Diet and behavioural ecology in sacred chacma baboons: A case study at Lwamondo Hill in the Limpopo Province, South Africa.

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Declaration

I, **Rendani Mulaudzi**, hereby declare that this dissertation is my own unaided work. It is being submitted for the degree Master of Environmental Sciences to the University of Venda. The material herein has not been submitted for a degree or other degree to this or any other university.

Signature……………………………..

Date..8/8/2014…………………….

Abstract

The chacma baboons (*Papio ursinus*) are regarded as the most intelligent and successful cercopithecines in southern Africa. A 10-month study was carried out to provide data on the activity patterns, diet, ranging patterns and raiding behaviour of the 163-member troop of the sacred chacma baboons at Lwamondo Hill on the eastern foothills of the Soutpansberg Mountain range in Limpopo Province, South Africa. The sacred status of these baboons to the Lwamondo Hill human inhabitants distinguishes them from all other populations in southern Africa. The activity types and dietary data were collected in 15-minute intervals of scan sampling on an average of 5 consecutive days per month from February to November 2013, covering both wet and dry seasons. A total of 34 faecal samples were collected and analysed to complement the direct observation data. The GPS sample points were used to quantify the home range size and daily range length. A total of 40 questionnaires from four villages were administered to gather data on key aspects of raiding behaviour. In order to assess the degree of damaged crops, three quadrats (3x5m) were sampled, from a total of twelve fields (i.e. three per village) during the early crop season from October to November. Foraging behaviour (which includes feeding) range between 30.7-65.1%. Their overall diet composition was dominated by plant resources, contributing 67.8%. The baboons consumed a total of 58 plant species, where the top ten accounted for 74.6% of their overall diet. The overall home range size was 4.33 km^2 and average distance travelled was 3.1 km. Results from the actual crop field assessments suggest that, farms located at close proximity to the forest edge were most susceptible to crop damage by baboons. Data from questionnaires show that, while the sacred chacma baboons are regarded as crop-raiders at Lwamondo, they are not killed due to cultural taboos associated with them.

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CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Chacma baboons (*Papio ursinus*) are regarded as the most intelligent and successful cercopithecines in southern Africa (Estes, 1992). Due to their behavioural and dietary flexibility (Else, 1991; Whiten *et al*., 1991; Alberts and Altmann, 2006), they are capable of surviving in disturbed or transformed environments, such as agricultural areas (Forthman-Quick and Demment, 1988; Else, 1991; Segal, 2008).

Chacma baboons inhabit different types of habitats in southern Africa. In South Africa this includes the Soutpansberg Mountain range (De-Raad, 2012), the Drakensberg Mountain (Whiten *et al*., 1987; Byrne *et al*., 1990, 1993), the North-Eastern Mountain Sourveld (Marais, 2005), grassland, shrubland and woodland in south Gauteng Province (Anderson, 1981; Falls, 1993; Segal, 2008) and Coastal areas in the Cape Peninsula (Hoffman and O'Riain, 2011, 2012). They also occur in fairly extreme habitats such as the Okavango Delta in Botswana (Palombit *et al*., 2001; Beehner *et al*., 2005; Kitchen *et al*., 2005) and the Namib Desert in Namibia (Hamilton *et al*., 1978; Hamilton, 1985; Brain, 1992).

Chacma baboons feed on a wide variety of plant species, invertebrates and small vertebrates (Altmann and Altmann, 1970; Codron *et al*., 2006; Swedell *et al*., 2008; Hoffman and O'Riain, 2011). According to Slater and Du Toit (2001), they help to maintain the structure and function of an ecosystem as they play an important role in dispersing the seeds of woody plants (e.g. Henzi and Barrett, 2003). Due to their behavioural plasticity, they have become problem animals to humans, and are renowned for raiding crops as well as human dwellings (Anderson, 1981; Naughton-Treves *et al*., 1998; Hill, 2000; Segal, 2008).

Chacma baboons are large, diurnal, terrestrial Old World monkeys with a dog-like face (Estes, 1992). Their fur ranges from yellowish and grey to dark brown (Rowe, 1996). Adult males weigh an average of 20 kg and their body length can reach up to 765 mm. Adult females are smaller and weigh an average of 16 kg and have a body length of approximately 587 mm (Rowe, 1996). Chacma baboons live in multi-male and multi-female troops, which vary in size from 10 to 200 individuals (Henzi *et al*., 1997). Females remain in the same troop their entire lives; however, males disperse to neighbouring troops (Estes, 1992; Weingrill *et al*., 2000). In terms of sexual maturity, females and males are mature at around 38 and 60 months respectively. Females have an approximate 35 day oestrous cycle and develop a pink sexual swelling, with a preference to mate with the dominant or alpha male at the peak of their cycle (Rowe, 1996; Dunbar and Barrett, 2000).

The need to study the chacma baboons at Lwamondo Hill arose due to lack of knowledge about their diet and ranging behaviour in the eastern part of the Soutpansberg Mountain range. The most fascinating fact about the study troop is its "sacred" status to the Lwamondo Hill human inhabitants. It is believed that these baboons protected the Lwamondo Hill human inhabitants against their enemies during the tribal wars in the late 1800s. It is said that the baboons would bark angrily and loudly, while showering the enemies with stones, thus alerting the clan of any incoming intruders. Moreover, this troop played a vital role during a traditional ceremony known as "Thevhula". The "Thevhula" ceremony is an annual event to thank the ancestors for providing a good crop season. The process involves pouring traditional beer or "mufhoho", made from finger millet, on the ground. There is a mythical story that the role of the baboons in this ceremony is to harvest the finger millet used to brew "mufhoho'' or traditional beer. The term "Zwifho" (where the ancestors have rested and wherein people communicate with them) is also employed to praise the baboons at Lwamondo (Netshivhandane, A. pers. comm.). These attributes distinguish the Lwamondo chacma baboons from all other populations in southern Africa.

My study investigated the diet, activity, ranging and crop raiding behaviour of the 163-member troop at Lwamondo Hill in a both wet and dry season. In particular the aim was to determine whether the troop consumes a high diversity of food types and species during the dry season compared to the wet season and if so, does the pattern of activity and home range use in either season change?

1.2 Problem statement

There is a lack of knowledge about the past and present interrelationships between human cultures and baboons in their natural environment along the eastern part of the Soutpansberg Mountain range in Limpopo Province of South Africa. Despite some studies conducted on the baboons in the pristine western part of the Soutpansberg (De-Raad, 2012), the Lwamondo baboons occur and range in a highly transformed landscape, mainly commercial forestry, subsistence farming and small villages. In addition, the Lwamondo hill is relatively unaltered in certain areas as the hill and the baboons are sacred. The Lwamondo clan and the baboons have lived in close association for over one hundred years; however, there is some degree of human-wildlife conflict. Although the local people do not kill the baboons, there is a risk that a strong likelihood for human-baboon conflict may lead to scenarios where baboons are no longer coexisting with local communities because of the closeness of baboons to human settlements. This study seeks to bridge the gap that exists between the baboons and communities in Lwamondo area in an effort to help societies relate to how scientific and indigenous knowledge about baboons positively impact on their livelihoods and on future generations; as such the intention was to establish behavioural and dietary relationships, with particular reference to both a wet and dry season.

1.3 Objectives

1.3.1 General objective

- ❖ To provide an insight on the activity patterns, dietary composition, ranging patterns and raiding behaviour of the sacred chacma baboons in both a dry and wet season at Lwamondo Hill in Limpopo Province, South Africa.

1.3.2 Specific objectives

- ❖ To determine the activity and ranging patterns of the baboons during the wet and dry season.
- ❖ To examine their dietary composition during the wet and dry season.
- ❖ To assess raiding behaviour during the wet and dry season.
- ❖ To determine what the impact of the sacredness status of the baboons has on the attitudes of farmers towards crop damage and damage from raiding.

1.4 Research hypotheses

- ❖ The troop uses more of its home range during the dry season compared with the wet season, thus increasing its habitat use.
- ❖ Baboons' diet preferences depend on the availability of food resources. Therefore, they consume a larger variety of food types in the wet season when food resources are abundantly available compared to the dry season, when food resources are scarce.
- ❖ Baboons raid cultivated and stored agricultural resources more frequently, when food resources are scarce.

1.5 Justification of the research

Baboons have been extensively investigated in Uganda, Kenya and Tanzania (e.g. Barton *et al*., 1992; Altmann, 1998; Strum, 2010). Despite many studies on the ecology of chacma baboons in the Drakensberg of South Africa (e.g. Henzi *et al*., 1992), and the Cape Peninsula (Davidge, 1978; Hoffman and O'Riain, 2011); there is a need to study baboon ecology along the eastern part of the Soutpansberg Mountain in Limpopo Province, as no studies have been conducted on the sacred chacma baboon or Lwamondo Hill Troop in this area.

There is a wide communication gap between the older human generation of the community who possess knowledge, and the younger generation to whom it should be transferred. The only means of transferring this knowledge has been through oral communication from generation to generation. Therefore, unless this knowledge is documented timeously, it is bound to be lost forever. The documentation of all information with reference to sacred baboons is important in the history of the Lwamondo Hill human inhabitants because it forms an integral part of their legacy.

1.6 Contents of the thesis

- Chapter one explains the background to the study, problem statement, research hypotheses and justification.
- Chapter two is the comprehensive review of literature on crucial aspects of diet, activity patterns, ranging patterns and raiding behaviour of baboons (*Papio spp.*) distributed throughout Africa.
- Chapter three gives an overview of the study area with particular reference to the location, climate, fauna and flora of Lwamondo Hill.
- Chapter four has a detailed description of the methodology used as well as the data analysis.
- Chapter five gives results on activity patterns, dietary composition, ranging patterns and raiding behaviour.
- Chapter six comprises the discussion, conclusion and recommendation.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The behaviour and ecology of baboons (*Papio spp.*) has been widely studied in various parts of the African continent. Available data refer mostly to the species in East Africa e.g. olive baboons (*Papio anubis*) in Uganda and Tanzania (Barton *et al.*, 1992; Naughton-Treves, 1998; Hill, 2000, 2005; Okecha and Newton-Fisher, 2006), yellow baboons (*Papio cynocephalus*) in Kenya (Altmann and Altmann, 1970; Post, 1982; Strum, 1987, 1994, 2010; Bronikowski and Altmann,1996), hamadryas baboons (*Papio hamadryas*) in Ethiopia (Kummer, 1968; Swedell *et al.*, 2008) and chacma baboons (*Papio ursinus*) in southern Africa (Anderson, 1981; Hamilton *et al.*, 1978; Henzi *et al.*, 1992; Kansky and Gaynor, 2000; Hill *et al.*, 2003; Brown *et al.*, 2006; Van Doorn *et al.*, 2010; Hoffman and O'Riain, 2011).

The aim of this chapter is to give a comprehensive literature review on crucial aspects of diet composition, activity patterns, ranging patterns and raiding behaviour of baboons (*Papio spp.*) across Africa.

2.2 Diet

Chacma baboons are described as omnivorous and opportunistic, which means that they will eat almost anything and adapt their diets to the changing environment they live in. Their diet includes a combination of fruit, flowers, leaves, seeds, pods, roots, corms, rhizomes, tubers and bulbs from many types of plants as well as invertebrate and small vertebrate animals (Hall, 1962; Altmann and Altmann, 1970; Norton *et al.*, 1987; Whiten *et al.*, 1987, 1991; Altmann, 1998). Due to their flexibility and commensalism, baboons also feed on human-derived foods, in particular agricultural products and human food waste, and have been reported to raid farms, households and picnic areas (Altmann and Muruthi, 1988; Forthman-Quick and Demment, 1988; Hill, 2000; Kansky and Gaynor, 2000; Van Doorn *et al.*, 2010; Hoffman and O'Riain, 2012).

Moreover, due to their strength, baboons are able to extract underground growths which are more difficult for smaller monkeys to feed on (Hamilton *et al.*, 1978; Swedell *et al.*, 2008). They exploit underground plant parts such as corms, bulbs and rhizomes that require skill to manipulate (Post, 1982). In the Cape Peninsula of South Africa, baboons feed on shellfish, including mussels, limpets and crabs (Davidge, 1978; Hoffman and O'Riain, 2012).

While showing high dietary diversity and flexibility, baboons are extremely selective in their diet choices. Their diet selection is largely related to nutrient composition. Patterns of diet selection in baboons are determined by a vast array of food constituents, including protein, lipids, fibre and potential toxins (Whiten *et al.*, 1991; Barton and Whiten, 1994; Altmann, 1998). According to Barton and Whiten (1994), high protein to low fibre ratio is the main factor influencing the level of diet selection in baboons.

In the Mikumi National Park, Tanzania, baboons showed preference towards certain species, when food was abundant (Norton *et al.*, 1987). Post (1982) found that baboons were highly dependent on reliable food sources, including the gum and dried seeds of *Acacia xanthophloea*, and the fresh pods of *Acacia tortilis* in the Amboseli National Park, Kenya. In addition, *A. xanthophloea* was consumed frequently throughout the year. These results are supported by Altmann (1998) who found that eleven yellow baboons (*P. cynocephalus*) were selective omnivores due to their dietary flexibility.

Barton and Whiten (1994) did their research on the eastern edge of the Laikipia Plateau in central Kenya and concentrated on the food selection by olive baboons (*P. anubis*) with specific emphasis on factors underlying their selectivity. They found that biomass availability has a strong influence on baboon food choices, and that chemical composition does play a significant role in shaping the diets of baboons in Laikipia Plateau. Okecha and Newton-Fisher (2006) studied the diet of olive baboons (*P. anubis*) in the Budongo Forest Reserve, Uganda and provided some evidence that baboons show considerable selectivity in food items they eat. These baboons were recorded feeding on species that were patchily distributed, including fruits of *Boswellia papyrifera*, *Celtis durandii*, *Ficus spp*; and seeds of *Ricinodendron heudelotii*. It was evident that most of the species preferred by baboons were patchily distributed (e.g. Newton-Fisher *et al*., 2000).

Diet and foraging behaviour in baboons was researched by Hill and Dunbar (2002), focusing on the data from 15 baboon populations in order to assess the relationship between foraging variables and dietary composition. Results showed that baboon populations consumed high proportions of fruits, leaves and subterranean items, with flowers, and animal matter accounting for a smaller proportion of their diet (e.g. Kummer, 1968; Harding, 1976; Whiten *et al*., 1991; Gaynor, 1994). Moreover, the study found that baboons exploited subterranean food items when fruits and seeds were less abundant (*inter alia* Post, 1978; Whiten *et al*., 1987).

