# The dynamics of small mammal populations in Rocky Highveld Grassland, Telperion, South Africa

**By**

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# Declaration

I, Duncan Neil MacFadyen do hereby declare that this thesis, which I do hereby submit for the degree of Doctor of Philosophy (Zoology) at the University of Pretoria is my own work and has not been previously submitted by me for a degree at this or any other tertiary institution.

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# DISCLAIMER

This thesis consists of a series of chapters that have been prepared as stand-alone manuscripts that either have been submitted or are intended for submission for publication purposes. Consequently, unavoidable overlaps and/or repetitions may occur between chapters.

# DEDICATION

This work is dedicated to my father and mother,

Neil and Jane MacFadyen

Thank you for always supporting me and for all the encouragement over the years, there is no way I could have completed this thesis without you.

You are also both the best field assistants any researcher could ask for, and you know each of the ten transects and the small mammals of Telperion as well as I do.

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# ABSTRACT

The present study investigates trap success, species richness, community structure, capture-recapture ratios, sex, population estimates, climatic effects, diversity, age structure, signs of reproduction, and seasonal changes in the body biomass in seven broad vegetation communities in the Bankenveld Grasslands of Telperion in Mpumalanga Province, and Ezemvelo Nature Reserve in Gauteng Province, South Africa. This study focuses on the effect of past management influences on diversity and abundance. The mean trap success recorded for the study is 8.6%. The Rocky Open Shrub community had the highest trap success recorded (37.03%), followed by the Northern Slope Woodland community (20.09%), Sheltered Woodland Community (14.51%), Rocky Highveld Grassland (11.98%), Degraded Grassland (7.25%), Moist Degraded Grassland (4.73%) and the lowest traps success was recorded in the Burkea Eragrostis Clumps community (4.39%). The capture frequency differed between transformed sites (12.9%) and non-transformed sites (87.1%), although the untransformed Rocky Highveld Grassland had the highest species richness, followed by the transformed Degraded Grassland community. The population of small mammals investigated appears to be resident, however certain species were not recorded at certain times of the year, and local movements are expected. Telperion and Ezemvelo Nature Reserve are estimated to have a population estimate of 377 620 small mammals on the properties. Climate appears to have a direct impact on small mammal fauna, influencing food availability, abundance, home range size and breeding. The summer months had the highest species diversity, possibly due to the fact that animals are reproductively active and more readily recorded, while maximum temperature does not appear to impact species richness, possibly due to the fact that the majority of the species recorded are nocturnal in habits. The Rocky Highveld Grassland community had the highest diversity score (H = 1.89), and is considered the most diverse community with ten species recorded. The Moist Degraded Grassland community had the second highest diversity score (H = 1.87) with eight species recorded. Three species were recorded in the Rocky Open Shrub community with the lowest diversity score (H = 0.65). The study site has a diverse and abundant small mammal fauna, indicative of a balanced ecosystem.

**Keywords:** Small mammal, trap success, richness, community, capture-recapture, sex, densities, climatic effects, diversity, age, condition, Telperion, Ezemvelo Nature Reserve, South Africa.

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# CHAPTER 1

## GENERAL INTRODUCTION

The role of herbivory and fire in creating habitat heterogeneity, and their consequent impact on small mammal populations can be complex (Birney *et al.* 1976; Yarnell *et al.* 2007). Plant succession, condition of habitat, grass palatability, ecological status, geographic location and vegetation structure are recorded to have an impact on small mammal diversity and community composition (Els & Kerley 1996; Fitzgibbon 1997; Monadjem 1997; Abramsky *et al.* 1998; Ferreira & Van Aarde 1999; Monadjem 1999; Avenant 2000a). It is generally accepted that when there are changes in habitats through ecological disturbances, a decrease in the species richness of small mammals can be expected (Monadjem & Perrin 2003). Rainfall, fire and grazing individually and in combination play a major role in shaping the vegetation dynamics of ecosystems around the globe. The relative influence of density dependence in the dynamics of rodent populations is a matter of considerable debate (Krebs 2002; Berryman 2004). Nevertheless, population growth rates are often related negatively to density, in that population abundance is likely to decline when high and increase when low (Turchin 1999). Populations of short-lived organisms, such as rodents, appear more sensitive to changes in fecundity than adult survival (Oli & Dobson 2003; Gaillard *et al.* 2005).

Rodents may reach large densities, particularly in agro-ecosystems (Leirs & Verheyen 1995; Julliard *et al.* 1999; Vibe-Petersen. *et al.* 2006; Sluydts *et al.* 2007) and are estimated to constitute >10% of the total mammal biomass in certain areas (Avenant *et al.* 2008). As primary and secondary consumers, they have an important direct and indirect influence on ecosystem functioning, often constituting the first link in the food chain of many predators (Sibly *et al.* 2005). The abundance of these populations can vary considerably over time and the cause of change in the trajectory of population growth is the central focus of population ecology (Sibly *et al.* 2005). Density dependence affects the population dynamics of many species (Sibly *et al.* 2005), whereas seasonal changes in survival and fecundity appear to exert great influence on certain populations (Boonstra & Krebs 2006). Habitat preferences of rodents in Africa are determined primarily by the type of cover available to them and in general, dense plant covers supports a higher diversity of small mammal species and are lowest at intermediate values of plant cover (Monadjem 1997). Food supply is another factor that influences small mammal biomass (Doonan & Slade 1995). In Africa, rainfall is regarded to have a primary influence on vegetation productivity (Bredenkamp *et al.* 2002), and fire and herbivory are considered to be key factors determining vegetation structure and composition (Scholes & Walker 1993). However, Parr & Chown (2003) reported that the impact of fire and grazing pressure on many components of ecosystems, such as biodiversity, are still poorly understood in Africa.

According to Yarnell *et al.* (2007) grazing negatively affected overall abundance of small mammals in general and *Mastomys* in particular, in contrast, fire alone had little immediate impact on small mammal diversity. Low level grazing and burning can help maintain small mammal biodiversity, if conducted under appropriate rainfall levels (Yarnell *et al.* 2007). A very high grazing pressure, combined with fire, especially under drought conditions, can have a negative impact on small mammal biodiversity in savanna habitats (Kern 1981). Many small mammal communities are directly influenced by vegetation structure (Linzey & Kesner 1997; Ferreira & Van Aarde 1999; Fuller & Perrin 2001) and consequently will be indirectly influenced by rainfall, fire and grazing; they can therefore be utilized to explore the interactions between these factors on ecosystem processes and biodiversity maintenance (Yarnell *et al.* 2007). Overgrazing is recorded to have negative impacts on the abundance and diversity of small mammals (Nyako-Lartey & Baxter 1995; Joubert & Ryan 1999) through the reduction in food quality (Keesing 1998) and cover (Kerley 1992). However, moderate levels of grazing may enhance small mammal diversity (Schmidt *et al.* 2005) by facilitating the creation of more ecological niches through heterogeneous habitat structuring (Kerley 1992). In the Karoo, South Africa (Joubert & Ryan 1999) and in Tanzania (Caro 2003), species richness was also lower in more heavily grazed areas and under drought conditions. Nyako-Lartey & Baxter (1995) found that grazing by cattle and sheep at carrying capacity caused small mammal densities to crash.

Yarnell *et al.* (2007) reported that small mammal species diversity and richness were consistently low in a lightly grazed, unburnt control area, which resulted in generalists dominating. Kern (1981) found that small mammal diversity was consistently higher in unburned control areas than in areas that were burnt annually. Similarly, Monadjem & Perrin (1998a, 1998b) and Monadjem (2001) also showed that control plots had higher species richness than plots whose vegetation cover was either experimentally removed or which were burnt. The difference between the study of Yarnell *et al.* (2007) and the other studies may be due to differences in the level of grazing. Grazing acts as a disturbance and, in moderation, opens up grasslands that can result in an increase in small mammal diversity (Ferreira & Van Aarde 2000; Fuller & Perrin 2001).

This study aims to research small mammal assemblages in seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. The study site is situated to the extreme north of the grassland biome in South Africa, recognized by Acocks (1988) as Bankenveld and Bredenkamp and Van Rooyen (1998) classified it as Rocky Highveld Grassland. On the Vegetation Map of South Africa, Lesotho and Swaziland (Mucina *et al.* 2005), this area is known as the Rand Highveld Grassland. The grassland biome covers South Africa's agriculturally most productive area. It is the country's major source of beef, crops, dairy and timber, and the majority of South Africa's population lives in the grassland biome. Mining also poses a threat as large coal and gold deposits exist in this area (Neke & Du Plessis 2004). The eastern parts with the higher rainfall are under extensive exotic tree afforestation. Other less apparent threats exist such as soil erosion, invasion by alien species and acid rain due to the sulphur dioxide released by the coal power stations (Neke & Du Plessis 2004). All these activities pose a serious threat to the existence of grasslands, their biodiversity and ecological process. South Africa's grassland biome has been identified as critically endangered based on total habitat loss, degree of fragmentation and taking into account future threats (Reyers *et al.* 2001). It is in need of conservation attention as little protection is given to this biome, despite its multiple sources and severity of threats to this biologically important resource (Neke & Du Plessis 2004).

This study was initiated in the Bankenveld Grasslands of Telperion and Ezemvelo Nature Reserve near Bronkhorstspruit (25º 42' 26'' S 28º 01' 02" E) in South Africa. In year one (2008), ten transects each comprising a North-South and East-West line of 15 Sherman live-traps (30 traps) placed in the seven identified vegetation communities on the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month.

The starting-point was placing transects in the seven vegetation communities, Northern Slope Woodland (NSW), Rocky Highveld Grassland (RHG), Degraded Grassland (DG), Sheltered Woodland (SW), Burkea Eragrostis Clumps (BEC), Moist Degraded Grassland (MDG) and Rocky Open Shrub (ROS). In the dominant vegetation communities, NSW, RHG and DG, two separate transects were placed. These included Northern Slope Woodland 1 (NSW1) and Northern Slope Woodlland 3 (NSW 3), Rocky Highveld Grassland 2 (RHG 2) and Rocky Highveld Grassland 4 (RHG 4), and Degraded Grassland 2 (DG 2) and Degraded Grassland 3 (DG 3). In year one, two transects were placed in each of the dominant communities to obtain a greater sample size. In year one, 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. Ten-meter spacing was adopted at the study site, the limitation being the availablility of traps to cover the area and access individuals across home ranges. De Wit (1972), however, reported that 20 m spacing gives a higher capture rate. In year two, three of the sites were discontinued, namely NSW 1, DG 3 and RHG 2. These transects were discontinued as preliminary results indicated that similar species and abundance were collected in the other transects within the same vegetation community. This also allowed freeing-up of traps used to intensify the surveys in the remaining transects, which covered all seven vegetation community at the study site. As a result, the number of traps at the remaining seven sites was doubled to 60 traps per transect. Size of transects remained constant, as the spacing between the traps in year two was halved to five meters between each trap in the remaining transects.

The objectives of the present study are therefore:

1. To assess association of small mammal fauna on Telperion with different vegetation communities on the property;

2. To determine the effects of past impacts on vegetation and ultimately on small mammal assemblages;

3. To identify representative small mammal species in these areas and their associated abundance within the different vegetation communities and ultimately the number occurring in the habitat;

4. To assess the status of the herbaceous and woody species component on the habitat and record changes over the two-year period. The floristic composition and habitat features of the vegetation will be identified and discussed.

5. To quantify diversity, species richness and abundance of small mammal on Telperion and Ezemvelo Nature Reserve;

6. To assess how small mammal communities are affected by climate, seasonality and changes in temperature.

7. To determine criteria from which the conservation of small mammal assemblages can be incorporated into the habitat's management plan focused on maximizing biodiversity and maintaining of ecosystem integrity; and

8. To determine trends in small mammal movement on the habitat, population estimates, age structure, sex ratio, reproduction and body condition, and by identifying areas of importance at critical times of the year, and through trap success and capture-recapture, identifying patterns of small mammal distribution in relation to vegetation.

## 2.1 Research hypotheses

The present study tested the following research hypotheses:

$H_o$: Small mammal diversity and abundance do not depend on vegetation and time on Telperion.

$H_a$: Small mammal diversity and abundance depend on vegetation and time on Telperion.

## JUSTIFICATION OF STUDY

It is estimated that 80% of South African grasslands are already irreversibly transformed by agriculture, forestry, urbanisation and mining (Bredenkamp 1999) while only 2.3% of grasslands are currently conserved (Low & Rebelo 1998). This is below the recommended 10% by the IUCN (Reyers *et al.* 2001). The small mammal assemblages in the Bankenveld grasslands are associated with vegetation type, condition and as a result of past land use practices, thus providing an ideal opportunity to study these populations in relation to past influences. Thus, the study endeavours to predict factors that are likely to affect the population densities of overall population in the study area, and to establish the distribution patterns of small mammal assemblages. Small mammals are also important indicators of environmental health and their ecological importance in the study area remain unknown. For these reasons, recording the status and understanding the ecology of small mammals in this sensitive veld type is of great importance. Little is known about the dynamics of small mammals in the Bankenveld, and this study fills an important gap in the literature. As mentioned above, South African grasslands are being transformed, it is therefore important to understand the complexities of these environments. In totality, this study provides the ground work for future studies, and will be effective baseline data on small mammal abundance, diversity and richness in this veld type. Monitoring changes in small mammal communities over time will provide managers insights into the affects of land changes at all levels. Small mammals, as important indicators of a balanced system, provide early warning signs to management of potential problems which ultimately affect the triple bottom line.

## THESIS OUTLINE

The layout of this thesis is assembled to follow the research as directed by the research questions posed at the start of the study. Firstly, this thesis summary provides an overall review of the whole study and relates the major findings of this work as detailed in the relevant chapters. This project provides an overview of the dynamics and abundance of small mammal communities in the Bankenveld grasslands of South Africa. Chapter four provides a full description of the vegetation communities at the study area, and investigates the dyamics of these different communities over time. This includes palatability, successional status, species diversity, herbaceous and woody communities and habitat structure. The following chapter investigates trap success and involves the recording of all animals, including both new and previously marked individuals. This chapter provides an indication of trapability of species and populations in different vegetation communities in the study area. The sixth chapter deals with the frequency of new and recaptured animals which provides valuable information on the population dynamics and abundance of the population. The frequency of new and recaptured animals generally differs seasonally as well as between species, which gives insights into the dynamics of small mammals at the study site. Chapter seven of the thesis explores species richness and the number of different species represented in each vegetation community in the study area, simply a count of species, which does not take into account the abundances of the species or their relative abundance distributions. Community composition is also investigated in this chapter and includes the structure of the assemblage and associations of populations of the different species occupying the same vegetation community or across the study area. The eighth chapter aims at understanding sex ratio of the population and provides insights into the behaviour, breeding, aggression, home range use, emigration, and immigration and population growth. This chapter also provides an indication of the trapability of the different sexes within a species.

In chapter nine, capture and recapture of individuals in order to estimate the population's size and assess the trapability of species. In this chapter a portion of the population which is captured, marked, and released was investigated. Since the number of marked individuals within the second sample is proportional to the number of marked individuals in the whole population, an estimate of the total population size can be obtained by dividing the number of marked individuals by the proportion of marked individuals in the second sample. In chapter ten assesses the population estimates of small mammals and calculations provide an indication of densities recorded for a species within a population per vegetation community, and ultimately over the entire study. Chapter eleven investigates the effects of short term climatic fluctuations on species richness and abundance. In this chapter these responses to fluctuations in temperature and rainfall are explored. Chapter twelve assesses diversity, and the Shannon Diversity Index is used, taking into account both abundance and evenness of species present in the community.

Chapter thirteen investigates age structure of the population which provides an indication of the health and status of such a population and assists with the identification of posible imbalances in the ecosystem are investigated. Chapter fourteen focuses on the reproductive status of a population and provides insights into the health and status of small mammal assemblages. Signs of reproduction in a population are an indication that the population is stable and that the population is increasing. The final chapter fifteen focusses on body condition and provides information on changes in weight and seasonal changes in the condition of small mammals.

Findings from individual chapters are summarized in the general conclusion, and provide concise and informative insights into the status and dynamics of small mammal populations in the Bankenveld grasslands.

# CHAPTER 2

## STUDY AREA

Telperion and Ezemvelo, 25 km north-east of Bronkhorstspruit (Fig. 1) are situated on the border between Gauteng and Mpumalanga Provinces, South Africa.

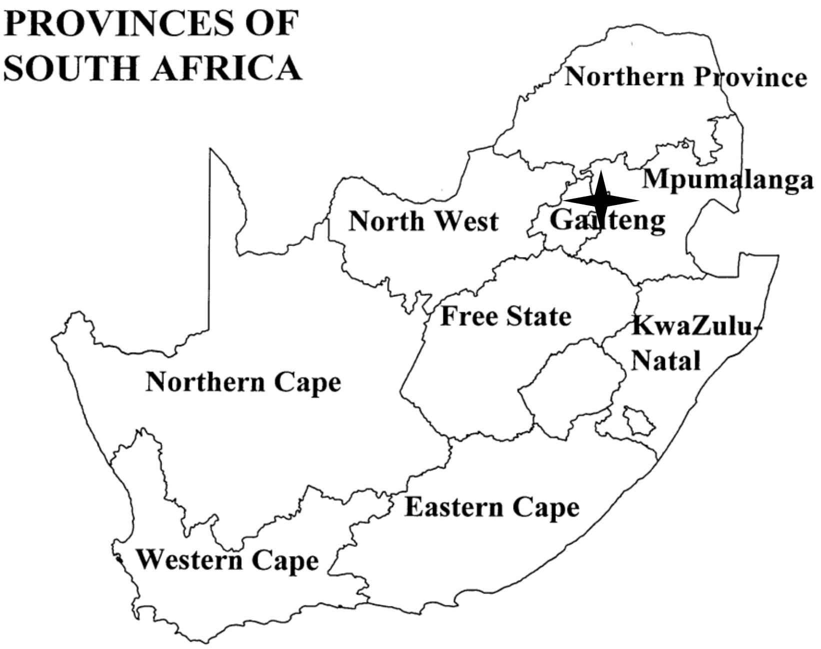

Figure 1. Map of South Africa showing Telperion on the border of Gauteng and Mpumalanga Provinces.

Telperion lies on the farm Elandsfontein 493 JR, between 25° 38` S and 28° 53` E. The area is situated in what is referred to as either the Rocky Highveld Grassland or Bankenveld (Veldtype 61) (Acocks 1988), in a Grassland Biome (Mucina *et al.* 2005). The landscape and topography are dominated by grassy plains, interspersed with rocky outcrops dominated by woody species. The lower lying, more steeply-sloped areas tend to be dominated by rocky woodlands (Grobler 1999). The area lies on the Wilge River, Ecca and Dwyka formations of the Waterberg and Karoo groups, which were formed during the Mokolian and Palaeozoic eras, respectively (Grobler 1999). The lithology is dominated by Arenite-Conglomerate, which produces dystrophic or mesotrophic soils with some red soils, as well as rocky areas with miscellaneous soil (Grobler 1999). The Tilite-Arenite produces some rocky areas with miscellaneous soils, as do shale based soils (Grobler 1999). The area receives summer rainfall averaging between 650 mm and 700 mm per year (Grobler 1999). The temperature reaches a maximum of 39˚ C and lows of -12˚ C (Louw & Rebelo 1998). The average minimum and maximum temperatures are 3˚ C and 28˚ C (Louw & Rebelo 1998). The highest average rainfall is recorded in January (Louw & Rebelo 1998). Frost occurs readily in winter from May to August (Bornman 1995). Telperion is bordered by the perennial Wilge River (Figure 2.) and contains three streams that originate from higher lying wetlands and sponge areas (Grobler 1999).

Figure 2. The Wilge River on Telperion is dominated by rocky outcrops and woody vegetation.

Vegetation on Telperion is varied, comprising grasslands (*Aristida* spp., *Eragrostis* spp., and *Hyparrhenia* spp.) on gentle slopes with short sparse shrubs, and rocky outcrops. The grass layer is thought to be maintained by frequent fires, usually not including rocky outcrops. The protection in the rocky areas against frost in winter also plays an important role in the distribution of the woody plant species (Louw & Rebelo 1998). Rocky hills and ridges carry bushveld vegetation dominated by *Protea caffra*, *Acacia caffra*, *Ochna pulchra* and *Burkea africana*. Certain sections of the reserve are historically disturbed by agriculture. The reserve has a rich diversity due to the fact that the study area is on an ecotone between grassland and bushveld.

Ten transects were placed in the different vegetation communities in Northern Slope Woodland (Figs. 3 & 4), Rocky Highveld Grassland (Figs. 5 & 6), Degraded Grassland (Figs. 7 & 8), Moist Degraded Grassland (Fig. 9), Sheltered Woodland (Fig. 10), Burkea Eragrostis Clumps (Fig. 11) and Rocky Open Shrub (Fig. 12). These transects were further divided into two transects, in the North-South and East-West direction indicated by arrows in Figure 3.

According to the working definitions of the Unesco Man and the Biosphere Programme/The Scientific Committee of Problems in the Environment (MAB/SCOPE)) working group (Holland *et al.* 1990), an ecotone is a zone of transition between adjacent ecological systems having a set of characteristics uniquely defined by space and time scales and by strength of the interaction between ecological systems. The definition of a vlei that best describes the conditions on Telperion is from Rogers (1995) who stated that: "*…floodplain vleis comprise a riverine area (either reed bed or a reed swamp) and a grassy floodplain of varying width on either side. The riverine area may be permanently flooded or seasonally inundated but the grassy floodplain is only inundated by occasional floods*". The *Protea welwetchii* dominated grassland is now obviously different from the degraded areas, where all the *Protea*s have disappeared.

# CHAPTER 3

# METHODOLOGY

## 3.1 Rodent-capture methodology

The experiment was initiated through the placement of transects in the different vegetation communities in NSW (Figs. 3 & 4), RHG (Figs. 5 & 6), DG (Figs. 7 & 8), MDG (Fig. 9), SW (Fig. 10), BEC (Fig. 11) and ROS (Fig. 12). These transects were further divided into two transects, in the North-South and East-West direction indicated by arrows in Figure 3. The NSW1 transect (Fig. 3) was placed on the northern boundary of the study area on a north slope consisting of moderately dense *B. africana* woodland, composed predominantly of small to medium-sized plants with a sparse herbaceous component, set amongst red sandstone boulders.

