FORAGING ECOLOGY OF THE VERVET MONKEY (*CHLOROCEBUS AETHIOPS*) IN MIXED LOWVELD BUSHVELD AND SOUR LOWVELD BUSHVELD OF THE BLYDEBERG CONSERVANCY, NORTHERN PROVINCE, SOUTH AFRICA.

by

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PREFACE

Vervet Monkeys (*Chlorocebus aethiops*) are versatile primates of the suborder HAPLORHINI, family CERCOPITHECIDAE, subfamily CERCOPITHECINAE, and genus *Chlorocebus* (Skinner & Smithers, 1990). They are a widely distributed species that adapt easily to a variety of environments, occurring throughout the Northern and Southern Savanna, from Senegal to Sudan and south to the tip of Southern Africa (Estes, 1992).

According to Estes (1992), vervets are opportunistic omnivores, being predominantly vegetarians that live on wild fruits, flowers, leaves, buds, seeds, pods, sap, roots and tubers. Occasionally they will feed on invertebrates (grubs, termites, grasshoppers) and vertebrates (bird and reptile eggs and chicks) (Skinner & Smithers, 1990).

Not much ecological research has been done on vervets outside the tropics to date, and it was thus considered necessary to determine how vervets cope with the effects of temperate area seasonality.

The aim of this study was to describe the habitat structure of a vervet monkey troop's territory and then to investigate the effects of seasonality on differences in their diet (both overall and with respect to sex differences), activity patterns and habitat utilisation.

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CHAPTER 1

INTRODUCTION

1.1 Prolegomenon

Vervet monkeys (*Chlorocebus aethiops*) are highly successful African primates occupying a wide variety of habitats. Due to their inherent ability to adapt to various, often harsh environments they occur widespread throughout Africa and are present in areas ranging from semi desert to gallery forest. Being omnivorous they are capable of finding food in even the poorest of environments (Skinner & Smithers, 1990; Estes, 1992; Kingdon, 1997; Isbell *et al*., 1998; Dunbar & Barrett, 2000). As a species they are second only to baboons in their ability to survive across a diverse range of ecological conditions. They appear to cope well in most habitats, having filled various niches in what often appears to be extreme surroundings.

In southern Africa, vervets have successfully adapted to living away from forests and occupy the African savanna. They are not as adept at utilizing their habitats as baboons are, being restricted mostly to areas in close proximity to water and trees; whereas baboons maximize the use of their environments, being labeled the most successful African primates (Dunbar & Barrett, 2000).

Being a highly adaptable and intelligent species, vervets have become a pest to humans, and are renowned for raiding crops, orchards and even human dwellings (Lee *et al*., 1986; Saj, 1999). According to Estes (1992), vervets rank second only to baboons as agricultural pests and are often found in the same areas as baboons, adding to the destruction in these areas.

Due to their perceived destructive natures, vervets frequently raise management issues in both protected and non-protected areas, particularly where commercial enterprises and protected areas are adjacent to one another. It is envisaged that by understanding their dietary requirements and seasonal movement patterns that a set of preliminary management proposals for minimizing damage to human interests could be drafted.

South Africa has a temperate sub-tropical climate with considerable regional variations caused by differences in elevation, wind systems, and ocean currents. Seasonality affects all animal species living in such temperate sub-tropical environments. Changes in temperature and day length that accompany changes in season are markedly different at different latitudes. Such changes influence the activity patterns of various animal species. Many migratory bird and mammal species are affected by seasonality, with fluctuations in day length and temperature often being the precursor to their migratory behaviour (Maclean, 1990; Alcock, 1993; Krebs & Davies, 1999). The life cycles of most insects, a source of food for vervets, are also seasonally driven (Skaife *et al*., 1979; Scholtz & Holm, 1989). Primates often share habitats with other animals and are similarly affected by seasonality. Seasonal variations in day length therefore have a strong behavioural affect on their activity patterns (Barton *et al*., 1992; Bronikowski & Altman, 1996; Hill *et al.*, 2003; Hill *et al*., 2004; Marais 2004). At Blydeberg the vervets share their habitats with baboons and though both species are similarly affected by seasonality, their respective reactions vary with the baboons spending more time in open grassland areas and the vervets remaining in or adjacent to areas of gallery forest.

Vegetation growth and production in Southern Africa is also seasonally dependant, with certain phases of a plants life cycle being sensitive to changes in day length and temperature fluctuations.

Examples of distinctive life cycle phases sensitive to seasonality in plants include rate of germination, rate in amount of die off and/or survival, biomass production, intensity and time of flowering and fruiting with accompanying yields, and overall reproductive capacity (Barbour *et al.,* 1987; Cowling *et al*., 1997; Kent & Coker, 1997). Rainfall, especially in South Africa, is another important factor affecting plant growth.

For any research on ecologically related issues of animals to be relevant, it is of utmost importance to first obtain an understanding of their habitat. Once the structure of their habitat is understood, it becomes easier to analyse their associated behaviour. Historically, several large scale vegetation research projects have been done on the vegetation of Southern Africa (Acocks, 1988; Bredenkamp & Bezuidenhout, 1995; Cowling *et al*., 1997; Van Oudtshoorn, 1999), with very little having been done on a micro-scale. However, currently the impetus of a lot of current vegetation and ecological research is on obtaining data of a more detailed and specific nature (Bredenkamp *et al.,* 1989; Mathews, 1991; Brown & Bredenkamp, 1994; Mathews *et al*., 1994; Bezuidenhout, 1993, 1996; Brown, 1997). There is no recorded vegetation analysis for the study area apart from a few descriptive studies having been undertaken in the surrounding area (Van der Schijff, 1963; Van der Schijff & Schoonraad, 1971).

Most studies on vervet foraging ecology have been done in equatorial Africa. Very little, if anything at all has been done in more temperate zones where seasonal climatic fluctuations and thus seasonal variations in food type and abundance are the order of the day. Wherever vervets and humans live in close proximity to one another, vervets are considered pests as their opportunistic natures cause them to take advantage of any opportunities for free meals. Often the important role vervets play in the ecology of areas they inhabit is not appreciated or understood as their negative stigma outweighs their benefits to such areas.

When land owners in the Blydeberg Conservancy experienced problems with vervets, such was seen as a unique opportunity to study a troop of semi-habituated vervets in their natural surroundings. Currently there is no available information on vervet foraging ecology in mixed and sour lowveld bushveld, or on vervet management in Southern Africa, and there are no management plans at Blydeberg. The problems vervets are envisaged to cause and problems experienced are not unique to Blydeberg but are widespread throughout their range. This study aims to provide some insight into vervet foraging ecology, whilst giving guidelines for a more comprehensive management plan for vervets to ensure their continued existence.

1.2 Research hypotheses under investigation

It was predicted that the study troop would:

- Utilize more of their home range during the dry season than during the wet season, thus increasing area used.
- Travel further during the dry season than during the wet season.
- Consume a larger variety of food species during the wet season than during the dry season.

1.3 Aims and objectives

The overall aims of this study were to provide an insight into the impacts of temperate area seasonality on the habitat utilisation, food selection and activity patterns of a vervet troop living in a temperate sub-tropical environment. Another intention of this study was to provide a set of basic management recommendations for vervet monkeys in general.

Specific objectives for this study were to:

- Identify, describe, classify and ecologically interpret the vegetation of the study area within the Blydeberg Conservancy on a floristic basis using Braun-Blanquet methodology.
- Compile a set of basic maps for the study area which could be used for the management of the area i.e. an infrastructure and roads map, a vegetation map, and a seasonal vervet habitat utilisation map.
- Locate and sufficiently habituate a vervet troop so that they could be followed and monitored for data collection purposes.
- Follow a troop of vervet monkeys over a twelve month period in order to record their seasonal habitat utilisation, foraging behaviour, food selection, movement patterns, and activity patterns.

1.4 Dissertation exposition

This dissertation consists of a research article [Chapter 5 - A vegetation classification and description as a precursor for vervet monkey (*Chlorocebus aethiops*) habitat utilisation, food selection and activity analysis in the Blydeberg Conservancy, Northern Province.] which has been submitted for publication in *KOEDOE,* as well as topics/aspects that are presented in the form of unpublished data chapters, some of which are to be published in other journals at a later stage.

Chapter 5 follows the format required by *KOEDOE*, whilst unpublished data chapters follow the format required by the respective journals they are to be published in. Consequently, some stylistic irregularities and repetitiveness occurs between the various data chapters, with each chapter forming an entity within itself.

A description of the methods used, study area, and a complete literature reference list are given in each data chapter. Annexures referred to in certain chapters are supplied at the end of the dissertation. Figures and Tables referred to within data chapters are applicable only to the specific chapters they occur in and are numbered consecutively within each respective chapter.

Tables too large to fit onto one page are included as fold-outs attached to the end of the dissertation. Subsections within all data chapters are unnumbered. All page numbering in this dissertation are consecutive for each page containing text, tables or figures, hence the published and unpublished articles pages have been renumbered accordingly.

1.5 Contents of dissertation

This dissertation contains detailed information on the phytosociology of the study area within the Blydeberg Conservancy, followed by information on the study troops seasonal habitat utilisation, foraging behaviour, movement patterns, food selection and activity patterns.

A complete species list of all plant species identified during plant surveys is provided as an Annexure at the end of the dissertation. A comprehensive list of all references cited in all chapters is also included.

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CHAPTER 2

LITERATURE REVIEW

2.1 Vervet evolution and taxonomy

According to Dunbar & Barrett (2000) primates are one of the most ancient mammal lineages currently alive. Their origins date back to the dinosaur age, over 65 million years ago. Fossil evidence suggests first anthropoids (group to which monkeys and apes belong) appeared around 30 to 35 million years ago (Dunbar & Barrett, 2000). As climate changes occurred around 12 million years ago, a new fruit- and seed-eating monkey lineage emerged – the cercopithenes, including baboons, macaques, guenons and their relatives (Dunbar & Barrett, 2000).

Vervets are guenons "any slender agile Old World monkey of the genus *Cercopithecus*, inhabiting wooded regions of Africa and having long hind limbs and tail with long hair surrounding the face" - Collins English Dictionary & Thesaurus, 1992. Like all other primates, vervets have an evolutionary history of being a tropical species dependant on forests and their rich supply of food types for survival.

Vervets successfully invaded the woodland and savanna habitats of Africa from their ancestral forest homes (Dunbar & Barrett, 2000), but not totally since they tend to be restricted to riparian and swamp areas.

According to Dunbar & Barrett (2000), vervets are no longer part of the genus *Cercopithecus* but have been deemed sufficiently different to be placed in their own genus *Chlorocebus*, in accordance with Wilson & Reeder (1993).

Vervets have been involved in several taxonomic debates, which have split them into as many as four species (including *pygerythrus, sabaeus*, *tantalus* and *djiamdjiamensis*) and twenty one subspecies (Wilson & Reeder, 1993).

Vervets are also referred to as the green or grivet monkey and are currently taxonomically classified as *Chlorocebus aethiops* (Dunbar & Barrett, 2000).

2.2 <u>Vervet distribution</u>

Vervets have a wide distribution in Africa, occurring from Senegal to Ethiopia and southwards to South Africa, as well as on the Islands of Zanzibar, Pemba and Mafia (Wilson & Reeder, 1993). Figure 1 is a revised map of vervet distribution in Africa, the map as far as possible matches existing river networks (Kingdon, 1997).

Figure 1: Known distribution of vervets in Africa (Kingdon, 1997; Skinner & Smithers, 1990).

As previously mentioned vervets inhabit a wide range of wooded habitat types outside the equatorial rainforest and occur in savanna, woodlands, forest/grassland mosaics and particularly in riverine or gallery forest throughout the savanna biome.

Vervets are extremely adaptable opportunistic generalists (similar to baboons, but less so) that easily move into disturbed areas, including agricultural areas, lodges and can even be found in specialised habitats such as mangrove swamps (Oates, 1996; Kingdon, 1997; Fedigan & Fedigan, 1988; Skinner & Smithers, 1990; Booth, 1979).

2.3 Previous studies on vervets

The general ecology of the vervet monkey (*Chlorocebus aethiops*) has been widely studied. Available information refers mostly to the species in East Africa, with less information available for Central Africa, West Africa and the Southern African Sub region.

East Africa:

Crucial aspects of vervet ecology were investigated on Lolui Island (Lake Victoria) by Moreno-Black & Maples (1977). In the Amboseli Game Reserve (Kenya), Lee *et al*. (1986), Struhsaker (1967) and Cheney & Seyfarth (1992) did research on vervet habitat use and preferences, diet, habits and behaviour. Brennan *et al.* (1985) studied the ecology and behaviour of vervets in a tourist-lodge habitat in Amboseli, Kenya. The study revealed that human food played an important role in the survival of the troop living close to the lodge. Increased aggression was observed and human-animal conflict occurred frequently. Changes to the time budgets of a troop of vervets living in a tourist and cultivated area in Entebbe, Uganda was investigated by Saj *et al*. (1999). Results revealed that the time budgets of provisioned vervet troops differed in that high proportions of time were spent resting and low proportions of time were spent feeding.

Lee *et al*. (1986) also focused on vervet interactions with humans. A study on habitat utilisation and preferences, spatial distribution and feeding habits was conducted at Diani Beach Forest (Kenya) by Moreno-Black & Maples (1977). Both Wrangham & Waterman (1981) and Whitten (1988) did research on the feeding behaviour of vervets in Kenya.

Wrangham & Waterman (1981) did their research in Amboseli and concentrated on the feeding behaviour of vervets on *Acacia tortilis* and *A. xanthophloea* with specific emphasis on reproductive strategies and tannin production. They found that the quality of diet has important long-term consequences for the behavioural ecology and population dynamics of vervets in Amboseli, and that tannins do play a significant role in shaping the diets of vervets. Whitten (1988) studied the effects of patch quality and feeding subgroup size on feeding success in vervet monkeys and provided some evidence to support the hypothesis that patch quality significantly influences foraging success, also it was suggested that individual differences in benefits and costs of group foraging may play an important role in the history and evolution of groups.

The long term consequences of changes in territory quality on feeding and reproductive strategies of vervets was researched in Kenya by Lee & Hauser (1998), it was found that the diets of vervets were related to dynamic changes in their environment and that habitat deterioration resulted in local group extinction over the medium term. Food properties and contest competition in vervets and patas monkeys was investigated in Laikipia, Kenya by Pruetz & Isbell (1999).

Results showed that foods which were clumped in their spatial distribution and which were characterized by long food-site depletion times were food types which monkeys were most likely to contest. Aspects of vervet behaviour, population structure and population dynamics in Amboseli Game Reserve were dealt with by Cheney *et al*. (1981) and Cheney & Seyfarth (1983, 1986, 1992).

Interspecific relationships and niche separation among coexisting primates of the Bole Valley (Ethiopia) were examined by Dunbar & Dunbar (1974).

Data on vervet occurrence and ecology are available for Ethiopia, Eritrea, and Somalia (Yalden *et al*., 1977, 1996; Nievergelt, 1981).

<u>Central and West Africa</u>:

The vervets' ecology has been poorly studied in this part of its distribution range. Harrison (1983) investigated spacing patterns and territorial behaviour in Senegal. Information on habitat utilisation and preferences in old and secondary growth forests is reported on by Fimbel (1994), who researched vervet at Tiwai (Sierra Leone). Differential habitat utilisation by patas and tantalus monkeys living sympatrically in northern Cameroon was researched by Nakagawa (1999). Results revealed that tantalus showed an overall preference for woodland, regardless of season; whereas patas had a preference for grasslands in the wet season.

Adeyemo (1997) did studies on the diurnal activities of vervets in Old Oyo National Park, Nigeria and showed that the research subjects were more active in the mornings and late afternoons, traveling and drinking occurred more in the dry season than in the wet season, and food supply had an impact on activity patterns regardless of season. Distribution and ecological data are available for Gabon (Blom *et al*., 1992), Ghana (Booth, 1979), Comoé National Park (Ivory Coast) (Geerling & Bokdam, 1973), and Kwiambana Game Reserve (Nigeria) (Ajayi *et al*., 1981).

<u>Southern African Sub region</u>:

Population structure in the Mosi-Oa-Tunya National Park (Zambia) was analysed by Tembo (1994). Some data on vervet density in relation to water availability in the Zambesi woodland (Zimbabwe) are reported in Dunham (1994). Data on vervet existence in the Sioma-Ngwezi Park (Zambia) are found in Tembo (1995).

Most of the aforementioned authors also give some information on the ecology of the species.

Diurnal and seasonal variations in vervet monkey activity patterns was researched in Natal by Baldellou & Adan (1998) and showed seasonal diurnal variations to activity patterns related to climatic constraints and metabolic requirements. Henzi (1982), did research on visual signaling and social organization in vervets, comparing data obtained from three free-ranging and one caged troop in Natal, South Africa with similar data from other localities and in other species. Results are similar to those recorded in East Africa and it was concluded that Natal vervets use fewer visual signals than do other species living in more open habitat.

Information on vervet distribution is available for most of South Africa (Pringle, 1974; Bruton, 1978; De Graaff & Rautenbach, 1983; Lynch, 1983, 1989; Skinner & Smithers, 1990) and northern Namibia (Viljoen, 1982). General information on vervet ecology and distribution is reported by several authors (Eisenberg *et al*., 1972; Struhsaker, 1979; Fedigan & Fedigan, 1988; Lernould, 1988; Skinner & Smithers, 1990; Estes, 1992; Kingdon, 1997; Mills & Hes, 1997; Stuart & Stuart, 1997). Its status and distribution are discussed by Skinner & Smithers (1990) and Oates (1996).

From the above it is apparent that not many studies have been carried on vervet ecology in temperate sub-tropical areas, emphasizing the need for this study.

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CHAPTER 3

STUDY SITE

3.1 Location, size and topography

The Blydeberg Conservancy is ***located*** along the great escarpment in the Northern Province, Longitude 30° 27' to 25° 56' E and Latitude 24° 23' to 24° 28' S. Altitude ranges from 350 m to 800 m above sea level (Bredenkamp & Van Rooyen, 1998a, 1998b). The study area constitutes the farms Dunstable (farm number 230) and Jongmanspruit (farm number 234) (Figure 2).

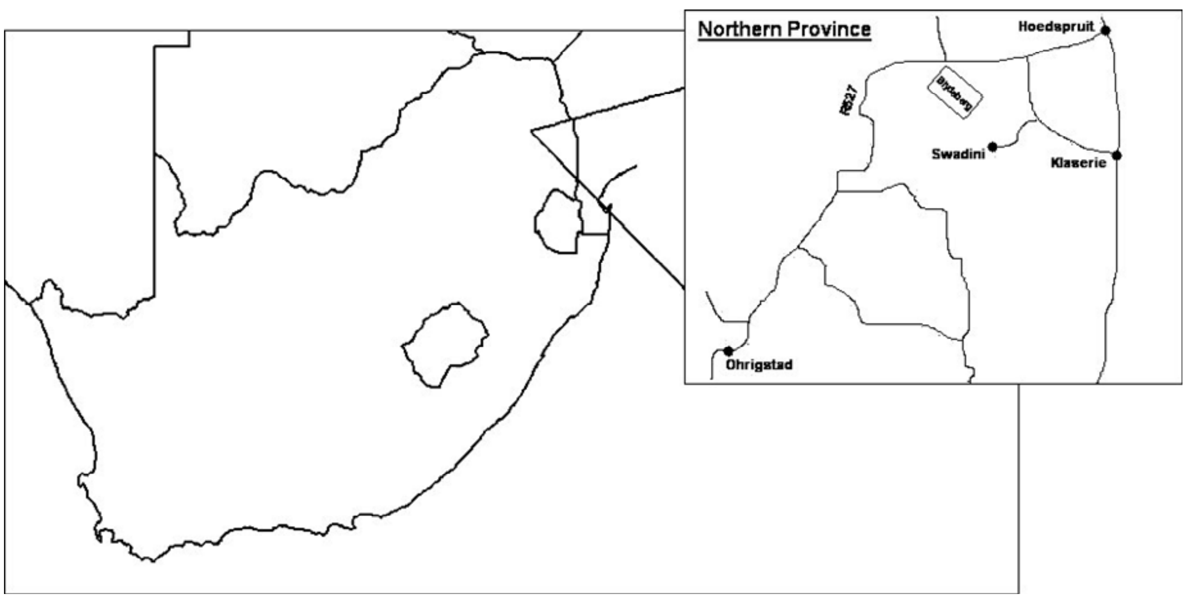

Figure 2: Location of the study area within the Northern province of South Africa. The study area is demarcated with a rectangle.

The ***size*** of the Blydeberg conservancy is approximately 3000 ha, with the study area being 816 ha.

The ***topography*** of the study area is mountainous in the south to flat and open in the north. There are several small mountain streams running from the watershed in the Drakensberg Mountains in the south into the Blyde River to the north of the conservancy.

Within the Blydeberg Conservancy there were areas that were off limits during the study. Such areas were private property where hunting occurred. Areas to the east and west of the demarcated study area (yellow rectangle in Figure 3) were such off limit zones.

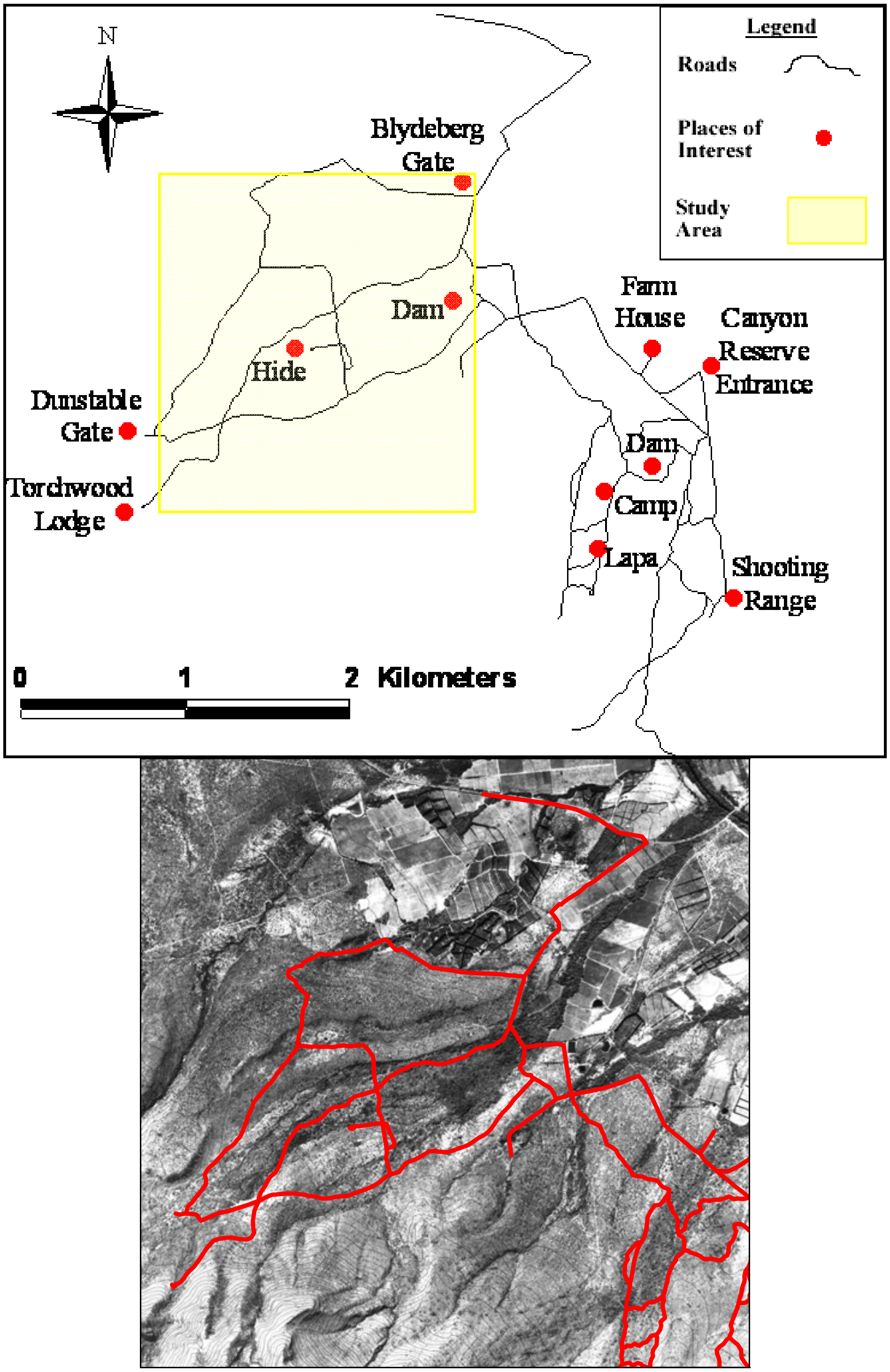

Figure 3: A GPS generated vector map of roads and infrastructure in Blydeberg Conservancy depicting the study area within the confines of the yellow rectangle and GPS mapped roads overlaid onto a digitized aerial photo of Blydeberg Conservancy.

3.2 Geology

The geology of the central and southern sections of the study area are a combination of volcanic and sedimentary rocks from the Black Reef formation of the Transvaal Sequence, from the Selati Formation of the undifferentiated upper part of the Wolkberg Group, and from the Abel Erasmus formation of the undifferentiated lower part of the Wolkberg Group; all dating back to the Vaalian Quaternary (Visser, 1989; Walraven, 1989; Buckle, 1992). The geology of the northern section of the study area is rock of intrusive origin, dating back to the Swazian Quaternary (Visser, 1989; Walraven, 1989; Buckle, 1992).

The geology of the study area ranges from a zone of fine to medium grained quartzite, gritty in places with pebble layers, basic lava, tuff, agglomerate and shale (lithologically classified as Vbr) in the South, to a zone of light-grey, medium grained biolite gneiss with coarse-grained quartz-feldspar leucosomes; recrystallised in places (lithologically classified as Zm) in the North (Figure 4) (Visser, 1989; Walraven, 1989). An intermediate zone of laminated micaceous and graphitic shale, locally interlayered with sandy shale, flagstone and quartzite (lithologically classified as Vwe) separates the southern Vbr and northern Zm zones (Figure 4) (Visser, 1989; Walraven, 1989). Also, according to Visser (1989) and Walraven (1989), intermittently layered along the south of the northern Zm zone and between such and the Vwe intermediate zone is another less distinct zone of greenish grey intermediate lava, amygdaloidal in places, interbedded porphyritic layers and layers of shale and quartzite (lithologically classified as Vwa) (Figure 4).

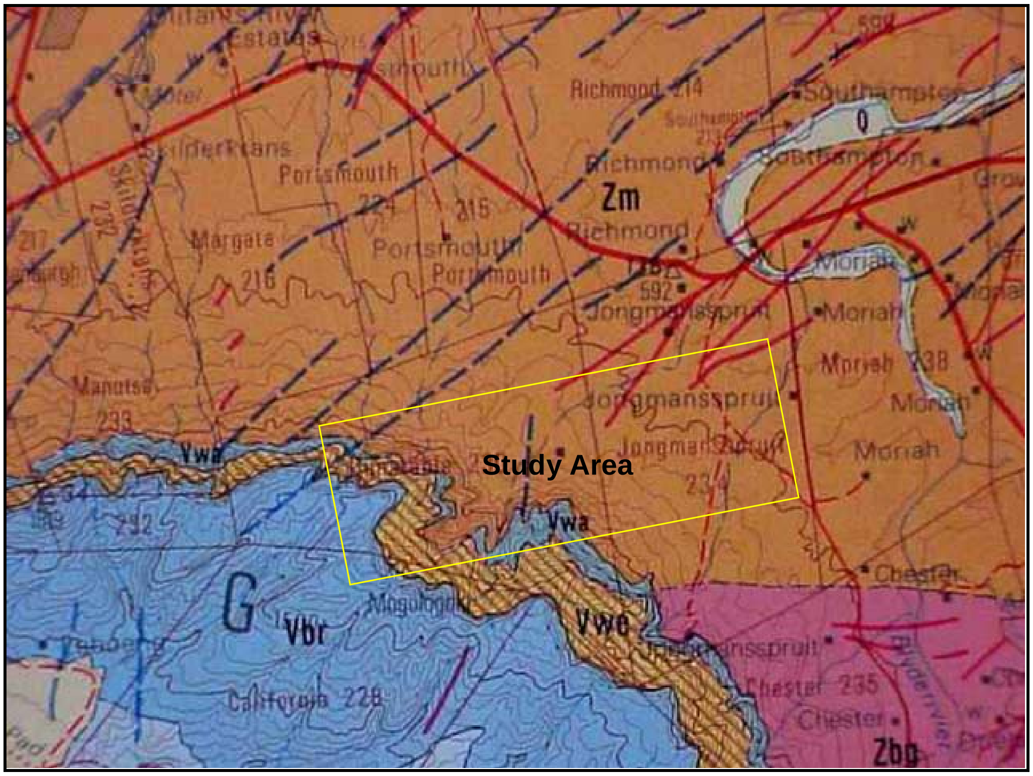

Figure 4: Geological map of the study area (demarcated by the yellow rectangle) and surrounds as adapted from the 1:250 000 Geological Series 2430 for Pilgrims Rest (South Africa, 1986).

Vbr, Vwe and Vwa are rocks of volcanic and sedimentary origin (Figure 4) (Visser, 1989; Walraven, 1989; Buckle, 1992). Vbr originates from the Black Reef formation of the Transvaal Sequence dating back to the Vaalian Quaternary. Vwe originates from the Selati Formation of the undifferentiated upper part of the Wolkberg Group dating back to the Vaalian Quaternary. Vwa originates from the Abel Erasmus Formation of the undifferentiated lower part of the Wolkberg Group and also dates back to the Vaalian Quaternary. Zm is rock of intrusive origin, dating back to the Swazian Quaternary (Figure 4) (Visser, 1989; Walraven, 1989; Buckle, 1992).

3.3 Land Types

Four land types, namely Fa, Fb, Ib and Ic occur in the study area as indicated in the terrain form sketch (Figure 5). According to Land Type Survey Staff (1989), “A land type denotes an area that can be shown at 1:250 000 scale and displays a marked degree of uniformity with respect to terrain form, soil pattern and climate”. A close association between the major plant communities and the different land types has been observed in other studies (Kooij *et al*., 1990; Bezuidenhout, 1993; Eckhardt, 1993; Brown, 1997).

The F land type refers to pedologically young landscapes that are not predominantly rock and alluvial or aeolian; in which the main soil forming processes have been rock weathering (Land Type Survey Staff, 1989). The formation of orthic topsoil horizons and clay illuviation have typically given rise to lithocutanic horizons (Land Type Survey Staff, 1989). Dominant soil forms are Glenrosa and Mispah, with Oakleaf present in upland areas (Soil Classification Working Group, 1991).

In the Fa land type lime in the soil is not commonly encountered and is rare or absent throughout the landscape. This land type consists of two terrain units, midslopes comprising 95 % of the land type, and valley bottoms constituting the remaining 5 % of the land type. Terrain type is D5, with less than 20 % of the area having slopes less than 8 %. Local relief varies from 300 to 900 m. Midslopes slope range varies between 6-30 % with range of slope length varying between 500-2000 m. Soil forms found on midslopes include Msinga (30 %), Mispah (20 %) and Trevanian (10 %). Rockiness is estimated at 40 %.

Valley bottoms slope range varies between 2-10 % with range of slope length varying between 10-40 m. Soil forms found in valley bottoms include Mispah (15 %), Trevanian (10 %), Waterridge and Cartref Series (20 %). Rockiness is estimated at 30 %, with stream beds comprising 25 % of the landscape. Soils are mostly medium sandy loam to sandy clay loam (Soil Classification Working Group, 1991). Soils are shallower than 400 mm. The geology consists of shale, quartzite, conglomerate and basalt of the Wolkberg group, Transvaal Sequence (Land Type Survey Staff, 1989).

In the Fb land type, lime in the soil is rare or absent in upland areas but, generally lime is present in low-lying areas. This land type consists of two terrain units, foot slopes comprising 80 % of the land type, and valley bottoms constituting 20 % of the land type. Terrain type is B3, with 50–80 % of the area having slopes less than 8 %. Local relief varies from 90 to 150 m. Foot slopes slope range varies between 4-10 % with range of slope length varying between 500-2500 m. Soil forms found on foot slopes include Cartref and Kusasa Series (20 %), Nyoka and Lindley Series (10 %), Shorrocks (10 %), Springfield (10 %), and Glenrosa (5 %). Soil rock complexes include Mispah (10 %), Platt and Glenrosa Series (20 %), and Shorrocks (5 %). Soil rockiness is estimated at 10 %. Valley bottoms slope range varies between 2-4 % with range of slope length varying between 50-100 m. Soil forms found in valley bottoms include Nyoka and Lindley Series (20 %), and Balfour and Darling Series (60 %). Rockiness is estimated at 5 %, with stream beds comprising 15% of the landscape. Soils are mostly medium to coarse sand to loamy sand (Soil Classification Working Group, 1991). Soils are shallower than 1200 mm. The geology consists of unnamed potassic granite and granodiorite (Land Type Survey Staff, 1989).

