

**IMPALA (*AEPYCEROS MELAMPUS*) HABITAT UTILISATION AND ACTIVITY  
PATTERNS IN SOURISH MIXED BUSHVELD**

By

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# DECLARATION

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SOURISH MIXED BUSHVELD**

I, Boitumelo Florina Mongale, declare that the above dissertation is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the dissertation to originality checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other higher education institution.



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17 January 2023

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## DEDICATION

I dedicate this dissertation to my mother **Rose M Mongale** who has been my pillar of strength, supported me tirelessly and late grandmother **Marope M Mongale** who always believed in me and encouraged me to do better for myself and others.

His promises are Yes and Amen - To God be the Glory!

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## ABSTRACT

The habitat utilisation and daily activity patterns of Impala at Loskop Dam Nature (LDNR) Reserve were studied to provide an insight into the management of this species. We used the Braun-Blanquet and TWINSpan methods to classify plant communities within the Impala home range. Movement data was collected using a GPS collar fitted onto an Impala ram (*Aepyceros melampus*), and field data about the animal's home range and the behaviour of the breeding herd associated with him was collected through direct observations. Seasonal home ranges, habitat selection and utilisation, as well as seasonal daily activity patterns were determined. Vegetation maps were produced to illustrate available plant communities, and seasonal home range maps were created to show Impala movement patterns and home range sizes. Environmental variables considered in the analyses included rainfall, temperature, and photoperiod. The Impala home range comprised of a variety of plant communities and species forming various habitats that provided the necessary resources for the Impala to live and procreate. Impala utilised habitats with available quality and quantity of forage. The *Euclea crispa-Vachellia karroo* closed woodland plant community was preferred by the Impala in both the wet and dry seasons. This community is the primary habitat for the Impala at LDNR. All environmental variables investigated had an impact on the daily activity patterns of Impala. The majority of Impala the activity patterns were influenced by seasonality for all social group types. Given that time is a limited and valuable resource for wildlife species in general, time partitioning affected the Impala's daily activity patterns at the study site. Time partitioning resulted in reduced or compromised activities at the expense of priority activities like vigilance. Vigilance was higher in both the wet and dry seasons, and often led to reductions in feeding time.

**KEY WORDS:** Impala, plant community, habitat utilisation, activity patterns, home range, Braun-Blanquet, TWINSpan, GPS collar, Ivlev's Electivity Index, seasonality.

## TABLE OF CONTENTS

<b>DECLARATION</b> .....	<b>II</b>
<b>DEDICATION</b> .....	<b>III</b>
<b>ACKNOWLEDGEMENTS</b> .....	<b>IV</b>
<b>ABSTRACT</b> .....	<b>V</b>
<b>TABLE OF CONTENTS</b> .....	<b>VI</b>
<b>CHAPTER 1</b> .....	<b>1</b>
<b>INTRODUCTION</b> .....	<b>1</b>
1.1 INTRODUCTION .....	1
1.2 PROBLEM STATEMENT .....	5
1.3 STUDY OBJECTIVES .....	6
1.4 DISSERTATION LAYOUT .....	6
REFERENCES .....	8
<b>CHAPTER 2</b> .....	<b>11</b>
<b>LITERATURE REVIEW</b> .....	<b>11</b>
2.1 STUDY SPECIES .....	11
2.2 HABITAT UTILISATION AND HOME RANGE .....	12
2.3 ACTIVITY BUDGET .....	14
2.3.1 FOCAL AND SCANS .....	15
2.3.2 VIGILANCE BEHAVIOUR .....	16
2.3.3 FORAGING .....	18
REFERENCES .....	20
<b>CHAPTER 3</b> .....	<b>28</b>
<b>STUDY AREA AND METHODS</b> .....	<b>28</b>
3.1 STUDY AREA .....	28
3.1.1 LOCATION AND SIZE OF THE AREA .....	28
3.1.2 TOPOGRAPHY AND GEOLOGY .....	29
3.2 SOIL .....	31
3.3 VEGETATION .....	32
3.4 FAUNA .....	33
3.5 CLIMATE .....	34
3.5.1 RAINFALL .....	34
3.5.2 TEMPERATURE .....	35
3.6. METHODOLOGY .....	36

3.6.1 IMPALA HOME RANGE PHYTOSOCIOLOGY .....	36
3.6.2 IMPALA SEASONAL HABITAT UTILISATION AND MOVEMENT PATTERNS .....	37
3.6.3 IMPALA HERD DAILY ACTIVITY BUDGETS .....	37
REFERENCES .....	38
<b>CHAPTER 4.....</b>	<b>40</b>
<b>IMPALA HOME RANGE PHYTOSOCIOLOGY .....</b>	<b>40</b>
4.1 INTRODUCTION .....	40
4.2 METHODS .....	42
4.2.1 VEGETATION SAMPLING SITE SELECTION .....	42
4.2.2 FLORISTIC AND ENVIRONMENTAL DATA.....	42
4.2.3 ENVIRONMENTAL VARIABLES.....	44
4.2.4 VEGETATION CLASSIFICATION ANALYSIS.....	46
4.2.5 TREE DENSITY .....	46
4.3 RESULTS.....	47
4.3.1 DESCRIPTION OF THE PLANT COMMUNITIES WITHIN THE IMPALA HOME RANGE.....	47
4.3.2 VEGETATION STRUCTURES IDENTIFIED FOR THE STUDY AREA.....	52
4.3.3 DESCRIPTION OF PLANT COMMUNITIES.....	52
4.3.4 PLANT FAMILIES.....	56
4.3.5 WOODY SPECIES DENSITY .....	58
4.4 DISCUSSION.....	59
4.4.1 THE WOODY LAYER .....	60
4.4.2 GRASS LAYER .....	61
4.4.3 PLANT FAMILIES.....	64
4.5 CONCLUSION .....	65
REFERENCES.....	67
<b>CHAPTER 5.....</b>	<b>71</b>
<b>IMPALA SEASONAL HABITAT UTILISATION AND MOVEMENT PATTERNS.....</b>	<b>71</b>
5.1 INTRODUCTION.....	71
5.2 METHODS .....	73
5.2.1 IMPALA SEASONAL DAILY MOVEMENTS AND DISTANCES TRAVELLED.....	73
5.2.2 RELATIONSHIP BETWEEN DAILY DISTANCE TRAVELLED, RAINFALL, TEMPERATURE, AND PHOTOPERIOD IN THE DRY, WET, AND COMBINED SEASONS.....	73
5.2.3 DIFFERENCE BETWEEN DAILY DISTANCES TRAVELLED IN THE DRY AND WET SEASONS	74
5.2.4 COMPARISON OF DAILY DISTANCE TRAVELLED ACROSS DIFFERENT TIME PERIODS WITHIN SEASON AND ACROSS SEASONS .....	74
5.2.5 IMPALA HOME RANGE DELINEATION AND HABITAT SELECTION .....	75
5.3 RESULTS.....	77
5.3.1 SEASONAL AVERAGE ENVIRONMENTAL FACTORS INFLUENCING THE DAILY MOVEMENT	

PATTERN OF THE COLLARD IMPALA .....	77
5.3.1.1 Impala dry season average daily distances travelled.....	76
5.3.2 Impala wet season average daily distances travelled .....	77
5.3.1.3 Impala combined season average daily distances travelled .....	77
5.3.2 RELATIONSHIP BETWEEN DISTANCE TRAVELLED, RAINFALL, TEMPERATURE, AND PHOTOPERIOD .....	78
5.3.2.1 Dry season relationships.....	78
5.3.2.2 Wet season relationships.....	81
5.3.2.3 Combined seasons relationships .....	84
5.3.3 THE DIFFERENCE BETWEEN MEAN DAILY DISTANCE TRAVELLED IN THE DRY AND WET SEASONS .....	87
5.3.4 SEASONAL RANGE OF DAILY DISTANCE TRAVELLED PER TIME INTERVAL, MORNING (06:00 – 10:00 AM), MIDDAY (10:00 AM – 14:00 PM), AFTERNOON (14:00 – 18:00 PM) AND NIGHT (18:00 PM – 06:00 AM) .....	87
5.3.5 COMPARISON OF DISTANCE TRAVELLED ACROSS DIFFERENT TIME PERIODS WITHIN SEASON AND ACROSS SEASONS .....	88
5.3.6 HOME RANGE DELINEATION AND DETERMINING HABITAT SELECTION.....	88
5.3.6.1 Plant community selection .....	93
5.3.6.2 Dry season habitat selection.....	95
5.3.6.3 Wet season habitat selection .....	95
5.3.6.4 Combined seasons habitat selection .....	96
5.4 DISCUSSION .....	97
5.5 CONCLUSION .....	102
REFERENCES.....	105
<b>CHAPTER 6.....</b>	<b>109</b>
<b>IMPALA HERD DAILY ACTIVITY BUDGETS.....</b>	<b>109</b>
6.1 INTRODUCTION.....	109
6.2 METHODS .....	111
6.2.1 DATA COLLECTION.....	111
6.2.2 DATA ANALYSIS .....	113
6.3 RESULTS.....	114
6.3.1 TIME BUDGET OF DIURNAL ACTIVITY PATTERNS .....	114
6.3.1.1 Combined wet and dry season proportions of time spent on various activities .....	114
6.3.1.2 Proportion of time spent on various activities in the wet season.....	116
6.3.1.3 Proportion of time spent on various activities in the dry season .....	117
6.3.2 DAILY ACTIVITY PATTERN COMPARISONS 06:00 – 10:00, 10:00 – 14:00, AND 14:00 – 18:00 FOR COMBINED WET AND DRY SEASONS. ....	119
6.4 DISCUSSION.....	126
6.4.1 TIME BUDGET OF DIURNAL ACTIVITY PATTERNS .....	126
6.4.2 COMPARING ACTIVITY PATTERNS OF IMPALA SOCIAL GROUP ACROSS WET AND DRY	



SEASONS .....	127
6.4.3 DAILY PERIOD ACTIVITY PATTERNS .....	128
6.5 CONCLUSION .....	131
REFERENCES.....	133
<b>CHAPTER 7.....</b>	<b>137</b>
<b>CONCLUSION.....</b>	<b>137</b>
REFERENCES.....	142

## LIST OF FIGURES

<b>Figure 3.1:</b> Location of the Loskop Dam Nature Reserve in the Mpumalanga Province of South Africa.....	28
<b>Figure 3.2:</b> Geology map of Loskop Dam Nature Reserve.....	31
<b>Figure 3.3:</b> Location of reserve within the Central Sandy Bushveld, Loskop Mountain Bushveld and Loskop Thornveld Vegetation Units .....	33
<b>Figure 3.4:</b> Loskop Dam Nature Reserve monthly rainfall figures for the study period. recorded at Loskopdam Nature Reserve Office Weather Station.....	35
<b>Figure 3.5:</b> Monthly average minimum and maximum temperatures for the study period for Loskop Dam Nature Reserve.....	36
<b>Figure 4.1:</b> Chart for a visual estimation of grain size, centred on sand classes.....	45
<b>Figure 4.2:</b> Vegetation map for the home range of a herd of Impala ( <i>Aepyceros melampus</i> ).....	477
<b>Figure 4.3:</b> Dominant plant families reflected as a percentage of the total flora in the Impala home range. ....	58
<b>Figure 5.1:</b> The relationship between mean daily distance travelled and rainfall in the dry season..	79
<b>Figure 5.2:</b> The relationship between mean daily distance travelled and temperature in the dry season.....	80
<b>Figure 5.3:</b> The relationship between mean daily distance travelled and photoperiod in the dry season.....	81
<b>Figure 5.4:</b> The relationship between mean daily distance travelled and rainfall in the wet season.....	82
<b>Figure 5.5:</b> The relationship between mean daily distance travelled and temperature in the wet season.....	83
<b>Figure 5.6:</b> The relationship between mean daily distance travelled and photoperiod in the wet season.....	84
<b>Figure 5.7:</b> The relationship between mean daily distance travelled and rainfall in the combined seasons. ....	85
<b>Figure 5.8:</b> The relationship between mean daily distance travelled and temperature in the combined seasons. ....	86
<b>Figure 5.9:</b> The relationship between mean daily distance travelled and photoperiod in the combined seasons. ....	87
<b>Figure 5.10:</b> The difference between mean daily distances travelled in the dry and wet seasons.....	87
<b>Figure 5. 11:</b> Seasonal range of daily distance travelled per time interval in the dry, wet and combined seasons. ....	88

<b>Figure 5.1:</b> Home ranges for the Impala ( <i>Aepyceros melampus</i> ) at Loskop Dam Nature Reserve.....	90
<b>Figure 5.23:</b> Dry season home ranges for the Impala ( <i>Aepyceros melampus</i> ).....	91
<b>Figure 5.14:</b> Wet season home ranges for the Impala ( <i>Aepyceros melampus</i> ).....	92
<b>Figure 5.35:</b> Combined seasons home ranges for the Impala ( <i>Aepyceros melampus</i> ).....	93
<b>Figure 5.16:</b> Impala habitat-use patterns represented by Ivlev's Electivity Indices for the dry season, the wet season and the combined wet and dry seasons. ...	95
<b>Figure 6.1:</b> Proportion of time spent on different activities by the various Impala social groups for both wet and dry seasons.....	115
<b>Figure 6.2:</b> Proportion of time spent on different activities by the various Impala social groups in wet seasons. ....	117
<b>Figure 6.3:</b> Proportion of time spent on different activities by the various Impala social groups in the dry season.....	118
<b>Figure 6.4:</b> Daily percentage of time spent engaged in different activities for the various Impala groups combined during the study period.....	119
<b>Figure 6.5:</b> Percentage of time spent foraging during the wet and dry seasons for all Impala social groups combined.....	120
<b>Figure 6.6:</b> Percentage of time spent resting during the wet and dry seasons for the combined Impala social groups.....	121
<b>Figure 6.7:</b> Percentage of time spent moving during the wet and dry seasons for the combined Impala social groups.....	122
<b>Figure 6.8:</b> Percentage of time spent being vigilant during the wet and dry seasons for the combined Impala social groups.....	123
<b>Figure 6.9:</b> Percentage of time spent ruminating during the wet and dry seasons for all Impala social groups combined.....	124
<b>Figure 6.10:</b> Percentage of time spent in flight during the wet and dry seasons for all Impala social groups combined.....	125

## LIST OF TABLES

<b>Table 4.1:</b> Modified Braun-Blanquet cover abundance scale.....	43
<b>Table 4.2:</b> Modified slope unit classification.....	44
<b>Table 4.3:</b> Modified soil erosion classification .....	44
<b>Table 4.4:</b> Phytosociological table for the Impala home range. ....	48
<b>Table 4.5:</b> Vegetation structural classes identified for the study area.....	52
<b>Table 4.6:</b> Plant families identified in the study area indicating the number of genera and species in each family. ....	57
<b>Table 4.7:</b> Woody plants species densities for the plant communities found in the Impala home range. ....	58
<b>Table 5.1:</b> Wet and Dry season average daily distances travelled per month. Also depicted are average rainfall, average temperature, and average photoperiod. ....	78
<b>Table 5.2:</b> Plant community sizes, seasonal utilization percentages and habitat electivity by Impala at Loskop Dam Nature Reserve.....	94
<b>Table 6.1:</b> Daily activities of Impala during the wet and dry seasons.....	113

# CHAPTER 1

## INTRODUCTION

### 1.1 INTRODUCTION

Impala are endemic to the African continent (Furstenburg, 2016). They are widespread within Angola, Botswana, Kenya, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe and are found in Uganda, Kenya, South Africa, Central Africa, and parts of East Africa (IUCN, 2016; Murray, 1982; Dorst & Dandelot, 1972). The black-faced Impalas (*Aepyceros melampus petersi*) are limited to Angola and Namibia and occur in the Western parts near the Zambezi River (Furstenburg, 2016). In the late 1800's and early 1900's, Southern Impala (*Aepyceros melampus*) were predominantly found in South Africa along the riverine, drainage lines and North-east of Kuruman town. Subsequently their numbers increased and currently they occur throughout the country (Furstenburg, 2016). According to the IUCN (2016), the present status of the global Impala population is estimated at two million, of which 50% are on privately owned properties.

According to Kurauwone et al. (2013), Impala in South Africa occur in abundance on state and privately owned lands when compared to other animal species that are also found in these areas. They are favoured for game farming, hunting and are an important prey species to larger predators. Their presence as buffer species prevents other important being killed by predators. They are economically important to the game ranching and conservation sectors (Kurauwone et al., 2013), and their numbers are stable and increasing (IUCN, 2016).

Home ranges can be defined as the areas that animals live in and traverse daily while performing their daily activities which include feeding, drinking, resting, moving, defecation and marking their territory ( Aini et al., 2015; Frohn et al., 2005). Home range estimation is an important tool in wildlife management, it is a spatial utilization measure

used as a primary source of data (Aini et al., 2015). Mitchell & Powell (2012) explain that different, and the same species of animals have home ranges that vary in size at different time periods. Home ranges represent a reciprocal relationship between the area that an animal occupies and how that animal understands its surroundings as well as its mental representation of its physical environment (Pearl, 2000; Börger et al., 2008; Spencer, 2012). According to Mitchell & Powell (2004), home range size and the utilisation thereof are used as one of the processes to illustrate how the natural resources used by animals are distributed and contribute towards their fitness.

Animal movements are limited to smaller areas within their specific home ranges than would be expected when one observes their overall level of mobility (White & Garrott, 1990). Wang & Grimm (2007) and Gautestad & Myrsetrud (2005) state that the restricted area that animals use during their daily routines, has underlying consequences on ecological processes such as the way the animals are dispersed, their population sizes and abundance, and habitat selection (Rhodes et al., 2005). Other consequences on ecological processes may include the relationships and dynamics of predators and prey (Lewis & Murray, 1993), biological processes, community structure (Burchat & Sokołowski, 2015), and the way that infectious diseases spread (Kenkre et al., 2007).

Understanding the way animals spread their daily activities out over time and space is important as this provides insight into managing them and their environments. Ecologists follow animals to study their home range sizes and shapes, daily movement patterns, the way in which their home ranges change over time, and how they utilise their home ranges and the available resources (Fieberg & Kochanny, 2005; Fieberg & Börger, 2012; Mitchell & Powell, 2012).

According to Mitchell & Powell (2004), vegetation cover and shelter, available quality of forage, and escape routes are not well known and understood. Home ranges are studied to understand how resources structure animals home ranges (Mitchell & Powell, 2012). Home ranges that are based solely on obtaining maximum yield of resource are normally small (Mitchell & Powell, 2004). Types of home ranges such as territories, are beneficial

in nature as they increase limiting factors like food availability and mates in terms of the costs of gaining available resources and their distribution (Mitchell & Powell, 2012).

According to Wang & Grimm (2007), home ranges are a result of processes (movement driven by habitat selection and biotic interactions) that consequently produce home range behaviour at population level and the time scale used for analysing home ranges (Pearl, 2000). According to Pittman & Mcalpine (2003), natal dispersal and migration may change secured stable home ranges. A definition of a home range can be obtained by looking at the presence of an individual and how it reacts without disturbance from neighbouring individuals (Brown & Orians, 1970). Home range sizes may vary from a few square metres to thousands of square kilometres, and be utilised for a particular season or several years (Börger et al., 2008).

The accumulation of resources distributed throughout home ranges promotes survival and reproduction of animals. Individuals need to select habitats with sufficient resources to offset any costs that they might incur (Mitchell & Powell, 2004). On the other hand, survival and reproduction asymptotes with acquiring maximum favourable resources that are distributed spatially within the home range.

Most animals rarely make use of the outer edges of their home ranges. Animals might care less when it comes to the exact border of their home ranges because most of their time is spent somewhere within the home range. According to Gautestad & Mysterud (1995), the outer edge areas of home ranges may be spread over a wide area, and this may cause the home range area indistinct. According to White & Garrott (1990), often times, home range area is regarded as the area demarcated with the minimum convex polygon surrounding the daily movement of animals in time and space. White & Garrott (1990) states that for the observed home range to function, it should approach an asymptote in large numbers. Considering that time is limited, an animal will also cover a limited area. Taking this into consideration, a home range is a well demarcated area, which is stable within temporal and spatial scales compatible with the animal's behaviour

(White & Garrott, 1990). A home range is critically important to most species of animals as it encompasses all resources the animal requires to survive and reproduce.

Time is one of the minimal resource for animals in natural ecosystems (Pollard & Blumstein, 2008) and the way animals allocate time to their daily activities has consequential effects to their survival and reproduction (Nakayama et al., 1999). Partitioning available time is influenced by social behaviour, which has constraints for free-ranging individuals (Pollard & Blumstein, 2008). Consequently, animals adapt to environmental changes including temporal and spatial shifts in food quality and availability, as well as to climate change. Adapting to environmental change may involve amongst others how time is partitioned on all different daily activity patterns (Jaman & Huffman, 2008; Pollard & Blumstein, 2008). According to Kurauwone et al. (2013), seasonal activity budgets provide important information on how Impala spend their time.

Habitat management is widely recognized as a fundamental practice for maintaining wildlife populations over the long term (Western et al., 1989). According to Pearl (2000), habitat management involves managing wildlife population and resources to protect and conserve threatened species and promoting a healthy environment and stable populations. This in turn, assumes some understanding of the ecological requirements of the populations being conserved (Kaunda et al., 2002). To assess the broad ecological needs of a species, ecologists commonly study the animal's habitat use which indicates selection and preference (Pearl, 2000). Individual animals reproduce or survive better in habitats that provide for their needs (Kaunda et al., 2002), which are their naturally preferred habitats (Pearl, 2000). At a point where habitats can be determined by an animal's respective preference, they can be assessed by means of their importance to an animal's fitness. Habitats can be manipulated to have good quality resources that will generate a lot of targeted species (Pearl, 2000). According to Bonyongo (2005), studies on habitat utilization by various forms of wildlife have provided wildlife managers with valuable information for managing wildlife and their environments.



Spatial and temporal activity budgeting by animals are determined by environmental and ecological parameters such as the abundance and distribution of food, mates, and predators (Jarman, 1974; Ferreras & Macdonald, 1999; Kaunda, 2000). In conservation biology it is imperative to assess habitat components for sites that might be locations for population manipulation such as reductions and re-introductions, or that might support critical biological processes (Kaunda, 2000). Animal habitat utilization is regarded as selective when an animal makes choices rather than moving around wandering through its environment. The availability of habitats may be compared to the disproportionate utilisation of habitats, this is seen as proof of selection, even though availability of resource may determine accessibility (Hall et al., 1997).

According to Negovetich et al. (2006), despite high population numbers and wide distribution patterns, little is known about Impala's seasonal habitat selection and utilization. Understanding the patterns of habitat utilization of ecotone species like Impala, and the consequences of conserving their habitats, is important. Seasonal habitat fragmentation caused by seasonal changes in forage availability, quantity and quality have great impacts on the seasonal patterns of habitat utilization by various wildlife species (Bonyongo, 2005).

## **1.2 PROBLEM STATEMENT**

Loskop Dam Nature Reserve (LDNR) is a core conservation area forming part of the Mpumalanga protected areas network. One of the reserve's management objectives is to undertake detailed studies and research on faunal populations occurring in the reserve. An ecological study on the resident Impala population at LDNR to determine seasonal home range utilization, behaviour and feeding ecology will contribute towards the reserve's management objectives. To date no study has looked at Impala ecology for the reserve, which highlights the need for such a study. This study will classify plant communities within an Impala's home range, and examine seasonal habitat selection and habitat use by the Impala. Collection of seasonal daily activity pattern data for Impala during a complete wet and dry season will be undertaken to see if there are noticeable

seasonal differences to daily activity budgets. An ecological study on the Impala at LDNR, to determine seasonal habitat utilisation and activity patterns, will provide valuable information for managing Impala, and the habitat they utilise.

### 1.3 STUDY OBJECTIVES

The objectives for the study are to:

- determine plant communities occurring within a collared Impala's home range,
- map and describe the plant communities within the home range,
- determine seasonal and combined home ranges of a GPS collared Impala male,
- determine forage availability in the home range (densities of woody plants and structural height classes of vegetation, as well as grass availability),
- determine plant community utilisation by the collared Impala ram, associated breeding herds, territorial males, and bachelor herds living within the confines of the male Impala's home range,
- investigate the Impala ram's seasonal daily activity and movement patterns using Geographic Information System (GIS) technology,
- monitor Impala behaviour to determine seasonal activity budgets and resource selection.

### 1.4 DISSERTATION LAYOUT

This dissertation comprises six chapters. Each chapter has its own reference list while the Figure and Table numbers are preceded by the chapter number. The **first chapter** provides an introduction with the problem statement and objectives listed. In **Chapter 2** a literature review on the study species is provided and is followed by **Chapter 3** which includes a description of the larger study area as well as the broad methodology followed. No detailed methods are discussed since a detailed description of the methods used are

provided in the results chapters (Chapters 4, 5 & 6). In **Chapter 4** a vegetation classification and description of the home range of the Impala are presented, while **Chapter 5** describes the seasonal habitat utilisation and movement patterns of the Impala over the study period. The daily activity budgets of the Impala herd is discussed in **Chapter 6**. The last chapter (**chapter 7**) provides a discussion and conclusion based on the results chapters.

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# CHAPTER 2

## LITERATURE REVIEW

### 2.1 STUDY SPECIES

Impala (*Aepyceros melampus*) are savanna dwelling antelope that belong to the Aepycerotinae family. Impala occur in East and southern Africa (Skinner & Smithers, 1990). Their body mass varies from 40 – 60 kg, with males weighing up to 60 kg and females up to 45 kg. Males possess rigid S-curved horns and females do not have horns. Impala are gregarious and territorial (Estes, 1991).

According to Estes (1992), Impalas are ecotone species that tend to choose light woody areas that have little undergrowth and grass areas with low to medium height. Impala have seasonal dietary requirements and can adapt to different local conditions and habitats, being both grazers and browsers depending on the available forage at a particular time (Skinner & Smithers, 1990). Impala browse foliage, forbs, shoots and seedlings when grass is unavailable (Estes, 1992). Impala have adaptations to their stomach lining to consume both monocotyledonous and dicotyledonous plants, making them versatile animals occupying the savanna ecosystems (Okello et al., 2002; Wronski, 2002). They differ from other animals as they have a four-chambered stomach to digest their food multiple times. In the wet season, when food is plentiful, they gather in large herds to browse on grasses, herbs, bushes, shrubs, and shoots (Rutagwenda et al., 1990). High densities of Impala are common in areas that offer a variety of both grazing and browse plant species (Smithers, 1983).

Impala occupy areas with well-drained soils, and average sloping topography (Coetzee et al., 1976). According to Skinner & Smithers (1990), Impalas are dispersed in irregular or clumped patterns, that range within a few kilometres of available water in the dry season when the vegetation they feed on contains less moisture (Smithers, 1983). In the wet season when the nutritious vegetation is available, Impala survive for longer periods

without drinking water. They have a tendency to prosper in areas where overgrazing and bush encroachment are widespread due to their catholic diets (Smithers, 1983; Estes 1995; Dangerfield et al., 1996).

## **2.2 HABITAT UTILISATION AND HOME RANGE**

Habitat is defined as an area with well-defined environmental factors which an animal use to live and reproduce successfully (Allaby, 2003). Habitat selection refers to an animal choosing or selecting a particular habitat among several available habitats. Habitat preference implies a choice of one habitat over others without the concern of its availability (Morris, 1992). Habitat availability has the potential capacity to effect population dynamics and community structure, specifically the distribution of sexes in space and time (Morris, 1988).

Previous studies have shown that when predators are present, animals that easily fall prey, seek habitats or areas within habitats where the threat of predation is diminished (Leuthold, 1970; Lima & Dill, 1990). The onset of parturition in wildlife species presents many challenges in respect of vulnerability to predation (Lima & Dill, 1990; Kaunda, 2001). Therefore, habitats should provide areas where animals would feel safe and protected to perform and engage in their daily activities such as reproducing and nurturing young with limited predation risks.

There are many factors influencing animal movements and distributions (Frohn et al., 2005). These include environmental variables such as distance from permanent water, forest types, vegetation structure, and physical and anthropogenic factors that are associated with spatial or geographical information (O'Neill et al., 1996). Geographic Information Systems (GIS) are a well-known means of providing data for environmental studies (Frohn et al., 2005). This technology provides a way to access and present environmental variables such as climate, topography, vegetation cover and more, which are imperative to manage and assess ecosystems (O'Neill et al., 1996) and to evaluate research and management efforts (Alcamo et al., 2005).



According to Kushwaha & Rahnejat (2002), GIS has been used for gathering data on the physical parameters of wildlife habitats. With advances in GIS and statistical tools, multiple habitat variables can now be explored, including vegetation cover, hydrology, topography, geology and lithology (Erickson et al., 1998). According to O'Neill et al. (1996), data collected using these technologies can provide meaning in many ways and provides a meaningful amount of information for the management and conservation of wildlife.

According to Kushwaha & Rahnejat (2002), home range estimation is important to wildlife managers as this assist them to determine and measure how much of the home range is utilized by a specific animal. Several methods are used to delimit home range patterns such as minimum convex polygons (MCP), harmonic mean, kernel distribution, and the Jennrich-Turner home range method (Fernández-Juricic et al., 2007).

According to Mtui (2014), research that took place in the Serengeti National Park using GIS technology to model the impacts of roads and traffic on the behaviour of Impala, found that such infrastructure directly affects wildlife populations through habitat loss, traffic mortality, resource inaccessibility and behavioral changes. All GPS coordinates were plotted on a Serengeti digital thematic map containing various landscape features such as the road network, vegetation and habitat types. Variables considered, and analysis conducted included determination of step length, habitat type, time of day, movement direction and distance to roads (Allaby, 2003). Results indicated an overall avoidance pattern towards roads by Impala, higher vigilance in proximity of roads, and an associated reduction in feeding times when close to roads. This indicates that anthropogenic factors impact Impala behaviour (Mtui, 2014).

Many animals limit and maintain their movements to smaller home ranges than expected when looking at the levels of mobility for the animals (White & Garrot, 1990). The restricted area that the animals use has essential outcomes for biological processes, such as the way populations are dispersed and their abundance (Gautestad & Mysterud, 2005;

Wang & Grimm, 2007), how animals select their habitat (Rhodes et al., 2005), predator–prey relationships (Lewis & Murray, 1993), biological processes and community structure (Burchat & Sokołowski, 2015), and animals being infected by the spread of infectious diseases (Kenkre et al., 2007).

### **2.3 ACTIVITY BUDGET**

According to Vasey (2005), seasonal activity budgets of animals might be flexible with respect to changes in seasonal food supply, shifting and corresponding to climate fluctuations. In natural habitats, there is a number of factors that have an effect on activity budgets and they correlate with the challenges of obtaining energy from the available food (Coelho et al., 1986). Daily activity budgets are influenced by metabolism and energy that an animal requires and vary across seasons or correlates to reproductive phases (Halle & Stensechth, 2000).

The availability and quality of food is influenced by a pattern of rapid changes in environmental factors (Rapaport & Ruiz-Miranda, 2006). Pays et al. (2007), has shown that enhancing forage quality makes minor changes to the trade-offs that take place between vigilance and foraging for improving feeding. Animals devote their time accumulating knowledge about available resources occurring in their home range environment, which affects the amount of time they have to allocate to other daily activities (Fortin et al., 2004).