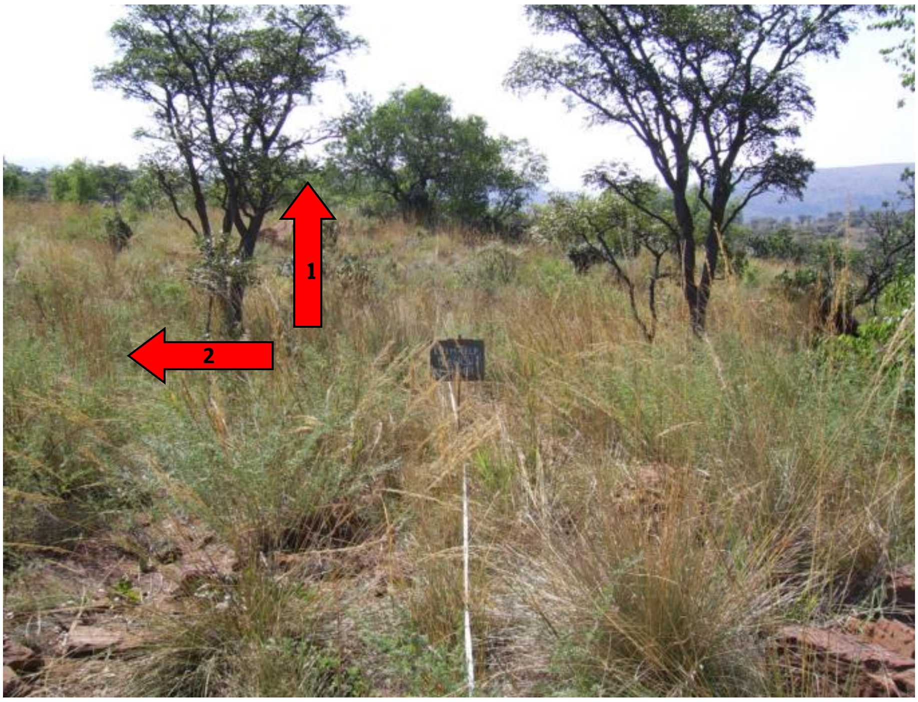

Figure 3. A photograph illustrating transect Northern Slope Woodland 1 (NSW 1 in the Northern Slope Woodland community (North-South transect (1) and East-West transect (2) direction indicated by arrows).

NSW3 transect (Fig. 4) was placed towards the southern boundary of the study area on a north slope consisting of moderately dense *C. gratissimus and Combretum* woodland, composed predominantly of medium-sized plants with a sparse herbaceous component, set amongst red sandstone medium to large boulders.

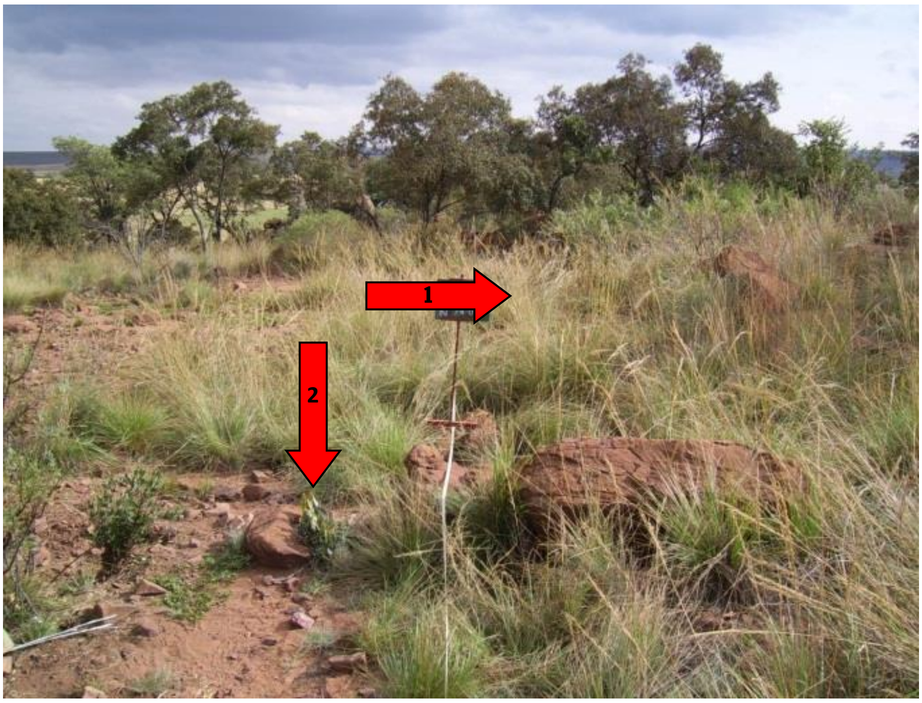

Figure 4. A photograph illustrating transect Northern Slope Woodland 3 (NSW 3) in the Northern Slope Woodland community (North-South transect (1) and East-West transect (2) direction indicated by arrows).

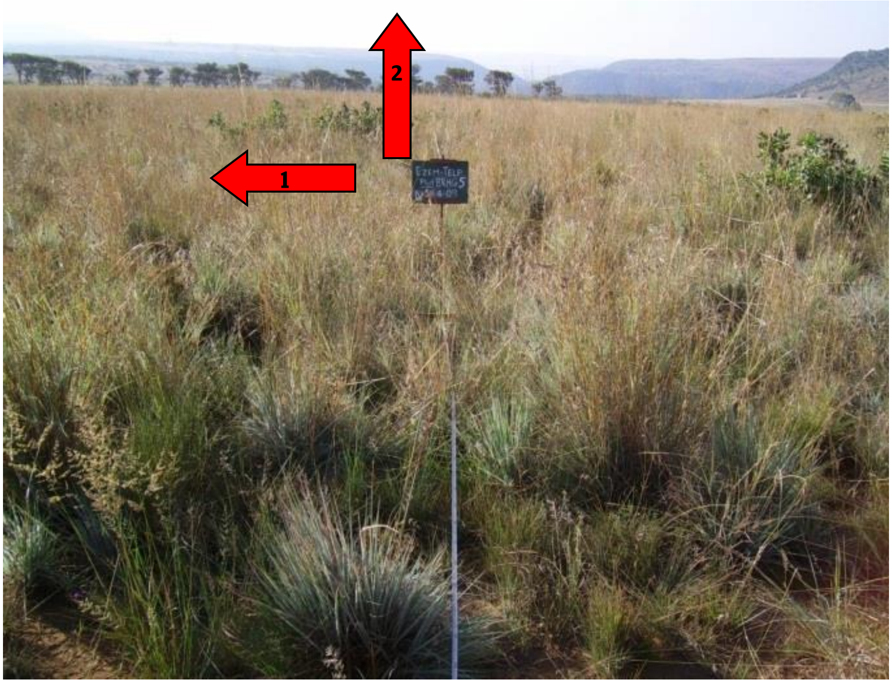

Figure 5. A photograph illustrating transect Rocky Highveld Grassland 4 (RHG 4) in the Rocky Highveld Grassland community (North-South transect (1) and East-West transect (2) direction indicated by arrows).

RHG2 transect (Fig. 6) was placed near the southern boundary of the property adjacent to the Renosterpoort farm border. This site consists of scattered red sandstone with a moderately dense grass cover, scattered with *Xerophyta retinervis.*

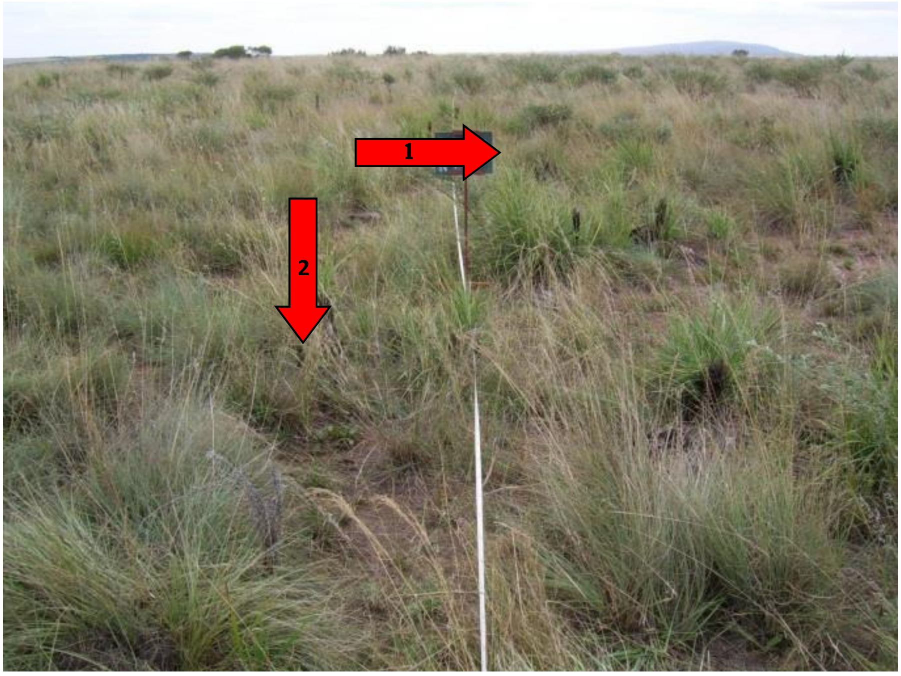

Figure 6. A photograph illustrating transect Rocky Highveld Grassland 2 (RHG 2) in the Rocky Highveld Grassland community (North-South transect (1) and East-West transect (2) direction indicated by arrows)

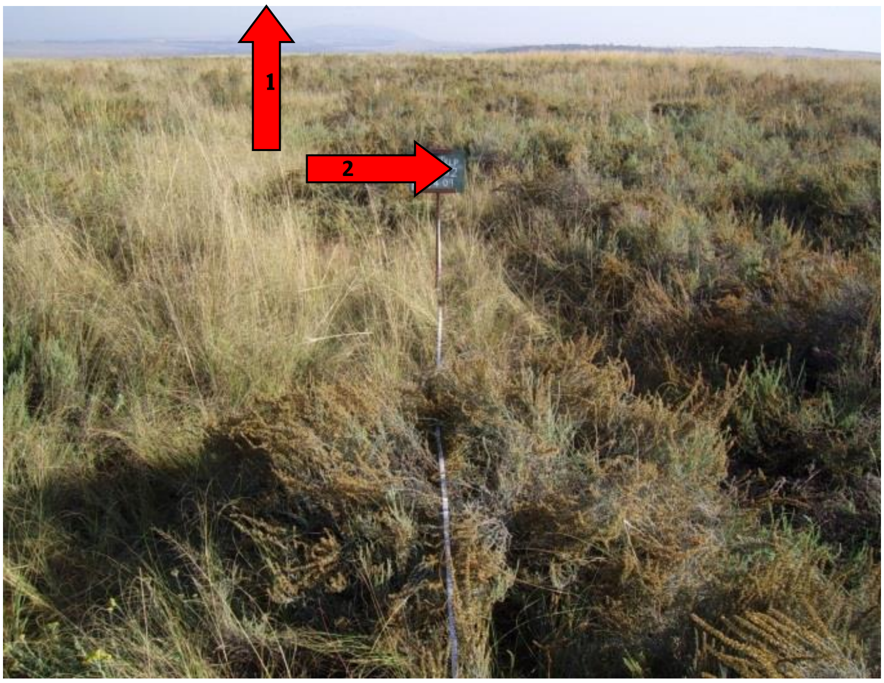

Figure 7. A photograph illustrating transect Degraded Grassland 2 (DG2) in the Degraded Grassland community (North-South transect (1) and East-West transect (2) direction indicated by arrows).

DG3 transect (Fig. 8) was placed to the right of the main road prior to road on route to Ezemvelo reception area. This site consists of dense stands of predominantly pioneer grass species and does not have a woody component.

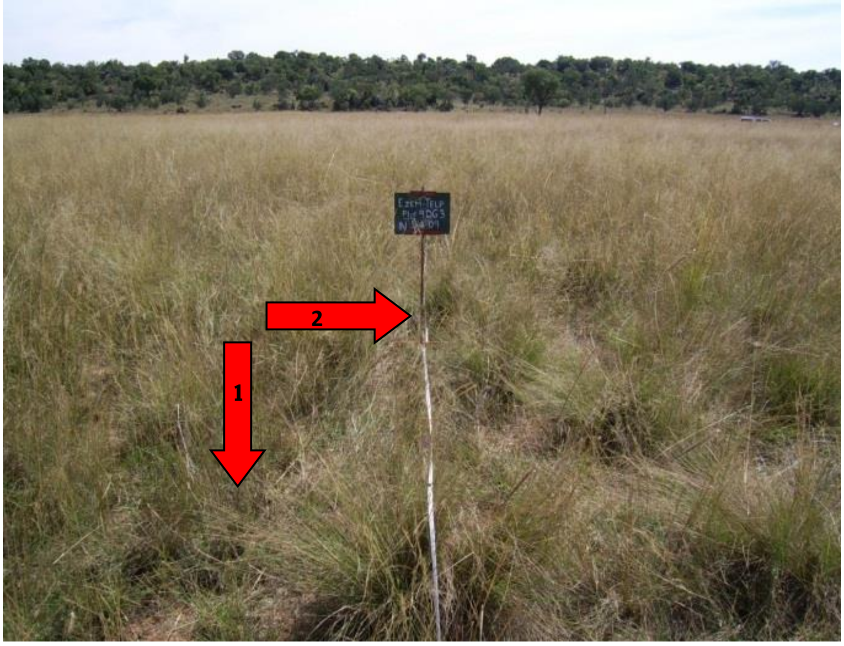

Figure 8. A photograph illustrating transect Degraded Grassland 3 (DG3) in the Degraded Grassland community (North-South transect (1) and East-West transect (2) direction indicated by arrows).

Figure 9. A photograph illustrating transect Sheltered Woodland 1 (SW1) in the Sheltered Woodland community (North-South transect (1) and East-West transect (2) direction indicated by arrows).

BEC1 transect (Fig. 10) was placed in the south east of the study area near the border of Bosch families' farm. This site consists of sandy soils with sparse grass cover and stands of *B. africana*.

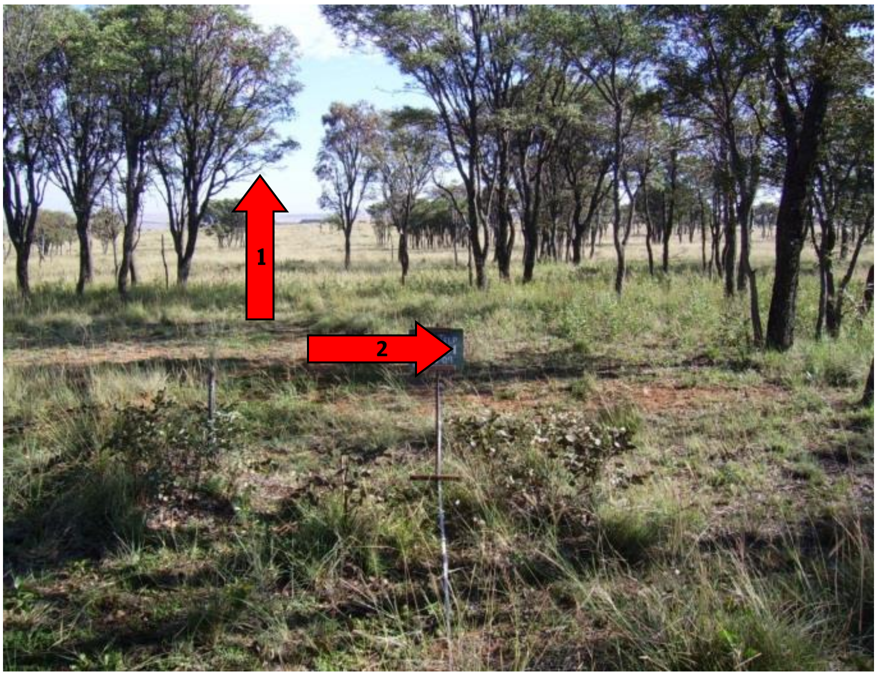

Figure 10. A photograph illustrating transect Burkea Eragrostis Clumps 1 (BEC1) in the Burkea Eragrostis Clumps community (North-South transect (1) and East-West transect (2) direction indicated by arrows).

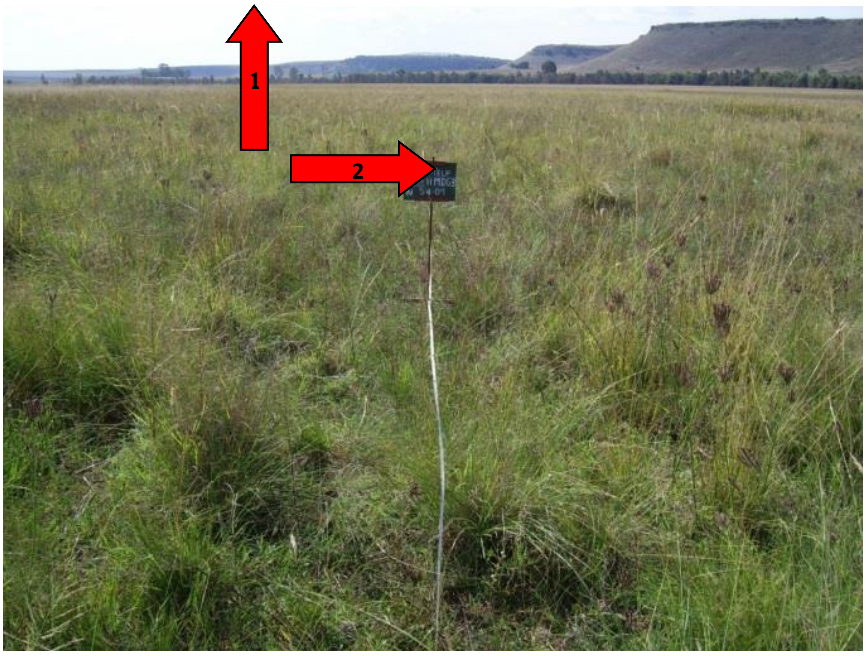

Figure 11. A photograph illustrating transect MDG 3 in the Moist Degraded Grassland community (North-South transect (1) and East-West transect (2) direction indicated by arrows).

ROS1 transect (Fig. 12) was placed near the southern boundary of the study area near the Ezemvelo gate on route to reception area. This transect has large red sandstone boulders and rocks and is dominated by *Englerophytum magalismontanum* and *Xerophyta retinervis*, composed predominantly of small- to medium-sized plants with a sparse herbaceous component.

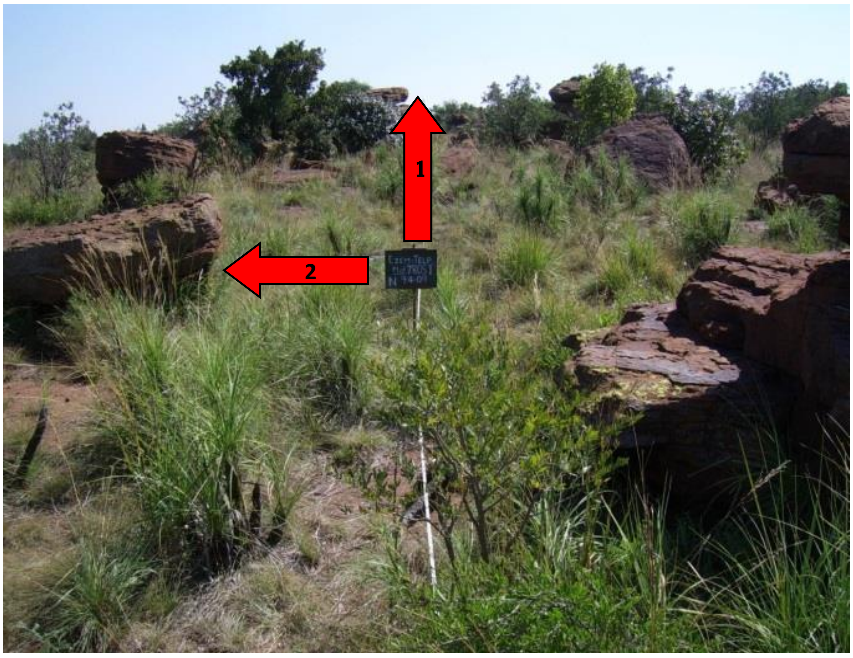

Figure 12. A photograph illustrating transect Rocky Open Shrub 1 (ROS 1) in the Rocky Open Shrub community (North-South transect (1) and East-West transect (2) direction indicated by arrows).

All individuals sampled were removed from the traps using a sturdy plastic bag and removed from the bag by hand after being anesthetized using ethyl acetate. Upon first sampling, specimens were identified, sexed, measured and weighed. Specimens were measured using a pair of calipers and weighed with a Pesola pull-scale. All specimens were recorded by toe-clipping (American Society of Mammalogists 1998) and marked using the 1-2-4-7 toe-clipping system (DeBlase & Martin 1981). Only the last phalange/s was removed during toe-clipping procedure. Recapture numbers and new specimen information were recorded electronically using Cyber Tracker.

All individuals were weighted (to the nearest g), measured (body and tail length to the neared mm), sexed and reproductive status noted. Males were classed as either scrotal (testes descended) or non-scrotal (testes in abdominal cavity), while females were classed as either perforate or non-perforate, depending on whether or not the vagina was open. In addition, any signs of either lactating or pregnancy were noted. All new specimens sampled were individually marked by toe-clipping and released at the site where captured.

Analysis of variance (ANOVA) was used to detect inter-group differences. The 95% level ($P < 0.05$) was regarded as statistically significant for all tests. All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008)

In the present study a small mammal was defined as a mammal species that could be trapped in standard Sherman traps. The method used to capture small mammals was standardized to compare small mammal trap success and composition in different vegetation communities and habitat types (Cole & Wilson 1996). Two cryptic *Mastomys* species, *M. coucha* and *M. natalensis* (Njobe 1997) could not be separated using morphological characters (Dippenaar *et al.* 1993; Avenant 1996) and both were treated as *Mastomys* spp.

Recaptured specimen numbers were documented and animals released where they were captured. Care was taken to ensure each visit followed exactly the same procedure. Trapping was undertaken over three days and two nights each month between January 2008 and January 2009 (Year 1) and seasonally for five days in February 2009 (summer), May 2009 (autumn), July 2009 (winter) and October 2009 (spring). The reason for the increase in trapping nights was to ensure trap shy species entering traps after three nights would be recorded.