The I land type refers to miscellaneous land classes (Land Type Survey Staff, 1989).

The land type Ib indicates land types with exposed rock (country rock, stones or boulders), which covers 60-80 % of the area. This land type consists of three terrain units, namely crests comprising 20 % of the land type, midslopes comprising 75 % of the land type, and valley bottoms constituting the remaining 5 % of the land type. Terrain type is D5, with less than 20 % of the area having slopes less than 8 %. Local relief varies from 300 to 900 m. The slope range of crests varies between 2-6 % with range of slope length varying between 20-100 m. Soil forms found on crests include Farningham and Hutton Series (20 %). Soil rock complexes include Mispah (10 %), Williamson, Trevanian and Sainfaiths Series (20 %). Soil rockiness is estimated at 50 %. Midslopes slope range varies between 10-60 % with range of slope length varying between 100-1000 m. Soil forms found on midslopes include Farningham and Hutton Series (5%). Soil rock complexes include Mispah (15 %), Williamson, Trevanian and Sainfaiths Series (10 %). Soil rockiness is estimated at 70 %. Valley bottoms slope range varies between 2-4 %, with range of slope length varying between 10-50 m. Soil forms found in valley bottoms include Cranbrook (10 %), and Jozini (10 %). Soil rock complexes include Williamson, Trevanian and Sainfaiths Series (20 %). Soil rockiness is estimated at 50 %, with stream beds comprising 10 % of the landscape. Soils are mostly medium sandy clay loam to sandy clay (Soil Classification Working Group, 1991). Soils are shallower than 900 mm. The geology consists of quartzite, conglomerate, shale and basalt of the Black Reef Formation, Transvaal Sequence (Land Type Survey Staff, 1989).

The land type Ic refers to land types with exposed rock (country rock, stones or boulders), covering more than 80 % of the area. This land type consists of four terrain units, crests comprising 10 % of the land type, scarps comprising 20 % of the land type, midslopes comprising 68 % of the land type, and valley bottoms constituting the remaining 2 % of the land type.

Terrain type is D5, with less than 20 % of the area having slopes less than 8 %. Local relief varies from 300 to 900 m. Crests slope range varies between 4-15 % with range of slope length varying between 50-100 m. Soils rock complexes found on crests include Mispah (25 %), Williamson and Trevanian Series (10 %), and Msinga (10 %). Soil rockiness is estimated at 55 %. Scarps slope range varies between 90-150 % with range of slope length varying between 50-150 m. Soil rock complexes found on scarps include Mispah (5 %). Soil rockiness is estimated at 95 %. Midslopes slope range varies between 8-50 % with range of slope length varying between 200-800 m. Soil forms found on midslopes include Mispah (5 %), Williamson and Trevanian Series (5 %), and Msinga (5 %). Soil rockiness is estimated at 85 %.

Valley bottoms slope range varies between 4-8 % with range of slope length varying between 10-40 m. Soil forms found in valley bottoms include Mispah (5 %), and Msinga (5 %). Soil rockiness is estimated at 85 %, with stream beds comprising 5 % of the landscape. Soils are mostly fine to medium sandy loam to sandy clay loam (Soil Classification Working Group, 1991). Soils are shallower than 300 mm. The geology consists of shale, quartzite, conglomerate and basalt of the Wolkberg Group, Transvaal Sequence (Land Type Survey Staff, 1989).

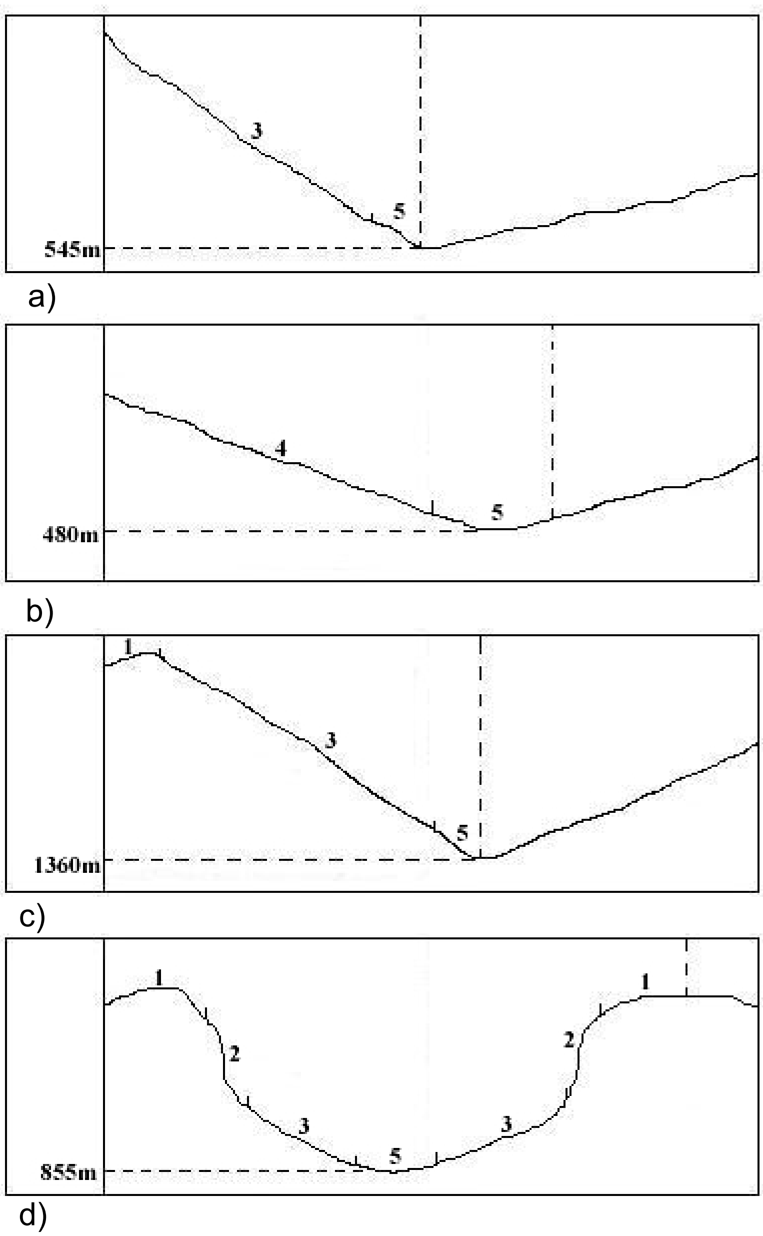

Figure 5: Terrain form sketch indicating the various land types of the study area. a) is land type Fa, b) is land type Fb, c) is land type Ib, and d) is land type Ic. Within the land type sketches, 1=Crest, 2=Scarp, 3=Mid slope, 4=Foot slope, 5=Valley bottom.

3.4 Climate

According to Bredenkamp & Van Rooyen (1998a, 1998b), the rainfall for the region encompassing the study area varies between 450 mm to 1000 mm per annum with temperatures ranging between -4 to 45 °C with a daily mean of 21 to 22° C.

Annual rainfall and temperature for Blydeberg for the four years preceding the study period was obtained from the Agricultural Research Council (ARC) institute for tropical and sub-tropical crops in Nelspruit. Climatic data collected over the study period was combined with ARC data for analyses. Rainfall and temperature figures for the same period for the Hoedspruit area was obtained from local farmers. Only five years of climatic data were used for analysis due to records from local farmers not being accurate for longer periods.

The average annual rainfall for the study area, as measured by a weather station situated on the Jongmanspruit farm for the period 05/1999 to 04/2004 was 561 mm, with a high of 953 mm and a low of 255 mm recorded in 2000 and 2002 respectively. For the period 05/1999 to 04/2004, average monthly rainfall varied from 0.7 mm during the dry winter season (May to October) to 106 mm in the wet summer season (November to April) (Figure 6).

For the larger Hoedspruit region, average annual rainfall for the period 05/1999 to 04/2004 was 900 mm with a high of 1463 mm and a low of 629 mm recorded in 2000 and 2002 respectively. For the period 05/1999 to 04/2004, average monthly rainfall varied from 2 mm during the dry winter season (May to October) to 189 mm in the wet summer season (November to April) (Figure 6).

Rainfall recorded for the study area is less than for the larger Hoedspruit region due to the study areas location on the foothills of the Drakensberg Mountains along the great escarpment. The mountains form a barrier leading to a rain shadow which could be responsible for less rainfall in the study area. However, the mountains do function as an important catchment for the study area and are the source of several small mountain streams (Van Zyl, 2003). Locally thunderstorms and fog are the main sources of precipitation for the study area.

Average annual temperature for the study area for the period 05/1999 to 04/2004 was 22^{o}C, with mean temperatures varying from 17^{o}C during the dry winter season to 26^{o}C in the wet summer season (Figure 6).

A minimum temperature of 3^{o}C and a maximum of 42^{o}C were recorded in the 05/2003 to 04/2004 period.

Average annual temperature for the larger Hoedspruit region for the period 05/1999 to 04/2004 was 17^{o}C, with mean temperatures varying from 11^{o}C during the dry winter season to 23^{o}C in the wet summer season (Figure 6). A minimum temperature of 11^{o}C and a maximum of 23^{o}C were recorded in the 05/2003 to 04/2004 period.

Temperatures for the study area are higher than those for the larger Hoedspruit region due to the study area lying along the north facing foot slopes of the Drakensberg Mountains along the great escarpment. The study area has more direct exposure to sunlight and is more sheltered from southerly winds than the surrounding areas (Tyson & Preston-Whyte, 2000).

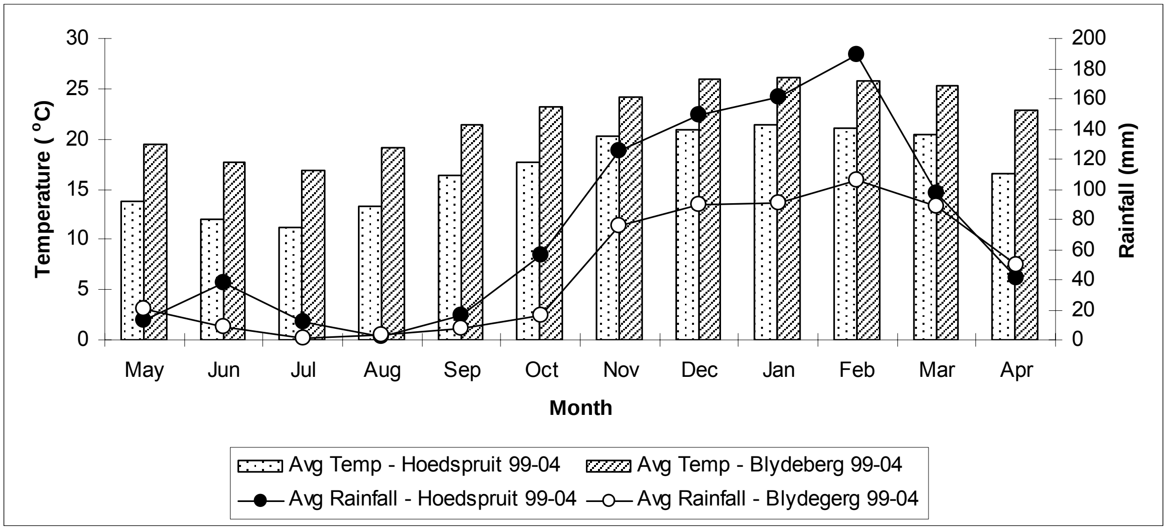

Figure 6: Average monthly rainfall and temperatures for Blydeberg Conservancy and Hoedspruit from 05/1999 to 04/2004.

Temperature and rainfall depicted in Figure 6 do not accurately represent monthly variations over the study period for the study area; hence a breakdown by month was created (Figure 7).

According to Figure 7, the coldest months at Blydeberg were June 2003 to August 2003, and the hottest were December 2003 to February 2004. No rainfall was recorded for July and August 2003, with only 2.5 mm recorded for October 2003. The highest rainfall of 136.5 mm was recorded in March 2004, with January and February 2004 being slightly less at 118.4 mm and 121.4 mm respectively.

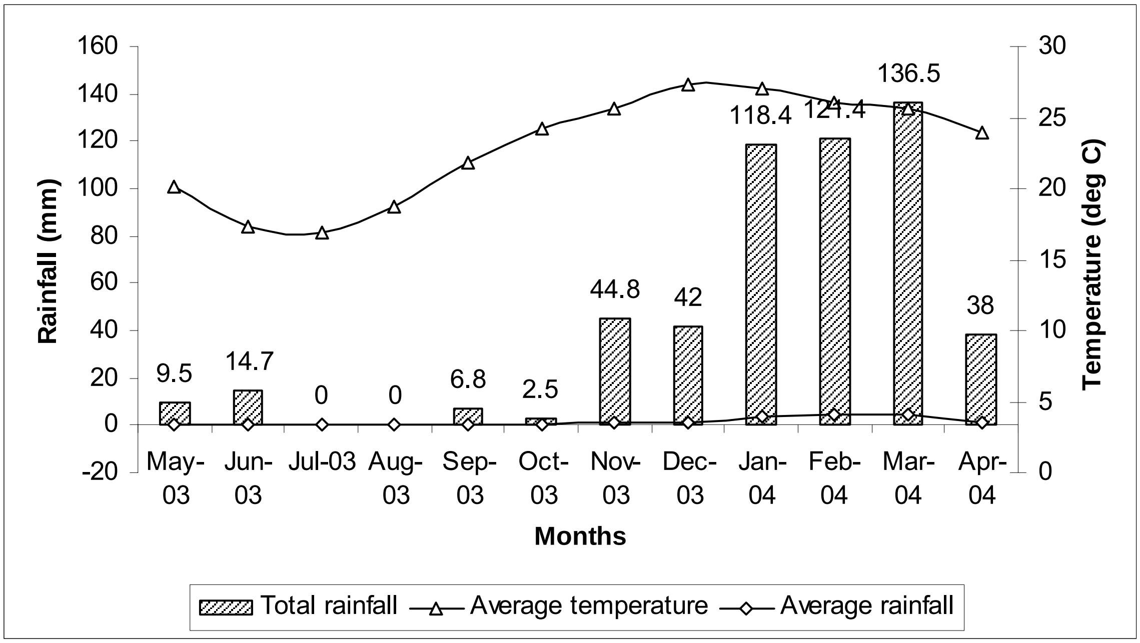

Figure 7: Rainfall and temperature summary for the study period 01 May 2003 to 30 April 2004 for the study area.

Table 1 depicts a rainfall summary for the last five years with a breakdown for the study period. Total rainfall for the first three quarters of the study period (238.7 mm) was less than rainfall for the fourth quarter (295.9 mm). From Table 1 it can be seen that the study period was mostly a dry period, with more than half (295.9 mm) of the total (534.6 mm) rainfall having fallen during the fourth quarter. The fourth quarter's rainfall as a percentage of the actual was 55.3 %, with the first to third quarters totaling only 44.7 %.

To further emphasize the above, the second half of the study period had 93.7 % of the total rainfall, as opposed to 6.3 % for the first half of the study period. The year before the study period was also a dry period, with only 254.6 mm of rain recorded for the year.

Rainfall during the study period was erratic and voluminous over short periods, with thunderstorms being the main source thereof. During thunderstorms large quantities of rain fell over very short periods of time, with most rainfall ending up as runoff and not much seepage.

Table 1: Rainfall for the last five years with a breakdown for the study period.

Period	Actual (mm)	Mean (mm)	% of Actual	Comment
05/1999-04/2000	953.3	79.4	n/a	n/a
05/2000-04/2001	467.1	38.9	n/a	n/a
05/2001-04/2002	595.3	49.6	n/a	n/a
05/2002-04/2003	254.6	21.2	n/a	n/a
05/2003-04/2004	534.6	44.6	n/a	n/a
1st quarter 05/2003-07/2003	24.2	2.0	4.5	Below mean
2nd quarter 08/2003-10/2003	9.3	0.8	1.7	Below mean
3rd quarter 11/2003-01/2004	205.2	17.1	38.4	Below mean
4th quarter 02/2004-04/2004	295.9	24.7	55.3	Above mean
1st half 05/2003-10/2003	33.5	2.8	6.3	Below mean
2nd half 11/2003-04/2004	501.1	41.8	93.7	Above mean

3.5 Flora

The conservancy's vegetation falls within the Mixed Lowveld Bushveld - vegetation type No. 19 (Bredenkamp & Van Rooyen, 1998a) and Sour Lowveld Bushveld - vegetation type No. 21 (Bredenkamp & Van Rooyen, 1998b); or within the Arid Lowveld (Acocks veld type No. 11) (Acocks, 1988).

The aforementioned veld types have high plant species richness with more than one thousand plant species recorded in the nearby Blyde River Canyon Nature Reserve. A checklist of all plant species recorded during this study for the Blydeberg Conservancy and the study area is attached (Appendix 1).

Adjacent to the conservancy, especially in the valleys, are cultivated agricultural lands containing sub-tropical fruits which include mangoes, bananas, papayas, oranges, vegetables and sugar cane.

For a comprehensive analysis of the study areas vegetation refer to Chapter 5.

3.6 Fauna

Several bird species including the martial eagle (*Polemaetus bellicosus*) and the crowned eagle (*Stephanoaetus coronatus*), which are known predators of vervets are frequently seen flying over the Blydeberg Conservancy. Mammals found on the Conservancy include aardvark (*Orycteropus afer*), baboon (*Papio ursinus*), banded mongoose (*Mungos mungo*), black backed jackal (*Canis mesomelas*), common duiker (*Sylvicapra grimmia*), blue wildebeest (*Connochaetes taurinus*), thick-tailed bushbaby (*Otolemur crassicaudatus*), bushbuck (*Tragelaphus scriptus*), caracal (*Felis caracal*), rock hyrax (*Procavia capensis*), giraffe (*Giraffa camelopardalis*), honey badger (*Mellivora capensis*), impala (*Aepyceros melampus*), kudu (*Tragelaphus strepsiceros*), leopard (*Panthera pardus*), porcupine (*Hystrix africaeaustralis*), scrub hare (*Lepus saxatilis*), slender mongoose (*Gelerella sanguinea*), large spotted genet (*Genetta tigrina*), vervet (*Chlorocebus aethiops*), warthog (*Phacochoerus aethiopicus*), waterbuck (*Kobus ellipsiprymnus*), and burchell's zebra (*Equus burchelli*).

Wild dog (*Lycaon pictus*) and cheetah (*Acinonyx jubatus*) have been known to pass through the Conservancy from time to time, but are not resident. Invertebrates are well represented and include several families.

A variety of frog and toad species occur in mountain streams and pools, and include the platanna (*Xenopus laevis laevis*), red toad (*Bufo carens*), common rain frog (*Breviceps mossambicus adspersus*), red-backed grass frog (*Ptychadena superciliaris*), painted reed frog (*Hyperolius viridiflavus taeniatus*), and common rana (*Rana angolensis*).

Snakes are well represented with the black mamba (*Dendroaspis polylepis*), mozambique spitting cobra (*Naja mossambica*), common night adder (*Causus rhombeatus*), twig or vine snake (*Thelotornis capensis*), stiletto snake (*Atractaspis bibronii*), southern African rock python (*Python sebae*), boom slang (*Dispholidus typus*), and puff adder (*Bitis arietans*) being the most noteworthy dangerous snakes. Several lizards and geckos are present throughout the area.

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CHAPTER 4

METHODS

This dissertation consists of a series of reports on the vegetation, vervet troop seasonal habitat utilisation and food selection, and seasonal activity patterns within the study area. The specific methods used in each data chapter (chapters 5, 6 and 7) are presented in each report. This chapter is a more detailed presentation of the general methods applied to this study.

4.1 Vegetation mapping and habitat description

One of the main objectives for this study was to identify, classify and describe the different plant communities within the study area. In order to compile such an ecological classification, the Zurich-Montpellier approach or the so called 'Braun-Blanquet' method was used (Braun-Blanquet, 1932; Mueller-Dombois & Ellenberg, 1974; Westhoff & Van der Maarel, 1978). The Braun-Blanquet method satisfies the three basic requirements of a vegetation ecology study in that it is: 1) scientifically sound, 2) it fulfills the necessity of classification at appropriate levels, and 3) it is more efficient and versatile among other comparable methods (Werger, 1974). Because of the aforementioned reasons and also due to the Braun-Blanquet methodology being easy to use, producing a reliable classification of an areas vegetation, it was decided to use this method for the classification of the study areas vegetation.

For orientation purposes and to gain knowledge of the study area, it was necessary to map the existing roads and infrastructure. Such was done with a Garmin 12 XL GPS and CARTALINX (Hagan *et al.*, 1998) mapping software.

Using a 1:10 000 digitized ortho photo for the Blydeberg area, the study area was stratified into homogeneous physiognomic-physiographic units based on geological formations, river banks, steep slopes, hills, valleys and floodplains, as well as areas with similar vegetation structure and texture (Barbour *et al.,* 1987; Kent & Coker, 1997). A total of 49 sample plots were located in a randomly stratified manner within these different stratification units to ensure all variations in the vegetation were considered and sampled. The number of plots were determined on a pro-rata basis subjective to the size of the unit, with more plots placed in the larger units than in the smaller ones. This subjective approach is often criticized but this strategy ensures that a statistically acceptable representative sample of the variation is obtained (Werger, 1974). Plot sizes were fixed at 400 m^2 (Barbour *et al.,* 1987; Brown & Bredenkamp, 1994; Brown, 1997). In each sample plot all plant species were recorded and cover abundance was assessed using the Braun-Blanquet cover abundance scale (Mueller-Dombois & Ellenberg, 1974; Barbour *et al.,* 1987)(Table2). Fieldwork was undertaken during April, May, and June 2003 and in January 2004. In the light of taxon names constantly changing, this publication conforms to those of Arnold & De Wet (1993).

Table 2: Modified Braun Blanquet cover abundance scale (Mueller-Dombois & Ellenberg, 1974).

Scale	Description
r	One or few individuals with less than 1 % cover of the total sample plot area.
+	Occasional and less than 1 % cover of the total sample plot area.
1	Abundant with low cover, or less abundant but with higher cover, 1-5 % cover of the total sample plot area.
2	Abundant with >5-25 % cover of the total sample plot area, irrespective of the number of individuals.
2a	>5-12.5 % cover.
2b	>12.5-25 % cover.
3	>25-50 % cover of the total sample plot area, irrespective of the number of individuals.
4	>50-75 % cover of the total sample plot area, irrespective of the number of individuals.
5	>75 % cover of the total sample plot area, irrespective of the number of individuals.

Environmental data collected include aspect, estimates of slope, percentage rockiness and percentage erosion. Floristic Data were analysed according to Braun-Blanquet procedures using the TURBOVEG suite (Hennekens, 1998), which includes the Two-way indicator species analysis multivariate classification technique (TWINSPAN)(Hill, 1979) for deriving an initial approximation of the main plant communities. This numerical classification technique is regarded as a successful approach to vegetation classification by various phytosociologists (Brown & Bredenkamp, 1994; Bredenkamp & Bezuidenhout, 1995; Brown *et al*., 1996; Cilliers, 1998).

The visual editor MEGATAB (Hennekens, 1996) was used to generate a phytosociological table. Using the phytosociological table and habitat information collected during sampling in the field, different plant communities were identified, described and ecologically interpreted. Further refinement of the classification was undertaken through the application of Braun-Blanquet procedures (Barbour *et al.* 1987; Bredenkamp *et al.* 1989; Kooij *et al.* 1990; Bezuidenhout 1993; Eckhardt 1993; Brown & Bredenkamp 1994; Kent & Coker 1997). Plant communities were recognized by using diagnostic species as defined by Westhoff & Van der Maarel (1978). Diagnostic or character species are those that are relatively restricted to a community. These species do not necessarily have a high importance value. The different plant communities are described according to their dominant species. Dominant species are those that are most conspicuous in the community and are high in one or more of the importance values (Whittaker, 1978), in this case cover and frequency.

A map of the various vegetation communities occurring within the conservancy (Ch5 Figure 4) was generated using a GPS and CARTALINX software (Hagan *et al.*, 1998).

4.2 <u>Vervet monitoring</u>

The study was conducted over a one year period to include at least one wet and one dry season.

Population structure and demography

Counts of the total vervet population in the Conservancy were obtained from random searches undertaken every month over the study period, and from conducting a census of the study area.

The location of all troops in the area was mapped as an overlay to the base map using GPS co-ordinates (Ch6 Figure 6). Individual animals were classified according to age class (adults, sub-adults, juveniles and neonates) and sex (male, female and unknown).

Ecology

A single vervet troop was habituated. The troop was followed on foot from a distance of 5-15 m for as long as possible on each day of data collection. Data were collected over an average of eleven days a month for a twelve-month period (1 May 2003 to 30 April 2004), resulting in 132 days of data, 30 of which were from dawn to dusk, the rest being dependent on when and for how long the troop was located. Data were recorded using a PALM HANDSPRING™ data-logger, pre-loaded with PENDRAGON FORMS™ software. Scan samples were taken approximately every thirty minutes from all visible animals (Altmann, 1974). Five mutually exclusive categories of activity were recognized: foraging (feeding, actively searching for or processing food), socializing (playing, aggression, grooming, maternal or paternal, mating), moving, resting and drinking. Chapter 7 depicts seasonal variations in the study troop's activity patterns.

When animals were recorded as foraging, the food source was identified and the specific part being consumed i.e. root, stem, fruit, flower, seed or leaf was documented.

4.3 <u>Census</u>

A census of the various species occurring in the study area was undertaken to determine diversity and numbers of animals. Combinations of the strip/line transect and known group counts were used.

A PALM HANDSPRING™ data-logger pre-loaded with PENDRAGON FORMS™ software was used for doing the census. A MICROSOFT ACCESS™ form was generated on a desktop computer and exported to the data-logger for data collection in the field. Collected Data were exported from the data-logger back to the desktop for analysis and processing.

- **Animal Census Protocol**

  According to Collinson (1985), the methods used for censusing animal populations needs to be standardized for comparison purposes between data collected by different individuals in potentially different areas, and for contingency purposes.

  Estimations of distances from animals encountered to the observer during the census are most likely to vary, and either a measuring tape should be used (this wasn't practical) or, more realistically, the individuals conducting the census should train themselves to estimate distances as accurately as possible (Barrett, pers. comm., 2003; Henzi, pers. comm., 2003).

- **Estimating Distance**

  Barrett (pers. comm., 2003) and Henzi (pers. comm., 2003), state that pacing is an effective method of measuring horizontal distances, provided the terrain is level and unobstructed. Pace length is calculated by counting one's steps along a straight pre-measured line and then dividing number of paces by distance.

  After pacing the line several times and regulating ones stride, average pace length can be determined. Pacing was used to measure distance between observer and animal.

Estimation of horizontal and vertical distances in the census habitat was done by making visual estimates along measured distances - multiples of known distances i.e. a person's height was used and the height of a tree was estimated as the number of multiples of the height of for example a 1.5 m tall person (Barrett, pers. comm., 2003; Henzi, pers. comm., 2003).

- **Timing of Censuses**

  Censuses were done at approximately the same time of day on census days i.e. from 07h00 to 11h00, this being consistent with recommendations for doing censuses (Collinson, 1985). The first 4-6 hours of the morning and the last 3 hours of the afternoon/evening are ideal for censusing primates as this is when animals tend to be most active (Barrett, pers. comm., 2003; Henzi, pers. comm., 2003). No censusing was done during rainy or very windy conditions, as such reduces visibility and leads to sample bias.

- **Transect Lines**

  Transect lines were kept as straight as possible, bearing in mind that the terrain was rocky and mountainous. A total of five transect lines were set out (Figure 8), with a total transect length of 17.3 km (transect lengths varied from 2.4 km to 4.3 km).

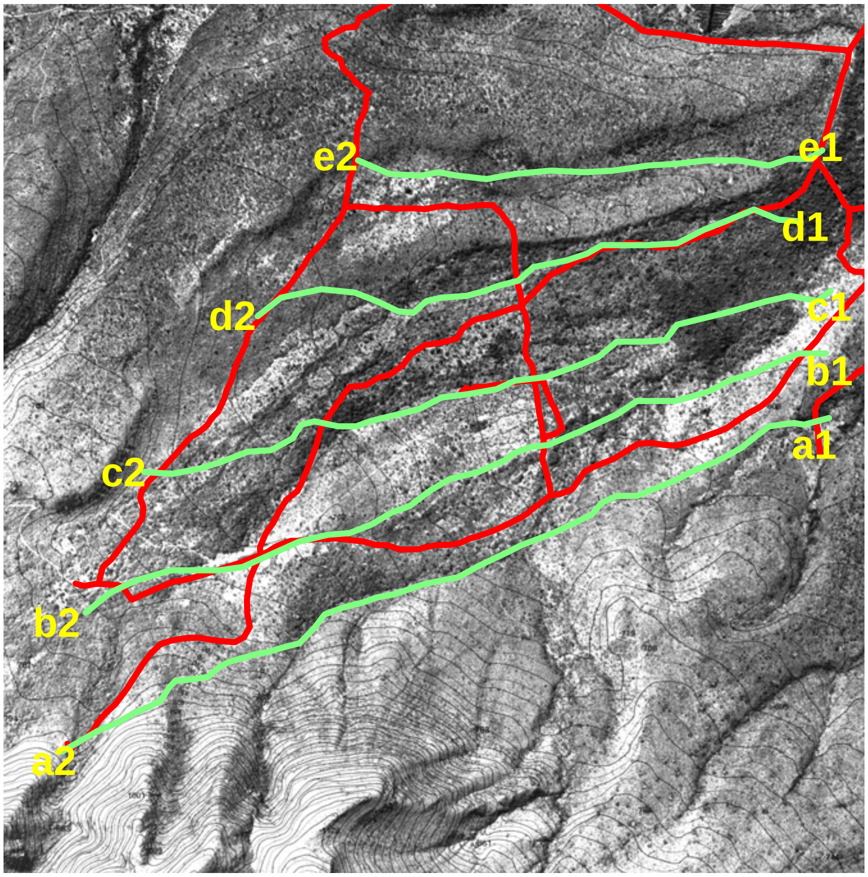

Figure 8: Census transects walked – all transects were walked from east to west i.e. a1 to a2, b1 to b2, c1 to c2 etc. to prevent the suns glare from distorting visibility. Census transects are depicted in green with roads in red.

Transects ran from east to west and were walked as such to prevent the suns glare from distorting visibility. Transects were walked bi-monthly for 5 months as per recommendations (Barrett, pers. comm., 2003; Henzi, pers. comm., 2003).

Transects were selected using stratified random sampling techniques and covered most of the potential habitats except mountain tops which were excluded due to their precipitous nature.

- **Conducting the Census**

  During the census the observer moved along a transect line and stopped frequently (every five minutes) to listen and scan the surrounding area. A walking pace of approximately 2-3 km/h was maintained with the use of a GPS.

  Distances paced and direction travelled were calculated and maintained by pre-plotting transects on a map of the area and using a GPS to pace from starting to ending points in as straight a line as possible. Each transects was walked alone.

  The following general information was collected during the census:

  - **Start and end GPS locations.**
  - **Date and time.**
  - **Weather conditions.**
  - **Observer name.**

  Whenever an animal was encountered, two to ten minutes was spent observing it, depending on the species and its behaviour. The observer remained on the census route and did not follow the animal or group. For each encounter the following information was recorded:

  - **Time encounter started.**
  - **Species** encountered.
  - **Animal to observer distance:** distance from observer's position to animal when first detected – also called sighting distance.
  - **Animal to transect distance:** shortest perpendicular distance from the animal to the transect line.
  - **Initial animal height (m)**.

- **Initial animal activity (of *first* animal detected):** resting, moving, foraging, socializing or other.
- **Number of animals counted**.
- **Estimated group size.**
- **Mode of detection:** visual moving, visual stationary, vocalization or sound while traveling through the bush.
- **Age class:** adult, sub-adult, juvenile, neonate.
- **Sex:** male, female or unknown.
- **Vocalizations.**
- **Time encounter ended.**
- **Comments.**

Census transects starting and ending GPS co-ordinates were predetermined and setup prior to starting with the census. On census days, transects were walked from east to west (Figure 8). A GPS was used to walk along transects and the starting and ending co-ordinates were captured into the GPS. The GOTO function was then used to go from the starting location to the end location in as straight a line as possible.

Starting and ending GPS co-ordinates with mean distances of each transect were recorded and are reflected in Table 3 below.

Table 3: Census transects for Blydeberg with starting co-ordinates, ending co-ordinates and length of transects.

TRANSECT	START CO-ORDINATE	END CO-ORDINATE	DISTANCE (km)
a1 to a2	30.780561 -24.432018	30.752140 -24.444224	± 3.2
b1 to b2	30.780437 -24.429663	30.753006 -24.439143	± 3
c1 to c2	30.780623 -24.427308	30.755174 -24.434000	± 2.7
d1 to d2	30.779509 -24.424706	30.759384 -24.428300	± 2.1
e1 to e2	30.780314 -24.422228	30.763100 -24.422537	± 1.7
Total			± 12.7

Transect lines shown in Figure 8 are an overlay of the roads and transects for orientation purposes. The mean or central lines of all census transects walked are shown as each time a particular transect was done it was impossible to do the entire transect exactly along a previous route.