A study focusing on seasonal food selection by Impala was conducted in the Timbavati Private Nature Reserve (Meissner & Pieterse, 1996). Three mature male Impalas were oesophageal fistulated and four were fistulated in the rumen. Samples on forage selection, ammonia concentration and volatile fatty acid production were obtained from these seven Impalas. It was revealed that during the wet season, grass is mostly present as their primary food resource and constituted about 90% of what they foraged and browse contributed about 35% in the dry season. The study concluded that Impala are

selective feeders that optimize food quality in their dietary selection (Meissner & Pieterse, 1996).

Seasonal differences in activity budgets and proportions of time spent on foraging, vigilance and ruminating were observed during a study in Mukuvisi Woodlands Wildlife & Environmental Centre located in Zimbabwe (Kurauwone et al., 2013). The results revealed that in the dry season, Impala spend most of their time feeding than during the wet season, and that feeding is the main activity they partake in. Proportions of time spent on their daily activities such as vigilance, resting, ruminating, and grooming were significantly different between harem and bachelor groups. Males use most of their time being vigilant, while only nursing females had an increase in vigilance compared to non-nursing females (Kurauwone et al., 2013).

### **2.3.1 Focals and Scans**

According to Amato et al. (2013), primatologists make use of scan sampling methods and direct observations to analyze behavior of different animals in captivity and the wild. Field data for activity budgets and selection of food by individual species groups are collected by means of scan at a certain time. Focal sampling methods are used in instances where the collection of data on certain behaviors has failed when using methods that do not need direct observations such as following a specific individual in most situations.

According to Altmann (1974), data describing different and connected behaviors are not easy to record with scan samples due to the challenge of locating and identifying the activity of each individual in a group in a short time space. Research on acquiring knowledge about behaviours that are recognised easy can be done with focal sampling, that has an advantage over scan sampling (Beauchamp, 2008). Focal data is important for recording the actual differences on the behaviour between individuals in a social group and determining different social interactions that are difficult to understand (Altmann, 1974).

Focal samples can be recorded without interruption and how well the two methods correspond depends on the interval between instantaneous records of behaviour during a focal sample, the type of behavioral data being recorded, and the frequency at which individuals of the species being observed shift behaviors (Altmann, 1974).

### **2.3.2 Vigilance behaviour**

Animals balance the time spent in acquiring resources and in gaining information about resources availability, their social environment, feeding competition as well as predators (Brown, 1999). Many studies have identified factors affecting individual vigilance levels (McNamara & Houston, 1986; Lung & Childress, 2007; Fernández-Juricic et al., 2007).

According to Beauchamp, (2008) animals hinder their food intake period by raising their heads to scan their environment, and this is regarded as an anti-predator strategy if potential predators can be spotted (Roberts, 1996). Vigilance refers to an animal scanning its surrounding and this may yield certain uses such as spotting predators and identifying the competition within-group (Couzin et al., 2002).

Vigilance while feeding is critical in behavioral ecology because it determines the organisation of other behavioral states that animals undertake (Pulliam, 1973; Caraco, 1979; Barnard & Thompson, 1985;). Group size has shown to affect animal's vigilance (Hoogland, 1979; Caraco, 1979; Barnard, 1980; Bertram, 1980; Elgar & Catterall, 1981; Sullivan, 1984), how individuals are positioned within the group (Jennings & Evans, 1980), accessibility to protective cover (Caraco, 1979; Barnard, 1980) or closeness to danger, nearby objects which limits visibility (Metcalf, 1984), and the available potential predators (Caraco, 1979; Sullivan, 1984). Vigilance of animals feeding is affected by different factors affiliated with the possibility of predation.

A negative relationship may be exhibited between vigilance and availability of food based on the limited time usually experienced by foraging animals (McNamara & Houston, 1992; Ale & Brown, 2007). Group size may affect the risk of predation for an individual, successful foraging, and accessibility to mating partners, this also influences the stability

between accessing food and at the same time, an individual's safety. When group sizes are large, individuals face lower risks and derive benefits from collective detection as well as the dilution effect (Brown, 1999). However, they are at higher risk when they are in a group and some of the members disturbs each other when moving and scanning for predators (Ale & Brown, 2007).

In species that form groups, members of the group monitor each other and competitors from other groups so that they may acquire information about food patches that offer quality forage. When food is limited, it may negatively affect the balance between food availability and level of vigilance even though predators are not a threat (Barnard & Sibly, 1981; Beauchamp & Giraldeau, 1999; Beauchamp, 2008). Being vigilant when foraging provides an individual to collect and handle food while looking for predators (Pays et al., 2011).

According to Cameron & Du Toit (2005), animals living in herds can positively lower the time dedicated to vigilance. According to Beauchamp (2008), group size vigilance may lead to decreased individual vigilance because there are more eyes on the lookout and more ears that allows the group to detect and identify predator activities (Pulliam et al., 1973). When there is an increase in group sizes, then there are more eyes on the lookout to detect possible predation risks (Powell, 1974; Kenward & Silby, 1978; Lima, 1995; Bednekoff & Lima, 1998). Therefore, many individuals in a group will result in a reduced predation attack if the predators go for one individual in the process of attacking prey in the group no matter the size of the group (Foster & Treherne, 1981).

Foragers within a group share the time spent on detecting predators that are in their vicinity; this also indicates that individuals would limit the time they allocate for vigilance and partition the remaining time to other activities like foraging which enhances their fitness (Pulliam et al., 1973; McNamara & Houston 1992; Ale & Brown 2007). Most prey species spend more time being vigilant when feeding (Popp, 1988) for example, mammals keep their heads up when chewing (Fortin et al., 2004; Makowska & Kramer, 2007).

In primate species, males are found being more vigilant than females (Cheney & Seyfarth, 1981; Boinski, 1988; van Schaik & van Noordwijk, 1989; Fragaszy, 1990; Steenbeek et al., 1999; Buchanan-Smith, 1999), and ungulate male species more vigilant than females and these include the African buffalo (*Syncerus caffer*), Burchell's zebra (*Equus burchellii*), blue wildebeest (*Connochaetes taurinus*), waterbuck (*Kobus defassa*), and springbok (*Antidorcas marsupialis*) (Ginnett & Demment, 1997). During the wet season giraffe (*Giraffa camelopardalis*), males seem to be more vigilant than females and during the dry season, females tend to be more vigilant than males in all habitats they utilize (Ginnett & Demment, 1997).

It is still a challenge to understand and explain how males and female partition their time on vigilance and other daily activities. This is related to the intra-specific competition that propose that animal species that live in herds need to spend most of their time to scan their habitats and the environment to evaluate competitors and their activities (Reboreda & Fernandez, 1997; Hart & Hart, 1992). A group that comprises of several adult males would be obliged to continuously monitor one another (Rose & Fedigan, 1995). Several studies done have shown that the presence of other individuals or neighbor has an influence on vigilance of the next individual in the same vicinity (Blumstein et al., 2001; Cameron & Du Toit, 2005).

### **2.3.3 Foraging**

Several studies have carried out research on seasonal changes in Impala diet (Dunham, 1980; Dunham, 1982; Van Rooyen & Skinner, 1989; Meissner et al., 1996; Omphile, 1997). According to Monro (1979), Impala are selective feeders with wide seasonal dietary variation resulting in changes from primary dependence on browse to grass, as the nutritional value of these two plant groups varies seasonally. Impalas feed on different herbaceous and woody plants in different plant communities (Van Rooyen & Skinner, 1989; Omphile, 1997), and during the wet season grasses and forbs make up a larger percentage of their diet than during the dry season (Monro, 1980; Dunham, 1980, 1982; Smithers, 1983; Van Rooyen, 1992; Meissner et al., 1996; Vronsky, 2002).

Food intake is limited by the amount of time needed for searching and handling food (Farnsworth & Illius, 1996). When forage is limited, animals spend more time searching for the food portions in the next patch with available forage than spending time chewing the portion of food from the previous forage (Illius & FitzGibbon, 1994). In most cases, vigilance influence the time allocated to searching for food (Illius & FitzGibbon, 1994), the time spent on vigilance would lead to a delay in finding the next food and this may reduce the rate of food intake. If the rate of food intake is minimal, animals would cut the next bite as soon as they finish chewing the food that is already in their mouth. When ungulates are about to cut their next food portion, and still chewing their previous portion, the time they take chewing is regarded to be the time that they could use on vigilance and not limit their food intake rate (Illius & FitzGibbon, 1994; Cowlshaw et al., 2009). Large ungulates might use 50% of their time to scan around for possible threats but not limit their food intake (Illius & FitzGibbon, 1994).

The quality and quantity of food in cool temperate areas diminish during the dry season and this causes animals living in these areas to experience an energy crisis (Mrosovsky & Sherry, 1980; Adamczewski et al., 1987; Tyler, 1987). The way these animals manage their energy has raised concerns as this influences the reproduction and survival rate (Bobek et al., 1983; Illius & Gordon, 1990). They use fuel reserves to manage and reducing energy expenditure (Moen, 1976; Nakayama et al., 1999).

Grazing capacity forms part of determining the veld condition (Trollope, 1990) and the availability of quality forage. The grazing capacity of veld depends on whether the quality of forage selected is optimized or not (Trollope, 1990). According to Moen (1976) and Nakayama et al. (1999), 60 to 70% of the variation in foraging intake by Impala is accounted for by the variation of cell wall constituents of forage material selected, with a variation in protein content also accounting for a significant portion.

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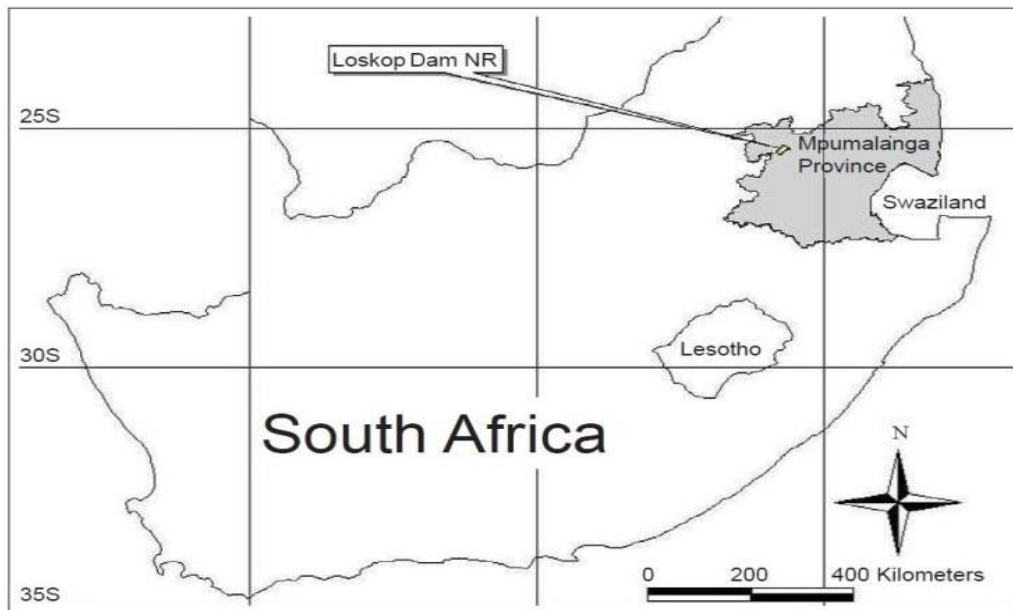
# CHAPTER 3

## STUDY AREA AND METHODS

### 3.1 STUDY AREA

#### 3.1.1 Location and size of the study area

The proposed study area is located within the Loskop Dam Nature Reserve (LDNR), which is found 55 km to the north of Middleburg stretching across the N11 national road of Mpumalanga Province (Figure 3.1). The reserve lies around the Olifants River in a scenic valley and located between the longitude 25°34' to 25°56' South and latitude 29°15' to 29°40' East. According to Eksteen (2003), the reserve covers 23 175 ha of land with elevation varying between 1 990 – 1 450 m above mean sea level (m.a.s.l.).



**Figure 3.1:** Location of the Loskop Dam Nature Reserve in the Mpumalanga Province of South Africa (Barrett, 2009).



In the year 1938, the wall of the dam was built, created the surface water area around 2 350 ha which resulted in flooding of the valley floor (Filmlalter, 2010). In 1954, the reserve was proclaimed to protect and manage land surrounding the dam to supply good quality water to farmers in the Loskop Valley and surrounds (Eksteen, 2003). The construction of the dam was completed in 1970 and it is approximately 30 km long. The four perennial streams occurring in the reserve includes Fontein Zonder End, Scheepersloop, Kerkplaasloop and Krantzspruit (Eksteen, 2003). The dam also receives water from the streams and drainage are on the small mountains found arising from the inside and outside borders of the reserve.

### **3.1.2 Topography and geology**

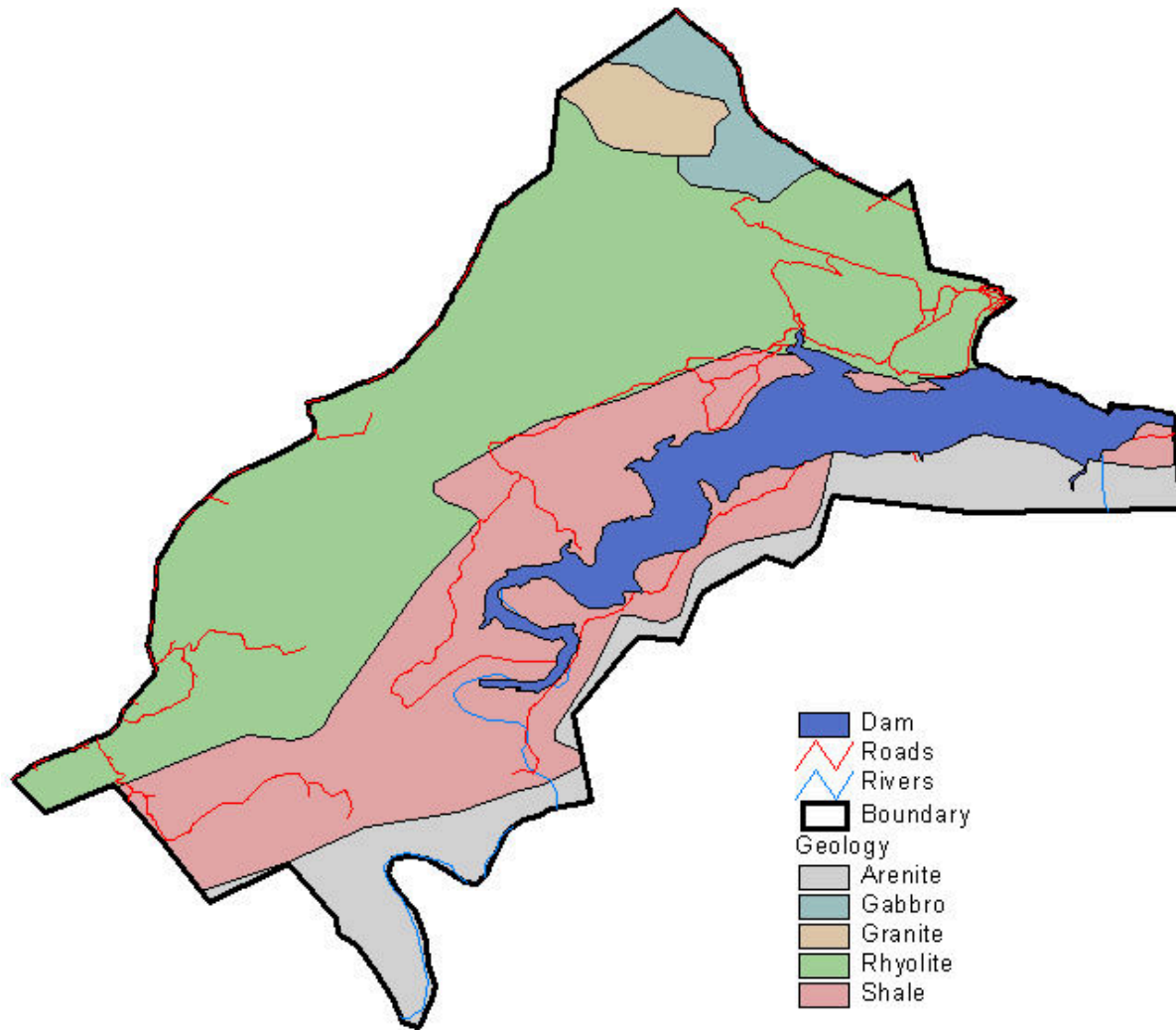
The reserve has a variety of elevations ranging from 990 to 1 450 m.a.s.l, giving rise to different types of topography. The topography includes incised plateaus on the higher lying areas through steep cliffs and a variety of slope types, to deep valleys and relatively flat valley bottoms (Van Biljon, 1960). Steep cliffs are formed through the uninterrupted breaks of the Waterberg Plateau that form the northern boundary of the reserve. The breaking Waterberg then continues up to the steep slopes until the Olifantsriver valley at the centre of the reserve (Cheney & Twist, 1986).

The geographical systems underlying the reserve has a diverse topography ranging from high lying areas with different slopes that give rise to mountain terrain with deep carved drainage lines (Figure 3.2). Eksteen (2003) explains that there are five geological formations found in the reserve and are included in the discussion:

3.1.1 Rooiberg Group: Rooiberg Group volcanics occurring in Loskop are 3.5 km thick (Schweitzer et al., 1995), even though, some of these are eroded in other areas (Buchanan et al., 2002). The Loskop formation is made of clastic sediments that has small volcanic intercalations and the Rooiberg Group overlies the eastern section of the reserve (Harmer & Armstrong, 2000). The rhyolite underlies the mountains to the north of the dam and reaches an elevation of about 1 420 m.a.s.l.

Rocks form a characteristic that produce and represents the structure of the original formation of lava with deep colour including reddish-brown.

- 3.1.2 Granophyre intrusions: Granophyric rocks in the Bushveld Complex are widely spread on top of the Rooiberg Volcanics. According to Walraven (1987), granophyre is represented by magma intrusions that have intruded just beneath the rhyolite roof on the Rooiberg Group. The rock underlies the koppies that forms part of the Lombards bay koppies. The rocks shows a brownish-red colour and when they weather, they form a sandy-clay soil (Walraven, 1987).
- 3.1.3 Loskop Formation: These are formations that are made of thick red beds that are 2.12 km (Martini, 1998; Jansen, 2006; Cheney & Twist, 1986). There are sandstones that lay between shale and conglomerate found on valley bottom. These sediments weathers to form sandy to sandy-loam soils that are common on hilltops and hillsides (Martini, 1998). The flat intrusion of igneous rocks are most extensively developed in the Waterberg and Middelburg basins in northern South Africa. They are typical fractionated gabbros and gabbro-norites, and largely andesite in composition (Bullen et al., 2012).
- 3.1.4 Waterberg Group: This group is distinguished by rough-reddish to purple sandstone and small patches of quartzite. Then between other layers of this group occur rocks such as Shale and Conglomerate. This group is also part of the eastern and south-eastern areas in LDNR (Eksteen, 2003).
- 3.1.5 Diabase/Dolerite - These rocks appear to be dense and dark in color. They are typically shallow intrusive bodies that weathers to form clayey soils (Eksteen, 2003).



**Figure 3.2:** Geology map of Loskop Dam Nature Reserve (Barrett, 2009).

### 3.2 SOIL

The varying geological substrate types results in the composition of different soil patterns and types that change over quite small intervals (Eksteen, 2003). Sandstone and Rhyolite are the underlying rocks that cause acidic soils. Soil types accommodate pedological landscapes that differ from a slope full of loose rocks at the base of a cliff to slopes with soils just below the narrow elevation of land, and very shallow soils on steeper slopes and ridges, to deeper soils in and around valley bottoms (Eksteen, 2003). Sandy to sandy-loam soils covers the Plateau areas, the soils are acidic (pH between 3.5 – 4.5) and foothills and valley floors characterized by sandy-loam to sandy clay soils with acidity (pH

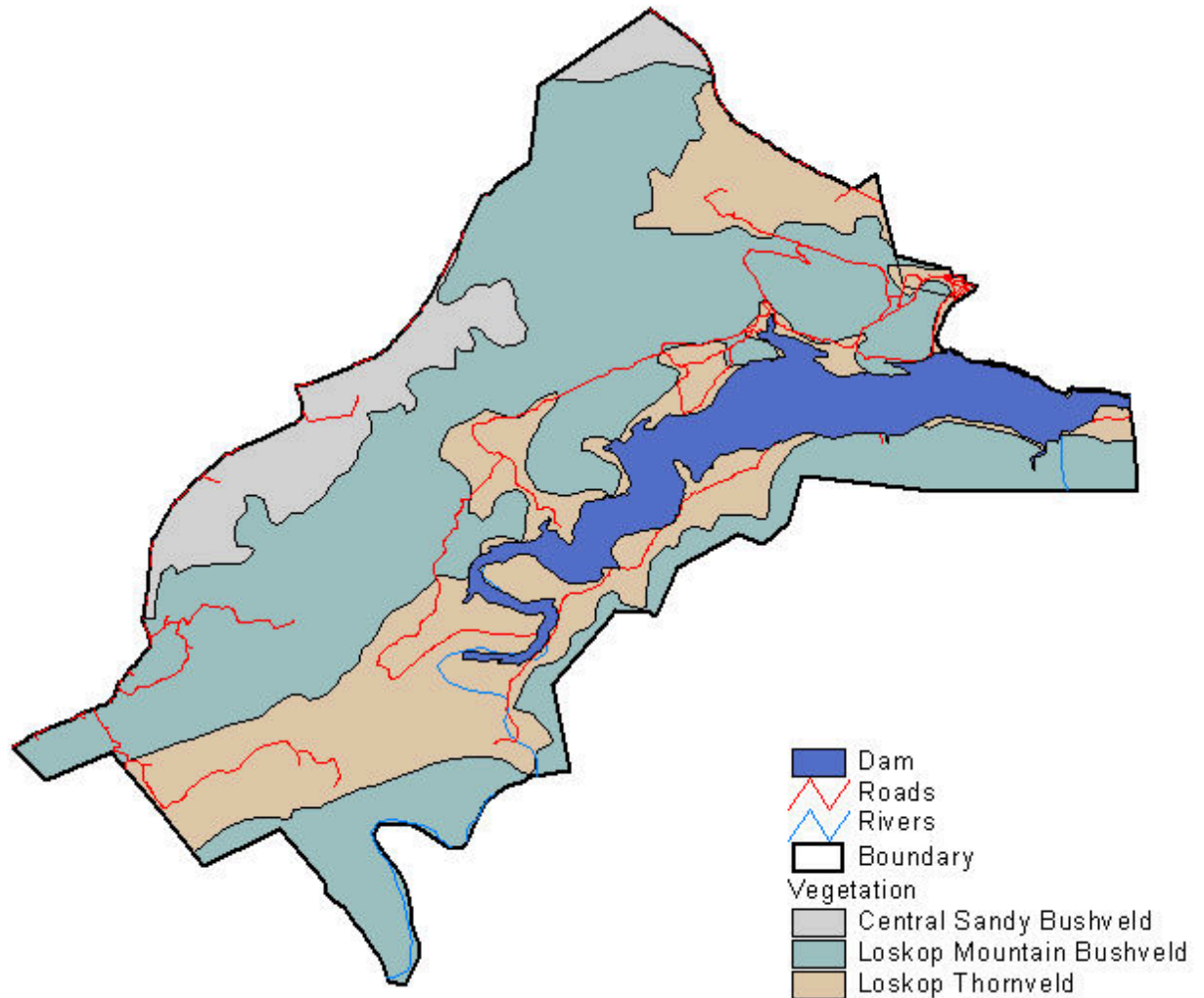
between 4.5 - 5.5) (Eksteen, 2003). Vegetation types found in the reserve are influenced by the type and depth of the soil (Eksteen, 2003).

### 3.3 VEGETATION

According to Rutherford & Westfall (1994), vegetation of the Loskop Dam Nature Reserve resembles both the Grassland and Savanna Biomes. Vegetation on the higher lying regions represent the Grassland Biome while the lower lying regions represent the Savanna Biome (Eksteen 2003). Emery et al., (2002) explained that there are ~1015 plant taxa listed for LDNR, with some common woody vegetation including *Combretum apiculatum*, *Burkea africana*, *Faurea saligna*, *Englerophytum magalismontanum* and *Vachellia caffra*. Threatened and highly localised endemic succulent *Haworthia koelmaniorum* also occurs on the reserve.

Originally Acocks (1988) classified the reserve's vegetation in the lower lying regions as Mixed Bushveld (Veldtype 18) and Sourish Mixed Bushveld (Veldtype 19) on the upper lying areas we find vegetation classified as Bankenveld (Veldtype 61). Subsequently Van Rooyen & Bredenkamp (1988) classified the reserve's vegetation on lower lying regions as Mixed Bushveld (Vegetation type 19) and on the higher lying areas the vegetation was classified as Rocky Highveld Grassland (Vegetation type 34)

Mucina & Rutherford (2006) recently classified the reserve's vegetation as Central Sandy Bushveld (SVcb 12), Loskop Mountain Bushveld (SVcb 13) and Loskop Thornveld (SVcb 14) (Figure 3.3). Various plant communities occur in the reserve, these are distinguished by various environmental factors such as different slopes, type of soils and altitude. Twenty-three different plant communities were classified by Theron (1973), these includes tree-savanna, shrub-savanna, woody thicket and hygrophilous communities and one of these is identified as old field.



**Figure 3.3:** Location of the Central Sandy Bushveld, Loskop Mountain Bushveld and Loskop Thornveld Vegetation Units within the reserve (Barrett, 2009).

### 3.4 FAUNA

According to Eksteen (2003), there are seventy species of mammals occurring in the reserve. These include the White rhino (*Ceratotherium simum*), Buffalo (*Syncerus caffer*), Oribi (*Ourebia ourebia*) and Sable antelope (*Hippotragus niger*). The mammal species that falls under threatened species include the African wild cat (*Felis silverstris* subsp. *lybica*), antbear (*Orycteropus afer*), African civet (*Civettictis civetta*), aardwolf (*Proteles cristata*), brown hyena (*Hyaena brunnea*), serval (*Leptailurus serval*) and leopard (*Panthera pardus*). The bird species occurring on the reserve are about three hundred

and seven and they include the Cape vulture (*Gyps coprotheres*), martial eagle (*Polemaetus bellicosus*), Stanley's bustard (*Neotis denhami*), Caspian tern (*Hydropogone caspia*), African finfoot (*Podica senegalensis*), bald ibis (*Geronticus eremita*), red-billed oxpecker (*Buphagus erythrorhynchus*) and the blue crane (*Anthropoides paradiseus*). A total of 42 reptile species, 19 amphibian species and 43 fish species are present in the reserve (Eksteen, 2003).

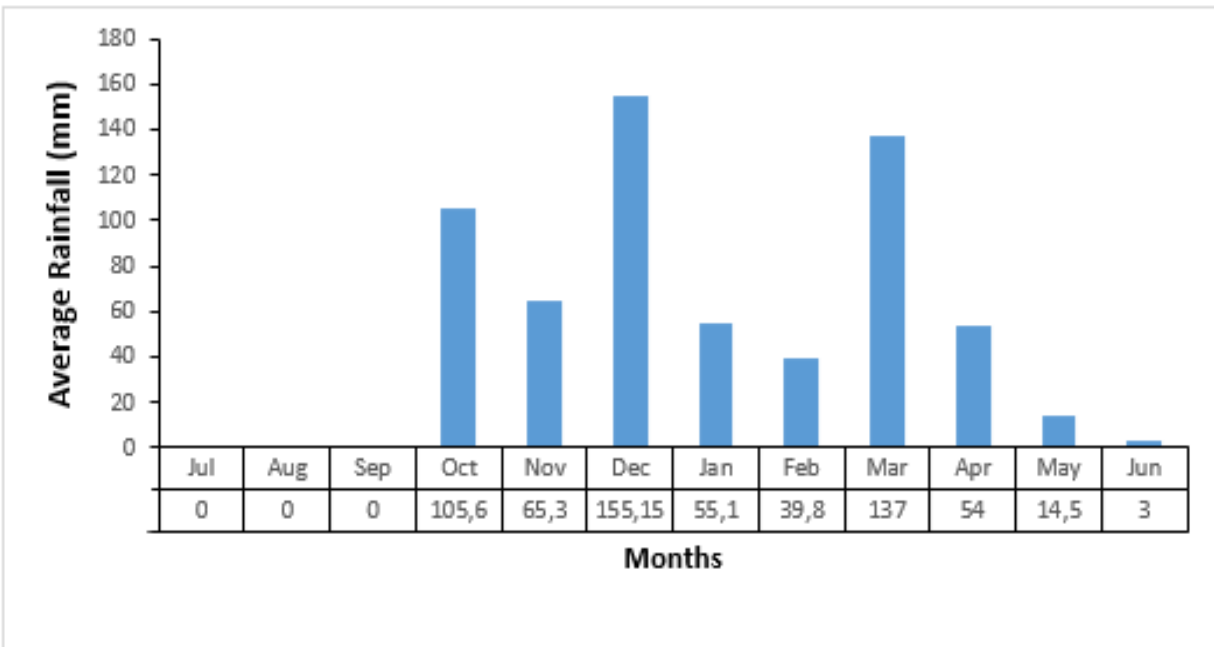
### **3.5 CLIMATE**

Climate is a primary factor influencing the distribution of vegetation and accompanying dependent wildlife in a specific region (Bond et al., 2003). The climate of the South African interior has been classified as semi-arid and along the east coast as sub-tropical, days are sunny and nights are cool. Being part of the summer rainfall region, the reserve receives mild to very hot (average of 21.6°C – 23.5°C) summers with moderate to cold (average of 11.6°C – 16.1°C) winters (Theron, 1973). During the wet season Loskop dam nature reserve receives rainfall during summer between November and April. Rainfall varies between showers to thunderstorms with strong lightning. Loskop dam nature reserve receives an average long-term rainfall of 650 mm annually and occurs between October and March. The higher lying areas experience a frost period that occurs between May and September and lower lying areas experience no frost.