During each survey, small mammals were live-trapped using Sherman live traps so that dispersal, relative distance and assemblage composition could be assessed (Johnson *et al.* 2002). Sampling in year 1 (January 2008 – January 2009) consisted of setting 300 traps per day (30 traps x 10 sites), and 460 traps per day seasonally in year 2. Each trap was uniquely identified in order to document animal movement between and within transects. Traps were placed relative to permanent markers spaced every 10 m along the transect line in year 1, and every 5 m in year two. Traps were baited with rolled oats, peanut butter, marmite (yeast extract) and cooking oil mixed approximately as two volumes of oats to one of peanut butter (Johnson *et al*. 2002). Oil was added to give the desired consistency. Traps were shaded with vegetation, inspected and baited daily between 06h00 and 14h00. It was generally found to be necessary to re-bait the Sherman traps every morning because of ants that also fed on the bait. Each transect was trapped for two days in year 1 and five days in year 2 to ensure trap-shy species were sampled.

The diversity within the vegetation communities was calculated using the Shannon Diversity Index as followes:

$$H = \sum_{i=1}^{s} - (Pi * \ln Pi)$$

where:

Pi = fraction of the entire population made up of species i
S = numbers of species encountered
∑ = sum from species 1 to species S

## 3.2 Vegetation survey methodology

Data were recorded annually at each of the ten transects.

### 3.2.1 Vegetation sampling method

For sound management purposes, it is imperative to distinguish between different plant communities, as each will need separate management (Bredenkamp & Brown 2001). This is the reason a plant species richness approach has been chosen as the preferred method for this study. The survey plots were initially marked according to plant communities plotted according to the classification of Swanepoel & Bredenkamp (2006). Four survey lines radiated from a central point in a north, south, east, west direction and were measured using a measuring tape and marked with a metal peg. The 200 points per survey plot were assessed, and repeated during 2008 and 2009, where at each point the nearest herbaceous plant was recorded, as well as "hit" and "miss" recording to establish basal cover (Du Plessis & Krynauw 2009).

The point survey nearest plant survey method was used in the study of herbaceous layer which proved to be efficient and a reliable method of vegetation surveying and assessment. The data recorded were processed according to various values of each recorded plant, in order to assess the ecological status and state of succession of the herbaceous layer.

According to Van Oudtshoorn (2002), the ecological status of grasses refers to the grouping of grasses on the basis of their reaction to the different levels of grazing. A grass reacts to grazing in one of two ways; it can either increase or decrease in abundance (Van Oudtshoorn 2002). Grasses abundant in a veld in a good condition, but decrease in abundance when the veld is either overgrazed or undergrazed are referred to as decreaser species. While three categories of increaser species are described; increaser 1, unpalatable grasses which are abundant in underutilized veld, increaser 2, grasses which are abundant in overgrazed veld, and are species which increase as a result of the disturbance caused by overgrazing and include mostly pioneers, and sub-climax grasses, and thirdly, increaser 3 grasses, which are grasses which occur in over-utilized veld, and are usually dense climax grasses which replace palatable species in a community.

Van Oudtshoorn (2002) described plant succession as the progressive succession of plant communities and continues until the climax community has been established. When a disturbance occurs in an area, the area is re-colonized by new, pioneer species. This process is repeated when a disturbance is repeated. Plants in this first stage are referred to as pioneer plants, which are usually unpalatable, hardened, annual plants which grow rapidly and in these unfavourable conditions. This was done in order to cover the soil after a disturbance and therefore prevent further soil erosion.  Sub-climax species are denser than pioneer species and offer even further protection to the soil. These species are mainly weak perennials with a lifespan of approximately two to five years. Over time as growth conditions improve, sub-climax species are replaced by climax species, which are strong perennials which are adapted to normal, optimal growth conditions and will grow in an area as long as the stable conditions remain. This climax stage is the most suitable for grazing and soil protection. Veld condition is assessed by calculating the species composition by using surveys and assessing the ecological status and succession of a plant community.

The woody component, which included trees, shrubs and dwarf shrubs was assessed at each survey site using the belt transect survey method (Du Plessis & Krynauw 2009). These belt surveys consisted of 2 m wide belts, along the four directions of the survey lines mentioned above. A 2 m plastic pole was used along the radiating lines and was held along the survey line in the middle, assessing 1 meter on each side of the line. The width and length of the belts were adapted at different survey plots according to local limitations and situations at these sites. All woody plants rooted within each of the belts were recorded, including species, height, browsing level and height of the browse line, if present. These data were recorded to determine the woody plant structure and browse impact at each of the survey sites. Fixed point photos were recorded at each site during 2008 and 2009, therefore creating a visual record of the surveyed vegetation at each site.

### 3.2.2 Reconnaissance

A reconnaissance is the preliminary inspection or familiarization of the study area prior to sampling which has the object of estimating floristic and environmental variation, familiarization with the flora and to obtain permission from authorities for later work and accommodation possibilities (Westfall 1992; Westfall *et al*. 1996). This exercise was completed in January 2008 during which time 10 transects were placed at sites defined previously by Tshwane University of Technology (Du Plessis & Krynauw 2009) as sites depicting a good quality representation of the vegetation communities of Telperion.

### 3.2.3 Baseline data

A general impression of the habitat gave an indication of the abiotic characteristics of each transect, which assists in the description of the plant communities. Vegetation is dependent on its physical habitat (Daubenmire 1968a; Gauch 1982). Notes on the following were made:

- Geology;
- Soil;
- Rockiness of soil surface percentage;
- Aspect (North, East, South, West);
- Gradient in degrees;
- Past management activity: Natural or disturbed state;
- GPS points for location of the plots on a map; and
- Other characteristics of note in the plot were recorded such as erosion, trampling, animal activities and any other notable characteristics.

### 3.2.4 Species identification

All the plant species at every sample plot were identified as far as possible. The plant species were identified either in the veld or by experts in the Department of Nature Conservation, Tshwane University of Technology. Various references were consulted including Van Wyk & Malan (1997), Van Wyk & Van Wyk (1997), Pooley (1998) and Van Oudtshoorn (2002). The names of the taxa are in accordance with Germishuizen & Meyer (2003).

### 3.2.5 Data collection

The number of vegetation sample plots corresponded directly with rodent capture methodology. The vegetation plots were surveyed in year 1 in March 2008 and again in April 2009. A cement marker was used to locate the centre of each vegetation survey. The step-point method was used along a 100 m line in a north, south, east, west direction. Disc pasture meter (Bransby & Tainton 1977) readings were taken at each plot to record standing mass of the herbaceous layer. Species not recorded using this method was recorded in each of the four quadrants. Woody plants were recorded in each quadrant and placed into height classes, class 1 (0–50 cm), class 2 (51–100 cm), class 3 (101–150 cm), class 4 (151–200 cm), class 5 (201–300 cm) and class 6 (≥ 301 cm) (Du Plessis & Krynauw 2009).

### 3.2.6. Description of Communities

The communities (and their associated sub-communities) were described in terms of distribution, broad habitat, diagnostic species, species with significant indicator value and dominant species. The plant community names were based on the representative and diagnostic species and dominant species of each community.

## 3.3. Statistical Analysis

Analysis of variance (ANOVA) was used to test for significant differences between trap success, diversity, sex ratio, age structure and capture-recapture within different seasons and vegetation communities (Fowler *et al.* 1998). Normality was tested for and confirmed. Tukey’s test was undertaken when the result from ANOVA indicated a significant difference between the variables. Tukey's test provides an indication of where significant differences occur.

Other statistical methods used include Chi-square ($\chi^2$) test to analyze frequencies and t-tests ($t$), analyzing variance when samples are small, using the mean difference between the two samples and dividing these by the standard error of the difference.

The strength between relationships or correlations between variables were analysed using the coefficient of determination $r^2$.

All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

# CHAPTER 4

# DESCRIPTION OF VEGETATION COMMUNITIES AND STRUCTURE DYNAMICS

## 4.1. Abstract

The aim of this chapter was to assess the status of the herbaceous and woody species component of the study area and monitor changes in vegetation attributes and characteristics over a two-year period. This information expands current knowledge on vegetation on Telperion and Ezemvelo Nature Reserve. The floristic composition and habitat features of the vegetation are identified and discussed. The status of each vegetation community is assessed according to whether the community is transformed. The size of each community and grazing and browsing value is noted. The contribution of individual community to the overall carrying capacity for game on the study area is assessed. The ecological index veld condition score, phytomass and utilization status of each community is recorded. Certain communities have very low utilization by game due to the limited grazing available and utilization is selective in nature, with signs of certain unpalatable species being utilized. Communities with high carrying capacities are limited in nature, but highly utilized by game. The woody vegetation component of the study area is confined to the rocky outcrops and protected from fire impact due to the rockiness of these areas. These species also have a limited browse potential and show little or no signs of utilization. It is for these reasons that the woody component is relatively stable, and not severely impacted by fire or browsing. Fixed point photographs of each vegetation community were taken in April 2008 and 2009 to monitor visual changes in vegetation structure.

**Keywords:** Telperion, Ezemvelo Nature Reserve, vegetation, community, herbaceous, woody, ecological index, phytomass, utilization, South Africa.

## 4.2. Introduction

Telperion and Ezemvelo Nature Reserve are situated to the extreme north of the grassland biome in South Africa. Acocks (1988) recognised the vegetation type as Bankenveld and Bredenkamp and Van Rooyen (1998) classified it as Rocky Highveld Grassland. On the new Vegetation Map of South Africa, Lesotho and Swaziland (Mucina *et al.* 2005), this area is classified as the Rand Highveld Grassland. A number of activities pose a serious threat to the existence of grasslands, their biodiversity and ecological processes.

The Bankenveld vegetation type consists of diverse plant communities such as woodland in sheltered ravines, woodland, grassland and wetlands. The location of these communities is dependent on the topography and their location in the landscape (Bredenkamp & Brown 2003). This diverse landscape houses many rare species, a rich biodiversity and provides habitat for many organisms (Mucina *et al.* 2005). However, the urban and industrial centres of Gauteng Province as well as the major coal mines are situated in this vegetation type. Reyers *et al.* (2001) estimated that 33.6% of Bankenveld is transformed and only 0.8% is protected. This includes nature reserves such as Witbank, Suikerbosrand, Rustenburg, Abe Bailey, Boskop Dam and Rietvlei Nature Reserves. The 8000 ha Telperion is therefore an important conservation area in this biome and diverse habitats provided by the study area are refuges for many small mammals, birds, invertebrates, amphibians and plant species, including two Red-Listed plant species, *Frithia humilis* and *Encephalartos middelburgensis* (Pfab & Victor 2002).

The vegetation of Telperion and its surrounding area is a transition between the grassland of the high inland plateau and savanna of the low inland plateau. The area is characterised by rocky hills and ridges such as the Magaliesberg, Timeball Hill, Daspoort, Suikerbosrand and Witwatersrand. The soil is shallow and rocky. These rocky outcrops and surface rock gave the veld type its name Bankenveld or ‘klipveld’ (Louw 1951; Acocks 1988; O’Connor & Bredenkamp 2003) and Rocky Highveld Grassland (Bredenkamp & Van Rooyen 1998). This vegetation type is located to the extreme north of the grassland biome in South Africa and central to grassland to the south, Drakensberg to the east, savanna to the north and Kalahari to the west, and its plant species composition is representative of all these areas (Bredenkamp & Brown 2003). This vegetation type covers 24 063 km$^2$ (Bredenkamp & Van Rooyen 1998) of which only 0.8% is protected (Reyers *et al.* 2001). It mainly occurs at an altitude ranging from 1500 to 1600 m. Summer rain brings 650 to 750 mm rainfall per year and temperatures vary between –12º C and 39º C (Bredenkamp & Van Rooyen 1998).

The single common feature across the Bankenveld is shallow, leached, acid lithosols (Bredenkamp & Van Rooyen 1998). Deeper soils are limited to broad valley bottoms. The vegetation of this veld type provides little grazing value as the high rainfall; frosty winters and regular burning renders this veld type particularly sour (Acocks 1988).

The great variety in topography and the resulting creation of a variety of microhabitats created by the rocky outcrops resulted in a large diversity of plant communities where no single species attain dominance (O'Connor & Bredenkamp 2003). Bredenkamp & Brown (2003) noted that Bankenveld vegetation consists of a mosaic of grassland and woodland communities controlled by microclimatic conditions that exist in the topographically heterogeneous landscape. Woodland communities occur in warm sheltered valleys and slopes, whereas grasslands occur on the cold, exposed plateaus and plains. Several studies suggest that a close affinity exists between certain grassland and woodland communities, especially if they exist on the same substrate (Bredenkamp 1975; Coetzee 1993; Grobler 2000). The woody species, of sour bushveld affinity, that occur on the ridges and hills led Acocks (1988) to believe it is a 'false grassveld' where the climax of this veld type was open *Acacia caffra* savanna. He advocated that if fire was excluded from this grassland type it would develop into savanna. This statement is rejected by Coetzee (1993), Bredenkamp (1999), Bredenkamp & Brown (2003), and O'Connor & Bredenkamp (2003) as there is no difference in the fire regimes between the grassland and savanna and it is rather the colder climate with frost during the non-growing season that prevents woody plant species from dominating these areas. The woodland communities occur on warmer locations such as sheltered valleys, kloofs and on slopes. Woody species are often associated with rocky areas where they are better protected against harsh conditions such as fire and frost (Bredenkamp & Brown 2003). The woody species show affinity to the Sour Bushveld and Sourish Mixed Bushveld described by Acocks (1988) when comparing it to species from communities in the Bushveld described by Theron (1973), Coetzee *et al*. (1976), Van der Meulen (1979), Van Rooyen (1983) and Westfall *et al*. (1985). Research results suggest that the vegetation of the Bankenveld often changed in the past, ranging from savanna during warm inter-glacial phases to cool open grassland during glacial maxima (Bredenkamp & Brown 2003). Wetter phases also provided the opportunity for the establishment of forests (Bredenkamp & Brown 2003).

The Bankenveld is related to the other grassland veld types described by Acocks (1988) (Bezuidenhout 1993; Coetzee 1993) (Fig. 13). The grass species of this vegetation type are also related to the Drakensberg flora (Bredenkamp & Brown 2003; O'Connor & Bredenkamp 2003) and the Kalahari Thornveld (Bredenkamp & Brown 2003).

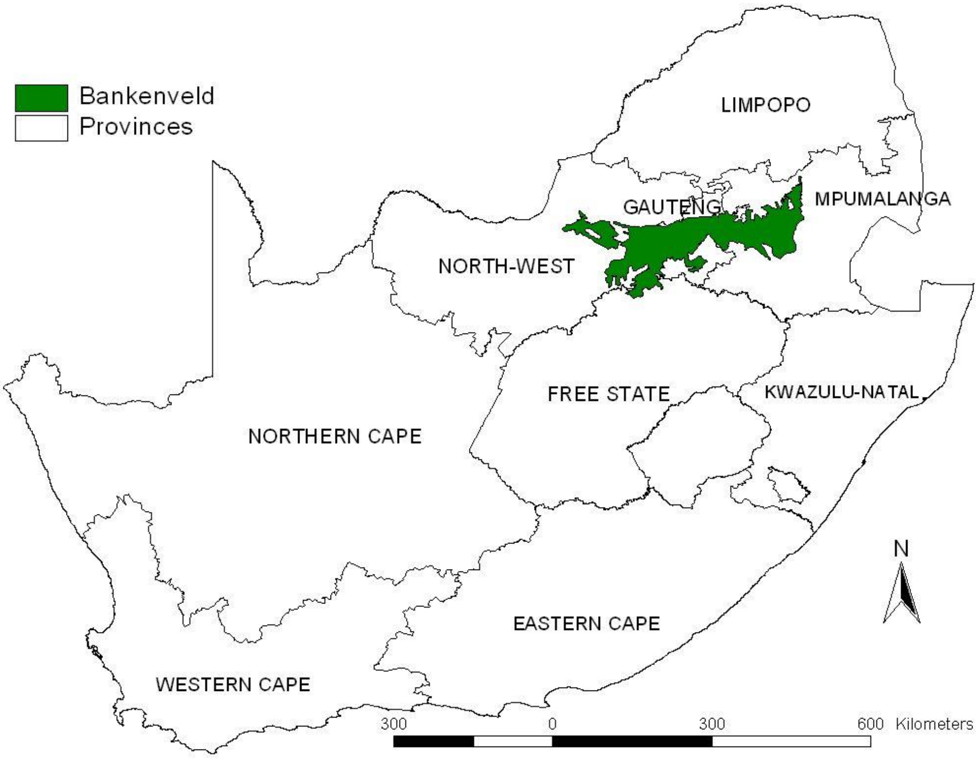

Figure 13. The location of Bankenveld veld type in South Africa (Swanepoel & Bredenkamp 2006)

Seven vegetation communities are recorded during the present study as described by Swanepoel & Bredenkamp (2006) (Fig. 14). These include Northern Slope Woodland (NSW 1; NSW3), Rocky Highveld Grassland (RHG 2; RHG 4), Degraded Grassland (DG2; DG3), Sheltered Woodland (SW1), Burkea Eragrostis Clumps (BEC1), Moist Degraded Grassland (MDG3) and Rocky Open Shrub (ROS1). Representative sites of these communities were monitored since 2007 by the Department of Nature Conservation of Tshwane University of Technology.

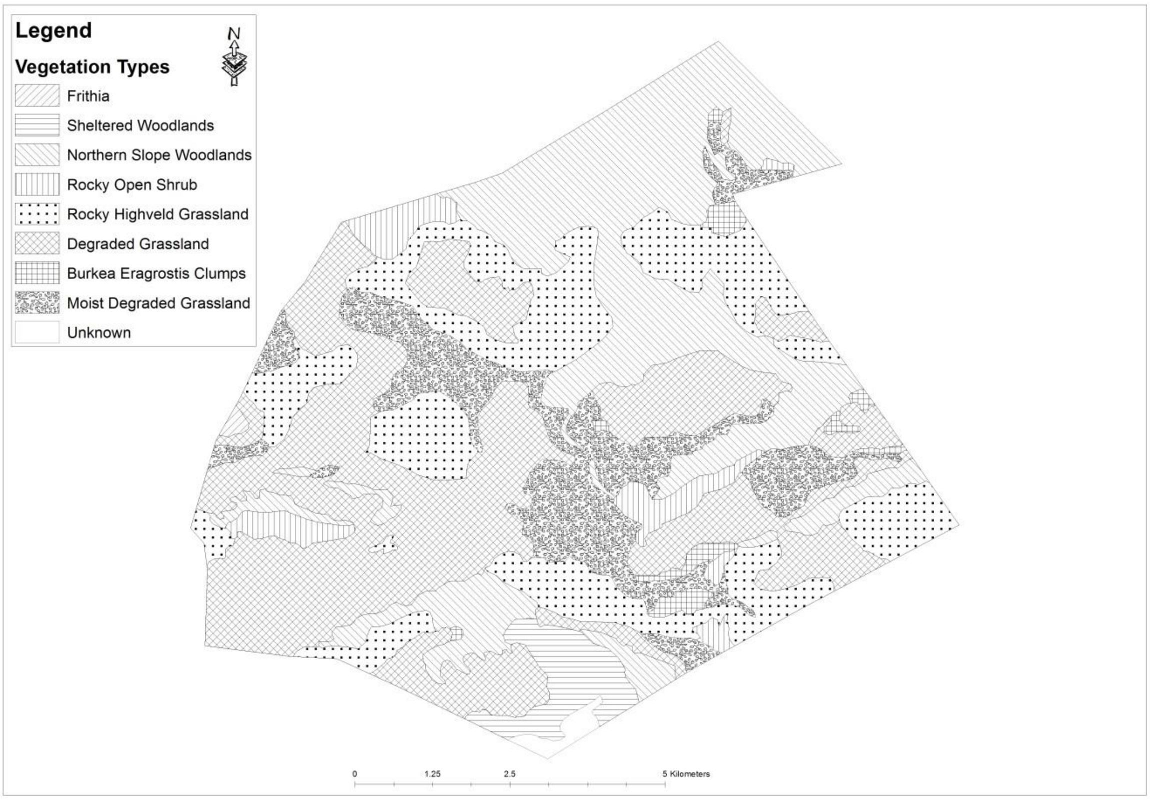

Figure 14: Illustration depicting the plant communities recorded on Telperion and Ezemvelo Nature Reserve

## 4.3. Habitat descriptions

### 4.3.1 Description of the Northern Slope Woodland vegetation community

Northern Slope Woodland is a primary non-transformed vegetation community which occupies approximately 20 - 25% of the study area and covers an area of 1968 ha (Fig. 14). This community dominates the less accessible sections of the study area, including the north-eastern corner, and has limited access to common game species. This community is particularly rocky, being situated on Red Sandstone outcrops. These sections of the reserve that fall within this community type remained natural and untransformed. These areas are aesthetic and have an abundance of rocks and outcrops which are often inaccessible. In terms of the grazing and browsing value, this area rates very low as evidenced by the very low utilization by game due to low grazing and browsing value of the sour, unpalatable vegetation present. Game appears to exercise extreme selective grazing in the area due to the patchy and rare occurrence of palatable plants. Due to the rocky nature and very shallow soils, plant production and consequent plant biomass is very low. This plant community contributes very little to the overall carrying capacity for game on the study area. The woody component is well-represented, and is quite rich in woody plant species and indicates the plant community is one of the few at the study site with a definite woody plant component. Due to the very low nutrition and palatability of the vegetation of this community, grazing and browsing impact is low. The only factor that may affect the woody component is fire. These woody plants species however, are well-adapted to fire and they mostly grow on or in between rocks where they are protected from severe fire. The woody component is therefore, expected to remain quite stable. The ecological index veld condition score of 50.5% for this community is an indication that the veld is in a reasonable ecologically condition (Table 1). Under utilization as indicated by 34.5% Increaser 1s is a serious problem is this vegetation type, and the main reason for the lack of a better ecological score. Fire would most likely reduce the Increaser 1 component and promote Decreasers, and should lead to a better ecological score.