Nutritional constraints on two groups (low and high altitudes) of mountain baboons (*Papio ursinus*) were examined in the Drakensberg Mountains of South Africa by Byrne *et al.* (1993) and showed seasonal differences in plant species eaten by each group. The study further argued that population density is much lower at higher altitude due to low food availability. The results are similar to those recorded by Whiten *et al.* (1987). Similarly, Henzi *et al*. (1992) observed that different baboon food resources were less abundant and patchily distributed at high elevations.

In the Suikerbosrand Nature Reserve of South Africa, Segal (2008) recorded a wide variety of plant materials (root, stem and leaf) during the early rainy season compared to the dry and late rainy seasons. The fruit of the buffalo thorn tree, *Ziziphus mucronata* was heavily consumed during the dry season. Additionally, Anderson (1982) also reported that plant material proportion was significantly higher in the overall diet of the Suikerbosrand Nature Reserve population. Seasonal patterns of the overall diet suggested that baboons were less selective in their diet during the dry season when the availability of food resources is low.

The ecology of chacma baboons has been studied in the North-eastern Mountain Sourveld region of Mpumalanga Province in South Africa. Marais (2005) investigated resource utilisation of chacma baboons in different vegetation types in this region in the Blyde Canyon Nature Reserve. Results revealed that baboons showed an overall preference for woody plants, regardless of season; whereas herbs and grasses were available in dry season. Due to a decline in the availability of fruit (*Ziziphus mucronata* and *Syzygium legatii*) and flowers (*Chamaecrista mimosoides*, *Hemizygia transvaalensis* and *Hemizygia parvifolia*), baboons increased their consumption of pods (*Acacia ataxacantha*) and roots (*Crotalaria doidgeae*) in the dry season.

Seasonal changes have significant influence on the availability of natural resources which is a crucial factor in diet preference by baboons (Alberts *et al*., 2005). Thackery *et al.* (1996) found a positive correlation between the intake of grasses and regional grass biomass in various environments in southern Africa. Information on inter- and intra-habitat dietary availability of chacma baboons in South African Savannas is reported by Codron *et al.* (2006), and showed that there were no changes in baboons' preferred food throughout the seasons.

Hall (1963) recorded 94 different species consumed by the chacma baboons in the Cape Peninsula of South Africa. In addition, the Cape Peninsula baboons supplement their diet by eating shellfish found along the coast. In other wild foraging baboons in the Cape Peninsula, Davidge (1978) revealed that baboons ingested high proportion of annual flowering plants (i.e. grasses) in winter compared to the high proportion of fynbos consumption in summer. Similar results were reported by Van Doorn *et al.* (2010) who found that baboons consumed a high proportion of alien plants species (acacia, pine, eucalyptus) and fynbos during the summer season; however, the consumption of underground storage organs was significantly higher in the winter season.

Hoffman and O'Riain (2011) recently did research on the spatial ecology of chacma baboons in a human-modified environment in the Tokai region of the Cape Peninsula. The study noted that grasses played an important role in the survival of the Tokai troop during the winter season compared with summer, thus accounting for nearly 50% of their diet. Seasonal comparison in consumption of pine nuts, leaves and fruit reveals that there were no significant seasonal differences.

2.3 Activity pattern

Different environmental factors such as rainfall and temperature act in varying ways to shape the time budgets of baboons (Bronikowski and Altmann, 1996) and factors such as group size, habitat type and resource availability influence time spent foraging (Altmann, 1974; Barton *et al*., 1992; Dunbar, 1992a). Studies have found that baboons in lower-quality habitats, including the highly seasonal Drakensberg Mountains of South Africa spend more time in feeding and foraging (e.g. Henzi *et al*., 1997). In support of this, studies in higher-quality habitats, including the fertile swamps of the Okavango Delta in Botswana, suggested that baboons spend more time in socialising and moving (*inter alia* Whiten *et al*., 1987; Bronikowski and Altmann, 1996). Dunbar (1996) also argued that time spent socialising is influenced by relative abundance of food, distribution of food and group size. It was also suggested that baboons use resting time for physiological processes, including digestion (Dunbar, 1992b).

Models have been proposed to explain time budgets for primates (*inter alia* Schoener, 1971) in particular for baboons (Dunbar, 1992b; Williamson and Dunbar, 1999). Schoener (1971) reported that the model proposed serves as an explanation for examining primate foraging strategies. The model argued that there are two strategies adopted by primates in foraging: time-minimising and energy-maximising strategies. The time minimising strategy has been observed in primates that spend less time foraging in order to reach their energy needs, for example geladas, macaques, and mangabeys (Barton *et al*., 1992; Gaynor, 1994; Iwamoto and Dunbar, 1983; Menard and Vallet, 1997). Lemurs and vervet monkeys are characterised as energy maximisers because they spend more time in foraging regardless of food availability (Harrison, 1985; Vasey, 2005). Gaynor (1994) suggested that baboons are time minimisers, however, due to their flexibility; they become energy maximisers during periods of low food availability (*inter alia* Hill *et al*., 2003, 2004).

Dunbar (1992b) used a cross-population model to explain the time budget for baboons, which was later improved by Williamson and Dunbar (1999). The parameters used were the relationship between the proportions of time spent on feeding, moving, resting and socialising, day journey length, mean annual rainfall (mm), Simpson's index of rainfall evenness, the number of dry months and mean annual temperature (Williamson and Dunbar, 1999).

Several studies have revealed that different variables play an influential role on how baboons spend their time (e.g. Williamson and Dunbar, 1999). A study on foraging time budgets in baboon population was conducted by Williamson and Dunbar (1999). The results showed that rainfall, temperature and day journey length were the most influential parameters in shaping the time budget.

Meanwhile, a study by Hill (1999) suggested that foraging time was influenced by temperature and day journey length. Bronikowski and Altmann (1996) found that rainfall and temperature play a large role in foraging time in yellow baboons, *P. cynocephalus* at Amboseli National Park in Kenya. Moreover, results revealed that time spent in resting was related to foraging time, but the study also showed that baboons spent more time resting when daily maximum temperatures are high (Bronikowski and Altmann, 1996).

In the Drakensberg Mountains of South Africa, Henzi *et al.* (1992) studied two chacma baboon troops. They found that time spent moving is influenced by rainfall, temperature, altitude, and group size parameters. Hill *et al.* (2003) did their research on the behavioural patterns of chacma baboons in a temperate environment at De Hoop Nature Reserve, Western Cape Province of

South Africa and concentrated on the impact of day length and climatic parameters on seasonal patterns of activity. They found that day length is an important factor for seasonal variation in behavioural activities and that latitude plays a significant role in resting time. Hill *et al.* (2003) observed a minimal increase in feeding time during summer compared with winter.

The effects of extreme seasonality of climate and day length on the activity budgets of semi-commensal chacma baboons were researched in the Cape Peninsula of South Africa by Van Doorn *et al.* (2010). The study found that baboons increase feeding and socialising time during the long summer days compared with short winter days. Results are similar to those recorded in wild foraging De Hoop troops (Hill, 1999; Hill, *et al*., 2003) and it was concluded that feeding time is related to day length and rainfall parameters in the Cape Peninsula compared to most other temperate regions in Africa (Van Doorn *et al.,* 2010). Activity budgets in commensal and wild foraging baboons have been researched by Altmann and Muruthi (1988) and showed that food-enhanced baboons significantly reduce travelling and feeding time and increase time spent resting and socialising.

Strum (2010) provided information on activity budgets of two baboon troops, raiders and non-raiders on Kekopey Ranch near Gilgil, Kenya. The study was part of a long-term research project (e.g. Strum, 1975; Harding, 1976) and revealed that raiders spent more time resting and socialising, and there was a positive correlation between feeding and socialising during a low biomass season. Stacey (1986) suggested evidence that there is a positive relationship between group size and foraging efficiency in members of three different-sized groups of yellow baboons (*P. cynocephalus*) in Amboseli National Park, Kenya and showed a significant difference in feeding activity within the groups. Shopland (1987) argued that foraging in groups increased competition for scarce food resources in yellow baboons (*P. cynocephalus*); however, Altmann (1998) reported that social foraging increases knowledge on resources availability and vigilance against predators resulting from cooperation.

Silk (1987) highlighted that yellow baboons (*P. cynocephalus*) in Amboseli National Park, Kenya spent more time foraging on grass, blades, leaves and flowers during periods of low food availability, but they reduced foraging time on fruit and tubers. Pochron (2005) provided compelling evidence to support this and showed that yellow baboons in Ruaha National Park, Tanzania, spent more time foraging on food types with higher energy gain.

The influence of day length and season are critical to baboons living in southerly latitudes, e.g. the Cape Peninsula of South Africa. In this region baboons are forced to consume more food during the short winter days in order to meet their energy requirements (e.g. Van Doorn *et al.*, 2010). Hoffman and O'Riain (2011) noted that there was no significant difference in foraging time between winter and summer seasons for the Tokai troop observed during their study in the Cape Peninsula. However, the Tokai troop spent more time travelling, resting and socialising in the longer summer days than in winter (Hoffman and O'Riain, 2011). A study on resource utilisation on the Blyde Canyon Nature Reserve baboons was conducted by Marais (2005). Results revealed that resources availability and distribution are influential factors on the time spent foraging and 61% of the overall activity budget was allocated to foraging activity.

2.4 Ranging Pattern

Group size and habitat use factors have been shown to influence the ranging patterns in baboons (Barton *et al.*, 1992; Hoffman and O'Riain, 2012). Shopland (1987) argued that spatial locations of resources including food (Altmann, 1974, 1998; Barton *et al.*, 1992; Henzi *et al.*, 1992), water (Altmann, 1974, 1998; Barton *et al.*, 1992; Hoffman and O'Riain, 2011) and sleeping sites (Altmann, 1970; Anderson, 1984, 1998, 2000), dictate ranging patterns. In a study on predation risk in a desert baboon population, Cowlishaw (1997a) noted that the degree of predation risk is another important factor that affects home range size and daily ranging in baboons (Cowlishaw, 1997b; Hill and Cowlishaw, 2002).

Home range estimation has been reported using methods such as the minimum convex polygon (MCP); however, some studies argued that the MCP method over-estimate home range size (Getz *et al*., 2007; Boyle *et al*., 2009). The MCP method is however used by many researchers investigating home range and habitat use in primates, e.g. orangutans, *Pongo pygmaes* (Wartmann *et al*., 2010); mountain gorilla, *Gorilla beringei* (Robbins and McNeilage, 2003); lemurs, *Indri indri* (Glessner and Brit, 2005); baboons, *Papio ursinus* (Henzi *et al*., 2011).

Altmann (1974) predicted that seasonal differences in home range size and daily range are inversely proportional to resource availability, thus baboons require larger home ranges when food resources are less abundant. Wahungu (2001) pointed out that seasonal changes and food availability influence daily paths in yellow baboons (*P. cynocephalus*) at Tana River in Kenya. Results revealed that baboons spent significantly more time foraging in the wet season when natural fruits are abundant in the forest and travelled approximately 3.4 km, however, during the dry season when food resources were scarce, baboons showed a dramatic increase in the daily path, travelling about 7.2 km.

Ranging patterns of hamadryas baboons (*P. hamadryas*) have been examined by Schreier and Grove (2010) who found that the average home range was 38.6 km^2 at Filoha in Awash National Park, Ethiopia. The mean daily path length was primarily influenced by cliffs (sleeping sites), with mean daily path lengths for troops of 49, 29, 12 and 15 individuals being 7.2 km, 9.6 km, 9.3 km and 8.0 km respectively (Schreier and Grove, 2010).

Sharman (1981) investigated feeding, ranging and social organisation of the guinea baboon (*Papio papio*) in south-eastern Senegal. Results showed that there were no significant differences in daily range length during the dry and wet seasons, and sleeping sites were influential on the ranging patterns of the guinea baboons. In addition, the distribution of water sources had an impact on choices of sleeping sites regardless of season. However, contrary to the guinea baboons, it has been reported that mature fruits and seeds size influenced the daily range lengths of olive baboons (*P. anubis*) in the Comoe National Park, northern Ivory Coast (Kunz and Linsenmair, 2007).

Hamilton *et al.* (1976) conducted a study on the desert troops in the Kuiseb River Canyon, Namibia. Results indicated that group size and altitude are not related in this region. Variation in water supply and food abundance was responsible for an increase in density of baboon troops in the Okavango Delta, Botswana (Hamilton *et al.*, 1976). Hoffman and O'Riain (2012) reported that there are two principal factors which influence the ranging patterns of chacma baboons (*P. ursinus*) in the Cape Peninsula of South Africa: the troop size and habitat use. The study found that larger troops have large home range sizes and increased day journey lengths. Similarly, DeVore and Hall (1965) studied ecology and behaviour of chacma baboons in the Cape of Good Hope Nature Reserve, South Africa. The study revealed that home range size was correlated with troop size, and home ranges varied between 9.1 and 33.7 km^2.

In the Limpopo Province of South Africa, Stoltz and Saayman (1970) found that availability of water and seasonal variation increased home range size. Anderson (1982) found a mean home range size of 24.6 km^2 for the approximately 78-member troop at the Suikerbosrand Nature Reserve in Gauteng Province, South Africa. This pattern is similar to the troops in the Drakensberg Mountains of South Africa (Whiten *et al.*, 1987) that also have low population density at higher altitude due to food limitations. The home ranges recorded at high and low altitudes were 18.9 and 10.0 km^2 respectively. Stone *et al.* (2013) reported data on the first quantitative and detailed distribution of chacma baboons (*P. ursinus*) across southern Africa. The results from the environmental envelope model projected that chacma baboons are likely to inhabit 3 600 000 km^2 of the entire sub-continent. It is important to note that the model further indicates that South Africa, is predicted to cover an estimated 1 100 000 km^2.

Climatic variables such as temperatures have been reported to be responsible for habitat selection in baboons (Hill, 2005). In addition, a study by Noser and Byrne (2007) at the Blouberg Nature

Reserve on the eastern foothills of the Blouberg Mountain in Limpopo Province, suggested that chacma baboons started their day journeys earlier during the days of higher temperatures, i.e. 40°C. De-Raad (2012) investigated travel routes and spatial abilities in wild ranging chacma baboons at Lajuma Research Centre in the western part of Soutpansberg Mountain range of South Africa, and showed that an increase in annual home range area estimation is influenced by the time interval and the length of the study period. A study by Hoffman and O'Riain (2012) in the Cape Peninsula of South Africa indicated that low altitudes and human-modified habitats were the two key landscape features influencing baboon occurrence and abundance patterns.