Density calculations were not performed as the area was too small to justify such, however from the census data obtained a table of the main species occurring in the area with average numbers was generated, known group counts and separate sightings have been included (Table 4).

Average number of animals was calculated by summing the number of animals counted for each species and dividing such by the number of times they were seen, the same was done for estimated group size – total animals counted and total estimated group size were added together and divided by two.

Table 4: Census data reflecting species occurring on Blydeberg Conservancy.

Species	Average Number Of Animals (Census)	Highest Animal Count (Census)	Tot Numbers From Known Group Counts
Aardvark (*Orycteropus afer*)	1	1	1
Baboon (*Papio ursinus*)	10	16	25 (16+9)*
Banded Mongoose (*Mungos mungo*)	9	14	15
Common Duiker (*Sylvicapra grimmia*)	1	1	2
Blue Wildebeest (*Connochaetes taurinus*)	4	10	10
Bushbuck (*Tragelaphus scriptus*)	3	3	5
Caracal (*Felis caracal*)	1	1	1
Giraffe (*Giraffa camelopardalis*)	2	3	4
Impala (*Aepyceros melampus*)	5	30	30
Porcupine (*Hystrix africaeaustralis*)	0	0	2
Slender Mongoose (*Gelerella sanguinea*)	1	1	1

Large Spotted Genet (*Genetta tigrina*)	0	0	1
Thick-tailed bushbaby (*Otolemur crassicaudatus*)	0	0	3
Vervet (*Chlorocebus aethiops*)	14	28	52 (33+11+8)**
Warthog (*Phacochoerus aethiopicus*)	2	5	5
Waterbuck (*Kobus ellipsiprymnus*)	1	1	2

* Two known troops, ±16 for the troop at Torchwood and ±9 for the troop at the gate – some of the latter troop's animals were injured i.e. broken limbs, limping etc.

** Three known troops, the study troop were 33, Dunstable troop ±11 and a small troop at the entrance gate of ±8.

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CHAPTER 5

A vegetation classification and description as a precursor for vervet monkey (*Chlorocebus aethiops*) habitat utilisation, food selection and activity analysis in the Blydeberg Conservancy, Northern Province.

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The plant communities of the Blydeberg Conservancy were investigated as part of a research project on the foraging ecology of the vervet monkey *(Chlorocebus aethiops)* in mixed lowveld bushveld and sour lowveld bushveld areas. From a TWINSPAN classification refined by Braun-Blanquet procedures, ten plant communities which can be placed into four major groups were identified. A classification and description of these communities, including a vegetation map are presented. Diagnostic species as well as prominent and less conspicuous species of tree, shrub, herb and grass strata are outlined. From the ten plant communities available to the vervet troop only six were utilized as a food source. Of the six communities utilized, one was utilized throughout the year, and two only during the dry season. These communities should be managed effectively to ensure continued availability of food for the vervets.

Keywords: Braun-Blanquet procedures, conservancy, plant communities, TWINSPAN, phytosociology, vervet monkey.

Introduction

The Blydeberg Conservancy constitutes a group of privately owned farms belonging to individuals with varying interests. Owners have diverse backgrounds including farming, hunting, research, business and property development. The intention of the conservancy was to pool resources and properties to form a large area containing various game species for tourism ventures and private utilisation.

Not many extensive vegetation studies have been carried out in the Blydeberg area or surrounds and those that have been done (Van der Schijff, 1963; Van der Schijff & Schoonraad, 1971), were done once off without any recorded follow ups to date. Due to the various land use practices occurring within the area and their long-term effects on ecosystems, as well as for the research project on vervet monkeys (*Chlorocebus aethiops*) undertaken in the area (Barrett, 2005), it was deemed important to undertake a vegetation description and classification of the Blydeberg Conservancy.

It is widely recognized that the detailed description, identification, classification and mapping of vegetation forms the basis of sound land-use planning and management (Van Rooyen *et al*. 1981; Tueller 1988; Fuls *et al*. 1992; Fuls 1993; Bezuidenhout 1996; Brown 1997). The results obtained from such an endeavor could be used to assist management in making decisions for the conservancy; whilst simultaneously providing data for the determination of the seasonal foraging ecology of the vervet monkeys *(Chlorocebus aethiops)*. The main aim of the vegetation study was thus to describe and map the plant communities of the study area within the Blydeberg Conservancy in order to determine the seasonal foraging ecology of a troop of vervet monkeys (*Chlorocebus aethiops*) living within the area. Vegetation assessments are prerequisites to any ecological or habitat related research, forming a basis to any further studies (Van Rooyen *et al*. 1981).

Vervet monkeys are extremely adaptable opportunistic generalists (similar to baboons but, less so) that easily move into disturbed areas, including agricultural areas, lodges and can even be found in specialized habitats such as mangrove swamps (Oates, 1996; Kingdon, 1997; Fedigan & Fedigan, 1988; Skinner & Smithers, 1990; Booth, 1979). Vervets are capable of becoming a pest species in areas where they are forced into close proximity with humans, leading to conflict and ultimately their wanton demise. The aim of the encompassing study on vervet foraging ecology hopes to elucidate some of their foraging behavior. It is anticipated that results obtained from such a study would assist management in successfully implementing management plans for vervets as part of their overall ecological management strategy. Not many detailed ecological studies of vervets have been undertaken in temperate sub-tropical areas (Struhsaker, 1967; Harrison, 1983, 1984; Whitten, 1988; Lee & Hauser, 1998; Isbell et al., 1998; Pruetz & Isbell, 2000). At these low latitudes, overall habitat productivity is high and seasonal variability is relatively constrained (Caughley & Sinclair, 1994). A better understanding of vervet ecological flexibility and the factors that might limit their distribution both broadly and locally is likely to be derived from the encompassing study and will benefit the overall management of the species. No related vervet studies have been undertaken locally. A study on baboon resource utilisation has been done in the adjacent Blyde Canyon Nature Reserve (Marais, 2005).

Study Area

The Blydeberg Conservancy is situated approximately 19 km south of the town of Hoedspruit in the Northern Province. It is located between longitude 30° 27’ to 25° 56’ E and latitude 24° 23’ to 24° 28’ S. Altitude ranges from 350 m to 800 m above sea level (Bredenkamp & Van Rooyen, 1998a, 1998b). The study area constitutes the farms Dunstable (farm number 230) and Jongmanspruit (farm number 234) (Figure 1).

The current size of the Blydeberg Conservancy is 3000 ha with the study area being 816 ha.

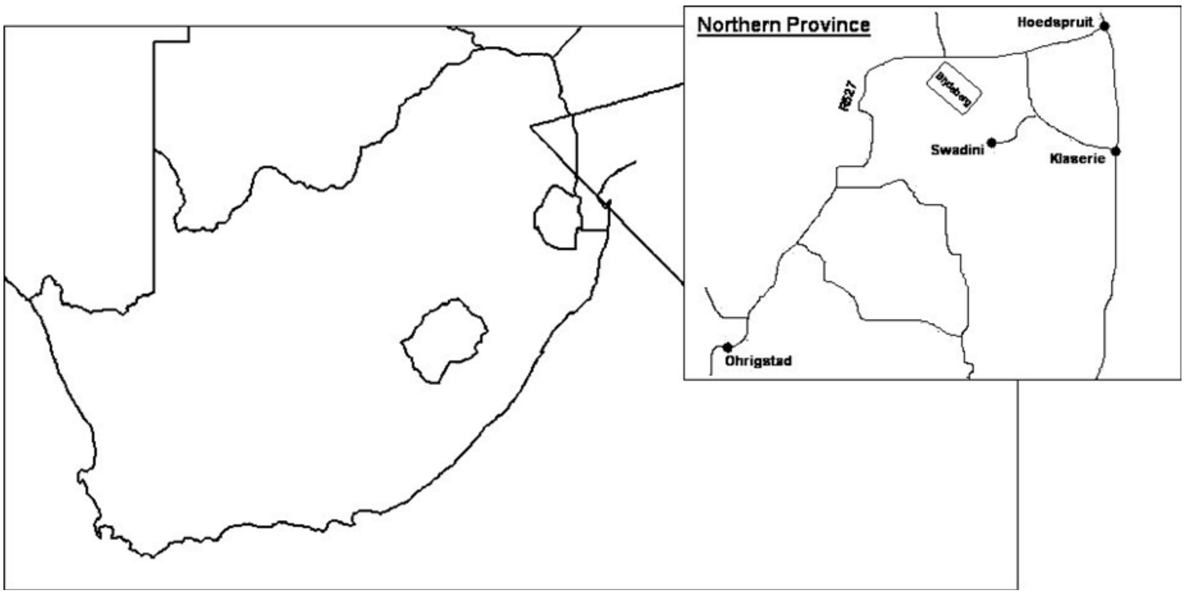


Figure 1: Location of Blydeberg Conservancy within the Northern Province of South Africa.

Geology and Topography

The **geology** of the conservancy ranges from a zone of fine to medium grained quartzite, gritty in places with pebble layers; basic lava, tuff, agglomerate and shale in the South; to a zone of light-grey, medium grained biolite gneiss with coarse-grained quartz-feldspar leucosomes; recrystallised in places in the North (Visser, 1989; Walraven, 1989). An intermediate zone of laminated micaceous and graphitic shale, locally interlayered with sandy shale, flagstone and quartzite separates the southern and northern zones (Visser, 1989; Walraven, 1989).

Also, according to Visser (1989) and Walraven (1989), intermittently layered along the south of the northern zone and between such and the intermediate zone is another less distinct zone of greenish grey intermediate lava, amygdaloidal in places, interbedded porphyritic layers and layers of shale and quartzite. Visser (1989) and Walraven (1989), state that the southern, intermediate and the less distinct zone between the northern and intermediate zones are rocks of volcanic and sedimentary origin dating back to the Vaalian Quaternary. The southern zone originates from the Black Reef formation of the Transvaal Sequence; the intermediate zone originates from the Selati Formation of the undifferentiated upper part of the Wolkberg Group and the less distinct zone between the northern and intermediate zones originates from the Abel Erasmus formation of the undifferentiated lower part of the Wolkberg Group (Visser, 1989; Walraven, 1989; Buckle, 1992). The northern zone is rock of intrusive origin, dating back to the Swazian Quaternary (Visser, 1989; Walraven, 1989; Buckle, 1992).

The **topography** of the study area is mostly mountainous with steep to moderately steep slopes gradually tapering off to a relatively flat mountain plateau. In the southern section of the area the Drakensberg Mountains form the southern boundary of the study area and have very steep slopes and rock faces that are almost impossible to traverse. The northern section of the study area is less steep and the terrain is relatively flat. The geology is a combination of volcanic and sedimentary rocks in the south, and intrusive rocks in the north.

Land Types

Four land types, namely Fa, Fb, Ib and Ic, occur in the study area as indicated in the terrain form sketch (Figure 2). According to Land Type Survey Staff (1989), “A land type denotes an area that can be shown at 1:250 000 scale and displays a marked degree of uniformity with respect to terrain form, soil pattern and climate”.

A close association between the major plant communities and the different land types has been observed in other studies (Kooij *et al*., 1990; Bezuidenhout, 1993; Eckhardt, 1993; Brown, 1997).

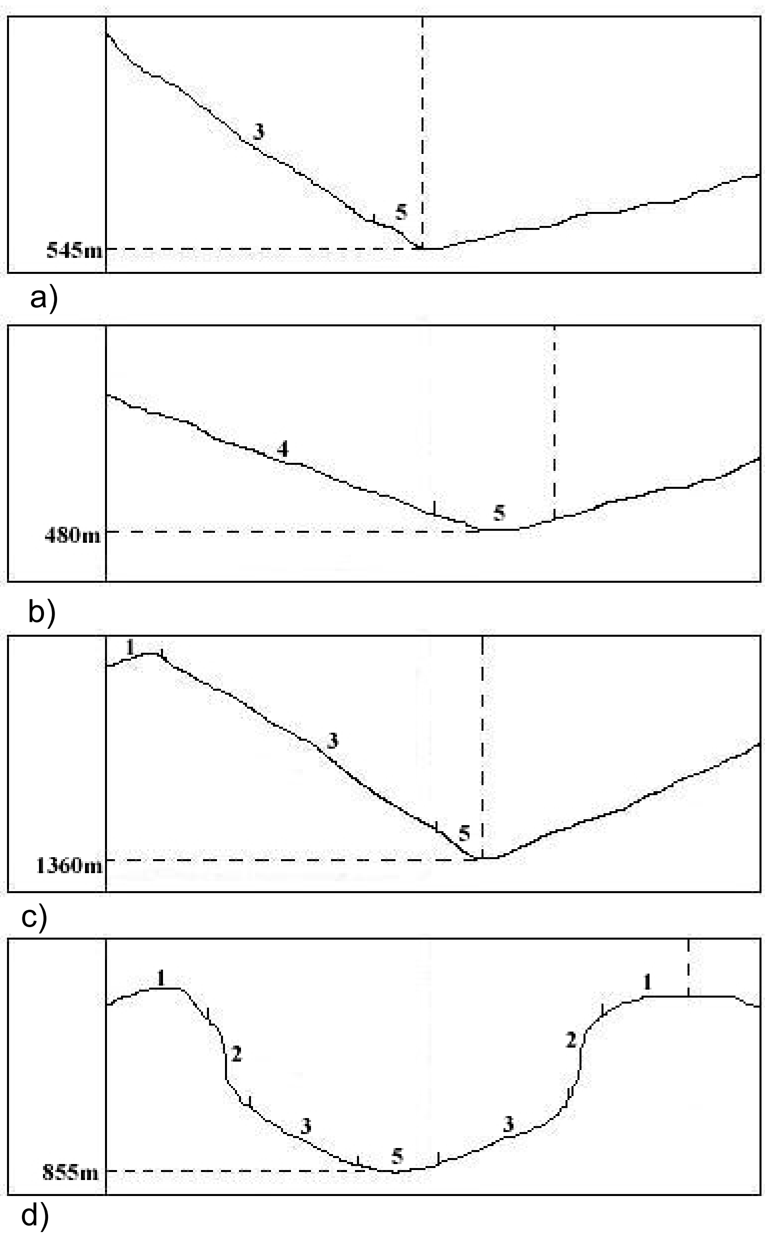


Figure 2: Terrain form sketches indicating the various land types of the study area. a) is land type Fa, b) is land type Fb, c) is land type Ib, and d) is land type Ic. Within the land type sketches, 1=Crest, 2=Scarp, 3=Mid slope, 4=Foot slope, 5=Valley bottom.

The F land type refers to pedologically young landscapes that are not predominantly rock and alluvial or aeolian, in which the main soil forming processes have been rock weathering (Land Type Survey Staff, 1989). The formation of orthic topsoil horizons and clay illuviation have typically given rise to lithocutanic horizons (Land Type Survey Staff, 1989). Dominant soil forms are Glenrosa and Mispah, with Oakleaf present in upland areas (Soil Classification Working Group, 1991).

In the Fa land type lime in the soil is not commonly encountered and is rare or absent throughout the landscape. Soils are mostly medium sandy loam to sandy clay loam (Soil Classification Working Group, 1991). Soils are shallower than 400 mm.

The geology consists of shale, quartzite, conglomerate and basalt of the Wolkberg group, Transvaal Sequence (Land Type Survey Staff, 1989).

In the Fb land type, lime in the soil is rare or absent in upland areas but, generally, lime is present in low-lying areas. Soils are mostly medium to coarse sand to loamy sand (Soil Classification Working Group, 1991). Soils are shallower than 1200 mm.

The geology consists of unnamed potassic granite and granodiorite (Land Type Survey Staff, 1989).

The I land type refers to miscellaneous land classes (Land Type Survey Staff, 1989). The land type Ib indicates land types with exposed rock (country rock, stones or boulders), which covers 60-80 % of the area. Soils are mostly medium sandy clay loam to sandy clay (Soil Classification Working Group, 1991). Soils are shallower than 900 mm.

The geology consists of quartzite, conglomerate, shale and basalt of the Black Reef Formation, Transvaal Sequence (Land Type Survey Staff, 1989).

The land type Ic refers to land types with exposed rock (country rock, stones or boulders) covering more than 80 % of the area. Soils are mostly fine to medium sandy loam to sandy clay loam (Soil Classification Working Group, 1991). Soils are shallower than 300 mm.

The geology consists of shale, quartzite, conglomerate and basalt of the Wolkberg Group, Transvaal Sequence (Land Type Survey Staff, 1989).

Vegetation

The area is rather patchy and vegetation varies from relatively open bushveld with long grass species on undulating hills and slopes, through dense shrub and scrub in dry ravines and dongas, to patches of semi-montane forest in sheltered kloofs. The area can be classified as intermediate between Mixed Lowveld Bushveld - veld type 19 (Bredenkamp & Van Rooyen, 1998a) and Sour Lowveld Bushveld - veld type 21 (Bredenkamp & Van Rooyen, 1998b).

Climate

The average annual rainfall for the study area, as measured by a weather station situated on the Jongmanspruit farm (farm number 234) for the period 05/1999 to 04/2004 was 561 mm, with a high of 953 mm and a low of 255 mm recorded in 2000 and 2002 respectively. For the period 05/1999 to 04/2004, average monthly rainfall varied from 0.7 mm during the dry winter season (May to October) to 106 mm in the wet summer season (November to April) (Figure 3).

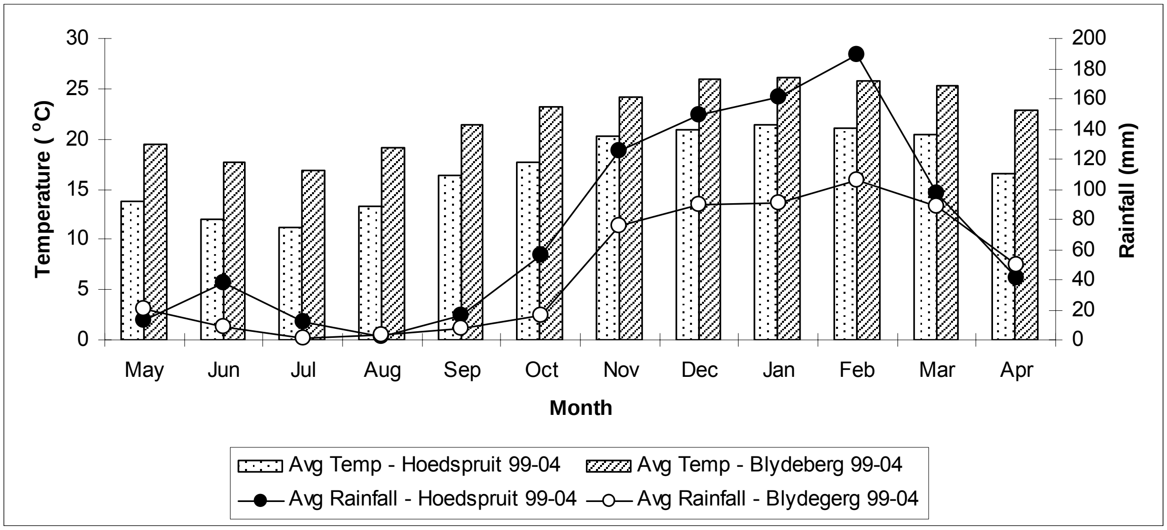


Figure 3: Average monthly rainfall and temperatures for the Blydeberg Conservancy and Hoedspruit from 05/1999 to 04/2004.

For the larger Hoedspruit region, average annual rainfall for the period 05/1999 to 04/2004 was 900 mm with a high of 1463 mm and a low of 629 mm recorded in 2000 and 2002 respectively. For the period 05/1999 to 04/2004, average monthly rainfall varied from 2 mm during the dry winter season (May to October) to 189 mm in the wet summer season (November to April) (Figure 3).

Rainfall recorded for the study area is less than that of the larger Hoedspruit region due to the study areas location on the foothills of the Drakensberg Mountains along the great escarpment. The mountains form a barrier leading to a rain shadow which could be responsible for less rainfall in the study area. However, the mountains do function as an important catchment for the study area and are the source of several small mountain streams (Van Zyl, 2003). Locally thunderstorms and fog are the main sources of precipitation for the study area.

Average annual temperature for the study area for the period 05/1999 to 04/2004 was 22°C, with mean temperatures varying from 17°C during the dry winter season to 26°C in the wet summer season (Figure 3). A minimum temperature of 3°C and a maximum of 42°C were recorded in the 05/2003 to 04/2004 period.

Average annual temperature for larger Hoedspruit region for the period 05/1999 to 04/2004 was 17°C, with mean temperatures varying from 11°C during the dry winter season to 23°C in the wet summer season (Figure 3). A minimum temperature of 11°C and a maximum of 23°C were recorded in the 05/2003 to 04/2004 period.

Temperatures for the study area are higher than those for the larger Hoedspruit region due to the study area lying along the north facing foot slopes of the Drakensberg Mountains along the great escarpment. The study area has more direct exposure to sunlight and is more sheltered from southerly winds than the surrounding areas (Tyson & Preston-Whyte, 2000).

Methods

Using a 1:10 000 digitized ortho photo for the Blydeberg area, the study area was stratified into physiognomic-physiographic units (Barbour *et al.,* 1987; Kent & Coker, 1997). A total of 49 sample plots were located in a randomly stratified manner within these units to ensure that all variations in the vegetation were considered and sampled. Plot sizes were fixed at 400 m^2 (Barbour *et al.,* 1987; Brown & Bredenkamp, 1994; Brown, 1997).

In each sample plot all species were recorded and cover abundance was assessed using the Braun-Blanquet cover abundance scale (Mueller-Dombois & Ellenberg, 1974; Barbour *et al.,* 1987).

Fieldwork was undertaken during April, May, and June 2003 and in January 2004. In the light of taxon names constantly changing, this publication conforms to those of Arnold & De Wet (1993).

Environmental data collected included aspect, estimates of slope, percentage rockiness and percentage erosion. Floristic Data were analyzed according to Braun-Blanquet procedures using the TURBOVEG suite (Hennekens, 1998), which includes the Two-way indicator species analysis multivariate classification technique (TWINSPAN) (Hill, 1979) for deriving an initial approximation of the main plant communities. This numerical classification technique is regarded as a successful approach to vegetation classification by various phytosociologists (Brown & Bredenkamp, 1994; Bredenkamp & Bezuidenhout, 1995; Brown *et al*., 1996; Cilliers, 1998). The visual editor MEGATAB (Hennekens, 1996) was used to generate a phytosociological table. Further refinement of the classification was undertaken through the application of Braun-Blanquet procedures (Barbour *et al.* 1987; Bredenkamp *et al.* 1989; Kooij *et al.* 1990; Bezuidenhout 1993; Eckhardt 1993; Brown & Bredenkamp 1994; Kent & Coker 1997). Using the final phytosociological table and habitat information collected during sampling in the field, different plant communities were identified, described and ecologically interpreted.

Erosion was estimated within the following classes (Matthee & Van Schalkwayk, 1984):

Class 1	Slight.
Class 2	Moderate loss of topsoil with slight soil cutting by run-off channels or gullies.
Class 3	Severe loss of topsoil with marked soil cutting by run-off channels or gullies.
Class 4	Total loss of topsoil and exposure of subsoil or deep intricate soil cutting by gullies.

Slope was estimated within the following categories:

Level	$0\text{-}3^0$
Gentle	$3\text{-}8^0$
Moderate	$8\text{-}16^0$
Steep	$16\text{-}26^0$
Very steep	$26\text{-}45^0$

Results

Classification

The analysis resulted in the identification of the following ten plant communities (Figure 4), which may be grouped into four major community types (Table 1):

1. *Eragrostis lehmanniana-Grewia flava* Shrubland.
    1.1 *Heteropogon contortus-Grewia flava* Shrubland.
    1.2 *Ziziphus mucronata-Grewia flava* Shrubland.
2. *Bridelia mollis-Acacia nigrescens* Woodland.
    2.1 *Berchemia zeyheri-Acacia nigrescens* Woodland.
    2.2 *Combretum imberbe-Acacia nigrescens* Woodland.
3. *Acacia nigrescens-Combretum apiculatum* Woodland.
4. *Gymnosporia glaucophylla-Panicum maximum* Woodland.
    4.1 *Balanites maughamii-Panicum maximum* Woodland.
    4.2 *Sclerocarya birrea-Panicum maximum* Woodland.
    4.3 *Combretum zeyheri-Panicum maximum* Woodland.
    4.4 *Asparagus setaceus-Philenoptera violacea* Woodland.
        4.4.1 *Pappea capensis* Variant.
        4.4.2 *Diospyros mespiliformis* Variant.

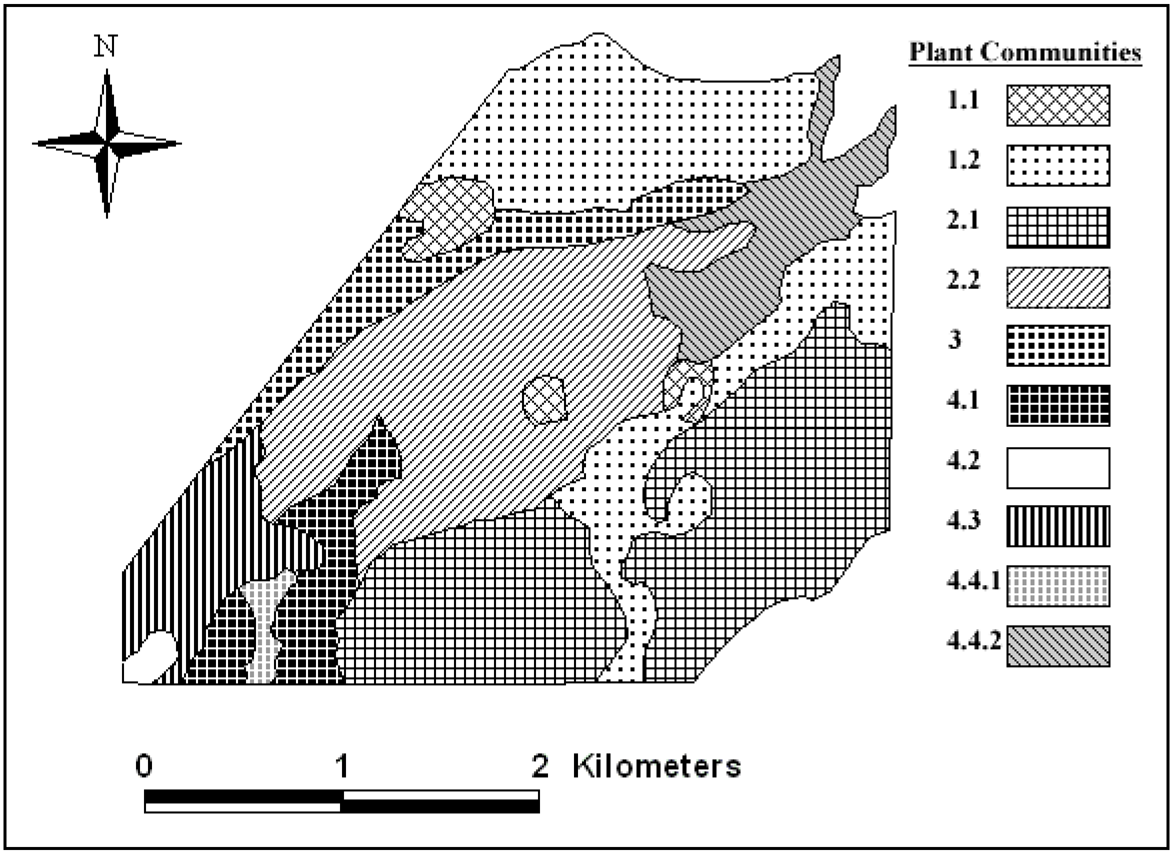


Figure 4: Vegetation map of the study area within the Blydeberg Conservancy. Map depicts the various plant communities, sub-communities and variants.

Description of plant communities

The study area is mostly open woodland with a depleted herbaceous layer due to a history of overgrazing and irregular agricultural practices leading to low plant species diversity. The vegetation comprises a mixture of dense montane forest in kloofs, open tree savanna sour bushveld on northern and western slopes, high mountain sour grass veld and dense riverine thickets along drainage lines and streams. There is a strong presence of the shrub species *Grewia flava* and *Grewia flavescens* throughout the study area.

The general vegetation of the study area is characterized by the presence of species from species groups O, P and Q occurring in communities 1, 2, 3 and 4; and with species from species group N found mostly in communities 1, 2 and 3. For all species groups refer to Table 1.

Prominent species include the shrubs *Grewia flavescens*, *Grewia flava* (species group Q)*, Dichrostachys cinerea* (species group P) and the grass *Elionurus muticus* (species group Q) which occur in all communities, and the trees *Combretum apiculatum* and *Ziziphus mucronata* (species group P) which occur in most communities with the exception of sub-community 4.4.2. The tree *Sclerocarya birrea* (species group O) is prominent in most communities except sub-community 4.4. The tree *Acacia nigrescens* (species group O) is dominant in communities 1, 2, 3 and sub-community 4.1 (Table 1).

Table 2 depicts additional plant species recoded for Blydeberg but not significant enough to be reflected in table 1. The species names and the communities they occur in are presented.

Table 2: Table of less prevalent plant species occurring at Blydeberg and not represented in Table 1.

Species Name	Community Number	Species Name	Community Number
Acacia burkei	1.1, 2.1	*Melinis repens*	2.2
Acacia galpinii	1.1	*Nuxia oppositifolia*	4.4
Acacia tortilis	1.1	*Olea europaea*	2.1, 4.1
Aloe dyeri	1.2	*Opuntia ficus-indica*	2.2
Aloe marlothii	4.1, 4.2	*Ozoroa paniculosa*	1.2, 2.2
Asparagus cooperi	1.1, 3	*Ozoroa sphaerocarpa*	4.2
Bacchar adoensi v. kot	2.1	*Pavonia columella*	4.2, 4.4
Boscia albitrunca	1.2, 2.2	*Plectroniella armata*	2.2
Canthium ciliatum	2.1	*Rauvolfia caffra*	4.3
Capparis tormentosa	4.3	*Rhigozum obovatum*	1.1
Celtis africana	4.4	*Rhus dentata*	4.4
Chloris virgata	1.1	*Rhus tumulicola*	4.3
Cussonia spicata	1.1	*Schotia brachypetala*	4.1
Diheteropogon filifolius	1.2	*Scolopia zeyheri*	4.4
Eragrostis rigidior	4.4	*Spirostachys africana*	4.4
Eragrostis superba	2.1	*Strelitzia nicolai*	1.2
Eustachys paspaloides	4.2	*Strophanthus gerrardii*	4.2, 4.3
Ficus sycomorus	4.3	*Strophanthus speciousus*	4.3
Garcinia livingstonei	4.3	*Tagetes minuta*	1.1, 1.2
Hippocratea crenata	4.3	*Terminalia sericea*	1.1, 2.1
Hyparrhenia hirta	1.2	*Trichilia emetica*	4.4
Hypoxis hemerocallidea	1.1	*Vernonia adoensis*	2.1
Leucosidea sericea	1.2	*Wachendorfia parviflor*	4.2
Maerua angolensis	4.1	*Xanthium spinosum*	2.1
Markhamia zanzibarica	4.2		

1. *Eragrostis lehmanniana-Grewia flava* Shrubland.

This shrubland plant community covers approximately 24 % of the study area (193 ha) and consists of flat rocky terrain with the vegetation in various stages of degradation (Figure 4). Soils are sandy, gravely and relatively well drained. Rock cover for this community varies between 20-45 % and erosion is estimated at 15 %.

Species belonging to species group A are diagnostic for this community and include the trees *Acacia exuvialis, Sterculia rogersii,* the grasses *Eragrostis lehmanniana, Aristida congesta, A. stipitata,* and the forbs *Sida cordifolia* and *Corchorus kirkii*.

Vegetation is dominated by the trees *Acacia nigrescens*, *Sclerocarya birrea* (species group O), *Ziziphus mucronata* and *Combretum apiculatum* (species group P), while the shrubs *Dichrostachys cinerea* (species group P), *Grewia flava* and *Grewia flavescens* (species group Q) are also prominent. The grass layer is not well developed and includes *Elionurus muticus* (species group Q), *Panicum maximum* (species group F) and *Eragrostis lehmanniana* (species group A).

Portions of this community were previously used for cultivation purposes and are in various stages of secondary succession as can be seen from the large number of different species that are prominent within this community. This community is divided into two sub communities.

Although they are delineated on the vegetation map, small sections of sub community 1.1 form a mosaic distribution pattern within sub community 2.2 and could therefore not be mapped.

1.1 *Heteropogon contortus-Grewia flava* Shrubland.

The *Heteropogon contortus-Grewia flava* sub-community is situated in three small areas in the northwest and central sections of the study site (Figure 4). This sub-community covers 3 % of the study area (20 ha) and 10 % of community 1, and occurs on what appears to be more disturbed sites or pockets. The areas are relatively rocky (20 %) and fairly open. Erosion is estimated at 15 % with gentle slopes. Soils are mostly sandy and gravely.