Table 1: The ecological index of the veld condition in the Northern Slope Woodland communities recorded on Telperion (Du Plessis & Krynauw 2009).

| Species Grouping | NSW 1 % Composition | NSW 3 % Composition | Community MEAN / Grouping (% Composition) |
|---|---|---|---|
| Decreasers | 19.5 | 17.5 | 18.5 |
| Increasers 1 | 37.5 | 31.5 | 34.5 |
| Increasers 2 | 18.5 | 8 | 13.3 |
| Increasers 3 | 1 | 0 | 0.5 |
| Forbs | 13 | 18 | 15.5 |
|  | % Compostion | Ecological Index Factors | Score |
| Decreasers | 18.5 | 10 | 185 |
| Increasers 1 | 34.5 | 7 | 241.5 |
| Increasers 2 | 13.3 | 4 | 53.2 |
| Increasers 3 | 0.5 | 1 | 0.5 |
| Forbs | 15.5 | 0 | 0 |
|  | 82.3 | 0 | 480.2 |
| Ecological index veld condition Score ( % ): x / 950 x 100 |  |  | 50.5 |

Two transects for vegetation surveying and subsequent small mammal trapping were placed in this habitat type due to the dominance of this habitat at the study site. Transect 1 was placed in the Northern Slope Woodland community (NSW1) (Fig. 14)  and was located on a slight northern slope consisting of moderately dense woodland composed of small- to medium-sized plants with a sparse grass component, set amongst numerous red sandstone rocky outcrops.  This community is not transformed through past disturbances and the veld remains in a natural climax state. The soils are shallow and sandy with a very low nutrient content. As a result of this low nutrient content, the grazing potential for large herbivores is limited as a result of the very low inherent utilization potential.  Fixed point photographs were taken in 2008 (Fig. 15) and 2009 (Fig. 16) at transect 1 in the Northern Slope Woodland community. In 2008, rainfall was above average which resulted in good plant growth and an increase in plant biomass in 2009.

Figure 15.  A fixed point photograph depicting the habitat structure of Northern Slope Woodland 1 (NSW 1) on Telperion in 2008.

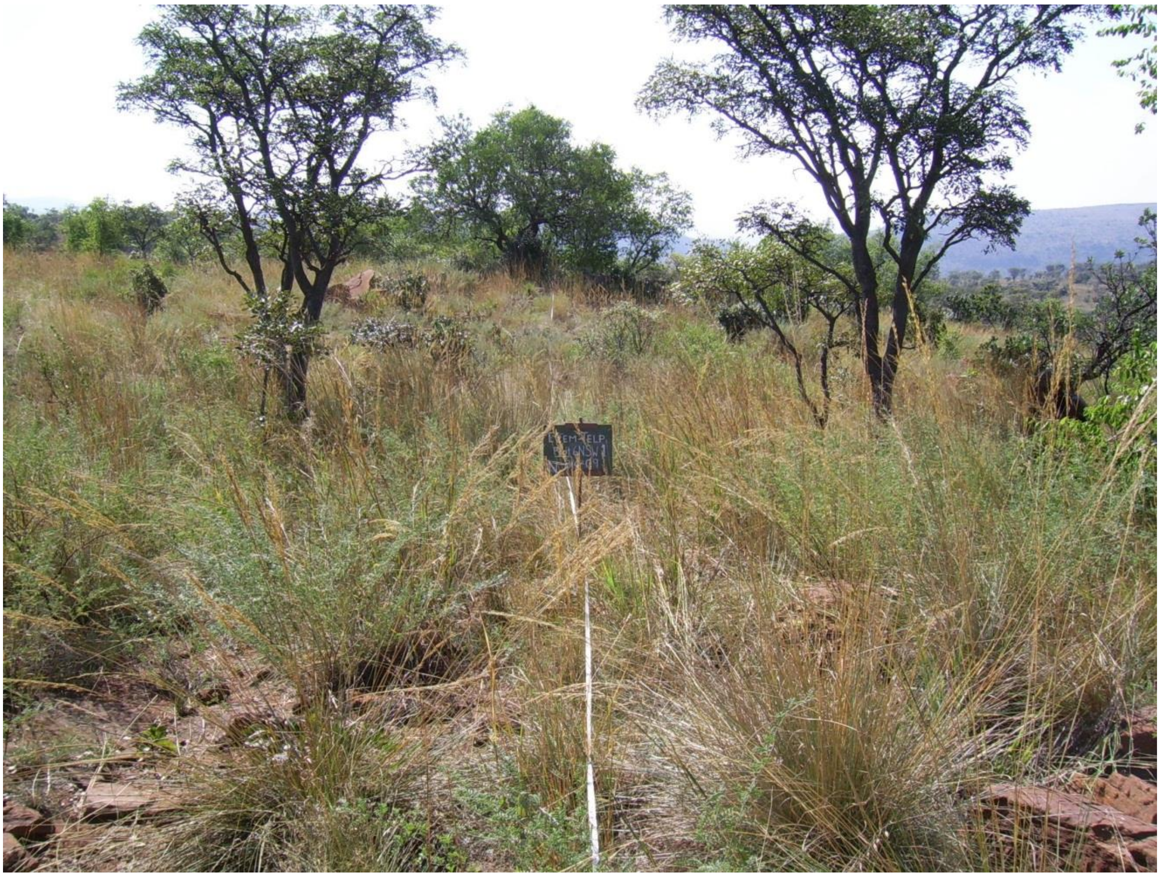

Figure 16. A fixed point photograph depicting the habitat structure of Northern Slope Woodland 1 (NSW 1) on Telperion in 2009.

The woody plant density at this site remained similar over the study period, but a change in size classes indicates an increase in the size of plants. Some aspects recorded are difficult to explain, such as the changes in frequency of certain plant species that appeared to either decline or increase at this transect.

Du Plessis & Krynauw (2007) reported that species composition of herbaceous plants comprises a relatively high diversity of dominant grass species were recorded at this site which were dominated by perennial grasses (Table 2). The forb component consisted of a frequency of approximately 5%, and therefore this transect was not exceptionally diverse. There is generally a low grazing value (57.5%) of plants recorded, the majority with no or little grazing value, although the remaining with some grazing value (24.5%) are impacted on by grazers.

Table 2: A comparative table of the species composition recorded at the Northern Slope Woodland (NSW 1) community between 2007 and 2009 on Telperion (Du Plessis & Krynauw 2009).

| Species | Grazing Value | Value Categories Ecological Succession | Increaser /Decreaser | Species Composition ( % ) 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|
| *Tristachya leucothrix* | Low | Climax | Increaser 1 | 4% | 2% | 4% |
| *Loudetia simplex* | Low | Climax | Increaser 1 | 25% | 23.50% | 19% |
| *Aristida transvaalensis* | Low | Sub-Climax | Increaser 2 | 4% | 3.50% | 2.50% |
| *Setaria sphacelata* | Medium | Sub-Climax | Decreaser | 9.50% | 7% | 10% |
| *Trachypogon spicatus* | Low | Climax | Increaser 1 | 5% | 3.50% | 3.50% |
| *Diheteropogon amplectens* | Medium | Climax | Decreaser | 7.50% | 7.50% | 8.50% |
| *Themeda triandra* | High | Climax | Decreaser | 5% | 2.50% | 0.50% |
| *Melinis repens* | Low | Pioneer | Increaser 2 | 3% | 10.50% | 12.50% |
| *Brachiaria serrata* | Medium | Climax | Decreaser | 1.50% | 1% | 0.50% |
| *Andropogon shirensis* | Low | Climax | Increaser 1 | 2% | 3% | 1% |
| *Shizachyrium sanguineum* | Low | Climax | Increaser 1 | 4% | 6% | 6.50% |
| *Panicum natalense* | Low | Climax | Decreaser | 1% | 0% | 0% |
| *Eragrostis nindensis* | Medium | Sub-Climax | Increaser 2 | 1% | 2% | 1% |
| *Bewsia biflora* | Low | Climax | Decreaser | 0.50% | 0% | 0% |
| *Michrochloa caffra* | Low | Sub-Climax | Increaser 2 | 0.50% | 0% | 0% |
| *Digitaria eriantha* | High | Climax | Decreaser | 0.50% | 0% | 0% |
| *Elionurus muticus* | Low | Climax | Increaser 3 | 0.50% | 0% | 1% |
| *Aristida stipitata* | Low | Sub-Climax | Increaser 2 | 0% | 0% | 0.50% |
| *Eragrostis curvula/chloromelas* | Low | Sub-Climax | Increaser 2 | 2% | 1.50% | 1.50% |
| *Tristachya rhemannii* | Low | Climax | Increaser 1 | 0.50% | 0.50% | 1% |
| *Pogonarthria squarrosa* | Low | Sub-Climax | Increaser 2 | 0% | 1% | 0.50% |
| *Unidentified grass sp.* | | | | 1% | 0% | 1% |
| *Melinis nerviglumis* | Low | Climax | Increaser 1 | 0% | 0% | 2% |
| *Triraphis andropogonides* | Low | Climax | Increaser 1 | 0% | 0% | 0.50% |
| *Parinari capensis* | Low | Climax | Increaser 1 | 0% | 0% | 1% |
| *Bulbostylis burchellii* | Low | Climax | Increaser 1 | 2% | 3.50% | 4% |
| Forbs | | | | 3.50% | 12% | 8% |
| Bare ground | | | | 16.50% | 9.50% | 10.50% |

The soils at this site are exceptionally nutrient-poor which results in medium grazing of plants with little grazing value for medium to large herbivores. However, sufficient cover and suitable seed bearing grasses make this site ideal for small mammals which favour a rocky substrate. The site is dominated by climax grasses (57%), and with a small component of sub-climax (17%) species, thus indicating a relatively stable ecological state with limited degradation of the area. Some pioneer plants (3%) are present as a result of the disturbance caused by the impact of selective grazing. This site is not degraded due to the low grazing and browsing value and is not transformed through past agricultural activities due to its shallow soils and rocky outcrops. The utilization status of the area indicates the site is slightly dominated by Increaser 1 species (40.5%) indicative of a general state of long-term under-utilization in the area, with a moderate Decreaser component (25.5%). Du Plessis & Krynauw (2007) recorded a small Increaser 2 component (10.5%) confirms the disturbance through the selective utilization impact of game in the area (Table 3).

Table 3: A summary of the herbaceous layer data collected between 2007 and 2009 in the Northern Slope Woodland (NSW 1) community (Du Plessis & Krynauw 2009).

| Aspect | Category | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Number of grass spp. recorded | Number | 20 | 15 | 19 |
| Basal cover (%) | % | 2% | 4.50% | 4% |
| Bare ground( % ) | % | 16.50% | 9.50% | 10.50% |
| Phytomass: (Kg/ha): | Kg/ha | Very Low | Very Low | Very Low |
| Grazing value | High | 1 | 0 | 0.5 |
| ( % of total ; excluding bare ground % ) | Medium | 24.5 | 17.5 | 20 |
|  | Low | 52 | 55 | 56 |
|  | No value | 5.5 | 15.5 | 13 |
| Increaser/Decreaser status | Decreaser | 25.5 | 18 | 19.5 |
|  | Increaser 1 | 40.5 | 38.5 | 37.5 |
|  | Increaser 2 | 10.5 | 18.5 | 18.5 |
|  | Increaser 3 | 0.5 | 0 | 1 |
| Forbs % | Forbs | 5.5 | 15.5 | 13 |
| Ecological succession status (Grasses) | Climax | 57 | 49.5 | 48 |
|  | Sub-Climax | 17 | 15 | 16 |
|  | Pioneer | 3 | 10.5 | 12.5 |
|  | Forbs | 6.5 | 15.5 | 13 |
| Forb type: | Perrential |  |  | 1 |
|  | Annual |  |  |  |
|  | Not Specified | 5.5 | 15.5 | 12 |

The phytomass is very low due the rockiness of the substrate and shallow, nutrient poor soil, thus leading to a very low inherent production potential in this area. This site does not easily sustain fire under these conditions and accidental veld fires appear to burn only small patches within this community. There is evidence of limited fire occurrence at this site. These cool fires however, have had a limited impact on the woody component due to the rockiness of this area. A “cool” fire is a low-intensity fire which rapidly spreads through an area with a low biomass, opposed to a “hot” fire, which burns slowly and against a prevailing wind in an area with a high phytomass. There is a very low basal grass cover (2%) at this site in spite of the major perennial grass component, resulting in a very sparse herbaceous component. The low basal grass cover combined with the extensive nature of the rocky outcrops and high bare ground record (16.5%) contributes to sparse vegetation and patches of grass cover in areas where soil is present between the rocks. There is very low utilization of area by game due to the limited available grazing and any utilization occurring is selective in nature, with signs of even certain unpalatable species being utilized. In some cases, these unpalatable grass species show signs of becoming moribund and are in the process of dying. Selective grazing by larger game species at this site has resulted in a high impact on plant species with grazing value and a decline in these species is expected over time. The woody vegetation component at this site comprises a diverse small tree- to shrub-sized woody component, having been largely protected from fire impact due to the rockiness of this area. The woody species at this site also have a very limited browse potential and show either little or no signs of browsing. It is for these reasons that the woody component seems relatively stable, as it is not severely impacted by either fire or browsing, with significant vegetation changes unlikely to occur.

The woody component is represented by *Searsia magalismontanum* and *Gymnosporia tenuispina*, with scattered *Burkea africana* trees in certain areas. There is high species richness and no single species dominates, although the all species are typical of these rocky, nutrient-poor soils. A recorded 68% of woody plants were below 0.5 m in height such that this site is dominated by fire-maintained small plants. A further 88% of the woody plants at this site are below 1 m in size, indicating the presence of fire-stunted woody plants typical of this type of area. There is very low browse utilization recorded at this site, with 83% of plants not being utilized, with only 13% showing some signs of utilization. There is a high density of woody plants at this site (11 025 plants/ha), but largely due to the abundance of fire-stunted plants. There is no danger of bush-thickening at this site as the woody plant structure and dynamic is typical of such areas in the Bankenveld. Appendix A provides a full species list of the woody and herbaceous plants recorded in this transect during 2008 and 2009.

Transect 2 is placed amongst numerous red sandstone boulders in the Northern Slope Woodland community (NSW3) (Fig. 14) and is located on a slight northern slope with moderately dense woodland of small- to medium-sized plants and a sparse grass component. The site is untransformed by past agricultural practices and is in a natural stable state. The shallow red soils located at this site are shallow and have a low nutrient content (Du Plessis & Krynauw 2009). As a result of the low fertility of the soil and the numerous rocky outcrops on the surface, this site is not important from a grazing or browsing perspective due to this very low inherent utilization potential.  This site however, has a relatively high diversity of grass species and is dominated by perennial grass species. Fixed point photographs were taken in 2008 (Fig. 17) and 2009 (Fig. 18) at transect 2 in the Northern Slope Woodland community to record changes in biomass and physical appearance of the vegetation. In 2008 the grass cover was sparser although late rains resulted in an increase in the height and density of the herbaceous layer in 2009.

Figure 17.  A fixed point photograph depicting the habitat structure of Northern Slope Woodland 3 (NSW 3) on Telperion in 2008.

Figure 18. A fixed point photograph depicting the habitat structure of Northern Slope Woodland 3 (NSW 3) on Telperion in 2009.

The species composition of herbaceous plants in transect 2 is relatively high, with a forb component of 12% at this site, although it is not diverse and rather uniform in species composition. According to Du Plessis & Krynauw (2007) grazing value of transect 2 is generally low, with 51.5% of the plants species recorded with no or very low grazing value (Table 4).

Table 4: A comparative table of the species composition recorded at the Northern Slope Woodland (NSW 3) community between 2007 and 2009 on Telperion (Du Plessis & Krynauw 2009).

| Species | Value Categories |  |  | Species Composition ( % ) |  |  |
|---|---|---|---|---|---|---|
|  | Grazing Value | Ecological Succession | Increaser/ Decreaser | 2007 | 2008 | 2009 |
| *Loudetia simplex* | Low | Climax | Increaser 1 | 19.5% | 24.5% | 15% |
| *Diheteropogon amplectens* | Medium | Climax | Decreaser | 6.5% | 6% | 6% |
| *Eragrostis curvula/chloromelas* | Low | Sub-Climax | Increaser 2 | 5.5% | 1% | 0.5% |
| *Melinis repens* | Low | Pioneer | Increaser 2 | 0.5% | 3% | 0.5% |
| *Eragrostis racemosa* | Medium | Sub-Climax | Increaser 2 | 5.5% | 0.5% | 2.5% |
| *Shizachyrium sanguinium* | Low | Climax | Increaser 1 | 4.5% | 1% | 4.5% |
| *Aristida transvaalensis* | Low | Sub-Climax | Increaser 2 | 2% | 1.5% | 3% |
| *Setaria sphacelata* | Medium | Sub-Climax | Decreaser | 3% | 2% | 3.5% |
| *Tristachya leucothrix* | Low | Climax | Increaser 1 | 1.5% | 6% | 5.5% |
| *Digitaria eriantha* | High | Climax | Decreaser | 1% | 0% | 0% |
| *Eragrostis rigidior* | Medium | Sub-Climax | Increaser 2 | 2% | 0% | 0.5% |
| *Brachiaria serrata* | Medium | Climax | Decreaser | 0.5% | 0.5% | 0.5% |
| *Aristida stipitata* | Low | Sub-Climax | Increaser 2 | 0.5% | 0% | 0% |
| *Andropogon shirensis* | Low | Climax | Increaser 1 | 0.5% | 0% | 0% |
| *Cymbopogon excavatus* | Low | Climax | Increaser 2 | 0.5% | 0.5% | 0% |
| *Panicum natalense* | Low | Climax | Decreaser | 1% | 0.5% | 0% |
| *Setaria lindenbergiana* | Low | Climax | Decreaser | 3.5% | 7.5% | 7.5% |
| *Elionurus muticus* | Low | Climax | Increaser 3 | 0% | 2% | 0% |
| *Heteropogon contortus* | Medium | Sub-Climax | Increaser 2 | 0% | 1% | 0% |
| *Pogonarthria squarrosa* | Low | Sub-Climax | Increaser 2 | 0% | 0.5% | 0% |
| *Trachypogon spicatus* | Low | Climax | Increaser 1 | 0% | 0.5% | 0% |
| *Perotis patens* | Low | Pioneer | Increaser 2 | 0% | 0.5% | 1% |
| *Melinis nerviglumis* | Low | Climax | Increaser 1 | 0% | 0.5% | 6.5% |
| *Eragrostis gummiflua* | Low | Sub-Climax | Increaser 2 | 0% | 0% | 1.5% |
| *Eragrostis unidentified* | Medium | Sub-Climax | Increaser 2 | 0% | 0% | 2% |
| *Cymbopogon plurinodis* | Low | Climax | Increaser 2 | 0% | 0% | 0.5% |
| *Parinari capensis* |  |  |  | 0% | 0% | 2.5% |
| Succulent |  |  |  | 0% | 0.5% | 0% |
| *Xerophyta retinervis* |  |  |  | 0% | 0.5% | 0.5% |
| *Bulbostylis burchelli* |  |  |  | 3.5% | 6% | 9.5% |
| Forbs |  |  |  | 8.5% | 12.5% | 5.5% |
| Bare ground |  |  |  | 30% | 21% | 21% |

Only a small number of plants species recorded at the site have an average grazing value (18.5%) and are therefore, impacted on by grazers. The soils at this site are extremely nutrient-poor (Du Plessis & Krynauw 2009) and therefore, plants at the site generally have very little grazing value to herbivores. This site is dominated by climax grasses (39%), and a small component of sub-climax grasses (18.5%), which indicates that the site is in a relatively stable ecological state and is not over-utilized due to its low grazing and browsing value. Transect 2 is slightly dominated by Increaser 1 species (26%) indicative of a general state of long-term under-utilization in the area, with a similar moderate Decreaser and Increaser 2 components (±16%). The Increaser 2 component of 16.5% confirms the disturbance of the selective utilization impact of game selecting palatable species at the site (Table 5).

Table 5: A summary of the herbaceous layer data collected between 2007 and 2009 in the Northern Slope Woodland (NSW 3) community (Du Plessis & Krynauw 2009).

| Aspect | Category | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Number of grass spp. recorded | Number | 17 | 19 | 17 |
| Basal cover (%) | % | 3.5 | 7 | 4 |
| Bare ground( % ) | % | 30 | 21 | 21 |
| Phytomass: (Kg/ha): | Kg/ha | Very Low | Very Low | Very Low |
| Grazing value | High | 1 | 0 | 0 |
| ( % of total ; excluding bare ground % ) | Medium | 17.5 | 10 | 15 |
| | Low | 39.5 | 49.5 | 46 |
| | No value | 12 | 19.5 | 18 |
| Increaser/Decreaser status | Decreaser | 15.5 | 16.5 | 17.5 |
| | Increaser 1 | 26 | 32.5 | 31.5 |
| | Increaser 2 | 16.5 | 8.5 | 8 |
| | Increaser 3 | 0 | 2 | 0 |
| Forbs % | Forbs | 12 | 19.5 | 18 |
| Ecological succession status (Grasses) | Climax | 39 | 49 | 45.5 |
| | Sub-Climax | 18.5 | 6.5 | 10 |
| | Pioneer | 0.5 | 3.5 | 1.5 |
| | Forbs | 12 | 19.5 | 18 |
| Forb type: | Perrential | 0 | 1 | 0 |
| | Annual | 0 | 0 | 0 |
| | Not Specified | 12 | 18.5 | 17.5 |

The phytomass is very low as a result of the rocky substrate and the resulting shallow soil which leads to a very low inherent production potential in the area. Generally, this site does not easily sustain fire and although there is evidence of limited fire occurrence in the area, such fires would have had limited impact on the woody layer due to the rockiness of the area. There is a very low basal grass cover (3.5%) at the site in spite of the major perennial grass component which is indicative of the very sparse nature of the herbaceous layer. A large percentage of this area is bare ground (30%), indicative of rocky nature of the area which further contributes to the sparse vegetation cover at this site. This site is under-utilized due to the limited available grazing and any utilization that occurs is very selective in nature. Unpalatable grass species at this site show signs of becoming moribund as a result of under-utilization by game species and the selected grazing of the few palatable species may result in a decline of these species over time. The woody component at the site comprises of small tree- to shrub-sized plants which largely grow in between the large boulders present. Largely species with a limited browse potential dominate at this site e.g., *Elephantorrhiza burkei, Burkea africana, Ochna pulchra and Croton gratissimus*. The majority of the species recorded are typical of the rocky nutrient-poor soils with an estimated 96% of recorded plants below 1.5 m, with half of these below 0.5 m, and the site is thus dominated by fire-stunted woody plants. 68% of the plants recorded at this site are not utilized, with a further 28% being lightly utilized, however, seemingly by insects and not browsers. There is a high woody plant diversity (6250 plants/ha) at the site, however, most are stunted plants typical of the area. There were some slight changes in height classes recorded during the study, however, no major changes were recorded in this transect. As expected, structurally the survey area remained very similar during the study period. Some slight changes in utilization levels were recorded and throughout the study period, most plants were not utilized at all. Some utilization was recorded on *Ancylobothys*, but possibly not by small mammals. A slight decline in woody plant density was recorded in 2009 when compared with plant densities in 2008. Grass was recorded growing in the areas between rocks where the soils are deeper and it is expected that small mammals rely heavily on these areas for food. Appendix B provides a full species list of the woody and herbaceous plants recorded in this transect during 2008 and 2009.