#### **3.5.1 Rainfall**

Rainfall is the primary factor that determines savanna dynamics (Bredenkamp & Brown, 2006). The reserve has an annual mean long-term rainfall of 650 mm with summer rainfall occurring from November to April. This rainfall oftentimes occur as high intensity thunderstorms which are usually accompanied by strong lightning and strong winds (Eksteen, 2003). The reserve's average monthly rainfall for the study period (2018) is depicted in Figure 3.4. Results show that a maximum rainfall of 155.15 mm was recorded for December and a minimum of 0 mm was recorded in June, July, August and September. Average mean rainfall for LDNR over the study period was 629.5 mm. The

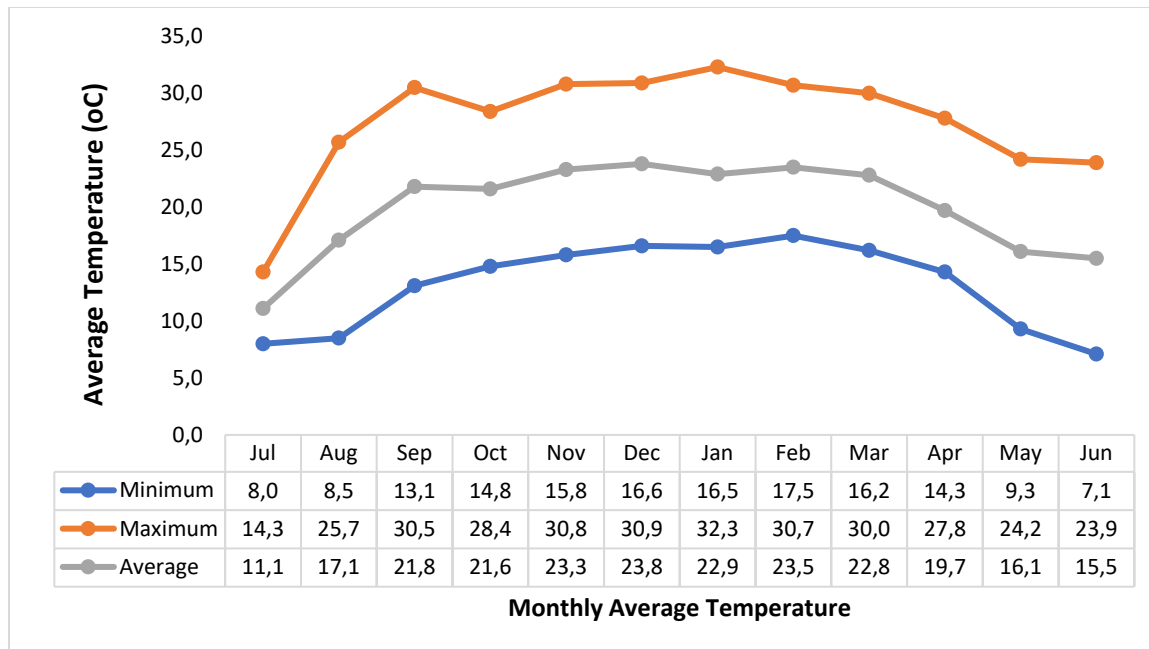
average rainfall collected from the reserve’s main office during 2010 – 2012 yielded 816 mm. This shows that the reserve has received less rainfall during the study period.



**Figure 3.4:** Loskop Dam Nature Reserve monthly rainfall figures for the study period (2018) recorded at the Loskop dam Nature Reserve admin office weather station.

### 3.5.2 Temperature

There are differences in temperature between higher lying areas and the lower lying areas. The higher lying areas are characterized by days of severe frost in winter whilst in the lower lying areas temperatures tend to drop to 3°C with no frost (Eksteen, 2003). These temperature variations are a result of the significant variations in the topography of the reserve. Temperatures recorded in the reserve for the study period (2018) are depicted in Figure 3.5.



**Figure 3.5:** Monthly average, minimum and maximum temperatures for the study period (2018) for Loskop Dam Nature Reserve.

Average maximum and minimum temperatures vary seasonally (winter and summer). The lowest average temperature was measured in June with a value of 7.1°C and the highest average temperature was in January with a value of 32.9°C

### 3.6. BROAD METHODOLOGY

The following is a broad description of the methodology followed in this study. The detailed methods used are described in each result chapter (Chapters 4, 5 & 6)

#### 3.6.1 Impala home range phytosociology

Vegetation surveys were done using the Braun-Blanquet sampling method (Westfall, 1984). Sampling plots were placed in a stratified random manner in the field to collect data. Vegetation data was classified using TWINSpan and described into different plant communities (Tichý, 2002).



### **3.6.2 Impala seasonal habitat utilisation and movement patterns**

Data from a GPS collared dominant Impala ram was used to determine seasonal daily movements and distances travelled. Spatial locations were extracted from the GPS data and used to delineate seasonal home ranges, as well as to determine habitat utilisation and habitat selection. Habitat utilisation data was analyzed using Ivlev's Electivity Index (Krebs & Singleton, 1993).

### **3.6.3 Impala herd daily activity budgets**

Impala ram, associated breeding herds in the ram's home range, and bachelor herds also in this ram's home range were followed during the wet and dry seasons for a 12-month (March 2019 – February 2020) period in the field to investigate social behaviour. Focal and scan sampling methods were used to collect Impala daily activity patterns and social behaviour (Ejigu et al., 2020). Daily activity patterns, date and time were recorded in the field. Data was analyzed using one-way Analysis of Variance (ANOVA) to compare the different activities. The detailed methods and analyses are presented in each results chapter.

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# **CHAPTER 4**

## **IMPALA HOME RANGE PHYTOSOCIOLOGY**

### **4.1 INTRODUCTION**

Vegetation plays an important role in all terrestrial ecosystems; therefore, every growth form and species are essential as they indicate the health of that specific ecosystem (Bredenkamp & Theron, 1976). Vegetation surveys, classification and mapping of an area form the basis where sustainable and justifiable scientific conclusions about the environment can be done (Brown et al., 2013). Plant communities provide important habitats and primary resources such as food and shelter for animals (Kent, 2011). Vegetation of an area is classified and described to provide important knowledge on the suitability of the area for different animal species (Brown & Bezuidenhout, 2018). Different groups of plant species growing together are defined as plant communities. According to Dansereau and Lems (1957), plant communities are the organization of individual plants in an area through their associations with other plants. The plant communities are classified and described according to types of growth forms, structure as well as cover abundance (Edward, 1983).

Plant communities are broad vegetation units characterized by specific plant species compositions and structures, that are influenced by various unique combinations of environmental factors (Kent, 2011). Habitats vary by means of their quality and quantity of forage availability offered in each particular season of the year (O'Donoghue et al., 2020) and as a result, they are utilized differently by a diversity of wildlife species (Kent, 2011; Brown et al., 2013). Each plant community is a representation of a unique ecosystem (Bredenkamp & Theron, 1976). It has often been demonstrated that different ecosystems in a particular area can be recognised by the delimitation of the plant communities within the area (Kuchler, 1973). According to Bredenkamp & Theron (1976),

plant communities are the important basic units of every ecosystem and studying these communities can contribute towards the compiling of management programmes.

Ecosystems do not react the same towards particular management practices such as grazing or burning. According to Timberlake et al. (1993), an understanding of the vegetation of an area gives good insight into the biological potential of that area. Some land uses depend directly on the vegetation resource (for example, grazing), and in this case an inventory of vegetation is of great importance (Timberlake et al., 1993).

Knowledge on vegetation is essential to assist in planning how to resolve and manage ecological problems in conservation areas. This provides the means of monitoring the conservation and management operations and also provide information on how to predict the changes that may happen in the plant species composition and distribution (Kent, 2011). According to Blüthgen et al. (2016), the stability of ecosystems depends on the populations of plant and animal communities that contribute to its ecosystem functioning. It is therefore important that animal utilization of various plant communities be studied to make scientifically based management decisions and conclusions and decide on the best way to manage the plant communities and animal populations.

There is not much known about the habitat utilisation and daily movement patterns of Impala (*Aepyceros melampus*) at Loskop Dam Nature Reserve and no formal study investigating their movement patterns has been conducted to date. Impalas are gregarious animals that are mostly associated with woodland areas while they generally avoid grassland (Skinner & Chimimba, 2005). They feed selectively in the wet season and when the food quality starts to decline as the dry season approaches, and in the dry season, they mainly feed on broad-leaved plants (Bothma & Du Toit, 2016). Part of this study is to determine the movement and habitat utilisation of Impala at Loskopdam Nature Reserve, the plant communities found in the home range of a collared Impala ram was studied.

The main objective in this chapter is to determine, classify and describe plant communities within the home range of the Impala ram and associated Impala social groupings (breeding and bachelor herds) found within their home range. This was done to obtain better knowledge and understanding of the plant species assemblages in different vegetation types available to the Impala within their home range (Siebert et al., 2003). According to Rouget et al. (2004), knowledge obtained from vegetation description and classification provides a clear understanding of the biodiversity of the area which includes species of animals, birds, insects, and other organisms found within each plant community (Nkosi et al., 2016).

## **4.2 METHODS**

### **4.2.1 Vegetation sampling site selection**

The different plant communities occurring within the Impala home range were delineated into relatively homogeneous physiographic-physiognomic units using Google Earth and QGIS. The Zürich-Montpellier method (Kent, 2011) was followed to identify, classify and describe the plant communities present within the home range area of the Impala. Stratified random placement of 39 vegetation sampling plots was done within the delineated areas to ensure that sample plots were placed in representative areas of the perceived plant communities (Brown et al., 2013).

### **4.2.2 Floristic data**

Data were collected during the 2018 wet season. Sample plot size was 20 x 20 m (400 m<sup>2</sup>) following Brown et al. (2013). Three plots were placed in each delineated unit. In the event that the randomly selected sampling plots were appearing to be out of the homogenous delineation plant stand were taken to the closest location with the same criteria (Brown et al., 2013). The GPS coordinates for each sampled plot were recorded.

Floristic data was recorded in each of the plots and included species composition, growth form (Mueller-Dombois & Ellenberg, 1974), and ground cover percentage for all species was estimated using the Old Braun-Blanquet cover abundance scale (Westfall, 1981) (Table 4.1). The woody vegetation was split into three height classes the lower (0–1 m), middle (>1–3 m) and upper (>3 m) in accordance with Brown & Bredenkamp (2004).

**Table 4.1:** Modified Braun-Blanquet cover abundance scale (Westfall, 1981).

SCALE	DESCRIPTION
r	One or a few individuals with less than 1% cover of the plot area
+	Species occur occasionally with less than 1% cover of the total area of the plot
1	Abundant, but with low cover or less abundant but with greater cover, but less than 5% of the total plot area (single individuals)
2	Abundant, but with 5-25% cover of the total plot area
3	25-50% cover of the total plot area irrelevant of amount of individuals (small clumps)
4	50-75% cover of the total area of the plot, irrespective of amount of individuals (extensive matts/clumps)
5	75-100% cover of the total area, irrespective of amount of individuals (continuous populations)

Within the 400 m<sup>2</sup> sample plot we randomly selected a series of ten (10) 1 x 1 m (1 m<sup>2</sup>) subplots where grasses were identified and recorded the total number of individual grasses for each species. Within each 400 m<sup>2</sup> plot we also identified and counted all the tree species and their percentage ground cover. A woody plant was sampled only if its base centre fell within a plot. Woody plants with several stems were included in the sample if a section of the canopy fell in the plot sampled. Every effort was made to correctly identify plants in the field.

### 4.2.3 Environmental variables

We also collected data on habitat variables for each sampling site by observing signs of tracks, trampling, dung, foraging, soil erosion (according to the modified soil erosion classification - Fitzpatrick et al., (1994) (Table 4.2)), and signs of previous veld fires.

**Table 4.2:** Modified soil erosion classification (Fitzpatrick et al., 1994).

Class	Description
1	No erosion or very little sheet erosion
2	Moderate loss of topsoil and/or some slight dissection by run-off channels or gullies
3	Severe loss of topsoil and/or marked dissection by run-off channels or gullies
4	Total loss of topsoil and exposure of sub-soil and/or deep intricate dissection by gullies

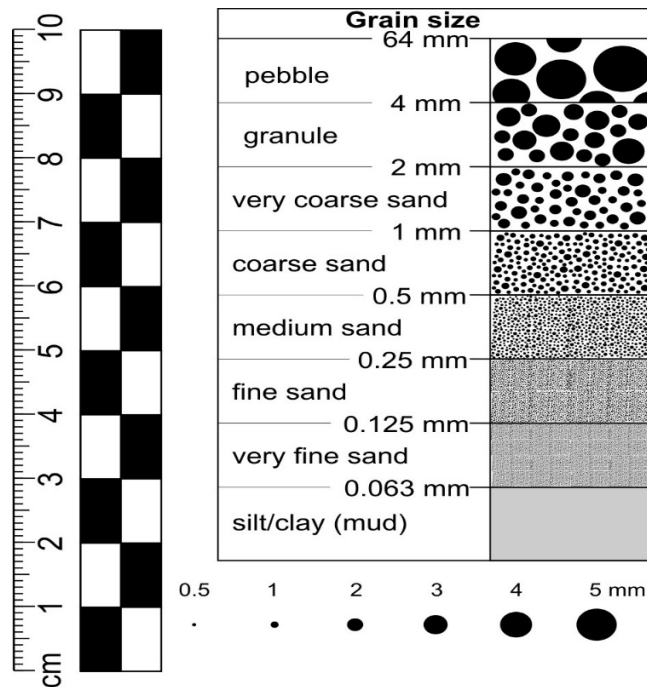
Environmental parameters were also collected and included altitude (m), aspect/slope (degrees) (Table 4.3), topographic unit (crest and upper midslope identified for this study), surface rock cover (%) and a general description of the underlying soil substrate (loam, sand, clay or gravel) (Westfall, 1981).



**Table 4.3:** Modified slope unit classification (Westfall, 1981).

Symbol	Description	Slope Class
L	Level	0° - 3°
G	Gentle	4° - 9°
M	Moderate	10° - 15°
S	Steep	16° - 25°
VS	Very steep	26° - 55°

There are several fairly accurate methods to measure grain sizes like sieve analysis and counting on thin sections. In the field, we estimated grain size through a visual comparison with grain size charts in figure 4.1 below. This chart is normally centred on the sand grain sizes, which measures the gravel or sand using rulers or measuring tapes (Blott & Pye, 2012).



**Figure 4.1:** Chart for a visual estimation of grain size, centred on sand classes (Blott & Pye, 2012).

#### 4.2.4 Vegetation classification and analysis

The TURBOVEG software programme (Hennekens, 1996) was used to capture the floristic data from where it was exported to the JUICE 7.1 software program (Tichý & Holt, 2006) for analysis. JUICE is a multifunctional editor specifically designed for phytosociological tables (Tichý, 2002). A hierarchical classification of the vegetation of the home range was obtained using the modified TWINSpan. Pseudospecies cut levels were set at 0–5–15–25–50–75 while the phi coefficient of association was used to determine fidelity. The resultant phytosociological table was refined according to Braun-Blanquet procedures to make interpretation and description of the data more understandable. The plant communities were named according to the dominant trees and shrubs as well as the indicator grass species and the structure of the woody layer as described by Brown et al. (2013).

#### 4.2.5 Tree density

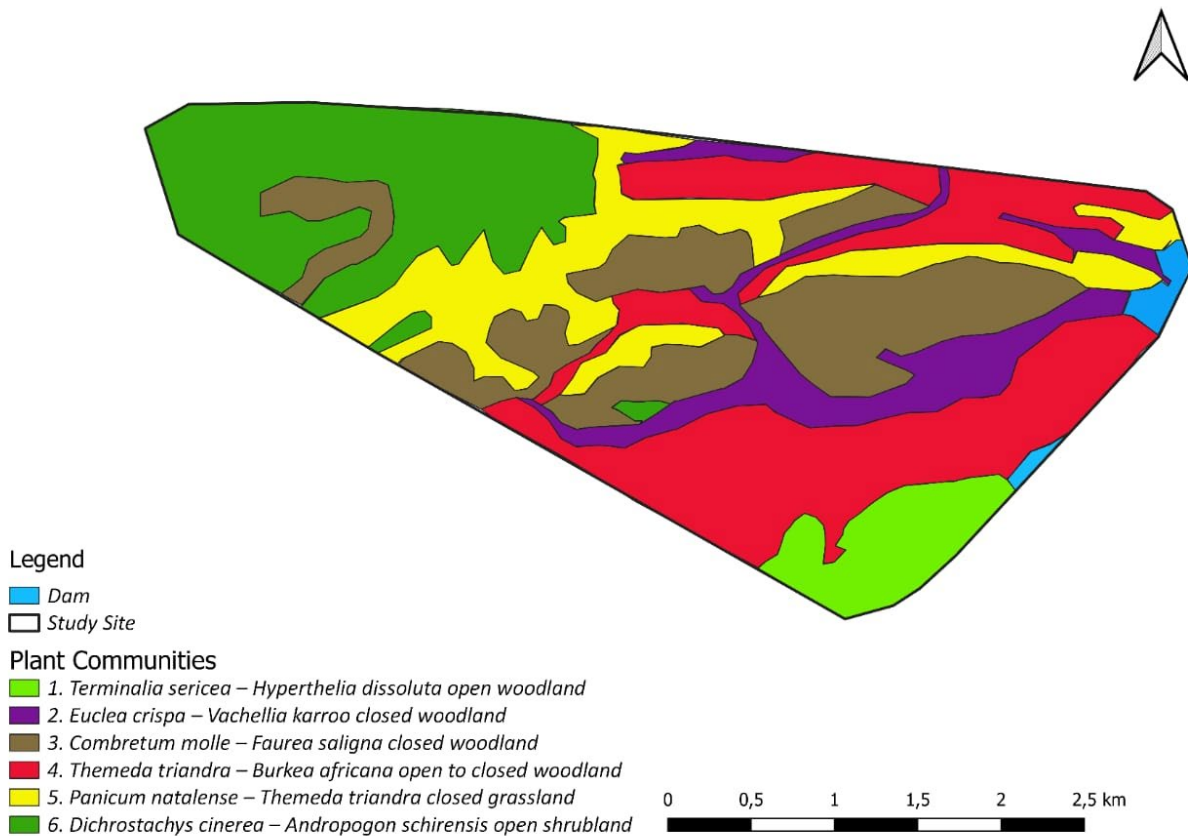
Density refers to the number of individuals per unit area; in this study it is the number of individual plants per hectare (Mueller-Dombois & Ellenberg, 1974). Density of trees per height class in all plant communities was calculated and expressed as individuals per hectare (ind/ha) using the following formula.

$$\text{Woody density} = \frac{\text{Total number of woody plants per plot}}{\text{Total size of sample plots (m}^2\text{)}} \times 10\,000$$

## 4.3 RESULTS

### 4.3.1 Description of the plant communities within the Impala home range

The results from this phytosociological analysis show that there are six major plant communities identified and classified (Figure 4.2 and Table 4.4). The description of these plant communities includes characteristic species and important and less conspicuous woody and grass species in the Impala's home range. Three structural vegetation units identified in the study area are woodlands, shrublands and grasslands (Table 4.4). All reference to plant species groups refers to Table 4.4.



**Figure 4.2:** Vegetation map for the home range of a herd of Impala (*Aepyceros melampus*).

**Table 4.4:** Phytosociological table for the Impala home range.

Plant Community Number	1			2							3								4			5						6												
Relevé Number	37	38	39	5	34	29	7	8	36	30	35	18	19	13	12	10	21	15	17	20	14	11	33	3	28	26	6	16	31	25	27	24	9	4	22	23	1	32	2	
<b>Species group A</b>																																								
<i>Hyperthelia dissoluta</i>	5	3	3	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
<i>Terminalia sericea</i>	2	3	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Cyperus denudatus</i>	3	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Conyza albida</i>	+	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Eragrostis gummiflua</i>	2	3	2	.	.	.	.	2	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.
<i>Eragrostis pallens</i>	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Pseudognaphalium undulatum</i>	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Perotis patens</i>	r	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Eragrostis hiemiana</i>	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Felicia muricata</i>	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Gnidia microcephala</i>	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Wahlenbergia species</i>	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Waltheria indica</i>	r	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<b>Species group B</b>																																								
<i>Vachellia karroo</i>	.	.	.	2	.	2	2	2	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Euclea crispa</i>	.	.	.	2	2	2	2	.	2	2	2	.	.	.	.	1	1	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.
<i>Searsia pyroides</i>	.	.	.	.	1	1	.	.	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Eragrostis superba</i>	.	.	.	.	.	1	2	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Grewia bicolor</i>	.	.	.	.	.	2	.	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
<i>Aristida canescens</i>	.	.	.	.	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Digitaria eriantha</i>	.	1	+	.	.	.	.	2	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
<i>Pogonathria squarrosa</i>	1	3	4	.	2	2	2	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
<i>Tristachya leucothrix</i>	.	.	.	.	.	.	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	2	.	.	2	.	.	.	.	.	.	.	.	.	.
<i>Dovyalis caffra</i>	.	.	.	2	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.



Species group G																																				
<i>Combretum molle</i>	. . . . .	2	2	2	2	2	2	. 2	1	1	2	2	. . . . .	2	. 1	2	2	. 1	2																	
<i>Aristida diffusa</i>	. . . . .	2	. . . . .	. . . . .	2	. . . . .	. . . . .	2	. . . . .	. . . . .	. 1	2	2	. . . . .	2	3	2	. . . . .	2	2	2	2	2	2	. . . . .											
<i>Cymbopogon validus</i>	. . . . .	. . . . .	2	. . . . .	. . . . .	. . . . .	. . . . .	1	2	. . . . .	. . . . .	. . . . .	2	2	2	2	2	2	1	2	2	. 1	2	2	1	2										
<i>Eragrostis trichophora</i>	. . . . .	. . . . .	. . . . .	. . . . .	2	. . . . .	. . . . .	2	. . . . .	3	. . . . .	2	2	. . . . .	2	2	2	2	1	2	. 2	. 2	2	2	2											
<i>Eustachys paspaloides</i>	. . . . .	. . . . .	. . . . .	2	. . . . .	. . . . .	2	. 3	. 2	2	2	2	1	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	1	. . . . .	1	2	2	. 2	2											
<i>Faurea saligna</i>	. . . . .	. . . . .	. . . . .	. . . . .	2	. . . . .	2	. 2	2	. 2	2	1	2	2	2	. . . . .	. . . . .	1	2	. . . . .	. . . . .	2	1	. . . . .	2	. 2	. . . . .									
Species group H																																				
<i>Themeda triandra</i>	. . . . .	. 3	2	2	. 2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	. 2	2	2	2	2	2	2		
<i>Setaria sphacelata</i> <i>var. sphacelata</i>	. . . . .	. 2	2	2	3	3	3	3	2	2	3	2	2	2	2	2	3	2	. 2	2	2	2	2	2	2	2	2	2	2	3	. 2	2	2	3	2	2
<i>Senegalia caffra</i>	. . . . .	. 2	1	2	. 2	2	1	2	2	. 1	2	1	. 2	1	1	2	. . . . .	. . . . .	1	. . . . .	. . . . .	. 2	1	2	. . . . .	. 2	1	2	. . . . .	. 2	1	. . . . .				
<i>Dichrostachy cinerea</i>	. . . . .	2	2	2	1	. 2	. . . . .	. . . . .	1	. . . . .	. 1	. 1	. . . . .	2	2	1	. . . . .	1	. 1	. . . . .	2	1	. 2	2	2	2	2									
<i>Aristida congesta</i> <i>subsp. barbicollis</i>	. . . . .	. . . . .	2	2	2	2	2	2	. . . . .	2	. . . . .	. 2	. . . . .	. . . . .	2	. . . . .	. 2	2	2	2	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. 1	. . . . .									
<i>Dombeya rotundifolia</i>	. . . . .	. 2	2	2	2	2	2	2	2	2	1	2	1	2	1	1	. 2	1	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. 1	2	. . . . .								
<i>Eragrostis chloromelas</i>	. . . . .	. 2	2	2	2	2	. 2	. . . . .	2	2	. 2	. 2	. . . . .	3	. . . . .	. . . . .	2	2	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. 2	2	. . . . .									
<i>Searsia leptodictya</i>	. . . . .	1	1	2	1	1	2	. 2	. . . . .	2	. 1	. . . . .	2	1	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	1	. . . . .	. . . . .	. . . . .											
<i>Triraphis adropogonoides</i>	. . . . .	. . . . .	2	. 2	. . . . .	. . . . .	. . . . .	1	2	2	. 2	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	2	. . . . .	. . . . .	. . . . .	2	. 2	2	2	1	2										
<i>Lanana discolor</i>	. . . . .	1	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	1	1	. 1	. 2	. . . . .	. 2	1	. . . . .	. . . . .	1	. . . . .	. . . . .	. . . . .	2	2	1	. 1	. . . . .											
<i>Aristida adscensionis</i>	. . . . .	. . . . .	2	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. 1	. . . . .	. . . . .	. . . . .	. . . . .	1	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. 2	. 1	. . . . .													
<i>Brachiaria brizantha</i>	. . . . .	. . . . .	2	2	. . . . .	2	. . . . .	. . . . .	2	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	2	. . . . .	2	. 3	. . . . .											
<i>Combretum apiculatum</i>	. . . . .	2	. . . . .	. . . . .	2	. 1	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	2	2	2	. . . . .	1	. 1	. . . . .	. . . . .	. . . . .	2	2	. 2	. . . . .										
<i>Combretum zeyheri</i>	. . . . .	. . . . .	2	. . . . .	. . . . .	1	2	. 1	. . . . .	. . . . .	. 1	. . . . .	. . . . .	. . . . .	2	. . . . .	. . . . .	1	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .												
<i>Panicum maximum</i>	. . . . .	. 2	2	. . . . .	. . . . .	. . . . .	. . . . .	2	2	. . . . .	. . . . .	. . . . .	. . . . .	2	. . . . .	. . . . .	. . . . .	. . . . .	2	2	. . . . .	3	. . . . .													
<i>Ziziphus mucronata</i>	. . . . .	1	. . . . .	. . . . .	1	. 1	1	2	. . . . .	2	1	. . . . .	. . . . .	. . . . .	. . . . .	. 1	. . . . .	. . . . .	. . . . .	1	. . . . .	. 2	. . . . .													
<i>Diplorhynchus condylocarpon</i>	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	2	1	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	2	. 1	. . . . .												
<i>Eragrostis cilianensis</i>	. . . . .	. . . . .	1	2	. . . . .	p	. . . . .	. . . . .	3	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	2	. . . . .	. 2	. . . . .	. . . . .	. . . . .	2	. . . . .														



### 4.3.2 Vegetation structures identified for the study area

The different plant communities can be grouped into three broad vegetation structural classes, namely woodlands, shrublands and grasslands (Table 4.5).

**Table 4.5:** Vegetation structural classes identified for the study area.

Structural Type	Plant Community	Size (Ha)
Woodland	1, 2, 3 & 4	1 741
Grassland	5	420
Shrubland	6	277

### 4.3.3 Description of plant communities

#### 1. *Terminalia sericea*–*Hyperthelia dissoluta* open woodland

This plant community is situated on a foot-slope close to the Loskop dam at an altitude between 1 010 and 1 015 m.a.s.l. (Figure 4.2). The slope varies from 4° – 9°, soils are silty (0.002 – 0.050 mm) with slight erosion (class 2) and rockiness between 5% and 15%, with rock size varying from 10 – 200 mm. The area is easily accessed by animals, with tree cover for the upper height class (> 3 m) being more than 10%, middle height class (1 – 3 m) between 15% and 25%, and the lower height class (0 – 1 m) between 10% and 25%. Grass cover ranges between 25% and 65% and forb cover between 10% and 40%. This community is defined by three sample plots which are characterised by species from species group A.

This open woodland community is dominated by *Terminalia sericea* (species group A) with heights that vary between 1 m to 3 m with a canopy cover between 10% and 30%. The grass layer is dominated by *Hyperthelia dissoluta* and comprises medium to tall grasses which also includes *Eragrostis gummiflua*, *Eragrostis pallens* (species group A), *Pogonarthria squarrosa* (species group B) and *Schizachyrium sanguineum* (species group I). The most prominent sedge is *Cyperus denudatus* and forb as



*Pseudognaphalium undulatum* (species group A). At the edge of this community, leading down towards the dam (the flood plain), the vegetation becomes shorter and drier, and the grass layer becomes less dense. There is evidence of previous fires in the community, with minimal damage to large trees. Signs of dung and moderate trampling are prevalent throughout the community.

## **2. *Euclea crispa*–*Vachellia karroo* closed woodland**

This is a closed woodland plant community found on gentle slopes with a gradient of 0° - 3°. It is located at elevations between 1 020 and 1 050 m.a.s.l. (Fig. 4.2). Rocky outcrops cover between 0% and 2%, with rock size being just smaller than 10 mm. Sample plots have silt soils (0.002 – 0.050 mm). Soils are slightly eroded (class 1). The average height of the woody layer varies from 1 m to >3 m. Upper height class tree cover (>3 m) was estimated between 15% and 20%, middle height class tree cover (1 – 3 m) between 10% and 25%, lower height class tree cover (0 –1 m) between 10% and 30%, grass cover ranged between 55% and 80%, and herbaceous cover between 4% and 20%.

Species from species group B are characteristic for this plant community, which is represented by eight (8) sampling plots. The woody layer is dominated by *Vachellia karroo* and *Euclea crispa* (species group B), while the grass layer is dominated by *Pogonarthria squarrosa* (species group B), *Themeda triandra* and *Setaria sphacelata* var. *sphacelata* (species group H). The grasses *Eragrostis superba* (species group B), and *Eragrostis chloromelas* (species group H) were also present. Moderate trampling was observed with wildlife tracks, dung and foraging signs evident. There was evidence of an old fire with minimal damage.

## **3. *Combretum molle*–*Faurea saligna* closed woodland**

This closed woodland plant community is distinguished by the presence of species from species group C (Table 1). It is found on a very steep mid-slope, with the gradient varying from 26° - 55°. It occurs at an elevation ranging between 1 210 and 1 260 m.a.s.l. (Figure

4.2). Rock cover varies between 15% and 35%, and rock size is between 10 – 200 mm. The soil type found is silt (0.002 – 0.050 mm). Slight erosion (class 2) occurs in some areas. The upper height class tree layer (>3 m) cover varies between 20% and 40%, middle height class tree cover (1 – 3 m) between 15% and 35% and lower height class tree cover (0 – 1 m) between 15% and 30%. Grass cover is estimated between 10% and 70% of the area and the herbaceous layer covers between 10% and 20% of the plant community.

A total of ten (10) sampling plots defines this plant community. Characteristic species found in this plant community include the woody species *Rhoicissus tridentata*, *Englerophytum magalismontanum*, *Berchemia zeyheri*, the grasses *Setaria lindenbergiana*, *Hyparrhenia tamba* and *Urelytrum agropyroides* (species group C). The area is difficult to access, and the vegetation layers are well-developed with the woody layer varying from open to dense. Wildlife signs observed include tracks, dung, foraging and moderate trampling, with little sign of fire damage observed.

#### **4. *Themeda triandra*–*Burkea africana* open to closed woodland**

The *Themeda triandra*-*Burkea africana* open to closed woodland (Figure 4.2) is mainly located on the foot-slopes of the Loskop mountains with a gradient between 8° - 16°. The elevation ranges between 1 036 and 1 290 m.a.s.l. This plant community occurs on sandy soils (0.050 – 2.000 mm) with slight erosion (Class 2) evident. Rockiness varies between 5% and 55%; rock sizes range between 10 mm and >200 mm. The woody vegetation canopy cover is represented by large, medium and lower height classes (1 – 3 m and >3 m). Upper height class (>3 m) tree cover ranges between 10% and 40%, middle height class tree cover (1 – 3 m) between 5% and 15% and lower height class tree cover (0 – 1 m) between 5% and 25%. Grass cover ranges from 20% to 65%, and the herbaceous layer covers between 5% and 25% of the plant community.