The grasses *Heteropogon contortus, Digitaria eriantha* and *Pogonarthria squarrosa* (species group B) are diagnostic for this sub-community.

The vegetation is dominated locally by the trees *Combretum apiculatum* (species group P), *Acacia nigrescens* and *Sclerocarya birrea* (species group O), together with the shrubs *Dichrostachys cinerea* (species group P), and *Grewia flavescens* (species group Q). The herbaceous layer is not well developed and includes the grasses *Eragrostis lehmanniana* (species group A), *Digitaria eriantha, Heteropogon contortus* (species group B) and *Panicum maximum* (species group F).

The average number of plants per 400 m^2 in this sub-community is 17. The tree layer has a 10-60 % cover with an average of 37 %, the shrub layer has a 10-70 % cover with an average of 29 %, the herb layer has a 0-5 % cover with an average of 2 %, and the grass layer has a 1-70 % cover with an average of 26 %.

The shrub *Dichrostachys cinerea* has the highest density of 5 333 ind/ha followed by the tree *Acacia nigrescens* with 2 583 ind/ha and the shrub *Acacia karroo* with 2 167 ind/ha.

1.2 *Ziziphus mucronata-Grewia flava* Shrubland.

This sub-community comprises two separate sections. One section is located on the northern boundary of the study area while the other is located on the eastern boundary extending towards the southern boundary in a narrow strip, isolating sub-community 2.1 from the rest of the study area (Figure 4). This sub-community covers 21 % of the study area (173 ha) and 90 % of community 1, being flat and relatively open with signs of prior mismanagement in the form of bush encroachment and several stands of same sized and aged trees occurring within this sub-community. The areas are quite rocky (45 %). Erosion is estimated at 15 % with gentle slopes. Soils are mostly sandy, gravely and relatively deep.

The tree *Commiphora africana,* the shrub *Balanites pedicellaris,* the herbs *Cyclopia capensis* and *Bidens pilosa,* the grass *Anthephora pubescens,* and the forb *Solanum panduriforme* (species group C) are diagnostic species for this sub-community.

The vegetation is dominated by the trees *Acacia nigrescens* (species group O), *Ziziphus mucronata, Combretum apiculatum (*species group P), and the shrub *Grewia flava* (species group Q). The tree *Sclerocarya birrea* (species group O), is also very prominent within this sub-community. The herbaceous layer comprises the grasses *Elionurus muticus* (species group Q) and *Eragrostis lehmanniana* (species group A) that are locally prominent. The pioneer forbs *Bidens pilosa* and *Solanum panduriforme* (species group C) are also present.

The average number of plant species per 400 m^2 in this sub-community is 15. The tree layer has a 5-80 % cover with an average of 46 %, the shrub layer has a 5-90 % cover with an average of 42 %, the herb layer has a 0-80 % cover with an average of 17 %, and the grass layer has a 1-70 % cover with an average of 17 %.

The tree *Acacia exuvialis* has the highest density of 6 000 ind/ha followed closely by the shrub *Grewia flava* with 5 222 ind/ha, and the tree *Ziziphus mucronata* with 2 667 ind/ha.

2. *Bridelia mollis-Acacia nigrescens* Woodland.

The *Bridelia mollis-Acacia nigrescens* woodland comprises the largest proportion of the study area and covers 51% (415 ha) of the conservancy (Figure 4). Soils are mostly sandy and well drained with a non-perennial mountain stream passing through the centre of this community. Rock cover and erosion estimates for this community varies between 25-35 % and 10-15 % respectively.

Species belonging to species group D are diagnostic for this community and include the trees *Ficus stuhlmannii, Combretum imberbe* and *Bridelia mollis.*

The vegetation is dominated by the trees *Acacia nigrescens* (species group O), *Combretum apiculatum* (species group P) and *Acacia karroo* shrubs (species group N). The trees *Bridelia mollis* (species group D) and *Sclerocarya birrea* (species group O) are locally prominent. Other species also present include the shrubs *Dichrostachys cinerea* (species group P), *Grewia flava, Grewia flavescens* (species group Q), and the grass *Elionurus muticus* (species group Q). The grass species *Anthephora pubescens* (species group C) occurs sparsely in the community, being locally dominant.

Within this community there are signs of previous overgrazing with old kraals, dipping structures and various old farming implements found throughout the area. This community consists of two sub-communities.

2.1 *Berchemia zeyheri-Acacia nigrescens* Woodland.

The *Berchemia zeyheri-Acacia nigrescens* sub-community is located in two large areas in the southern and southeastern sections of the study area (Figure 4). This sub-community is relatively large covering 28 % of the study area (226 ha) and 54 % of community 2, and occurs in areas where there are signs of historical disturbance, particularly overgrazing with some relics of agricultural farming found within the area. The areas are flat with gentle slopes and sandy soils. Intermittent rocks are scattered throughout (35 % rockiness). There is slight evidence of erosion in the form of small furrows at places (erosion estimated at 10 %).

The trees *Berchemia zeyheri, Commiphora mollis, Lannea discolor,* the shrubs *Mundulea sericea, Euclea divinorum,* and the grasses *Imperata cylindrica* and *Brachiaria brizantha* (species group E) are diagnostic for this sub-community.

The woody layer comprises a mixture of species with the vegetation dominated by the trees *Acacia nigrescens* (species group O), *Combretum apiculatum* (species group P), and *Acacia karroo* shrubs (species group N). The trees *Berchemia zeyheri* (species group E), *Sclerocarya birrea* (species group O) and *Ziziphus mucronata* (species group P) are locally prominent. The shrubs *Grewia flava, Grewia flavescens* (species group Q), *Gymnosporia glaucophylla* (species group G), the grass *Elionurus muticus* (species group Q) and the forb *Lobelia* species (species group N) are also present.

The average number of plants per 400 m^2 in this sub-community is 16. The tree layer has a 10-80 % cover with an average of 46 %, the shrub layer has a 5-80 % cover with an average of 34 %, the herb layer has a 1-30 % cover with an average of 8 %, and the grass layer has a 1-60 % cover with an average of 20 %. The shrub *Acacia karroo* has the highest density of 5 615 ind/ha followed by the trees *Acacia nigrescens* with 3 962 ind/ha and *Combretum apiculatum* with 3 308 ind/ha.

2.2 *Combretum imberbe-Acacia nigrescens* Woodland.

This sub-community is located centrally and towards the western boundary of the study area, east of community 3 that forms part of the western boundary of the study area (Figure 4). This woodland is relatively large covering 23% of the study area (189 ha) and 46 % of community 2, and is mainly flat and open with signs of mismanagement in the form of previous overgrazing. Rockiness is estimated at 25 % with most rocks occurring adjacent to a dry river bed. Erosion is estimated at 15 %. The area has a gentle slope with soils being predominantly sandy and well drained.

Characteristic of this sub-community is the absence of species from species group E. The trees *Peltophorum africanum* (species group G), *Combretum apiculatum, Ziziphus mucronata* (species group P) and the shrub *Dichrostachys cinerea* (species group P) dominate the vegetation. Other species also present are the tree *Bridelia mollis* (species group D), the shrub *Corchorus kirkii* (species group A), and the grass *Elionurus muticus* (species group Q) being locally prominent.

The average number of plants per 400 m^2 in this sub-community is 18. The tree layer has a 30-90 % cover with an average of 60 %, the shrub layer has a 5-40 % cover with an average of 18 %, the herb layer has 0 % cover, and the grass layer has a 1-40 % cover with an average of 19 %. The shrub *Dichrostachys cineria* has the highest density of 5 500 ind/ha, with the tree *Combretum apiculatum* having 2 500 ind/ha and the shrub *Grewia flavescens* having 1 667 ind/ha.

3. *Acacia nigrescens-Combretum apiculatum* Woodland.

This woodland community forms part of the western boundary of the study area covering approximately 6 % (48 ha) of such (Figure 4). Slope is moderate with shallow soils as most of the community is on a rocky protrusion. Average erosion for this community is estimated at 10 %, with average rockiness estimated at 15 %.

The *Acacia nigrescens-Combretum apiculatum* Woodland is characterized by the absence of any diagnostic species. Also characteristic of this woodland is the presence of species from species group F and the absence of species from species groups G to M. Vegetation is dominated by the trees *Combretum apiculatum* (species group P), *Acacia nigrescens, Sclerocarya birrea* (species group O), the shrub *Grewia flava* (species group Q), and the grass *Elionurus muticus* (species group Q).

Characteristic of this community is the absence of the shrubs *Dichrostachys cinerea* (species group P) that are present in almost all the other communities of the study area. *Acacia karroo* shrubs (species group N) are present. This community has a more developed herbaceous layer with the increaser 2 grass *Eragrostis lehmanniana* (species group A) and the decreaser grass *Panicum maximum* (species group F) present throughout.

There are signs of previous overgrazing by cattle in this community, with several old farm implements scattered throughout the community. The dominance of the increaser 3 grass *Elionurus muticus* (species group Q) is indicative of the degraded condition of the herbaceous layer. However, the presence of the grasses *Panicum maximum* (species group F) and *Eragrostis lehmanniana* (species group A) is indicative that this community is recovering and in a secondary successional phase.

The average number of plants per 400 m^2 in this community is 13. The tree layer has an average estimated cover of 32 %, the shrub layer has an average estimated cover of 18 %, the herb layer has an average estimated cover of 1 %, and the grass layer has an average estimated cover of 33 %. The shrub *Grewia flava* has a density of 4833 ind/ha, the tree *Combretum apiculatum* has 4000 ind/ha and the shrub *Acacia karroo* has 3333 ind/ha.

4. *Gymnosporia glaucophylla-Panicum maximum* Woodland.

This woodland plant community covers approximately 20 % of the study area (160 ha) and is mostly mountainous (Figure 4). Soils are predominantly sandy and relatively well drained. Rock cover for this community varies between 10-50 % and erosion is estimated at 10 %.

Species belonging to species groups F and G are diagnostic for this community and include the trees *Peltophorum africanum* and *Rhus leptodictya,* the shrub *Gymnosporia glaucophylla,* and the grass *Panicum maximum.*

The vegetation is dominated by the shrubs *Grewia flavescens* and *Grewia flava* (species group Q), while the grass *Elionurus muticus* (species group Q) is also prominent. The trees *Combretum apiculatum* and *Ziziphus mucronata* (species group P), and the shrub *Dichrostachys cinerea* (species group P) are also dominant throughout, except in the *Diospyros mespiliformis* Variant.

There are many signs of animal activity throughout this community, mainly game tracks, middens and foraging evidence. There are also signs of previous cattle grazing. A few roads pass through the community and a few small dwellings are present. This community consists of four sub-communities and two variants.

4.1 *Balanites maughamii-Panicum maximum* Woodland.

This sub-community is located in the south western section of the study area and consists of two separate areas split by the *Pappea capensis* Variant (Figure 4). This sub-community covers 5 % of the study area (43 ha) and 27 % of community 4, and is found on the relatively steep, predominantly north facing foot slopes of the Drakensberg Mountain Range constituting the southern boundary of the study area. There are signs of previous cattle grazing in the low lying areas. The areas are relatively rocky (30 %). Erosion is estimated at 10 % with a moderate to steep slope. Soils are mostly sandy.

The trees *Combretum erythrophyllum* and *Balanites maughamii,* the shrub *Gossypium herbaceum,* and the perennial herb *Argyrolobium velutinum* (species group H) are diagnostic for this community.

The woody layer comprises a mixture of species with the vegetation dominated by the trees *Combretum apiculatum, Ziziphus mucronata* (species group P) and *Sclerocarya birrea* (species group O), the shrubs *Dichrostachys cinerea* (species group P) and *Grewia flavescens* (species group Q), and the grass *Elionurus muticus* (species group Q). The tree *Acacia nigrescens* (species group O) and the shrub *Grewia flava* (species group Q) are also present.

The average number of plants per 400 m^2 in this sub-community is 15. The tree layer has a 40-80 % cover with an average of 55 %, the shrub layer has a 20-50 % cover with an average of 30 %, the herb layer has 1 % cover, and the grass layer has a 40-60 % cover with an average of 49 %. The shrub *Dichrostachys cineria* has the highest density of 7995 ind/ha followed by the shrubs *Grewia flavescens* with 5750 ind/ha and *Grewia flava* with 4125 ind/ha.

4.2 *Sclerocarya birrea-Panicum maximum* Woodland.

This is a small sub-community occupying the south western corner of the study area (Figure 4). This woodland covers 1 % of the study area (5 ha) and 3 % of community 4. The area is steep and has a large cliff like rock face forming part of its eastern boundary. There are many signs of wild animal activity and several animal tracks traverse this sub-community. Rockiness and erosion are estimated at 30 % and 10 % respectively. Soils are predominantly sandy and shallow.

The grass *Cymbopogon excavatus* and the herbaceous shrublet *Pelargonium sp.* (species group I) are diagnostic for this sub-community.

The vegetation is dominated by the trees *Sclerocarya birrea* (species group O) and *Combretum apiculatum* (species group P). The shrub *Grewia flavescens* (species group Q) and the grass *Elionurus muticus* (species group Q) are also very prominent within this sub-community. The tree *Acacia exuvialis* (species group A) is also present.

The average number of plants per 400 m^2 in this sub-community is 15. The tree layer has a 30-80 % cover with an average of 47 %, the shrub layer has a 5-80 % cover with an average of 42 %, the herb layer has 0-1 % cover with an average of 1 %, and the grass layer has a 40-90 % cover with an average of 70 %.
The tree Combretum *apiculatum* has the highest density of 5000 ind/ha, followed by the tree *Sclerocarya birrea* that has 2333 ind/ha and the shrub *Grewia flavescens* that has 2320 ind/ha.

4.3 *Combretum zeyheri-Panicum maximum* Woodland.

This sub-community is found in the south western section of the study area (Figure 4). This woodland covers 6 % of the study area (51 ha) and 32 % of community 4. The area is moderate to steep in the south, gradually becoming moderate towards the north. A few small dwellings are found within this sub-community. There are many signs of wild animal activity and some previous signs of human agricultural disturbance in the form of old farm implements lying in the veld. Small unused man made dams and open areas with stands of similar size and aged *Dichrostachys cinerea* shrubs occur throughout, indicating overgrazing by cattle. Rockiness and erosion are estimated at 45 % and 10 % respectively. Soils are sandy and shallow in the south, becoming deeper towards the north.

The trees *Acacia caffra* and *Combretum zeyheri*, and the shrub *Ptaeroxylon obliquum* (species group J) are diagnostic for this sub-community.

The vegetation is dominated by the trees *Sclerocarya birrea* (species group O) and *Combretum apiculatum* (species group P), and the shrub *Grewia flavescens* (species group Q). The shrub Dichrostachys *cineria* (species group P) and the grass *Elionurus muticus* (species group Q) are also prominent within this sub-community. There is also a strong presence of the tree *Bridelia mollis* (species group D).

The average number of plants per 400 m^2 in this sub-community is 17. The tree layer has a 70-80 % cover with an average of 73 %, the shrub layer has a 15-70 % cover with an average of 35 %, the herb layer has a 0-1 % cover with an average of 1 %, and the grass layer has a 1-80 % cover with an average of 29 %. The tree *Combretum apiculatum* has the highest density of 4500 ind/ha, the shrub *Dichrostachys cineria* has 3833 ind/ha and the shrub *Grewia flavescens* has 3500 ind/ha.

4.4 *Asparagus setaceus-Philenoptera violacea* Woodland.

This woodland sub-community consists of two variants, the *Pappea capensis* Variant located in the south western section of the study area, and the *Diospyros mespiliformis* Variant located in the north eastern section (Figure 4). This sub-community covers approximately 8 % of the study area (61 ha) and 38 % of community 4. The terrain ranges from steep (the *Pappea capensis* Variant) to gentle (the *Diospyros mespiliformis* Variant). Rockiness for this sub-community varies between 10-50% and erosion is estimated at 10 %. Soils are predominantly sandy and well drained.

The trees *Philenoptera violacea, Combretum hereroense* and *Combretum* molle, the shrub *Dovyalis caffra,* and the herbs *Asparagus setaceus* and *Tacazzea apiculata* (species group K) are diagnostic for this sub-community.

The vegetation is dominated by the shrub *Grewia flavescens* (species group Q). The shrub *Grewia flava* and the grass *Elionurus muticus* (species group Q) are also prominent within this sub-community. There is a strong presence of the tree *Berchemia zeyheri* (species group E).

There are signs of previous and current human disturbance in the form of old cattle dipping structures, old cattle kraals, recent vegetation removal for development, a few recently constructed log cabins and a new earthen dam.

4.4.1 *Pappea capensis* Variant.

This variant is located on the north facing mid- and foot-slopes of the Drakensberg Mountains in the south eastern section of the study area and divides the *Balanites maughamii-Panicum maximum* Woodland sub-community into an eastern and western section (Figure 4). This variant covers 1 % of the study area (7 ha) and 11 % of sub-community 4.4, and is found on the moderate to steep mid- and foot-slopes of the Drakensberg Mountain Range. Signs of human disturbance include previous cattle dipping structures and kraals. Rockiness is estimated at 50 % and erosion is estimated at 10 %. Soils are sandy.

The tree *Pappea capensis* and the shrubs *Bolusanthus speciosus, Euclea crispa, Ehretia rigida* and *Grewia monticola* (species group L) are diagnostic for this variant.

The vegetation is dominated by the tree *Combretum apiculatum* (species group P) and the shrub *Grewia flavescens* (species group Q). The tree *Commiphora mollis* (species group E) and the grass *Elionurus muticus* (species group Q) are also prominent in this variant. The trees *Ziziphus mucronata* (species group P), *Ficus stuhlmannii* (species group D) and *Berchemia zeyheri* (species group E), and the shrubs *Dichrostachys cinerea* (species group P), *Grewia flava* (species group Q) and *Euclea divinorum* (species group E) are also present.

The average number of plants per 400 m^2 is 22. The tree layer has a 70-90 % cover with an average of 80 %, the shrub layer has a 15-60 % cover with an average of 38 %, the herb layer has a 2-5 % cover with an average of 4 %, and the grass layer has a 20-70 % cover with an average of 45 %. The shrub species *Grewia flavescens* has the highest density of 2500 ind/ha, with the tree species *Combretum apiculatum* having 1750 ind/ha, and the shrub species *Grewia flava* with 1500 ind/ha.

4.4.2 *Diospyros mespiliformis* Variant.

This variant is located in the north eastern section of the study area (Figure 4), covering 7 % of the study area (54 ha) and 89 % of sub-community 4.4. Slope is gentle. A dry river bed with several large riverine trees growing adjacent to the river bed runs through the area. There are many signs of recent human disturbance throughout this variant. Several small wooden cabins and an earthen dam have recently been constructed along the river bed due to the shady and aesthetic nature of the area. A portion of the variants vegetation has also been removed for development. Average erosion for this community is estimated at 10 %, with average rockiness also estimated at 10 %. Soils are deep, sandy and well drained.

Species belonging to species group M are diagnostic for this variant and include the trees *Diospyros mespiliformis, Acacia schweinfurthii* and *Dombeya rotundifolia,* the shrubs *Indigofera arrecta* and *Morella pilulifera,* the herb *Asparagus virgatus,* and the liana *Dalbergia armata*.

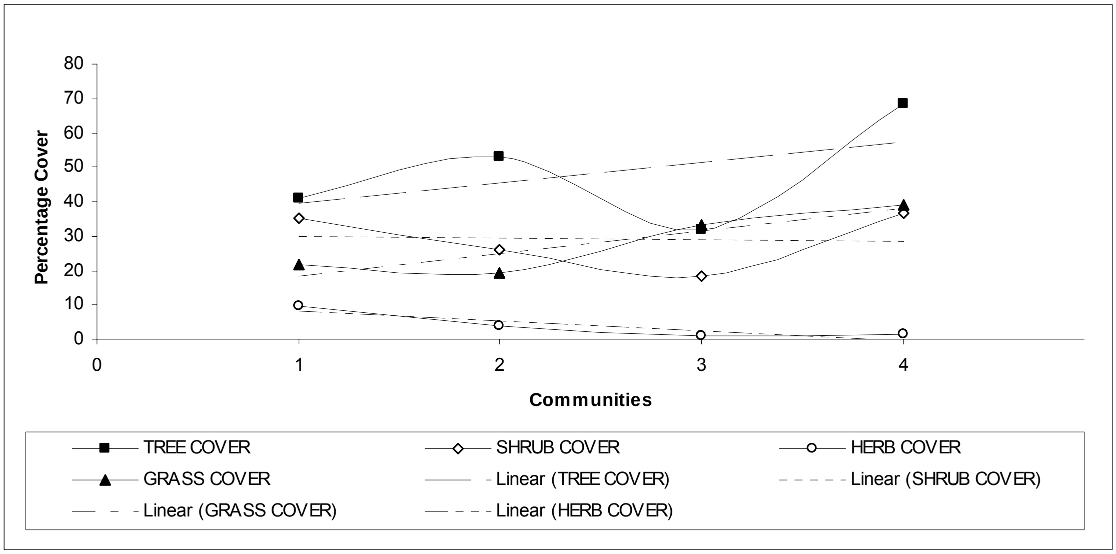
The vegetation is dominated by the shrubs *Grewia flavescens* and *Grewia flava* (species group Q). The tree *Berchemia zeyheri* (species group E) is also prominent. The grass layer is not well developed and includes the grasses *Panicum maximum* (species group F) and *Elionurus muticus* (species group Q).

The average number of plants per 400 m^2 is 16. The tree layer has an 80-90 % cover with an average of 87 %, the shrub layer has a 30-60 % cover with an average of 40 %, the herb layer has a 2-3 % cover with an average of 2 %, and the grass layer has a 0-5 % cover with an average of 2 %. The shrub species *Grewia flava* has the highest density of 2000 ind/ha, with the tree species *Berchemia zeyheri* having 1950 ind/ha, and the tree species *Diospyros mespiliformis* with 1667 ind/ha.

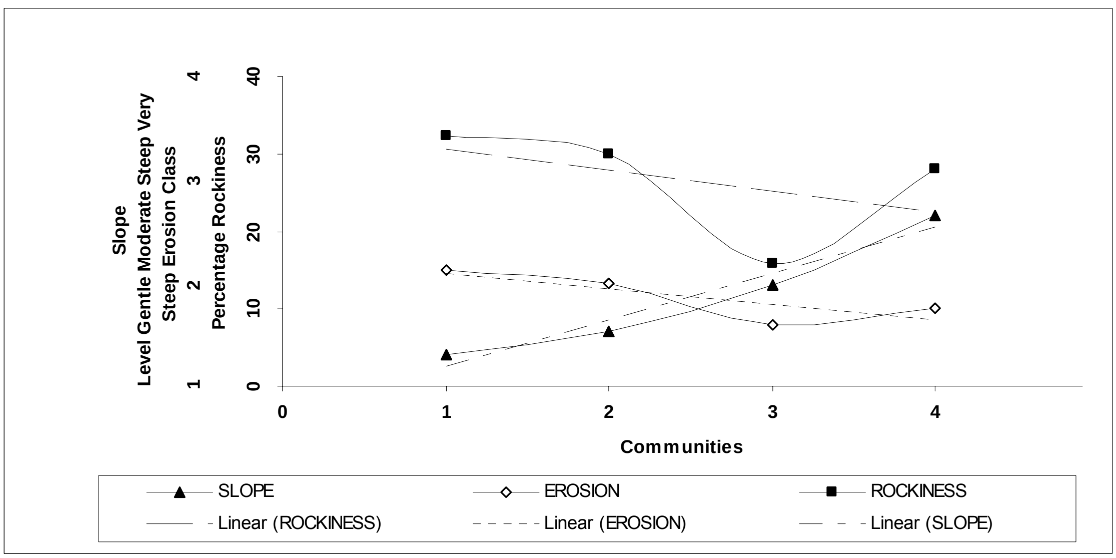
Ordination

Figure 5 depicts community vegetation cover percentages and abiotic parameters along estimated gradients of slope, erosion and rockiness. There is a general increase in tree cover from community 1 to community 4, with the exception of community 3 which occurs on a rocky protrusion with shallow soils which is more conducive to grasses (Figure 5a). An increase in tree cover along this gradient could be attributable to declines in estimated erosion and rockiness from community 1 to community 4, reaching their respective troughs in community 3 due to the rocky protrusion (Figure 5b). Shrub and herb cover decrease from community 1 to community 3, but increase slightly in community 4 (Figure 5a). This decrease could be related to a trend of increasing tree cover which blocks sunlight and out competes non-woody vegetation. The tree and shrub cover are very similar in community 1. This can be ascribed to the community being disturbed by previous agricultural practices. As a result large areas that have been cleared of bush are now being encroached by shrubs while the natural areas are characterised by large trees. Increases in slope and decreases in erosion and rockiness (with the exception of community 3 which occurs on a rocky outcrop as mentioned previously) from community 1 to community 4 (Figure 5b), might also be partially responsible for increases in shrub cover for community 4.

Grass cover generally increases with increasing slope, decreasing erosion, and decreasing rockiness from community 1 to community 4 (Figure 5a & 5b), with a slight exception for community 2 which could be due to previous mismanagement and overgrazing. As grass cover increases, erosion decreases.



a)



b)

Figure 5: Community ordination scatter diagrams depicting a) tree cover, shrub cover, herb cover, and grass cover with trend lines portraying tendencies in the aforementioned parameters from community 1 to community 4; and b) slope, erosion and rockiness with trend lines depicting inclinations of aforementioned parameters from community 1 to community 4.

Discussion and conclusion

There are relatively clear distinctions between the various communities identified at the Blydeberg Conservancy. The stratification and classification using TWINSPAN (Hill, 1979) and the refinement thereof using Braun-Blanquet procedures proved successful as the various vegetation units are recognizable in the veld (Figure 4).

All plant communities identified at Blydeberg reflect some form of human related impact. These are mostly historical and agriculturally related influences that are in the process of self rectification to a more stable successional stage, with the exception of the *Diospyros mespiliformis* Variant (community 4.4.2) occurring within the *Gymnosporia glaucophylla-Panicum maximum* Woodland (community 4). In this variant there are recent signs of large scale vegetation destruction through clearing by a landowner. This is not consistent with the definition and objectives of a conservancy, which is the conservation of the natural resources occurring within the area, and should be addressed by all members of the conservancy.

According to Van Oudtshoorn (1999), the grass species *Elionurus muticus* is considered to be mostly an Increaser IIb that occurs in broken country of lower rainfall areas, it grows on a variety of soil types with a preference for poor, stony soils. The presence of similar size and aged clumps of the shrub species *Dichrostachys cinerea* tends towards poor veld conditions in certain areas.

A decline in the condition of the grass or herbaceous layer is typically accompanied by an increase in the density of trees and shrubs (Smit *et al*., 1999). This can be seen at Blydeberg (Figure 5a), where many of the low-lying areas have dense woodlands and a poorly developed herbaceous layer, possibly due to long term previous overgrazing by cattle, of which there is evidence.

Overgrazing by cattle has compromised the herbaceous layer by removing the natural tree/grass competition factor, resulting in areas that appear to be in a semi-degraded condition. According to (Donaldson, 1978; Dye & Spear, 1982; Moore *et al*., 1985), woody species compete more successfully than grasses for resources required for growth, whilst simultaneously tolerating utilisation better. This is due to trees and shrubs having exclusive access to soil water at depth in the soil profile (Dye & Spear, 1982).

Grasses are unable to survive in dense woody communities as they are deprived of water and sunlight, however trees can survive unaffected in dense grass communities. Woody species are partially protected against excessive utilisation as part of their canopy is often out of reach from browsing animals. This is not the case for grasses which are mostly within reach for grazers. Reduced competition from grass communities in overgrazed areas leads to an increase in the density of woody species. In most cases these changes are irreversible due to woody species out competing grasses for moisture (Smit *et al*., 1999). Over time, fuel loads are reduced in areas with a degraded grass layer and fire can no longer be used as an effective means of bush control.

An understanding of the various plant communities with their associated habitats is fundamentally important and are deemed critical for devising sound management and conservation strategies for any protected area (Smit *et al*., 1999). In order to develop suitable management plans and to determine habitat suitability for various species of animals, it is important that more detailed vegetation studies be undertaken to compile an inventory of the flora of a conservation area (Brown & Bredenkamp, 1994).

There are no known detailed vegetation maps for the study area. Previous vegetation studies were conducted on broader plant communities within the region (Deall, 1985; Deall *et al*., 1989; Mathews, 1991; Matthews *et al*., 1996; Marais, 2004). Data obtained from this initial assessment could be incorporated into a larger vegetation map for the entire Blydeberg conservancy. The information generated could be utilised as part of a management plan for the area and would form the basis thereof.

Ongoing analysis of the areas vegetation over the medium to long term is recommended as it would provide an accurate data set that could serve as guidelines for future management actions. From such data, trends in vegetation could be identified and any negative tendencies with their causes could be rectified before such leads to further degradation.

This study forms part of a larger study on the foraging ecology of a single troop of vervet monkeys (*Chlorocebus aethiops*) in Mixed Lowveld Bushveld and Sour Lowveld Bushveld of the Blydeberg Conservancy. To date there are no formal management plans for vervet monkeys. This is attributed to the limited knowledge of vervets and their utilisation of, and impacts on ecosystems. Plant communities identified and described in this study form part of the study area containing the study troop's home range, thereby providing detailed data on various plant species as well as habitats occurring within their home range. This study provides essential information pertaining to community utilisation within the study troops' home range. Data obtained from this study as mentioned previously will also provide base line information for management plans of the study area, providing information that could be used to assist with the development and implementation of a set of guidelines for the management of vervets in similar areas. Without the classification and delineation of the different plant communities, food availability and utilisation in such communities by the vervets could not have been determined.

Having knowledge of vervet habitat utilisation aids in management's decision making.

With regards to habitat utilisation, the vervets had ten plant communities, sub-communities and variants available to them within their home range. Of the ten available plant communities, sub-communities and variants, they utilized only six during the study period i.e. sub-community 2.2 (*Combretum imberbe-Acacia nigrescens* Woodland), community 3 (*Acacia nigrescens-Combretum apiculatum* Woodland), sub-community 4.1 (*Balanites maughamii-Panicum maximum* Woodland), sub-community 4.2 (*Sclerocarya birrea-Panicum maximum* Woodland), sub-community 4.3 (*Combretum zeyheri-Panicum maximum* Woodland), and variant 4.4.1 (*Pappea capensis* Variant)(Barrett, 2005). Of the six plant communities, sub-communities and variants utilized, sub-community 4.2 was used the most during both the wet and the dry season. Community 3 and variant 4.4.1 were only used during the dry season, whereas, the other communities, sub-communities and variants were randomly utilized across both seasons (Barrett, 2005).

There are no specific management plans for the Blydeberg Conservancy and it appears as though there is very little consensus on the management of the area between the different land owners and involved parties. Setting up goals and objectives for the management of the area would be crucial to its continued existence over the medium to long term and such should be seen as a priority by all involved. It is suggested that all land owners meet and agree to a set of minimum objectives for the area. These objectives must be obtainable under current conditions where there are conflicting interests between owners. A baseline management plan needs to be established where the natural vegetation is managed and protected as it forms the basis of any current or future endeavour.

A veld management program needs to be implemented as a priority so that a thorough knowledge of the ecosystem and its functioning can be understood and managed to the benefit of all animals and humans in the area. By knowing the seasonal utilisation of plant communities by vervets, a management plan can be developed that would ensure the minimum disturbance to these communities. Such a management plan should prevent the vervets from seeking additional food sources in the adjacent commercial plantations.

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CHAPTER 6

Habitat utilisation and food selection by vervet monkeys (*Chlorocebus aethiops*) in South African Bushveld.

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Abstract

A 12-month study was conducted in the Northern Province of South Africa to determine the seasonal habitat utilisation and food selection of a free ranging troop of vervet monkeys (*Chlorocebus aethiops*).

It was hypothesized that the study troop would utilize varying proportions of their habitat based on seasonality. The study troop's habitat was mapped and plant communities occurring within their home range was determined. Seasonal community utilisation did not differ significantly.

It was suggested that the study troop would cover more area during the dry season than during the wet season. This was found to be true.

It was anticipated that the study troop would utilize more of their home range during the dry season than during the wet. Such was the case - they used more of what was available to them during the dry season than during the wet season.

It was predicted that the vervets would travel further during the dry season, thus utilizing a larger area of their home range than during the wet season when food sources are more abundant and accessible. This was the case for the study troop - they covered significantly more area during the dry season.

It was expected that a larger variety of foods would be consumed during the wet rather than during the dry season. This was observed. It has been suggested that vervet diets are usually restricted to a small number of staple foods, with a wider supplementation based on seasonality (Harrison, 1983a; Lee, 1984; Whitten, 1988; Lee & Hauser, 1998). The aforementioned appeared to be true for the research troop that had certain staple food sources making up the mainstay of their diet, with a large variety of other foods used for purely supplementary purposes as and when such became available.