### 4.3.2 Description of the Rocky Highveld Grassland vegetation community

This primary non-transformed vegetation community occupies approximately 15% of Telperion and Ezemvelo Nature Reserve and covers an area of 1944 ha. The community occurs predominantly in areas where cultivation was excluded due to the rocky surface substrate which would have made ploughing difficult (Fig.14). The rockiness of the area varies considerably with low to high surface rock cover, varying in size from boulders to flat rocky ridges. The plant species richness is relatively high in this community and the vegetation is primary and untransformed due to these areas not been historically cultivated. The grass species that fall within this community is generally sour due to the soils which are sandy, nutrient-poor and shallow, resulting in the grasses being not well-utilized by plains game species. The ecological index veld condition score for this community is 62% which is indicative of veld in a good ecological condition (Table 6). Under-utilization is a serious problem in this vegetation type, and the main reason for the lack of a better ecological score. This vegetation community occurs widely on the property and makes a significant contribution to the diversity of plants and animals at the study area.

Table 6: The ecological index of the veld condition in the Rocky Highveld Grassland communities recorded on Telperion (Du Plessis & Krynauw 2009).

| Species Grouping | NSW 1 % Composition | NSW 3 % Composition | Community MEAN / Grouping (% Composition) |
|---|---|---|---|
| Decreasers | 4.5 | 9.5 | 11.8 |
| Increasers 1 | 8.5 | 47 | 51.3 |
| Increasers 2 | 42 | 14.5 | 28.3 |
| Increasers 3 | 3.5 | 0 | 1.8 |
| Forbs | 41.5 | 26 | 33.8 |
| | | | |
| Decreasers | 11.8 | 10 | 117.5 |
| Increasers 1 | 51.3 | 7 | 358.8 |
| Increasers 2 | 28.3 | 4 | 113 |
| Increasers 3 | 1.8 | 1 | 1.75 |
| Forbs | 33.8 | 30.5 | 591 |
| | | | |
| Ecological index veld condition Score ( % ): x / 950 x 100 | | | 62 |

Transect 3 is placed on open natural grassland over sandstone in the Rocky Highveld Grassland (RHG 2) community (Fig. 19). This site is located on a plateau on an even mid-slope, characterised by shallow, sandy soils with a very low fertility (Du Plessis & Krynauw

2009). There are areas with scattered red sandstone rocks on the surface and occasional rock sheeting. This site, although not transformed, is not important for grazing of large game due to the inherent low utilization potential. There is a high diversity of grass species at this site, which are dominated by perennial plants species, while the forb component is not particularly diverse, although certain species occur in large numbers. Due to the high diversity of grass species, suitable habitat for a range of small mammal species is provided at this site. Fixed point photographs were taken in 2008 (Fig. 19) and 2009 (Fig. 20) at transect 3 in this Rocky Highveld Grassland community to record changes in biomass and physical appearance of the vegetation. The species composition of herbaceous plants at the site is high although with an average grazing value potential with a large number of plants with some grazing value, although approximately 58.5% of plants have no or very little value (Table 7).

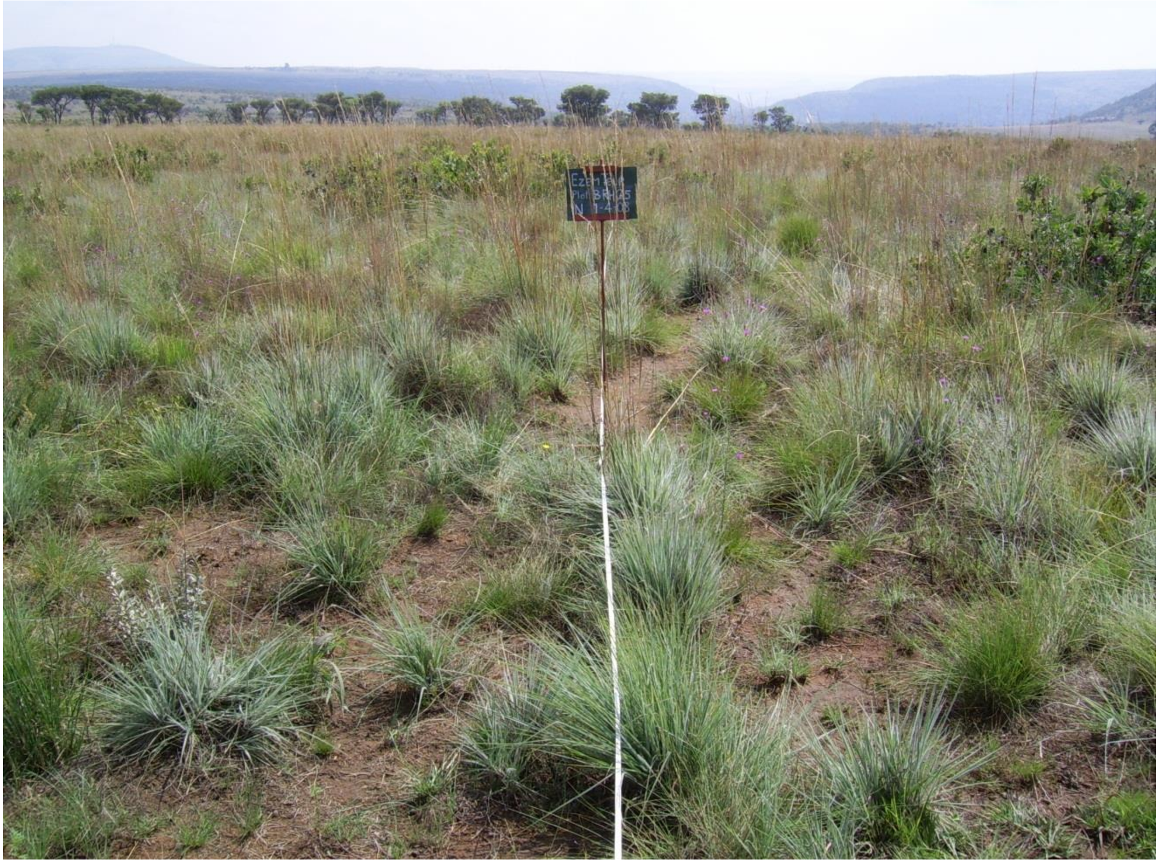

Figure 19. A fixed point photograph depicting the habitat structure of Rocky Highveld Grassland 2 (RHG 2) on Telperion in 2008.

Figure 20. A fixed point photograph depicting the habitat structure of Rocky Highveld Grassland 2 (RHG 2) on Telperion in 2009.

Table 7: A comparative table of the species composition recorded at the Rocky Highveld Grassland (RHG 2) community between 2007 and 2009 on Telperion (Du Plessis & Krynauw 2009).

| Species | Value Categories | | | Species Composition ( % ) | | |
|---|---|---|---|---|---|---|
| | Grazing Value | Ecological Succession | Increaser/ Decreaser | 2007 | 2008 | 2009 |
| *Aristida transvaalensis* | Low | Climax | Increaser 1 | 1.5% | 1% | 2.5% |
| *Themeda triandra* | High | Climax | Decreaser | 3.5% | 1% | 1% |
| *Loudetia simplex* | Low | Climax | Increaser 1 | 5% | 11% | 5.5% |
| *Tristachya leucothrix* | Low | Climax | Increaser 1 | 37% | 25% | 33% |
| *Bewsia biflora* | Low | Climax | Decreaser | 0.5% | 0% | 0.5% |
| *Eragrostis curvula/ chlorom.* | Low | Sub-Climax | Increaser 2 | 1.5% | 0.5% | 0% |
| *Shizachyrium sanguineum* | Low | Climax | Increaser 1 | 1.5% | 3% | 3% |
| *Elionurus muticus* | Low | Pioneer | Increaser 2 | 2.5% | 2.5% | 2.5% |
| *Aristida stipitata* | Low | Sub-Climax | Increaser 2 | 0.5% | 1% | 0% |
| *Setaria sphacelata* | Medium | Sub-Climax | Decreaser | 0.5% | 0.5% | 1% |
| *Melinis nerviglumis* | Low | Climax | Increaser 1 | 5.5% | 4.5% | 13.5% |
| *Melinis repens* | Low | Pioneer | Increaser 2 | 3% | 5.5% | 6% |
| *Trichoneura grandiglumis* | Low | Sub-Climax | Increaser 2 | 1% | 0.5% | 0% |
| *Sporobolus festivus cf* | Low | Pioneer | Increaser 2 | 1% | 0% | 0% |
| *Diheteropogon amplectens* | Medium | Climax | Decreaser | 2.5% | 5% | 3% |
| *Trachypogon spicatus* | Low | Climax | Increaser 1 | 11% | 13.5% | 6% |
| *Panicum natalense* | Low | Climax | Decreaser | 6.5% | 1.5% | 1% |
| *Urelytrum agropyriodes* | Low | Climax | Increaser 1 | 5% | 0% | 0% |
| *Brachiaria serrata* | Medium | Climax | Decreaser | 0.5% | 1.5% | 0% |
| *Tristachya rehmannii* | Low | Climax | Increaser 1 | 1% | 1% | 0.5% |
| *Eragrostis racemosa* | Low | Sub-Climax | Increaser 2 | 1% | 1.5% | 1.5% |
| *Sporobolus staphianus cf* | Low | Climax | Decreaser | 1.5% | 0.5% | 0% |
| *Eragrostis nindensis* | Medium | Sub-Climax | Increaser 2 | 0% | 1% | 0.5% |
| *Sporobolis pectinatus* | Medium | Sub-Climax | Increaser 2 | 0% | 4% | 2% |
| *Cymbopogon excavatus* | Low | Climax | Increaser 2 | 0% | 0% | 1% |
| *Heteropogon contortus* | Medium | Sub-Climax | Increaser 2 | 0% | 0% | 1% |
| *Andropogon chinensis* | Low | Climax | Increaser 1 | 0% | 0% | 0.5% |
| *Loudetia simplex* | Low | Climax | Increaser 1 | 0% | 0% | 1% |
| *Xerophyta retinervis* | | | | 0% | 0% | 0% |
| *Parinari capensis* | | | | 0% | 0% | 1% |
| *Bulbostylis burchellii* | | | | 1.5% | 1% | 5% |
| Forbs | | | | 5% | 13 | 7.5 |
| Bare ground | | | | 0% | 0.5% | 0% |

This site is dominated by climax grasses (61%), coupled with a high percentage of sub-climax grasses (27%), indicating a relatively stable ecological state with moderate impact from the selective grazing of palatable species. This site is not over-utilized or degraded due to its low grazing value and because the site was never transformed through previous agricultural practices. The site is slightly dominated by Increaser 1 grass species (34.5%) resulting from the under-utilization by game, although a moderate Decreaser component (30.5%) was recorded. The presence of Increaser 2 species (20.5%) at the site indicates a significant measure of selective utilization impact in the area (Table 8).

Table 8: A summary of the herbaceous layer data collected between 2007 and 2009 in the Rocky Highveld Grassland (RHG 2) community (Du Plessis & Krynauw 2009).

| Aspect | Category | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Number of grass spp. recorded | Number | 22 | 21 | 21 |
| Basal cover ( %) | % | 10 | 8.5 | 4 |
| Bare ground( % ) | % | N/A | N/A | N/A |
| Phytomass: (Kg/ha): | Kg/ha | 3.5 | 1 | 1 |
| Grazing value | High | 3.5 | 12 | 7.5 |
| ( % of total ; excluding bare ground % ) | Medium | 86.5 | 72.5 | 78 |
|  | Low | 6.5 | 14 | 13.5 |
|  | No value | 15.5 | 10 | 6.5 |
| Increaser/Decreaser status | Decreaser | 67.5 | 59 | 65.5 |
|  | Increaser 1 | 8 | 16.5 | 14.5 |
|  | Increaser 2 | 3 | 0 | 0 |
|  | Increaser 3 | 6.5 | 14 | 13.5 |
| Forbs % | Forbs | 82.5 | 68.5 | 72 |
| Ecological succession status (Grasses) | Climax | 4.5 | 9 | 6 |
|  | Sub-Climax | 6.5 | 8 | 8.5 |
|  | Pioneer | 6.5 | 14 | 13.5 |
| Forb type: |  |  |  |  |
|  | Annual | 6.5 | 14 | 13.5 |
|  | Not Specified |  |  |  |

The phytomass of this site is moderate to high as a result of low utilization by game and is therefore, expected to be able to sustain an intense fire, although no evidence of a recent fire was recorded. This amount of plant cover is favoured by small mammals and the diversity recorded at this site was high. The perennial grass component contributes to a moderate basal cover of 7.5%. This site shows signs of selective grazing, with more palatable species being very well-utilized, while extensive patches of moribund unpalatable grass species occur in certain areas. Due to the high level of phytomass and the site's extensive areas of moribund grass it requires regular fire to maintain and improve its ecological status, therefore, increasing the Decreaser grass component through limiting the effects of selective grazing. This vegetation community represents true fire climax grasslands (Acocks 1988), which require regular burns to remove surface carbon and stimulate new growth. This site has a very low bare ground recording (1%) due to the substantial grass and forb cover. Fire adapted, stunted shrub-sized woody plants dominate this site and are typical of these areas subjected to past fire impact and moderate numbers of *Protea welwitchii*, *Seriphium plumosum* and *Elephantorrhiza elephantina* occurring in certain sections of the site. Appendix C provides a full species list of the woody and herbaceous plants recorded in this transect during 2008 and 2009 (Du Plessis & Krynauw 2009).

Transect 4 is located on open natural grassland over sandstone in the Rocky Highveld Grassland (RHG 4) community (Fig. 14). This site has a considerable rocky surface, with shallow, sandy soils which are leached and therefore, have a low fertility. This site, although not transformed by previous agriculture or overgrazing, is not well-utilized by grazing as a result of its inherent low utilization potential. There is a high diversity of perennial grass species recorded at this site, although the phytomass is lower than that which was recorded in transect 3. Fixed point photographs were taken in April 2008 (Fig. 21) and April 2009 (Fig. 22) at transect 4 in this Rocky Highveld Grassland community to record changes in biomass and physical appearance of the vegetation. This species composition of herbaceous plants is listed for this community (Table 9). This site has a significant forb component (14.5%), dominated by *Xerophyta retinervis,* although the diversity of forbs is relatively low.

Figure 21. A fixed point photograph depicting the habitat structure of Rocky Highveld Grassland 4 (RHG 4) on Telperion in 2008.

Figure 22. A fixed point photograph depicting the habitat structure of Rocky Highveld Grassland 4 (RHG 4) on Telperion in 2009.

Table 9: A comparative table of the species composition recorded at the Rocky Highveld Grassland 4 (RHG 4) community between 2007 and 2009 on Telperion (Du Plessis & Krynauw 2009).

| Species | Value Categories | | | Species Composition ( % ) | | |
|---|---|---|---|---|---|---|
| | Grazing Value | Ecological Succession | Increaser /Decreaser | 2007 | 2008 | 2009 |
| *Tristachya leucothrix* | Low | Climax | Increaser 1 | 26.5% | 23% | 19% |
| *Trachypogon spicatus* | Low | Climax | Increaser 1 | 4.5% | 3% | 1.5% |
| *Eragrostis curvula/chloromelas* | Low | Sub-Climax | Increaser 2 | 4.5% | 8% | 12% |
| *Setaria sphacelata* | Medium | Sub-Climax | Decreaser | 26% | 9% | 11.5% |
| *Digitaria monodactyla* | Medium | Sub-Climax | Increaser 2 | 2% | 0% | 0% |
| *Diheteropogon amplectens* | Medium | Climax | Decreaser | 1% | 1% | 2% |
| *Themeda triandra* | High | Climax | Decreaser | 2% | 1% | 1.5% |
| *Melinis repens* | Low | Pioneer | Increaser 2 | 3.5% | 4.5% | 13.5% |
| *Loudetia simplex* | Low | Climax | Increaser 1 | 1% | 1% | 1.5% |
| *Brachiaria serrata* | Medium | Climax | Decreaser | 2% | 1.5 | 0.5% |
| *Aristida transvaalensis* | Low | Climax | Increaser 1 | 3.5% | 2.5 | 2% |
| *Trichneura grandiglumis* | Low | Sub-Climax | Increaser 2 | 3% | 0.5 | 2.5% |
| *Eragrostis plana* | Low | Sub-Climax | Increaser 2 | 0.5% | 0% | 1.5% |
| *Schizachyrium sanguineum* | Low | Climax | Increaser 1 | 1% | 0% | 1% |
| *Digitaria ternata* | Low | Pioneer | Increaser 2 | 0.5% | 0% | 0% |
| *Pogonarthria squarrosa* | Low | Pioneer | Increaser 2 | 2.5% | 3.5 | 0% |
| *Eragrostis stipitata* | Low | Sub-Climax | Increaser 2 | 0.5% | 0% | 0% |
| *Heteropogon contortus* | Medium | Sub-Climax | Increaser 2 | 0.5% | 0% | 0% |
| *Elionurus muticus* | Low | Climax | Increaser 3 | 0.5% | 0% | 0% |
| *Aristida stipitata* | Low | Sub-Climax | Increaser 2 | 0% | 1.5 | 0% |
| *Melinis nerviglumis* | Low | Climax | Increaser 1 | 0% | 0.5 | 2% |
| *Andropogon chirensis* | Low | Climax | Increaser 1 | 0% | 0% | 0.5% |
| *Eragrostis racemosa* | Medium | Sub-Climax | Increaser 2 | 0% | 0% | 0.5% |
| *Eragrostis* sp. (Large) | Low | Sub-Climax | Increaser 2 | 0% | 0% | 0.5% |
| Grass sp.(Bulblike hairy edge) | Medium | Climax | Decreaser | 0% | 0% | 0.5% |
| Forbs (incl *X. retinervis*) | | | | 9% | 9% | 5% |
| *Bulbostylis burchellii* | | | | 3.5% | 9.5% | 8.5% |
| *Parinari capensis* | | | | 0% | 1% | 6% |
| *Oldenlandia herbacea* | | | | 0% | 12% | 1% |
| *Xerophyta retinervis* | | | | 0% | 0% | 2.5% |
| *Indigophora* sp. | | | | 0% | 0% | 1% |
| Bare ground | | | | 2% | 8.5% | 2% |

The site has a low grazing value, with 66.5% of plants recorded with no or little grazing value, although 31.5% of medium value grasses were also recorded. This site is dominated by climax grasses species (42%), with a significant component of sub-climax grasses species (37%), which indicates a relatively stable ecological status, with a moderate impact through selective grazing of palatable species. This site is not heavily impacted due to the low grazing potential and certain areas are under-utilized. This site is semi-dominated by Increaser 1 species (36.5%) indicative of this history of under-utilization, although a moderate Decreaser component is present (26.5%). The number of Increaser 2 grass species (17.5%) indicates the measure of selective utilization impact in the area (Table 10).

Table 10: A summary of the herbaceous layer data collected between 2007 and 2009 in the Rocky Highveld Grassland (RHG 4) community (Du Plessis & Krynauw 2009).

| Aspect | Category | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Number of grass spp. recorded | Number | 19 | 14 | 18 |
| Basal cover (%) | % | 10 | 1 | 8 |
| Bare ground (%) | % | 2 | 8.5 | 2 |
| Phytomass: (Kg/ha): | Kg/ha | No Record | 3802 | 5251 |
| Grazing value | High | 2 | 1 | 1.5 |
| ( % of total ; excluding bare ground % ) | Medium | 31.5 | 11.5 | 15 |
| | Low | 52 | 47.5 | 57.5 |
| | No value | 14.5 | 31.5 | 24 |
| Increaser/Decreaser status | Decreaser | 31 | 12.5 | 16 |
| | Increaser 1 | 36.5 | 30 | 27.5 |
| | Increaser 2 | 17.5 | 18 | 30.5 |
| | Increaser 3 | 0.5 | 0 | 0 |
| Forbs % | Forbs | 14.5 | 31.5 | 24 |
| Ecological succession status (Grasses) | Climax | 42 | 33.5 | 32 |
| | Sub-Climax | 37 | 19 | 28.5 |
| | Pioneer | 6.5 | 8 | 13.5 |
| | Forbs | 14.5 | 31.5 | 24 |
| Forb type: | Perrential | | | |
| | Annual | | | |
| | Not Specified | 14.5 | 31.5 | 24 |

The phytomass is moderate due to the under-utilization of the herbaceous layer by herbivores and would sustain a high intensity fire, although no evidence of recent fire at this site exists. The perennial grass layer contributes to a relatively high basal cover (10%), while a recording of 2% bare ground indicates few bare ground patches possibly due to selective grazing in these areas. The unpalatable grass species at the site are under-utilized and have become moribund, while selective grazing has impacted considerably on grasses with a moderate grazing value. This community requires regular burning to improve its ecological status and increase palatability of the majority of grasses present. The woody component at the site is not dominant due to past fire impacts and is sparse and limited to the fire resistant species, *Xerophyta retinervis*, which is a plant typical of this fire climax grassland (Acocks 1988). Appendix D provides a full species list of the woody and herbaceous plants recorded in this transect during 2008 and 2009.

### 4.3.3 Description of the Degraded Grassland vegetation community

This transformed plant community occupies the largest portion of the study area of approximately 45% and covers an area of 2604 ha (Fig.14). These areas are well-utilized by game and understanding of their dynamics is therefore, important for management of the area. This community is situated on nutrient-poor sandy soils derived from sandstone and are predominantly old cultivated lands disturbed by ploughing action in the past. The veld recovery in these areas in terms of herbaceous layer biodiversity is relatively poor, with a low species richness recorded due to these past disturbances. This community is extensively utilized by game, although large sections are moribund and are avoided by game, or very selectively utilized, which contributes to its degradation. Large portions of certain areas of these sites are encroached by *Seriphium plumosum* which further decreases the plant species richness of the herbaceous layer. The ecological index veld condition score of 30.5 was calculated for this community. This poor score is due to the large percenetage of Increaser 2 species, indicative of the degraded state of the veld due to past degradation (Table 11).