This plant community is represented by three (3) sampling plots. The vegetation in this community is characterised by the presence of species from species group D and is

dominated by the grasses *Themeda triandra* (species group D), *Loudetia simplex* (species group I) and the trees *Burkea africana* (species group D) and *Combretum apiculatum* (species group H). Prominent plant species include the grasses *Enneapogon desvauxii* (species group D), *Setaria sphacelata* var. *sphacelata*, *Eragrostis trichophora* (species group G) *Eragrostis chloromelas* (species group H), *Diheteropogon amplexans*, *Melinis repens* (species group I) and the trees *Dombeya rotundifolia*, *Dichrostachys cinerea*, and *Diplorhynchus condylocarpon* (species group H). There is evidence of previous fire damage that is minimal. Moderate trampling was observed, and signs of wildlife were observed including foraging, dung and tracks/paths.

##### **5. *Panicum natalense*–*Themeda triandra* closed grassland**

This plant community is found at elevations between 1 022 and 1 345 m.a.s.l. (Figure 4.2). It is an exposed community located on the crest of the top of the Loskop mountains with slope gradients ranging between 26° - 55°. The soils in this area are shallow and sandy (0.050 – 2.000 mm) with slight erosion and rock cover ranging between 15% to 25%. Rock sizes vary between 10 mm and >20 mm. Accessibility in this plant community is moderate to difficult. The estimated tree cover varies between 0% and 5%, with upper height class trees covering 5%, middle height class trees (1 – 3 m) covering 2% and lower height class trees (0 – 1 m) covering 3% of the plant community. Grass cover ranges between 60% and 80% and the herbaceous layer covers between 5% and 10% of the plant community.

This plant community comprises seven (7) sample plots. Species from species group E are characteristic species for this community. The vegetation is dominated by a variety of species namely the grasses *Themeda triandra*, *Setaria sphacelata* (species group H), *Cymbopogon validus* (species group G), *Loudetia simplex*, *Melinis repens* and *Schizachyrium sanguineum* (species group I). Other species prominent in this area include the grasses *Panicum natalense* (species group E), *Eragrostis trichophora* (species group G), *Aristida congesta* subsp. *barbicollis* and *Heteropogon contortus* (species group I). Wildlife tracks, dung, and signs of foraging were observed with

moderate trampling also being evident. There was evidence of previous fires with minimal damage.

## **6. *Dichrostachys cinerea*–*Andropogon schirensis* open shrubland**

The *Dichrostachys cinerea*-*Andropogon schirensis* open shrubland community is located on slopes varying between 8° – 16°. The community is exposed on mid-slopes in mountainous areas. The altitude ranges between 1 202 and 1 155 m.a.s.l. Soils are mainly fine and silty (0.002 – 0.050 mm), while the rock cover ranges between 10% and 35%, with rock sizes between 10 and >200 mm. Woody species in the upper height class occurring in this community cover between 15% and 20% of the area, middle height class trees (1 – 3 m) between 10% and 25%, and lower height class cover (0 – 1 m) between 10% and 35%. Grass cover ranges between 20% and 35%, and the herbaceous layer covers between 5% and 25% of the plant community.

Eight (8) sampling plots were placed out in this community that is defined by the presence of species from species group F and species group H. The vegetation in this community is dominated by the woody species *Dichrostachys cinerea* (species group H), which is represented by all height classes, and the grass species *Andropogon schirensis* (species group F). Other prominent species include the trees *Combretum molle*, *Faurea saligna*, (species group G), *Senegalia caffra* and *Lannea discolor* (species group H), and the grasses *Cymbopogon validus* (species group G), *Setaria sphacelata* var. *sphacelata*, *Themeda triandra*, *Triraphis andropogonoides* (species group H), *Melinis repens* and *Schizachyrium sanguineum* (species group I). Foraging, dung and tracks with moderate trampling was evident in this community.

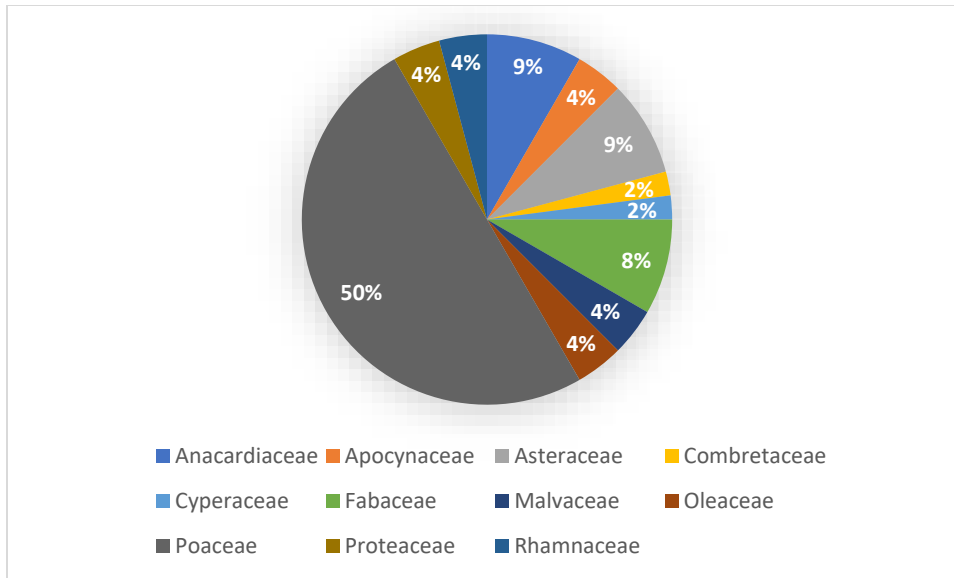
### **4.3.4 Plant families**

The Impala home range had 93 plant species that were represented by 66 genera and 29 families. All plant families occurring in the home range are shown alphabetically in Table 4.6.

**Table 4.6:** Plant families identified in the study area indicating the number of genera and species in each family.

<b>29 Families 66 Genera 93 Species</b>		
<b>Family</b>	<b>Genera</b>	<b>Species</b>
Amaranthaceae	1	1
Anacardiaceae	4	5
Apocynaceae	2	2
Asteraceae	4	4
Campanulaceae	1	1
Caryophyllaceae	1	1
Cleomaceae	1	1
Combretaceae	1	3
Cyperaceae	1	2
Ebenaceae	1	1
Euphorbiaceae	1	1
Fabaceae	4	5
Loganiaceae	1	1
Malvaceae	2	3
Oleaceae	2	2
Orobanchaceae	1	1
Pedaliaceae	1	1
Poaceae	24	45
Proteaceae	2	2
Rhamnaceae	2	2
Rubiaceae	1	1
Salicaceae	1	1
Sapindaceae	1	1
Sapotaceae	1	1
Thymelaeaceae	1	1
Vitaceae	1	1
<b>Total</b>	<b>66</b>	<b>93</b>

The largest plant families in the study area are indicated in Figure 4.3. These eleven families comprise 79 species from 48 genera.



**Figure 4.3:** Dominant plant families reflected as a percentage of the total flora in the Impala home range.

#### 4.3.5 Woody species density

Communities 1 and 2 had the highest woody species density with 1 766 ind/ha and 1 726 ind/ha respectively. As expected, the grassland vegetation (community 5) had the lowest woody species density (Table 4.7).

**Table 4.7:** Woody plants species densities for the plant communities found in the Impala home range.

Plant Community Number	<u>Woody Species Densities (Ind/ha)</u>			Total
	Upper Class	Medium Class	Lower Class	
1	816	734	216	1 766
2	400	858	417	1 675
3	365	646	715	1 726
4	425	442	508	1 375
5	108	167	17	292
6	390	355	255	1 000

#### 4.4 DISCUSSION

Vegetation characteristics are a key component of common territories, administering the dissemination of herbivores (Van Rooyen et al., 1991; du Toit, 1995). Plant-herbivore relationships keep up the fundamental balance between herbivory and vegetation recovery (du Toit et al., 1990; Skarpe, 1991; O'Connor, 1994).

There was a clear difference between the six (6) distinct plant communities occurring within the Impala home range. Three structural vegetation classes were identified as discussed earlier, namely woodlands, grasslands and shrublands. Vegetation in the home range was heterogeneous and comprised of 94 different plant species (Table 4.1). The plant communities had little or no signs of disturbance with few encroacher species present.

According to various authors (Bredenkamp & Brown, 2003; Van Staden et al., 2021), habitat variables such as topography, geology, land type, altitude, soil type, rockiness, aspect, fire and evidence of erosion play an imperative role in characterizing the species composition and structure of plant communities. In the home range of the Impala, each plant community was characterized by the occurrence of such habitat variables and environmental factors.

An overall contribution to the management of the reserve can be made from evaluating the woody strata to assess the browsing capacity and possibilities of bush encroachment (Brown & Bredenkamp, 1994). Woody species contribute to the structure and function of savanna ecosystems (Belsky, 1994). They are important for management decision making and if not managed correctly, may lead to woody species densification within the plant communities. According to Owen-Smith (1988), trees that are taller than 3 m are less impacted by fire and are accessible to large herbivores such as giraffe and elephant only.

Essential determinants that impact the structure and vegetation densities of savannas are climate and soil, whereas auxiliary determinants include herbivore impact and fires

(Teague & Smit, 1992). The auxiliary determinants may be overseen and adjusted directly through the exclusion of fires and increased stocking rates (Filmlalter, 2010).

#### 4.4.1 The woody layer

Community 1, (*Terminalia sericea*–*Hyperthelia dissoluta* open woodland) and community 4, (*Themeda triandra*–*Burkea africana* open to closed woodland) are open woodlands with a total woody density of 1 766 ind/ha and 1 375 ind/ha respectively. Predominant species in these communities include the seedlings of *Terminalia sericea* and *Burkea africana*. The high number of woody plant species in the lower height class for community 1 is a cause of concern as it may lead to bush densification and eventual loss of veld condition that would negatively affect grazing for antelopes.

The closed woodland communities 2, (*Euclea crispa*–*Vachellia karroo*) and 3, (*Combretum molle*–*Faurea saligna*) had woody species densities of 1 675 ind/ha and 1 726 ind/ha respectively. The woody plants with the highest density in plant community 2 were *Euclea crispa* and *Vachellia karroo* while for community 3 *Rhoicissus tridentata*, *Englerophytum magalismontanum* and *Berchemia zeyheri*, had the highest densities. *Combretum molle* and *Faurea saligna* are also found in community 3. All these species are typical of warm sheltered rocky slopes and hills where they normally occur in dense stands and are mostly associated with quartzite formations (Palgrave, 2002). *Faurea saligna* is an indicator species of well-drained, sour veld with nutrient poor soils (Schmidt, et al., 2002).

Community 2, (*Euclea crispa*–*Vachellia karroo* closed woodland) had 1 675 ind/ha with most (858 ind/ha) individuals within the middle height class (Table 4.7). This community is dominated by the tree *Vachellia karroo*, which according to Van Oudtshoorn (2012) occurs in sweetveld, where it is often associated with the climax grass *Themeda triandra* that provides good grazing. The veld condition of these dense plant communities could be negatively affected should they become denser. According to Brown (1997), bushveld



vegetation with woody vegetation densities higher than 1 800 ind/ha could negatively affect veld condition.

Community 5 (*Panicum natalense*–*Themeda triandra* closed grassland) and community 6 (*Dichrostachys cinerea*–*Andropogon schirensis* open shrubland), are the communities with the lowest woody species densities recorded in the study area. The total density for communities 5 and 6 is 292 ind/ha and 1 000 ind/ha respectively. *Faurea saligna* and *Combretum mole* had high densities in communities 5 and 6, while *Dichrostachys cinerea* is also found in high densities in community 6. *Englerophytum magalismontanum*, *Ximenia caffra* and *Lanena discolor* are also present in community 6.

#### 4.4.2 Grass Layer

According to du Plessis et al. (1998), the ecological status of grass species (Increasers and Decreasers) is used for calculating veld condition scores. Veld condition refers to how good or poor the vegetation is in connection to some functional characteristic, for example, maximum forage production potential and resistance to soil erosion (Trollope et al., 1989). Decreaser species prevail in veld considered to be in good condition but diminish with poor veld management practices. Increaser species prevail in veld that is under- or over-utilised (Tainton, 1988).

Community 1 (*Terminalia sericea*–*Hyperthelia dissoluta* open woodland) was dominated by *Hyperthelia dissoluta*, a climax increaser II species characteristic of sandy soils (Van Oudtshoorn, 2012) that is usually grazed during the young stages and can form dense stands in undergrazed veld. *Eragrostis gummiflua*, a subclimax perennial tufted increaser II grass species that occurs in degraded veld in sandy well-drained soil (Van Oudtshoorn, 2012), and which is rarely grazed, was present in this community. *Eragrostis pallens*, an unpalatable climax Increaser II grass species, that is seldomly grazed, also occurred in the community. These species together with the tree *Terminalia sericea* indicate sandy soil hence a low production potential in this plant community and it is not readily utilized by animals.

Community 2 (*Euclea crispa*–*Vachellia karroo* closed woodland) is dominated by the grasses *Themeda triandra* and *Setaria sphacelata* which are both palatable and highly productive climax grasses (Van Oudtshoorn, 2012). The grass *Eragrostis superba*, a perennial subclimax grass that is highly palatable and well grazed especially in spring, was also present. *Eragrostis chloromelas*, both a climax and subclimax grass that is relatively palatable in the growing season, was also present, while the prominence of grasses such as *Aristida congesta* subsp. *barbicollis* (an Increaser II species that is only grazed when it is still young) and *Pogonarthria squarrosa* (an unpalatable subclimax grass species occurring in disturbed soils) (Van Oudtshoorn, 2012), indicate some localized areas that have been overgrazed/disturbed within this community.

In the *Combretum molle*-*Faurea saligna* closed woodland (3) and the *Themeda triandra*-*Burkea africana* open to closed woodland (4) communities, we observed grasses such as *Melinis repens*, *Heteropogon contortus*, *Themeda triandra* and *Setaria sphacelata* to be prominent. *Melinis repens* is an important grass to bring about stability on disturbed soil and is relatively palatable. It grows on well-drained soils (Van Oudtshoorn, 2012), mostly in disturbed areas. *Heteropogon contortus*, occurs in previously disturbed loamy soil areas (Van Oudtshoorn, 2012), and tends to form dense stands. This grass is a relatively palatable and well grazed subclimax and increaser II species. *Themeda triandra* is a climax grass that prefers fertile soils and is common in undisturbed open grassland and bushveld areas (Van Oudtshoorn, 2012). It is a Decreaser grass species that is palatable and often dominant in dense stands in the veld. *Setaria sphacelata* var. *sphacelata*, is a densely tufted perennial grass species that occurs in well drained sandy bushveld and open grassland (Van Oudtshoorn, 2012). It is a palatable climax Decreaser species that is well utilised by game. Communities 3 and 4 has undisturbed and stable soil structure and provides well utilised vegetation. The occurrence of grasses like *Themeda triandra* and *Setaria sphacelata* var. *sphacelata* in these communities show that the grass layer provides well-developed and palatable grazing patches to the Impala. The presence of the pioneer grass *Melinis repens* in these communities, indicates that some parts of the community were disturbed due to overgrazing of the palatable grasses mentioned above.

The grass layer of these communities seems to be stable due to the prominence of these climax and pioneer grasses. This is also supported by the prominence of the climax grasses *Schizachyrium sanguineum* and *Eustachys paspaloides* in community 3. *Schizachyrium sanguineum* is poorly grazed, especially later in the growing season and prefers sandy and gravelly soil (Van Oudtshoorn, 2012). *Schizachyrium sanguineum* is a climax grass commonly known as an increaser I perennial grass. *Eustachys paspaloides* is a perennial tufted grass that occurs in grassland and bushveld and is found on sandy and gravelly soil but can also be found in clay soil (Van Oudtshoorn, 2012). This is a palatable climax grass that is easily overgrazed and is one of the grasses that tends to disappear during overgrazing.

Community 5 (*Panicum natalense-Themeda triandra*) is a grassland community with the most prominent grasses being *Panicum natalense*, *Cymbopogon validus*, *Eragrostis trichophora*, *Themeda triandra*, *Setaria sphacelata* var. *sphacelata* and *Melinis repens*. The grass *Panicum natalense* is a perennial grass that mostly grows in well-drained sandy and sandy-loam soil (Van Oudtshoorn, 2012). This grass is known to be abundant in good veld but is seldom utilised during early spring when veld is burnt. *Themeda triandra* and *Setaria sphacelata* var. *sphacelata* are palatable climax grass species occurring in most fertile soils (Van Oudtshoorn, 2012) and are indicative of veld in healthy condition. *Cymbopogon validus* usually grows in open veld in damp soil, along roadsides and in wetlands. This is a perennial tufted climax Increaser I and poor grazing value grass. *Melinis repens* stabilizing is a pioneer grass that occurs on disturbed soils but is relatively palatable (Van Oudtshoorn, 2012). The presence of both palatable climax and unpalatable pioneer grasses indicates this community to be in a stable condition with good grazing to the Impala, though some sections have been disturbed in the past.

Community 6 (*Dichrostachys cinerea-Andropogon schirensis*) is an open shrubland community. That is characterised by the prominence of a combination of palatable and unpalatable grasses. Palatable grasses include *Eustachys paspaloides*, *Themeda triandra* and *Setaria sphacelata* var. *sphacelata*, while unpalatable grasses include *Andropogon schirensis*, *Aristida diffusa*, *Cymbopogon validus* and *Triraphis*

*andropogonoides*. All of the grasses are however indicative of climax to sub-climax conditions (Van Oudtshoorn, 2012) and this community therefore presents moderate grazing to grazers.

#### **4.4.3 Plant families**

The Poaceae family is the largest family with 45 species from 24 genera representing 50% of the total vegetation in the area. This is followed by Anacardiaceae with 5 species from 4 genera, and Asteraceae with 4 species from 4 genera, both occupying 9% of the total area. These two families are followed by the Fabaceae family, which had 5 species from 4 genera representing 8% of the total vegetation.

## 4.5 CONCLUSION

The Impala's home range comprises different plant species, and plant communities (habitats) that provides the necessary resources for the Impala to live and procreate. It is important that the Impala home range in the reserve be well monitored and managed because it is an important conservation area, not just to the Impala, but to various other ungulates that share the same area with them.

The identified plant community descriptions and classification contribute to the known vegetation for the reserve and surrounding areas (Brown et al., 1996). Plant communities were mapped and classified according to the prominent and characteristic plant species. The Braun–Blanquet classification framework has been effective at this brought about the accomplishment of the study objectives, which was to determine which plant communities occur in the seasonal home ranges of the collared Impala. The method used in this study has been used previously by authors including (Brown et al., 1996; Nkosi et al., 2016), and has shown to yield positive results and accomplish the objectives. The results of the study may be used to add-on the existing monitoring and management goals (Nkosi et al., 2016).

The outcomes of this study could form part of the underlying future conservation monitoring, planning and management of vegetation in the Impala home range and the reserve in general. It is important that the woody vegetation density is monitored in all communities to ensure that the threshold whereafter veld condition declines, is not exceeded. It is suggested that consistent monitoring measures be undertaken to guarantee woody species densities persist below 1800 ind/ha, and that if this increases, suitable management action such as bush encroachment/densification control be implemented. Vegetation monitoring assessments such as burning, measures of grazing and browsing should be performed annually to determine variability reactions to these practices. The plant communities in the Impala home range were investigated. This provided a better knowledge and understanding in the role they play in the Impala's home range. This knowledge will enable management to make scientifically based decisions

and conclusions regarding the monitoring and management of these different plant communities.

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# **CHAPTER 5**

## **IMPALA SEASONAL HABITAT UTILISATION AND MOVEMENT PATTERNS**

### **5.1 INTRODUCTION**

Most animals utilise restricted areas in which they perform their daily activities. These confined areas are termed home ranges (Powell, 2000). According to Burt (1943), areas occupied by animals during their daily activities such as searching for food, mating, and nurturing their offspring, is considered to be the animals home range. Animals are well equipped with the knowledge of where to find suitable shelters, available resources, prospect mating partners, and routes they use to escape predation (Tétreault & Franke, 2017). A home range is the part of the environment which an animal maintains to perform their daily activities and for survival (Powell & Mitchell, 2012). Home range is an area of importance in animal studies as that is where ecologists can gather and collect information about a certain animal's distribution, quality and quantity of resources which has an influence on the behavior of animals, which in turn provides insight into their home range utilisation (Powell & Mitchell, 2012).

Individuals from different species select and occupy their home ranges in different ways, displaying distinct behaviour (Powell, 2000). Species that use cognitive maps of where they live know how to find different resources and features within their home ranges and how to move along these areas (Peters, 1978). Locations and quality of resources allow animals to make decisions about which resource to utilise so that they can meet their daily nutritional requirements (Powell, 2000).

Loskop Dam Nature Reserve (LDNR) has a dynamic ecosystem and to date no research has investigated how Impala use their home ranges in Loskop Mountain Bushveld (SVcb 13) and Loskop Thornveld (SVcb 14). It is important to study and understand the habitat

utilization patterns adopted by Impala, as they are an important species in the reserve and need to be considered when management actions are implemented. Impalas feed on both herbaceous and woody plants, they feed more of grass during the wet season and consume both woody and herbaceous vegetation during the dry season and have the ability to utilize different types of habitats (Klein & Fairall, 1986; Meissner et al., 1996; Bonyongo, 2005).

Impalas are occasional browsers that reduce leaves and the biomass of shoots on trees that they can reach with their height when foraging (du Toit et al., 1990; Gowda, 1996; Oba & Post, 1999; Gadd et al., 2001; Augustine & McNaughton, 2004). Browsers influence the density of shrubs as they mostly feed on shoots and damage the shoot ends, which has an overall reducing effect on shrub densities (du Toit et al., 1990; Gowda, 1996; Augustine & McNaughton, 2004). They have the ability to feed on leaves of *Vachellia* and *Senegalia* sp., this assists them to survive through the dry season and maintain their numbers within a population (Augustine & McNaughton, 2004). Being a mixed feeder shows the generally neglected potential of Impala to regulate woody vegetation growth in savannas (Weltzin et al., 1997).

In this chapter the habitat utilisation patterns for a dominant male Impala within his overall and seasonal home ranges is investigated. Comparing seasonal home range utilization patterns will provide information about the sizes of male Impala home ranges and daily/ distances travelled. Knowing which plant communities occur in a home range is imperative to determining seasonal and combined season proportional utilization of the plant communities. The seasonal and combined season preference for specific plant communities are also determined.

## **5.2 METHODS**

### **5.2.1 Impala seasonal daily movements and distances travelled**

The Impala used for this study was collared with a GPS satellite collar as part of an encompassing study to investigate the use of a natural salt lick on the Loskop Dam Nature Reserve by various antelope species. The salt lick study never materialised and since the Impala was already collared, MTPA (Mpumalanga Tourism & Parks Agency) allowed us to use the collared animal for this study. The GPS collar was sourced from Africa Wildlife Tracking who build customised collars for a variety of animal species. The collar was programmable from a mobile cellular telephone and during the data collection times set, locations and waypoints were recorded every four hours. GPS collar location data was collected for a dominant Impala ram and was analyzed to determine seasonal and combined home range boundaries. Daily movement data was extracted and compared across seasons for: four periods morning (06:00 – 10:00); midday (10:00 – 14:00); afternoon (14:00 – 18:00) and night (18:00 – 06:00). Daily movement data points for the collared Impala were split into wet season (1 November to 30 April) and dry season (1 May to 31 October) season movements. Collected locations were mapped using QGIS and interrogated.

### **5.2.2 Relationship between daily distance travelled, rainfall, temperature, and photoperiod in the dry, wet, and combined seasons**

Linear regressions were used to assess the linear relationship between rainfall, temperature, photoperiod, and daily distance travelled by the Impala (Hawkins, 2019). The regressions were done using Microsoft Excel and the add-in Analysis Tool Pack. The significance level ( $\alpha$ ) was set to 0.05. The null hypothesis for the linear regression tests was that the dependent variables were not related to the independent variable in a linear manner. Scatterplots were produced to visually present the relationships between the variables.

### 5.2.3 Difference between daily distances travelled in the dry and wet seasons

A paired *t*-test was used to assess the difference between the distance travelled in the dry and wet seasons (Hawkins, 2019). The null hypothesis for the paired *t*-test was that there is no significant difference between the daily distance travelled in the dry and wet seasons. The significance level ( $\alpha$ ) was set to 0.05 and the paired *t*-test was computed using Microsoft Excel and the add-in Analysis Tool Pack.

### 5.2.4 Comparison of daily distance travelled across different time periods within season and across seasons

A Kruskal-Wallis ANOVA was used to test the difference between distance travelled across different time periods ***within seasons*** (Hawkins, 2019). Differences between the daily distances travelled within seasons were compared across four time periods, morning (06:00 – 10:00), midday (10:00 am – 14:00), afternoon (14:00 – 18:00) and night (18:00 – 06:00). The null hypothesis for the Kruskal-Wallis ANOVA test was that there is no significant difference between the daily distances travelled in the dry and wet seasons across the four time periods. The critical significance level used was 5% (0.05) and the Kruskal-Wallis ANOVA test was computed using the Microsoft Excel Analysis Tool Pack. A Dunn's post-hoc test was conducted to determine which of the daily periods means were significantly different from those of other periods.

Comparison of daily distances travelled in different time periods ***for the combined seasons*** was tested using a One-way ANOVA to determine whether there were significant differences or not (Hawkins, 2019). The across seasons daily distance was compared across the four time periods/intervals morning (06:00 – 10:00), midday (10:00 am – 14:00), afternoon (14:00 – 18:00) and night (18:00 – 06:00). The null hypothesis for the one-way ANOVA test was that there were no significant differences between the daily distances travelled across seasons for the time periods. The significance level was set to 0.05 and the one-way ANOVA was computed using the Microsoft Excel Analysis Tool Pack. A t-Test: Two-Samples Assuming Equal Variances was conducted as a post-hoc

test to see which of the periods were significantly different from one another. To avoid making type 1 errors mistakes (false positive results), we did a Bonferroni post hoc test.

### **5.2.5 Impala home range delineation and habitat selection**

The plant communities in the combined home range (wet and dry seasons) were mapped to determine the vegetation available to and utilized by the Impala and associated social groupings (bachelor and breeding herds) in his home range (Chapter 4). Waypoints stored on a remote database for the satellite collar placed on the dominant Impala ram were downloaded and converted to spatial points in ArcGIS. We used QGIS (Quantum Geographic Information System). Distribution data for the Impala was plotted to determine seasonal and combined home range sizes, and seasonal distribution and movement patterns. The Impala's seasonal and combined movement data was overlaid onto the vegetation map to establish which plant communities the Impala utilised. QGIS was also used to determine the number of waypoints that occurred in the various plant communities, providing rudimentary utilization percentages for the wet, dry and combined seasons.

The six different plant communities as mapped and described in Chapter 4 that occur within the Impala home range are 1. *Terminalia sericea-Hyperthelia dissolute* open woodland, 2. *Euclea crispa-Vachellia karroo* closed woodland, 3. *Combretum molle-Faurea saligna* closed woodland, 4. *Themeda triandra-Burkea africana* open to closed woodland, 5. *Panicum natalense-Themeda triandra* closed grassland and 6. *Dichrostachys cinerea-Andropogon schirensis* open shrubland (Figure 4.2).

Area sizes for the different plant communities were summed for seasonal and combined season home ranges of the Impala. The proportional composition of each plant community within the home range was calculated, as well as the proportion of seasonal and combined utilisation (waypoints collected by the GPS collar) for the Impala in each plant community (Carey et al., 1990). Habitat selection was determined by comparing the

proportions of plant communities available to the Impala with the plant communities selected and utilized within the home range (Byers et al., 1984).

Seasonal home range plant community utilisation was compared using all collar data for the Impala to examine proportional use. Seasonal and combined seasons habitat electivity indices were calculated to determine which plant communities (Figure 4.2) the Impala selected and which not. Preference-avoidance for the six habitats were calculated using Ivlev's Electivity Index (Krebs, 1989):

$$\text{Habitat Electivity} = \frac{(r1 - n1)}{(r1 + n1)}$$

Where  $r1$  = proportion of habitat utilized

$n1$  = proportion of habitat available



## **5.3 RESULTS**

### **5.3.1 Seasonal average environmental factors influencing daily movement patterns**

The Impala's combined and seasonal home ranges are based on daily distances travelled. GPS waypoints downloaded from the collared Impala were used to determine movement patterns within seasonal home ranges (Young, 1972).

#### **5.3.1.1 Impala dry season average daily distances travelled**

The Impala used well established paths that clearly marked the edges or limits of seasonal home ranges. The average dry season daily distance travelled by the collared Impala was 1, 094.35 m. The longest average daily distance travelled during the dry season was 1, 703.70 m in July 2015 and the shortest average daily distance travelled was 395 m in October 2015. Average dry season temperature was 19.6°C with a daily average photoperiod of 11.35 hours and average rainfall of 11.8 mm (Table 5.1).

**Table 5.1:** Wet and Dry season average daily distances travelled per month. Also depicted are average rainfall, average temperature, and average photoperiod.

Month	Total monthly distance (m)	Total days in month	$\bar{x}$ daily distance (m)	Season (0=dry,1=wet)	$\bar{x}$ Rainfall (mm)	$\bar{x}$ Temperature (°C)	$\bar{x}$ Photoperiod (Hrs)
Nov-14	40547	30	1351,6	1	2,0	24,1	13,4
Dec-14	39540	31	1275,5	1	14,0	25,4	13,7
Jan-15	30049	31	969,3	1	1,8	26,1	13,5
Feb-15	19679	28	702,8	1	20,6	26,3	13,0
Mar-15	23157	31	747,0	1	1,4	25,0	12,2
Apr-15	36928	30	1230,9	1	0,0	21,8	11,5
May-15	50406	31	1626,0	0	0,0	19,7	10,9
Jun-15	43708	30	1456,9	0	0,0	15,2	10,6
Jul-15	52816	31	1703,7	0	6,0	15,6	10,7
Aug-15	22975	31	741,1	0	0,0	18,9	11,2
Sep-15	19302	30	643,4	0	33,2	22,0	12,0
Oct-15	12244	31	395,0	0	31,4	25,9	12,7
Nov-15	14058	30	468,6	1	48,6	24,9	13,4
Dec-15	9377	31	721,3	1	65,8	28,2	13,7

### 5.3.1.2 Impala wet season average daily distances travelled

The average daily distance travelled in the wet season was 933.38 m. The longest average daily distance travelled during the wet season was 1,351.60 m in November 2014 and the shortest average daily distance travelled was 468.6 m in November 2015. Average wet season temperature was 25.2°C with a daily average photoperiod of 13.1 hours and average rainfall of 19,28 mm (Table 5.1).