2.5 Raiding behaviour

2.5.1 Crop raiding

Crop raiding by wildlife is a growing problem in Africa and has gained little attention particularly in subsistence farming (Hill, 1997). Over the past decade, a number of authors have proposed models to explain this phenomenon (*inter alia* Sillero-Zubiri and Switzer, 2001). Due to increasing human population and expansion of cultivated land to natural habitat containing wildlife, crop raiding is perceived as the driving factor which leads to human-wildlife conflict (Strum, 1987, 2010; Hill, 2000).

Warren (2003) pointed out that several studies have indicated that baboons are responsible for human-wildlife conflicts throughout Africa. Gautier and Biquand (1994) reported that baboons are successful crop raiders because they possess attributes such as behavioural, social and dietary flexibility, and a broad habitat tolerance. Else (1991) argued that primates, including baboons are good crop raiders because of their intelligence. While the main primates for raiding crops are baboons, other primates such as redtail monkeys (*Cercopithecus ascanius*), vervet monkeys (*Chlorocebus aethiops*) and chimpanzees (*Pan troglodytes*) are also responsible for crop raiding especially in East Africa (Naughton-Treves, 1997; Naughton-Treves *et al.*, 1998). Few studies have found that baboons raid free-ranging livestock in land adjacent to protected areas (*inter alia* Butler, 2000; Holmern *et al.*, 2007).

Hill (2005) reported that farmers have developed manpower based techniques to tackle crop raiders. The most common method that is traditionally used to prevent crop raiding is to chase the raiders away from crop fields (Hill, 2000); however, Byamukama and Asuma (2006) noted that guarding crops against crop raiders is a common practice in many parts of Africa. The raiding behaviour of olive baboons (*P. anubis*) has been extensively studied around the forest reserves of Kibale National Park and Budongo Forest Reserve, Uganda (Naughton-Treves, 1998; Naughton-Treves *et al*., 1998; Hill, 2000). Naughton-Treves *et al*. (1998) also reported that olive baboons were responsible for damaging the greatest area of crop fields around Kibale National Park. The cultivated crops that were vulnerable to damage were maize, sweet potatoes and groundnuts. Crop raiding frequency was at its peak about eight weeks after the rainy period, but maize crops were damaged throughout their life cycle (Naughton-Treves, *et al*., 1998).

Naughton-Treves (1997) reported that crop losses to olive baboons were within 200 m from the edge of the park around Kibale National Park. In a study on the edge of Budongo Forest Reserve in Masindi District, Uganda, results showed that the most commonly grown carbohydrate sources such as maize, cassava, sweet potatoes, beans and groundnuts are susceptible to raiding by wildlife (Hill, 2000). Naughton-Treves *et al.* (1998) argued that primates including redtailed monkeys (*Cercopithecus ascanius*), olive baboons (*P. anubis*) and chimpanzees (*Pan troglodytes*) selected different crops or plant parts. These results have been revealed in a 23-month field study of three primates carried out from four villages around Kibale National Park, Uganda.

Warren (2008) examined the crop-raiding behaviour of a group of habituated baboons near the village of Gashaka on the south-western border of Gashaka Gumti National Park, Nigeria. The study showed that maize was the most frequently raided crop. Similarly, a high level of maize consumption has been reported in many studies (*inter alia* Forthman-Quick and Demment, 1988; Else, 1991; Naughton-Treves *et al*., 1998; Hill, 2000). Strum (2010) discussed the development of baboon raiding at Kekopey Ranch, Gilgil in Kenya and suggested that baboons raid human foods because they were easier to process and digest. The study showed that raiding baboons were faced with three challenges, namely people, avoiding injury and learning new foraging strategies.

Livestock predation by baboons has been reported in Gokwe communal land, Zimbabwe by Butler (2000). Results revealed that chacma baboons were responsible for 52% of the livestock (young goats and sheep) killed in the area. Holmern *et al.* (2007) found that yellow baboons were responsible for 0.4% of livestock killed in villages adjacent to the Serengeti National Park in Tanzania. However, Kolowski and Holekamp (2006) did not record any livestock killings by baboons in areas around the Masai Mara National Reserve, Kenya.

Strum (2010) suggested that traditional control techniques, like guarding and chasing can be successful when raiding is treated as a foraging strategy (e.g. Osborn and Hill, 2005). Several studies have recommended different ways to minimise the costs of raiding by wildlife (e.g. Strum, 1994; Naughton-Treves, 1998). According to Strum (1994) guarding is regarded as the most successful strategy for limiting crop damage in many parts of East Africa. In Nyabyeya Parish, Uganda, it was demonstrated that guarding is labour intensive (Strum, 1994).

In the Cape Peninsula of South Africa, several male raiders have been killed as a result of raiding. This method had an immediate effect because the baboons were killed in full view of the troop (Pers. obs.). However, the long-term effectiveness of this shooting method has yet to be demonstrated (e.g. Treves and Naughton-Treves, 2005). A modern variant of the traditional guarding/chasing approach known as "baboon monitoring" is currently implemented in the Cape Peninsula of South Africa. The City of Cape Town, CapeNature, SANParks and various private stakeholders employ baboon monitors to protect residential areas from known baboon raiders (Pers. obs.; Kansky, 2002; Van Doorn, 2009, Hoffman and O'Riain, 2011).Western *et al.* (1994) argued that the most effective approach to human-baboon conflict was by engaging the community, thus Community Based Conservation.

2.6 Sacred primates and possible conservation benefits

One of the findings made by Sosis and Alcorta (2003), in the study of religious evolution, is that there is an association of belief in supernatural agents with religion. The suggestion is, therefore, that belief in ancestral gods is significantly influenced by socioecology (Roes and Raymond, 2003). A particularly clear example is shown by the Arunta hunter-gatherers of Australia. Studies have found that religious ritual is associated with sacredness (Douglas, 1966; Durkheim, 1969; Rappaport, 1999). Additionally, Rappaport (1999) pointed out that sacred things are transformed through ritual. It has been reported that animal such as primates display ritual signals which play a pivotal role in communicating with humans (Rowe, 1999; Rogers and Kaplan, 2000).

Hinduism has been characterised as consisting of numerous gods, however, it is important to note that there are many religious rituals which grant primates with moral considerations as humans. In Hinduism religion, Wolfe (2002) pointed out that Hanuman langurs or monkey gods are considered sacred by many Indians. These monkeys constitute prominent elements, including faithfulness, obedience and devotion. Although monkeys are often agricultural pests and impose considerable crop losses, Pirta *et al.* (1997) noted that religious attitudes promote conservation and protection of the primates.

In Nigeria, Baker *et al.* (2009) found that taboos play a vital role in the protection of the sacred monkeys, Sclater's guenon (*Cercopithecus sclateri*). Despite the various kinds of problems the sacred monkeys cause to local people, including crop damage, they were not killed owing to religious doctrines associated with them. Furthermore, the context provided by the above study, promotes long-term conservation and possible future survival of the *Cercopithecus sclateri*.

Saj *et al*. (2006) discussed the importance of traditional taboos and suggested that they play a pivotal role in the conservation of two species of primates (the ursine black and white colobus, *Colobus vellerosus*, and the campbell's monkey, *Cercopithecus campbelli lowei*) in Boabeng, Central Ghana. The hunting and killing of these primates are prohibited because the local communities regard them as gods who protect their villages.

2.7 Conclusion

Although the diet and behavioural ecology of the baboons have been studied in the past, most studies concentrated on East Africa, the Drakensberg Mountains in South Africa, the Cape Peninsula of South Africa and few were conducted in the Soutpansberg Mountains range of South Africa, which is one of the biodiversity hotspots in southern Africa (De-Raad, 2012). However, for chacma baboons in particular, there is insufficient information about the diet, activity and ranging patterns along the Soutpansberg Mountains, Limpopo Province. More studies are needed in areas where baboons and humans co-exist and conflict might likely arise. In an era where human population growth has led to encroachment into wildlife habitats, we will have to deal with human-wildlife conflict more often in the future. Research into the latter is vital for the future co-existence of humans and wildlife. There is good evidence to suggest that because of the sacredness of the baboons, in the area of this study events such as crop raiding do not result in killing of the baboons.

CHAPTER THREE: STUDY AREA

3.1 Introduction

Lwamondo forms part of the recently established UNESCO'S Vhembe Biosphere Reserve (VBR). The Vhembe Biosphere Reserve is widely recognised internationally because of its wildlife, combined with its unique biological and cultural diversity in Limpopo Province (Berger *et al*., 2003). Due to its high levels of biodiversity in terms of the number of different and endemic species, the reserve covers two major centres of biodiversity and endemism, namely the Soutpansberg and Blouberg. In addition, the reserve also includes a wide array of provincial nature reserves, the northern part of the Kruger National Park, the Mapungubwe National Park and World heritage site (UNESCO, 2009).

3.2 Locality of the Study Area

The study took place at Lwamondo Hill (80 ha), located in the eastern part of Soutpansberg Mountains in the Limpopo Province, South Africa (23°02'26''S. 30°20'04''E). The Lwamondo Hill is situated approximately 10 km off the R524 road that links Thohoyandou and Makhado towns (Figure 1). It is approximately 68 km east of Makhado and 18 km west of Thohoyandou. The topography of the study area is mountainous with cliffs and valleys. The altitude ranges from 873-1099 m asl and the study area is surrounded by four villages (Belemu, Tshiema, Tshiozwi and Tshivhale), farmlands and commercial pine plantations. People who reside in this area are dependent on subsistence farming as their main source of livelihood.

The people of this area, the Lwamondo clan, are an amalgamation of the Vhalaudzi of Tshimudi and Gwamasenga. According to the oral history, the Vhalaudzi of Tshimudi, led by Tshilande, settled at Lwamondo in the late 1800's. When Tshilande died, his son, Mapungwi took over the leadership. It appears that two of Mapungwi's sons, Radali and Randuhu battled for the throne, and Radali succeeded to become the new chief of Lwamondo. In order to emphasise that he was the chief of Lwamondo, Radali changed his surname to Nelwamondo. When Radali died he was succeeded by his son, Mathule. After the death of Mathule, one of his sons, Maboho, was confirmed as the rightful heir by the family. Divisions amongst the Lwamondo people increased steadily after the death of Maboho, with Maboho's two sons, Phophi and Raidimi fighting for the throne. Although Phophi was younger than Raidimi, he was more powerful and had significant support from the Lwamondo people. Lupenyo Mugaguli took over the throne after Phophi's death. The incumbent paramount chief, Aifheli Nelwamondo, was declared as the throne heir in 1971, after the death of his father, Lupenyo Mugaguli Nelwamondo in 1970 (Netshivhandane, A., Pers. comm.).

The Lwamondo people are familiar with some Venda cultural dances such *tshikona* and *domba*. Oral communication findings show significant positive associations between the tshikona dance and the sacred baboons. It has emerged that during the *tshikona* dance, one young male is dressed in skins from the baboons. Moreover, a number of outsiders believed baboons are responsible for beating the drums during the *tshikona* dance (Nelwamondo, P., Pers. comm.).

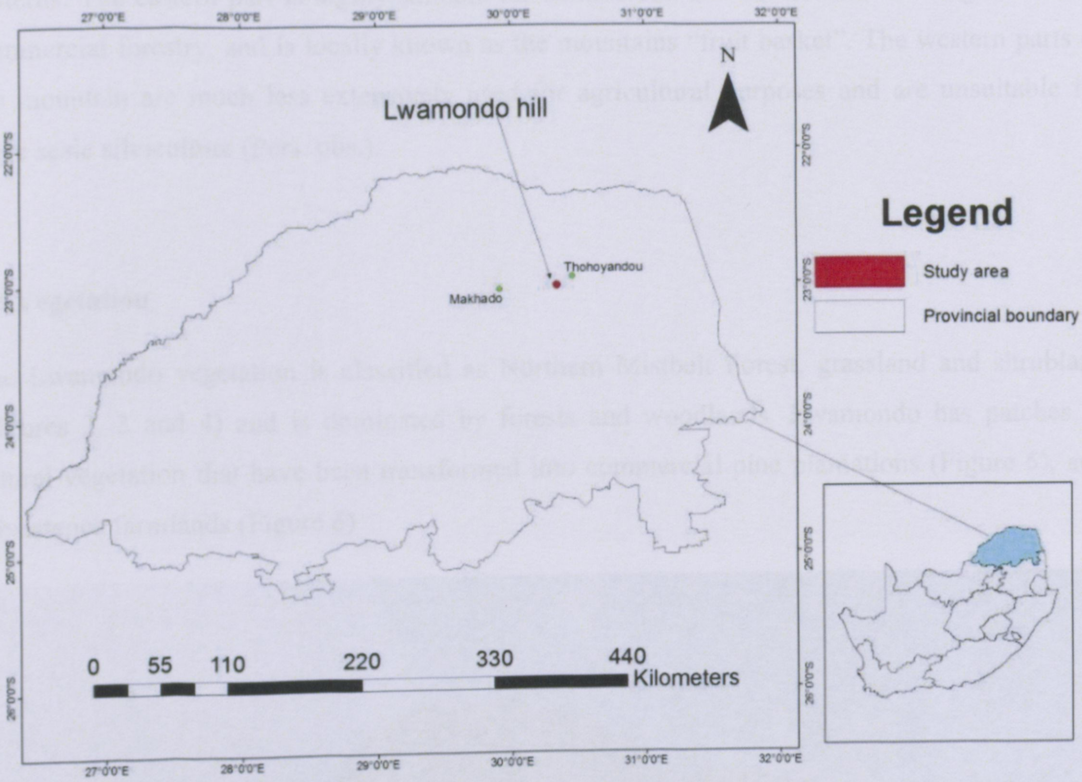

Figure 1. Location of the study area, Lwamondo hill in the Limpopo Province, South Africa.