Introduction

The opportunistic omnivery that characterizes the cercopithecines, together with locomotory and postural adaptations that reduce their reliance on continuous canopy have resulted in vervets being the most widely-distributed species in the guenon group (Struhsaker, 1967a).

Vervets are well adapted to practically any wooded habitats outside equatorial rain forests. They spend a large portion of their moving time on the ground making them semi-terrestrial (Dunbar & Barrett, 2000). They are typically an ‘edge’ species, never venturing too far from the cover of trees and the protection such provides.

Vervets are always found relatively close to water and are associated with the accompanying riverine or gallery forest vegetation (Nagel, 1973; Harrison, 1983b; Skinner & Smithers, 1990; Estes, 1991; Nakagawa, 1999; Dunbar & Barrett, 2000; Zinner *et al.,* 2002). In Eritrean vervet home-ranges, proportions of forested and wooded areas were significantly higher than expected, with trees serving as main food sources and for sleeping sites. Large portions of agricultural areas were also included in their home-ranges (Zinner *et al.,* 2002). Vervets are non-specialist feeders adapted to strongly fluctuating resource availability (Wrangham & Waterman, 1981; Harrison, 1984; Lee & Hauser, 1995). Their diet includes fruits, seeds, pods, flowers, leaves, buds, sap, gum, grasses, invertebrates and, occasionally vertebrates such as small reptiles, nestling birds and eggs (Skinner and Smithers, 1990).

Despite the attendant ability to respond to local circumstances that their broad latitudinal distribution indicates (i.e. their ecological plasticity), few detailed ecological studies of the species have been undertaken in the tropics (Struhsaker, 1967c; Harrison, 1983b, 1984; Whitten, 1988; Lee & Hauser, 1998; Isbell *et al.*, 1998; Pruetz & Isbell, 2000). At these low latitudes overall habitat productivity is high and seasonal variability, while obviously evident is relatively constrained (Caughley & Sinclair, 1994). A fuller understanding of the extent of vervet ecological flexibility and the factors that might limit their distribution both broadly and locally is likely to be derived from data collected at higher latitudes, where overall productivity is generally much lower and therefore likely to magnify any seasonal effects on food choice and habitat use by omnivores (Bronikowski & Altmann, 1996; Lee & Hauser, 1998; Dunbar & Barrett, 2000). Lawes *et al.* (1990) for example, found that sources of protein rich foods were the critically limiting factor for samango monkey (*Cercopithecus mitis*) foraging behaviour.

Samangos are the most widely distributed of the arboreal guenons and cope with seasonal declines in the availability of insects at high latitudes by ingesting large amounts of foliage and flowers, as well as where necessary unripe fruit and mature leaves. It has been argued that this ability to turn to leaves, made possible by a suite of gut adaptations, is responsible for the radiation of samangos out of the tropics. Comparison of the gut morphology of vervet and samango monkeys indicate that vervets do not share these adaptations, at least not to the same extent (Bruorton *et al*., 1991), suggesting that the successful response of vervets to higher latitudes rests on different foundations.

In the Kala Maloue National Park, Cameroon, a distinct seasonal change in the diet of *Cercopithecus aethiops tantalus* was observed by Nakagawa (1999 & 2003). According to Nakagawa (1999) and Zinner *et al.* (2002), during the dry season more time is spent feeding on woody plants than on grasses, with slightly more time spent in grasslands during the wet season. According to Brennan *et al.* (1985), seasonality has a definite influence on the diet of vervets in a tourist-lodge habitat in Amboseli National Park, Kenya: where vervets around the lodge become more dependent on human foods during the dry season when fewer natural food sources are available, often leading to conflict with man.

Due to there not being much of a variety to choose from at some other temperate sub-tropical sites, vervets utilized more of what was available to them seasonally i.e. vervets in north central Kenya were restricted to what Pruetz & Isbell (2000) refer to as simple habitats with small randomly distributed food patches. In such patches the vervets would maximize the use of their resources, feeding on various parts of a particular plant species as such became available i.e. leaves, flowers, seeds, exudates, insects attracted to the plants and even swollen thorns were utilized.

According to Pruetz & Isbell (2000), *Acacia drepanolobium* accounted for over half of the vervet's diet when they were in *A. drepanolobium* habitat, and *Acacia xanthophloea* similarly accounted for more than half of their diet when they were in *A. xanthophloea* habitat.

Regardless of the precise dietary response to latitude and seasonality, there is also indirect energetic consequences to a reduction in food availability that result from the need to cover a greater area, and hence travel further in order to maintain adequate intake. Other things being equal, it is expected that social primates will extend both the size of their home range and their day range distances as food availability declines (Adeyemo, 1997; Baldellou & Adan, 1998). Vervet monkeys are territorial (Henzi, 1984; Skinner & Smithers, 1990; Cheney & Seyfarth, 1992; Estes, 1992; Dunbar & Barrett, 2000) and, while territory size will reflect local resource density, it may well be that vervets at high latitude are constrained in the extent to which they can respond when resources decline. Alternatively, they may work during times of good resource availability to maintain territories of a sufficient size to support them when resources are scarcer.

We begin to address these issues with data from a free-ranging troop of vervet monkeys occupying temperate sub-tropical bushveld in the Northern Province, South Africa. Although the study population is not near the limit of the species distribution, which lies in the Western Cape Province, it is to our knowledge the southern most population for which detailed ecological information is available. In this paper, we present data on diet and habitat use and assess the animals' response to seasonal variation in resource availability.

Methods

Study animals

A troop of vervet monkeys living on the Blydeberg Conservancy was habituated. At the end of the study period the troop (N=33) comprised 5 adult males, 8 adult females and 20 non-adults.

Study site

The Blydeberg Conservancy is approximately 3000 ha in size, located along the great escarpment in the Northern Province of South Africa, Longitude 30° 27' to 25° 56' E and Latitude 24° 23' to 24° 28' S. Altitude ranges from 350 m to 800 m above sea level (Bredenkamp & Van Rooyen, 1998a, 1998b). The study area constitutes the farms Dunstable (farm number 230) and Jongmanspruit (farm number 234) (Figure 1).

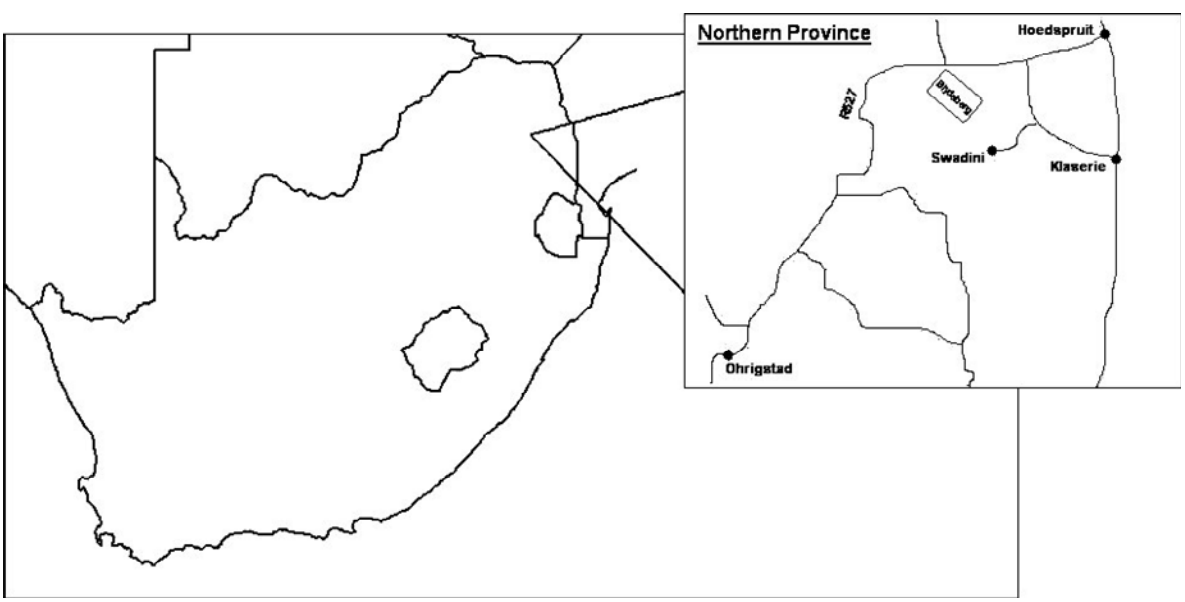


Figure 1: A map of the study area within the Northern Province of South Africa.

The topography of the area is mountainous in the south to flat and open in the north. There are several small mountain streams running from the watershed in the Drakensberg Mountains that make up the southern boundary of the conservancy, into the Blyde River to the north of the conservancy.

The climate along the escarpment is mostly mild (Figure 2). Mean temperature of the hottest months (December 2003 and January 2004) was 27.2^{o}C, whilst that of the coldest month (July 2003) was 19.9^{o}C. Average annual temperature over the last five years has increased from 21.8 °C in 1999/2000 to 22.9 °C in 2003/2004 – an average increase of 0.2 °C per year. Average temperature for the study period was 0.6 °C above the average for the last five years, which was 22.3 °C. Mean monthly rainfall for the study period was 44.6 mm, with no rainfall being recorded for July and August 2003, and only 2.5 mm for October 2003. The highest rainfall of 136.5 mm was recorded in March 2004. Rainfall for the study period (534.6 mm) was below average, with the mean for the previous five years being 561 mm.

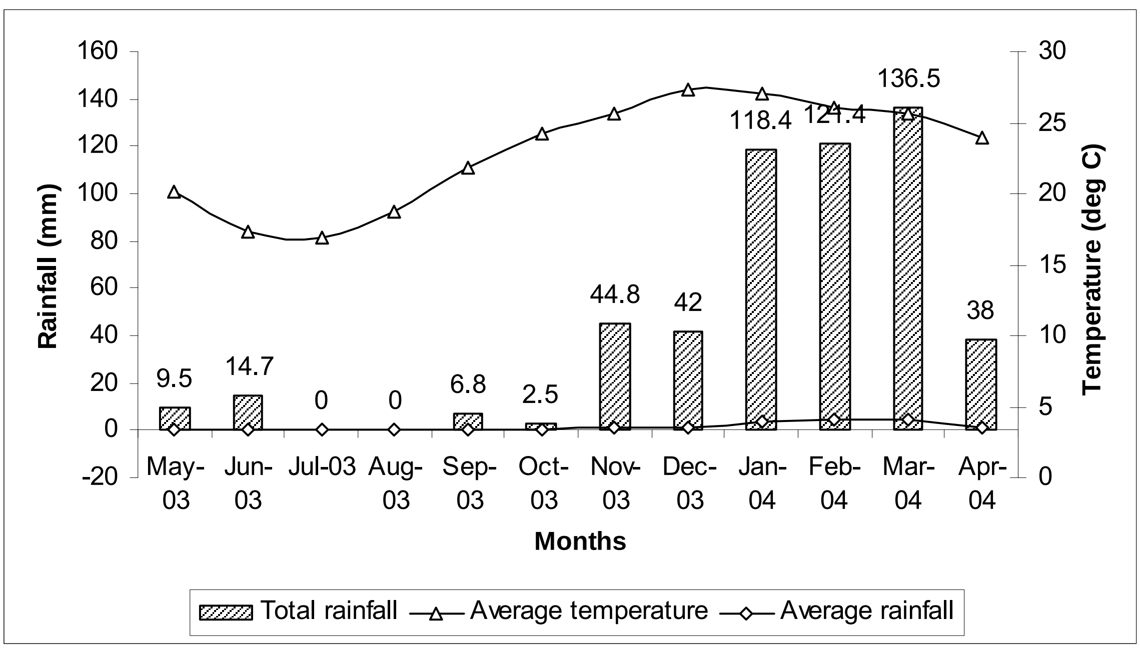


Figure 2: Rainfall and temperature summary for the study period.

Data collection

i. Activity and diet.

The troop was followed on foot from a distance of 5-15 m for as long as possible on each day of data collection. Data were collected over an average of eleven days a month for a twelve-month period (1 May 2003 to 30 April 2004), resulting in 132 days of data, 30 of which were from dawn to dusk, the rest being dependent on when and for how long the troop was located. Data were recorded using a PALM HANDSPRING™ data-logger, pre-loaded with PENDRAGON FORMS™ software. Scan samples were drawn approximately every thirty minutes from all visible animals (Altmann, 1974).

Five mutually exclusive categories of activity were recognized: foraging (feeding, actively searching for or processing food), socializing (playing, aggression, grooming, maternal or paternal, mating), moving, resting and drinking. When animals were recorded as foraging, we identified the food source and the specific part being consumed. A total of 4504 individual scans were collected.

ii. Habitat structure

A GARMIN 12 XL™ handheld GPS with CARTALINX™ mapping software (Hagan *et al.*, 1998) was used to digitize a map of the study site. A map of vegetation types and habitat structure was generated using a 1:10 000 digitized ortho photo for the Blydeberg area. The study area was stratified into physiognomic-physiographic units i.e. the vegetation of the study area was divided up broadly into obviously different vegetation types by examining the ortho photo. Sampling quadrats were then allocated to each separately identified vegetation unit in a randomly stratified manner (Barbour *et al.,* 1987; Kent & Coker, 1997).

A total of 49 sample plots were located within these units to ensure all variations in vegetation were considered and sampled. Plot sizes were fixed at 400 m^2 (Barbour *et al.,* 1987; Brown & Bredenkamp, 1994; Brown, 1997). In each sample plot all plant species were recorded and cover abundance was assessed using the Braun-Blanquet cover abundance scale (Mueller-Dombois & Ellenberg, 1974; Barbour *et al.,* 1987). This component of the fieldwork was undertaken during April, May, and June 2003 and in January 2004. Floristic Data were analyzed according to Braun-Blanquet procedures using the TURBOVEG™ suite (Hennekins, 1998), which includes the Two-way indicator species analysis multivariate classification technique (TWINSPAN™ – Hill, 1979), for deriving an initial approximation of the main plant communities. This numerical classification technique is regarded as a successful approach to vegetation classification by various phytosociologists (Brown & Bredenkamp, 1994; Bredenkamp & Bezuidenhout, 1995; Brown *et al*., 1996; Cilliers, 1998).

The visual editor MEGATAB™ (Hennekens, 1996) was used to generate a phytosociological table. Using the phytosociological table and habitat information collected during sampling in the field, different plant communities were identified, described and ecologically interpreted. Further refinement of the classification was undertaken through the application of Braun-Blanquet procedures according to (Barbour *et al.,* 1987; Bredenkamp *et al.,* 1989; Kooij *et al.,* 1990; Bezuidenhout, 1993; Eckhardt, 1993; Brown & Bredenkamp, 1994; Kent & Coker, 1997).

iii. Food and community Selection

Electivity of the main plant species consumed was calculated using Ivlev's electivity index i.e. Species Electivity = (r1-n1)/(r1+ n1) where r1 = proportion of food item in diet and n1 = proportion of food item in home range (Krebs, 1989).

For species electivity the proportion of a food item in their diet was calculated as a percentage of all plants in their diet, and a proportion of a food item in the home range was calculated as a percentage of all species occurring within the home range.

Similarly, electivity of available plant communities was also calculated using Ivlev's electivity index i.e. Community Electivity = (r1-n1)/(r1+ n1) where r1 = proportion of community utilized and n1 = proportion of community available in home range. For community electivity the proportion of a community utilized was calculated as a percentage of the overall communities' size, and a proportion of a communities availability within the home range was calculated as a percentage of the size of all communities.

Values for Ivlev's electivity index range between -1 and 1; >0 indicates positive selection of a food item, <0 indicates selection against, or avoidance of a food item.

iv. Day range length and home range area estimation.

When the troop was located, GPS co-ordinates of their centre of mass was recorded. If the troop started moving, the subsequent route would be mapped by recording a GPS co-ordinate every 10 seconds until they stopped moving for a continuous period exceeding 5 minutes. The co-ordinates of their new location would then again be recorded. This was done for three days a month to provide estimates of home range area. Co-ordinates collected were plotted onto a 1:10 000 ortho-photo of the study area forming a backdrop to simplify analysis. To estimate home range size, all day journeys were combined to generate a bounding polygon.

GIS software utilized for analyses uses fractal theory and a combination of simple algorithms for its area calculations i.e. minimum convex polygons and a series of increasing sized ‘gliding boxes’ are used to sample spatial or gridded data. For information on the specifics of algorithms used in GIS software, refer to Bartlett (1978), Davis (1986) and Allain & Cloitre (1991).

A census of the various animal species occurring in the study area was undertaken to determine diversity and numbers. Combinations of the strip/line transect and known group counts census methods were used (Collinson, 1985). Five transect lines were set out with a combined length of 17.3km. Transects were walked bi-monthly for 5 months. Transects were selected using stratified random sampling techniques and covered most of the potential habitats. Mountain tops were excluded as they could not be reached. Counts of known vervet groups were undertaken whenever these were observed.

By the end of the study period two additional vervet troops had been identified: a troop on the adjacent farm Dunstable consisting of approximately eleven individuals, and another troop of at least eight individuals residing in the proximity of the conservancy’s entrance gate. Both troop sizes are only of individuals actually observed and are likely to be underestimates (Figure 6b).

v. Statistical analysis

SPSS™ (version 11.5.0) was used for all statistical analyses. All tests were two-tailed with alpha set at 0.05.

Results

Habitat utilisation

Several distinct physiognomically physiographic plant communities were identified within the study area. Figure 3 depicts the various plant communities. Descriptions of plant communities are as follows:

1. *Eragrostis lehmanniana-Grewia flava* Shrubland.
   - 1.1 *Heteropogon contortus-Grewia flava* Shrubland.
   - 1.2 *Ziziphus mucronata-Grewia flava* Shrubland.
2. *Bridelia mollis-Acacia nigrescens* Woodland.
   - 2.1 *Berchemia zeyheri-Acacia nigrescens* Woodland.
   - 2.2 *Combretum imberbe-Acacia nigrescens* Woodland.
3. *Acacia nigrescens-Combretum apiculatum* Woodland.
4. *Gymnosporia glaucophylla-Panicum maximum* Woodland.
   - 4.1 *Balanites maughamii-Panicum maximum* Woodland.
   - 4.2 *Sclerocarya birrea-Panicum maximum* Woodland.
   - 4.3 *Combretum zeyheri-Panicum maximum* Woodland.
   - 4.4 *Asparagus setaceus-Philenoptera violacea* Woodland.
     - 4.4.1 *Pappea capensis* Variant.
     - 4.4.2 *Diospyros mespiliformis* Variant.

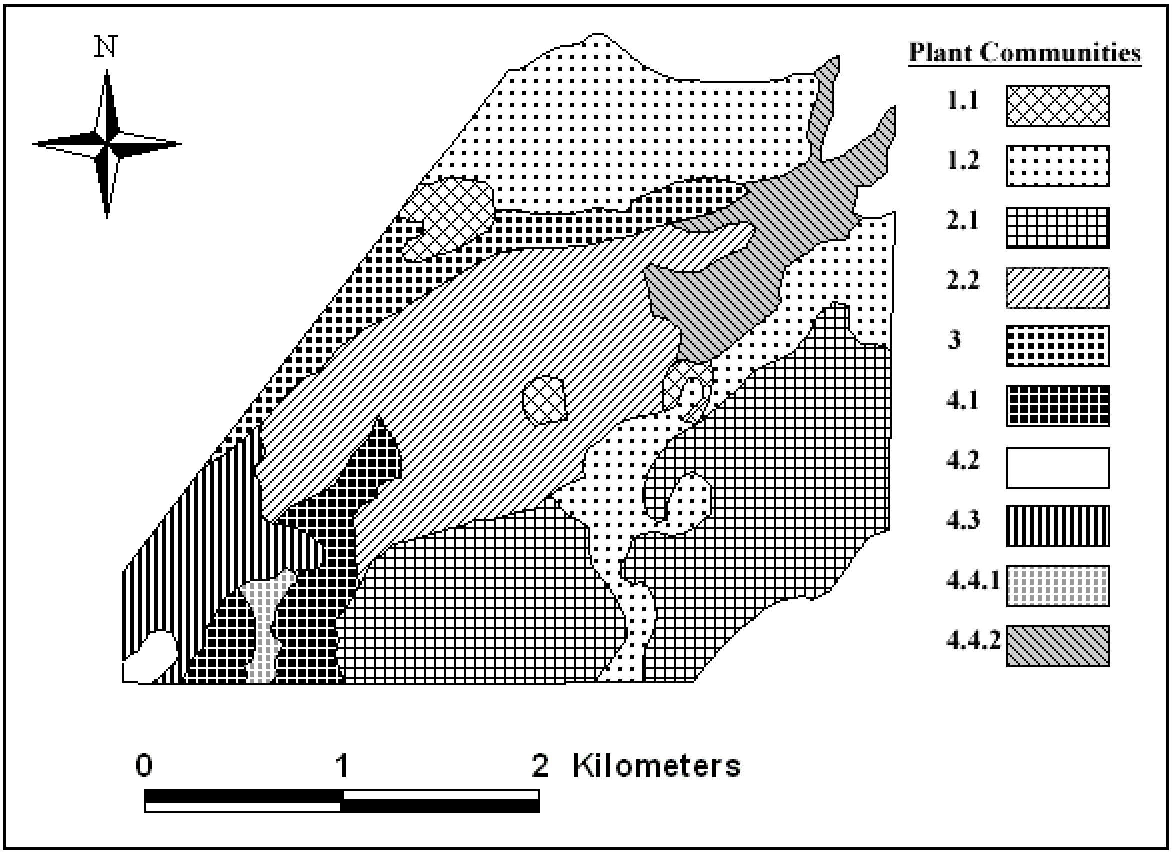


Figure 3: Vegetation map of the study area depicting various communities, sub-communities and variants.

Table 1 is a breakdown of seasonal community, sub-community and variant utilization and shows that community 3 and variant 4.4.1 were only used during the dry season; whereas the other communities, sub-communities and variants were used across both seasons.

Table 1: Communities utilized seasonally by the study troop.

Comms in Blydeberg	Comm Description	Comm Size (ha)	Comm in Territory	Total (ha)	Season Utilised	In Territory: Total (ha)	Utilised Wet (ha)	Utilised Dry (ha)	% Representation of Main Plant sp.: *AS*	*BZ*	*CA*	*DA*	*DM*	*FS*	*PA*	*TD*
1	*Eragrostis lehmanniana-Grewia flava* Shrubland	(193)	No	--	--	--	--	--	--	--	--	--	--	--	--	--
1.1	*Heteropogon contortus-Grewia flava* Shrubland	20	No	--	--	--	--	--	--	--	--	--	--	--	--	--
1.2	*Ziziphus mucronata-Grewia flava* Shrubland	173	No	--	--	--	--	--	--	--	--	--	--	--	--	--
2	*Bridelia mollis-Acacia nigrescens* Woodland	(415)	No	--	--	--	--	--	--	--	--	--	--	--	--	--
2.1	*Berchemia zeyheri-Acacia nigrescens* Woodland	226	No	--	--	--	--	--	--	--	--	--	--	--	--	--
2.2	*Combretum imberbe-Acacia nigrescens* Woodland	189	Yes	189	Wet/Dry	23.7	0.2	3.0	5.76	8.64	0.00	0.00	2.89	2.89	11.53	0.00
3	*Acacia nigrescens-Combretum apiculatum* Woodland	48	Yes	48	Dry	0.4	0.0	0.1	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.00
4	*Gymnosporia glaucophylla-Panicum maximum* Woodland	--	No	--	--	--	--	--	--	--	--	--	--	--	--	--
4.1	*Balanites maughamii-Panicum maximum* Woodland	43	Yes	43	Wet/Dry	9.0	0.5	1.3	0.00	0.00	0.00	0.00	0.82	0.00	1.64	0.00
4.2	*Sclerocarya birrea-Panicum maximum* Woodland	5	Yes	5	Wet/Dry	2.6	0.7	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.3	*Combretum zeyheri-Panicum maximum* Woodland	51	Yes	51	Wet/Dry	41.4	7.2	6.7	0.00	5.05	0.00	0.00	20.17	0.00	40.31	0.00
4.4	*Asparagus setaceus-Lonchocarpus capassa* Woodland	--	No	--	--	--	--	--	--	--	--	--	--	--	--	--
4.4.1	*Pappea capensis* Variant	7	Yes	7	Dry	0.1	0.0	0.1	0.00	0.03	0.02	0.00	0.00	0.06	0.03	0.03
4.4.2	*Diospyros mespiliformis* Variant	54	No	--	--	0.0	--	--	--	--	--	--	--	--	--	--
		816		343		77.2	8.6	11.7	5.76	13.72	0.02	0.10	23.93	2.94	53.51	0.03

AS=Acacia schweinfurthii, BZ=Berchemia zeyheri, CA=Celtis africana, DA=Dalbergia armata, DM=Diospyros mespiliformes, FS=Ficus sur, PA=Peltophorum africanum, TD=Trichilia dregeana

Community utilisation was as follows (Table 1):

- Sub-community 2.2 made up 55.1 % of the study area, during the wet season they used 0.1 % of it and during the dry season they used 1.6 % of it.
- Community 3 made up 14.0 % of the study area, during the wet season they did not use it and during the dry season they used 0.2 % of it.
- Sub-community 4.1 made up 12.5 % of the study area, during the wet season they used 1.1 % of it and during the dry season they used 3.0 % of it.
- Sub-community 4.2 made up 1.5 % of the study area, during the wet season they used 13.4 % of it and during the dry season they used 13.1 % of it.
- Sub-community 4.3 made up 14.9 % of the study area, during the wet season they used 14.2 % of it and during the dry season they used 13.1 % of it.
- Variant 4.4.1 made up 2.0 % of the study area, during the wet season they did not use it and during the dry season they used 1.2 % of it.

Figure 4 below depicts community utilisation across seasons for the study area and study period. Community information shown is reflected in Table 1 above.

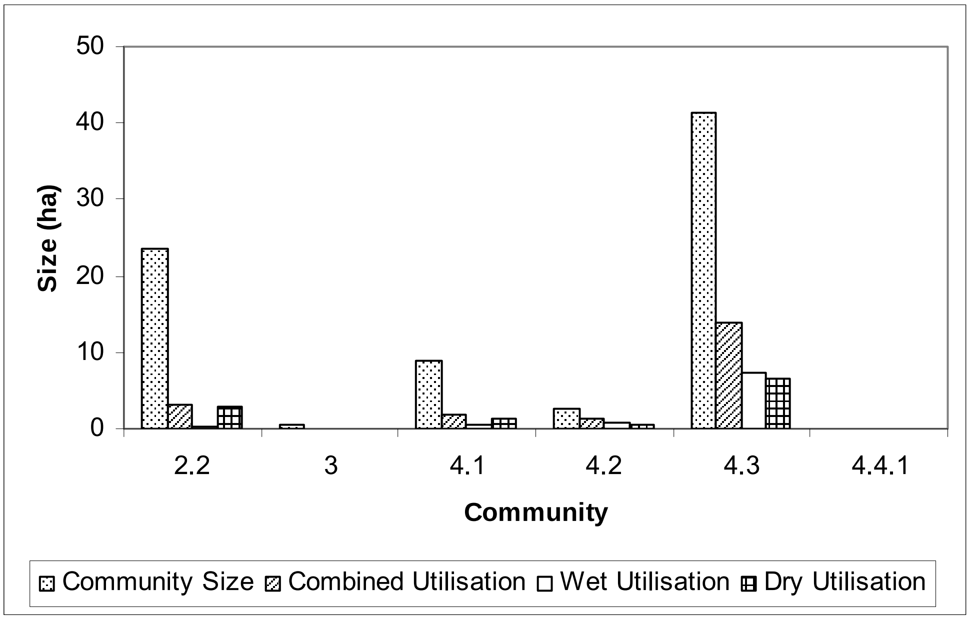


Figure 4: Community utilisation. Community utilisation for wet and dry seasons is depicted, with community size reflected for comparison.

Community utilisation was not significantly different for wet and dry seasons ($u = 23.000$, $p = 0.4233$).

Seasonal area traversed

It was predicted that the study troop would cover larger areas during the dry season than during the wet season. This was the case (Table 2 and Figure 5). Table 2 depicts area and average area covered in hectares (ha) with sub-totals for wet and dry periods.

Table 2: Seasonal average distances travelled and average area covered monthly for the study period.

Date	FromNode	ToNode	AreaHa	Season	Avg Ha
May 1, 2003	23	24	0.82	D	0.2982
June 1, 2003			0.67	D	0.2995
July 1, 2003	37	38	1.31	D	0.7247
August 1, 2003	33	34	1.95	D	1.0718
September 1, 2003	33	34	0.58	D	0.8619
October 1, 2003	41	42	1.17	D	1.1981
May 1, 2004	31	32	0.28	D	1.1474
			0.97		
April 1, 2003	31	32	1.32	W	0.5901
November 1, 2003	7	8	0.69	W	0.3317
December 1, 2003	18	19	0.96	W	0.5957
January 1, 2004	3	2	0.45	W	0.5466
February 1, 2004	33	33	0.40	W	0.7184
March 1, 2004			0.33	W	0.6769
April 1, 2004	38	17	1.15	W	1.1835
			0.76		

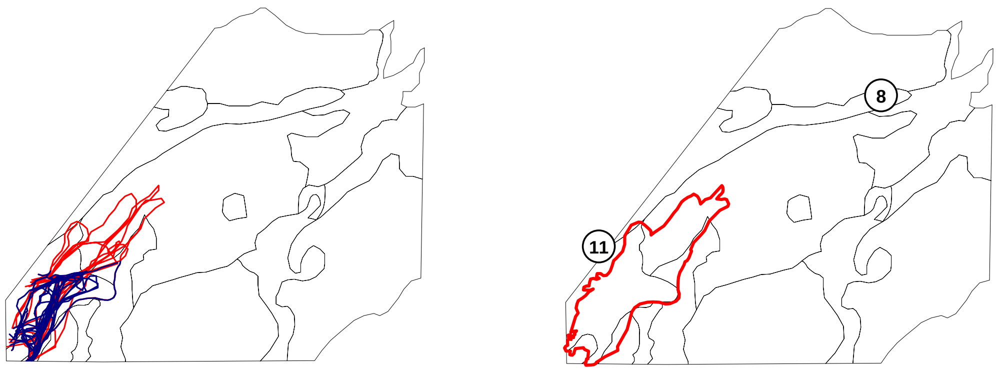
The study troop traversed a significantly larger area during the dry season compared to that of the wet season (Chi 2 test: $\chi^2 = 6.908$; $p = 0.0086$; $df = 1$). Area traversed during the dry season (Figure 5a) was more than double the area covered during the wet season (Figure 5b) i.e. 76 ha and 37 ha respectively.

a) **b)**

Figure 5: Daily distances travelled and area covered by the study troop during the study period. a) Represents movement patterns for the period including May 2003 to October 2003 and May 2004 (dry season). b) Represents movement patterns for the period including April 2003 and November 2003 to April 2004 (wet season).

Home range

The study troop's home-range size was calculated as 77 ha, (Figure 6).



a) **b)**

Figure 6: Study troop home range during the study period. Area was calculated in ha using the area within the bounding polygon. a) Is combined study troop wet and dry ranges – blue arcs are wet season daily ranges and red arcs are dry season daily ranges. b) Is bounding polygon for combined wet and dry ranges. Numbered circles depict neighbouring troop locations and sizes as observed during census transects walked.

Diet and food selection

The various food types that made up the vervets diet are depicted in Figure 7.