### 5.3.1.3 Impala combined season average daily distances travelled

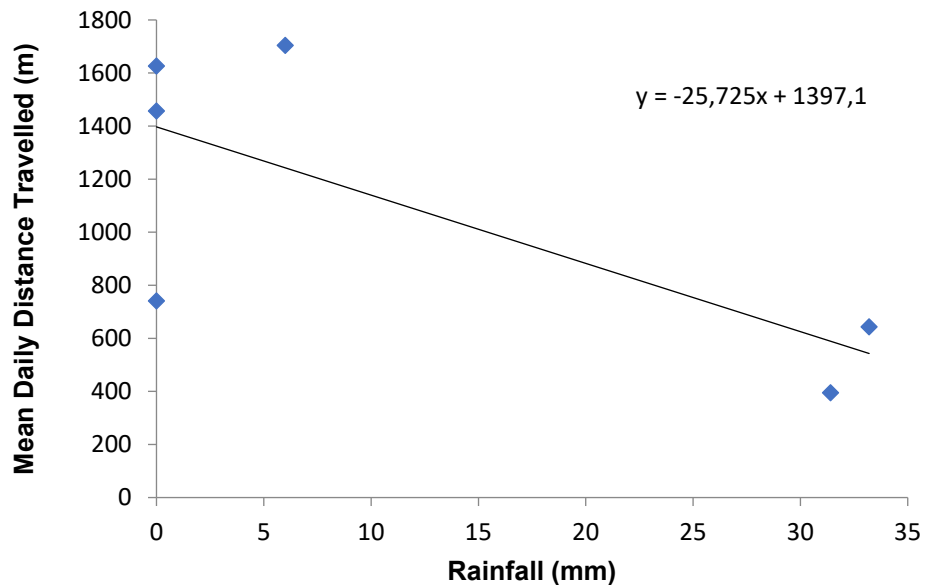
The average combined seasons daily distance travelled was 1,002.36 m. The longest average daily distance travelled was 1,703.70 m in July 2015 and the shortest average daily distance travelled was 395.00 m in October 2015. Average temperature was 22.8°C

with a daily average photoperiod of 12.3 hours and average rainfall of 16,06 mm (Table 5.1).

### 5.3.2 Relationship between distance travelled, rainfall, temperature, and photoperiod

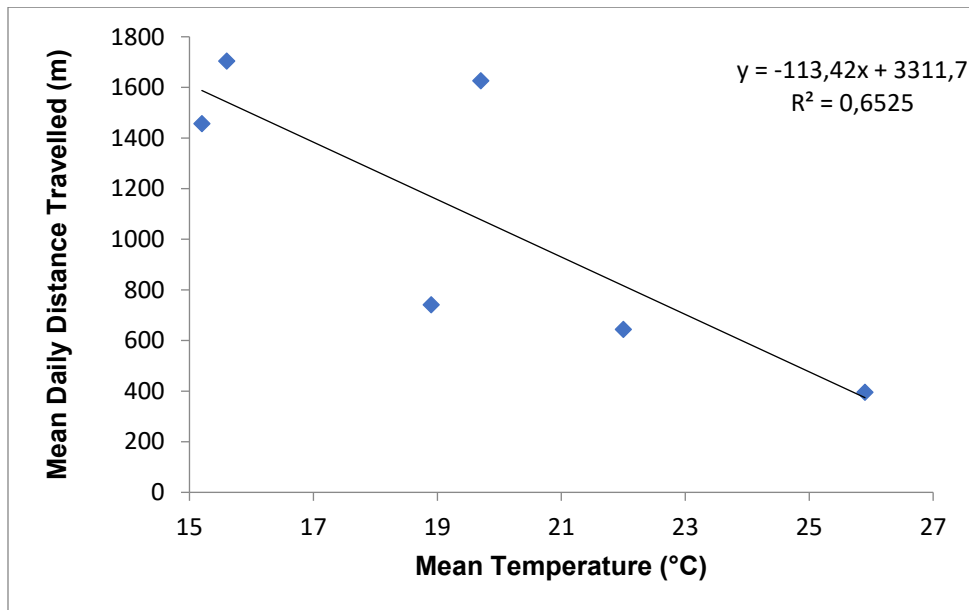
#### 5.3.2.1 Dry season relationships

The relationship between mean daily distance travelled and rainfall for the dry season was not significant (Linear regression:  $r^2 = 0.53$ ,  $F = 4.59$ ,  $P > 0.05$ ). The relationship between the independent variable (rainfall) and the dependent variable (mean daily distance travelled) was negative (Figure 5.1), and as rainfall increased, mean daily distance travelled decreased. For the dry season, 53% of the variance in mean daily distance travelled can be accounted for by rainfall.



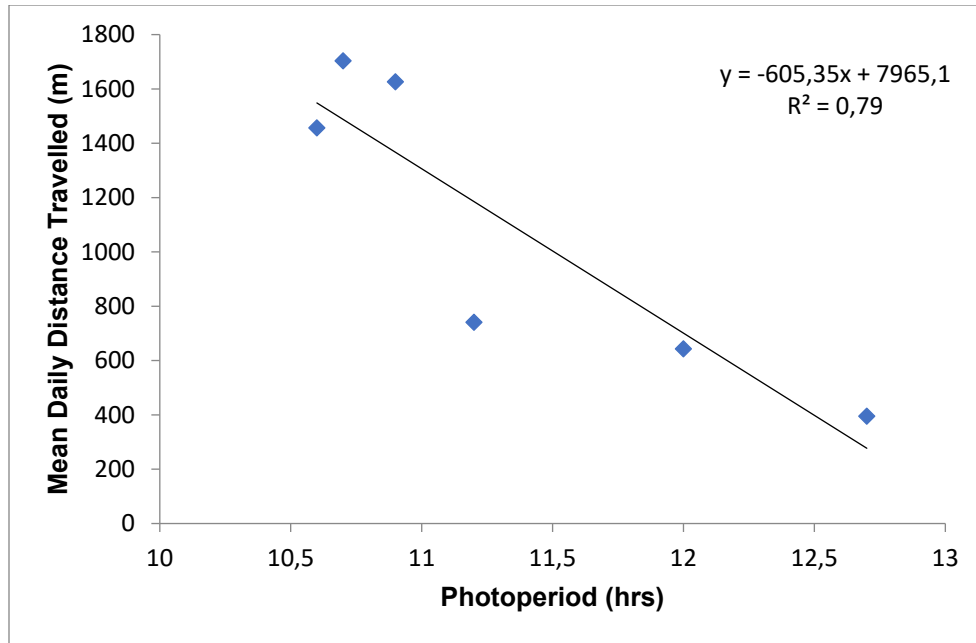
**Figure 5.4:** The relationship between mean daily distance travelled and rainfall in the dry season.

The relationship between mean daily distance travelled and temperature for the dry season was not significant (Linear regression:  $r_2 = -0.65$ ,  $F = 7.51$ ,  $P = 0.05$ ). Mean daily distance travelled and temperature had a negative relationship (Figure 5.2), and as temperatures increased, mean daily distance travelled decreased. During the dry season, 65% of the variance in mean daily distance travelled can be accounted for by temperature.



**Figure 5.5:** The relationship between mean daily distance travelled and temperature in the dry season.

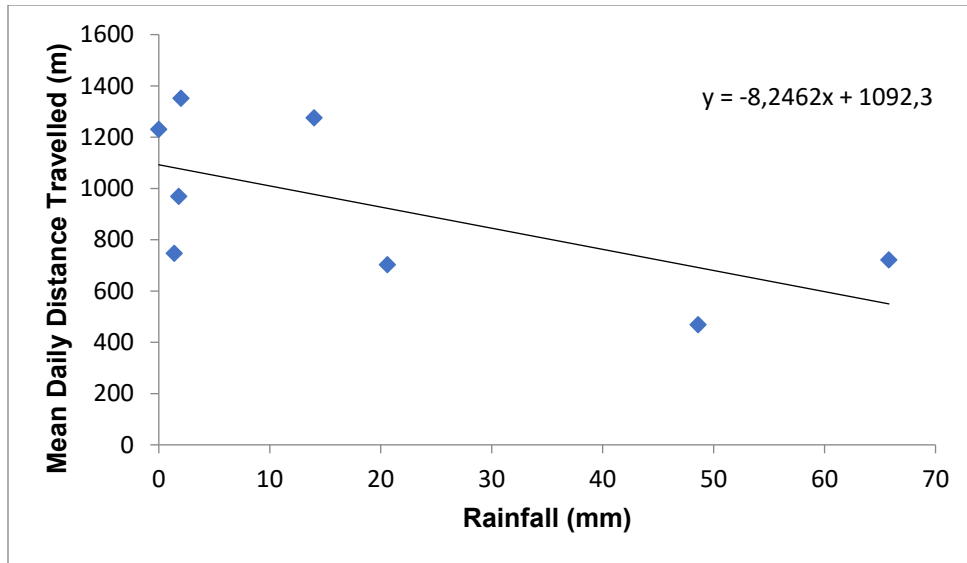
A linear regression test indicated a significant relationship (Linear regression:  $r_2 = 0.79$ ,  $F = 15.05$ ,  $P \leq 0.05$ ) between mean daily distance travelled and photoperiod for the dry season. Figure 5.3 indicates that mean daily distance travelled and photoperiod had a negative relationship, with mean daily distance travelled decreasing as photoperiod increases. Photoperiod accounted for 79% of the variance in mean daily distance travelled.



**Figure 5.6:** The relationship between mean daily distance travelled and photoperiod in the dry season.

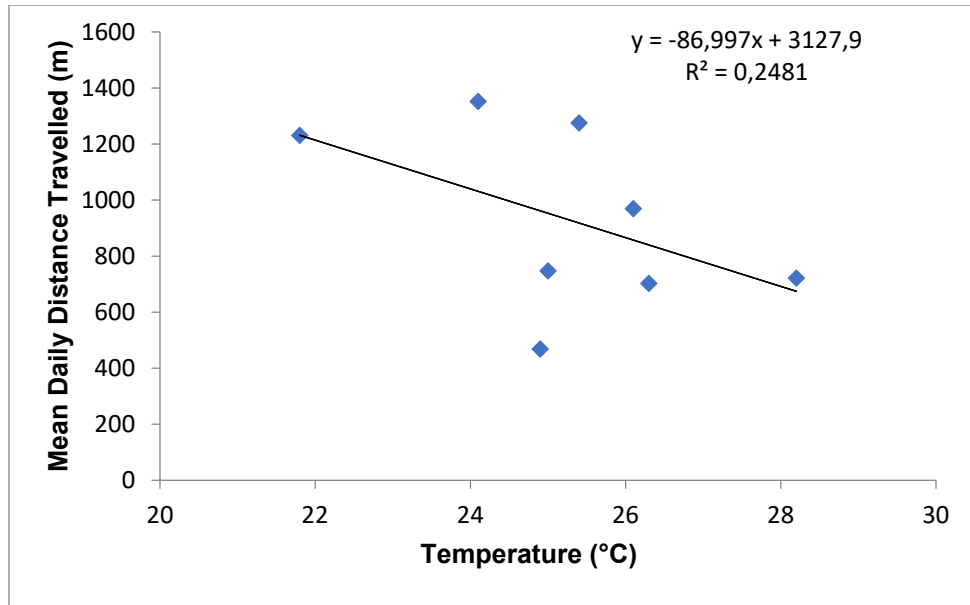
### 5.3.2.2 Wet season relationships

As for the dry season, the relationship between mean daily distance travelled and rainfall for the wet season was not significant (Linear regression:  $r_2 = 0.40$ ,  $F = 4.08$ ,  $P > 0.05$ ). The relationship between the independent variable (rainfall) and the dependent variable (mean daily distance travelled) was negative (Figure 5.4). As rainfall increased, mean daily distance travelled decreased. For the wet season, 40% of the variance in mean daily distance travelled can be accounted for by rainfall.



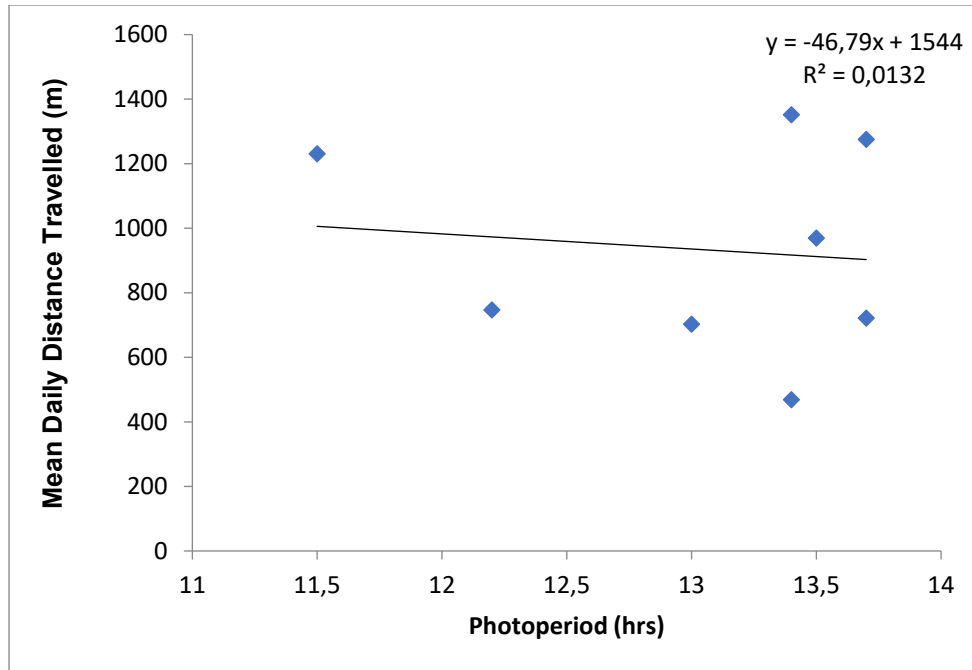
**Figure 5.7:** The relationship between mean daily distance travelled and rainfall in the wet season.

There is a non-significant linear relationship between mean daily distance travelled, and temperature in the wet season. The computed value (Linear regression:  $r_2 = 0.25$ ,  $F = 1.98$ ,  $P > 0.21$ ) is higher than the critical significance level. Figure 5.5 below shows that during the wet season, temperature and mean daily distance travelled had a negative relationship. As temperature increased, mean daily distance travelled decreased. Twenty five percent of the variance in mean daily distance travelled was accounted for by temperature in the wet season.



**Figure 5.8:** The relationship between mean daily distance travelled and temperature in the wet season.

A linear regression test indicated that the relationship between mean daily distance travelled, and photoperiod was not significant during the wet season (Linear regression:  $r_2 = 0.01$ ,  $F = 0.08$ ,  $P > 0.795$   $P > 0.05$ ). There was a negative linear relationship between mean daily distance travelled and photoperiod (Figure 5.6). As photoperiod increased, mean daily distance travelled decreased. During the wet season, 1% of the variance in the mean daily distance travelled was accounted for by photoperiod.

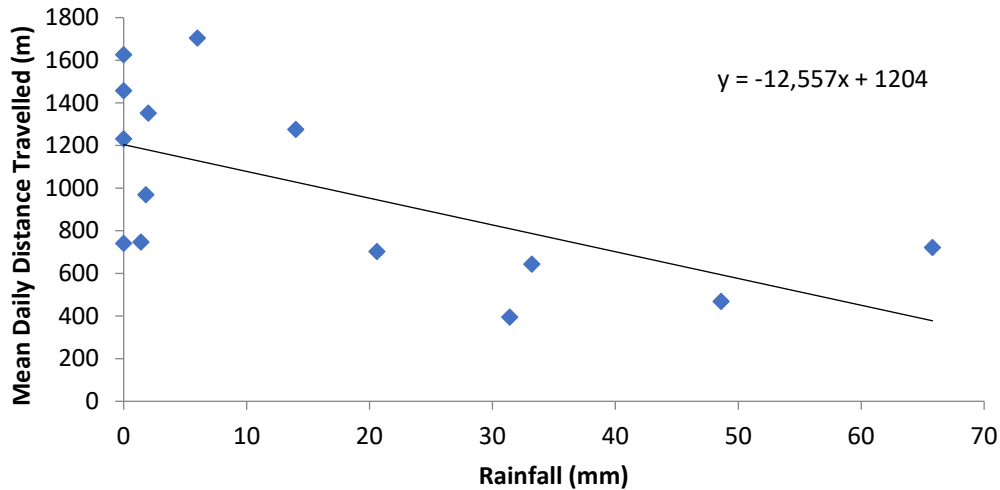


**Figure 5.9:** The relationship between mean daily distance travelled and photoperiod in the wet season.

### 5.3.2.3 Combined seasons relationships

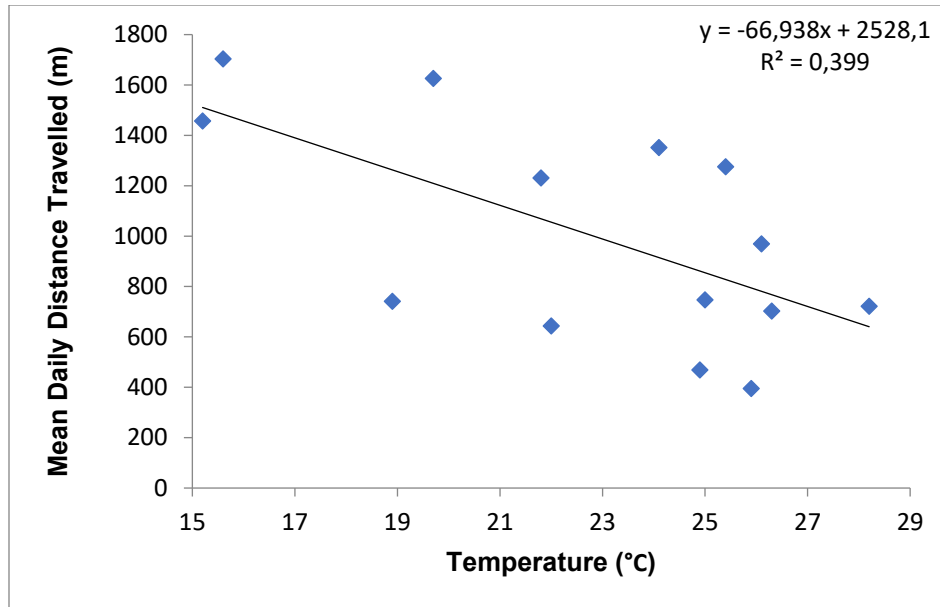
For the combined seasons, mean daily distance travelled was significantly related to rainfall (Linear regression:  $r_2 = 0.38$ ,  $F = 7.35$ ,  $P < 0.05$ ). The relationship between mean daily distance travelled and rainfall was negative, as rainfall increased mean daily distance travelled decreased (Figure 5.7). For the combined dry and wet seasons, 38% of the variance in mean daily distance travelled can be accounted for by rainfall.





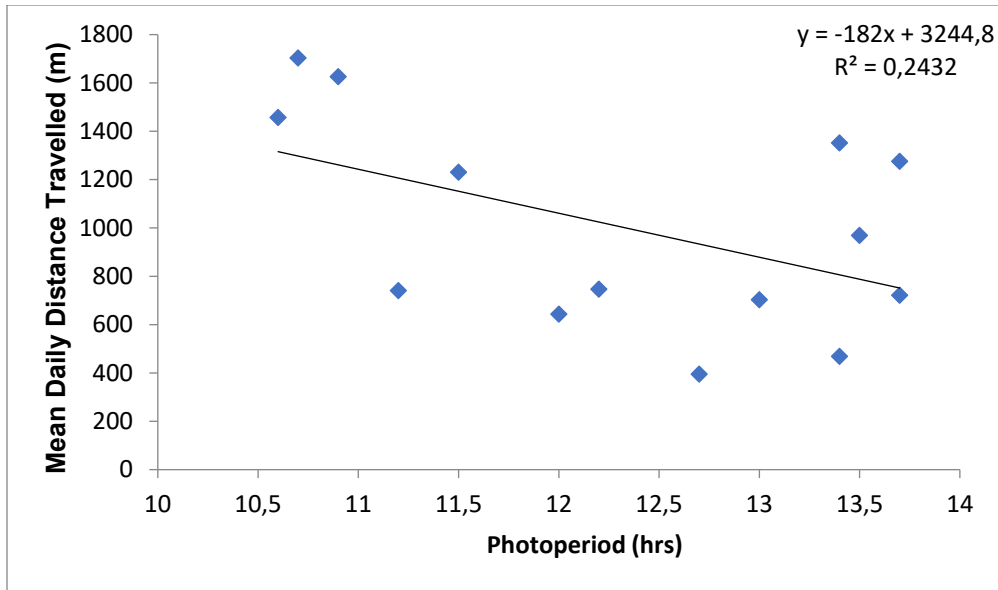
**Figure 5.10:** The relationship between mean daily distance travelled and rainfall in the combined seasons.

There was a significant relationship between mean daily distance travelled and temperature in the combined wet and dry seasons (Linear regression:  $r_2 = 0.40$ ,  $F = 7.97$ ,  $P < 0.05$ ). Figure 5.8 below shows that during the combined seasons, temperature and mean daily distance travelled had a negative relationship. As temperature increased, mean daily distance travelled decreased. Forty percent of the variance in mean daily distance travelled was accounted for by temperature.



**Figure 5.11:** The relationship between mean daily distance travelled and temperature in the combined seasons.

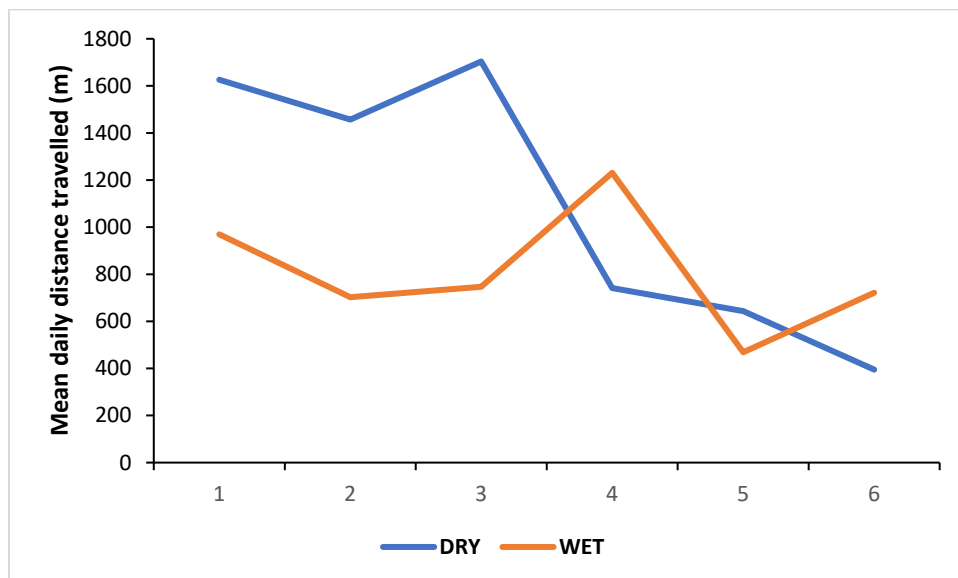
A linear regression test indicated that there was no significant relationship between photoperiod and daily distance travelled for the combined seasons (Linear regression:  $r_2 = 0.24$ ,  $F = 3.86$ ,  $P > 0.07$   $P > 0.05$ ). Figure 5.9 indicates that mean daily distance travelled and photoperiod had a negative relationship, with daily distance travelled decreasing as photoperiod increases. It is also indicated that 24% of the variance in mean daily distance travelled was accounted for by photoperiod.



**Figure 5.12:** The relationship between mean daily distance travelled and photoperiod in the combined seasons.

### 5.3.3 Difference between mean daily distance travelled in the dry and wet seasons

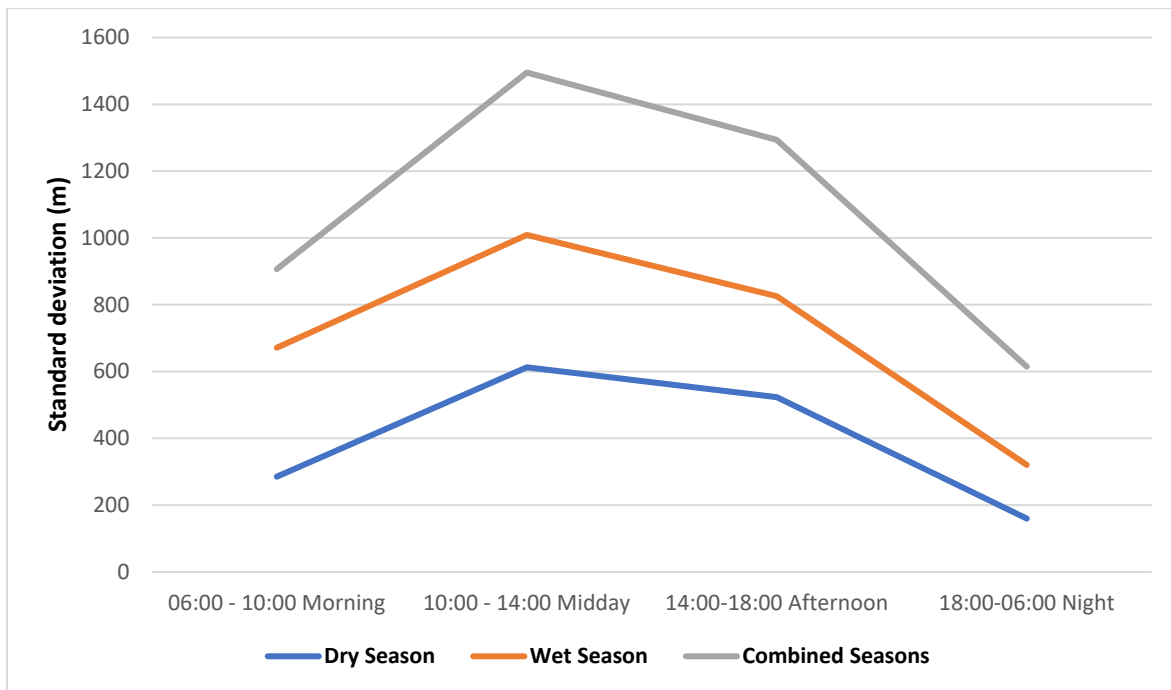
The difference between wet and dry season daily distances travelled by the Impala were not statistically significant (paired t-test:  $t = 0.55$ ,  $p > 0.05 = 0.55$ ) (Figure 5.10).



**Figure 5.13:** The difference between mean daily distances travelled in the dry and wet seasons.

**5.3.4 Seasonal range of daily distance travelled per time interval, morning (06:00 – 10:00 am), midday (10:00 am – 14:00 pm), afternoon (14:00 – 18:00 pm) and night (18:00 pm – 06:00 am).**

Figure 5.11 shows the range of the daily distances travelled by the GPS collared Impala in the dry, wet and combined seasons for the different daily periods. The daily distance standard deviation is depicted for the time periods in the wet season, the dry season, and for the combined wet and dry seasons. Daily distance travelled in the morning and night for the wet, dry, and combined seasons had low standard deviations; while distances travelled during midday and the afternoon had high standard deviations.



**Figure 5.14:** Seasonal range of daily distance travelled per time interval in the dry, wet, and combined seasons.

### **5.3.5 Comparison of distance travelled across different time periods within season and across seasons**

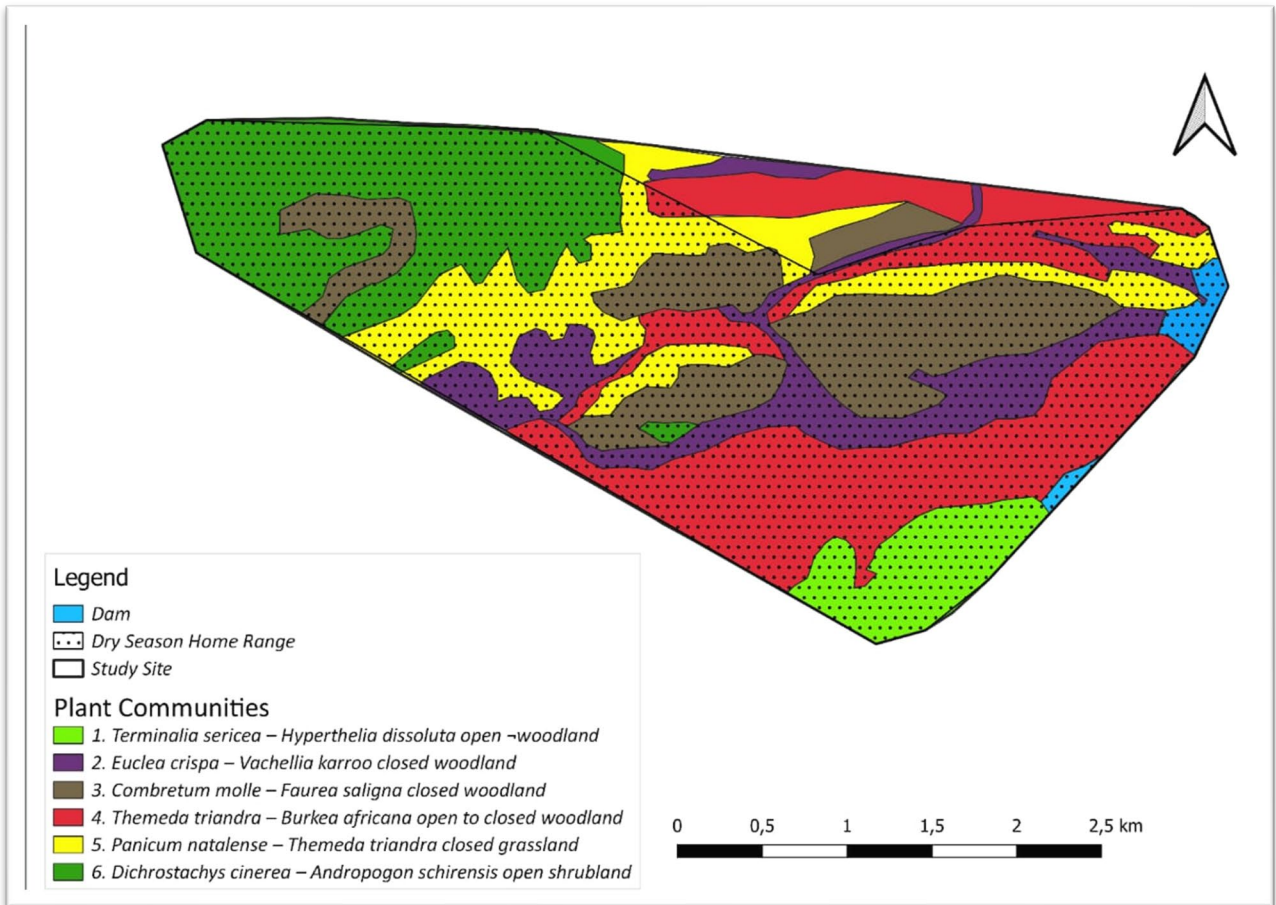
We performed a Kruskal-Wallis ANOVA test to assess the difference between distance travelled across different time periods for the dry and wet seasons. Results from the test indicated no significant difference across the four time periods in the dry season (Kruskal-Wallis ANOVA:  $\chi^2 = 7.81$ ,  $p \geq 0.05$ ); however, there was a noticeable difference between the daily distances travelled for the four time periods in the wet season (Kruskal-Wallis ANOVA:  $\chi^2 = 7.81$ ,  $p \leq 0.05$ ). We also performed a Dunn's post hoc test for the wet season and found that there were significant differences for the distance travelled between 06:00 – 10:00 and 10:00 – 14:00 (Dunn's test: 27889,66,  $p \leq 0.05$ ), between 06:00 – 10:00 and 14:00 – 18:00 (Dunn's test: 25726,09,  $p \leq 0.05$ ), between 06:00 – 10:00 and 18:00 – 06:00 (Dunn's test: 15,36,  $p \leq 0.05$ ), between 10:00 – 14:00 and 14:00 – 18:00 (Dunn's test: 2179,34,  $p \leq 0.05$ ), between 10:00 – 14:00 and 18:00 – 06:00 (Dunn's test: 27905,02,  $p \leq 0.05$ ) and between 14:00 – 18:00 and 18:00 – 06:00 (Dunn's test: 25725,88,  $p \leq 0.05$ ).