3.3 Climate and Landuse

The Lwamondo area experiences distinct dry and wet seasons, with a long wet season from September to April and relatively short dry season from May to August. During the wet season, the area experiences warm temperatures ranging from 15-38°C; during the dry season temperatures range from 10-23°C (Mulaudzi, R., Unpubl. data). The rainfall distribution in the eastern part of Soutpansberg Mountains is strongly influenced by the east-west orientated mountain range. The mean annual rainfall varies dramatically, but annual precipitation at Lwamondo Hill can reach up to 3000 mm due to orographic mist and this area is generally wetter compared with the western Soutpansberg which receives a low average of 750 mm (e.g. Hahn, 2006). The climatic gradient from west to east has also resulted in very different land use patterns. The eastern part is highly suitable for commercial and subsistence farming as well as commercial forestry, and is locally known as the mountains "fruit basket". The western parts of the mountain are much less extensively used for agricultural purposes and are unsuitable for large scale silviculture (Pers. obs.).

3.4 Vegetation

The Lwamondo vegetation is classified as Northern Mistbelt Forest, grassland and shrubland (Figures 2, 3 and 4) and is dominated by forests and woodlands. Lwamondo has patches of natural vegetation that have been transformed into commercial pine plantations (Figure 5), and subsistence farmlands (Figure 6)

Figure 2. View of Lwamondo Northern Mistbelt Forest habitat (Photo: Rendani Mulaudzi, February 2013).

Figure 3. View of Lwamondo grassland (Photo: Rendani Mulaudzi, April 2013).

Figure 4. View of Lwamondo shrubland habitat (Photo: Rendani Mulaudzi, February 2013).

Figure 5. View of Lwamondo pine plantations (Photo: Rendani Mulaudzi, February 2013).

Figure 6. View of subsistence farmland at Lwamondo (Photo: Rendani Mulaudzi, February 2013).

3.5 Fauna

The Soutpansberg Mountain range contains 56% of bird species found in southern Africa (Harrisson *et al*., 1997). According to Berger *et al*. (2003), 60% of South Africa's mammal species occur on the Mountain Range (e.g. Gaigher and Stuart, 2003). In addition, the region is inhabited by all five primate species found in southern Africa, namely the chacma baboon (*Papio ursinus*), the vervet monkey (*Chlorocebus aethiops*), the samango monkey (*Cercopithecus albogularis*), the lesser bushbaby (*Galago moholi*) and the greater bushbaby (*Otolemur crassicaudatus*). Apart from the five primates' species, other common animal species in the area are shown in Table 1.

Table 1. List of the common animal species in the study area (Nelwamondo, P., Pers. comm.).

Common Name	Scientific Name
Selous' mongoose	*Paracynictis selousi*
Slender mongoose	*Galerella sanguinea*
Greater canerat	*Thryonomys swinderianus*
Porcupine	*Hystrix africaeaustralis*
Rock hyrax	*Procavia capensis*
Cape hare	*Lepus capensis*
Bushpig	*Potamochoerus larvatus*
African rock python	*Python sebae*
Black mamba	*Dendroaspis polylepis*
Mozambican spitting cobra	*Naja mossambica*
Puff adder	*Bitis arietans*
Boomslang	*Dispholidus typus*

3.6 Flora

The Soutpansberg Mountain range is one of the centres of plant endemism and biodiversity in southern Africa (Van Wyk and Smith, 2001; Hahn, 2006). It also has 41% of all plant genera of the flora in southern Africa. According to personal observations and personal communications, a wide variety of plant species are commonly used as source of medicine by the Lwamondo people. The common plant species that are used for medicinal purposes are depicted in Table 2. For example, the root and bark of *Mimusops zeyheri* is boiled and used for abdominal complaints. The infusion of *Ziziphus mucronata* is taken by women to enhance fertility.

Table 2. A list of plant species that are used for medicinal purposes (Nelwamondo, P., Pers. comm.; Pers. obs.).

Common Name	Scientific Name
Transvaal red milkwood	*Mimusops zeyheri*
Tree Strawberry	*Cephalanthus natalensis*
Common wild fig	*Ficus burkei*
Wonderboom fig	*Ficus salicifolia*
Red-leaved fig	*Ficus ingens*
Forest fig	*Ficus craterostoma*
Broom cluster fig	*Ficus sur*
Bufallo thorn	*Ziziphus mucronata*
Guava tree	*Psidium guajava*
Forest fever-berry	*Croton sylvaticus*
Monkey pod	*Senna petersiana*

(Cont.)

Wild olive	*Olea europaea*
Crow berry	*Rhus pantheri*
Water berry	*Syzygium cordatum*
Mobola tree	*Parinari curatellifolia*
Common bush-cherry	*Maerua cafra*
Forest nuxia	*Nuxia floribunda*
Rock alder	*Canthium mundianum*
Wild pear	*Dombeya rotundifolia*
Northern Bushman's grape	*Rhoicissus tridentate*
Sickle bush	*Dichrostachys cinearea*
Climbing turkey-berry	*Keetia quenzii*
Hairy guarri	*Euclea natalensis*
African wattle	*Peltophorum africanum*
Lemon wood	*Xymalos monospora*
River bushwillow	*Combretum erythrophyllum*
Common forest grape	*Rhoicissus tomentosa*
Red currant	*Ras chirindensis*
Black forest spine-thorn	*Gymnosporia harveyana*

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Field survey and materials

The present study was conducted from February to November 2013. A preliminary survey was undertaken for three weeks in January 2013 to identify the study site and the study troop. The 163-member study troop was habituated for 16 consecutive days to allow closer human observations on foot within 20 metres. In addressing the troop size, baboons were counted every month, while crossing the main road. Moreover, the estimated observer to animal distance was 15 metres throughout the study period.

When following the troop, a Geko 201-Garmin Global Positioning System (GPS) was used to record the location sites. The behavioural activities of the troop were recorded in a notebook containing data sheets. In order to keep track of time, a stop-watch was used for marking time in 15-minute intervals during the observations. Whenever possible, activities relevant to the objectives of the study were captured using a digital camera, whenever possible. The crop fields were surveyed and sampled using a tape measure in an attempt to assess crop damage by baboons. Furthermore, for each sampled field, a permanent marker and flagging tape were used to identify sampling sites. Plastic Ziploc bags were used to collect faecal samples and labeled with date, GPS coordinates and altitude.

4.2 Data collection

4.2.1 Diurnal activity pattern

The scan sampling technique (Altmann, 1974) was used to collect behavioural data. Activity data were collected from the study troop on an average of five consecutive days per month, covering both wet and dry seasons. The wet season data were collected during the months of February-April 2013 (late rainy season) and September-November 2013 (early rainy season), whereas dry season data were collected from May-August 2013. The activities of all individuals in the line of sight were recorded for five minutes at 15 minute intervals from 06:00-18:00. In addition, the observation time was broken down into four sessions: early morning (06:00-09:00), late-morning (09:00-12:00), early afternoon (12:00-15:00) and late afternoon (15:00-18:00). The troop was scanned each time from left to right to avoid biases, especially for activities such as fighting as well as sampling the same individual twice during one sample.

The identity of the scanned individuals was classified to one of the following age/sex classes: adult male, adult female, sub-adult male, sub-adult female and juvenile. An individual scanned was recorded as performing one of the five main behavioural activities: feeding, foraging, moving, resting and socialising (after Marais, 2005).

Feeding was recorded when baboons manipulated, masticated or ingested a particular food item. Foraging was recorded when the act of searching for and exploiting food resources was observed. Moving was noted when baboons changed their spatial position, including walking, running, climbing and jumping. Resting was recorded when baboons were inactive, usually sitting or lying down. Finally, socialising activities included playing, i.e. chasing and interacting in a non-aggressive manner; grooming (self- and allo-grooming), using hands to explore and clean the body. The act of sexual procreation and aggression (the act of threatening another baboon) were also recorded (after Saj *et al*., 1999; Marais, 2005).

The activity time budget was calculated by dividing the proportion of the number of behavioural records for each activity category by the total number of activity records each day. The behavioural records were then summed within each month to construct monthly percentage of time budgets (Vasey, 2005). The grand mean proportion of the monthly budgets provided the overall seasonal budgets, including annual budgets following methods set forward by Di Fiore & Rodman (2001) and Di Fiore (2003).

4.2.2 Dietary composition

During activity scan sampling, dietary data were collected on the members of the study troop. When the baboons were observed feeding, the type of food item consumed was recorded as leaf, fruit, stem, root, flower, grass, maize or invertebrate. The species consumed was also recorded. Plant species were identified using indigenous knowledge and a field guide to South African plants from the South African Biodiversity Institute (Retief & Herman, 1997; Germishuizen & Meyer, 2003).

Dietary composition was evaluated by calculating the proportion of different food items and types of species consumed by the baboons. The daily food items and species consumed were summed within each month to construct monthly proportion of food items and species consumed. The monthly proportion of each food item in the scans was calculated as follows: total number of monthly individual scans for each food item divided by the total number of individual scans for all food items. The relative proportion of food items and species consumed by the baboons was calculated from the monthly percentage of different species, in accordance with the protocols of Fashing (2001) and Di Fiore (2004). The overall seasonal and annual diets were calculated using the grand mean of the monthly proportion of food items and species consumed.

4.2.2.1 Faecal samples

Faecal samples were collected *ad libitum* during the last four months (August-November 2013) of the study period to supplement the direct observation technique and determine the main components of the diet of the baboons. It was difficult to locate faecal samples from February-July 2013 because there was a high demand of the baboon scats for medicinal purposes around Lwamondo Hill. There appears to be an increasing trend of collecting the sacred baboons' scats in the study area. For example, baboons' scats are highly prized as source of medicine. The spiritual view plays a critical role in shaping the local people's perceptions towards scats collection. It is important to note that baboons' scats are commonly used for treatment of children and livestock, to remove the effects of supernatural force. While there are some local people that do not use baboons' scats, collecting them persisted, because collectors traded them to people in other areas. In addition scats collection was at its peak between January and August. This period did not clash with the annual ritual ceremony known as *thevhula*.

Despite an increase in the collection of baboon scats in the study area, only 34 faecal samples were collected for this study. All the faecal samples were stored in a freezer until analysis. In order to extract food types from the faecal samples, each sample was dissolved in water for two days. The faecal samples were then sieved through a 0.5mm sieve (see Heikamp, 2008). Each sample was then placed in an open plastic dish and left to dry in the sun for a day. Dried materials were placed in a Petri dish and sorted using a dissecting microscope (Zeiss Stemi 2000-C) and identified by comparing the samples with an existing reference collection (provided by Heikamp, 2008) to identify different food types.

To establish the estimate percentage of the food types available per each scat, they were examined to establish if a food type constituted more or less than 50% of the surface area of the Petri dish (following Kent and Coker, 1996; Hill *et al.,* 2005). If the food type covered >50% of the Petri dish, it was estimated whether it covered more or less than 60%. In addition, if the percentage cover was less than 50%, it was further estimated whether the food type was more or less than 40%.

4.3 Ranging pattern

During the scan sampling, Global Positioning System (GPS) coordinates were recorded every five minutes while following the study troop, thus aiding to determine the total home range size and day range length. Day range lengths were calculated based on full-day follows only (De-Raad, 2012).

In order to draw each day range on a GIS-system generated map (ArcMap10), the total distances travelled per day were connected with the consecutive Global Positioning System (GPS) location records. The GIS software, ArcGIS was employed to calculate the distances from the map. The minimum convex polygon (MCP) was used to determine the home range size of the baboons. The home range size was estimated by combining all day ranges to generate a bounding polygon using 100% MCP's (Henzi *et al*. 2011).

4.4 Raiding behaviour

4.4.1 Questionnaire survey

Questionnaire surveys (Appendix 2) were administered to gather information about crop raiding in the vicinity of four villages (Belemu, Tshiema, Tshiozwi, and Tshivhale) around Lwamondo Hill. The questionnaire surveys were conducted for three months, June-August 2013.

4.4.2 Quadrats

With the help of two local people, a total of twelve fields (i.e. three per village) were visited during the early crop season from October to November. In order to assess the degree of crop damage, three quadrats were sampled, 3x5m, from each crop field in each village. Two key factors were estimated, namely farm size and the distance from the forest edge. The crops available on the farms were noted and the number of stands planted was recorded. To make independent assessments of crop damage, visual assessment of bite size and spoor were used. All the quadrats were sampled randomly within the crop field. The proportion of damaged crops was calculated as follows: counting the number of damaged or missing plants/parts divided by the total crop population planted in the field. The mean of the three quadrat values for each damaged field was used to measure the proportion of crop damage sustained per sample. The mean percentage crop losses for each crop field were estimated taking into consideration the number of stands planted and the stands that sustained crop damage. This method was carried out in order to cross-check the responses from the farmers (Hill, 2000).

4.5 Statistical Analysis

Statistical analysis was carried out using GraphPad Instant 3.1 Version. Differences in behavioural activities between age-sex classes and between months and time sections of the day were analysed using a non-parametric Kruskal-Wallis test. Seasonal differences in each activity were investigated using Mann-Whitney U tests (Zar, 1999). We used Kruskal-Wallis tests to identify differences in the monthly consumption of different food types, and Mann-Whitney U tests were used to compare the seasonal consumption of different food types. Mann-Whitney U tests were also used to analyse changes in home range size and daily distance travelled between seasons. Curvilinear model was used to predict variation in crop damage/distance from the natural habitat edge data.

CHAPTER FIVE: RESULTS

5.1 Activity pattern

5.1.1 Activity budget

A total of 117 539 individual behavioural observations were recorded from 1031 group scans over a period of 45 days. The overall activity time budget (%) of the baboons is presented in Figure 7.

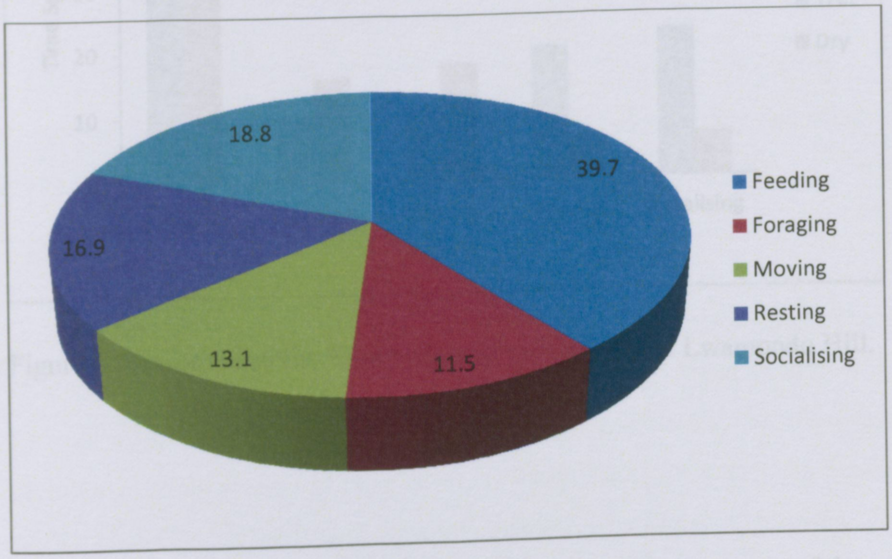

Figure 7. Overall activity time budget (%) of a baboon troop at Lwamondo Hill during the course of the study period (n= 117539).