Table 11: The ecological index of the veld condition in the Degraded Grassland communities recorded on Telperion (Du Plessis & Krynauw 2009).

| Species Grouping | DG 2<br>% Composition | DG 3<br>% Composition | Community MEAN / Grouping<br>(% Composition) |
|---|---|---|---|
| Decreasers | 0 | 11 | 5.5 |
| Increasers 1 | 0 | 1.5 | 0.8 |
| Increasers 2 | 52 | 63 | 57.5 |
| Increasers 3 | 0 | 0 | 0 |
| Forbs | 46 | 24.5 | 35.3 |
| | | | |
| Decreasers | 5.5 | 10 | 55.0 |
| Increasers 1 | 0.8 | 7 | 5.3 |
| | | | |
| Increasers 2 | 57.5 | 4 | 230.0 |
| Increasers 3 | 0 | 1 | 0.0 |
| Forbs | 35.3 | 0 | 0.0 |
| | 99.1 | | 290.3 |
| | | | |
| Ecological index veld condition Score ( % ): x / 950 x 100 | | | 30.5 |

Transect 5 is placed in Degraded Grassland (Fig.14) and appears to show signs of being over-utilized for many consecutive years. Degraded Grassland 2 is a site which is located on a level plateau on yellow loam soils, indicative of moist soil conditions and relatively fertile soils, which possibly resulting in it being historically over-utilized. The species diversity of plants at the site is low as a result of large dense stands of *Seriphium plumosum*. There are two sub-climax grass species (*Eragrostis curvula* and *Eragrostis racemosa*) and one climax species (*Elionurus muticus*) which dominate at this site. Fixed point photographs were taken in 2008 (Fig. 23) and 2009 (Fig. 24) at transect 5 in this Degraded Grassland community to record changes in biomass, increased abundance of plants which encroach and physical appearance of the vegetation. The presence of *S. plumosum* (*S. vulgaris)* increased dramatically between 2008 and 2009, displacing numerous other plant species at this site. The species composition of herbaceous plants at Degraded Grassland 2 is relatively low (Table 12). The grazing value is very low, with 62% of plants recorded having little or no grazing value and only 6.5% of plants with good grazing potential.

Figure 23. A fixed point photograph depicting the habitat structure of Degraded Grassland 2 (DG 2) on Telperion in 2008.

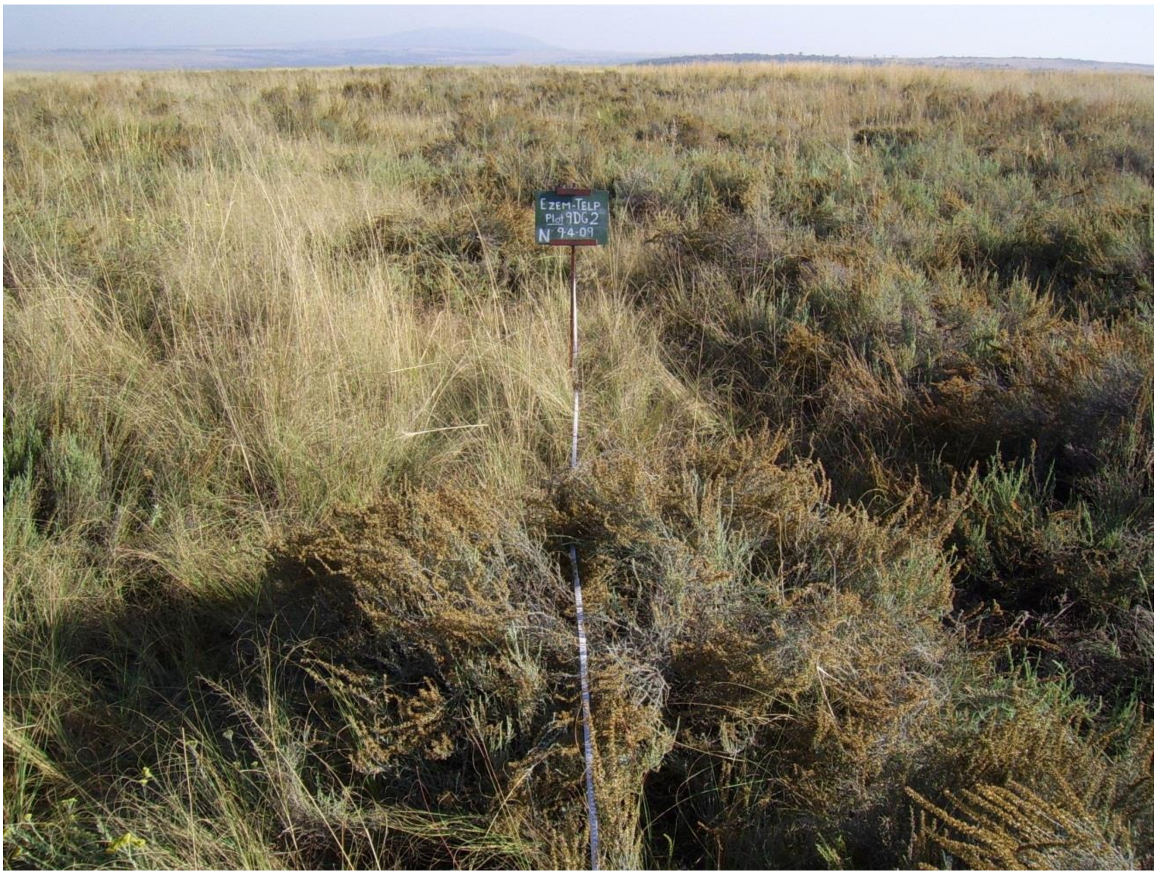

Figure 24. A fixed point photograph depicting the habitat structure of Degraded Grassland 2 (DG 2) on Telperion in 2009.

Table 12: A comparative table of the species composition recorded at the Degraded Grassland (DG 2) community between 2007 and 2009 on Telperion (Du Plessis & Krynauw 2009).

| Species | Value Categories | | | Species Composition (%) | | |
|---|---|---|---|---|---|---|
| | Grazing Value | Ecological Succession | Increaser/ Decreaser | 2007 | 2008 | 2009 |
| *Eragrostis curvula/chloromelas* | Low | Sub-Climax | Increaser 2 | 39.5% | 35% | 31.5% |
| *Cynodon dactylon* | Medium | Sub-Climax | Increaser 2 | 20.5% | 8% | 8.5% |
| *Melinis repens* | Low | Pioneer | Increaser 2 | 1% | 2% | 2% |
| *Schizachyrium sanguineum* | Low | Climax | Increaser 1 | 0.5% | 0.5% | 0% |
| *Aristida stipitata* | Low | Sub-Climax | Increaser 2 | 2.5% | 0% | 2.5% |
| *Themeda triandra* | High | Climax | Decreaser | 1% | 0.5% | 0% |
| *Aristida transvaalensis* | Low | Sub-Climax | Increaser 2 | 0.5% | 1.5% | 0% |
| *Eragrostis gummiflua* | Low | Sub-Climax | Increaser 2 | 0.5% | 0.5% | 1% |
| *Perotis patens* | Low | Pioneer | Increaser 2 | 0.5% | 2% | 2.5% |
| *Elionurus muticus* | Low | Climax | Increaser 3 | 0.5% | 0% | 0% |
| *Pogonarthria squarrosa* | Low | Pioneer | Increaser 2 | 0.5% | 0% | 1% |
| *Eragrostis racemosa* | Medium | Sub-Climax | Increaser 2 | 0% | 1% | 2.5% |
| *Aristida congesta* | Low | Pioneer | Increaser 2 | 0% | 1% | 0.5% |
| *Andropogon eucomus* | Low | Sub-Climax | Increaser 2 | 0% | 0.5% | 0% |
| *Eragrostis capensis* | Low | Sub-Climax | Increaser 2 | 0% | 0% | 0.5% |
| *Trichoneura grandiglumis* | Low | Sub-Climax | Increaser 2 | 0% | 0% | 0.5% |
| *Schurria pinnata* | | | | 0% | 0% | 0.5% |
| *Oldenlandia herbacea* | | | | 0% | 0% | 0.5% |
| *Bulbostylis burchellii* | | | | 25% | 28% | 26% |
| Sedges | | | | 0% | 2% | 1% |
| Forbs | | | | 4% | 16 | 18% |
| Bare ground | | | | 3.5% | 2% | 1% |

The ecological status of the site indicates dominance by sub-climax grasses (55.5%), which are indicative of the disturbed nature of the area. The moderate climax species component (35.5%) of this site appears as relics of the past, plants which possibly dominated this site prior to utilization. The effects of over-utilization are noted by the dominance of Increaser 2 and Increaser 3 (62%) grass species, further indicative of the history of over-utilization at this site in past years. The presence of Increaser 1 grass species is a measure of the present under-utilization of the area by game which is possibly due to the poor condition of the area (Table 13).

Table 13: A summary of the herbaceous layer data collected between 2007 and 2009 in the Degraded Grassland (DG 2) community (Du Plessis & Krynauw 2009).

| Aspect | Category | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Number of grass spp. recorded | Number | 11 | 11 | 11 |
| Basal cover (%) | % | 7 | 7 | 4.5 |
| Bare ground( % ) | % | 3.5 | 2 | 1 |
| Phytomass: (Kg/ha): | Kg/ha | 3016 | N/A | N/A |
| Grazing value | High | 1 | 0.5 | 0 |
| ( % of total ; excluding bare ground % ) | Medium | 20.5 | 9 | 11 |
| | Low | 46 | 43 | 42 |
| | No value | 29 | 46 | 46 |
| Increaser/Decreaser status | Decreaser | 1 | 0.5 | 0 |
| | Increaser 1 | 0.5 | 0.5 | 0 |
| | Increaser 2 | 65.5 | 51 | 52 |
| | Increaser 3 | 0.5 | 0 | 0 |
| Forbs % | Forbs | 29 | 46 | 46 |
| Ecological succession status (Grasses) | Climax | 2 | 1 | 0 |
| | Sub-Climax | 63.5 | 46 | 47 |
| | Pioneer | 1.5 | 5 | 6 |
| | Forbs | 29 | 46 | 46 |
| Forb type: | Perrential | | | |
| | Annual | | | |
| | Not Specified | 29 | 46 | 46 |

The phytomas (6012 Kg/ha) recorded at the site is high due to poor utilization and the high numbers of *S. plumosum*, while ground cover is relatively low (6.5%) due to the sub-climax nature of the area. A low bare ground percentage was recorded at this site as a result of the poor utilization of the vegetation with numerous unpalatable grasses becoming moribund. Signs of selective grazing in certain areas are recorded on a few palatable species, such as *Themeda triandra*, which resulted in a relative low succession state, further hampered by high densities of *Seriphium plumosum* and *Hyparrhenia hirta*. *S. plumosum* is the only woody plant recorded at the site, displacing palatable grass species and other forbs. The recovery potential of the area under present conditions is limited and no evidence of recent fire is recorded, although regular burning of the veld would be beneficial to improving diversity and reducing the selective utilization of the vegetation at this site. The dense stands of *S. plumosum* appear to provide favourable cover to certain small mammal species, especially *Dendromus melanotis*, during winter months when grass cover is reduced.

Appendix E provides a full species list of the woody and herbaceous plants recorded in this transect during 2008 and 2009.

Transect 6 is placed in Degraded Grassland (Fig.14.) and the site located on deep sandy, leached soils with a slight gradient mid-slope. Degraded Grassland 3 is historically cultivated land which has resulted in low species diversity due to these past disturbances. The site is dominated by two sub-climax grass species (*Eragrostis curvula* and *Aristida stipitata*) and one climax grass species (*Digitaria erianha*) dominate. Fixed point photographs were taken in 2008 (Fig. 25) and 2009 (Fig. 26) at transect 6 in this Degraded Grassland community to record changes in biomass, increased diversity of plants which encroach the physical appearance of the vegetation. The phytomass increased considerably between 2008 and 2009, due to good rains and low utilization by game. The species composition of herbaceous plants recorded at the site is relatively low (Table 14). The grazing value at this site is exceptionally low, with approximately 70% of plant species recorded having no or very little grazing value, resulting in these non-palatable species being under-utilized and then becoming moribund.

Figure 25. A fixed point photograph depicting the habitat structure of Degraded Grassland (DG 3) on Telperion in 2008.

Figure 26. A fixed point photograph depicting the habitat structure of Degraded Grassland (DG 3) on Telperion in 2009.

Table 14: A comparative table of the species composition recorded at the Degraded Grassland (DG 3) community between 2007 and 2009 on Telperion (Du Plessis & Krynauw 2009).

| Species | Value Categories | | | Species Composition (%) | | |
|---|---|---|---|---|---|---|
| | Grazing Value | Ecological Succession | Increaser/ Decreaser | 2007 | 2008 | 2009 |
| *Eragrostis curvula/chloromelas* | Low | Sub-Climax | Increaser 2 | 28% | 18% | 23% |
| *Digitaria eriantha* | High | Climax | Decreaser | 28% | 9.5% | 11% |
| *Aristida stipitata* | Low | Sub-Climax | Increaser 2 | 28.5% | 42% | 34% |
| *Cynodon dactylon* | Medium | Sub-Climax | Increaser 2 | 0.5% | 3.5% | 0.5% |
| *Perotis patens* | Low | Pioneer | Increaser 2 | 3% | 2.5% | 3.5% |
| *Setaria sphacelata sphacelata* | Medium | Sub-Climax | Decreaser | 1% | 1.5% | 0% |
| *Digitaria diagonalis* | Medium | Climax | Increaser 1 | 0.5% | 0% | 1% |
| *Andropogon shirensis* | Low | Climax | Increaser 1 | 0.5% | 0% | 0.5% |
| *Trichoneura grandiglumis* | Low | Sub-Climax | Increaser 2 | 0.5% | 0% | 0% |
| *Heteropogon contortus* | Medium | Sub-Climax | Increaser 2 | 0.5% | 1% | 0.5% |
| *Tricholaena monachne* | Medium | Sub-Climax | Increaser 2 | 0% | 0.5% | 0.5% |
| *Pogonarthria squarrosa* | Low | Pioneer | Increaser 2 | 0% | 0% | 1% |
| *Bulbostylis burchellii* | | | | 5.5% | 16% | 17% |
| Forbs | | | | 3.5% | 6.5% | 7.5% |

A low percentage of plants (28%) recorded at the site have grazing potential and are selectively grazed by herbivores. The ecological status of the area is indicated by the dominance of sub-climax grasses (59%), indicative of the historical disturbance of the area. There is however, some improvement towards a more climax state with a climax grass component of 29% recorded, thus indicating movement towards a more stable ecological state (Table 15).

Table 15: A summary of the herbaceous layer data collected between 2007 and 2009 in the Degraded Grassland (DG 3) community (Du Plessis & Krynauw 2009).

| Aspect | Category | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Number of grass spp. recorded | Number | 10 | 8 | 10 |
| Basal cover (%) | % | 7.5 | 7 | 8 |
| Phytomass: (Kg/ha): | Kg/ha | 3207 | 1447 | 4217 |
| Grazing value | High | 28 | 9.5 | 11 |
| ( % of total ; excluding bare ground % ) | Medium | 2 | 6.5 | 2.5 |
| | Low | 60.5 | 62.5 | 62 |
| | No value | 9 | 22.5 | 24.5 |
| Increaser/Decreaser status | Decreaser | 29 | 11 | 11 |
| | Increaser 1 | 0.5 | 0 | 1.5 |
| | Increaser 2 | 61 | 67.5 | 63 |
| | Increaser 3 | 0 | 0 | 0 |
| Forbs % | Forbs | 9 | 22.5 | 24.5 |
| Ecological succession status (Grasses) | Climax | 28.5 | 9.5 | 12.5 |
| | Sub-Climax | 59 | 66.5 | 58.5 |
| | Pioneer | 3 | 2.5 | 4.5 |
| | Forbs | 9.5 | 22.5 | 24.5 |
| Forb type: | Perrential | | | |
| | Annual | | | |
| | Not Specified | 9 | 22.5 | 24.5 |

A high phytomass (3207 Kg/ha) is recorded at the site due to plants being poorly utilized by game due to its generally low grazing value. Transect 6 has a relatively low basal cover (7.5%) due to the sub-climax dominated nature of the grasses found at the site, and only a few bare ground patches were recorded due to selective grazing of the palatable species by game. There is no evidence of past fire impact at the site, although the site requires burning to reduce the number of low-quality grazing plants, rejuvenate the area, through relieving selective grazing pressure and the quantity of moribund grass present. Being a historically disturbed area, with the majority of palatable species being heavily utilized by grazers, this area is in a relatively low successional state and the recovery potential of the area is limited under present conditions. The woody component at this site is sparse, with only a few species being recorded, including *Parinari capensis*, *Elephantorrhiza elephantina* and small *Ochna pulchra*. This site, unlike Degraded Grassland 2, is not encroached by *S. plumosum*, which is possibly related to the soil structure and lack of sufficient water.

Appendix F provides a full species list of the woody and herbaceous plants recorded in this transect during 2008 and 2009.

### 4.3.4. Description of the Sheltered Woodland vegetation community

The Sheltered Woodland plant community occupies a non-transformed 8% of the study area and covers an area of 219 ha (Fig. 14). This community consists of the extremely rocky areas adjacent to the Wilge River and incorporates sections of the study area which remain in a natural state. The sandy and nutrient-poor soils within this community are shallow and occur in saddles between the rocky outcrops. Grasses and forbs grow in limited number in narrow openings between the rocks, which are also occupied by woody plants which root between the rocks.

Plant diversity within this community is relatively high due to the absence of historical agricultural disturbances. Small sections of moderately palatable grasses occur within this community, although no utilization by medium- to large-sized game is recorded, possibly due to the nature of the terrain. The structure of this community with its large boulders and sufficient crevices provides an ideal habitat for rock-dwelling small mammal species. Fire seldom enters the community, but on the few occasions that it does, only small sections are affected as a result of the low phytomass, sparse vegetation and rocky substrate. The Sheltered Woodland community is in a relatively stable state without the extreme dynamics of typical Bankenveld vegetation and therefore, maintains its biodiversity due to the unaffected nature of the area. The ecological index veld condition score for this community was calculated at 54.1% (Table 16), which is an indication that the veld is in a reasonable condition ecologically, although under-utilization is a problem, and moribund conditions are present due to the under utilization, which is likely to have promoted an influx of some Increaser 2s and forbs in the area. This ecological condition is confirmed by the fact that sub climax grasses dominate the area and that no pioneer grasses were recorded, an indication that no recent disturbances in the area have occurred.

Table 16: The ecological index of the veld condition in the Sheltered Woodland communities recorded on Telperion (Du Plessis & Krynauw 2009).

| Species Grouping | SW 1<br>% Composition | | Community Mean / Grouping<br>(% Composition) |
|---|---|---|---|
| Decreasers | 34.5 | | 34.5 |
| Increasers 1 | 11 | | 11 |
| Increasers 2 | 23 | | 23 |
| Increasers 3 | 0 | | 0 |
| Forbs | 30 | | 30 |
| | % Compostion | Ecological Index Factors | Score |
| Decreasers | 34.5 | 10 | 345 |
| Increasers 1 | 11 | 7 | 77 |
| Increasers 2 | 23 | 4 | 92 |
| Increasers 3 | 0 | 1 | 0 |
| Forbs | 30 | 0 | 0 |
| | 98.5 | | 514 |
| Ecological index veld condition Score ( % ): x / 950 x 100 | | | 54.1 |

Transect 7 is placed in Sheltered Woodland community (Fig.14.) and is characterized by extensive woodland on red sandstone outcrops interspersed with grass dominated saddles. The high lying rocky areas at the site are interspersed with small- to large-sized woody plants and a relatively high diversity of forbs and ferns. The soils present at the site are limited due to the rocky nature of the substrate, although shallow to medium depth soils occur in areas where grass dominates. These soils are characteristic of this type of habitat and are very low in fertility, resulting in the site not being important for grazing due to the inherent moderate to low grazing potential of the area. This site has high dominant grass species diversity and is dominated by perennial plants which grow on the shallow soils sheltered by large boulders. Fixed point photographs were taken in 2008 (Fig. 27) and 2009 (Fig. 28) at transect 7 in the Sheltered Woodland community to record changes in biomass and physical appearance of the vegetation. The phytomass increased between 2008 and 2009, due to above average rainfall, absence of fire and low utilization by game. Appendix G provides a full species list of the woody and herbaceous plants recorded in this transect during 2008 and 2009. The species composition of herbaceous plants recorded at this site is high (Table 17). A relatively rich forb component (35.5%) typical of this habitat type is recorded at the site. Generally, the grazing value of the site is low, with 74.5% of the grass plants recorded with little or no grazing value.

Figure 27. A fixed point photograph depicting the habitat structure of Sheltered Woodland 1 (SW 1) on Telperion in 2008.

Figure 28. A fixed point photograph depicting the habitat structure of Sheltered Woodland (SW 1) on Telperion in 2009.