### **5.3.6 Home range delineation and determining habitat selection**

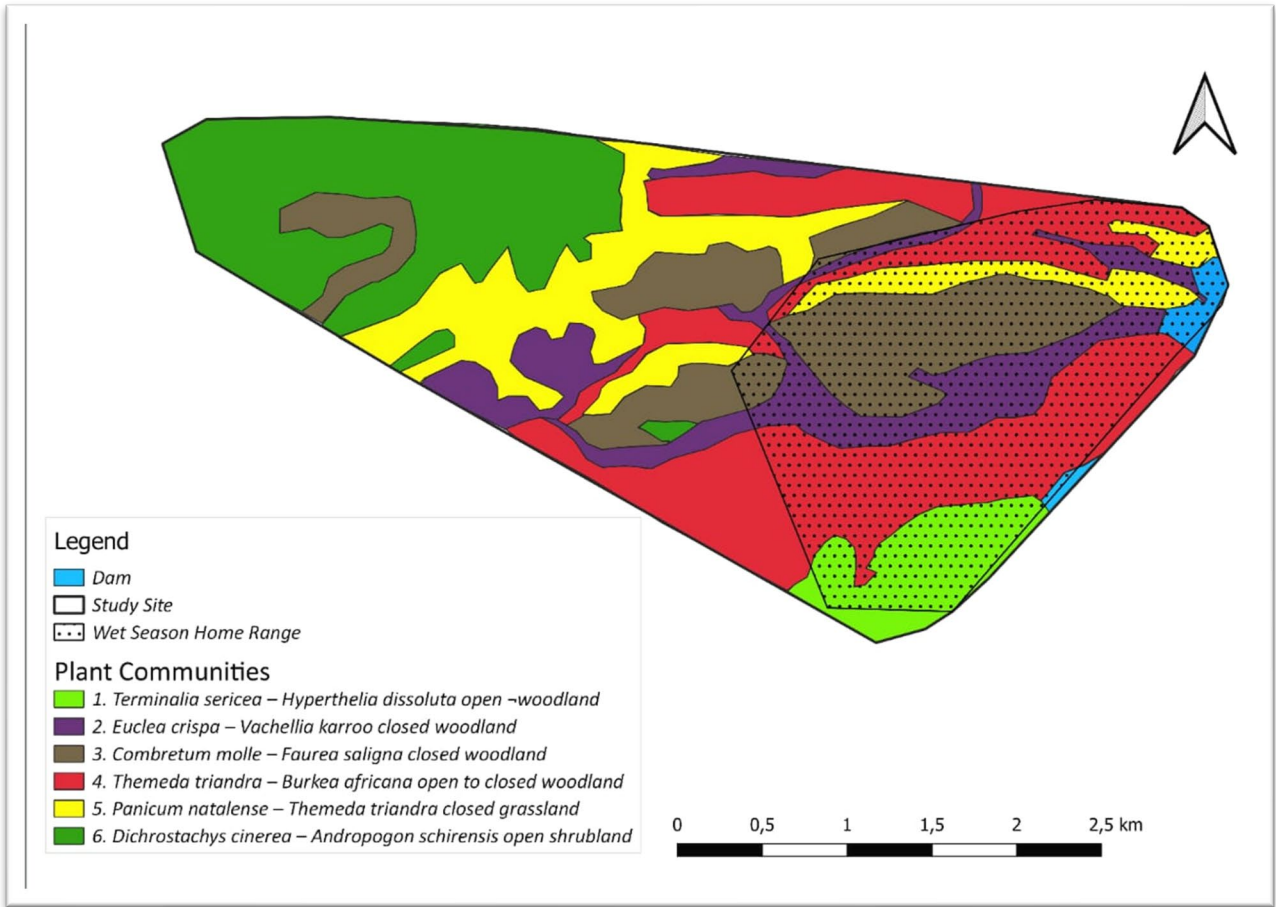
Home range of the Impala at Loskop Dam Nature Reserve is shown in Figure 5.12. The seasonal and combined home ranges overlaid onto the different plant communities that occur in the Impala's home range are depicted in Figures 5.13, 5.14 and 5.15.



**Figure 5.15:** Home range for the Impala (*Aepyceros melampus*) at Loskop Dam Nature Reserve.

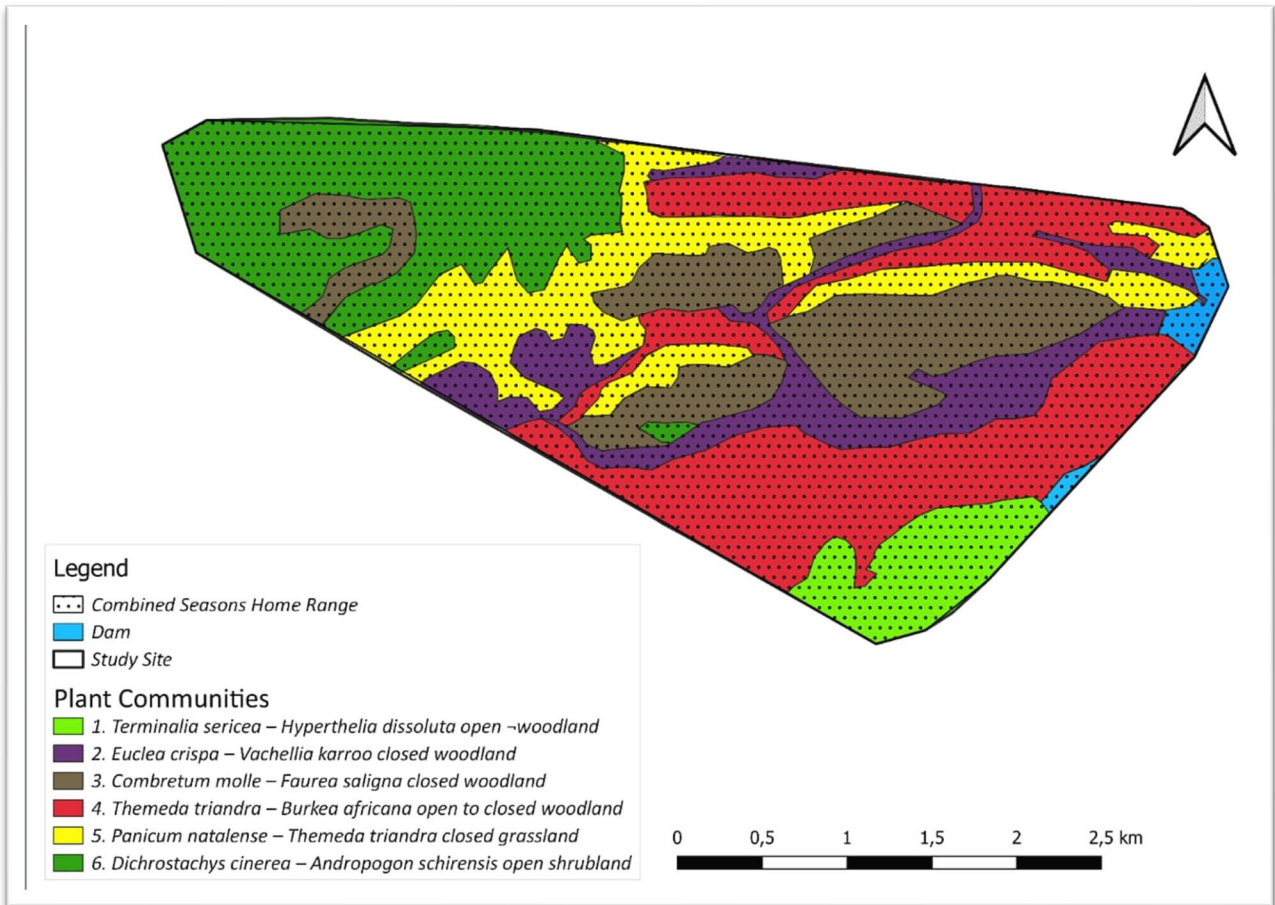


**Figure 5.163:** Dry season home ranges for the Impala (*Aepyceros melampus*).



**Figure 5.14:** Wet season home ranges for the Impala (*Aepyceros melampus*).





**Figure 5.175:** Combined seasons home ranges for the Impala (*Aepyceros melampus*).

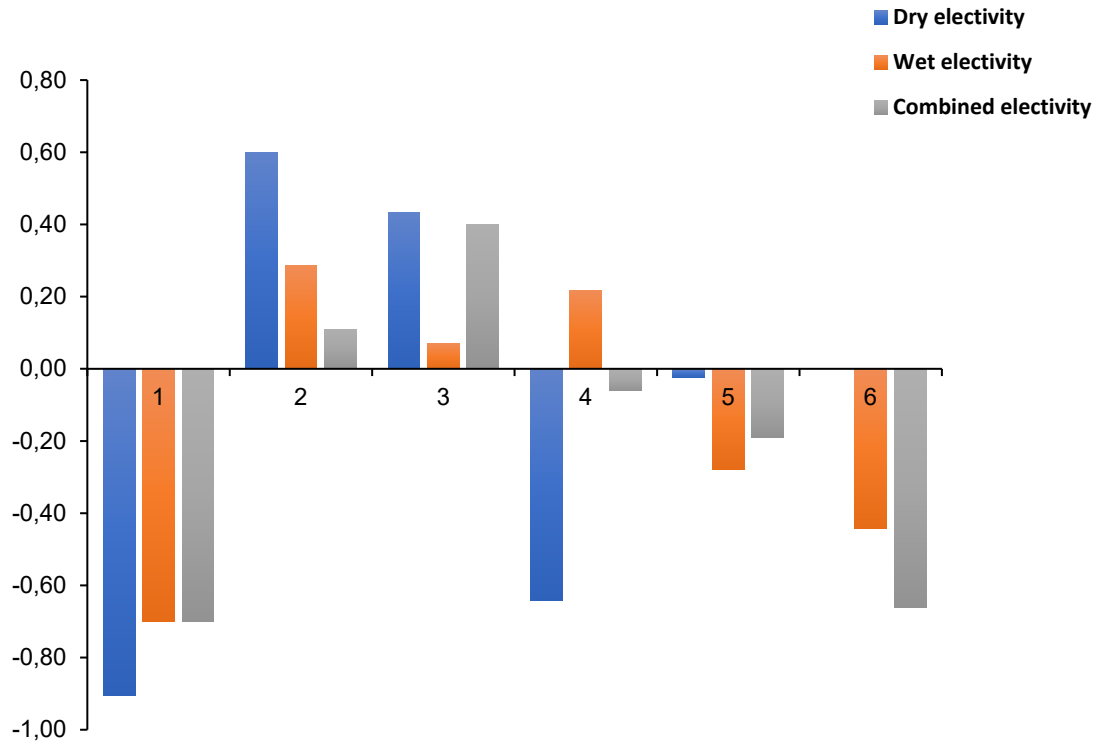
### 5.3.6.1 Plant community selection

Comparisons of Impala home ranges for the wet and dry seasons indicated larger home ranges for the dry season (1, 092.81 ha) than for the wet season (409.63 ha). The combined dry and wet season home range was 1 572.06 ha (Table 5.2).

**Table 5.2:** Plant community sizes, seasonal utilization percentages and habitat electivity by Impala at Loskop Dam Nature Reserve.

Plant communities	Wet Season Size (ha)	Dry Season Size (ha)	Combined Seasons Size (ha)	Wet Season Utilised (ha)	Dry Season Utilised (ha)	Combined Seasons Utilised (ha)	Wet Season Prop of plant comm utilized	Dry Season Prop of plant comm utilized	Combined Seasons Prop of plant comm utilized	Wet Season Plant comm prop of total size	Dry Season Plant comm prop of total size	Combined Seasons Plant comm prop of total size	Wet Season Electivity	Dry Season Electivity	Combined Seasons Electivity
1	60,47	74,43	82,42	0,68	1,19	0,92	0,68	1,19	0,92	7,63	6,07	5,24	-0,91	-0,70	-0,70
2	16,57	101,15	204,94	16,08	16,71	16,39	16,08	16,71	16,37	12,49	9,94	13,04	0,60	0,29	0,11
3	104,69	236,55	297,33	63,40	24,67	44,03	63,40	24,67	45,49	25,27	20,12	18,91	0,43	0,07	0,40
4	186,42	281,44	450,17	10,15	40,58	25,36	10,15	40,58	24,22	35,18	28,00	28,64	-0,64	0,22	-0,06
5	41,47	163,16	210,43	9,69	8,36	9,03	9,69	8,36	9,07	19,44	15,47	13,39	-0,02	-0,28	-0,19
6	0,00	236,09	326,77	0,00	8,49	4,27	0,00	8,49	3,92	0,00	20,39	20,79	0,00	-0,44	-0,66
<b>Total</b>	<b>409,626</b>	<b>1092,819</b>	<b>1572,06</b>	<b>100,00</b>	<b>100,00</b>	<b>100,00</b>	<b>100,00</b>	<b>100,00</b>	<b>100,00</b>	<b>100,00</b>	<b>100,00</b>	<b>100,00</b>	<b>-0,55</b>	<b>-0,84</b>	<b>-1,10</b>

Plant community 2 (*Euclea crispa-Vachellia karroo* closed woodland) was mostly selected by the Impala during the dry season as indicated by Ivlev's Electivity Indices (Figure 5.16, Table 5.2). The Impala selected plant community 1 habitat (*Terminalia sericea-Hyperthelia dissolute* open woodland) less in the dry season. During the wet season, the Impala selected plant community 3 (*Combretum molle-Faurea saligna* closed woodland) less, while plant community 1 was also least selected during this season (Table 5.2). Combined seasons electivity indicated that the Impala preferred plant community 3 and spent the least amount of time in community 1 (Table 5.2).



PLANT COMMUNITIES 1 - 6

**Figure 5.186:** Impala habitat-use patterns represented by Ivlev’s Electivity Indices for the dry season, the wet season and the combined wet and dry seasons.

### 5.3.6.2 Dry season habitat selection

Plant communities 2 and 3 were positively selected during the dry season as indicated by the Ivlev’s Habitat Electivity Index (Figure 5.16, Table 5.2). Plant community 2 (*Euclea crispa-Vachellia karroo* closed woodland) was the most preferred plant community, with a size of 101.15 ha. The second most preferred plant community was 3 (*Combretum molle-Faurea saligna* closed woodland), which was 236.55 ha in size.

### 5.3.6.3 Wet season habitat selection

During the wet season, plant communities 1 (*Terminalia sericea–Hyperthelia dissolute* open woodland – 60.47 ha) and 5 (*Panicum natalense–Themeda triandra* closed grassland – 41.47 ha) were not selected. Ivlev’s Habitat Electivity (Table 5.3) indicated

that community 2 (*Euclea crispa-Vachellia karroo* closed woodland – 16.57 ha) was the most selected, followed by community 4 (*Themeda triandra–Burkea africana* open to closed woodland – 186.42 ha) and lastly community 3 (*Combretum molle-Faurea saligna* closed woodland – 104.69 ha).

#### **5.3.6.4 Combined seasons habitat selection**

Plant community 3 (*Combretum molle-Faurea saligna* closed woodland – 297.33 ha), was most selected during the study period as indicated by Ivlev's Electivity Indices, followed by plant community 2 (*Euclea crispa-Vachellia karroo* closed woodland – 204.94 ha). Plant community 2 is identified as a closed woodland plant community and includes browse trees/shrubs such as *Euclea crispa* and *Vachellia karroo*. Plant community 1 (82.42 ha), *Terminalia sericea-Hyperthelia dissolute* open woodland and plant community 6 (326.77 ha), *Dichrostachys cinerea-Andropogon schirensis* open shrubland were most avoided by the Impala in the combined seasons home range (Figure 5.16, Table 5.2).

## 5.4 DISCUSSION

The results show that the dry season home range of the Impala was larger than the wet season. The Impala's home range at the study site comprised of six (6) plant communities that were utilised differently in the wet and dry seasons. Carey et al. (1990) also found that Impala partitioned the use of plant communities available to them. The six (6) plant communities were available as types of habitats for the Impala to utilize in different seasons.

The longest average daily distance travelled during the dry season was during the month of July 2015, and the shortest average daily distance was travelled in October 2015. The longest daily distance travelled in the dry season may be due to a lower proportion of time spent resting (Martin et al., 2015). Zidon et al., (2017) states that herbivores move longer distances to where water is available during the dry season. Distance to the water sources may have been another factor in increased daily distances travelled in the dry season for the current study, as the dam in the reserve is the main water source, and when ephemeral pools and streams dry up, the Impala have to travel to the dam for water. Since daily average rainfall in the dry season was low, rainfall had no influence on daily distance travelled by Impala in this season. Temperature and photoperiod had a noticeable influence on daily distances travelled in the dry season, with increases in both variables resulting in shorter daily distances travelled. The results of the linear regression for the dry season infer a negative relationship between daily distance and rainfall, daily distance and temperature, and daily distance and photoperiod, with increases in all of these variables resulting in decreased mean daily distances travelled. When there is a decrease in quality and quantity of forage during the dry season, herbivores travel further to find forage, leading to increased mean daily distances travelled (Redfern et al., 2003).

During the wet season, the longest average daily distance travelled was in November 2014 and the shortest average daily distance was travelled in November 2015. Long daily distances travelled in the wet season may be due to the wet season being characterized by an increase in Impala foraging at the expense of resting (Martin et al., 2015). Rainfall,

temperature, and photoperiod had no influence on mean daily distance travelled in the wet season. The results shows that during the days with high rainfall and warm temperatures, Impala travelled shorter distances in the wet season. This was probably because of the availability and abundance of forage in the wet season and higher rainfall and temperatures causing slower movement rates while foraging (Owen-Smith & Goodall, 2014). The linear regression test shows that there was a negative relationship between mean daily distance travelled and rainfall, temperature, and photoperiod.

The combined seasons longest daily distance travelled was during the month of July 2015 and the shortest daily distance travelled was in October 2015. Temperature and rainfall influenced mean daily distance travelled in the combined seasons, with photoperiod having no effect. Linear regression results for the combined season indicated a negative relationship between mean daily distance travelled and rainfall, temperature, and photoperiod. This indicates that Impala remain within areas that offer sufficient resources to meet their seasonal metabolic requirement for survival (O'kane & Macdonald, 2018).

Environmental factors play a major role in structuring and arrangement of resources in home ranges, resulting in different seasonal home range sizes and shapes (Mattisson et al., 2013). According to Foerster & Vaughan (2002), dry season home ranges are most likely larger as animals need to travel further to find resources, compared to wet season home ranges that are smaller due to an abundance of available resources. At the study site, it was found that the collared Impala travelled longer distances during the dry season, resulting in his dry season home range being larger than his wet season home range. Young (1972) indicated that animals are capable of travelling long distances from their grazing patches to their drinking areas and back again, this was not the case at Loskop Dam Nature Reserve, and animals did not need to travel long distances for water, as water was always in relatively close proximity due to the dam being at the centre of the reserve.

Impala were more active between 10:00 – 14:00 for both the dry, wet and combined seasons. This was due to Impala being a diurnal species that are not normally active

during the night (18:00 – 06:00). Between 10:00 – 14:00 and 14:00 – 18:00 Impala moved more and engaged in their daily activities. Shorter distances were covered during the night between 18:00 and 06:00 for both dry, wet, and combined seasons. These findings are in line with the behaviour of other diurnal ungulate species who have a tendency to remain inactive and vigilant during the night to avoid predation (Wolfe & Summerlin, 1989; Kotler et al., 2004; Harmsen et al., 2011). According to Jacobs (1993), the tendency to avoid movement in the night might reflect limited visual ability in Impala. Poor nocturnal vision would contribute towards Impala being less able to detect predators during dark nights. Impala also travelled less during inclement weather in the wet season, likely due to them sheltering from the rain.

A Kruskal-Wallis ANOVA test showed no significant difference between the daily distance travelled across the four time periods for the dry season. The wet season Kruskal-Wallis ANOVA test results showed that there was a significant difference between the daily distances travelled for the four time periods. Post hoc Dunn's tests for the wet season showed that there were significant differences between mean daily distance travelled in the mornings and midday, mornings and late afternoons and mornings and night. The Impala travelled longer distances during midday and late afternoons and shorter distances in the mornings and during the night. Shorter distances travelled in the morning and at night might have been orchestrated by low activities during those times and increased daytime activities (Harmsen et al., 2011). Impala also spend time in the morning to warm up and feed, which then contributes towards less movements and shorter daily distances travelled during this period. According to Owen-Smith (1998), foraging is dominant in the early hours of the morning until late in the afternoon and resting takes place throughout the day and much of it happens at night, hence there is less movements and travelling during the night.

The analysis for the one-way ANOVA show that there was a significant difference between daily distances travelled for the different time periods in the combined seasons. The post hoc t-tests for the combined seasons indicated that there were significant differences between mean daily distances travelled for the following periods, between

06:00 – 10:00 in the morning and 10:00 – 14:00 midday, between 06:00 – 10:00 in the morning and 14:00 – 18:00 in the afternoon, between 06:00 – 10:00 in the morning and 18:00 – 06:00 at night, between 10:00 – 14:00 in the morning and 14:00 – 18:00 in the afternoon, between 10:00 – 14:00 in the morning and 18:00 – 06:00 at night, and 14:00 – 18:00 in the afternoon and 18:00 – 06:00 at night.

The Impala showed a noticeable pattern of seasonal habitat use, with a preference for the *Euclea crispa-Vachellia karroo* closed woodland, *Themeda triandra–Burkea africana* open to closed woodland and the *Combretum molle-Faurea saligna* closed woodland in the wet season. These plant communities were preferred by the Impala because they offered forage in both the wet and dry seasons (Fischhoff et al., 2007). During the dry season the Impala preferred the *Euclea crispa-Vachellia karroo* closed woodland, and the *Combretum molle-Faurea saligna* closed woodland. The *Euclea crispa-Vachellia karroo* closed woodland was highly selected due to the quality and presence of forage in these plant communities (*Themeda triandra*, *Setaria sphacelate* var. *sphacelate*, *Dombeya rotundifolia*, *Vachellia karroo*, *Euclea crispa*). During the combined seasons, Impala preferred the *Euclea crispa-Vachellia karroo* closed woodland, the *Themeda triandra–Burkea africana* open to closed woodland, and the *Combretum molle-Faurea saligna* closed woodland. Impala had different seasonal preferences that were influenced by the availability and abundance of highly nutritional forage, so that they could maximize opportunities to reproduce and increase their probability of survival (Mtui, 2014).

Impala are mixed feeders that prefer low to medium height grasses and open woodlands (Kingdon & Lagen, 1997). In this study, it was found that during the dry season, Impala spend most of their time in the *Euclea crispa-Vachellia karroo* closed woodland vegetation community that is situated close to the dam. The unavailability of surface water in the other plant communities during the dry season could be a reason that this community was selected as it is adjacent to the dam (Jarman, 1974, Skinner & Smithers, 1990; Djagoun et al., 2013).



Although predation may be a determining factor for animal distribution and habitat selection (Kaunda et al., 2002), there were no visible signs of predator activity in the study area during the field work. Even though there are Leopards on the reserve, we speculate that the underlying factor influencing the Impala's habitat selection was seasonal abundance and availability of forage in the different plant communities found in the home range and not predator avoidance (Jarman, 1974; Monro, 1980; Dunham, 1982).

The presence of *Vachellia karroo*, *Euclea crispa*, *Combretum mole*, *Terminalia sericea*, *Faurea saligna*, and *Burkea africana* at the study site provided an abundance of browsable woody plant species for the Impala across both seasons. It has been documented that being mixed feeders, Impala are able to cope with seasonal changes in various habitat types, even in areas where rangeland conditions have degenerated because of overgrazing and bush encroachment, (Skarpe, 1991; van Rooyen et al., 1991; Dangerfield et al., 1996; Djangoun et al., 2013).

According to Augustine & Mcnaughton (2004), selective browsers play an important role in balancing the rate at which shrub density increases, while non-selective browsers allow shrubs to increase at lower, but positive rates. Browsers are important in ecosystems as they regulate the rate of bush encroachment in protected natural areas. Impalas consume various grasses, herbs and shrubs, and often feed on *Vachellia* spp. and *Senegalia* spp. pods and seedlings (Prins, 1993; Lamprey, 1963). According to Prins (1993), Impala spend most of their time in woodlands, and are likely candidates for suppressing seedling recruitment in their home ranges.

## 5.5 CONCLUSION

In this study we investigated habitat utilization by Impala and found that they utilized available habitats in their home range differently in the wet season compared to the dry season because of the seasonal changes in the availability of resource (Kaunda et.al, 2002). The comparison of seasonal home range patterns provided us with information about the sizes of home ranges and daily distances travelled. Plant communities occurring in the seasonal home ranges and how much of each plant community was used in each season, and in the combined dry and wet seasons were determined. Preference for specific plant communities for the combined, dry and wet seasons were also determined.

The selection of the *Euclea crispa-Vachellia karroo* closed woodland plant community by the Impala all year round is a clear indication that this community is a key habitat for the Impala at LDNR. This plant community is a closed woodland with available browse including *Combretum mole*, *Faurea saligna*, *Vachellia karroo*, *Euclea crispa*, *Terminalia sericea*, and *Burkea africana* trees, and grazing such as *Digitaria eriantha*, *Themeda triandra*, and *Setaria sphacelata* var. *sphacelata*. Woodlands are generally highly utilised during the rainy season (Bonyongo, 2005). The extensive use of mixed open woodlands, which were the most available habitat type for the Impala utilise.

No significant relationship between mean daily distance travelled and rainfall, but a significant relationship was found between mean daily distance travelled and temperature, and mean daily distance travelled and photoperiod in the dry season. This indicates that daily distance travelled was influenced by these two environmental variables in the dry season. No significant relationships were found between mean daily distances travelled and rainfall, mean daily distance travelled and temperature, and mean daily distance travelled and photoperiod in the wet season. A significant relationship was found between mean daily distance and photoperiod and a non-significant relationship was found between mean daily distance and rainfall, and between mean daily distance

and temperature in the combined seasons. There was a non-significant difference in the distances travelled in the wet and dry seasons.

According to Young (1972), the use of equipment such as GPS simplify the studies of animal movements. Important information and knowledge about the ecology of a species that is studied may be acquired when repeating the observations for that specific animal. The movements of Impala are often associated with available water and how their preferred forage types are dispersed (Young, 1972). Impalas inhabit small areas that are close to the water sources, and this may cause overgrazing and trampling close to the water sources (Young, 1972).

Protection strategies for the preservation of habitat diversity by wildlife conservationists should support maintaining habitat integrity and diversity within Impala home ranges in general and in the greater LDNR. This can be achieved by performing regular vegetation assessments and monitoring, managing animal populations so that they remain within their carrying capacities, and preserving biodiversity with an emphasis on habitat integrity and abundance (Hald, 1999; Rydberg & Milberg, 2000). Wildlife conservationists should take suitable and essential legislative and administrative actions to prioritise the protection of wild flora and fauna species (Reichlin et al., 2006). Conservation practitioners should prioritize protected areas with high habitat quality for effective ecosystem functioning (Mtui, 2014).

The results from this study are useful in that the management of wildlife populations and specifically Impala, should include habitat monitoring and management that presupposes some understanding of habitat preferences by the species present on LDNR. Results confirm predictions that Impala are able to utilise a wide range of habitats, being mixed feeders (Bonyongo, 2005). Due to differences in vegetation characteristics that determine forage quality and quantity, Impala responded well towards the selection of preferred habitats in different seasons. To improve the understanding of habitat use by Impala and various ungulate species, it is recommended that further studies be undertaken on forage quality and availability in the physiognomic vegetation types identified in this study. We

also recommend the use of GPS technology for animal habitat studies as it could provide budgetary savings when sampling field data on a larger scale. The GPS technology was useful in identifying the seasonal movements, daily distances, and habitat preferences at LDNR.

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# CHAPTER 6

## IMPALA HERD DAILY ACTIVITY BUDGETS

### 6.1 INTRODUCTION

Time is a valuable resource for all animals and its subdivision is influenced by the various activities that they partake in, including aspects such as socialising, vigilance, foraging, resting, moving, territoriality, flight and excretion (Pollard & Blumstein, 2008; Kurauwone et al., 2013). Environmental changes influence food availability, often forcing animals to adapt to new conditions. Adjustments to changing conditions impact the amount of time animals have available for doing their daily activities (Jaman & Huffman, 2008). Herbivores spend much of their time foraging due to seasonal variations in quality of forage. Low quality forage is often indigestible and low in nutrients requiring herbivores consume large quantities to meet their daily nutritional requirements (Owen, 1980).

Seasonality of animal activity patterns is adaptable and has a positive response to fluctuations in availability of quality food supply, which is influenced by temperature and rainfall (Vasey, 2005). Activity patterns are influenced by the quantity and quality of resources available to animals, and their daily metabolic requirements that vary between males and females (Leuthold, 2012; Szemán et al., 2021). The impact of seasonality on food quality and availability in tropical areas and savanna ecosystems impacts activity patterns and the way in which animals partition their time over a 24-hour period (Rapaport & Ruiz-Miranda, 2006). Pollard & Blumstein (2008) state that activity budgets can be divided into four activity categories including subsistence activities (foraging or feeding), locomotion (moving or traversing), rest (inactivity), and socialising (mating, courtship, play and aggression).

According to Negovetich et al. (2006), adult male Impalas associate in bachelor herds that follow a linear hierarchy. Dominant males compete for territory during the rut, which commences in mid-April and continues through to July and mid-August. Dominant Impala

rams maintain one or two spots within their territories (called middens) where they defecate as a form of territoriality. Territorial males maintain a small territory less than a hectare in size and are the only adult males in a female herd. When the breeding season concludes, territorial males without breeding herds return to bachelor herds at the lowest level of the hierarchy (Negovetich et al., 2006). Females require high nutrients, therefore, are selective and spend more of their time feeding (Szemán et al., 2021), and males spend more of their time walking (Shrestha et al., 2014). Grazing mammals usually form larger groups when available forage is enough in the wet season, and reduce the group size in the dry season when the nutrient quality of forage declines (Koenig et al., 2013; Stears et al., 2014). Differences in forage quality has huge profound effects on behaviour and daily activity patterns of animals in savanna environments (Mramba, 2022).

Since activity budgets are adaptable inherently more flexible than metabolic rates, animals of different species allocate time to main daily activities such as feeding, resting, and moving, gives information about its energy allocation and adaptations (Vasey, 2005). The time dedicated to feeding may be adjusted seasonally based to the change in climatic conditions, forage quality and forage availability. Time spent feeding affects other activities, with more time feeding resulting in less time for other activities such as socialising. A species strives to be successful in obtaining the most favourable and tolerable energy balance (Coelho et al., 1986).

