition. Such data will allow for more precise determination of their diet and assist to assess diet preferences. This would aid rangeland management.
2. Investigate the relationship between seasonal variation in the available food sources in the habitat of Chacma baboons and the diet composition. This information will contribute to understanding how chacma baboons utilize their home ranges to obtain their food.
3. Undertake radiotracking study of the behavior of chacma baboons. Satellite tracking of radio-collared baboons will provide data and information on home ranges and hence on how they utilize their habitats. Drones may also be used for such purposes. This is important for rangeland management.
4. Investigate the impact regular waste collection will have on raiding baboons by ensuring that the trash bins are emptied regularly to minimize the accumulation of food waste that might attract baboons.

5. Explore the impacts of using deterrents like motion activated alarms and sprinklers that can scare baboons away from the premises.

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APPENDIX

UNAM

ETHICAL CLEARANCE CERTIFICATE

Ethical Clearance Reference Number: SOS-0052 Date: 27 April 2022

This Ethical Clearance Certificate is issued by the University of Namibia Ethics Committee (REC) in accordance with the University of Namibia's Research Ethics Policy and Guidelines. Ethical approval is given in respect of undertakings contained in the Research Project outlined below. This Certificate is issued on the recommendations of the ethical evaluation done by the ethics committee.

Title of Project:	AN ANALYSIS OF THE DIETARY COMPOSITION OF WILD CHACMA BABOONS (PAPIO URSINUS SUBSP. RUACANA SHORTRIDGE) IN SELECTED AREAS AROUND WINDHOEK IN CENTRAL NAMIBIA
Student:	BERNHARD ZIGY MUKUVE MUKUVE
Student Number:	201303778
Supervisor(s):	PROF. JOHN MFUNE

Centre for Research Services

Take note of the following:

1. Any significant changes in the conditions or undertakings outlined in the approved Proposal must be communicated to the ethics committee. An application to make amendments may be necessary.
2. Any breaches of ethical undertakings or practices that have an impact on ethical conduct of the research must be reported to the ethics committee
3. The Principal Researcher must report issues of ethical compliance to the ethics committee (through the Chairperson) at the end of the Project or as may be requested by the ethics committee
4. The ethics committee retains the right to:

i) Withdraw or amend this Ethical Clearance if any unethical practices (as outlined in the Research Ethics Policy) have been detected or suspected,

ii) Request for an ethical compliance report at any point during the course of the research.

The ethics committee wishes you the best in your research.

____

Dr. Zivayi Chiguvare (Chairperson Ethics Committee)

____

Prof. Davis Mumbengegwi (Head, Multidisciplinary Research)

Figure 20: Ethical clearance certificate.

Table 4: Kruskal-Wallis Pairwise comparison of behavioral activities

Behavior 1	**Behavior 2**	**P-value**
Playing	Feeding	0.71
Fighting	Feeding	0.649
Playing	Scavenging	0.793
Playing	Moving	0.552
Playing	Vigilance	0.039*
Fighting	Grooming	0.935
Playing	Relaxing	0.71
Fighting	Relaxing	0.649
Playing	Fighting	0.999
Playing	Grooming	0.947
Playing	Foraging	0.947
Fighting	Foraging	0.935
Fighting	Scavenging	0.75
Fighting	Moving	0.467
Fighting	Vigilance	0.024*

Grooming	Foraging	0.999
Grooming	Scavenging	0.386
Grooming	Relaxing	0.064
Grooming	Feeding	0.077
Grooming	Moving	0.003*
Grooming	Vigilance	0.005*
Foraging	Scavenging	0.331
Foraging	Relaxing	0.017*
Foraging	Feeding	0.027*
Foraging	Moving	<.001*
Foraging	Vigilance	0.005*
Scavenging	Relaxing	0.563
Scavenging	Feeding	0.576
Scavenging	Moving	0.089
Scavenging	Vigilance	0.009*
Relaxing	Feeding	0.996
Relaxing	Moving	0.048*

Relaxing	Vigilance	0.011*
Feeding	Moving	0.074
Feeding	Vigilance	0.011*
Moving	Vigilance	0.021*

* Significant at 5% level

Table 5: Normality test, time across sites.

Tests of Normality

	Location	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Time_min	Dobra	.176	249	<.001	.848	249	<.001
	Krumhuk	.159	285	<.001	.876	285	<.001

a. Lilliefors Significance Correction

Table 6: Normality test, time across time of day.

Tests of Normality

	Time_of_day	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Time_min	Morning	.167	297	<.001	.865	297	<.001
	Afternoon	.163	237	<.001	.852	237	<.001

a. Lilliefors Significance Correction

Table 7: Normality test, time across seasons.

Tests of Normality

	Season	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Time_min	Wet	.152	260	<.001	.897	260	<.001
	Dry	.203	274	<.001	.820	274	<.001

a. Lilliefors Significance Correction

Table 8: Normality test, time across behavior.

Tests of Normality

	Behaviour	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Time_min	Vigilance	.385	3	.	.750	3	<.001
	Playing	.	2	.			
	Fighiting	.441	4	.	.630	4	.001
	Grooming	.240	42	<.001	.807	42	<.001
	Raiding	.180	32	.010	.877	32	.002
	Foraging	.165	79	<.001	.864	79	<.001
	Moving	.192	136	<.001	.864	136	<.001
	Feeding	.166	102	<.001	.865	102	<.001
	Relaxing	.156	134	<.001	.908	134	<.001

a. Lilliefors Significance Correction

Table 9: Normality test, Mass across food types.

Tests of Normality

	Food_Type	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Mass_Of_Food_Categori es	Root, stem and leaf	.131	46	.046	.882	46	<.00
	Fruit and Seeds	.186	46	<.001	.808	46	<.00
	Invertebrates	.324	46	<.001	.547	46	<.00
	Others	.149	46	.012	.864	46	<.00

a. Lilliefors Significance Correction

Table 10: Normality test, Mass across seasons.

Tests of Normality

	Season	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Mass_Of_Food_Categori es	Wet	.230	72	<.001	.793	72	<.001
	Dry	.271	112	<.001	.647	112	<.001

a. Lilliefors Significance Correction

Table 11: Normality test, Mass across sites.

Tests of Normality

	Site	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Mass_Of_Food_Categories	Dobra	.213	112	<.001	.785	112	<.001
	Krumhuk	.301	72	<.001	.606	72	<.001

a. Lilliefors Significance Correction

Table 12: Fruiting plant species observed being consumed by baboons at Dobra and Farm Krumhuk.

Dobra	Farm Krumhuk
Vachellia tortilis	*Cyperus* bulb
Willow sp	*Ziziphus mucronata*
Prosopis sp (debarked)	*Vachellia karroo*
Euclea pseudebenus	*Vachellia erioloba*
Vachellia erioloba	
Dactyliandra welwitschii	
Dichrostachys cinereal	
Senegalia hereoensis	