Table 17: A comparative table of the species composition recorded at the Sheltered Woodland (SW 1) community between 2008 and 2009 on Telperion (Du Plessis & Krynauw 2009).

| Species | Value Categories | | | Species Composition ( % ) | |
|---|---|---|---|---|---|
| | Grazing Value | Ecological Succession | Increaser/Decreaser | 2008 | 2009 |
| *Tristachya leucothrix* | Low | Climax | Increaser 1 | 0.5% | 1.0% |
| *Loudetia simplex* | Low | Climax | Increaser 1 | 9.0% | 10.0% |
| *Setaria sphacelata* | Medium | Sub-Climax | Decreaser | 18.5% | 50.0% |
| *Trachypogon spicatus* | Low | Climax | Increaser 1 | 1.0% | 0.0% |
| *Diheteropogon amplectens* | Medium | Climax | Decreaser | 1.0% | 1.5% |
| *Themeda triandra* | High | Climax | Decreaser | 0.5% | 0.5% |
| *Brachiaria serrata* | Medium | Climax | Decreaser | 0.5% | 0.0% |
| *Shizachyrium sanguineum* | Low | Climax | Increaser 1 | 0.5% | 0.0% |
| *Eragrostis curvula/chloromelas* | Low | Sub-Climax | Increaser 2 | 22.0% | 21.0% |
| *Eustachys paspaloides* | High | Climax | Decreaser | 3.0% | 2.0% |
| *Heteropogon contortus* | Medium | Sub-Climax | Increaser 2 | 0.5% | 0.0% |
| *Setaria lindenbergiana* | Low | Climax | Decreaser | 0.5% | 2.0% |
| *Eragrostis gummiflua* | Low | Sub-Climax | Increaser 2 | 4.0% | 2.0% |
| *Cymbopogon excavatus* | Low | Climax | Increaser 1 | 1.5% | 0.0% |
| *Protasparagus laricinus* | | | | 0.0% | 1.0% |
| *Pteridium aquilinum* | | | | 2.5% | 2.0% |
| *Fadogia homblei* | | | | 1.5% | 4.5% |
| Sedges | | | | 5.0% | 3.0% |
| *Bulbostylis burchellii* | | | | 3.0% | 2.5% |
| Forbs | | | | 23.5% | 17.0% |
| Bare ground | | | | 1.5% | 1.5% |

A relatively small component of the plants recorded at the site had some grazing value (24%), although these species remain under-utilized and appear to be avoided by game. The Rock Hyrax (*Procavia capensis*), is the primary herbivore at the site, although it appears to have a limited impact on palatable grasses recorded. The ecological status of the site is indicated by the dominance of sub-climax grasses (45%) and a small component of climax grasses (18%), which is indicative of a relatively stable ecological state with a limited level of natural disturbance. No pioneer grasses were recorded at the site, which is indicative of the absence of grazing impact. The under-utilized nature of the site is indicated by a dominance of Increaser 1 grass component (12.5%), while some unpalatable grass species show definite signs of becoming moribund due to under-utilization and the absence of fire. The moderate component of Decreaser grasses (24%) and Increaser 2 grasses (26.5%) recorded do not indicate any definite trend when all dominant species involved are considered (Table 18).

Table 18: A summary of the herbaceous layer data collected between 2008 and 2009 in the Sheltered Woodland (SW 1) community (Du Plessis & Krynauw 2009).

| Aspect | Category | 2008 | 2009 |
|---|---|---|---|
| Number of grass spp. recorded | Number | 14 | 9 |
| Basal cover ( %) | % | 8.5 | 6.5 |
| Bare ground( % ) | % | 1.5 | 1.5 |
| Phytomass: (Kg/ha): | Kg/ha | Medium | Medium |
| Grazing value | High | 3.5 | 2.5 |
| ( % of total ; excluding bare ground % ) | Medium | 20.5 | 30 |
| | Low | 39 | 36 |
| | No value | 35.5 | 30 |
| Increaser/Decreaser status | Decreaser | 24 | 34.5 |
| | Increaser 1 | 12.5 | 11 |
| | Increaser 2 | 26.5 | 23 |
| | Increaser 3 | 0 | 0 |
| Forbs % | Forbs | 35.5 | 30 |
| Ecological succession status (Grasses) | Climax | 18 | 15 |
| | Sub-Climax | 45 | 53.5 |
| | Pioneer | 0 | 0 |
| | Forbs | 35.5 | 30 |
| Forb type: | Perrential | 2.5 | 7.5 |
| | Annual | | |
| | Not Specified | 33 | 22.5 |

The phytomass recorded is very low to absent in most areas at the site, although it increases from moderate to high in the valleys. This site can sustain fire under these conditions however, only small sections are expected to burn due to the rocky nature of the site. There is generally a low inherent production potential in the area as a whole due to the limited number of areas suitable to optimize grass growth. A moderate basal cover of 8.5% is recorded in the valleys between the outcrops, although little to no herbaceous cover is present as a result of the extensive nature of these outcrops at the site. There is some evidence of past fire occurrence at this site, although this is limited and appears to have had no impact on the tree and shrub-sized woody plants due to the rockiness of the area. Most species at this site have a poor browse potential and thus this woody component seems relatively stable, not severely impacted by fire or browse, with significant vegetation changes unlikely to occur. Under-utilization of the area is a problem, but this effect seems to be limited to certain areas due to patch-burn occurrences which appear to maintain the ecosystem dynamics of the site.

### 4.3.5 Description of the Burkea Eragrostis Clumps vegetation community

The Burkea Eragrostis Clumps community occupies a non-transformed area which occupies 4% of the study area and covers an area of 116 ha (Fig. 14.). This is a relatively small plant community, characterised by noticeable clumps of tall stands of *Burkea africana* trees. This community occurs in areas with deep nutrient-poor sandy soils and as a result of the shelter these areas provide, they are well-utilized by large game. The veld in this plant community scored an average 48% in terms of its ecological ecological index (Table 19). The main reason for this average score is the large percentage Increaser 2s as a result of relatively heavy utilization of the area.

Table 19: The ecological index of the veld condition in the Burkea Eragrostis Clumps communities (BEC 1) recorded on Telperion (Du Plessis & Krynauw 2009).

| Species Grouping | BEC 1 % Composition | | Community Mean / Grouping (% Composition) |
|---|---|---|---|
| Decreasers | 27 | | 27 |
| Increasers 1 | 0 | | 0 |
| Increasers 2 | 47.5 | | 47.5 |
| Increasers 3 | 0 | | 0 |
| Forbs | 24.5 | | 24.5 |
| | 99 | | 99 |
| | | | |
| Decreasers | 27 | 10 | 270 |
| Increasers 1 | 0 | 7 | 0 |
| Increasers 2 | 47.5 | 4 | 190 |
| Increasers 3 | 0 | 1 | 0 |
| Forbs | 24.5 | 0 | 0 |
| | 99 | | 460 |
| | | | |
| Ecological index veld condition Score ( % ): x / 950 x 100 | | | 48 |

Transect 8 is placed in the Burkea Eragrostis Clumps (BEC1) community (Fig.14) and is characterized by extensive *Burkea* woodland and is dominated by a high number of perennial forbs typical of areas with deep soils in the Bankenveld. Fixed point photographs were taken in 2008 (Fig. 29) and 2009 (Fig. 30) at transect 8 in the Burkea Eragrostis Clumps community to record changes in biomass and physical appearance of the vegetation. The phytomass remained similar between 2008 and 2009, although the percentage bare ground decreased due to above average rainfall. The species composition of herbaceous plants recorded at this site is relatively low (Table 20). The grazing value at this site is medium (42%) to low (54%) with many plant species with little to no grazing value, however, this site remains well-utilized due to the shelter offered by trees.

Figure 29. A fixed point photograph depicting the habitat structure of Burkea Eragrostis Clumps 1 (BEC 1) on Telperion in 2008.

Figure 30. A fixed point photograph depicting the habitat structure of Burkea Eragrostis Clumps 1 (BEC 1) on Telperion in 2009.

Table 20: A comparative table of the species composition recorded at the Burkea Eragrostis Clumps (BEC 1) community between 2007 and 2009 on Telperion (Du Plessis & Krynauw 2009).

| Species | | Value Categories | | Species Composition ( % ) | | |
|---|---|---|---|---|---|---|
| | Grazing Value | Ecological Succession | Increaser/ Decreaser | 2007 | 2008 | 2009 |
| *Setaria sphacelata sphacelata* | Medium | Sub-Climax | Decreaser | 38% | 14.5% | 26.5% |
| *Aristida stipitata* | Low | Sub-Climax | Increaser 2 | 15.5% | 7% | 8% |
| *Eragrostis chloromelas / curvula* | Low | Sub-Climax | Increaser 2 | 8% | 17% | 11% |
| *Melinis repens* | Low | Pioneer | Increaser 2 | 7% | 4% | 5.5% |
| *Panicum maximum* | High | Sub-Climax | Decreaser | 0.5% | 0% | 0% |
| *Schizachyrium sanguineum* | Low | Climax | Increaser 1 | 2% | 1% | 0% |
| *Pogonarthria squarrosa* | Low | Pioneer | Increaser 2 | 2.5% | 2.5% | 5% |
| *Tricholaena monachne* | Medium | Sub-Climax | Increaser 2 | 1% | 2.5% | 2.5% |
| *Elionurus muticus* | Low | Climax | Increaser 2 | 2% | 0.5% | 0% |
| *Unidentified grass* | | | | 0.5% | 0% | 0% |
| *Eragrostis rigidior* | Medium | Sub-Climax | Increaser 3 | 2% | 4.5% | 0.5% |
| *Perotis patens* | Low | Pioneer | Increaser 2 | 2% | 6% | 10.5% |
| *Themeda triandra* | High | Climax | Decreaser | 0.5% | 0.5% | 0% |
| *Pogonarthria squarrosa* | Low | Pioneer | Increaser 2 | 4.5% | 1.5% | 1.5% |
| *Aristida congesta congesta* | Low | Pioneer | Increaser 2 | 2% | 0% | 1% |
| *Panicum natalense* | Low | Climax | Decreaser | 0.5% | 0% | 0.5% |
| *Cynodon dactylon* | Medium | Sub-Climax | Increaser 2 | 1% | 1.5% | 2% |
| *Aristida adscensionis* | Low | Pioneer | Increaser 2 | 0% | 0.5% | 0% |
| *Eleusine coracana* | Low | Pioneer | Increaser 2 | 0% | 1% | 0% |
| *Aristida congesta* | Low | Pioneer | Increaser 2 | 0% | 0.5% | 0% |
| *Bulbostylis burchellii* | | | | 0% | 3% | 11% |
| *Oldenlandia herbacea* | | | | 0% | 3% | 2% |
| *Solanum incanum* | | | | 0.5% | 0.5% | 0% |
| Sedges | | | | 2.5% | 3% | 0% |
| *Fadogia homblei* | | | | 2% | 1% | 2% |
| *Pygmaeothamnus zeyheri* | | | | 1% | 0% | 0% |
| Forbs | | | | 2% | 23% | 9.5% |
| Bare ground | | | | 2.5% | 1.5% | 1% |

The ecological status of the site is dominated by sub-climax grasses (66%), indicative of the high grazing pressure on the site. Ideally, this site should have a higher number of climax species present as there is no history of agricultural disturbance. The utilization status of the area indicates a measure of over-utilization with 46% Increaser 1 grasses present, although the site has a reasonable Decreaser grass component (40%) (Table 21).

Table 21: A summary of the herbaceous layer data collected between 2007 and 2009 in the Burkea Eragrostis Clumps (BEC 1) community (Du Plessis & Krynauw 2009).

| Aspect | Category | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Number of grass spp. recorded | Number | 17 | 20 | 12 |
| Basal cover (%) | % | 9.5 | 3 | 3.5 |
| Bare ground( % ) | % | 2.5 | 1.5 | 1 |
| Phytomass: (Kg/ha): | Kg/ha | 1896 | 1907 | 3369 |
| Grazing value | High | 1 | 0.5 | 0 |
| ( % of total ; excluding bare ground % ) | Medium | 42 | 23 | 31.5 |
|  | Low | 46 | 41.5 | 43 |
|  | No value | 8 | 33.5 | 24.5 |
| Increaser/Decreaser status | Decreaser | 40 | 15 | 27 |
|  | Increaser 1 | 2 | 1 | 0 |
|  | Increaser 2 | 45.5 | 48.5 | 47.5 |
|  | Increaser 3 | 2 | 0.5 | 0 |
| Forbs % | Forbs | 16 | 33.5 | 24.5 |
| Ecological succession status (Grasses) | Climax | 5 | 2 | 0.5 |
|  | Sub-Climax | 66 | 47 | 50.5 |
|  | Pioneer | 18 | 16 | 23.5 |
|  | Forbs | 0.5 | 33.5 | 24.5 |
| Forb type: | Perrential | 6 | 7.5 | 2 |
|  | Annual | 0 | 3 | 2 |
|  | Not Specified | 2 | 23 | 20.5 |

The phytomass recorded at the site is moderate due to the grazing pressure by herbivores of the palatable species. The amount of phytomass is insufficient to sustain a high-intensity fire, which could result in serious damage to the woody plant component present at this site. There is a large number of woody plant seedlings present, which could hamper grass growth and reduce fire intensity should this area be burnt. There is no evidence of recent fire at this site, although should fire occur, little damage to the woody component is expected due to the limited quantity of phytomass. If this site receives fire, the adjacent grasslands must be burnt to ensure this small community is protected from being destroyed due to the heavy grazing pressure sustained by herbivores after fire, and certain sections should be left unburnt for the protection of biodiversity in these sensitive areas. The perennial component contributes to a relatively good basal cover (9.5%), although there are large areas of bare ground due to the patch-type selection of plants by herbivores. Potentially, the site has very sour vegetation due to the leached, sandy, nutrient poor soils present, although it appears well-utilized due to the sheltered habitat. A stable woody component is recorded at the site, with trees in various size groups. The plant species *Ochna pulchra* and *Burkea africana* dominate the woody component, as well as dense stands of the unpalatable *Fadogia homblii* are recorded at the site. Appendix H provides a full species list of the woody and herbaceous plants recorded in this transect during 2008 and 2009.

### 4.3.6 Description of the Moist Degraded Grassland vegetation community

The transformed Moist Degraded Grassland community occupies 10% of the study area and covers an area of 894 ha (Fig.14). This community is characterized by historically cultivated or extensively disturbed areas with some degree of moist soil condition. This community consists of areas which are moderate to well-utilized by game, possibly due to their moist nature and resulting green grazing extending into the winter months. This community occurs on loamy, nutrient poor soil, with definite edaphic signs of water saturation and seepage at or near the surface at certain times. Although the soils are generally leached and nutrient-poor, leached fertile materials from above are deposited and accumulated in the subsoil B-horizons (Du Plessis & Krynauw 2009).

This community has low plant diversity due to historical agricultural disturbances and recovery is slow. Woody plants are mostly absent from this community, except for *S. plumosum* in some areas, although the stands in moist degraded grassland are less dense and extensive than in the degraded grassland communities. The ecological index veld condition score for this community was calculated at 57.9%, which is surprisgly high due to the presence of good quality grass species; although this community shows signs of histotical degradation, as well as the impact of heavy grazing (Table 22).

Table 22: The ecological index of the veld condition in the Moist Degraded Grassland communities recorded on Telperion (Du Plessis & Krynauw 2009).

| Species Grouping | MDG 3<br>% Composition | | Community Mean / Grouping<br>(% Composition) |
|---|---|---|---|
| Decreasers | 36.5 | | 36.5 |
| Increasers 1 | 5.5 | | 5.5 |
| Increasers 2 | 36.5 | | 36.5 |
| Increasers 3 | 0.5 | | 0.5 |
| Forbs | 21 | | 21 |
| | | | |
| Decreasers | 36.5 | 10 | 365 |
| Increasers 1 | 5.5 | 7 | 38.5 |
| Increasers 2 | 36.5 | 4 | 146 |
| Increasers 3 | 0.5 | 1 | 0.5 |
| Forbs | 21 | 0 | 0 |
| | 100 | | 550 |
| Ecological index veld condition Score ( % ): x / 950 x 100 | | | 57.9 |

Transect 9 is placed in the Moist Degraded Grassland (MDG3) community (Fig.14) and is historically a cultivated area situated on an even mid-slope which is graded into a foot-slope. The fertile, yellow in colour, loamy soils found at the site are indicative of moist soil conditions, although low species diversity was recorded (Table 23).

Table 23: A comparative table of the species composition recorded at the Moist Degraded Grassland (MDG 3) community between 2007 and 2009 on Telperion (Du Plessis & Krynauw 2009).

| Species | Value Categories | | | Species Composition ( % ) | | |
|---|---|---|---|---|---|---|
| | Grazing Value | Ecological Succession | Increaser/ Decreaser | 2007 | 2008 | 2009 |
| Cynodon dactylon | Medium | Sub-Climax | Increaser 2 | 15.50% | 7% | 20.50% |
| *Sporobolus africanus* | Low | Sub-Climax | Increaser 3 | 0.50% | 1% | 0.50% |
| *Digitaria eriantha* | High | Climax | Decreaser | 55.50% | 49% | 36.50% |
| *Eragrostis curvula/chloromelas* | Low | Sub-Climax | Increaser 2 | 15% | 3% | 10.50% |
| *Eragrostis plana* | Low | Sub-Climax | Increaser 2 | 6% | 6% | 5% |
| *Hyparrhenia hirta* | Low | Sub-Climax | Increaser 1 | 0.50% | 3% | 3.50% |
| *Paspalum urvillei* | Medium | Sub-Climax | Increaser 2 | 0% | 0.50% | 0% |
| *Digitaria* | High | Sub-Climax | Increaser 2 | 0% | 7% | 0.50% |
| *Mischantus capensis* | Low | Climax | Increaser 1 | 0% | 0% | 2% |
| *Chamaecrista mimosoides* | | | | 0% | 8.50% | 2% |
| Sedges | | | | 0% | 7.50% | 2% |
| Forbs | | | | 25 | 7% | 13% |
| *Verbena brasiliense* | | | | 4.50% | 1% | 4% |
| Bare ground | | | | 0.50% | 0% | 0% |

This site is a historically cultivated pasture and presently consists of a high percentage of the climax grass species *Digitaria eriantha* (55.5%), and two sub-climax grass species, *Cynodon dactylon* (15.5%) and *Eragrostis curvula/chloromelas* (15%), which dominated the remainder. Fixed point photographs were taken in 2008 (Fig. 31) and 2009 (Fig. 32) at transect 9 in the Moist Degraded Grassland community to record changes in biomass and physical appearance of the vegetation. The phytomass remained similar between 2008 and 2009, although the soil showed signs of water saturation and seepage on the surface in 2008.

Figure 31. A fixed point photograph depicting the habitat structure of Moist Degraded Grassland 3 (MDG 3) on Telperion in 2008.

Figure 32. A fixed point photograph depicting the habitat structure of Moist Degraded Grassland 3 (MDG 3) on Telperion in 2009.

The grazing value of this site is good with 55% of grasses being palatable and a further 15.5% recorded with a medium grazing value. The ecological status of the site is dominated climax grasses (55%), remnants of established pastures in the past. This site has also a substantial sub-climax grass component (37.5%), which are a result of the historical agricultural disturbance and the present impact of heavy grazing at the site**.** The impact of this utilization at the site is indicated by the dominance of Decreasers grass species (55.5%), although Increaser 2 species (37.5%) are indicative of its disturbed nature (Table 24).

Table 24: A summary of the herbaceous layer data collected between 2007 and 2009 in the Moist Degraded Grassland (MDG 3) community (Du Plessis & Krynauw 2009).

| Aspect | Category | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Number of grass spp. recorded | Number | 6 | 8 | 8 |
| Basal cover (%) | % | 6.5 | 7 | 10.5 |
| Bare ground( % ) | % | 0.5 | 0 | 0 |
| Phytomass: (Kg/ha): | Kg/ha | 2977 | 5048 | 4088 |
| Grazing value | High | 55.5 | 56 | 37 |
| ( % of total ; excluding bare ground % ) | Medium | 15.5 | 7.5 | 20.5 |
| | Low | 22 | 13 | 21.5 |
| | No value | 6.5 | 24 | 21 |
| Increaser/Decreaser status | Decreaser | 55.5 | 56 | 36.5 |
| | Increaser 1 | 0.5 | 3 | 5.5 |
| | Increaser 2 | 36.5 | 16 | 36.5 |
| | Increaser 3 | 0.5 | 1 | 0.5 |
| Forbs % | Forbs | 6.5 | 24 | 21 |
| Ecological succession status (Grasses) | Climax | 55.5 | 56 | 38.5 |
| | Sub-Climax | 37.5 | 13.5 | 40.5 |
| | Pioneer | 0 | 0 | 0 |
| | Forbs | 6.5 | 24 | 21 |
| Forb type: | Perrential | 0 | 0 | 0 |
| | Annual | 0 | 0 | 0 |
| | Not Specified | 6.5 | 24 | 21 |

The phytomass at the site is moderate (2077 Kg/ha) with large areas being well-utilized by herbivores. There is evidence of previous fire impact at the site, although there is a low basal cover (6.5%) and few bare ground recordings at the site were recorded. The palatable grass species at this site are heavily utilized, although less palatable species are under-utilized and moribund in nature. The high grazing pressure on the palatable grass species indicates this area is a preferred grazing site of herbivores at the study site. The vegetation is in a relatively good condition in terms of grazing value, although the ecological recovery potential of the area to have more palatable species under present grazing conditions is limited. There are no woody plants recorded at this site, although the diversity of weed-like forbs is high. Appendix I provide a full species list of the woody and herbaceous plants recorded in this transect during 2008 and 2009 (Du Plessis & Krynauw 2009).

### 4.3.7 Description of the Rocky Open Scrub vegetation community

The stable, non-transformed Rocky Open Shrub community occupies 7 % of the study area and covers an area of 272 ha (Fig. 14). This relatively small community occurs on very shallow and nutrient-poor soils and is characterized by conspicuous red sandstone outcrops. The site is dominated by medium-sized shrubs and a sparse herbaceous layer, which results in fire rarely entering the community. This community has a low utilization potential by large herbivores due to the unpalatable nature of the vegetation. The ecological index veld condition score for this community was calculated at 48%, indicative of the under-utilization of grass, compounded by the problem that fire does not occur in this community due to the sparseness of the vegetation and therefore the present ecological condition is accepted as natural for this community (Table 25). The rocky substrate and abundance of suitable crevices result in this community being a favoured habitat of rock-loving small mammal species.

Table 25: An ecological index of the veld condition in the Rocky Open Shrub community recorded on Telperion (Du Plessis & Krynauw 2009).

| Species Grouping | ROS 1<br>% Composition | | Community Mean / Grouping (% Composition) |
|---|---|---|---|
| Decreasers | 14 | | 14 |
| Increasers 1 | 34.5 | | 34.5 |
| Increasers 2 | 18.5 | | 18.5 |
| Increasers 3 | 0.5 | | 0.5 |
| Forbs | 15.5 | | 15.5 |
| | % Compostion | Ecological Index Factors | Score |
| Decreasers | 14 | 10 | 140 |
| Increasers 1 | 34.5 | 7 | 241.5 |
| Increasers 2 | 18.5 | 4 | 74 |
| Increasers 3 | 0.5 | 1 | 0.5 |
| Forbs | 15.5 | 0 | 0 |
| | 83 | | 456 |
| Ecological index veld condition Score ( % ): x / 950 x 100 | | | 48 |

Transect 10 is placed in the Rocky Open Scrub 1 (ROS1) community (Fig.14) and is characterized by very rocky, red sandstone formations. The site is located on a slightly elevated plateau and is dominated by shrubs and a sparse herbaceous component. The soils at the site are shallow and sandy and as a result have a very low fertility. This site is not important for grazing due to its very low inherent utilization potential, although a high diversity of perennial grass species dominates. This site has a limited forb component (4%), with low species diversity, typical of this rocky, protected environment in the Bankenveld vegetation type. Fixed point photographs were taken in 2008 (Fig. 33) and 2009 (Fig. 34) at transect 10 in the Rocky Open Shrub community to record changes in biomass and physical appearance of the vegetation. The phytomass remained similar between 2008 and 2009, although less bare ground was recorded in 2009. The species composition of herbaceous plants at this site is relatively high (Table 26). This site has a low grazing potential with 50.5% of plants recorded with little or no grazing value, although 27.5% of grasses had a moderate grazing value.