In this chapter, the focus is on investigating the behaviour of Impala to determine their daily activities at Loskop Dam Nature Reserve (LDNR) for the wet, dry and combined seasons. The following social group types were looked at: bachelor herds, breeding herds and territorial males. According to Negovetich et al. (2006), Impala females gather into a group in discrete clans known as breeding herds. During the lambing season, pregnant females isolate themselves from the breeding herd and give birth in dense vegetation. Usually, lambs associate with one another and during herd movements they return to their mother for protection and to nurse. Male offspring leave the natal clan at the beginning of maturity and form short-term peer groups called bachelor herds, while females remain in the maternal breeding herd (Negovetich et al., 2006).

## 6.2 METHODS

### 6.2.1 Data Collection

We studied the activity patterns of free-ranging Impala (*Aepyceros melampus*) living within a GPS collared territorial rams home range at Loskop Dam Nature Reserve (LDNR) in Mpumalanga, South Africa. Impala are considered to be a buffer species that experience high levels of predation in most conservation areas (Périquet et al., 2012). To describe the daily activity patterns of Impala, data about the ecology and social behaviour of a dominant Impala male and the various breeding and bachelor herds found in his home range were collected over a 12-month (March 2019 – February 2020) study period.

A combination of focal and scan sampling techniques was used to collect data on diurnal Impala activities and behaviour (Ejigu et al., 2020). A scan of the whole group was done when they were located and settled to the observer's presence from 06:00 – 18:00 each day, 35 days for the dry season and 35 days for the wet season. The scans were repeated at 30-minute intervals. When scanning, the observer moved around to ensure that as many animals as possible were being scanned. Focal sampling of selected individuals in the herds was also done at 30-minute intervals and involved selecting a random animal whose activities were identified and recorded. To ensure equivalent sampling effort, different age and sex classes were used during consecutive focals (Altman, 1974; Bosholn & Anciães, 2018).

Field observations were done from a vehicle using binoculars with a variable power zoom. We recorded data from groups that were in the observer's full line of sight during the time of recording and not more than 50 m from the observer's vehicle. There were no difficulties encountered in defining a group using 30 m between the groups and 50 m away from the observer (Périquet et al., 2010). Distance of the observation vehicle from the animals being watched was a minimal distance of 50 m in open vegetation and 20 m in closed vegetation. This ensured minimal disturbance to the animals who were already habituated to tourist vehicles. The observer recorded the location of the herd and of any

sub-adult rams that were present within the herd. The height of grasses in the area where the individuals were foraging was classified into three height classes: short when not above the focal Impala's hooves, medium when the height was below the upper part of the metacarpals and tall when the height reached the tibia (Périquet et al., 2010).

The daily activities of Impala at LDNR were classified into six main activities, namely: vigilance, foraging, ruminating, resting, moving and flighting (Table 6.1) as listed by Kurauwone et al. (2013). Activity budget observations were recorded from three Impala social group categories namely, bachelor males, breeding herds and territorial males. Time spent on different daily activities was recorded for the establishment of activity time budgets per time interval and for wet and dry seasons (Ejigu et al., 2020). We spread observations across a 24-hour period, which was divided into four-time intervals from 06:00 – 10:00 (morning period), 10:00 – 14:00 (midday period), 14:00 – 18:00 (afternoon period), and 18:00 – 06:00 (night period). To further refine our activity analyses, the morning period was further subdivided into early morning (06:00 – 08:00) and late morning (08:00 – 10:00) periods, and the afternoon period was subdivided into early afternoon (14:00 - 16:00) and late afternoon (16:00 – 18:00) periods.

**Table 6.1:** Daily activities of Impala during the wet and dry seasons.

<b>Activity</b>	<b>Definition</b>
<b>Foraging</b>	Ingesting food or drink, or processing (chewing) food items during a grazing bout and or food searching with head below the vertebral column.
<b>Vigilance</b>	Individuals scanning their surroundings and exhibiting agonistic displays.
<b>Resting</b>	Standing or sleeping in the sun or shade, neither ruminating nor scanning the environment.
<b>Ruminating</b>	Chewing the cud while standing, lying or in locomotion.
<b>Moving</b>	Locomotion between foraging areas or within study area.
<b>Flight</b>	Animal running away, out of view from the observer.

### 6.2.2 Data analysis

We calculated the duration of activities as the proportion of time (expressed as a percentage) that individual Impala spent participating in an activity state. Microsoft Excel was used to determine the mean ( $\bar{x}$ ) and standard error (SE) for the proportions of time spent seasonally by Impala in the various activity states. We used one-way Analysis of Variance (ANOVA) for the comparison of differences in diurnal activities during and across wet and dry seasons, and across Impala social groups. Tukey post hoc tests were conducted to identify significant differences in the proportion of time spent on various activities.

## 6.3 RESULTS

### 6.3.1 Time budget of diurnal activity patterns

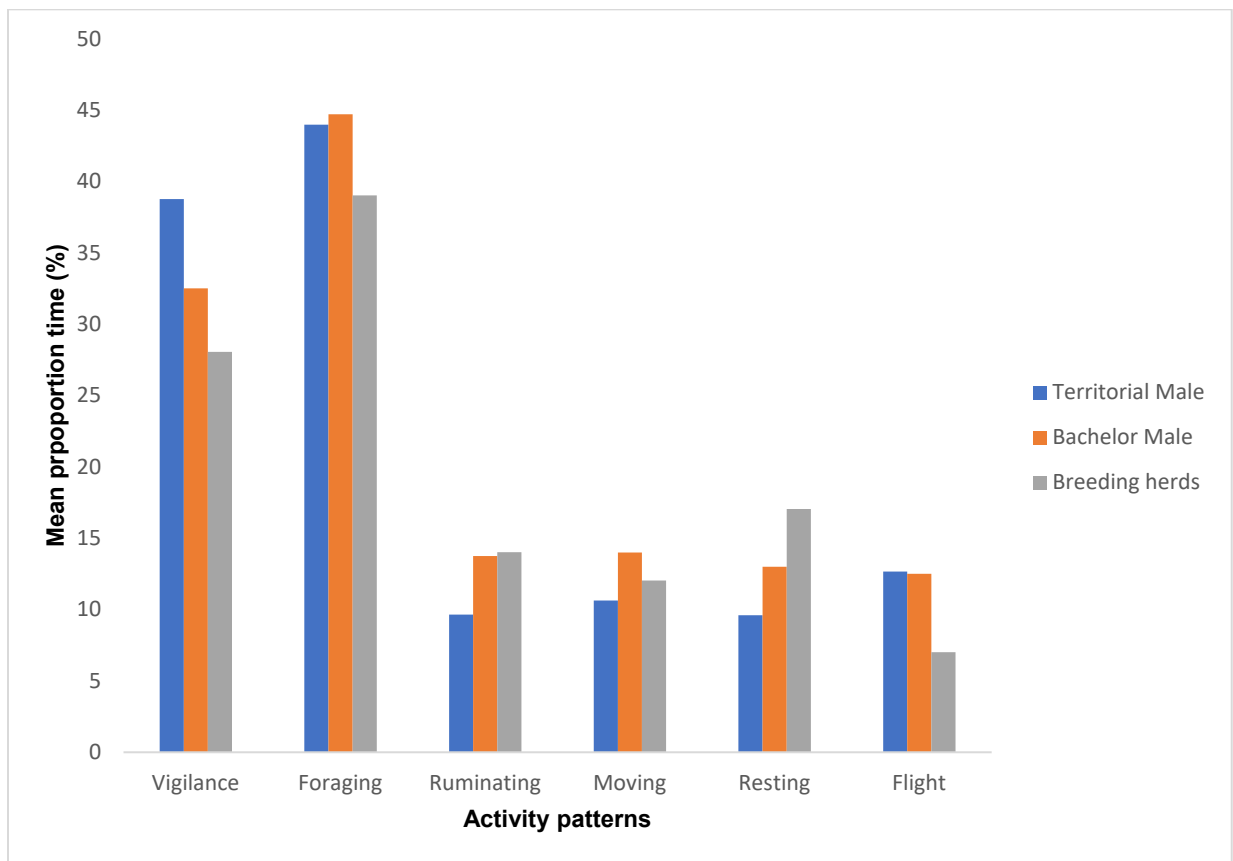
#### 6.3.1.1 Combined wet and dry season proportions of time spent on various activities

The proportion of time that the various Impala social groups spent doing the different activities is depicted in Figure 6.1. The proportion of time spent being vigilant by the breeding herds ( $23.01 \pm 3.53$ ), bachelor males ( $32.5 \pm 2.02$ ) and territorial males ( $38.76 \pm 0.58$ ) was not significantly different (ANOVA:  $F = 0.81$ ,  $P > 0.05$ ). Although not statistically significant, territorial males were more vigilant, followed by the bachelor males. There was no significant difference (ANOVA:  $F = 0.005$ ,  $P > 0.05$ ) in the proportion of time spent foraging by breeding herds ( $43.76 \pm 4.09$ ), bachelor males ( $44.7 \pm 6.75$ ) and territorial males ( $43.97 \pm 6.37$ ). Again, we found that bachelor males forage more than territorial males and breeding herds respectively, although not statistically significant. The proportion of time spent moving by the breeding herds ( $13.03 \pm 2.01$ ), bachelor males ( $14 \pm 1.19$ ) and territorial males ( $10.63 \pm 0.49$ ) was not significant (ANOVA:  $F = 1.58$ ,  $P > 0.05$ ), though bachelor males move more followed by breeding herds and territorial males.

The results showed no significant difference in the proportion of time spent ruminating (ANOVA:  $F = 4.19$ ,  $P > 0.05$ ) by the breeding herds ( $13.02 \pm 1.38$ ), bachelor males ( $13.75 \pm 1.19$ ) and territorial males ( $9.65 \pm 3.64$ ); however, our observations reveal that territorial males ruminate least compared to breeding herds and bachelor males that ruminate for similar proportions of time. We also found no significant differences for resting (ANOVA:  $F = 4.37$ ,  $P > 0.05$ ) and flight activities (ANOVA:  $F = 7.05$ ,  $P > 0.05$ ) in the proportions of time spent doing these activities by breeding herds, bachelor males and territorial males. For resting, although not statistically significant, breeding herds spent the most time resting compared to bachelor males and territorial males respectively. Territorial males and bachelor males spent similar proportions of time on flight compared to breeding herds that spent the least amount of time spent on flight.

The proportion of time apportioned to activities other than ruminating, moving and flight by Impala varied seasonally. The proportion of time spent vigilant for the different Impala groups occurring in the wet, and dry seasons did not differ significantly (ANOVA:  $F = 0.81$ ,  $P = 0.47$ ). The wet season presented the highest proportion of time spent in terms of vigilance. A non-significant difference was noted for foraging (ANOVA:  $F = 0.06$ ,  $P = 0.99$ ) and moving (ANOVA:  $F = 1.58$ ,  $P = 0.25$ ) across the wet, and dry seasons (Figure 6.1).

The results indicated that there was no significant difference in the proportion of time spent on all activities by Impala social groups in the wet and dry seasons (ANOVA:  $F = 0.003$ ,  $P = 0.99$ ).



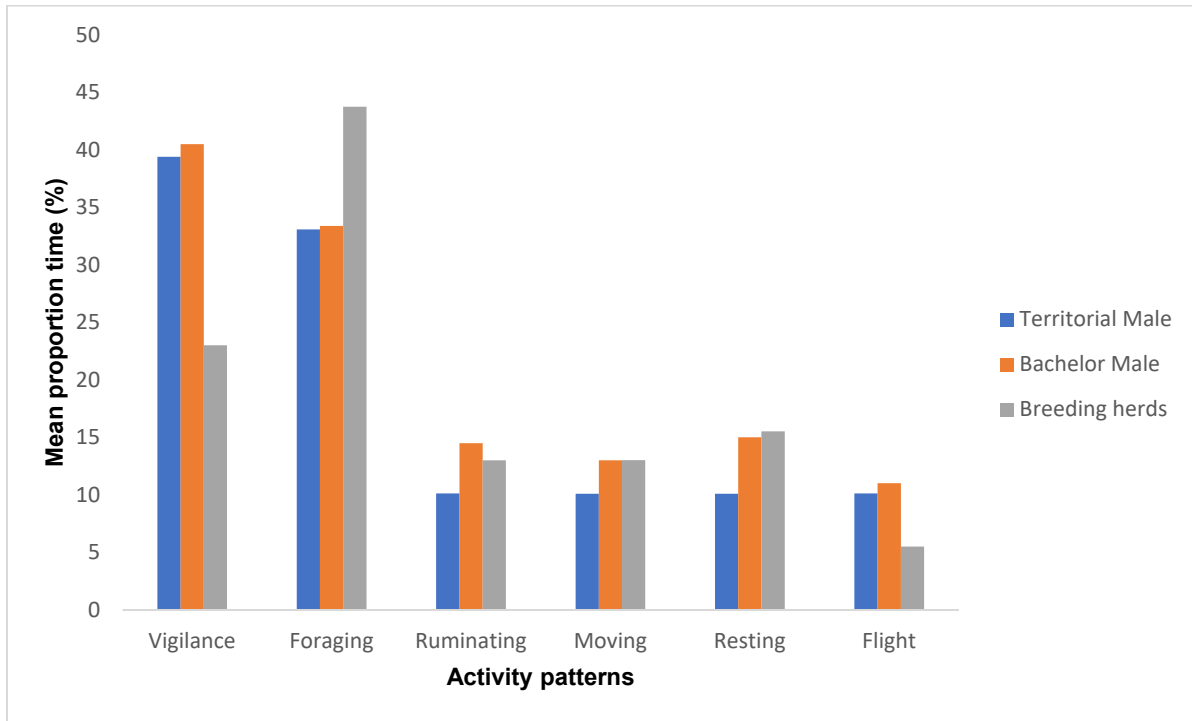
**Figure 6.1:** Proportion of time spent on different activities by the various Impala social groups for both wet and dry seasons.

### 6.3.1.2 Proportion of time spent on various activities in the wet season

The proportion of time that the various Impala social groups spent doing their different activities in the wet season are shown in Figure 6.2. Results indicate that, with the exception of ruminating, there were no significant differences in the proportion of time spent on the other activities investigated for breeding herds, territorial males and bachelor males during the wet season. The proportion of time spent on vigilance by the breeding herds ( $28.05 \pm 3.79$ ), bachelor male ( $40.5 \pm 2.4$ ) and territorial males ( $39.4 \pm 1.4$ ) was not significantly different (ANOVA:  $F = 4.48$ ,  $P > 0.05$ ). However, the territorial and bachelor males were more vigilant than the breeding herds (38 – 41% compared to 23%). The proportion of time spent foraging by the breeding herds ( $39.02 \pm 2.22$ ), bachelor males ( $39.4 \pm 0.6$ ) and territorial males ( $33.09 \pm 0.09$ ) were not significantly different (ANOVA:  $F = 1.86$ ,  $P > 0.05$ ), although breeding herds foraged more (43%) than the territorial males and bachelor males which had a similar foraging proportion (33%). There was no significant difference (ANOVA:  $F = 1.23$ ,  $P > 0.05$ ) in the proportion of time spent moving by bachelor males ( $13.01 \pm 0.9$ ), breeding herds ( $12.03 \pm 2.08$ ) and territorial males ( $10.1 \pm 0.1$ ). However, bachelor males and breeding herds, having a similar moving proportion (13%), moved more than the territorial males (10%). There was no significant difference (ANOVA:  $F = 3.05$ ,  $P > 0.05$ ) in the proportion of time spent resting by bachelor males ( $15.02 \pm 3.1$ ), breeding herds ( $17.04 \pm 1.66$ ) and territorial males ( $10.1 \pm 0.1$ ). However, bachelor males and breeding herds rested more than the territorial males (15 – 15.5% compared to 10%). The proportion of time spent on flight by the breeding herds ( $7.01 \pm 1.21$ ), bachelor males ( $11.03 \pm 2.1$ ) and territorial males ( $10.13 \pm 0.18$ ) was also not significantly different (ANOVA:  $F = 2.31$ ,  $P > 0.05$ ), although territorial males and bachelor males (10-11%) were in flight (running away) more than the breeding herds (5.5%). We did however find that there was a significant difference (ANOVA:  $F = 56$ ,  $P < 0.05$ ) in the proportion of time spent ruminating by bachelor males ( $14.5 \pm 1.6$ ), breeding herds ( $14.02 \pm 2.52$ ) and territorial males ( $10.13 \pm 0.18$ ). To find out which specific groups means (compared with each other) were different, we performed Tukey post hoc tests and the



results revealed significant differences between the territorial males and bachelor males (Tukey:  $P < 0.05$ ) and between bachelor males and breeding herds (Tukey:  $P < 0.05$ ).

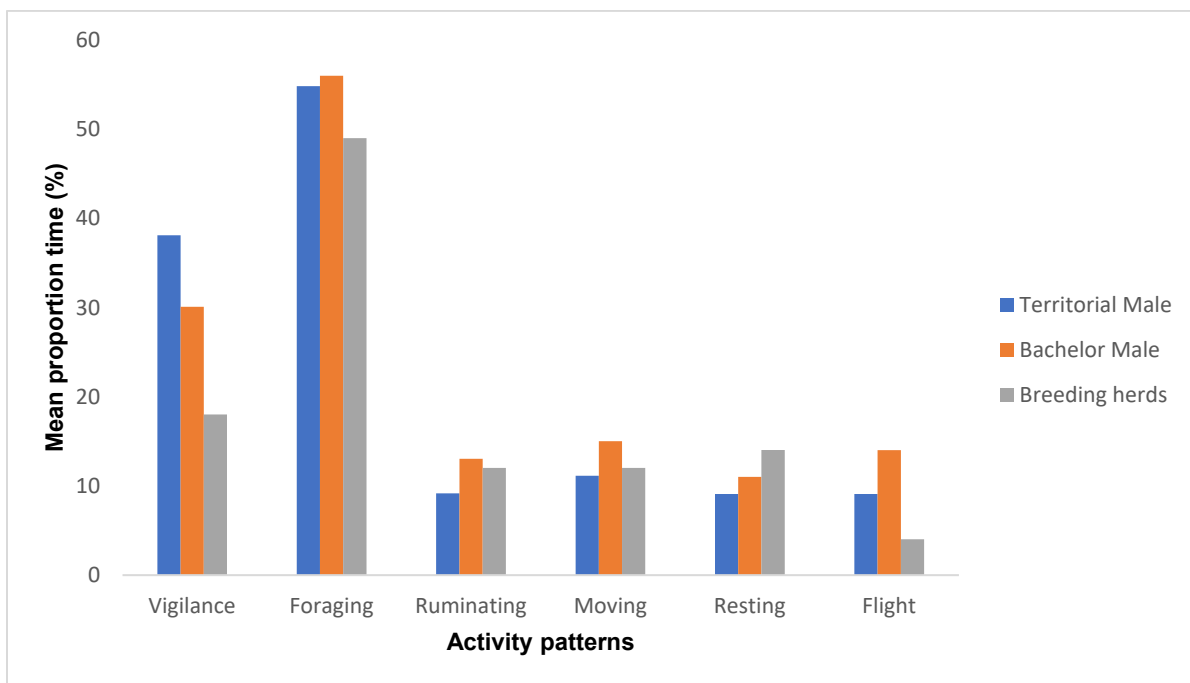


**Figure 6.2:** Proportion of time spent on different activities by the various Impala social groups in wet seasons.

### 6.3.1.3 Proportion of time spent on various activities in the dry season

Proportions of time spent doing different activities by the various Impala social groups in the dry season are shown in Figure 6.3. Results indicate that, with the exception of vigilance and flight, there were no significant differences in the proportion of time spent on the other activities investigated for breeding herds, territorial males and bachelor males during the dry season. The proportion of time spent on vigilance by the breeding herds ( $18.02 \pm 3.39$ ), bachelor males ( $30.1 \pm 2.6$ ) and territorial males ( $38.13 \pm 0.18$ ) was significantly different (ANOVA:  $F = 16.85$ ,  $P < 0.05$ ). Tukey post hoc test results revealed that the significant difference was found between the territorial males and breeding herds (Tukey:  $P < 0.05$ ).

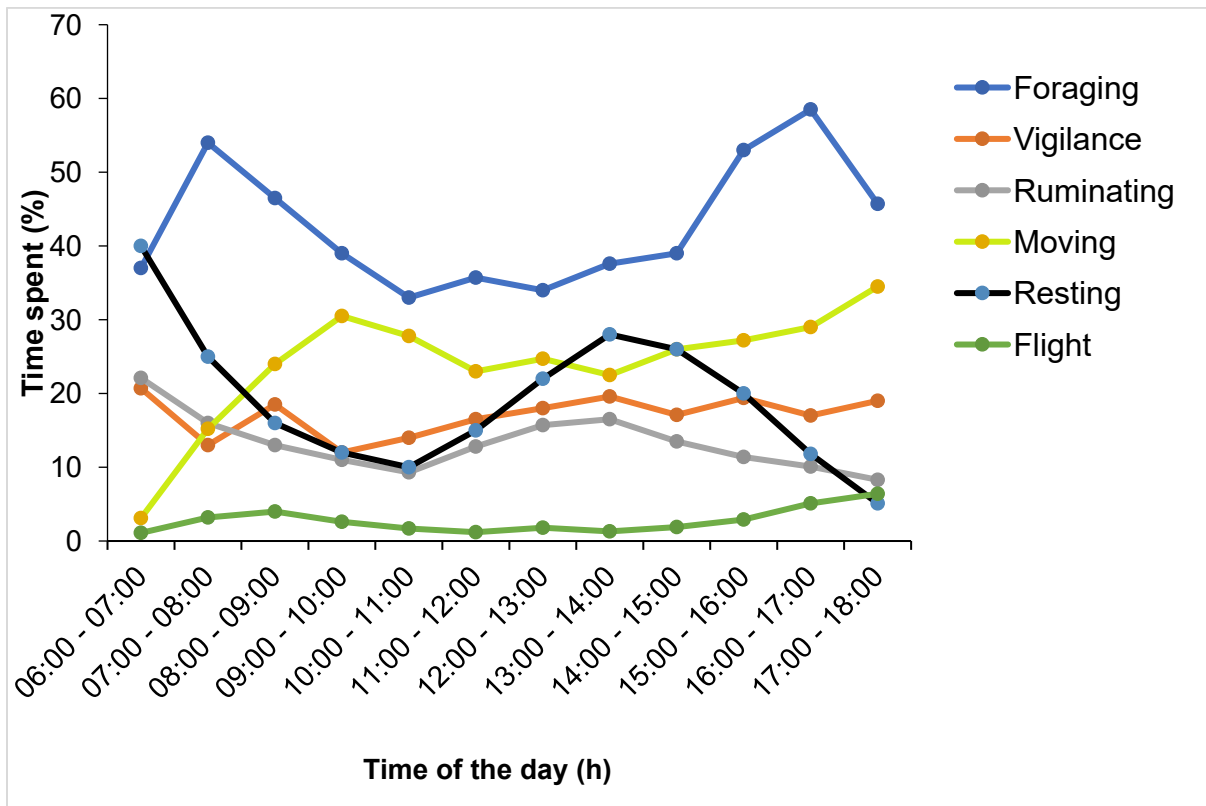
The proportion of time spent on flight by the breeding herds ( $4.03 \pm 2.13$ ), territorial males ( $9.1 \pm 0.4$ ) and bachelor males ( $14.02 \pm 2.32$ ) was significantly different (ANOVA:  $F = 8.69$ ,  $P < 0.05$ ). Tukey post hoc test results revealed that the significant difference was found between the territorial males and breeding herds (Tukey:  $P < 0.05$ ). The proportion of time spent foraging by the breeding herds ( $49.01 \pm 6.61$ ), by bachelor males ( $56.02 \pm 4.22$ ) and territorial males ( $54.85 \pm 2.55$ ) was not significantly different (ANOVA:  $F = 0.62$ ,  $P > 0.05$ ). However, territorial males and bachelor males foraged more than the breeding herds (55 – 56% compared to 48%). There was no significant difference (ANOVA:  $F = 0.49$ ,  $P > 0.05$ ) in the proportion of time spent moving by bachelor males ( $15.02 \pm 2.42$ ), breeding herds ( $12.03 \pm 2.08$ ) and territorial males ( $11.15 \pm 0.95$ ); however, bachelor males moved more than territorial males and breeding herds (16% compared to 11 – 12%). There was also no significant difference (ANOVA:  $F = 1.71$ ,  $P > 0.05$ ) in the proportion of time spent resting by bachelor males ( $11.02 \pm 0.51$ ), breeding herds ( $14.04 \pm 4.24$ ) and territorial males ( $9.1 \pm 0.4$ ), although breeding herds were observed resting more than the bachelor males and the territorial males (15% compared to 11-9%).



**Figure 6.3:** Proportion of time spent on different activities by the various Impala social groups in the dry season.

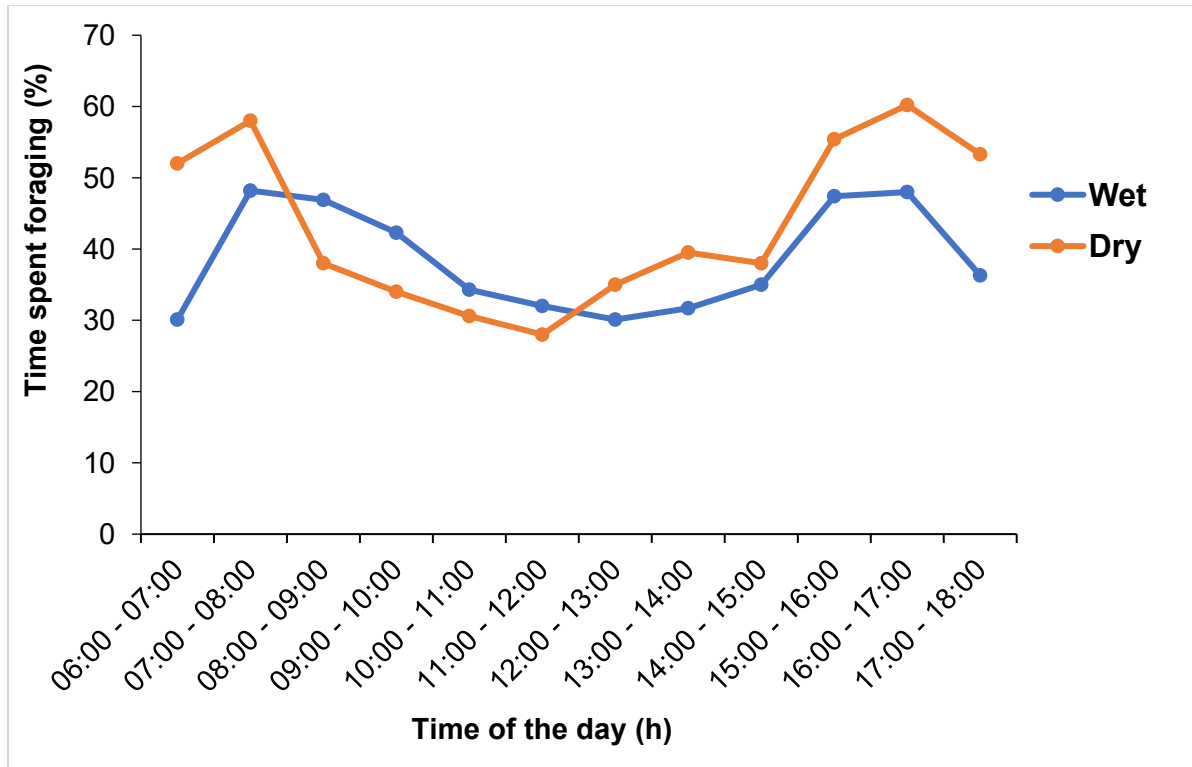
### 6.3.2 Daily activity pattern comparisons 06:00 – 10:00, 10:00 – 14:00, and 14:00 – 18:00 for combined wet and dry seasons

We observed that the activities of all Impala social groups combined vary throughout the day when combining wet and dry season observations together. Figure 6.4 reveals that Impala spent more time foraging during the morning period and in the afternoon period. As expected, resting decreased during these periods due to the foraging activity. Moving slowly increased during the day from the morning period through to the afternoon period, while flight remained constant throughout the day at below 10%. Vigilance of the Impala groups tended to fluctuate throughout the day.



**Figure 6.4:** Daily percentage of time spent engaged in different activities for the various Impala groups combined during the study period.

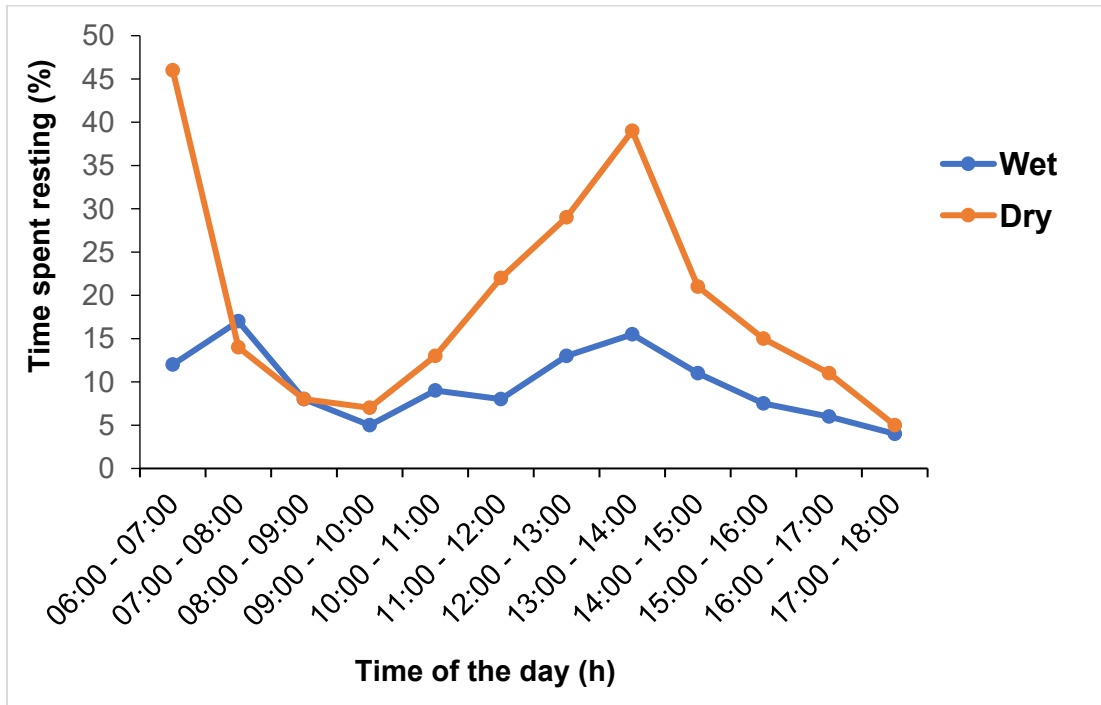
There were no significant differences in foraging activity across the daily periods between the wet and dry seasons (ANOVA:  $F = 1.59$ ,  $P > 0.05$ ) (Figure 6.5). Foraging activities for the various Impala groups increased during the wet season for the morning period and decreased in the dry season. Foraging for both the dry and wet seasons increased in the afternoon period, reaching their peak in the late afternoon.