The baboons spent on average, nearly 40% of their time during the study period feeding for different food items, while socialising accounted for more than 18%. Resting constituted over 16% to the overall activity time budget, while moving and foraging constituted around 12% of the activity budget (Figure 7).

Mann-Whitney U tests showed significant differences between seasons in time spent feeding ($P<0.05$), foraging ($P<0.05$), moving ($P<0.05$), resting ($P<0.05$) and socialising ($P<0.05$).

Feeding activity was higher during the dry season (more than 52%) than the wet season (35%). Socialising and resting accounted for nearly 44% of the activity time budget during the wet season compared to 13% in the dry season. On average, moving and foraging time was around 34% during the dry season and less than 22% during the wet season (Figure 8).

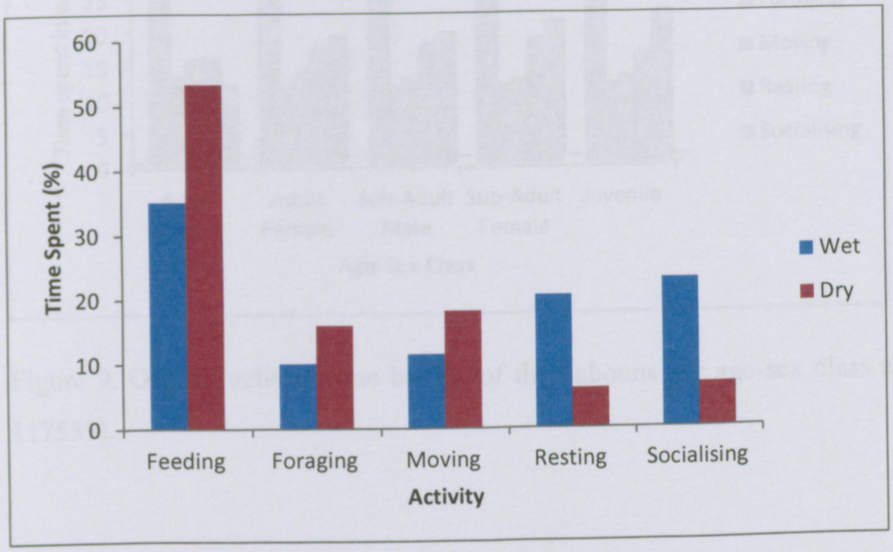

Figure 8. Seasonal activity time budget of the baboons at Lwamondo Hill.

All the age-sex classes spent more time feeding during the course of the study period (Figure 9). However, the results showed that adult males devoted over 45% of their time in feeding activity, while socialising accounted around 11%. Kruskal-Wallis tests showed that there was a significant difference in the allocation of time to feeding and socialising activities by adult males versus other age-sex classes (*P*<0.05) (Figure 9).

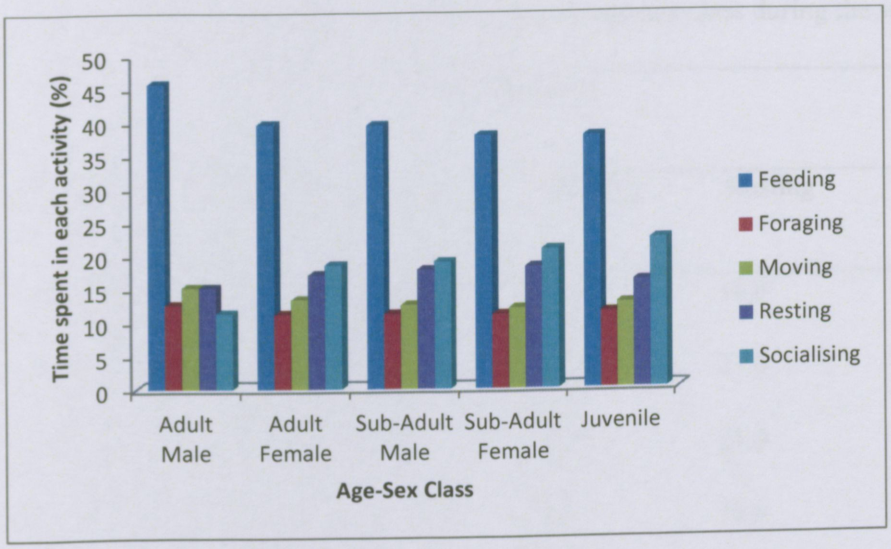

Figure 9. Overall activity time budget of the baboons per age-sex class at Lwamondo Hill (n= 117539).

A comparison of age-sex classes in different seasons revealed that all classes spent less time feeding during the wet season (Table 3) than the dry season (Table 4). Mann-Whitney U tests showed significant differences between all age-sex classes in allocation of time to different activities in both wet and dry seasons ($P<0.05$) Foraging was at its peak during the dry season, with both sub-adult males and females spending equal time of more than 16% (Table 4). Moving activity was higher during the dry season than the wet season. The five different age-sex classes spent more time resting and socialising during the wet season than during the dry season.

Table 3. Activity time budget of the baboons per age-sex class during the wet season.

	Activities (%)				
Age-sex class	Feeding	Foraging	Moving	Resting	Socialising
Adult Male	42.5	11.5	13.6	18.6	13.8
Adult Female	34.4	9.6	11.7	21.3	23
Sub-Adult Male	33.8	9.5	10.8	21.6	24.3
Sub-Adult Female	33.2	9.6	10.4	21.8	25
Juvenile	33.3	10	11	19.2	26.5

Table 4. Activity time budget of the baboons per age-sex class during the dry season.

	Activities (%)				
Age-sex class	Feeding	Foraging	Moving	Resting	Socialising
Adult Male	53.6	15.2	19.3	6.8	5.1
Adult Female	54.7	16	18.1	5.2	6
Sub-Adult Male	54.1	16.5	17.7	5.7	6
Sub-Adult Female	53.2	16.5	17.2	6.2	6.9
Juvenile	51.2	15.4	17.9	6.3	9.2

The time spent feeding during the course of the study period varied across different months ranging from nearly 31% during November to around 65% during April and May. Activity pattern comparison across months is depicted in Table 5. There was a significant difference in time allocated to feeding by adult females and other groups during April, May and June (Kruskal-Wallis H tests, $P<0.05$). However, there was no significant difference in time spent by other age-sex classes for foraging, moving, resting and socialising across months ($P>0.05$).

Table 5. Monthly variation in the time spent by the baboons for different behavioural activities.

	Activities (%)				
Months	Feeding	Foraging	Moving	Resting	Socialising
February	45	10.6	13.1	13.2	18.1
March	49.3	8.6	13.9	11	17.2
April	65.1	8.2	8.2	7.1	11.4
May	65	9.6	8	7.9	9.5
June	62.2	7.5	16.8	4.8	8.7
July	55.8	14.3	18.2	5.3	6.4
August	50.1	18.1	19.1	6.4	6.3
September	43	10.5	12.3	16.7	17.5
October	32	10.2	11.2	22.7	23.9
November	30.7	9.6	11.1	22.2	26.4

Although adult males exhibit significantly high time allocation for feeding activity in the late mornings (Kruskal-Wallis H test, $P<0.05$), comparisons with other age-sex classes revealed no significant differences in other activities. On average, the baboons spent about 43% of their time feeding in the late mornings. Socialising and resting peaked during the early afternoons, accounting for nearly 19% and around 20%, respectively. Moving was higher in the late afternoons, constituting over 14% of the activities (Figure 10).

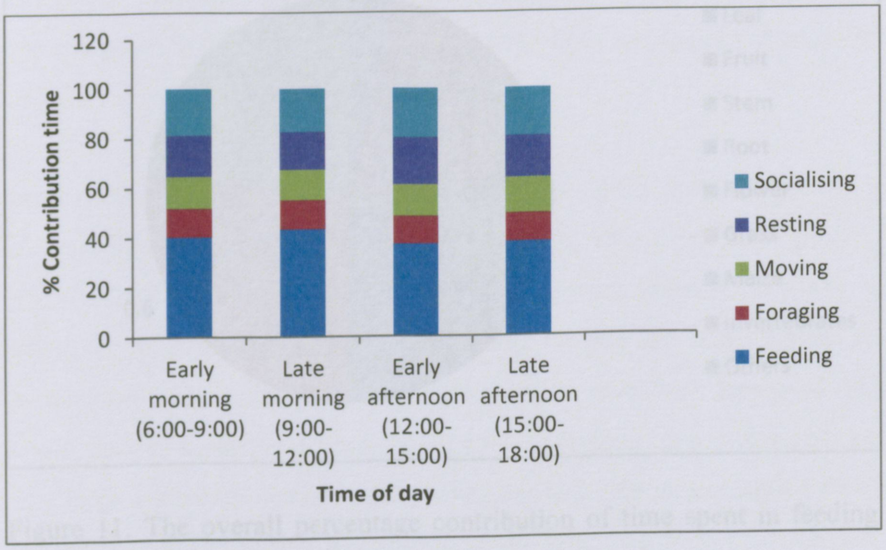

Figure 10. Diurnal activity pattern from 06h00 to 18h00 in a baboon troop at Lwamondo Hill.

5.2 Dietary composition

A total of 46 663 feeding behavioural records were obtained from observational data during the study period. The overall diet of the chacma baboons is presented in Figure 11 (observational technique) and Figure 12 (faecal analysis).

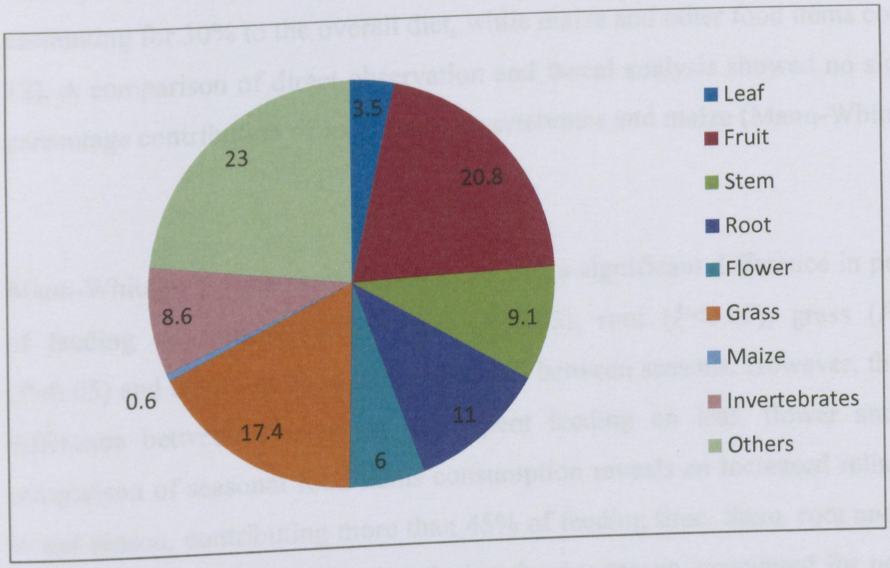

Figure 11. The overall percentage contribution of time spent in feeding for different types of food items during the course of the study period (n= 46663)

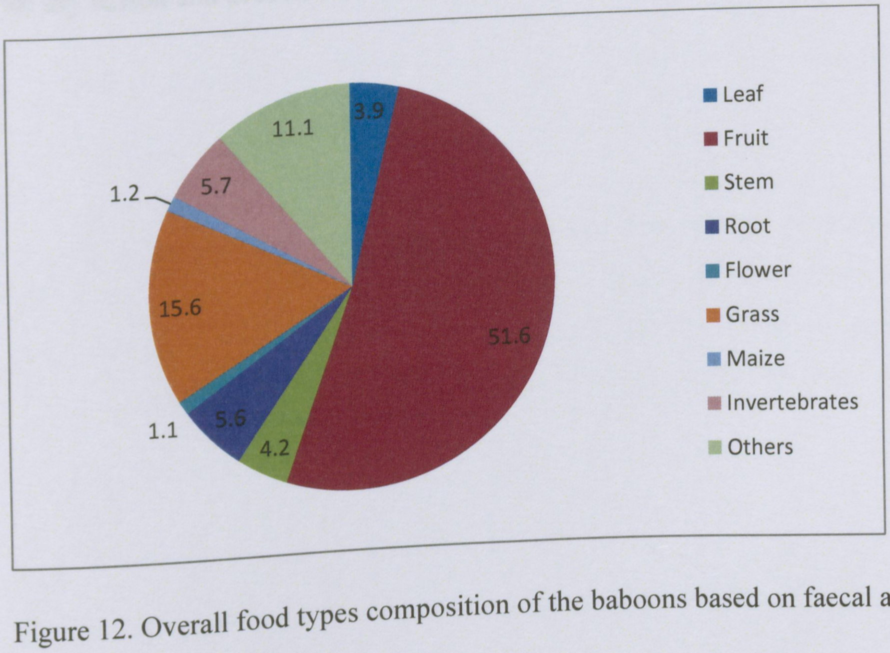

Figure 12. Overall food types composition of the baboons based on faecal analysis.

The direct observation results revealed that plant resources, including fruit, grass, root, stem, flower and leaf made the largest contribution to the overall diet of the baboons at nearly 68%. Invertebrates, maize and other food items contributed about 32% to the overall diet (Figure 11). Faecal analysis also showed that fruit contributed nearly 52% of the overall diet of the baboons. Other plant resources (grass, root, stem, leaf and flower) were also found in the faecal samples accounting for 30% to the overall diet, while maize and other food items constituted 18% (Figure 12). A comparison of direct observation and faecal analysis showed no significant difference in percentage contribution of leaf, grass, invertebrates and maize (Mann-Whitney U test, $P>0.05$).