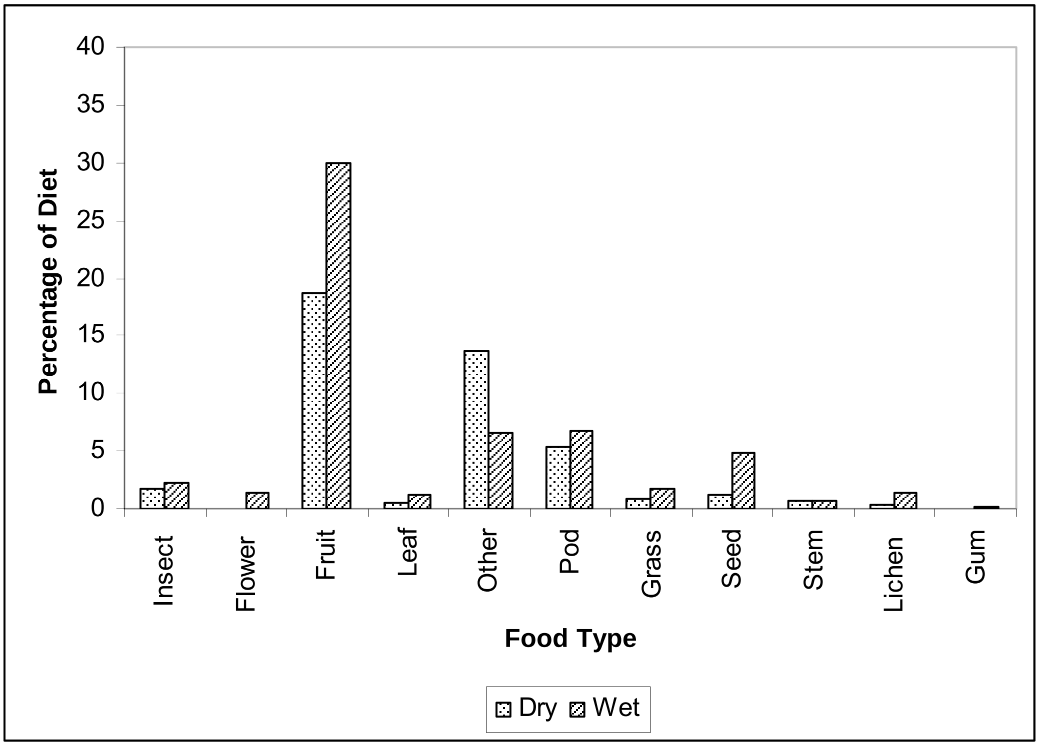


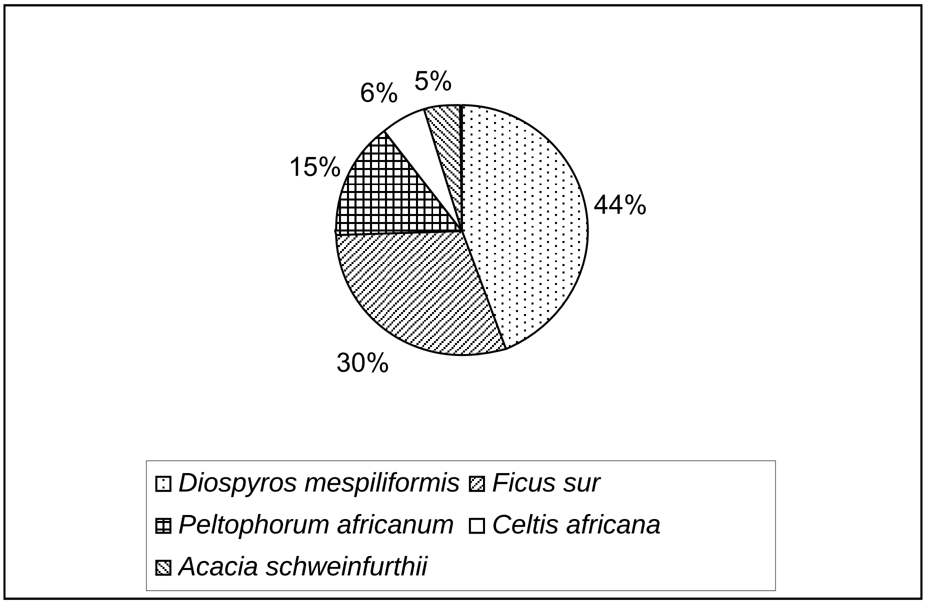
Figure 7: Seasonal foraging. The graph depicts various food sources selected for both dry and wet seasons.

Table 3 below shows whether significantly more of a particular food source was consumed during the wet season.

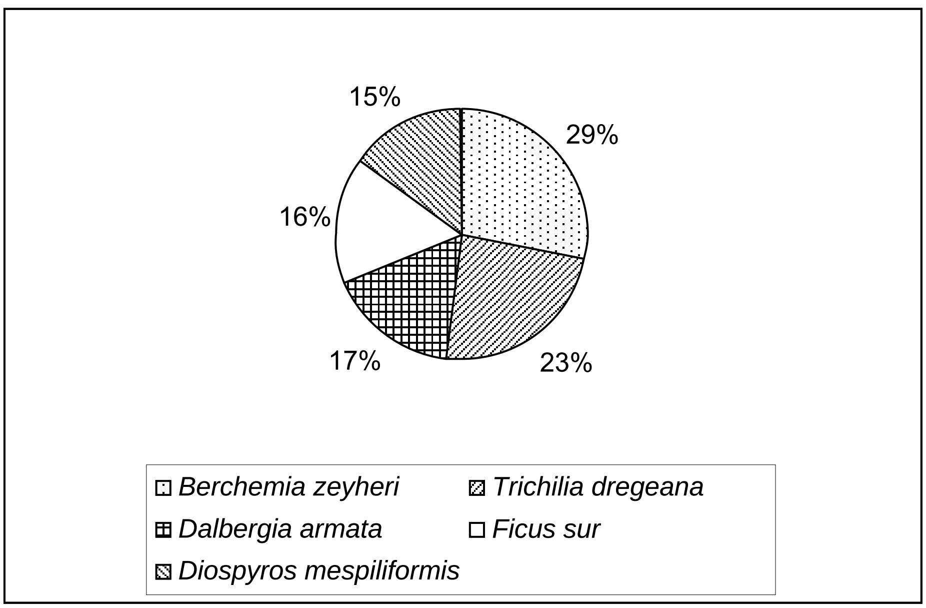
Table 3: Vervet food selection for the study period. Table reflects diet item, Chi square test results and significance of diet items with regards to wet season. Exceptions are marked and discussed.

Food eaten	Chi 2 test results	Significantly more consumed during the wet season
Insect	$\chi^2 = 0.812$; $p = 0.3676$; df = 1	No
Flower	$\chi^2 = 12.233$; $p = 0.0005$; df = 1	Yes
Fruit	$\chi^2 = 20.853$; $p < 0.0001$; df = 1	Yes
Leaf	$\chi^2 = 2.129$; $p = 0.1445$; df = 1	No
Other - Debris/leaves on ground	$\chi^2 = 20.354$; $p < 0.0001$; df = 1	No *
Pod	$\chi^2 = 1.292$; $p = 0.2557$; df = 1	No
Grass	$\chi^2 = 2.400$; $p = 0.1213$; df = 1	No
Seed	$\chi^2 = 41.007$; $p < 0.0001$; df = 1	Yes
Stem	$\chi^2 = 9.466$; $p = 0.0021$; df = 1	Yes
Lichen	$\chi^2 = 6.951$; $p = 0.0084$; df = 1	Yes
Gum	$\chi^2 = 0.825$; $p = 0.3638$; df = 1	No
* **Significantly more consumed during the dry season**		

Figure 8 depicts the five most commonly utilized plant species for both the wet and dry seasons.



a)



b)

Figure 8: Five most commonly utilized plant species for a) the wet and b) the dry seasons. Pie charts show preferred plant species by season.

There were some species that were consumed across seasons as they started fruiting during the wet season and continued into the dry season.

Various plant species foraged on for both seasons were plotted as a cumulative percentage contribution (Figure 9).

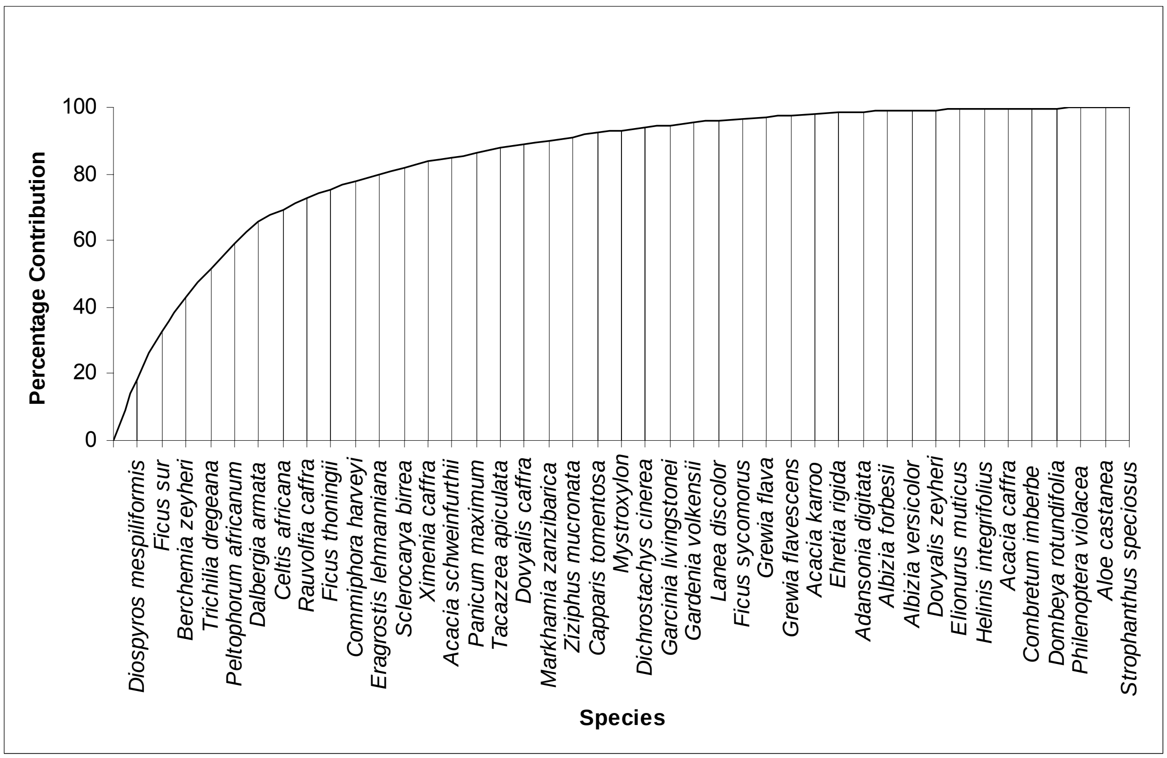


Figure 9: Cumulative Percentage Species Contribution of various plant species foraged on.

Table 4 depicts a breakdown of the various plant part percentages contributing towards the study troops diet for the wet and dry seasons as shown in the cumulative percentage contributions (Figure 9).

Table 4: Breakdown of various plant part percentages contributing towards the study troops diet for the wet and dry seasons.

					Contribution Towards Tot % Dry							Contribution Towards Tot % Wet						
PLANTSPECIES	% of Total	Cumulative	Tot % Dry	Tot % Wet	Dry Stem %	Dry Seed %	Dry Root%	Dry Pod %	Dry Flower %	Dry Fruit %	Dry Leaf %	Wet Stem %	Wet Seed %	Wet Root %	Wet Pod %	Wet Flower %	Wet Fruit %	Wet Leaf %
Diospyros mespiliformis	18.39	18.39	13.31	5.08	1.3	0.0	0.7	0.0	0.0	96.1	2.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Ficus sur	14.36	32.75	8.93	5.43	1.0	0.0	0.0	0.0	0.0	99.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Berchemia zeyheri	10.16	42.91	0.61	9.54	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	98.2	1.8
Trichilia dregeana	8.84	51.75	0.96	7.88	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	87.8	0.0	12.2	0.0
Peltophorum africanum	7.53	59.28	4.55	2.98	0.0	0.0	0.0	98.1	0.0	0.0	1.9	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Dalbergia armata	6.30	65.59	0.61	5.69	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	95.4	0.0	4.6	0.0
Celtis africana	3.85	69.44	1.75	2.10	5.0	0.0	0.0	0.0	0.0	95.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Rauvolfia caffra	3.24	72.68	0.18	3.06	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Ficus thoningii	2.63	75.31	0.53	2.10	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Commiphora harveyi	2.45	77.76	0.00	2.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Eragrostis lehmanniana	2.19	79.95	1.05	1.14	58.3	0.0	0.0	0.0	0.0	0.0	41.7	23.1	0.0	0.0	0.0	0.0	0.0	76.9
Sclerocarya birrea	2.01	81.96	0.18	1.84	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Ximenia caffra	1.66	83.63	0.00	1.66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Acacia schweinfurthii	1.40	85.03	1.40	0.00	0.0	0.0	0.0	93.8	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Panicum maximum	1.40	86.43	0.00	1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0	0.0	0.0	0.0	0.0	81.3
Tacazzea apiculata	1.23	87.65	0.26	0.96	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3	0.0	0.0	72.7
Dovyalis caffra	1.23	88.88	0.00	1.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Markhamia zanzibarica	1.14	90.02	0.00	1.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
Ziziphus mucronata	1.14	91.16	0.00	1.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	0.0	7.7	76.9	7.7
Capparis tomentosa	1.05	92.21	0.00	1.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	75.0	0.0
Mystroxylon aethiopicum	0.88	93.08	0.00	0.88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Dichrostachys cinerea	0.79	93.87	0.79	0.00	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garcinia livingstonei	0.79	94.66	0.00	0.79	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Gardenia volkensii	0.70	95.36	0.00	0.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Lanea discolor	0.70	96.06	0.00	0.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Ficus sycomorus	0.61	96.67	0.26	0.35	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Grewia flava	0.53	97.20	0.26	0.26	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7	33.3
Grewia flavescens	0.53	97.72	0.44	0.09	0.0	0.0	0.0	0.0	0.0	80.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Acacia karroo	0.44	98.16	0.35	0.09	75.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Ehretia rigida	0.26	98.42	0.00	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
Adansonia digitata	0.18	98.60	0.00	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Albizia forbesii	0.18	98.77	0.18	0.00	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Albizia versicolor	0.18	98.95	0.00	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
Dovyalis zeyheri	0.18	99.12	0.00	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Elionurus muticus	0.18	99.30	0.00	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Helinis integrifolius	0.18	99.47	0.00	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Acacia caffra	0.09	99.56	0.09	0.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Combretum imberbe	0.09	99.65	0.09	0.00	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dombeya rotundifolia	0.09	99.74	0.09	0.00	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lonchocarpus capassa	0.09	99.82	0.09	0.00	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aloe castanea	0.09	99.91	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Strophanthus speciosus	0.09	100.00	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

According to an electivity index calculated for main plant species consumed (Figure 10), there was a relatively high preference for most of the species across both the wet and the dry seasons, with the exception of *Acacia schweinfurthii* which was not selected during the wet season.

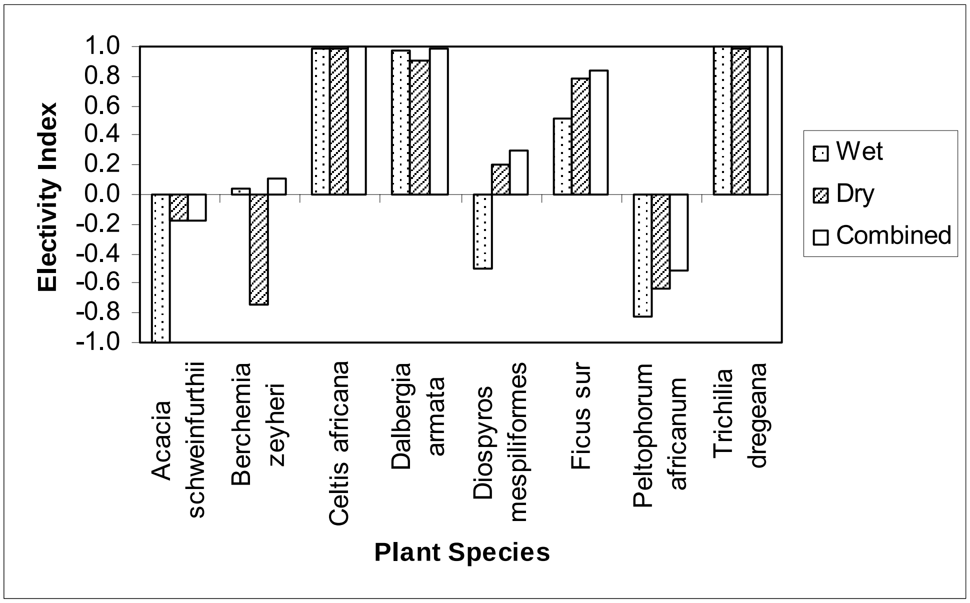


Figure 10: Main forage plant species electivity index. Utilisation of main forage species in relation to the availability of such, expressed as an electivity/selectivity index for the wet season, dry season and combined for both seasons.

For plant communities utilized, the electivity index (Figure 11) shows that there was a distinct preference for sub-community 4.2 (*Sclerocarya birrea-Panicum maximum* Woodland) in both the wet and dry seasons. Community 3 (*Acacia nigrescens-Combretum apiculatum* Woodland) and variant 4.4.1 (*Pappea capensis* Variant) were avoided during wet season. Refer to Habitat Utilisation above for plant community descriptions.

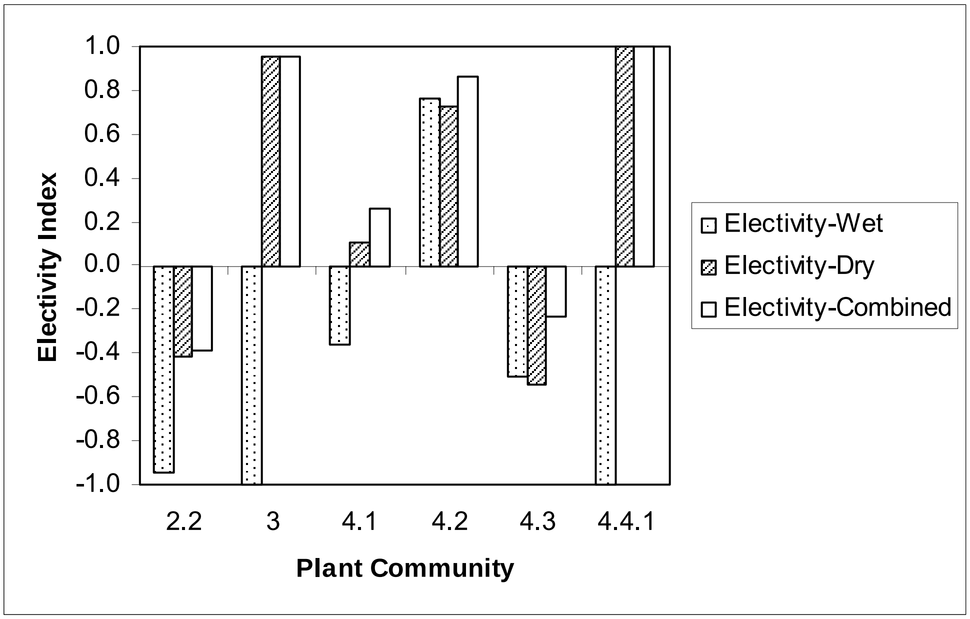


Figure 11: Plant community electivity index. Utilisation of plant communities in relation to their availability expressed as an electivity/selectivity index for the wet season, dry season and combined for both seasons.

Discussion

Once the property was mapped and the vervets were habituated, data collection commenced. The study troops group composition and population density (0.4 vervets per ha) appeared within the norms, taking into consideration that their habitat was close to optimal with very few disturbances for the study troop.

According to Pruetz & Isbell (2000), food distribution and patch size has a correlation to agonistic behaviour, with food scarcity leading to increased agonistic interactions. During the study period several agonistic interactions were observed, however due to there being a constant supply of various food sources throughout both seasons, such interactions could not be linked to food distribution or patch size.

The study troop's habitat was considered 'ideal' in terms of food and water availability, being rich in resources compared to potential surrounding habitats. The study troop established their territory in the centre of the 'ideal' habitat, with other troops occupying territories adjacent to such. From observations of other troops in the study area, it was clear that the study troop was a larger and more successful troop than the others and that they were successful in the defense of their territory. According to Brown (1982), who did most of his work on birds, one of the main reasons a territory is defended is for its economic value. He pointed out that there are several costs and benefits to defending a territory with its resources. Energy expenditure and risk of injury are some of the costs. Benefits include priority of access to resources. Territorial behaviour becomes favoured by selection whenever the benefits outweigh the costs, making the resource economically defendable as is the case with vervet troops (Krebs & Davies, 1999). The idea of economic defendability has also been used to predict levels of resource availability, which in turn could lead to territorial defense.

If resources are scarce or too freely available, the gains from excluding others becomes less cost effective and not worth the effort (Krebs & Davies, 1999).

With regards to habitat utilisation, the vervets had ten communities, sub-communities and variants available to them within their home range. Of the ten available communities, sub-communities and variants they utilized only six during the study period i.e. sub-community 2.2 (*Combretum imberbe-Acacia nigrescens* Woodland), community 3 (*Acacia nigrescens-Combretum apiculatum* Woodland), sub-community 4.1 (*Balanites maughamii-Panicum maximum* Woodland), sub-community 4.2 (*Sclerocarya birrea-Panicum maximum* Woodland), sub-community 4.3 (*Combretum zeyheri-Panicum maximum* Woodland), and variant 4.4.1 (*Pappea capensis* Variant). Of the six communities, sub-communities and variants utilized, sub-community 4.2 was used the most during both the wet and the dry season. Community 3 and variant 4.4.1 were only used during the dry season, whereas the other communities, sub-communities and variants were randomly utilized across both seasons.

The daily ranging patterns of vervets varies according to habitat type, predator presence, competing neighbouring troops, distribution and nature of food, access to water and sleeping sites (Estes, 1991; Skinner & Smithers 1990; Adeyemo, 1997). Adequate vegetative cover is a prerequisite for vervet protection, feeding and procreation, with food availability strongly influencing their daily activity patterns regardless of season (Michael, 1983). When foraging on the ground the vervets often disperse over quite a broad front and progress relatively slowly.

There was no statistically significant difference between distances travelled and area covered on a daily basis during dry and wet seasons. What was noted was that during dry periods when the vervets extended their range, they would often spend evenings in trees close to where they were foraging. Such trees were not their ‘usual’ sleeping sites.

Even though they were moving into dry season areas they never visited during the wet season, once in such areas, daily distances travelled and area covered remained relatively constant regardless of season. This could be attributed to the general habitat the troop occupies and the amount of time available for traveling. The area appears to be pristine vervet habitat with a permanent water source and several mountain river streams with accompanying riparian vegetation. There was an abundant supply of various food sources throughout the year, with movement patterns mostly coinciding with the fruiting times of several tree and plant species. There was no need for the study troop to move far from their territory and they remained within the boundaries of such.

On average distances travelled and area covered daily were 0.2 km and 0.2 ha further and larger respectively for the dry season. On examination of Figure 5a and 5b it appears as though distances travelled and area covered daily are significantly more during the dry season. However, upon further investigation of the data, what emerges is that during wet and dry periods they still on average travel similar distances and cover similar sized areas daily. They did extend the boundaries of their wanderings by sleeping closer to food sites enabling them to travel further into areas they never utilized during the dry season in search of additional food sources (Figure 5a).

The vervets range more than doubled during the dry season, however, their daily range was on average only 2 ha more than during the wet season. Home range size appeared to be linked to food and particularly water availability, with the troops mean daily distance travelled increasing slightly during the dry season. According to Cheney (1987), home-range sizes of vervets are 0.12-1.78km^2. The fact that the study troop had a permanent water source within their home range was an important factor affecting their ranging patterns.

During the dry season they frequented their water source on an almost daily basis, this corresponds to observations of other primate species for example patas and tantalus in the Kala Maloue National Park in northern Cameroon, who also drank water on an almost daily basis (Nakagawa, 1999).

During the wet season longer periods of time were spent away from the permanent water source as there was an abundant supply of ground water throughout their home range, particularly after rain had fallen.

The vervets do not utilize their home ranges evenly, but rather tend to concentrate on areas of abundant food supply and move through adjacent areas solely to get to resources. Several studies have documented that primates in general utilize areas with higher food concentrations within their home range in order to maximize food intake relative to energy expenditure (Clutton-Brock, 1975; Harrison, 1983b; Vedder, 1984; Barton *et al.*, 1992; Nakagawa, 1999). During the dry season they are not as selective as during the wet season when there is a much larger selection of food resources. The vervets appear to have an intrinsic knowledge of where their food sources are located (Krebs & Davies, 1999); however, it does not appear that they know precisely when to visit some seasonal resources and they visit some trees on a relatively regular basis as if to investigate whether such are bearing fruit or not.

Although vervets have diverse and seasonally variable diets, and with over seventy-five different food species being identified and consumed by the study troop for the study period, they concentrated mostly on the plants depicted in Figure 8. *Berchemia zeyheri* and *Trichilia dregeana* were the most important species during the wet season, with *Diospyros mespiliformis* and *Ficus sur* being most important during the dry season. The study troop's diet consisted of a number of staple food items with a relatively wide seasonal variation for additional supplementation.

According to Lee & Hauser (1998), vervets eat in proportion to what is available (density, size and standing crop), and do not select food based on specific macronutrients, rather, a large proportion of the variance in their diets is merely a simple function of numbers, size and monthly availability or standing crop of food resources.

The proportion of a food item in the diet of the consumer depends on the consumers' electivity (preference for a particular food) and the availability of that food in the environment. According to Ivlev's electivity index, the study troop positively selected the majority of their main food items, which was expected. Sub-community 4.2 was positively selected across both the wet and dry seasons. Community 3 and variant 4.4.1 were not selected during the wet season and were only utilized during the harsher dry season. Remaining communities, sub-communities and variants were utilized less extensively. Results are as expected bearing in mind that the vervets used only small portions of what was available in most habitats (Figure 11).

Grasses and insects were less important sources of food, with 'tree food' being the mainstay of their diets. It appeared that insect meals were never planned for and that only when the study troop by chance came a cross a termitarium with winged allates being released, did they 'cash in' on the nutritious supply of protein, much to the amusement of the juveniles and babies.

An interesting observation that Estes (1991) noted, was that vervets were able to assist in the propagation of their favourite fruit trees. The same was observed at the study site where areas containing large *Diospyros mespiliformis* trees had several young *Peltophorum africanum* trees growing under them and vice versa.

The vervets were feeding on one tree species and during the course of their daily wanderings visiting the other tree species where they defecated the first trees seeds under the second tree, leading to the combination of trees growing together. Both tree species fruited at the same time of the year. There were many other less conspicuous tree combinations throughout their home range further supporting the observation.

Commonly the vervets were seen turning sticks and small logs over whilst foraging on the ground. They scratched around in leaf litter and herbivore dung in search of insects and undigested seeds or pods. Unlike baboons that are capable of digging, the vervets were never seen digging - their hands did not appear tough enough. When foraging on *Diospyros mespiliformis* the adults bit into the fruit and peeled such before eating it. When fruit was taken from the ground, it was rubbed between the hands before being consumed, this is contrary to what was observed in the Amboseli by Struhsaker (1967b).

The majority of the study troop often only fed on one particular food item at a time, albeit for a relatively short period of time, before switching to another food item or moving off. Dominant animals usually orchestrated the troops feeding behaviour, only allowing sub-ordinates to feed when they were done. However, this did not prevent submissive animals from feeding on less preferred food items or from foraging on the ground. When strange or unknown food sources were encountered, it would more often than not be the sub-adults and juveniles that would be the first to experiment with such, and only once they seemed to approve of it would the adults partake.

It was extraordinary to witness the vervets moving off in a set direction with no apparent reason for doing so and no sign of food in the close proximity, only to be surprised at their ability to find a food source/patch amongst what appeared to be sterile vegetation – it was as though they had a memory of food sources and potential times when such sources would provide food. On several occasions when they visited such potential sites, the trees were not yet in a position to provide food and the vervets just moved on, signifying that they could not predict the exact timing of trees fruiting, nevertheless they knew exactly where to go.

The vervets frequently visited sites when the fruiting times of trees at such sites were close, until the trees provided fruit, in which case they would visit the site regularly until its fruit was depleted. The sophisticated knowledge that certain species have of their environment, which includes the vervets' ability to remember the location of food sources, is relatively well documented (Griffin 1984). Food patch depletion and rate of return have been investigated for various bird species (Krebs and McCleery 1984; Kamil and Roitblat 1985; and Kamil, Krebs, and Pulliam 1987). Such could have relevance to vervet foraging strategies, particularly for plant species that provide fruit at regular intervals throughout the year for example the various *Ficus sp.* occurring throughout the study troops home range.

In most other temperate sub-tropical research sites it appears as though food variability and availability was less than at the Blydeberg study site. At Blydeberg there was a large variety of food species to choose from, however, the study troop did have a definite seasonal preference for particular species. This correlates with finding by Lee & Hauser (1998) in Amboseli - Kenya, and Harrison (1984) in Senegal, where findings suggest that vervet diets are usually restricted to a small number of staple foods with a wider seasonal supplementation. Foods are consumed in proportion to their availability, with variation in diet being a simple function of various food species available standing crop.

As one food species standing crop diminishes, to be cost effective in their foraging strategies, vervets move off to find alternative species to forage on (Lee & Hauser, 1998).

According to Clutton-Brock (1977), many species of monkey including the vervet monkey are able to recall the location and phenological patterns of food and water within their home ranges. This appears to be the case with the study troop that somehow knew when to visit areas not often frequented, to 'check' whether trees in the area were fruiting or not. In all instances they started visiting such sites a short period before trees started producing fruit and continued to visit until the trees were no longer bearing fruit.

Often when the vervets were observed foraging, they were in the presence of antelope species that moved around with them, particularly the Bushbuck (*Tragelaphus scriptus*). Bushbuck foraged on leaves of broken branches and fruit that the vervets dropped. The vervets were very wasteful feeders and dropped large amounts of fruit when feeding. On several occasions a resident group of Banded Mongoose (*Mungos mungo*) was observed traveling with the vervets, it is not clear whether there was a feeding association or whether the arrangement was for safety purposes, the latter seems more probable. Several bird species were also seen feeding in the same trees as the vervets, particularly the Purplecrested Lourie (*Tauraco porphyreolophus*). However, the association appeared to be of a more competitive nature, with the lourie eating the same fruits that the vervets were feeding on. There was also a resident troop of Baboons (*Papio ursinus*) that lived in the study area and frequently their wanderings overlapped with those of the vervets. Certain trees and the permanent water source in the area were shared by both species. According to Estes (1991), it is common for the two species to have overlapping territories, they do compete for resources, and in some instances the baboon can be an occasional predator of young vervets – this behaviour was not observed during the study period.

During the dry season the baboons spent most of their time in the more open grassy areas foraging, and competition for resources with the vervets was not noted. During the wet season when trees and shrubs were fruiting, the baboons were often observed displacing the vervets from large trees and shrubs containing ripe or semi ripe fruit, particularly *Sclerocarya birrea, Diospyros mespiliformis* and various *Grewia sp.* When the vervets were feeding in a particular tree, and the baboons arrived, the vervets would simply unobtrusively move off to another area or just remain in the background until the baboons had finished, this sympatric relationship has been recorded on other occasions (Zinner *et al.*, 2001).

Several species of non-human primates are renowned for their crop raiding antics, with the vervet being one of the main culprits (Maples *et al.*, 1976). The problems are however becoming more widespread, with food-raiding tactics occurring in reserves, suburban areas, at picnic sites and at lodges. According to Saj *et al.* (1999), human food is of a higher quality than the vervets natural food, having more energy per unit and thus allowing the vervets to reach their metabolic demands much sooner than if they were only eating their natural foods. With this option available to vervets in certain situations, it is obvious that they would utilize high-quality human food sources. In many situations it is no longer a matter of choice but one of survival and the vervets have no choice but to utilize human food sources as their natural habitats have been degraded to such an extent that they are unable to meet their daily caloric requirements from remaining natural food sources alone (Else, 1991).

As our knowledge about vervet's increases, the challenge to protect them becomes more apparent. With habitat destruction and hunting being at the forefront of all primates' demise, it is critical that we nurture a better understanding of, and appreciation for all primates and the habitats they live in. Increasing human populations and intensified agricultural practices, particularly in riverine habitats is likely to increase the conflict between man and vervet.

In Eritrea 37.2 % of all vervet records reflect them to be within 500 m of an agricultural area, and 31.8 % were within 1000 m of the nearest village. Vervets are considered pests and are chased and killed to such an extent that there is a strong negative effect on the entire population in Eritrea (Zinner *et al.*, 2002).

With vervets being seasonal breeders (Lee, 1987; Hauser & Fairbanks, 1988; Dunbar & Barrett, 2000), it is important that the timing of births corresponds to the fruiting of trees and the onset of the wet season. Seasonality thus plays an important role in vervet society and dictates their daily and monthly activity patterns. The abundance of seasonal foraging sites and the absence of such during the drier months make vervet movement patterns almost predictable once their habitat and resources has been identified and mapped. Due to some areas having been modified by man for agricultural activities, prime vervet habitat has been destroyed, leaving the animals no choice but to raid crops, in turn leading to them being labeled vermin under current legislation in South Africa. This status allows farmers to shoot vervets on site without having to justify themselves. No permits or permission is required. To vervets the benefits of crop raiding seem to outweigh the costs, or it might be that they have not yet learnt to adapt to the 'new' threat of high-powered rifle wielding farmers that eliminate them from a distance. Many farmers believe vervets to be destructive due to their wasteful feeding habits, but such is their natural habits in a very unnatural man made environment (Dunbar & Barrett, 2000).

Ongoing reduction of vervet habitat for agricultural purposes, with accompanying increases in human populations in such areas leads to intensified conflict between man and vervet, with the outcome being obvious as long as vervets are seen as pests. This represents a real danger of extinction in the medium term to localized vervet populations, with loss of genetic variability (Zinner *et al.*, 2002).