**Figure 6.5:** Percentage of time spent foraging during the wet and dry seasons for all Impala social groups combined.

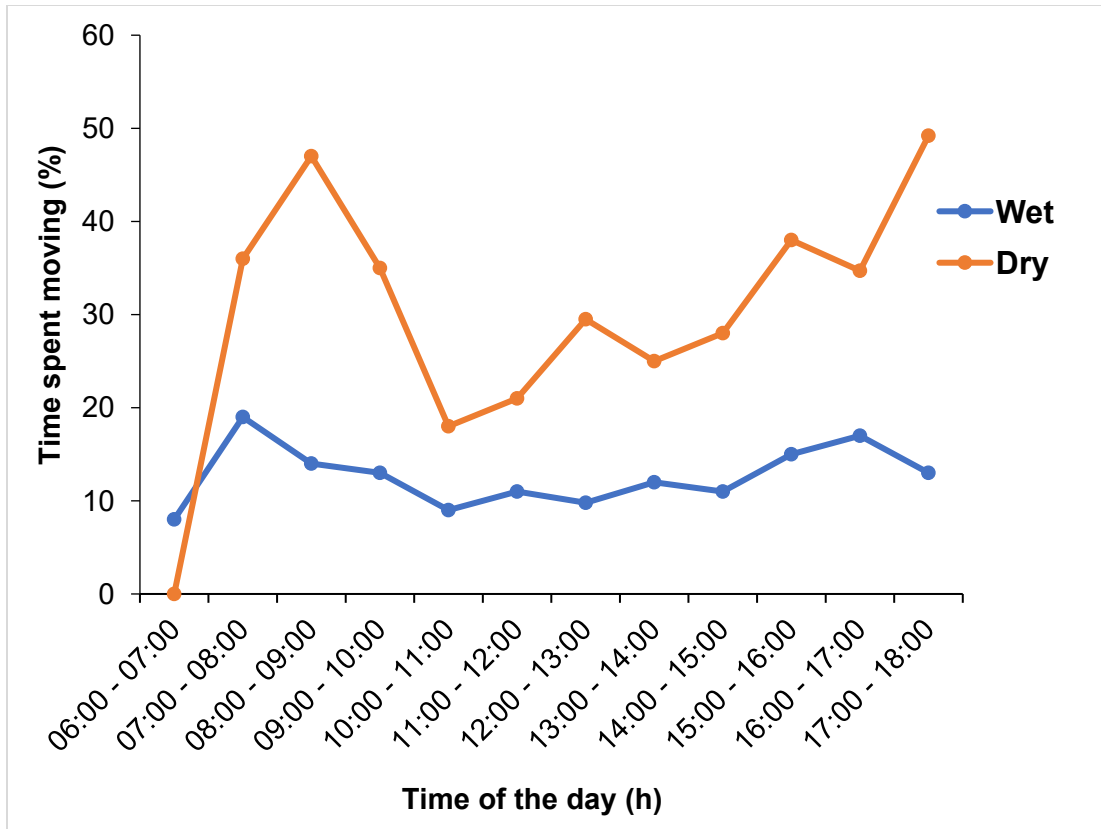
We observed a significant difference in resting (ANOVA:  $F = 5.87$ ,  $P \leq 0.05$ ) (Figure 6.6) and moving (ANOVA:  $F = 19.41$ ,  $P \leq 0.05$ ) (Figure 6.7) for the various Impala groups across the wet and dry seasons. We performed Tukey post hoc tests for resting and the results revealed significant differences for the early morning period (Tukey:  $P < 0.05$ ) and for the midday period (Tukey:  $P < 0.05$ ). Further, the Tukey post hoc test results for moving revealed that significant differences were found for the early morning period (Tukey:  $P < 0.05$ ) and the late afternoon period (Tukey:  $P < 0.05$ ). Resting decreased

sharply in the morning period during the dry season and peaked in the midday period, before decreasing again in the afternoon period and reaching its lowest in the night. During the wet season, resting increased during the midday period despite the groups moving fairly constantly.



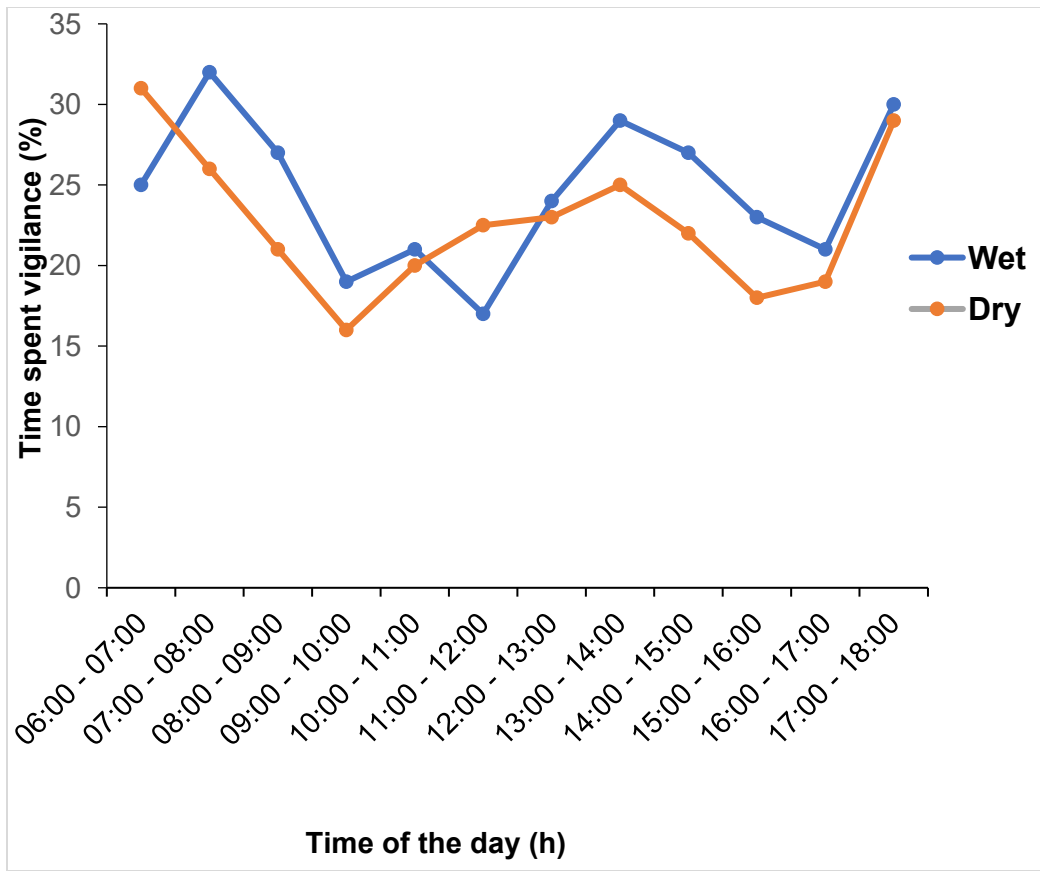
**Figure 6.6:** Percentage of time spent resting during the wet and dry seasons for the combined Impala social groups.

In the dry season, moving increased in the early morning period and reached its peak in the late afternoon period (Figure 6.7). Moving during the wet season also increased in the early morning period, before levelling off and remaining constant throughout the day, only dropping again in the late afternoon period.



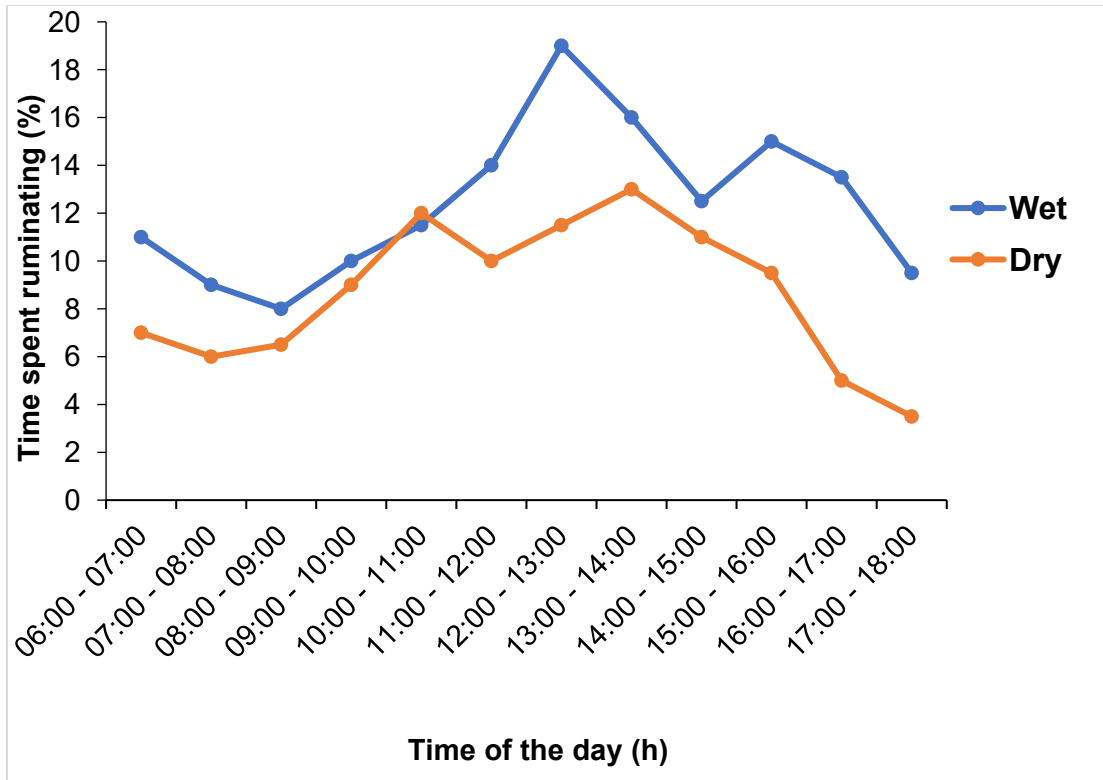
**Figure 6.7:** Percentage of time spent moving during the wet and dry seasons for the combined Impala social groups.

Results show that there was no significant difference in daily vigilance between the wet and dry seasons (ANOVA:  $F = 1.03$ ,  $P > 0.05$ ) (Figure 6.8). During the wet season, vigilance peaked in the early morning period and slowly declined towards midday, increasing again in the late afternoon period. During the dry season, vigilance declined from its peak in the early morning period and reached its lowest point in the late morning period, before increasing in the late afternoon period.



**Figure 6.8:** Percentage of time spent being vigilant during the wet and dry seasons for the combined Impala social groups.

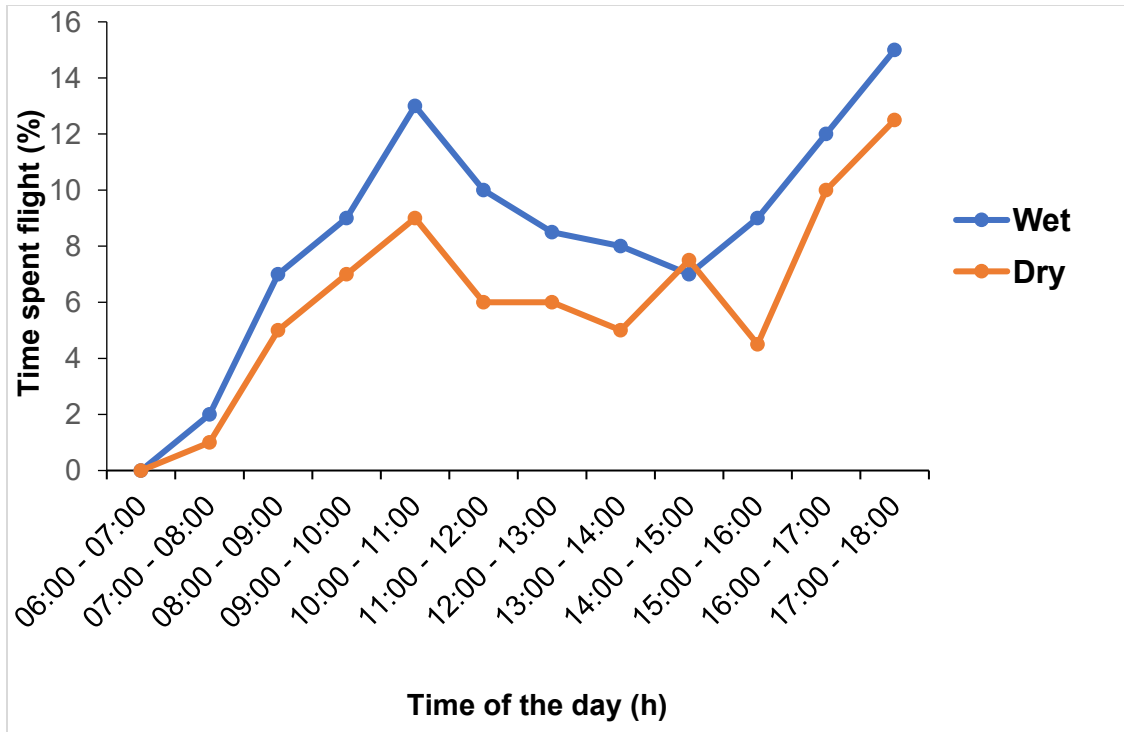
Ruminating during the wet and dry seasons differed significantly (ANOVA:  $F = 8.61$ ,  $P \leq 0.05$ ) (Figure 6.9). Tukey post hoc test results revealed significant differences between 11:00 – 13:00 (Tukey:  $P < 0.05$ ). Ruminating during the wet and dry seasons declined in the morning period, reaching its peak before midday and again in the late afternoon period for both the wet and dry seasons. Ruminating activity patterns for the various Impala social groups during both seasons were similar.



**Figure 6.9:** Percentage of time spent ruminating during the wet and dry seasons for all Impala social groups combined.

Daily flight activity patterns between the wet and dry seasons were not significantly different ( $F = 2.01$ ,  $P > 0.05$ ) (Figure 6.10). During both the wet and dry seasons, flight activity increased from the early morning period and peaked in the late morning period. In the wet season, after this peak, flight events decreased into the early afternoon period and increased again into the late afternoon and night periods. In the dry season, after the late morning period peak, flight events decreased until the early afternoon period when they peaked and dropped again, increasing into the late afternoon and night periods. Overall, daily flight activity for the wet and dry seasons was similar.





**Figure 6.10:** Percentage of time spent in flight during the wet and dry seasons for all Impala social groups combined.

## 6.4 DISCUSSION

### 6.4.1 Time budget of diurnal activity patterns

The activity budgets of territorial males, bachelor males and breeding herds at Loskop Dam Nature Reserve (LDNR) were significantly different across seasons for the proportion of time spent ruminating, being vigilant and for flight. Our results are similar to findings from Kurauwone et al. (2013), who studied the activity budgets of Impala in enclosed environments. Although the proportion of time spent on vigilance by territorial males, bachelor males and breeding herds was not statistically significant, we found that males (territorial males and bachelor males) spend more time on vigilance, as opposed to females (breeding herds). Our findings are similar to those of several other scientists who studied Impala and related ungulates (Dyck & Baydack, (2004); Shorrocks & Cokayne (2005); Li et al., (2009); Xia et al. (2011)). Males scan their surroundings frequently to detect predators and lookout for their group members (Muposhi et al., 2016). The variation in vigilance between territorial males, bachelor males, and breeding herds in our study could be associated to the presence of visitors in the reserve, as many visitors may trigger human-induced disturbance stimuli, which is perceived as a threat by the Impala groups (Muposhi et al., 2016). Vigilance displays can be defined as a strategic behaviour that allows animals to take control of their environment and monitor predation risk (Javurkova et al., 2011).

The proportion of time spent being vigilant, foraging, moving, resting, ruminating and in flight vary due to the amount of disturbance caused by tourists (Steidl & Anthony, 2000) and possibly the risk of predation (Lima, 1998) as observed by Kurauwone et al. (2013). According to Frid & Dill (2002), ecotourism can be considered as one of predation risks, which limits the time spent on daily activities. Animals perceive humans as one of the potential predators and behave appropriately (Kurauwone et al., 2013).

In this study it was found that the proportion of time spent on vigilance by the three categories of Impala social groups did not statistically differ, although as previously stated, the males were more vigilant. This is likely caused by Impala social groups being

habituated to the presence of humans on the reserve and not being exposed to a high density of predators, even though leopards are present on the reserve. Whittaker & Knight (1998) explained that habituation in animals occur when individuals are usually exposed to constant neutral stimuli. This further implies that Impala groups do not consider human presence as a constant or persistent threat at LDNR, although ecotourism tends to be considered as a form of predation risk that may influence the time Impala spend on various activities (Frid & Dill, 2002). According to Kurauwone et al. (2013), the long-term socioecological implications and unplanned consequences of ecotourism are still uncertain.

#### **6.4.2 Comparing activity patterns of Impala social group across wet and dry seasons**

Across seasons, results reveal that all three Impala social groups (territorial males, breeding herds and bachelor males) spend most of their time foraging and being vigilant. Territorial males spend the least amount of time resting, while bachelor males and breeding herds spend the least amount of time on flight.

In the wet season, territorial males spent most of their time on vigilance and foraging and the least amount of time ruminating, moving, resting and on flight. Bachelor males spent most of their time on vigilance and foraging and the least amount of time moving and on flight. Breeding herds spent most of their time foraging and the least amount of their time on flight.

In the dry season, territorial males spent most of their time on foraging and on vigilance and spent the least amount of time ruminating, resting and on flight. Territorial males spent equal amounts of time resting and on flight in the dry season. Bachelor males spent most of their time foraging and being vigilant and the least amount of time on ruminating and resting. Although at different proportions, just like territorial males, bachelor males and breeding herds spent most of their time foraging and being vigilant, and the least amount of time on flight.

The activity budgets of territorial males, bachelor males and breeding herds differed seasonally in the proportion of time spent ruminating, being vigilant, and in flight. According to Periquet et al. (2012), group size and seasonality influence vigilance. We found that territorial males, bachelor males and breeding herds forage more in the dry season than in the wet season. This is likely due to seasonal differences in the quality and availability of forage. Wronski (2002) found that Impala in Mburu National Park, Uganda spends more time foraging during the dry season than in the wet season and tend to increase their foraging time during the dry season. Foraging time by ungulates increases during the dry season because forage quality and quantity is limited (Di Blanco & Hirsch, 2006).

We found that all Impala social groups spent less time moving during the wet season compared to the dry season. This is similar to a study done by Dunham (1982), who found that individuals spent less time moving and foraging during the wet season due to the availability of sufficient high nutrient forage in this season, compared to the dry season when forage was nutrient poor and animals had to travel further to meet their daily nutritional requirements. Variation in the proportion of time spent moving is also related to the location of water and shade. We observed that during the dry season, Impala actively looked for shade during the hot midday period and often travelled to water or stayed in close proximity to water. Impala social groups spent less time resting during the dry season compared to the wet season. These results are similar to those of Komers et al. (1992) and Kurauwone et al. (2013).

#### **6.4.3 Daily period activity patterns**

High levels of foraging activity were observed in the early morning and afternoon periods. Resting increased during the midday period. Our findings revealed that foraging increased during the dry season in the early morning and late afternoon periods, which could be attributed to decreasing forage quality and availability. According to Owen-Smith (1982), foraging time of several African grazers increased in the early morning and late afternoon periods with decreasing forage availability during the dry season. The

difference we observed in foraging across seasons could be explained by the availability of palatable and nutritious feed during the wet season. We found that time spent foraging was longer in the dry season than in the wet season, and time spent foraging during the wet season could be easily interrupted before midday. We observed two foraging peaks for both the dry and wet seasons, in the early morning period and in the late afternoon period. Ruminating peaked during the midday period for both the wet and dry seasons, from 12:00 –13:00 for the wet season and from 13:00 – 14:00 for the dry season.

During the wet season, resting occurred throughout the day, with slight variations in terms of movement in the early morning period. During the dry season, resting fluctuated and increased from the late morning period into the early afternoon period. Resting showed a significant difference between the dry and wet seasons, with stronger peaks during the dry season compared to the wet season.

In this study, Impala showed two peaks for movement in the dry season, in the late morning period and in the late afternoon period as they continued foraging while moving. Moving remained constantly below 20% of all activities combined throughout the day during the wet season. Flight also peaked in the late afternoon period for the dry season, and in the late morning and late afternoon periods for the wet season. Movement and flight peaks in the morning and late afternoon periods might be due to bachelor males and breeding herds socialising, or due to other social group types returning to their resting spots after foraging during the late afternoon period.

Generally, Impala were constantly vigilant throughout the day; however, they were more vigilant in the early morning and late afternoon periods. The highest proportion of vigilance was found during the wet season, where it reached a peak of 33% in the early morning period, compared to 17% during the midday period. This is likely due to less visibility in the wet season, which is also the growing season when vegetation is dense, resulting in Impala having to increase their level of vigilance. In the dry season visibility increases as vegetation becomes less dense and many deciduous trees lose their leaves. Higher visibility in the dry season causes Impala to spend more time looking for food, or

disturbances (human or non-human) and anticipating the movement of their predators. According to Hayward et al. (2006), leopards prey preferences include Impala, bushbuck, and common duiker, which occur in small herds, in dense habitat and afford the hunter minimal risk of injury during capture. Our observations were in line with Abraham & Simon (2020), who reported that individuals found on the border of herds or are solitary spent more time being vigilant than those found within the groups.

## 6.5 CONCLUSION

Territorial males were more vigilant than other social groups, and bachelor males foraged more than breeding herds and territorial males. Impala social groups at LDNR spent more time foraging in both the dry and wet seasons than partaking in any other activity. Males were more vigilant compared to breeding herds in both the wet and dry seasons. Overall, the proportions of time spent on different activities were significantly different between territorial males, bachelor males and breeding herds.

Across seasons, Impala social groups spent more time foraging in the early mornings and afternoons than during the midday period. Foraging increased in the morning period in the wet season and decreased in the morning period in the dry season. Moving for all social groups increased slowly throughout the day from the morning period into the afternoon period. Flight was generally constant throughout the day. Resting oscillated considerably throughout the day and across seasons, increasing significantly between the late morning and early afternoon periods.

In the dry season, moving increased from the early morning period into the late afternoon period, as opposed to the wet season where Impala social group moving increased in the early morning period and remained constant during the rest of the day, before decreasing in the late afternoon period. During the wet season, vigilance of the various Impala social groups varied, peaking in the early morning period, and decreasing towards midday, before increasing again in the late afternoon period. In the dry season, vigilance peaked at night, and during the early morning and late afternoon periods. Impala were least vigilant during the late morning and in the early afternoon periods. Ruminating remained similar during both the wet and dry seasons for the various Impala social groups.

Forage quality has indicated to reduce Impala movements (Pays et al., 2021), the amount of time spent being vigilant (Pays et al., 2012), and influences feeding behaviour (Blanchard et al., 2008). Vigilance is a key anti-predator strategy for ungulates and can cost individuals by decreasing time available for foraging (Kie, 1999). When herbivores

alter their foraging rate to survive during times of decreased food availability, they also tend to modify or reduce their moving rate in view of a limited resources influenced by intraspecific competition (Smith & Cain, 2009). Behavioural responses of ungulates to environmental stimuli, group size and vigilance can affect foraging behaviour (Smith & Cain, 2009).

Knowledge about activity patterns is important for informing conservation management plans. In this study, wet and dry seasonal differences in activity budgets were minimal for the three Impala social group types observed in the reserve. Observed differences are likely influenced by resource availability and disturbance (human and non-human). The understanding of diurnal activity patterns of Impala social groups is important for reserve managers, allowing them to understand the effects of human activity on animal activities, particularly Impala. Knowing how resources affect Impala activities provides managers with valuable information that they can use to improve their resource monitoring programs, ensuring that there are sufficient resources for the sustainable conservation of Impala and the other animals living on the reserve in the future.

Abraham & Simon (2020) have indicated that there are four factors that may influence ungulate daily activity patterns. These include 1) seasonal differences the quality and quantity of forage, 2) time of day and environmental and climatic factors, 3) ungulate movements and human activity, and 4) biological process occurring during a 24-hours interval. It is recommended that LDNR performs regular monitoring of Impala social groups behaviour to produce long-term knowledge and information to use in adaptive management studies (Kurauwone et al., 2013).



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# CHAPTER 7

## CONCLUSION

Studying habitat utilisation and daily activity patterns of the various Impala groups at LDNR using GPS technology and direct observation has shown to be successful. During the direct observations, Impala groups were not affected negatively by the presence of the observer's vehicle. The Impala treated the observer's vehicle as part of their natural environment since this did not interrupt their daily activities.

We classified and mapped the various plant communities occurring within Impala seasonal home ranges and examined seasonal habitat selection and habitat use. We determined which plant communities were selected most in the dry, wet, and combined seasons. Seasonal daily activity pattern data collected for the Impala provided a clear understanding about how they provision their activities diurnally. This habitat utilisation and activity pattern data will provide information for the management of Impala and their habitats at LDNR.

Managing the plant communities in the Impala's home range is important for maintaining and improving the veld condition and browsing capacity of the area. High densities of woody plant species in the lower height class occurring in Community 1, (*Terminalia sericea*–*Hyperthelia dissoluta* open woodland) may cause bush encroachment that will affect the veld condition in the future and may lead to poor grazing conditions. The grass and tree species in this community are seldomly utilized as they have a low production potential. Community 2, (*Euclea crispa*–*Vachellia karroo* closed woodland) species may lead to negative effects such as bush encroachment if not properly maintained. This community provides good feeding patches as some areas are overgrazed. Some parts of community 3, (*Combretum molle*–*Faurea saligna*) closed woodland and community 4, (*Themeda triandra*–*Burkea africana* open to closed woodland) were overgrazed due to the presence of palatable grasses. Community 5 (*Panicum natalense*–*Themeda triandra* closed grassland) and community 6 (*Dichrostachys cinerea*–*Andropogon schirensis* open

shrubland) had the lowest number of woody species for the whole study area. These communities were balanced in terms of palatable and unpalatable species.

According to the findings of this study, the Impala wet season home range was considerably smaller than the dry and combined seasons home ranges. It was found that during the dry season, Impala travelled longer distances to search for available feed patches that were situated further from drinking places.

During the wet season, Impala utilised more of the *Euclea crispa-Vachellia karroo* closed woodland, *Themeda triandra–Burkea africana* open to closed woodland and the *Combretum molle-Faurea saligna* closed woodland plant communities. These open to closed woodland habitats were preferred because they might have offered the Impala abundant forage while providing them with shady areas for resting during the heat of the day (Fischhoff et al. 2007). In the wet season, forage quality and quantity is abundant, allowing Impala to survive for longer periods without drinking water, as they spend time in shady areas and available forage provides sufficient moisture.

Preferred habitats in the dry season were the *Euclea crispa-Vachellia karroo* closed woodland, and the *Combretum molle-Faurea saligna* closed woodland plant communities. These two plant communities offered Impala at LDNR sufficient forage for them to meet their daily metabolic needs. Both the *Euclea crispa-Vachellia karroo* and *Combretum molle-Faurea saligna* plant communities are closed woodlands, which likely played a role in Impala avoiding predation by having sufficient places to hide, while providing shelter from the elements (Fischhoff et al. 2007). Availability of acceptable browse influences Impala habitat use during the dry season (Omphile, 1997). Results indicated that due to the reduced availability of browse in the dry season, the *Terminalia sericea-Hyperthelia dissoluta* open woodland was a poor habitat for Impala. These plant communities occur in areas with well-drained soils and average sloping topography, within travel distance of available water sources that Impala utilise during the dry season when the vegetation they feed on has less moisture (Smithers, 1983).

A seasonal pattern of habitat utilisation was evident in this study. Combined season plant community selection showed that Impala utilised *Euclea crispa-Vachellia karroo* closed woodland, *Themeda triandra–Burkea africana* open to closed woodland, and *Combretum molle-Faurea saligna* closed woodland. These different seasonal habitat preferences were influenced by the presence and availability of quality and quantity of forage (Mtui, 2014). The presence of *Vachellia karroo*, *Euclea crispa*, *Combretum mole*, *Terminalia sericea*, *Faurea saligna*, and *Burkea africana* provided an abundance of woody plant species that Impala browse on.

The selection of open to closed woodlands by Impala in the dry, wet, and combined seasons show that these types of habitats are important for the Impala population at LDNR. Woodlands are predominantly utilised during the wet season when there is an abundance of resources to choose from. The presence of nutritious seed pods during the dry season was probably the reason why the Impala were attracted to the *Vachellia karroo* dominated areas in the *Euclea crispa – Vachellia karroo* woodland plant community during this season. Knowing which habitats are seasonally important provides valuable information to reserve management about these primary Impala habitats so that they can be managed in a sustainable manner (Bonyongo, 2005).

It was found that all Impala social groups spent less time moving during the wet season compared to the dry season. The wet season provide quality and sufficient nutrient forage hence Impala spent less time moving and foraging (Dunham, 1982). The wet season is also known as the growing season where vegetation becomes thick and visibility is compromised, therefore, Impala become more vigilant when vegetation is dense as a mechanism to avoid predation.

During the dry season, more time was spent foraging and moving because this is a period where forage was nutrient poor and animals had to travel further to meet their daily nutritional requirements (Dunham, 1982). Impala were searching for shade during the hot midday period of the dry season and would also move closer to water sources, resulting in less time being spent resting. Visibility increased in the dry season when vegetation

became less dense, and many deciduous trees abscised their leaves. Impala spend more time searching for food and moving at the same time due to threats from predators in the dry season, which might increase their exposure as their habitats are more open. When the quality and quantity of food is low, feeding and ruminating time are impacted. During this period, males are affected because they limit their feeding and ruminating time, spending more time on being vigilant and territorial. The energy cost of territoriality is large; however, territorial males must pay this price to keep their territories and accompanying uninterrupted mating rights (Estes & Goddard, 1967; Schaller, 1968; Caraco & Wolf, 1975; Fuller & Kat, 1990).

According to Okello et al., (2002), Impala, being smaller in stature than many other medium sized antelope and being selective feeders, have a higher foraging efficiency. Its daily energy requirements are higher; hence selectivity ensures highly nutritious plants to meet its energy needs. The selection of browse by this species indicates that suitable forage intake requires limited searching for quality and nutritious forage, which is an adaptation to survive during periods when there is a shortage of suitable forage. In such instances, Impala would search and forage for longer periods to avoid starvation (Owen-Smith 1982; Haschick & Kerley, 1997).

The use of GPS collar technology allows for the remote collection of location data and does not cause any disturbance to the collared animals. Movement patterns can be used to indicate the daily activity patterns and the benefits derived from different types of habitats within animal home ranges (Pays & Jarman, 2008).

The findings of the daily activity patterns for Impala at LDNR may contribute towards management plans and future research related to the integration of behavioural responses to environmental fluctuations. Managers need to regulate habitat disturbance levels in such a way that Impala's daily activities are not compromised, promoting the quality and quantity of available forage seasonally (Muposhi et al., 2016). Nature reserves should aim to promote the management and conservation of Impala habitats to promote their survival (Kurawone et al., 2013).



The results from this study correspond to other findings and support the findings that vigilance and foraging are the main activities observed for Impala. Quality and quantity of forage not only contributes to the nutrition requirements of Impala, but also has an impact on the way they partition their time and activities (Muposhi et al., 2016).

The results from this study suggest that the management of Impala habitats is imperative for LDNR reserve. Further quantitative studies related to Impala daily activity patterns be carried out, as this would contribute towards understanding the ecological limitations of the species (Pays & Jarman, 2008).

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