Mann-Whitney U tests showed that there was a significant difference in percentage contribution of feeding on fruit ($P<0.05$), stem ($P<0.05$), root ($P<0.05$), grass ($P<0.05$), invertebrates ($P<0.05$) and unknown food items ($P<0.05$) between seasons. However, there was no significant difference between seasons in time spent feeding on leaf, flower and maize ($P>0.05$). A comparison of seasonal food items consumption reveals an increased reliance on fruit and grass in wet season, contributing more than 45% of feeding time. Stem, root and invertebrates made a very large contribution to the diet during the dry season, accounted for nearly 40%. Maize was only consumed during the wet season, while unknown food items were mostly preferred during the dry season and accounted for nearly 30% of the feeding effort (Table 6).

Table 6. Seasonal percentage contribution of food items consumed by the baboons during the wet and dry seasons.

% Contribution of food items		
Food items	Wet season (n=30856)	Dry season (n=15807)
Leaf	3.7	3.1
Fruit	27	8.7
Stem	6.9	13.5
Root	9.6	13.7
Flower	6.2	5.5
Grass	18.8	14.8
Maize	0.9	0
Invertebrates	6.8	12
Others	20.1	28.7

Fruit consumption showed a monthly variation, with greater proportions recorded during November (Table 7). Despite a relatively high proportion of unknown food items during August (Table 7), Kruskal-Wallis H tests showed that there were no significant differences in the percentage contribution of different types of food items to diet (P>0.05).

Table 7. Monthly variation in percentage contribution of different types of food items consumed by the baboons (n= 46663).

	Food items (%)								
Months	Leaf	Fruit	Stem	Root	Flower	Grass	Maize	Invertebrates	Others
February	8.1	32.2	7.6	4.8	2.4	9.3	7.6	1.6	26.4
March	6.2	31.9	9.8	11.9	1.1	5.1	4	4.3	25.7
April	7.2	22.5	8.1	16.1	0.5	12.1	3.1	14.9	15.5
May	3.8	9.2	18.2	17.2	5.4	14.5	0	14.6	17.1
June	4.7	7.8	23.5	23.4	3.6	7.6	0	15.4	14
July	2.8	8.5	14.2	14.3	10.9	13.1	0	12.5	23.7
August	2.9	8.9	11.2	11.6	3.1	16.7	0	11	34.6
September	5.2	18.4	9.4	10.8	12.4	9.5	0	10.1	24.2
October	2.4	29.4	6	7.7	5.3	26.4	0	5.2	17.6
November	2.7	32.3	5.3	10.2	2.8	21.3	1.7	5.3	18.4

The baboons consumed a total of 58 different plant species during the study period (Appendix 3). The top ten most consumed plant species accounted for over 74% of their overall diet (Table 8a). Based on the overall percentage contribution of plant species that were regularly consumed, *Acacia ataxacantha* and *Mimusops zeyheri* were the most heavily utilised, accounting for more than 30% of the overall diet (Table 8a).

During the wet season, *Mimusops zeyheri*, *Cephalanthus natalensis* and *Psidium guajava* constituted the highest record of more than 42% (Table 8b). The proportion of *Acacia ataxacantha* made up a large portion of the diet during the dry season and accounted nearly 37% of the feeding effort (Table 8c). *Mimusops zeyheri*, *Acacia ataxacantha* and *Ficus salicifolia* were fed on during both wet and dry seasons (Tables 8b and 8c).

Table 8a. The most common ten plant species consumed by the baboons during the course of the study period.

Common Name	Scientific Name	% Contribution
Flame thorn	*Acacia ataxacantha*	17.3
Transvaal red milkwood	*Mimusops zeyheri*	13.5
Tree Strawberry	*Cephalanthus natalensis*	9.1
Common wild fig	*Ficus burkei*	8.8
Buffalo thorn	*Ziziphus mucronata*	6.6
Guava tree	*Psidium guajava*	6.4
Forest fever-berry	*Croton sylvaticus*	5.8
Monkey pod	*Senna petersiana*	2.8
Wild olive	*Olea europaea*	2.3
Wonderboom fig	*Ficus salicifolia*	2

Table 8b. Ten most commonly utilised plant species by baboons during the wet season.

Common Name	Scientific Name	% Contribution
Transvaal red milkwood	*Mimusops zeyheri*	18.7
Tree Strawberry	*Cephalanthus natalensis*	14.1
Guava tree	*Psidium guajava*	10.1
Forest fever-berry	*Croton sylvaticus*	9.1
Flame thorn	*Acacia ataxacantha*	7
Common wild fig	*Ficus burkei*	5.3
Crow berry	*Rhus pantheri*	3
Water berry	*Syzygium cordatum*	2.3
Wonderboom fig	*Ficus salicifolia*	1.8
Forest num-num	*Carissa bispinosa*	1.7

Table 8c. Ten most commonly consumed plant species by baboons during the dry season.

Common Name	Scientific Name	% Contribution
Flame thorn	*Acacia ataxacantha*	36.4
Buffalo thorn	*Ziziphus mucronata*	18.3
Common wild fig	*Ficus burkei*	15.1
Monkey pod	*Senna petersiana*	7.3
Wild olive	*Olea europaea*	6.5
Transvaal red milkwood	*Mimusops zeyheri*	2.7
Mobola tree	*Parinari curatellifolia*	2.7
Wonderboom fig	*Ficus salicifolia*	2.4
Pink dombeya	*Dombeya burgessiae*	1.9
Red-leaved fig	*Ficus ingens*	1.6

5.3 Ranging pattern

5.3.1 Home range

The overall home range area of the baboons based on the minimum convex polygon (MCP) was 4.23 km^2. The home range area of the study troop shifted more during the dry season than in the wet season (Figure 13). Mann-Whitney U test showed a significant difference in home range area between the two seasons ($P<0.05$).

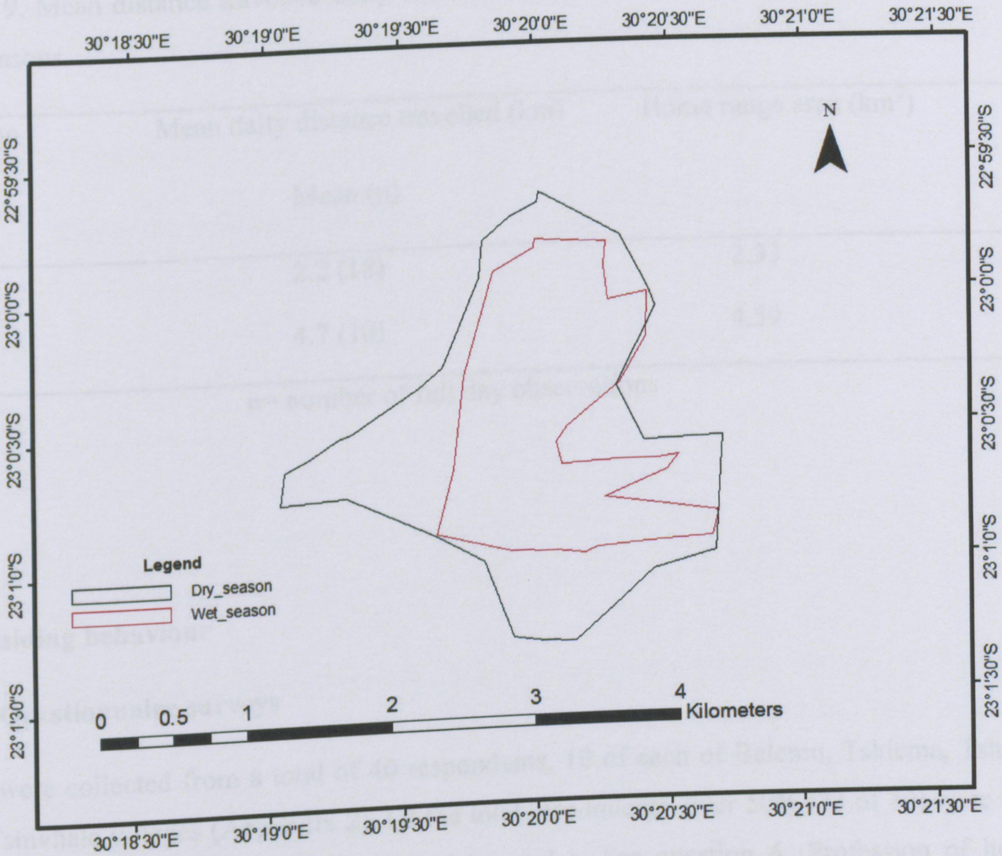

Figure 13. Home range of a baboon troop at Lwamondo Hill, based on minimum convex polygon (MCP) method.

5.3.2 Daily range length

On average, the daily range length for the baboons was 3.1 km. The average daily lengths during the wet and dry seasons are presented in Table 9. The mean daily distance travelled was 4.7 km in the dry season and 2.2 km during the wet season. There was a significant difference in the daily range lengths between the wet and dry seasons (Mann-Whitney U test, $P<0.05$).

Table 9. Mean distance travelled daily and home range size of the baboons during the wet and dry seasons.

Season	Mean daily distance travelled (km) Mean (n)	Home range area (km^2)
Wet	2.2 (18)	2.33
Dry	4.7 (10)	4.59

n= number of full day observations

5.4 Raiding behaviour

5.4.1 Questionnaire surveys

Data were collected from a total of 40 respondents, 10 of each of Belemu, Tshiema, Tshiozwi, and Tshivhale villages (Appendix 2). Of the total respondents, over 50% (23 of 40) were males, and most of the households were headed by males. For question 6 (Profession of head of household), a significant majority (32 of 40) of the respondents were farmers, showing that most of the local people rely primarily on subsistence farming as a source of their livelihood. In terms of age-groups of the respondents, 50% (20 of 40) were of ages between 30-50 years.

Taking into consideration question 11 (What time of year do they raid most frequently), a significant majority (31 of 40) of the respondents reported that baboons raid their farms more often during the crop/summer season than winter. Moreover, for question 12 (How often do they raid each season) results revealed that a significant majority of 27 respondents reported that baboons usually raid once a day, 11 respondents reported once a week and two respondents said less often during the crop season.

Of the total number of respondents, the majority (30 of 40) answered yes to question 16 (Do you believe baboons are sacred). Crop field sizes ranged from 0.5-2.5 hectares, and over 90% of the respondents reported that they cultivate less than 2.5ha, indicating that farmers were practicing subsistence farming (Table 10).

Table 10. Size of the land (ha) cultivated by the respondents in Lwamondo area.

Size (ha)	No. of respondents
0.5	11
1	14
2	12
2.5	03

Most farmers reported that baboons were primarily responsible for crop damage, with over 97% of the respondents sustaining maize losses. Only one respondent claimed that baboons attacked children. Majority of the farmers (34 of 40) reported that maize was damaged throughout its life cycle (early germination, maturity stages). In terms of plant parts preferred, over 87% of the respondents reported that baboons were feeding on cobs and roots. Mangoes, avocadoes and macadamia nuts were also reported to be raided by baboons. Raiding was reported to be at its peak during the afternoons by the majority (28 of 40) of the respondents.

Majority of the respondents (27 of 40) claimed that baboons caused major destruction on their crop fields (Table 11). On average, a farmer spends up to R1000 every year due to baboon raids, and this was supported by 43% of the respondents who reported financial losses between R500-R1000 each year.

Table 11. The extent of crop field damage by baboons in Lwamondo area.

Portion of crop field damaged	No. of respondents
Less than half	13
Half of all	15
More than half of all	7
The whole crop field	5

Chasing and guarding were ranked as the most frequently used deterrents. Other alternative methods reported to reduce crop raiding were the use of dogs, weapons i.e. fire crackers and poisons; however, only six respondents reported using traps and snares (Figure 14).

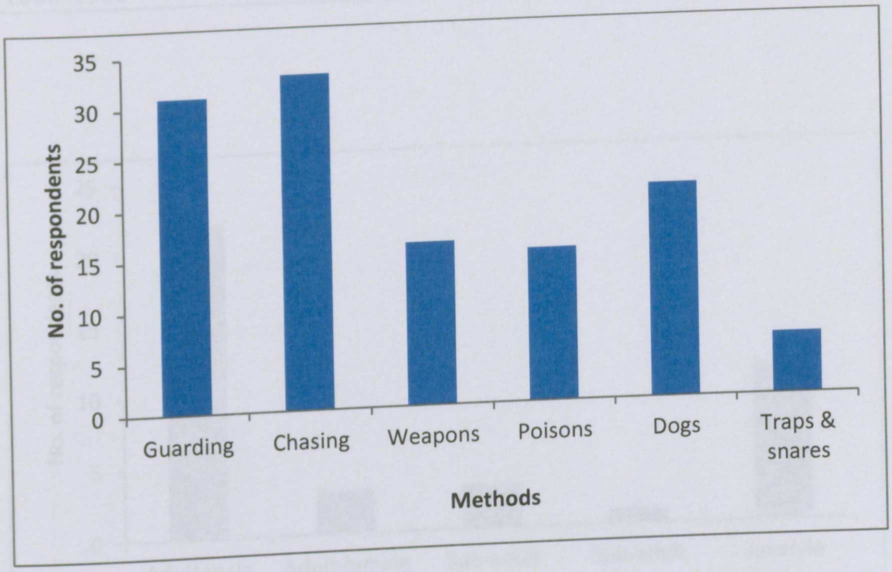

Figure 14. Methods employed by farmers to prevent baboons' crop raiding in the vicinity of Lwamondo Hill.

Results showed that more than 57% of the respondents incurred direct monetary costs between R500-R1500 every year to prevent baboons' raiding (Table 12). Taking into consideration age-sex group of the baboons that were seen raiding, 33 respondents reported that adult males and juveniles were involved in crop-raiding (Figure 15).

Table 12. Costs associated with baboons control options.