Conflicts between non-human primates and local human populations are well documented throughout Africa (Basckin & Krige, 1973; Kavanagh, 1978, 1980; Skinner & Smithers 1990; Estes, 1991; Dunbar & Barrett, 2000). Inclusion of human food in the vervet diet impacts their activity budget and they tend to feed and travel less, with more time being spent on other activities including resting and socializing (Saj *et al.*, 1999). Should the inclusion of human food be a permanent arrangement, it is possible that the affected troop's home range will become smaller as they travel less. According to Saj *et al.* (1999) and Basckin & Krige (1973), obvious costs associated with the inclusion of human food into a vervet diet are increased aggression leading to injuries, and direct competition with humans. Of interest is that adult females, particularly females with babies, spend much less time consuming human food in comparison to other group members, except for juveniles that spend the most time consuming human food - it has been suggested that this is due to their more adventurous and exploratory tendencies (Saj *et al.*, 1999). With the study troop, as mentioned previously, often the juveniles would eat or 'try' a new or novel food source through a 'trial and error' approach. Once the juveniles were consuming the new food, only then would the other troop members taste it. This behaviour suggests that troops with large proportions of juveniles could be more likely candidates to become 'pests' in the future should they become exposed to human food sources.

To prevent vervet damage to crops and lodges, and to reduce or control potentially detrimental incidents, it is critical to develop management plans in areas where vervets are problematic. According to Brennan *et al.* (1985), the removal of accessible sources of human food accompanied with the trapping and removal of known offenders and excess animals will go a long way towards solving the problem. Simply removing an entire troop will only create a vacuum for another troop to fill and will not alleviate the problem. Management plans should include an assessment of the situation from a distanced perspective, taking the habitat requirements of the vervets into consideration.

One of the objectives of a vervet management plan should include the provision of natural food sources which could be achieved on the medium to long term by planting trees that provide food throughout the year. Another objective should be the education of all humans visiting and residing or working in such areas to not provide food or encourage the vervets to beg for food. Yet another objective could be to ensure no food is left lying around for the vervets to notice and steal. With a minimum amount of effort and simple logic it would be possible to manage problematic situations involving vervets to the benefit of both man and vervet. According to Brennan *et al.* (1985), removal of accessible sources of human food, accompanied by limited trapping and removal to reduce population density with regular follow-up studies to ensure the problem is sufficiently controlled, is the recommended form of control for problem vervets.

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CHAPTER 7

Seasonal variation in the activity budget of a troop of vervet monkeys (*Chlorocebus aethiops*) in South African Temperate Sub-tropical Bushveld

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Abstract

This report describes the activity budget of a troop of vervet monkeys (*Chlorocebus aethiops*) in the Blydeberg Conservancy situated in the Northern Province of South Africa, between 1 May 2003 and 30 April 2004, covering both a wet and a dry season and using scan sampling methods.

The study area is broadly classified as temperate sub-tropical bushveld, having a distinct wet and dry season with accompanying variations in temperature and day length. The focal troop selected was a semi-habituated troop residing close to a permanent water source adjacent to the upper reaches of a tributary feeding into the Blyde River. The troops home range is relatively undisturbed and provides for all their nutritional requirements without them having to travel too far a field.

Activities recorded included foraging, socialising, moving, travelling and resting. The study troop was generally more active during the morning and late afternoon than around midday when they mostly rested and socialised.

This particular study formed part of a larger study to determine the study troops home range, habitat utilisation and food selection within the Blydeberg Conservancy. The specific aims of this study were to investigate the activity budget of vervets in their natural habitat and whether such was affected by seasonality.

On average, the study troop drank for 3 % of all observations, foraged for 39 %, moved for 15 %, rested for 17 %, and socialised for 26 %. Results revealed that they socialized, drank and rested more during the wet season than during the dry season. They foraged and moved more during the dry season compared to the wet season. Adult females socialized and foraged slightly more than males. Males were observed resting, drinking and moving more than females.

Introduction

The time animals allocate to their various activities has an important influence on their survival and reflects demands made on them by local environmental conditions. Vervets respond to climatic and resource variability in their environments through the adjustment of their activity patterns. This issue is relevant to a consideration of the animal as seasonality increases because its ecological persistence depends on the severity of the harshest time of the year, and its coping strategies at such times. Vervets are regarded as opportunistic omnivores and have various strategies for coping with harsh environmental conditions during the dry winter months in temperate habitats.

Coping behaviour includes adjusting their behaviour to travel further in order to find sufficient resources to meet their metabolic needs, changing their diets if necessary, and even taking foreign human food if available (Brennan *et al*., 1985; Chapman, 1985; Harrison, 1985; Oates, 1987; Adeyemo, 1997; Baldellou & Adan, 1997; Saj *et al*., 1999).

Existing research on vervet activity patterns in response to seasonality or seasonally driven variations in food abundance are limited for temperate areas and for vervets in general. Existing activity related literature includes studies on the effects of habitat changes over time on diets and reproduction in vervet monkeys in Kenya (Lee & Hauser, 1998), analysis of the seasonal and diurnal differences in foraging, moving, resting and socialising of free-ranging vervet monkeys in Natal (Baldellou & Adan, 1998), and studies of seasonal vervet activity budgets in Nigeria, including their movements, foraging, resting, drinking and socialising (Adeyemo, 1997). Research on vervet time budgets with regards to their movements, foraging, resting, socialising and sleeping was done at Windy Ridge in South Africa (Baldellou & Adan, 1997). The distribution of food and its effects on female relationships in vervets and patas monkeys was studied in Kenya (Pruetz & Isbell, 2000). A study on the differences in food selection between patas monkeys and vervets was undertaken in Cameroon (Nakagawa, 2003). Also, the movements of vervets and patas monkeys in relation to food abundance was studied in Kenya (Isbell *et al*., 1998).

Generally vervets are known to inhabit gallery forest along water courses, being dependent on such for their existence. The effects of seasonality and its impacts on resource availability act as precursors to vervet activity related behaviour and daily activity patterns. Most activity related studies suggest that vervet activity budgets are affected by resource availability, particularly food, which in turn is seasonally dependant in temperate areas.

According to Lee & Hauser (1998), in Kenya where vervets are restricted mainly to two species of acacia trees (*Acacia xanthophloea* and *A. tortilis*), availability of food resources is the main determinant of activity patterns, with the abundance and location of such being critical to their survival. Also, in Kenya Isbell *et al*. (1998) showed that vervet activity patterns, particularly movement patterns, were affected by the type of food available and the palatability thereof. According to research in Nigeria by Adeyemo (1997), food availability had a strong impact on daily activity patterns. Brennan *et al*. (1985), and Saj *et al.* (1999) studied vervet activity in a tourist lodge environment in Kenya, and in an agricultural environment in Uganda respectively. Both studies revealed that vervet activity budgets changed when human foods and the often perilous acquisition thereof became part of their diets.

The vervet monkey (*Chlorocebus aethiops*) is well known and well researched throughout its range, however very little behavioural ecological research has been done in the sub-tropical areas that constitute the southern limits of their range (Fedigan & Fedigan; 1988). Like most mammals, vervets do not make uniform use of their available habitats. They tend, rather, to be selective regarding habitat use and their patterns of activity reflect this (De Moor & Steffens, 1972; Chapman, 1985; Lee & Hauser, 1998;). In general primates have broad inter- and intraspecific variations to their home range sizes often associated with the territorial defense of their home ranges and accompanying territorial behaviour (Clutton-Brock & Harvey, 1977; Mitani & Rodman, 1979; Cheney, 1987; Dunbar & Barrett, 2000).

An understanding of how animals divide up their activities throughout the day and by season is important for understanding their lifestyles and indicates broadly how they interact with their environment and invest their energy and time for survival and reproduction (Defler, 1995).

Other primate studies use activity budget analysis to assist in gaining an insight and understanding into the ecology and behaviour of the species being investigated (Chapman, 1985; Lawes & Piper, 1992; Nakagawa, 2000; Poulsen *et al*., 2001; Hill *et al*., 2003; Hanya, 2004; Raboy & Dietz, 2004).

Generally vervet activity patterns are related to resource availability which fluctuates seasonally in temperate sub-tropical areas. Seasonal fluctuations in plant food resources which comprise the largest portion of the vervets' diet across both the wet and the dry season are strongly related to ambient temperatures and changes in day length (Chapman, 1985; Harrison, 1985; Adeyemo, 1997; Dunbar & Barrett, 2000).

In most areas where vervets occur, water availability can be a restricting factor, forcing the vervets to remain within traveling distance of such, which in turn almost pre-determines their activity patterns (Chapman, 1985; Harrison, 1985; Adeyemo, 1997). At Blydeberg the vervets had a permanent water supply and the habitat surrounding the water source provided for all their nutritional requirements. Their home range consisted of almost pristine gallery forest (when compared to neighboring areas), and contained large specimens of fruiting trees that provided food all year round, especially trees from the *Ficus* genus. Due to the nature of their habitat the study troop did not travel as much as would be expected. During the dry season their range was slightly extended to include areas of fruiting trees that were further from their core area.

The overall objective of this study is to probe the consequences of increased seasonality associated with higher latitudes by examining variation in the study troop's patterns of activity. This study aims to provide an insight into seasonal vervet activity budgets in temperate sub-tropical areas. Expectations are that seasonality will have a significant influence on the structuring of activity patterns by the study troop.

It is hoped that this study will contribute towards our understanding the impacts that seasonal variations might have on the activity patterns of vervets, and ultimately to our understanding of the interrelationships that exists between vervet ecological behaviour and their seasonally driven environment in the Blydeberg Conservancy.

The specific aims of this study were to compare vervet activity patterns across seasons at Blydeberg, with specific emphasis on seasonal differences in diurnal activity allocation, overall male and female activity pattern differences, and male to female seasonal activity pattern differences. It is predicted that there will be overall seasonal differences in the allocation of time to different activities for the study troop and that there will be seasonally prominent diurnal variations to activity patterns. It is also expected that there will be noticeable seasonal variations between male and female activity patterns for the study period due to males being larger in size than females and requiring more nourishment leading to longer foraging times. Male foraging time could be compensated for by their feeding on nutritionally richer foods leading to reduced foraging bouts. Seasonal predictions originate from the fact that rainfall and dependent resources are seasonal.

Methods

<u>Study animals.</u>

A troop of vervet monkeys residing within the confines of the Blydeberg Conservancy in the Northern Province of South Africa was habituated. The troop consisted of 33 animals (5 adult males, 8 adult females and 20 non-adults). Only data collected for adult males and females are used in the following analyses.

Daily activity data collected were allocated to three time periods of four hours each i.e. 06h00 to 10h00, 10h00 to 14h00 and 14h00 to 18h00. The study period was split into a dry winter season (May to October) and a wet summer season (November to April) based on rainfall figures for the study area.

<u>Study site.</u>

The Blydeberg Conservancy is approximately 3000 ha in size and is situated along the great escarpment in the Northern Province of South Africa, Longitude 30° 27' to 25° 56' E and Latitude 24° 23' to 24° 28' S. Altitude ranges from 350 m to 800 m above sea level (Bredenkamp & Van Rooyen, 1998a, 1998b). The study area constitutes the farms Dunstable (#230) and Jongmanspruit (#234) (Figure 1).

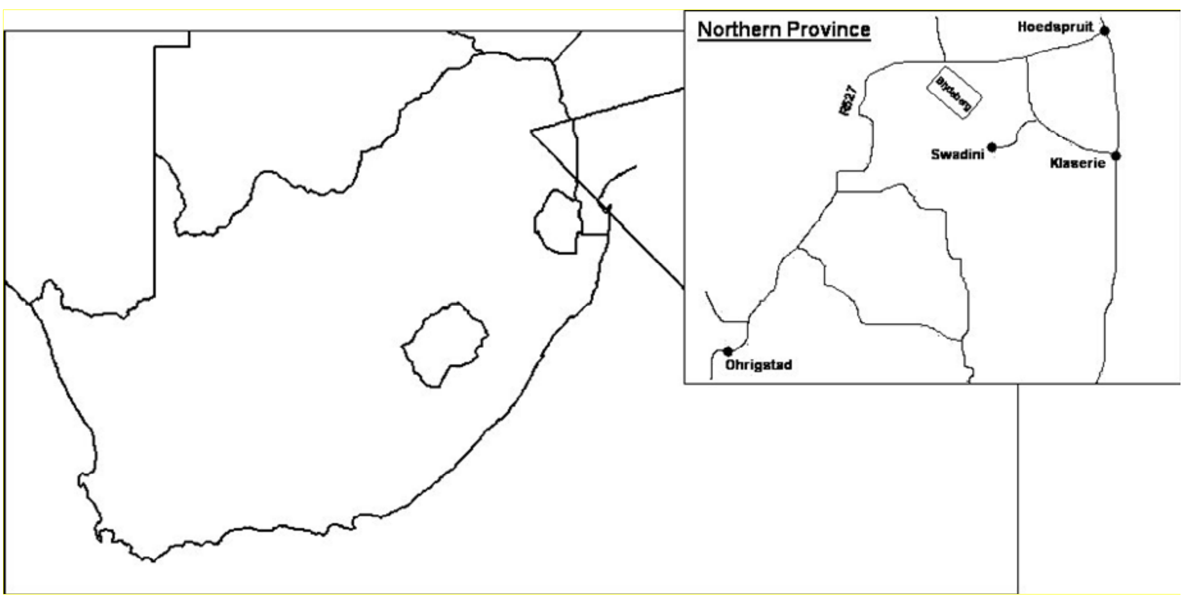


Figure 1: Location of the Blydeberg Conservancy within the Northern Province of South Africa.

The topography of the area is mountainous in the south to flat and open in the north. Several small mountain streams make their way from a watershed in the Drakensberg Mountains constituting the southern boundary of the conservancy, down into the Blyde River to the north of the conservancy. Only a few of these streams provide water throughout the year, mostly in the form of rock pools relatively high up in their catchments and close to their source.

The average annual rainfall for the study area, as measured by a weather station situated on the Jongmanspruit farm for the period 05/1999 to 04/2004 was 561 mm, with a high of 953 mm and a low of 255 mm recorded in 2000 and 2002 respectively. For the period 05/1999 to 04/2004, average monthly rainfall varied from 0.7 mm during the dry winter season (May to October) to 106 mm in the wet summer season (November to April) (Figure 2).

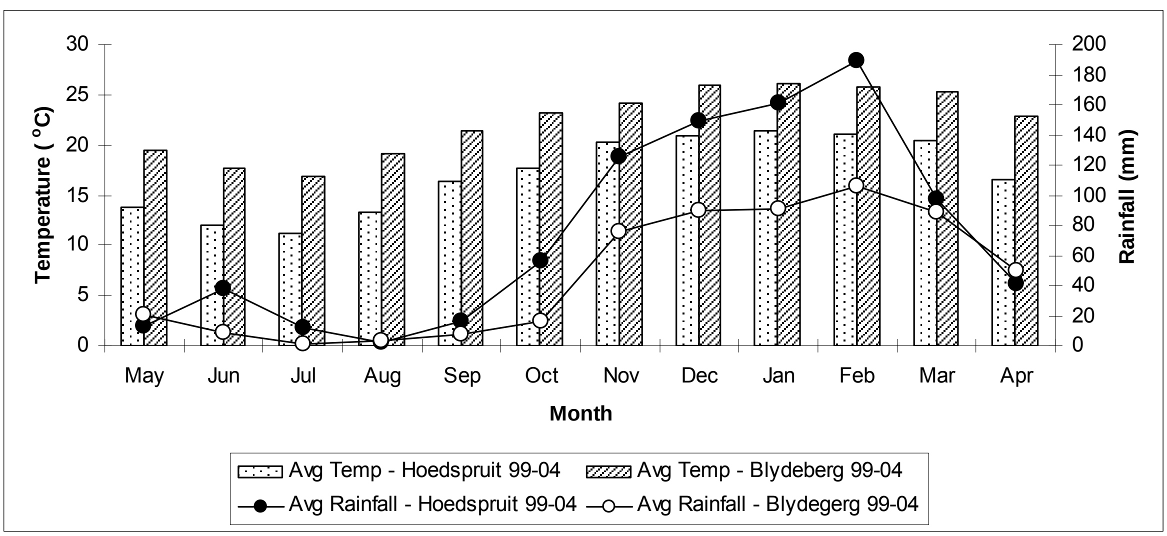


Figure 2: Rainfall and temperature summary for the study period.

For the larger Hoedspruit region, average annual rainfall for the period 05/1999 to 04/2004 was 900 mm with a high of 1463 mm and a low of 629 mm recorded in 2000 and 2002 respectively.

For the period 05/1999 to 04/2004, average monthly rainfall varied from 2 mm during the dry winter season (May to October) to 189 mm in the wet summer season (November to April) (Figure 2).

Rainfall recorded for the study area is less than for the larger Hoedspruit region due to the study areas location on the foothills of the Drakensberg Mountains along the great escarpment. The mountains form a barrier leading to a rain shadow which could be responsible for less rain in the study area; however, the mountains do function as an important catchment for the study area and are the source of several small mountain streams (Van Zyl, 2003). Locally thunderstorms and fog are the main sources of precipitation.

Average annual temperature for the study area for the period 05/1999 to 04/2004 was 22 ^{o}C, with mean temperatures varying from 17 ^{o}C during the dry winter season to 26 ^{o}C in the wet summer season (Figure 2). A minimum temperature of 3 ^{o}C and a maximum of 42 ^{o}C were recorded in the 05/2003 to 04/2004 period.

Average annual temperature for the larger Hoedspruit region for the period 05/1999 to 04/2004 was 17 ^{o}C, with mean temperatures varying from 11 ^{o}C during the dry winter season to 23 ^{o}C in the wet summer season (Figure 2). A minimum temperature of 11 ^{o}C and a maximum of 23 ^{o}C were recorded in the 05/2003 to 04/2004 period.

Temperatures for the study area are higher than those for the larger Hoedspruit region due to the study area lying along the north facing foot slopes of the Drakensberg Mountains along the great escarpment. The study area has more direct exposure to sunlight and is more sheltered from southerly winds than the surrounding areas (Tyson & Preston-Whyte, 2000).

Data collection.

The troop was followed on foot from a distance of 5-15 m for as long as possible on each day of data collection. Data were collected over an average of eleven days a month for a twelve-month period, resulting in 132 days of data, 30 of which were from dawn to dusk, the rest being dependent on when and how long the troop was located for. Data were recorded using a PALM HANDSPRING™ data-logger, pre-loaded with PENDRAGON FORMS™ software. Scan samples were taken approximately every thirty minutes from all visible animals (Altmann, 1974). Five mutually exclusive categories of activity were recognized: foraging (feeding, actively searching for or processing food), socializing (playing, aggression, grooming, maternal/paternal, mating), moving, resting and drinking. Troop members were categorised into various age and sex classes i.e. Adult Male, Adult Female, Sub-adult, Juvenile and Neonate.

A total of 4504 individual scans were collected of which 2243 were of adult animals. Only adult activity budgets are considered in the analyses that follow.

Statistical analysis.

SPSS™ (version 11.5.0) was used for all statistical analyses. All tests were two-tailed with alpha set at 0.05.

Results

<u>Overall activity budget and seasonal comparisons.</u>

The allocations by adult subjects to the five activity categories over the entire study period are provided in Figure 3.

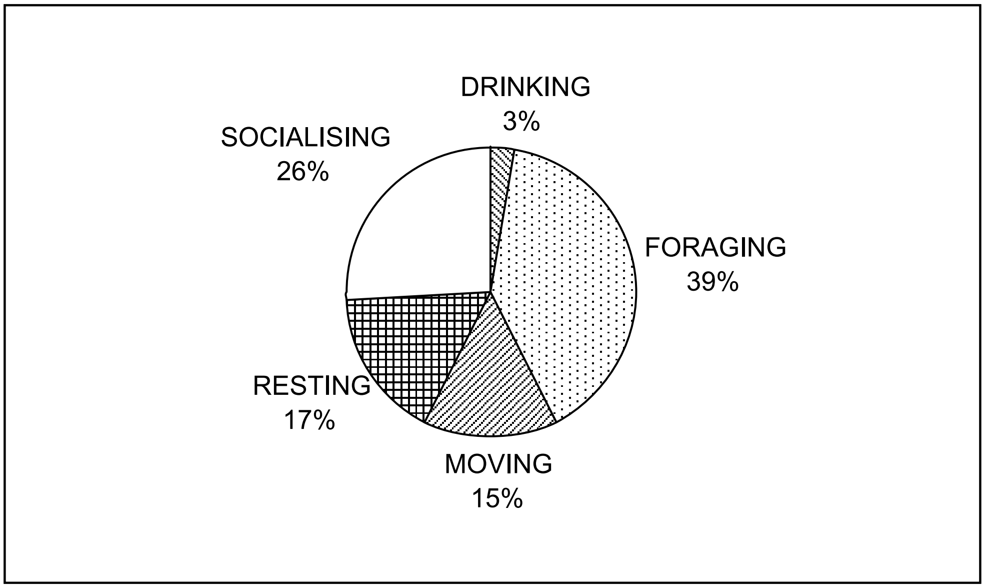


Figure 3: Percentage of total time allocated to various activities.

Seasonal comparisons reveal no differences in the allocation of time to the different activities (Chi-sq = 8.49, 4 df, $P<0.05$).

Figure 4 shows the percentage of time allocated to different activities for both wet and dry seasons.

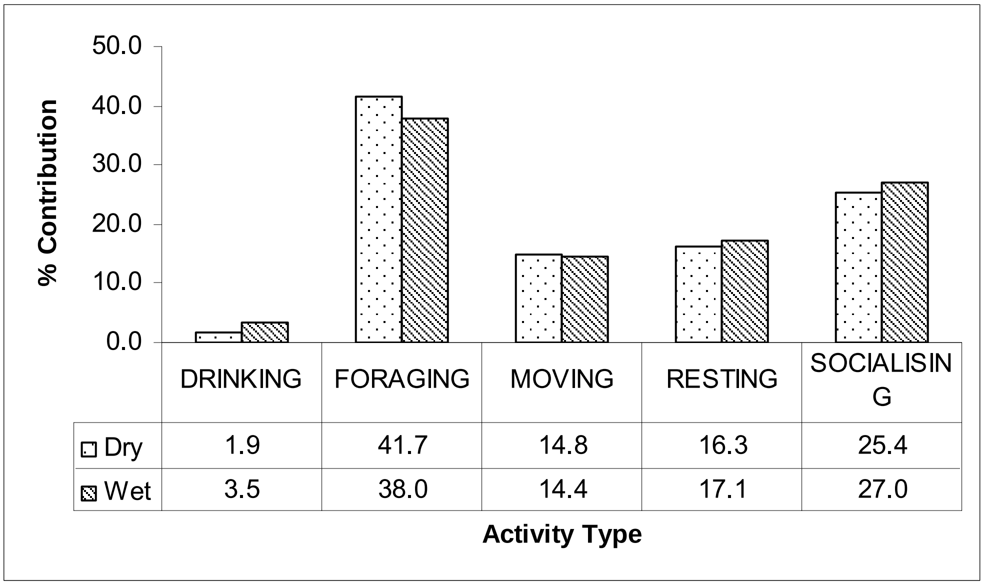
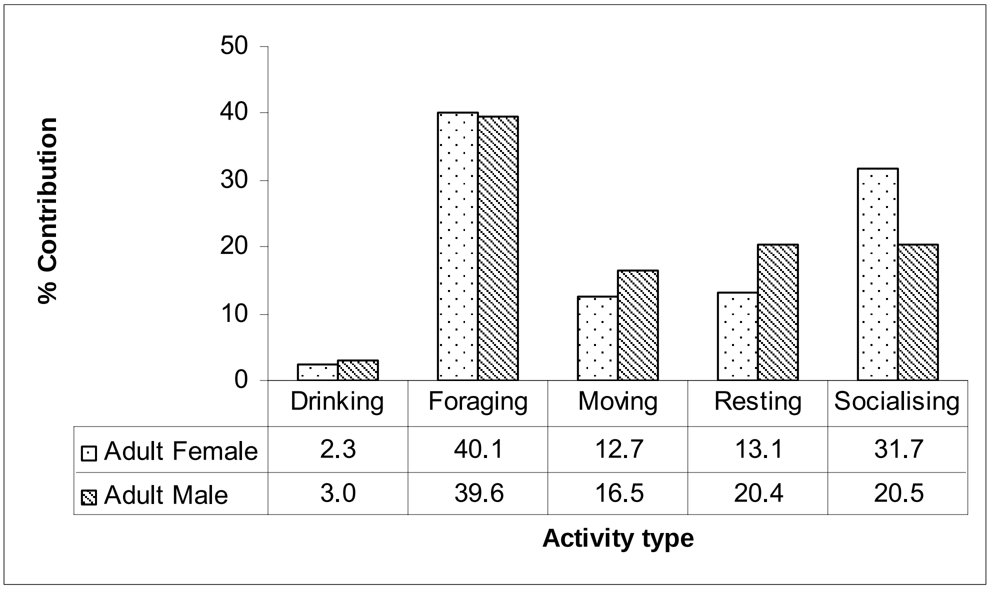


Figure 4: Seasonal activity breakdown.

Overall comparison of male and female activity budgets.

Male to female comparisons reveal that there were differences in the allocation of time to the different activities (Chi-sq = 51.10, 4 df, P>0.05).

Time allocated to different activities by adult females and males over the entire study period are provided in Figure 5.



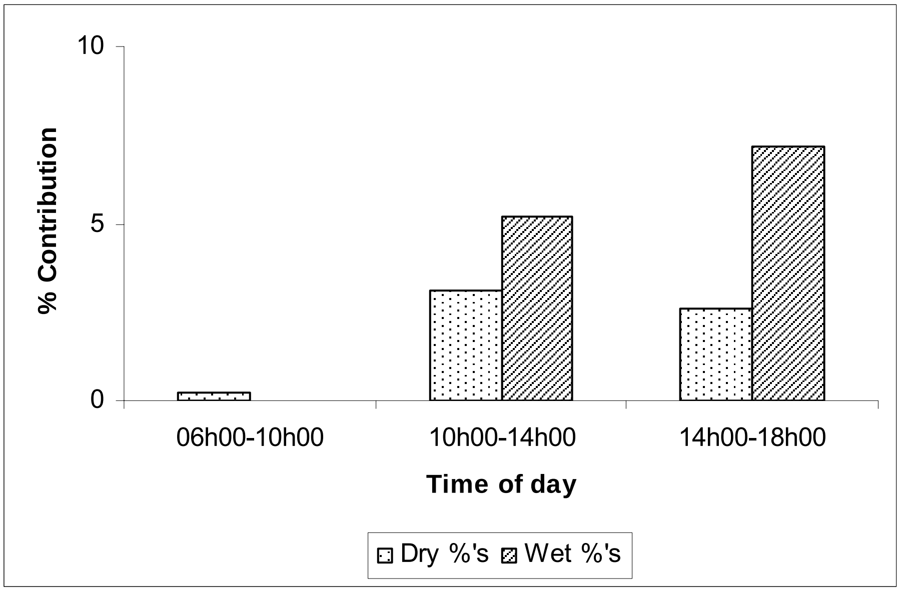
	Drinking	Foraging	Moving	Resting	Socialising
Adult Female	2.3	40.1	12.7	13.1	31.7
Adult Male	3.0	39.6	16.5	20.4	20.5

Figure 5: Activity breakdown by sex.

<u>Diurnal activity budget comparisons by season.</u>

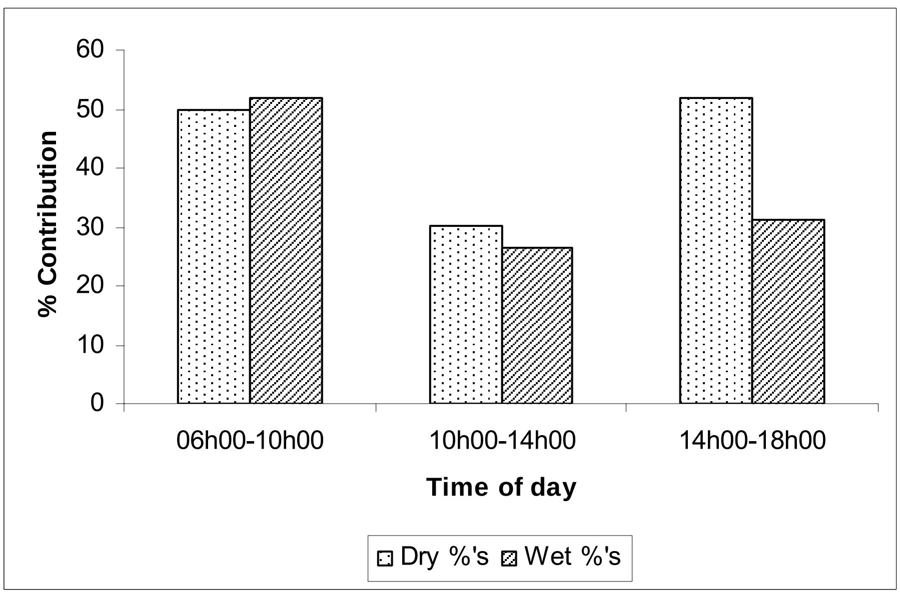
Diurnal activity comparisons by season show that there were differences in diurnal allocation of activities across seasons (Chi-sq = 14.95, 2 df, P>0.05).

Diurnal activity pattern comparisons across seasons are depicted in Figure 6.



10
5
0
% Contribution
06h00-10h00
10h00-14h00
14h00-18h00
Time of day
Dry %'s
Wet %'s

a)



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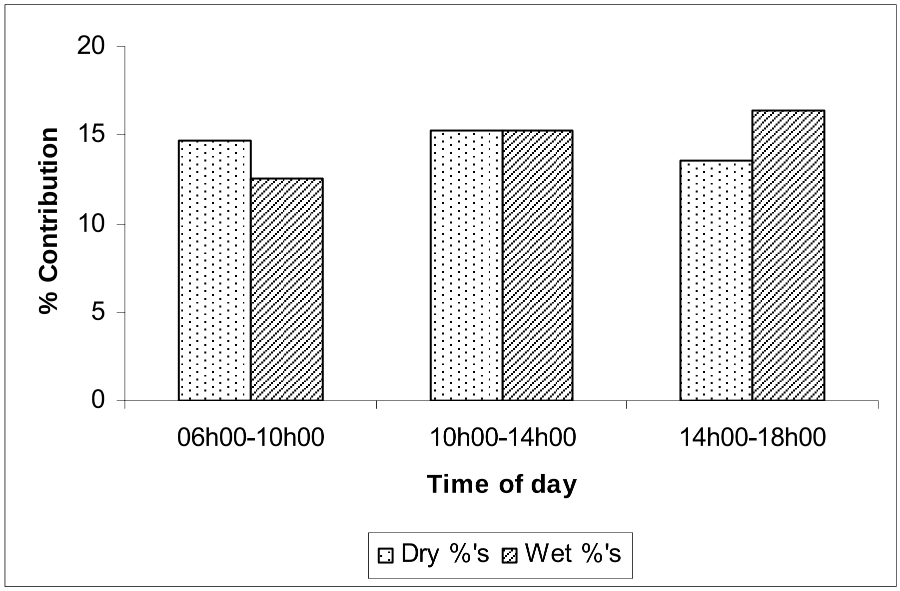
Time of day
Dry %'s
Wet %'s

b)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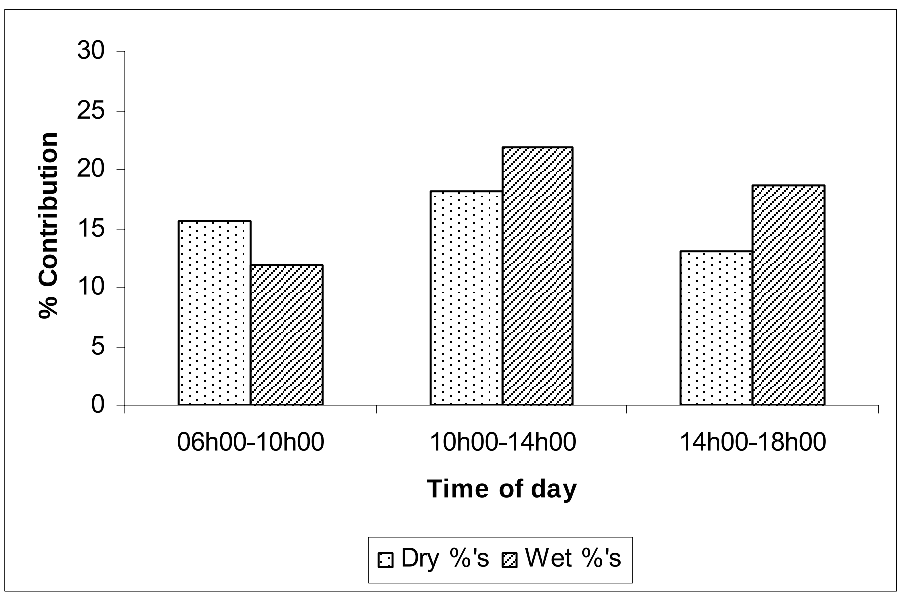
c)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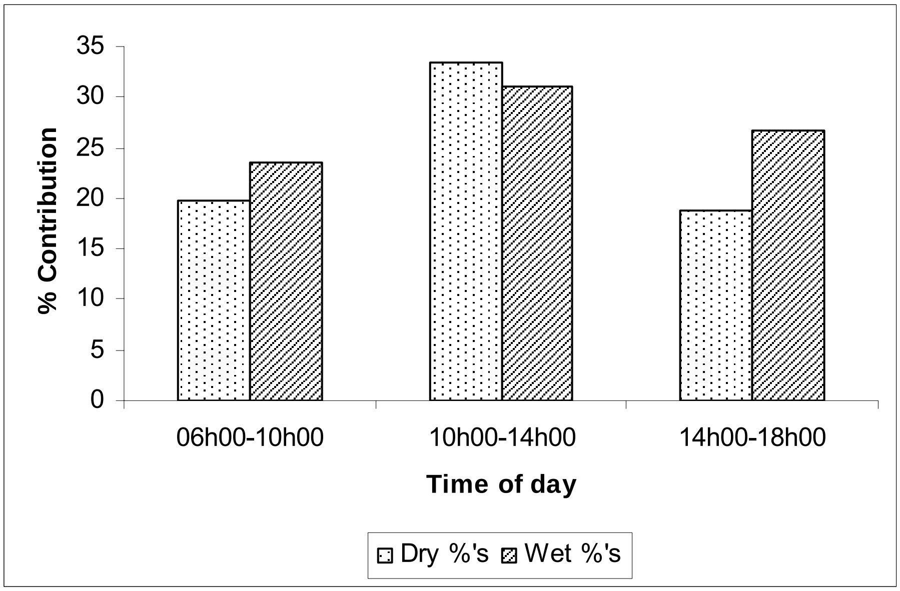
Wet %'s

d)



e)

Figure 6: Diurnal comparison of a) drinking across seasons, b) foraging across seasons, c) movement across seasons, d) resting across seasons, and e) socializing across seasons..

Discussion

Vervet monkeys are markedly active animals, spending large amounts of time foraging, travelling or socialising throughout the day, regardless of season (Chapman, 1985; Harrison, 1985; Adeyemo, 1997; Dunbar & Barrett, 2000). Thermoregulatory mechanisms have a strong influence on a number of primate activities, particularly during the colder winter months when day length is shorter and temperatures are lower (Chapman, 1985; Lawes & Piper, 1992; Poulsen *et al.*, 2001; Hill *et al.*, 2003). Seasonal variations in day length may limit vervet activity patterns, reducing the amount of time available to procure sufficient food during an already stressful dry winter season. At such times climatic conditions place additional metabolic demands on species in order for them to survive. More time and energy is required for foraging in order to maintain homeostasis. Energy requirements increase during a time when resources are already constrained, making daily existence in harsh environments all the more difficult.

Daily activity patterns of most primates are dependent on habitat type, availability of food resources, water accessibility and seasonality (Adeyemo, 1997). Numerous field studies have shown that activity budgets vary in response to changes in a number of environmental factors, including distribution and abundance of food sources (Milton, 1980; Rylands, 1982; Oates, 1987; Peres, 1993). In some instances when there is an increase in food abundance, more time is allocated to moving and foraging (Smith, 1977; Milton, 1980). This is presumably to obtain better quality food from a now larger variety of available resources. According to Dawson (1979), vervets need to drink and rest for set periods of time during the day in order to maintain a normal metabolic equilibrium. For vervets to survive within their often harsh environments, it is crucial that food eaten is assimilated into their bodies as optimally as possible to produce energy for basic body functions.

Due to the diverse nature of their diets, vervets need to drink and rest to assist in the breakdown of often complex food items for incorporation into body tissues for the maintenance of basal metabolic rates and ongoing existence. Also, with vervets being social animals they need to spend time together as a group reinforcing social bonds - resting time permits for this.

Food availability influenced the overall daily activity patterns of the study troop during both the wet and the dry season. Ranging patterns appeared to be influenced by seasonal resource acquisition which is common for primates inhabiting temperate sub-tropical areas (Bercovitch, 1983; Chapman, 1985; Harrison, 1985; Lawes & Piper, 1992; Swart & Lawes, 1996; Baldellou & Adan, 1997; Hill *et al*., 2003) and most tropical forests that exhibit distinct dry and wet seasons (Terborgh, 1986; Remis, 1997; Tutin *et al.,* 1997; Passamani, 1998; Hanya, 2004; Raboy & Dietz, 2004).

Activity patterns for the study group depicted as total observations for the study period showed that the largest portion of the vervets daytime activities were allocated to foraging (39 %), followed by socialising (26 %), resting (17 %), moving (15 %), and drinking (3 %) (Figure 3).

Seasonal comparisons of overall vervet activity patterns at Blydeberg reveal no significant differences in the allocation of time to the various activities monitored. Seasonal activity patterns are expected to vary according to the availability in time and space of the resources in an area (Clutton-Brock & Harvey, 1977; Mitani & Rodman, 1979; Rylands, 1982; Chapman, 1985; Oates, 1987; Remis, 1997; Tutin *et al*., 1997). At Blydeberg the study troop's home range contained a permanent water source and a large variety of different food species that contributed to their not having to move as much as would be expected, compared to vervets living in areas with more limited resources.

The effects of seasonality at Blydeberg were not as pronounced due to the general habitat structure providing for all the vervets nutritional needs.

Percentage contributions of each activity type to the dry and wet seasons are depicted in Figure 4. The study troop spent more time foraging during the dry season than during the wet season, this could be related to nutritive quality of certain food resources dropping during the dry season forcing them to consume more to meet their daily energy requirements. They spent more time socialising during the wet season, possibly related to resource availability with more and a larger variety of resources being more freely available, and being less distributed during the wet season compared to the dry season. This made resource acquisition easier and freed up more time for activities like socialising.

More time was spent resting during the wet season than during the dry season, this could also be attributable to resources being more readily available, not requiring them to travel longer distances to meet their daily metabolic requirements. Slightly more time was spent moving during the dry season than during the wet season - due to food resources not being as freely available during the dry season and being more distributed i.e. a lesser variety of resources was available compared to the wet season when more plants were available to forage on. Dry season resources were further apart compared to the wet season when several resources in relatively close proximity provided food. Fewer insects and other alternative resources were available during the dry season and reductions in resources led to the vervets travelling slightly further a field in order to meet their daily dietary requirements. More time was spent drinking during the wet season than during the dry season, probably due to water being more freely available throughout their home range, particularly after rain.

Comparisons of male and female activity patterns for the study period indicate that there were significant differences in time allocated to various activities. Males moved, rested and drank more than females (Figure 5). Females foraged and socialised more than males (Figure 5). It was expected that males would forage more than females due to the relative size difference between the sexes, but such was not the case and foraging time was similar. This could be due to the high quality of foods being eaten which is linked to a larger variety of edible species occurring within the study troops' home range.

Diurnal activity pattern comparisons across seasons show that there were marked activity differences for diurnal breakdowns. Seasonal comparisons of daily activities for the three time periods 06h00-10h00, 10h00-14h00, and 14h00-18h00 are depicted in Figure 6. According to Figure 6 the study troop drank more during the wet season. Drinking took place mostly during midday and the late afternoon. When more surface water was available during the wet season the vervets took advantage of such. Foraging increased during the dry season, especially in the afternoons. A general drop in the nutritive quality of food resources during the dry season could be the reason for increased foraging. The study troop travelled more in the mornings during the dry season, and more in the afternoons during the wet season. Dry season morning movements were to locate food. Resting and socializing occurred more frequently during the wet season, with socializing taking place more frequently in the early mornings and late afternoons. With more food being available and daily energy requirements being met faster during times of greater food abundance, additional time became available during the wet season for resting and socializing.

The overall percentage of time allocated to various activities has been tabulated for comparison with similar activity related studies on vervets (Table 1).

Table 1: Percentage of time allocated to various activities for different vervet activity related studies.

Percentage of time allocated to various activities						
Study location	**Foraging**	**Resting**	**Moving**	**Socialising**	**Drinking**	**References**
Blydeberg - South Africa	39	17	15	26	3	Current study (2005)
Windy Ridge - South Africa	35	38	19	8	n/a	Baldellou & Adan (1997)
Entebbe - Uganda	24	44	14	11	n/a	Saj *et al*. (1999)
Amboseli - Kenya	20	43	16	20	n/a	Brennan *et al*. (1985)
Amboseli - Kenya	40	32	25	5	n/a	Lee (1981)
Old Oyo National Park - Nigeria	32	10	30	8	20	Adeyemo (1996)

According to Table 1, the Blydeberg results are most consistent with results from the study undertaken in Amboseli Kenya (Brennan *et al.*, 1985), with the exception of resting which was much higher for the Amboseli study, possibly due to the Amboseli troop being accustomed to food handouts and food raiding behaviour. Marked foraging differences for some comparisons could be due to habitat structure and an accompanying increased variety of food resources being available to select from at Blydeberg. The overall seasonal tendency for each activity was for the most part in line with other studies on primates in general (Bercovitch, 1983; Harrison, 1985; Lawes & Piper, 1992; Defler, 1995; Adeyemo, 1997; Baldellou & Adan, 1997; Passamani, 1998; Hill *et al*., 2003; Hanya, 2004).

Other influences to the study troop's daily activity patterns were the proximity of adjacent vervet troops and the movements of a baboon troop (*Papio hamadryas ursinus*) that shared portions of the study troop's home range with them.

Other studies also report sympatric relationships between vervets and other primate species (Nagel, 1973; Dunbar & Dunbar, 1974; Zinner *et al*., 2002). When neighbouring vervet troops were encountered, the study troop spent much of their time vocalising, observing and sometimes even displaying antagonistic behaviour towards members of the other troop. Their reactions to the baboons was either to move off into the surrounding vegetation and to wait patiently for the baboons to leave, or to leave the area moving off in an alternative direction to that of the baboons – no direct encounters with baboons were observed during the study period.

At the onset of this study it was expected that seasonality would significantly impact vervet activity patterns at Blydeberg. Such was not the case and no clear cut significant seasonal differences to the study troops overall activity patterns were observed. The lack of significant seasonal activity variations could partly be attributed to the study area within Blydeberg providing an almost sheltered habitat for the study troop, with all their needs being provided for in a relatively stable and mostly constant environment. The study troop's home range consisted of a sheltered kloof with a permanent water source and gallery forest containing several tree species that provided food throughout the year. Adjacent habitats that do not have permanent water sources and protected kloofs should show more severe seasonal impacts, and comparative research in such areas could be undertaken to substantiate that the study troops habitat is superior and less prone to seasonal fluctuations. In areas where food is patchy, scarce or clumped, primate groups have been recorded to travel farther a field and to feed for longer periods of time (Chapman, 1988; Overdorff, 1996). Many cercopithecines are able to change their diets to include 'fall back' foods when preferred high quality foods become seasonally scarce (Clutton-Brock & Harvey, 1977; Mitani & Rodman, 1979; Oates, 1987; Nakagawa, 1989; Strier, 1999). Availability of surface water is a key factor in determining primate ranging patterns and has an impact on vervet activity patterns (Barton *et al*., 1992; Hill *et al*., 2003).

What this study revealed, was that if vervets live in an area of increased relative food abundance such as Blydeberg, that the impacts of seasonality are buffered and seasonal variations to activity budgets are less prominent. By living in an environment containing a large variety of food resources to choose from, enables the study troop to selectively choose food items with a high nutritive value which in turn impacts on their daily metabolic needs and related activity patterns. This leads to the study troops' activity patterns not adhering to the norms of vervets living in habitats that are restricted in terms of food abundance and variability. Variations in activity patterns across seasons should be more apparent in areas where the environment is harsher. It is envisaged that when conditions at Blydeberg become more extreme, that the study troop will react accordingly by adjusting their behaviour to ensure their survival.

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CHAPTER 8

GENERAL DISCUSSION AND CONSERVATION ISSUES

Each respective data chapter (chapters 5, 6 and 7) has its own discussion which should be examined with this section in order to provide a more comprehensive view of the specific chapters' findings without having to repeat what has already been stated. Various statistical analyses were performed on sampled data, the results of which are also presented in the respective data chapters. Following is a summary of the main data chapters with an overview of results obtained. Damage caused by vervets and measures of reducing such are commented on.

Chapter 5, the vegetation analysis of the study area provided an insight into the areas phytosociology, with the subsequently generated vegetation map forming the basis of the study and providing a starting point for any subsequent studies. An understanding of the various plant communities with their associated habitats is fundamentally important for creating sound management and conservation strategies, providing a base dataset for the study area.

Seasonal habitat utilisation and food selection analysis (chapter 6), indicated that the study troop do not uniformly utilise their home range, rather, it appears as though they tend to concentrate on areas of abundant food supply and move through adjacent areas to get to resources. They forage mostly on a number of staple food items, with a relatively wide seasonal variation for additional supplementation. There is a seasonal preference for various plant communities based mainly on resource availability in such communities. A map of the study troops seasonal ranges, as well as an overall home range map was created. Dietary preferences for both the wet and dry seasons was determined and compared, revealing forage species availability and selection by the study troop.

Cumulative plant species contributions to the study troops diet was determined and presented graphically and in tabular format. Electivity indices were generated for the main plant species consumed and for plant communities utilised. Electivity indices revealed that the vervets do have specific preferences for certain species and communities based on seasonal availability.

An examination of the study troop's activity patterns was undertaken to probe the consequences of increased seasonality associated with higher latitudes (chapter 7). The specific aims of chapter 7 were to compare vervet activity patterns across seasons at Blydeberg, with emphasis on seasonal differences in diurnal activity allocation, overall male and female activity pattern differences, and male to female seasonal activity pattern differences. Findings reveal that food availability influenced the overall daily activity patterns of the study troop during both the wet and the dry season. Seasonal comparisons of overall vervet activity patterns showed no significant differences in the allocation of time to the various activities monitored. Overall and seasonal comparisons of male and female activity patterns exhibit no marked differences in time allocated to the various activities for the study period. Activity breakdown for adult female and adult male vervets showed that females foraged and socialised more than males. Males rested, drank and moved more than females. Diurnal activity allocation comparisons across seasons revealed significant seasonal differences for diurnal breakdowns.

Plant communities identified and described in this study form part of the study area containing the study troop's home range, providing detailed data on various plant species as well as habitats occurring within their home range. This information combined with the study troops utilisation thereof is valuable for future planning. Without the classification and delineation of the different plant communities, food availability and utilisation in such communities by the vervets could not have been determined.

Having determined what was available to the study troop in terms of resources, the next logical step was to determine their utilisation thereof and then finally to determine the impacts that seasonal variations in their habitat would have on their overall and diurnal activity patterns. With regards to habitat utilisation, the vervets had ten plant communities, sub-communities and variants available to them within their home range. Of the ten available plant communities, sub-communities and variants, they utilized only six during the study period i.e. sub-community 2.2 (*Combretum imberbe-Acacia nigrescens* Woodland), community 3 (*Acacia nigrescens-Combretum apiculatum* Woodland), sub-community 4.1 (*Balanites maughamii-Panicum maximum* Woodland), sub-community 4.2 (*Sclerocarya birrea-Panicum maximum* Woodland), sub-community 4.3 (*Combretum zeyheri-Panicum maximum* Woodland), and variant 4.4.1 (*Pappea capensis* Variant)(Barrett, 2005). Of the six plant communities, sub-communities and variants utilized, sub-community 4.2 was used the most during both the wet and the dry season. Community 3 and variant 4.4.1 were only used during the dry season, whereas, the other communities, sub-communities and variants were randomly utilized across both seasons. As mentioned previously, no overall seasonal differences to activity patterns for the study troop were observed. This indicated that their habitat and the utilisation thereof was efficient compared to other sites where seasonal changes in habitat structure and resource availability led to changes in activity patterns.

The impacts of seasonality were not as prominent as predicted, based on previous studies on vervet avtivity patterns and the impacts that seasonality had on such. What became apparent through the current study, was that relative food abundance and availabiliy had an impact on vervet activity patterns.

With Blydeberg affording a habitat for the study troop that provided a large variety and abundance of food resources regardless of season, the study troops' seasonal activity comparisons revealed activity patterns not adhering to the norms for vervets living in habitats that are restricted in terms of food abundance and variability. It is expected that variations in activity patterns across seasons should be more apparent in areas where the environment is harsher.

From the current study it is evident that vervets are very successful at exploiting temperate sub-tropical habitats, having adapted well to the impacts of alternative wet and dry seasons by adjusting their behaviour accordingly. Vervets have very flexible ecological requirements and their overall range, with the exception of more arid areas, appears to be suitable to their continued existence.

There are no formal management plans for vervet monkeys, this is most probably attributed to the limited knowledge available on vervets and their habitat utilisation. It is vital to understand that no animal is actually a problem, they become problems when man encroaches on their natural environments or when man interferes with the normal running of events.

In agricultural and farming areas, one of the most common complaints is that vervet monkeys destroy crops, however on closer inspection, it has been found that:

- Crops like the Avocado, Mango and Banana are usually picked when they are still very green and vervets seldom if ever eat off these crops when they are in that stage. When these crops have been eaten by vervets it is either because they have ripened early on the tree, have been stung by some insect or when they have a burn spot. In all of the aforementioned instances the fruit is useless to the farmer anyway.

- Within orchards there are also abundant insects, spiders, lizards, fungus and various insect larvae and eggs which vervets consume. While more than often assisting the farmer to control these other potential problems, the vervet is wrongly accused of damaging crops.
- Crops such as Litchi, Macadamia and most vegetable crops stand the highest risk of vervet damage, but vervets prefer a diverse diet and do not concentrate excessively on such.

On small holdings control measures may have to be taken to curb vervet activities. The following can be done to minimize damage:

- Make sure lands are clean of all waste.
- Discard waste or unsaleable crop at the edge of a property where the vervet monkeys enter.

If there are claims that damage caused by vervets is great, it would be worthwhile investing in someone to patrol the area, or to install an electrified fence. Electric fencing is quickly becoming an inexpensive and permanent trouble free solution if erected properly.

Vervet monkeys do not eat the skins of commercial crops and one will always find bite size pieces of skins, husks, shells and pips under their feeding sites. This should aid in finding the true culprits before putting the blame on the more visible and active vervets.

Other animals that exacerbate the problem and cause damage in areas where vervets occur include:

- Fruit bats.
- Bush babies.
- Some antelope species.
- Porcupine.

- Rabbits and hares.
- Birds.

Many of the aforementioned animals come out only at night and are thus very seldom seen causing damage.

Vervets are usually seen after the damage has occurred as they are diurnal, and being inquisitive and opportunistic will investigate any food they find, even if it is the left overs from a previous nights foraging by another animal. Before putting the blame on vervets, it is essential that one determines that damage caused is actually their doing. Also, it is worth taking the advantages of having vervets around into consideration - they control several pest insect species numbers, they pollinate certain plant species, they assist in feeding other animals through their methods of feeding, they 'prune' dead wood and old growth and they are propagation mechanisms for some plants through the distribution of seeds by means of their droppings and feeding methods.

Problems in areas where vervets and man live in close proximity to one another are aggravated by people feeding the monkeys. This is very difficult to control and once a vervet has learnt to get free food, it is hard to teach them differently. Being quick learners they are fast to pick up where humans are getting the food from, leading to the raiding of tents, bungalows and caravans in order to obtain a quick meal when no one is around. When this stage has been reached the only solution is electrification of perimeter fencing – this does however come at a cost (both initial and ongoing in the form of maintenance). Other alternatives could be the setting up of feeding areas away from human recreational and dwelling areas. This does not appear to be a viable solution as the vervets become reliant on humans for their food and lose their ability to forage successfully over the long term. Sign boards stressing that people must not feed the monkeys should be displayed.

Boards should state that all windows and doors must be closed before leaving and that food should not be left out or put into easily accessible places like open or non-monkey proofed dustbins. If people adhere to this, over time the monkeys will look elsewhere for food and will not be seen as pests.

The basis of a successful vervet management strategy would thus incorporate the aforementioned. An educational initiative with good public relations would further assist in informing guests to wildlife areas as to how their actions affect the vervets. Education would help people become aware of and appreciate the value of vervets in their natural surroundings and the part they play in the ecosystems they form a part of. Guests could be made aware of any threats to the well being of vervets and could be involved in the management process, empowering them through participation to become custodians of not just the vervets but the entire area and all its inhabitants, to the benefit of all. A public relations initiative geared towards informing farmers and land owners that have vervets living on their properties as to the benefits of vervets, would go a long way towards creating an understanding and a more tolerable attitude towards vervets in general. In protected areas management plans should be in place for the overall protection of habitats, ecological processes, and living resources. Such plans should be 'living' documents that are constantly changing and being updated or improved upon to keep up with ever changing objectives and attitudes. Where such management plans are not in place it is crucial to determine the objectives of the area and to setup management plans for the successful long term prosperity of such an area.

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APPENDIX 1

Plants prefixed with an asterisk are species recorded at the study site. Plants not prefixed with an asterisk are found on the greater Blydeberg Conservancy and could be present in the study area, but were not encountered and recorded during the study.

ACANTHACEAE

Barleria elegans
B. gueinzii
B. maderaspatensis ssp. Rubiifolia
B. saxatilis
Blepharis maderaspatensis ssp. Maderaspatensis var. maderaspatensis
Dyschoriste rogersii
Ecbolium revolutum
Hypoestes forskaolii
Hypoestes sp. Aff H. forskaolii
Isoglossa grantii
I. stipitata
Isoglossa sp.
Justicia flava
J. petiolaris spp. Petiolarus
J. protracta ssp. Rhodesiana
Monechma cleomoides
Phaulopsis longifolia
Ruellia cordata
R. otaviensis
R. patula

ANACARDIACEAE

* *Lannea discolor*

* *Ozoroa paniculosa*

* *O. sphaerocarpa*

* *Rhus dentata*

* *R. lancea*

* *R. leptodictya*

* *R. tumulicola*

* *Sclerocarya birrea*

APIACEAE

* *Steganotaenia araliacea*

APOCYNACEAE

* *Acokanthera oppositifolia*

* *Carrissa bispinosa*

* *C. edulis*

Diplorhynchus condylocarpon

* *Rauvolfia caffra*

* *Strophanthus gerrardii*

* *S. speciousus*

ARACEAE

Stylochiton natalense

ARALIACEAE

* *Cussonia spicata*

ASCLEPIADACEAE

Ceropegia ampliata

Cordylogyne globosa

Pachycarpus concolor

Pergularia daemia var. daemia

Sarcostemma viminale

Secamone parvifolia

ASTERACEAE

Arctotis venusta

* *Bidens pilosa **

Conyza attenuata

Eclipta prostrata

Gerbera jamesonii

Laggera crispata

Mikania capensis

* *Vernonia adoensis*

V. neocorymbosa

* *Tagetes minuta **

* *Xanthium spinosum*

BALANITACEAE

* *Balanites maughamii*

BALANOPHORACEAE

Sacrophyte sanguinea ssp. Sanguinea

BIGNONIACEAE

* *Markhamia zanzibarica*

* *Rhigozum obovatum*

* *Tecoma capensis*

BOMBACACEAE

* *Adansonia digitata*

BORAGINACEAE

Cordia ovalis

* *Ehretia amoena*
* *E. rigida*

Heliotropium steudneri

BURSERACEAE

* *Commiphora africana*
* *C. harveyi*
* *C. glandulosa*
* *C. mollis*

CACTACEAE

* *Opuntia ficus-indica* *

CAESALPINIACEAE

Bauhinia tomentosa

Chamaecrista absus

Chamaecrista plumosa var. erecta

* *Peltophorum africanum*
* *Piliostigma thonningii*
* *Schotia brachypetala*

Senna occidentalis *

CANELLACEAE

Warburgia salutaris

CAPPARACEAE

* *Boscia albitrunca*

Capparis fascicularis

* *C. tormentosa*

Cleome gynandra

C. monophylla

* *Maerua angolensis*

M. edulis

M. juncea ssp. crustata

M. parvifolia

CELASTRACEAE

Cassine aethiopica

Catha edulis

Hippocratea africana var. richardiana

* *H. crenata*

H. longipetiolata

Gymnosporia senegalensis

* *G. glaucophylla*

Putterlickia pyracantha

CHENOPODIACEAE

Chenopodium ambrosiodes

C. carinatum

CLUSIACEAE

* *Garcinia livingstonei*

COMBRETACEAE

* *Combretum apiculatum ssp. apiculatum*

C. collinum ssp. Suluense

* *C. erythrophyllum*

* *C.hereroense*

* *C. imberbe*

* *C. molle*

* *C. zeyheri*

* *Terminalia phanerophlebia*

* *T. sericea*

COMMELINACEAE

Commelina erecta

CONVOLVULACEAE

Ipomoea albivenia

I. magnusiana

I. simplex

Merremia tridentata ssp. Angustifolia var. angustifolia

CRASSULACEAE

Crassula setulosa var. jenkinsii

CUCURBITACEAE

Corallocarpus bainessii

Trochomeria macrocarpa ssp. macrocarpa

DRACAENACEAE

* *Sansevieria hyacinthoides*

EBENACEAE

* *Diospyros mespiliformes*

D. villosa var. parvifolia

* *Euclea crispa ssp. Crispa*

* *E. divinorum*

E. natalensis ssp. angustifolia

* *E. undulata*

EQISETACEA

Equisetum ramosissimum

EUPHORBIACEAE

Acalypha petiolarus

A. villicaulis

* *Bridelia mollis*

Chamaesyce neopolycnemoides

Dalenchampia galpinii

* *Flueggea virosa*

Margaritaria discoidea ssp. Dicoidea

Phyllanthus burchellii

P. incurvus

P. reticulatus

* *Pseudolachnostylis maprouneifolia*

Securinega virosa

* *Spirostachys africana*

Tragia glabrata var. glabrata

T. durbanensis

FABACEAE

Abrus precatorius

* *Argyrolobium velutinum*

* *Bolusanthus speciosus*

Calpurnea aurea ssp. aurea

C. distans

C. doidgeae

C. monteiroi var. galpinii

Crotolaria capensis

* *Dalbergia armata*

* *D. melanoxylon*

Eriosema psoralioides

* *Erythrina lysistemon*

* *Indigofera arrecta*

I. hedyantha

I. swaziensis var. swaziensis

Lotononis carinata

* *Mundulea sericea*

Pearsonia cajanifolia ssp. cajanifolia

* *Philenoptera violacea*

Rhynchosia hirta

Sesbania sesban ssp. Sesban var. sesban

Strylosanthes fruiticosa

Tephrosia aequilata

T. purpurea ssp. Leptostachya

T. rhodesiaca var. rhodesiaca

Vigna nervosa

FLACOURTIACEAE

* *Dovyalis caffra*

* *D. zeyheri*

* *Scolopia zeyheri*

GERANIACEAE

Monsonia angustifolia

M. glauca

Pelargonium multicaule

* *Pelargonium sp.*

HETEROPYXIDACEAE

* *Heteropyxis natalensis*

HYPOXIDACEAE

* *Hypoxis hemerocallidea*

IRIDACEAE

Gladiolus crassifolius

Lapeirousia erythrantha

LABIATAE / LAMIACEAE

Aeollanthus parvifolius

Becium filamentosum

Becium sp. Nov. aff. B. knyanum

Endostemon tereticaulis

Hemizygia elliotii

H. petrensis

Leonotis ocymifolia

Leucas neuflizeana

Ocimum canum

O. urticifolium

Orthosiphon suffrutescens

Plectranthus hadiensis

Pycnostachys hadiensis

Tinnea rhodesiana

LILIACEAE

* *Aloe dyeri*

* *A. marlothii*

* *Asparagus cooperi*

* *A. setaceus*

* *A. virgatus*

Dipcadi viride

Eriospermum abyssinicum

Urginea sp.

LOBELIACEAE

* *Lobelia sp.*

LOGANIACEAE

* *Nuxia oppositifolia*

* *Strychnos cocculoides*

LORANTHACEAE

Pedistylis galpinii

Plicosephalus kalachariensis

Tieghemia bolusii

MALVACEACE

* *Gossypium herbaceum var. africanum*

Hibiscus calyphyllus

H. meyeri ssp. transvaalensis

* *Pavonia columella*

Sida alba

* *S. cordifolia*

MELIACEAE

* *Trichilia emetica*

Turraea nilotica

MENISPERMACEAE

Cissampelos mucronata

Cocculus hirsutus

MIMOSACEAE

* *Albizia forbesii*

A. harveyi

* *A. versicolor*

* *Acacia burkei*

* *A. caffra*

* *A. exuvialis*

* *A. galpinii*

* *A. karroo*

* *A. nigrescens*

* *A. nilotica ssp. Kraussiana*

* *A. schweinfurthii*

* *A. tortilis*

* *Dichrostachys cinerea*

MORACEAE

* *Ficus ingens*
* *F. stuhlmannii*
* *F. sur*
* *F. sycomorus*

MYRICACEAE

* *Morella pilulifera*
* *M. serrata*

MYRTACEAE

Syzygium cordatum

NYCTAGINACEAE

Boerhavia diffusa var. hirsuta

Commicarpus africanus

OCHNACEAE

Ochna inermis

OLACACEAE

Ximenia americana

* *X. caffra var. natalensis*

OLEACEAE

Jasminum fluminense

* *Olea europaea*

OPHIOGLOSSACEAE

Ophioglossum vulgatum

PASSIFLORACEAE

Adenia digitata

PERIPLOCACEAE

Raphionacme procumbens

PLUMBAGINACEAE

* *Plumbago zeylanica*

POACEAE

* *Anthephora pubescens*

* *Aristida congesta*

* *A. stipitata*

* *Brachiaria brizantha*

* *Chloris virgata*

* *Cymbopogon excavatus*

* *Digitaria eriantha*

* *Diheteropogon filifolius*

* *Elionurus muticus*

* *Eragrostis lehmanniana*

* *E. rigidior*

* *E. superba*

* *Eustachys paspaloides*

* *Heteropogon contortus*

* *Hyparrhenia hirta*

* *Imperata cylindrica*

* *Melinis repens*

* *Panicum maximum*

* *Pogonarthria squarrosa*

Sporobolus festivus

POLYGALACEAE

Polygala asbestina

P. sp. Aff. P. erioptera

P. sphenoptera

POLYGONACEAE

Persicaria serrulata

PORTULACACEAE

Talinum caffrum

PTAEROXYLACEAE

* *Ptaeroxylon obliquum*

RHAMNACEAE

* *Berchemia discolor*

* *B. zeyheri*

* *Helinis integrifolius*

* *Ziziphus mucronata*

ROSACEAE

* *Leucosidea sericea*

RUBIACEAE

Agathisanthemum bojeri var. bojeri

Anthospermum streyi

Breonadia salicina

* *Canthium ciliatum*

Catunaregam spinosa ssp. Spinosa

* *Gardenia volkensii*

* *Hypercanthus amoenus*
Kohautia caespitosa ssp. Brachyloba
Oxyanthus speciosus
Pachystigma pygmaeum
Pavetta catophylla
P. schumanniana
Pentodon pentandrus var. pentandrus
* *Plectroniella armata*
Psydrax livida
Pyrostria hystrix
Ticalysia lanceolata
Vangueria cyanescens
V. infausta

RUTACEAE
* *Toddaliopsis bremekampii*
* *Vepris reflexa*

SALICACEAE
Salix mucronata ssp. woodii
S. woodii

SANTALACEAE
Osyridocarpus schimperianus
Thesium deceptum
Thesium sp.

SAPINDACEAE
Cardiospermum halicacabum
* *Pappea capensis*

SAPOTACEAE

* *Englerophytum magalismontanum*
* *Mimusops zeyheri*
  Sideroxylon inerme

SCROPHULARIACEAE

  Alectra orobanchioides
  Aptosimum lineare
* *Halleria lucida*
  Striga bilabiara

SOLANACEAE

* *Solanum panduriforme*

STERCULIACEAE

* *Dombeya cymosa*
* *D. rotundifolia var. rotundifolia*
  Hermannia quartiniana
  H. tomentosa
  Melhania didyma
  M. forbesii
  M. prostata
* *Sterculia rogersii*
  Waltheria indica

STRELITZIACEAE

* *Strelitzia nicolai*

THUNBERGIACEAE

  Thunbergia amoena

THYMELAEACEAE

Gnidia capitata

G. robusta

TILIACEAE

Corchorus asplenifolius

* *C. kirkii*

C. tridens

* *Grewia flava*

* *G. flavescens*

* *G. hexamita*

* *G. monticola*

* *G. occidentalis*

TURNERACEAE

Tricliceras longipedunculatum

ULMACEAE

* *Celtis africana*

* *Chaetachme aristata*

UMBELLIFERAE / APIACEAE

Heteromorpha pubescens

Steganotaenia araliacea

URTICACEAE

* *Obetia tenax*

* *Pouzolzia mixta*

VAHLIACEAE

Vahlia capensis ssp. vulgaris

VERBENACEAE

Clerodendrum ternatum var. ternatum

Lantana rugosa

Lanata sp.

* *Vitex ferruginea subsp. amboniensis*

VIOLACEAE

Hybanthus enneaspermus

VISCACEAE

Viscum combreticola

VITACEAE

Cissus cornifolia