Rand (R)	No. of respondents
0-500	17
500-1000	15
1000-1500	08

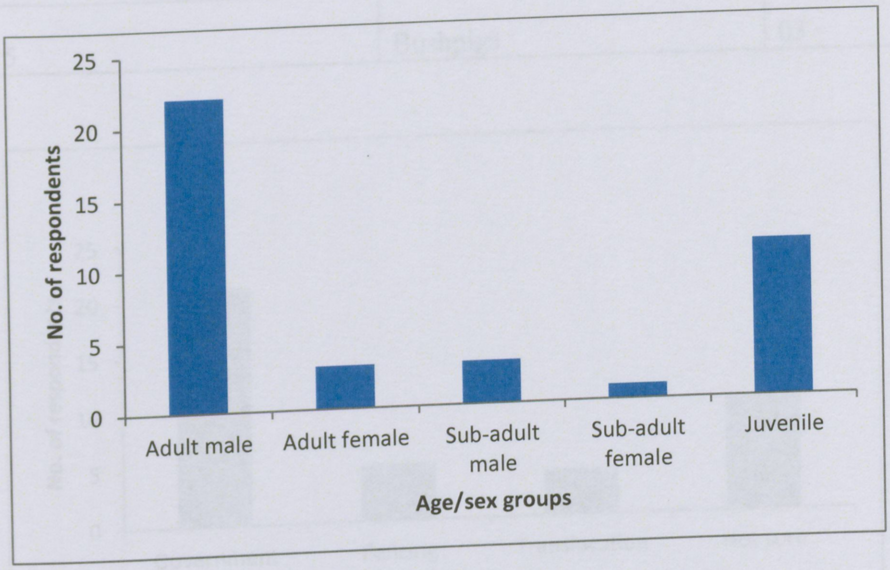

Figure 15. Age-sex groups of the baboons that were reportedly crop raiding in Lwamondo area.

Apart from the baboons, vervet monkeys and porcupines were regarded as the most frequent raiders by 23 and six respondents, respectively (Table 13). Majority of the respondents (26 of 40) recommended that government should intervene and they also suggested that there should be a fence around Lwamondo indigenous forest in order to address the problems of baboons in the area (Figure 16)

Table 13. Other animals that were involved in crop raiding.

Rank	Animal	No. of respondents
1	Vervet monkeys	23
2	Porcupines	06
3	Rodents	05
4	Birds	03
5	Bushpigs	03

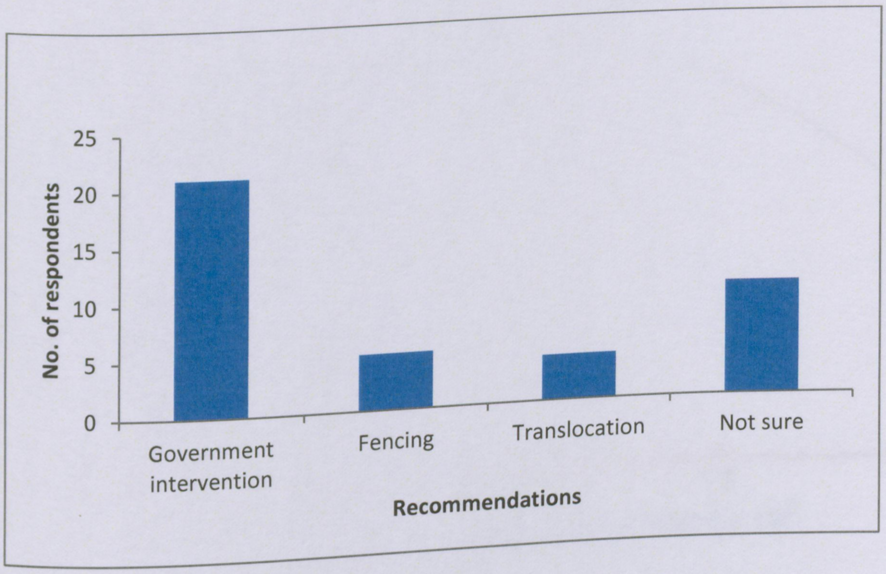

Figure 16. Recommendations about how baboon problems could be reduced.

5.4.2 Quadrats

The size of the study farms ranged from 1.5 hectares (Belemu, Tshiozwi and Tshivhale villages) to 2.5 hectares in Tshiema village. The distance from the edge of the natural habitat varied in different farms. The farm which was located at a distance of 500 metres from the natural habitat suffered no damage, while farms lying within 45 metres from the natural habitat edge sustained crop damage. Of the twelve farms sampled, two farms (both at Tshiema) and only one farm at Tshiozwi experienced a mean percentage maize crop losses of over 60%. The curvilinear regression model analysis (n=12) explained 76% (r^2= 0.76; $p<0.001$) of the variation in crop damage with distance from the natural habitat edge (Figure 17). Percentage (%) of maize damage = -0.00055 (distance from the forest) ^{2} + 0.217 (distance from the forest) + 38.367.

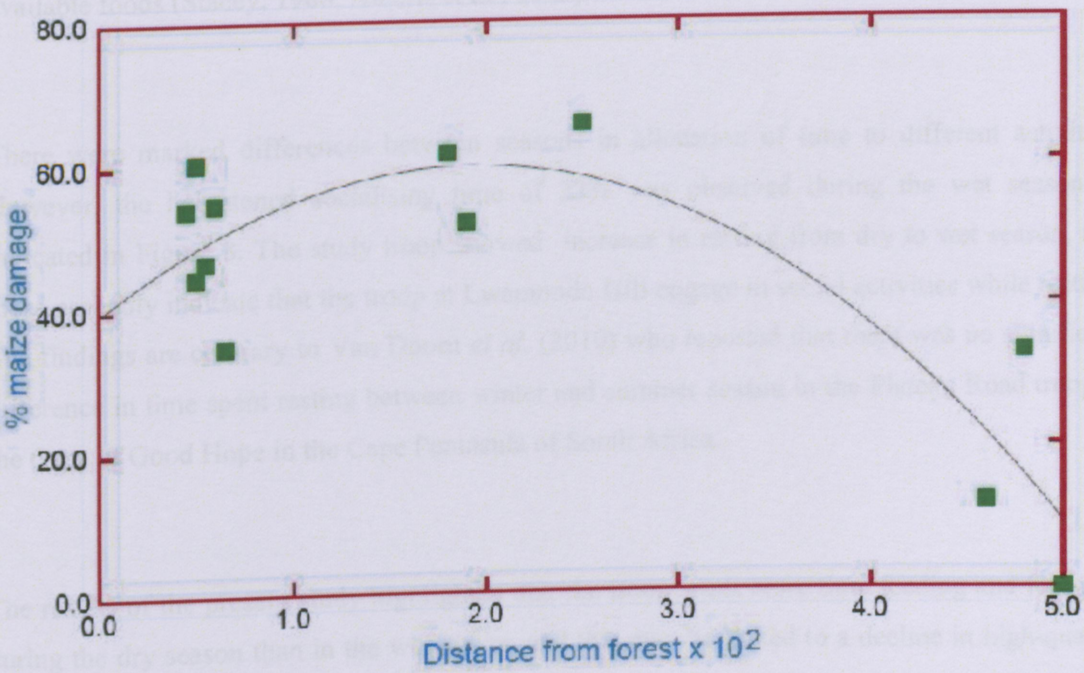

Figure 17. Curvilinear model analysis on crop damage/distance from the edge of baboons' natural habitat.

CHAPTER SIX: DISCUSSION, CONCLUSION AND RECOMMENDATION

6.1 Discussion

6.1.1 Activity pattern

6.1.1.1 Activity budget

The results of the study indicate that the study troop allocated more time for feeding activity, followed by socialising, resting, moving and foraging (Figure 7). These findings are in contrast with the evidence provided by Henzi *et al*. (1997) who found that small troop sizes (Mean troop size = 21.4) invested more time in foraging in the Drakensberg Mountain population. It is likely, however, that the present study troop size (n=163) increased intraspecific competition for available food resources during the study period, thus contributing to more time spent feeding. For example, an increase in troop size would mean the troop members have to feed more on available foods (Stacey, 1986; Alberts *et al*., 2005).

There were marked differences between seasons in allocation of time to different activities. However, the heightened socialising time of 23% was observed during the wet season as indicated in Figure 8. The study troop showed increase in resting from dry to wet season, and these probably indicate that the troop at Lwamondo Hill engage in social activities while resting. The findings are contrary to Van Doorn *et al*. (2010) who reported that there was no significant difference in time spent resting between winter and summer season in the Plateau Road troop at the Cape of Good Hope in the Cape Peninsula of South Africa.

The results of the present study highlighted that the troop spent more time feeding and foraging during the dry season than in the wet season and this may be linked to a decline in high-quality food resources during the dry season which forced the troop to feed more in order to meet their daily energy requirements. More time was spent socialising and resting during the wet season than in the dry season. The study suggests that this is due to availability of a variety of food resources which were easily acquired by the troop. In addition, socialising activity, notably grooming maintains their social relationships (Dunbar, 1992b). Moving was carried out more during the dry season than during the wet season because nutritious food resources were less abundant during the dry season.

Comparisons of activity patterns for all age-sex classes during the study period show that there were no marked differences in time allocated to different activities. However, time spent feeding by adult males was significantly higher than other age-sex classes (Figure 9). This would suggest that their relative size difference is solely linked to increased feeding time. Sub-adult females and juveniles spent almost equal time socialising, and this could be due to a high level of grooming behaviour which is associated with maintaining relationships of the troop (Kappeler and van Schaik, 1992; Aureli and de Waal, 2000).

The results showed that there were no marked daily activity differences for the four time periods 6:00-9:00 (early morning), 9:00-12:00 (late morning), 12:00-15:00 (early afternoon) and 15:00-18:00 (late afternoon) (Figure 10). The study troop spent more time feeding in the early mornings whereas resting and socialising peaked in the early afternoon or middle of the day. These activity patterns show that the troop make use of the lower temperatures for feeding in the mornings, whereas they spent more time resting and socialising when the temperatures are highest, thus conserving their energy required while moving back to their sleeping sites.

6.1.2 Diet

The results show that the study troop appears to eat a vast array of food types, as has been noted in other baboon populations in South Africa (Whiten *et al*., 1987; Gaynor, 1994; Marais, 2005). Although baboons generally have variable diets, the study troop concentrated mainly on plant resources as depicted in Figures 11 and 12. The percentage of high fruit proportion based on faecal analysis (Figure 12) indicated that the study troop modify their diet in response to available fruits. As previously reported (Kunz and Linsenmair, 2007), ripe fruits are source of high levels of sugar and carbohydrates.

In a study by Segal (2008) on the diet for Suikerbosrand Nature Reserve population, it appears that the overall diet comprised mainly of plant resources, especially fruit, with other food types constituting small proportions to the diet. This pattern is similar to the findings of previous studies at the Cape of Good Hope Nature Reserve in the Cape Peninsula (Davidge, 1978), Giant's Castle Nature Reserve in the Drakensberg Mountains (Whiten *et al.*, 1987), Mkuzi Nature Reserve in Kwazulu-Natal (Gaynor, 1994) and the Blyde Canyon Nature Reserve in Mpumalanga (Marais, 2005), all in South Africa. The findings from these studies correlate strongly with the results of the current study.

An interesting observation noted, was that the study troop was more frugivorous during the wet season than the dry season (Table 6). This trend may be explained by the availability and abundance of fruits within the range. For example, the fruit consumption of *Mimusops zeyheri* was at a peak during the wet season. A study of the diet on the olive baboons (*Papio anubis*) at the Budongo Forest Reserve in Uganda, reported that fruits were highly preferred over other food items during the wet season (Okecha and Newton-Fisher, 2006).

According to Altmann (1998), leaves provide a good source of protein and minerals while containing low levels of fibre, tannin and toxins. However, the current study shows that leaves appears to be less desired food by the study troop as depicted in Tables 6 and 7. In addition, the present study suggests that the troop fed on invertebrates in order to supplement their protein, with a higher consumption recorded during the dry season than the wet season (Table 6).

Grasses and flowers were also more preferred as source of food during the wet season than the dry season, but there were no significant seasonal differences. These results suggest that the baboons at Lwamondo Hill rely on available foods regardless of the nutrient value (Wrangham *et al*., 1998; Alberts *et al*., 2005). As depicted in Table 6, roots and stems were utilised more in the dry season than the wet season. The high reliance of these food items in dry season may support the idea that this is a period of food scarcity. Furthermore, other food items, including anthropogenic sources were largely consumed during the dry season compared to the wet season. These findings may be attributed to a decline in natural food resources.

Forthman-Quick and Demment (1988) suggested that anthropogenic foods provide quick and high energy gains for the baboons. However, the present study reveals that maize consumption was observed only in wet season, thus the study baboons fed on maize crops when they are available during the crop season months (February, March, April and November) as shown in Table 7. Although the study troop appeared to change their dietary preferences, it is important to note that maize made up a small proportion of the troop's diet compared with other studies on baboons in general (e.g. Strum, 2010). This could be attributed to the availability of orchard crops such as mangoes, bananas, avocadoes and oranges within the study troop's home range during the study period.

With regards to plant species utilisation, the study troop preferred *Acacia ataxacantha* during the course of the study period (Table 8a). This species was also consumed in abundance during the dry season (Table 8c). The findings suggest that the latter was readily available and more accessible within the baboons' home range (Pers. Obs). All ten plant species utilised in wet and dry seasons (Tables 8b and c) were used for medicinal purposes by the local people around Lwamondo Hill. The present study demonstrates that the baboons consume a more diverse range of medicinal plants (Appendix 3). These findings are supported by the study on the chacma baboons in the western part of the Soutpansberg Mountain range (De Raad, 2012).

6.1.3 Ranging pattern

6.1.3.1 Home range

According to Van Beest *et al.* (2011), the ranging behaviour of an animal species is primarily quantified by home range and daily path lengths. Furthermore, it has been suggested that several factors affect the home range size; these include resource density (Barton *et al.*, 1992), food availability (Nakagawa, 1999) and group size (Isbell, 1991). Moreover, day journey length is influenced by habitat quality (Dunbar, 1992b). There was a significant expansion in the home range areas between the two seasons; the home range area of the study troop was larger during the dry season than the wet season (Table 9).

The main reason why the home range area shifted in the dry season is likely due to decline in the availability of high-return fruits such as *Cephalanthus natalensis* and *Psidium guajava.* Similarly, Olupot *et al.* (1997) found that the ranging pattern of the Mangabey (*Cercocebus albigena*) was in response to less abundant fruit during the dry season.

Some studies have shown that troop size is correlated with home range size (Table 14).

Table 14. Summary of troop size and home range size for chacma baboons in South Africa.

Study site	Troop size	Home range size (km^2)	Reference
Lwamondo Hill, Limpopo	163	4.2	present study, 2014
Tokai, Cape Peninsula	115	9.5	Hoffman & O'Riain, 2011
Honnet Nature Reserve, Limpopo	60	23.3	Stoltz & Saayman, 1970
Suikerbosrand Nature Reserve, Gauteng	51	22.5	Segal, 2008
De Hoop Nature Reserve, Cape Peninsula	31	15.6	Hill, 1999
Giant's Castle Nature Reserve, Drakensberg	14	12	Whiten *et al*, 1987

Comparison with other study sites reveals that the Lwamondo Hill troop has access to limited human food resources; this might have been due to availability of vital resources within the baboons' home range, including food (DeVore and Hall, 1965; Altmann and Altmann, 1970, Barton et al., 1992; Altmann, 1998), water (Altmann, 1998) and sleeping sites (Anderson, 2000).

Daily path lengths of primates with large group size are generally longer, thus covering larger home range areas compared with other primates (Isbell, 1991). The results of the current study reveal that the mean distance travelled per day was 3.1 km. This distance is very similar to the findings by Hoffman and O'Riain (2011), who found that the Tokai troop only travelled 2.93 km per day in the Cape Peninsula. However, a comparison with data from other baboon troops indicates that the distance travelled by the study troop was shorter. For example, chacma baboons move, 14.4 km (Stoltz and Saayman, 1970), hamadryas baboons, 9.6 km (Schreier and Grove, 2010) and yellow baboons, 8 km (Altmann and Altmann, 1970). The findings from the current study suggest that shorter daily distances are linked with the location of suitable sleeping sites which are inaccessible to predators.

There were distinct differences between daily distances travelled during the wet and dry seasons, and it was noted that the study troop travelled longer distances in the dry season in search for *Mimusops zeyheri*, *Acacia ataxacantha* and *Ficus salicifolia* which supply the baboons with food throughout the study period. The shorter distances travelled in wet season could be attributed to fruiting time of various plant species. In addition, shorter distances are also associated with concentration of critical food resources within the home range (Kumar *et al*., 2007).

6.1.4 Raiding behaviour

6.1.4.1 Crop raiding

Data from the questionnaire survey indicate that above 80% of the farmers in all four villages report baboons' crop-raiding during the study period. Hill (1997) argued that there are several factors which influence raiding behaviour in baboons, including distance from the forest. Farmers indicated that maize crops were raided more frequently throughout their life cycle, and they witnessed crop raiding more during the crop season than during the fallow season. In addition, baboons were also reported feeding on all plant parts of the maize (Pers. Obs). Naughton-Treves *et al*. (1998) also reported that olive baboons (*P. cynocephalus*) raid maize throughout its life cycle around Kibale National Park in Uganda. The study suggests that maize preference may be due to higher carbohydrates and calories than other natural food items.

During the fallow season, baboons raided orchard crops (mangoes, avocadoes, bananas, pawpaw, macadamia nuts and oranges) more frequently when maize was not available. These findings are similar to those found by Pahad (2010) in the Suikerbosrand Nature Reserve, which show an increased reliance on anthropogenic foods during the period of low natural food availability.

Farmers generally concurred that baboons are largely responsible for crop damage. These outcomes are supported by the actual field assessment which demonstrates that the percentage of maize crops lost to baboons was above 60% as depicted in Figure 17. In addition, the damage/distance from the forest explains 76% variation in crop damage with fields in close proximity being damaged much more than those located hundreds of metres away (Figure 17). These distinct behavioural responses have been observed in vervet monkeys, *Cercopithecus aethiops* (Willems and Hill, 2009) at the Lajuma Research Centre in the western part of the Soutpansberg. Although the results obtained during this study are in accordance with previous studies, this trend may be attributed to the absence of farmers guarding their crop fields (Gillingham and Lee, 2003).

The greater proportion of farmers perceived adult males and juveniles as the main raiders amongst other age-sex groups (Figure 15). Farmers also rank vervet monkeys (*Cercopithecus aethiops*) as the worst pest found in the study area (Table 13). Dunbar and Barrett (2000) pointed out that vervet monkeys successfully adapt to survive across a diverse range of ecological conditions, thus capable of exploiting food resources in the extreme environments.

The crop field assessment results show that study farms located beyond 400 metres from the natural habitat edge were at low risk of crop damage. These findings contrast with Hill (2000) who found that baboons frequently visit crop fields in close proximity to the forest edge, less than 450 metres. As a measure of actual crop damage, there was a decline with distance from the edge of the natural habitat attributed to the retaliation from the farmers (Pers. Obs). The study troop responded similarly to other baboons (e.g. Naughton-Treves, 1997), with an increase in crop damage around the edges of the natural habitat and perceived it as area with foraging opportunities. According to Ludicker (1999), increased habitat fragmentation is one of the factors which affect activity patterns and spatial distribution of wildlife. In measuring the predator-specific landscapes of fear and resource distribution of *Cercopithecus aethiops*, Willems and Hill (2009) concluded that space use is generally determined by the distribution of resources.

By protecting the baboons, the people of Lwamondo derive many benefits. The medicinal plants consumed by the baboons, for example, serve important health needs for the community of Lwamondo. There appears to be an increasing trend of collecting the sacred baboons' scats in the study area. For example, baboons' scats are highly prized as source of medicine. The spiritual view plays a critical role in shaping the local people's perceptions towards scats collection. It is important to note that baboons' scats are commonly used for treatment of children and livestock, to remove the effects of supernatural force. While there are some local people that do not use baboons' scats, collecting them persisted, because collectors traded them with people in other areas. The study suggests that the baboons are protected primarily because they are the keepers and ancestors of Lwamondo Hill. The study also found that the Lwamondo community abides by the taboos as they fear supernatural consequences from violating this prohibition that regulates their behaviour. These results are similar to findings by Saj *et al.* (2006) who found that traditional taboos promote monkeys conservation around the Boabeng-Fienna Monkey Sanctuary, Ghana, owing to prohibition of killing the black and white colobus.

Farmers asserted that chasing and guarding are their preferred control techniques (Figure 14). These methods are labeled as labour intensive because they require farmers to guard their crop fields throughout the crop season. The study also observed that farm owners hired Zimbabwean men to guard their crop fields. This observation is supported by previous studies which argued that baboons are more afraid of men than women and children (Strum, 1994; Kansky, 2002).

Although farmers' perceptions of using dogs, weapons, poisons, traps and snares in the current study are in accordance with previous findings (Strum, 2010), these techniques are not providing a long-term solution. The present study found that traditional techniques can help preventing baboons' crop raiding, however, farmers suffered monetary costs when using all the methods (Table 12). General recommendations captured from farmers dwell more on government interventions, particularly the Department of Environmental Affairs (Figure 16).

6.2 Conclusion

This study showed that the sacred chacma baboons at Lwamondo Hill spent more time feeding than any other behavioural activities. The troop size may be interlinked with feeding time, suggesting that heightened feeding time could simply be attributed to intra-group feeding competition. The study troop was largely dependent on plant resources rather than other food types available during the study period. This has been confirmed by the accumulation of fruit remains during the dung analysis. The consumption of fruits was dependent on their availability, with more fruits eaten during the wet season than the dry season, explaining that the study troop heavily utilised more fruit bearing plant species when they are available. The home range sizes and day range lengths used by the baboons were extended more during the dry season than the wet season. This pattern was probably linked to low abundance of food resources during the dry season.

The reports from the farmers suggested that raiding behaviour is generally associated with the availability of maize crops. The fact that majority of farmers were aware of the crop-raiding problem may imply that they are making efforts to address the problem. However, the idea that the study troop is sacred plays a critical role in shaping farmers' perceptions and attitudes when dealing with the issue of baboon conflict in the study area. Actual crop damage assessment shows that a farm lying adjacent the forest edge was targeted by raiders. In addition baboons' crop-raiding is affecting the livelihoods of the local farmers due to costs associated with control techniques.

6.3 Recommendation

The study could not consider other factors such as the long-term conservation and management implications of the study troop owing it to the duration of the study (10 months). Although the troop is protected by traditional beliefs, it is of utmost importance to conserve its habitat. Conservation of the baboons' natural habitat will enhance implementation of a long-term monitoring plan to ensure the existence of these baboons in the future. Studies dealing with the role of the baboons in seed dispersal are necessary to be carried out in the study area. Future studies could also focus on the role of predation in shaping the group size and foraging efficiency of the baboons. Another area of study is the fusion-fission of the troop which could influence the general foraging and raiding of the Lwamondo Hill troop

Regarding the raiding behaviour, it is important to explore alternative crops which are less palatable than maize. Moreover, it would also be important to use both traditional control methods and modern techniques, for example the use of paintball guns in conjunction with monitoring the troops has proved to be an effective deterrence in the Cape Peninsula of South Africa (Pers. Obs).

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Appendix 1. Daily activity pattern record sheet.

Time Interval--------------------------------

Date---

Time	Age/Sex group (AM, AF, SAM, SAF, JU); Activity (Fe, Fo, Mo, Re, So); Food items (Le, Fr, St, Ro, Fl, Gr, Ma, In)	Notes

Age/Sex group: AM: Adult male; AF: Adult female; SAM: Sub-adult male; SAF: Sub-adult female; Ju: Juvenile, **Activity:** Fe: Feeding; Fo: Foraging; Mo: Moving; Re: Resting; So: Socialising, **Food items:** Le: Leaf; Fr: Fruit; St: Stem; Ro: Root; Fl: Flower; Gr: Grass; Ma: Maize; In: Invertebrates

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Appendix 2. Baboon Questionnaire Survey

Interviewer ____
Date ____
Household name: ____
Questionnaire index # ____

1) Region — Limpopo Province; Vhembe District
2) Village ____

3) Interviewed person(s)
- Female(s)
- Female(s) plus male
- Male

4) Age groups of interviewed persons
- Female(s): below 30 yrs; 30 - 50 yrs; 50 yrs and above
- Male: below 30 yrs; 30 - 50 yrs; 50 yrs and above

5) Gender of head of household (tick) (Who is in charge of household, legally or as a matter of fact, due to absence of husband?)
- Male
- Female (de facto or de jure)

6) Profession of head of household
- Farmer
- Other ____

7) How many members does your household have? (People who stay there permanently, >5days/wk) (Indicate number) (Adults: 18 years and above)
- Adult males ____
- Adult females ____
- Children ____
- Total ____

8) How much land do you cultivate? ____

Unit: (hectare)

9) List the sorts of problems baboons cause for the family (crop damage, storage losses, attacking children)

10) What crops / fruits / food types do you grow and which are damaged/not damaged by baboons
What crop stages and parts of plants are preferred?

11) What time of year do they raid most frequently (summer/crop season, winter)?

12) How often do they raid each season (Once a day / once a week / less often)?
a) In crop season:
b) In fallow season:

13) What time of day do they raid most often (evening, night, morning, afternoon, midday)

14) Can you quantify these problems? (what are the financial losses each year to baboons crop raiding)

15) List control options used (guarding, chasing, weapons, poisons, dogs) (costs associated with control)

16) Do you believe baboons are sacred?

17) Which baboons do you see raiding (Adult male or female, Sub-adult male or female, juvenile)

18) What other animals are problems destroying maize crops and stored grain (vervet monkeys,porcupines, ro rodents, birds, bushpigs)

19) Do you have any additional ideas/recommendations about how baboon problems could be reduced?

Appendix 3. A List of all plant species consumed by chacma baboons during the study period.

Common Name	Scientific Name	% Contribution
Flame thorn	*Acacia ataxacantha*	17.3
Transvaal red milkwood	*Mimusops zeyheri*	13.5
Tree Strawberry	*Cephalanthus natalensis*	9.1
Common wild fig	*Ficus burkei*	8.8
Buffalo thorn	*Ziziphus mucronata*	6.6
Guava tree	*Psidium guajava*	6.4
Forest fever-berry	*Croton sylvaticus*	5.8
Monkey pod	*Senna petersiana*	2.8
Wild olive	*Olea europaea*	2.3
Wonderboom fig	*Ficus salicifolia*	2
Crow berry	*Rhus pantheri*	1.9
Water berry	*Syzygium cordatum*	1.8
Red-leaved fig	*Ficus ingens*	1.4
Blue guarri	*Euclea crispa*	1.1
Forest num-num	*Carissa bispinosa*	1.1
Mobola tree	*Parinari curatellifolia*	1
Pink dombeya	*Dombeya burgessiae*	1
Wild apricot	*Dovyalis zeyheri*	1
Bushman's tea	*Catha edulis*	0.8

(Cont.)

Common bush-cherry	*Maerua cafra*	0.8
Forest fig	*Ficus craterostoma*	0.8
Forest nuxia	*Nuxia floribunda*	0.8
Rock alder	*Canthium mundianum*	0.8
Wild pear	*Dombeya rotundifolia*	0.8
Northern Bushman's grape	*Rhoicissus tridentate*	0.7
Sickle bush	*Dichrostachys cinearea*	0.7
Broom cluster fig	*Ficus sur*	0.6
Climbing turkey-berry	*Keetia quenzii*	0.6
Hairy guarri	*Euclea natalensis*	0.6
African wattle	*Peltophorum africanum*	0.5
Lemon wood	*Xymalos monospora*	0.5
River bushwillow	*Combretum erythrophyllum*	0.5
Common forest grape	*Rhoicissus tomentosa*	0.4
Red currant	*Ras chirindensis*	0.4
Black forest spine-thorn	*Gymnosporia harveyana*	0.3
Common coral tree	*Erythrina lysistemon*	0.3
Cross-berry	*Grewia occidentalis*	0.3
Forest bushwillow	*Combretum kraussii*	0.3

Forest mahogamy	*Trychillia dregeana*	0.3
Mitzeeri	*Bridelia micrantha*	0.3
Quinine tree	*Rauvolfia caffra*	0.3
Transvaal milkplum	*Englerophytum magalismontanum*	0.3
Velvet wild-medlar	*Vangueria infausta*	0.3
Common spike-thorn	*Gymnosporia buxifolia*	0.2
Forest iron plum	*Drypetes gerrardii*	0.2
Karoo bluebush	*Diospyros lycoides*	0.2
Twin Red-berry	*Erythrococca trichogyne*	0.2
White stinkwood	*Celtis africana*	0.2
Wild mulberry	*Trimeria grandifolia*	0.2
Cape ash	*Ekebergia capensis*	0.1
Cape beech	*Rapanea melanophloeos*	0.1
Cork-bush	*Mundelea sericea*	0.1
Forest silver-oak	*Brachylaena transvaalensis*	0.1
Hairy myrtle	*Eugenia woodii*	0.1
Sand apricot	*Landolphia kirkii*	0.1
Small-leaved yellowwood	*Afrocarpus falcatus*	0.1
Thorny gardenia	*Hyperacanthus amoenus*	0.1
Tinderwood	*Clerodendrum glabrum*	0.1