Figure 33. A fixed point photograph depicting the habitat structure of Rocky Open Shrub 1 (ROS 1) on Telperion in 2008.

Figure 34. A fixed point photograph depicting the habitat structure of Rocky Open Shrub 1 (ROS 1) on Telperion in 2009.

Table 26: A comparative table of the species composition recorded at the Rocky Open Shrub 1 (ROS 1) community between 2007 and 2009 on Telperion (Du Plessis & Krynauw 2009).

| Species | Value Categories | | | Species Composition ( % ) | | |
|---|---|---|---|---|---|---|
| | Grazing Value | Ecological Succession | Increaser/ Decreaser | 2007 | 2008 | 2009 |
| *Setaria sphacelata sphacelata* | Medium | Sub-Climax | Decreaser | 10.50% | 1.50% | 9.50% |
| *Melinis repens* | Low | Pioneer | Increaser 2 | 3.50% | 2.50% | 1.50% |
| *Eragrostis racemosa* | Medium | Sub-Climax | Increaser 2 | 5% | 1.50% | 2% |
| *Themeda triandra* | High | Climax | Decreaser | 4.50% | 0% | 1% |
| *Pogonarrthria squarrosa* | Low | Pioneer | Increaser 2 | 0.50% | 1% | 0.50% |
| *Digitaria diagonalis* | Medium | Climax | Increaser 1 | 1% | 0% | 1% |
| *Loudetia simplex* | Low | Climax | Increaser 1 | 14% | 18% | 10.50% |
| *Diheteropogon amplectens* | Medium | Climax | Decreaser | 8% | 5.50% | 3.50% |
| *Tristachya leucothrix* | Low | Climax | Increaser 1 | 4% | 3% | 3% |
| *Brachiaria serrata* | Medium | Climax | Decreaser | 1% | 0.50% | 0% |
| *Trachypogon spicatus* | Low | Climax | Increaser 1 | 5% | 5.50% | 4% |
| *Aristida transvaalensis* | Low | Climax | Increaser 1 | 3% | 4% | 3% |
| *Elionurus muticus* | Low | Climax | Increaser 3 | 0.50% | 0% | 0.50% |
| *Eragrostis chloromelas/curvula* | Low | Sub-Climax | Increaser 2 | 6.50% | 4.5 | 4.50% |
| *Cymbopogon excavatus* | Low | Climax | Increaser 1 | 1% | 0% | 0.50% |
| *Panicum natalense* | Low | Climax | Decreaser | 4% | 0% | 0% |
| *Melinis nerviglumis* | Low | Climax | Increaser 1 | 1.50% | 2% | 8.50% |
| *Eragrostis capensis* | Medium | Sub-Climax | Increaser 2 | 1% | 0% | 0% |
| *Sporobolis staphianus* | Low | Sub-Climax | Increaser 2 | 0.50% | 0% | 0% |
| *Microchloa caffra* | Low | Sub-Climax | Increaser 2 | 1% | 0% | 3.50% |
| *Eragrostis racemosa* | Medium | Sub-Climax | Increaser 2 | 0.50% | 0% | 1.50% |
| *Andropogon shrirensis* | Low | Climax | Increaser 1 | 0.50% | 0% | 3% |
| *Shizachyrium sanguinium* | Low | Climax | Increaser 1 | 0.50% | 1.50% | 1% |
| *Digitaria monodactyla* | Medium | Sub-Climax | Increaser 2 | 2% | 3% | 4% |
| *Eragrostis gummflua* | Low | Sub-Climax | Increaser 2 | 0% | 1% | 1% |
| *Eragrostis nindensis* | Medium | Sub-Climax | Increaser 2 | 0% | 1.50% | 0% |
| *Bewsia biflora* | Low | Climax | Decreaser | 0% | 0.50% | 0% |
| *Xerophyta retinervis* | | | | 1% | 7.50% | 8.50% |
| *Bulbostylis burchellii* | | | | 0% | 0% | 1% |
| Bulb-like-hairy forb (unidentified) | | | | 0% | 0% | 0.50% |
| Sedge | | | | 1.50% | 3.50% | 2% |
| Forbs | | | | 1.50% | 12% | 3.50% |
| Bare ground / rock | | | | 16.50% | 20% | 17% |

This site is dominated by climax grasses (47.5%), although a significant number of sub-climax grasses (28%) were recorded, indicative of a relatively stable ecological state with moderate degradation in isolated areas**.** The site is not degraded due to its low grazing potential and no prior historical agricultural disturbances due to the shallow and rocky nature of the soil. The site has a high occurrence of Increaser 1 grass species (29.5%) indicative of under-utilization, with a similar moderate Decreaser grass component (29%). The high occurrence of Increaser 2 grasses (20%) indicates a level of selective utilization of the palatable species at the site (Table 27).

Table 27: A summary of the herbaceous layer data collected between 2007 and 2009 in the Rocky Open Shrub 1 (ROS 1) community (Du Plessis & Krynauw 2009).

| Aspect | Category | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Number of grass spp. recorded | Number | 24 | 17 | 21 |
| Basal cover ( %) | % | 6 | 4.5 | 3.5 |
| Bare ground( % ) | % | 16.5 | 20 | 17 |
| Phytomass: (Kg/ha): | Kg/ha | N/A | N/A | N/A |
| Grazing value | High | 4.5 | 0 | 1 |
| ( % of total ; excluding bare ground % ) | Medium | 27.5 | 13.5 | 21.5 |
| | Low | 46.5 | 43.5 | 45 |
| | No value | 4 | 23 | 15.5 |
| Increaser/Decreaser status | Decreaser | 29 | 8 | 14 |
| | Increaser 1 | 29.5 | 34 | 34.5 |
| | Increaser 2 | 20 | 15 | 18.5 |
| | Increaser 3 | 0.5 | 0 | 0.5 |
| Forbs % | Forbs | 4 | 23 | 15.5 |
| Ecological succession status (Grasses) | Climax | 47.5 | 40.5 | 39.5 |
| | Sub-Climax | 28 | 13 | 26 |
| | Pioneer | 4 | 3.5 | 2 |
| | Forbs | 4 | 23 | 15.5 |
| Forb type: | Perrential | 4 | 7.5 | 8.5 |
| | Annual | - | - | - |
| | Not Specified | 4 | 15.5 | 7 |

The phytomass recorded at the site is low due to the rockiness of the area and associated shallow soils, and is therefore, too low to sustain an intensive fire, and therefore, of no threat to this plant community. The perennial herbaceous component at this site contributes to the low basal cover (6%) recorded, with a high ground cover recording

(16.5%), indicative of an area covered by a rocky substrate. The site has a low grazing and browsing utilization, with only some selective utilization of more palatable species recorded. The unpalatable grass species recorded at the site are under-utilized and moribund in extreme cases. This site is not reliant on fire which is largely excluded from the area due to the rockiness of the area. The woody component is represented by medium to small fire-sensitive shrubs with little browsing value, including other species such as *Myrothamnus flabellifolius* and *Xerophyta retinervis,* which are regularly encountered in shallow infertile rocky soils. The site is dominated by *Gymnosporia polyacantha*, a small shrub that flourishes under these conditions. The soil depth at the site limits woody plant development, and is predominantly the reason for the shrub-like appearance of the woody vegetation. No utilization was observed on 99% of the woody plants recorded, indicative of the poor browse potential at this site. The density of woody plants recorded is very high (7075 plants/ha), with the majority of woody species recorded small, lower than 1 m and unlikely to grow taller, indicative of the nature of the dominant woody vegetation, although there are a variety of larger species occurring in low numbers at the site. Appendix J provides a full species list of the woody and herbaceous plants recorded in this transect during 2008 and 2009 (Du Plessis & Krynauw 2009).

# CHAPTER 5

# ASSESSMENT OF TRAP SUCCESS IN SMALL MAMMALS IN DIFFERENT VEGETATION COMMUNITIES

## 5.1. Abstract

This chapter aims to determine and monitor changes in trap success of small mammal fauna in seven different vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Trap success is recording all specimens captured, which includes both new and recaptured individuals from the 16 200 trap nights. The results of this chapter provide an indication of trapability of species and populations in different communities. The trap success percentage recorded for the study is 8.6%. The Rocky Open Shrub community had the highest trap success recorded (37.03%), followed by the Northern Slope Woodland community (20.09%), Sheltered Woodland Community (14.51%), Rocky Highveld Grassland (11.98%), Degraded Grassland (7.25%), Moist Degraded Grassland (4.73%) and the lowest traps success was recorded in the Burkea Eragrostis Clumps community (4.39%). The undisturbed, rocky areas had a higher trap success when compared with areas previously disturbed by agriculture. Large differences between trap success and vegetation were recorded, except between Burkea Eragrostis Clumps and Moist Degraded Grassland and Degraded Grassland; Moist Degraded Grassland and Degraded Grassland, Sheltered Woodland, and Rocky Highveld Grassland; Degraded Grassland and Sheltered Woodland, and Rocky Highveld Grassland; Sheltered Woodland and Rocky Highveld Grassland. Sites with historical agricultural activities were also noted. The mean trap success of small mammal captures differed between undisturbed and previously cultivated area. Trap success of *Micaelamys namaquensis* was higher than for other species recorded and the dominant species trapped on Telperion. Fluctuations in trap success occurred monthly. The least captured species during this study included *Otomys irroratus*, *Graphiurus murinus*, and two species of insectivores, *Suncus infinitesimus* and *Crocidura cyanea*.

**Keywords:** Telperion, Ezemvelo Nature Reserve, trap success, trapability, small mammal fauna, vegetation, communities, undisturbed, cultivated South Africa.

## 5.2. Introduction

The purpose of this chapter being identify and monitor changes in abundance of small mammal fauna within seven different vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Trap success (or percentage success) is the number of small mammals captured over 100 trap nights. Generally, there were differences in small mammal trap success between different plant communities and habitat type. The questions addressed through this study being whether farming practices influence abundance of rodent species game in a “natural system”. The impact of herbivores on shelter and the availability of seed bearing plants are without question. The stocking rates of game farms and nature reserves directly and indirectly affect small mammal populations. It is expected that certain vegetation communities would be more stable habitats for certain species of small mammals which would reflect in the trap success.A further objective is to identify and monitor changes in trap success within each vegetation community. Trap success is ultimately recording all specimens captured, includng both new and recaptured individuals. The results of this chapter will provide an indication of trapability of species and populations within different communities. This chapter will also report on the trap success of the component species of small mammals present in specific habitats and plant communities at the study site. Plant succession, condition of habitat, grass palatability, ecological status, geographic location and vegetation structure are recorded to have an impact on small mammal trap success (Els & Kerley 1996; Fitzgibbon 1997; Monadjem 1997; Abramsky *et al.* 1998; Ferreira & Van Aarde 1999; Monadjem 1999; Avenant 2000a).

Rainfall, fire and grazing individually and in combination play a major role in impacting the trap success of small mammals. Rodents may reach large densities, particularly in agro-ecosystems (Leirs & Verheyen 1995; Julliard *et al.* 1999; Vibe-Petersen. *et al.* 2006; Sluydts *et al.* 2007). Food supply is another factor that influences small mammal trap success, as with more natural food available, a lower trap success is expected. Yarnell *et al.* (2007) found heavy grazing negatively affected trap success of small mammals in general, and in contrast, fire alone had little immediate impact on trap success. A very high grazing pressure, combined with fire, especially under drought conditions, may have a negative impact on trap success. Grazing has been recorded to have a negative impact on the trap success of small mammals (Nyako-Lartey & Baxter 1995; Joubert & Ryan 1999) through the long-term reduction in food quality (Keesing 1998) and cover (Kerley 1992). Avenant & Watson (2002) found small mammal communities correlated with the abundance of pioneer plant species and their ecological value of the veld, indicating that a similar curve could be expected. Avenant (2005) felt that together, these finding support the idea that direct monitoring of small mammals could be used as a relatively effective and efficient method of indicating ecological disturbance, habitat health and integrity, and therefore a useful tool for reserve managers and ecologists. Historical agricultural activities are expected to impact trap success at certain sites, and non-transformed communities to have a higher trap success than those previously cultivated. It is thought that the changes in vegetation species composition are a possible cause. The number of microhabitats and primary productivity is also high at the point of climax, and able to sustain a number of individuals from different species, which would influences trap success. The conserving of biodiversity is one of the major goals justifying the presence of nature reserves and conservation areas. Small Mammals are important components in Bankenveld grassland habitats ecosystems, as predators, consumers, dispersers of seed, burrowers and prey for carnivores, reptiles and raptors. Total biomass and density of small mammals should be taken into account when calculating carrying capacity on a reserve. More practically, their use should be maximised when monitoring ecosystems, and through trap success data, population estimates are possible.

## 5.3. Methodology

Data were recorded between January 2008 and October 2009 from 17 sampling trips covering 16200 trap nights, with a trap success of 8.5% recorded for the study, with a capture frequency of 1369 representing 18 small mammal species. The difference in the percentage of small mammals sampled differed significantly between vegetation communities. Transects were placed in different vegetation communities from which trap success was recorded. These included Northern Slope Woodland, Rocky Highveld Grassland, Degraded Grassland, Sheltered Woodland, Burkea Eragrostis Clumps, Moist Degraded Grassland and Rocky Open Shrub. Two transect lines in each transect were placed in a North-South and East-West direction. The trap succes recorded during this study provides valuable information on the population dynamics and abundance of the population. Trap success was recorded in each transect over two to five nights. In year one (2008), ten transects each comprising 30 live-traps Sherman each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month. The starting-point was placing transects in the seven vegetation communities. In year one, two transects were placed in the dominant communities to obtain a greater sample size. In year one, 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. 10 m spacing was adopted at the study site with the available traps. In year two, three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per transect. Trap success (or percentage success) is the number of small mammals captured per 100 trap nights. The term "trap night" is used to describe one trap which was set for a 24-hour period (Rowe-Rowe & Meester 1982a).

Analysis of variance (ANOVA) was used to test for significant differences between trap success, diversity, sex ratio, age structure and capture-recapture within different seasons and vegetation communities (Fowler *et al.* 1998). Tukey's test was undertaken when the result from ANOVA indicated a significant difference between the variables. Tukey's test provides an indication of where significant differences occur. Other statistical methods used include Chi-square ($\chi^2$) test to analyze frequencies and t-tests ($t$), analyzing variance when samples are small, using the mean difference between the two samples and dividing these by the standard error of the difference. All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 5.4. Results

ANOVA revealed a highly significant differences between trap success and vegetation community ($F_{1.6} = 69.19$; $n = 16200$; $P = 0.001$), except between Burkea Eragrostis Clumps and Moist Degraded Grassland (Tukey's: $P = 0.52$) and Degraded Grassland (Tukey's: $P = 0.64$); Moist Degraded Grassland and Degraded Grassland (Tukey's: $P = 1.00$), Sheltered Woodland (Tukey's: $P = 0.44$), and Rocky Highveld Grassland (Tukey's: $P = 0.49$); Degraded Grassland and Sheltered Woodland (Tukey's: $P = 0.24$), and Rocky Highveld Grassland (Tukey's: $P = 0.27$); Sheltered Woodland and Rocky Highveld Grassland (Tukey's: $P = 0.99$ (also see Fig. 35). The previous veld management practices were also noted. The mean trap success of small mammal captures differed significantly ($t_{(12898)} = 7.88$; $n = 16200$; $P = 0.001$) between prestine and previously cultivated area.

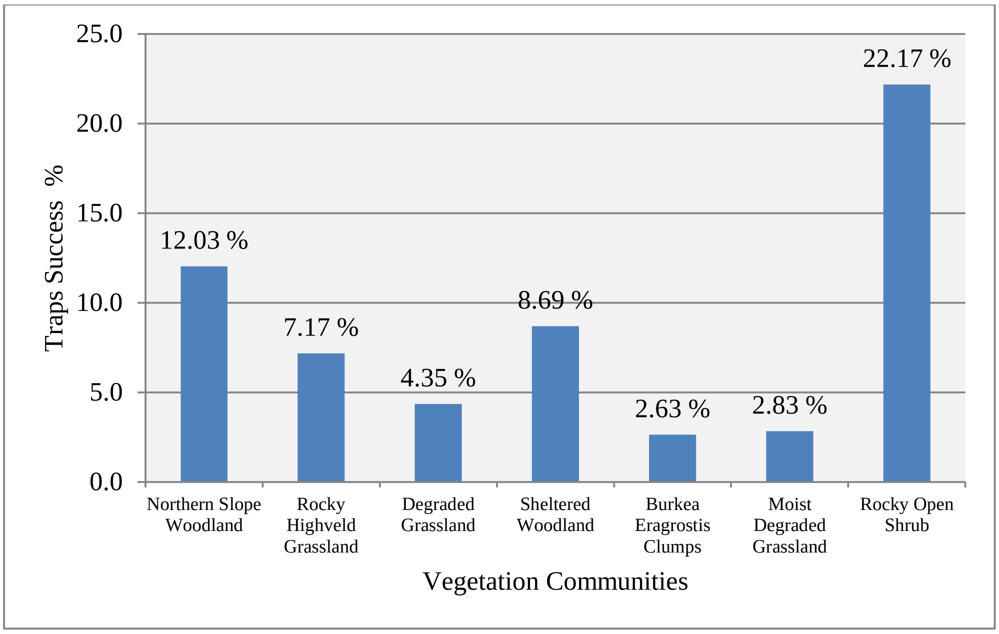

Figure 35. Graph illustrating the percentage trap success recorded in the vegetation communities on Telperion.

Tapping success varied seasonally and with climatic conditions. Spring harbored the highest trap success rate in Northern Slope Woodland, Sheltred Woodland and Rocky Open Shrub, dominated by *Micaelamys namaquenss*. Trapping success dropped significantly $\chi^2$ = 5.92; $n$ = 692; $P$ = 0.015, between the winter to summer months (< 9.4%). This is expected to be as a result of food being more readily available in the summer months. Eighteen small mammal species were sampled: *Micaelamys namaquensis*, *Aethomys chrysophilus*, *Dendromus melanotis*, *Dendromus mystacalis*, *Mus minutoides*, *Gerbilliscus brantsii*, *Gerbilliscus leucogaster*, *Lemniscomys rosalia*, *Rhabdomys pumilio*, Steatomys *pratensis*, *Acomys spinosissimus*, *Otomys irroratus*, *Mastomys* spp., *Graphiurus murinus*, *Elephantulus myurus*, *Crocidura mariquensis*, *Crocidura cyanea*, and *Suncus infinitesimus* (Table 28).

Table 28. Trapping success for species sampled on Telperion over the duration of the study period. (Also see Appendix A)

| Species | Percentage captured | Numbers Sampled |
|---|---|---|
| *Micaelamys namaquensis* | 56.4% | 772 |
| *Elephantulus myurus* | 16.0% | 219 |
| *Dendromus melanotis* | 8.4% | 115 |
| *Lemniscomys rosalia* | 3.1% | 42 |
| *Mus minutoides* | 3.0% | 41 |
| *Acomys spinosissimus* | 1.8% | 24 |
| *Gerbilliscus leucogaster* | 1.8% | 24 |
| *Rhabdomys pumilio* | 1.6% | 22 |
| *Gerbilliscus brantsii* | 1.5% | 21 |
| *Dendromus mystacalis* | 1.3% | 18 |
| *Steatomys pratensis* | 1.0% | 14 |
| *Mastomys* spp. | 0.9% | 13 |
| *Crocidura mariquensis* | 0.9% | 12 |
| *Aethomys chrysophilus* | 0.8% | 11 |
| *Otomys irroratus* | 0.5% | 7 |
| *Graphiurus murinus* | 0.4% | 6 |
| *Suncus infinitesimus* | 0.4% | 5 |
| *Crocidura cyanea* | 0.2% | 3 |
| Total | 100% | 1369 |

*Micaelamys namaquensis* had significantly ($\chi^2 = 22.406$; $df = 1$; $n = 1369$; $P = 0.000$); higher numbers than other species recorded and was the dominant species trapped on Telperion (56.4%). Fluctuations in species diversity occurred monthly, *Micaelamys namaquensis* being dominant in the rocky areas. Fluctuations in species richness and abundance occurred monthly at the study area. *Elephantulus myurus* (16%) and *Dendromus melanotis* (8.4%) were the next most recorded species, the latter more common in open areas. The least captured species during this study included *Otomys irroratus* (0.5%), *Graphiurus murinus* (0.4%), and two species of insectivores, *Suncus infinitesimus* (0.4%) and *Crocidura cyanea* (0.2%). There was a significant ($t_{(6)} = 3.60$; $n = 7$; $P = 0.001$) difference in trap success recorded between the different vegetation communities.

## 5.5. Trap success recorded for small mammals on Telperion

### 5.5.1. Trap success percentage recorded for small mammal species recorded in the Northern Slope Woodland community on Telperion

The Northern Slope Woodland community had a higher trap success than the majority of other vegetation communities on the property ($\chi^2 = 50.18627$; $df = 1$; $n = 504$; $P = 0.000$), with a trap success of 12.03%, which was higher than the average trap success of 8.6% recorded for the study. There is a significant difference in trap success for different the species recorded for this vegetation community ($\chi^2 = 39.789$; $df = 7$; $n = 8$; $P = 0.000$). The highest percentage recorded was for *M. namaquensis* (8.44%), followed by *E. myurus* (2.43%), however, this difference in trap success is insignificant ($\chi^2 = 3.319$; $df = 1$; $n = 504$; $P = 0.068$). A low trap success were recorded for the remaining species, *A. spinossimus* (0.08%), *A. chrysophilus* (0.04%), *D. melanotis* (0.04%), *G. murinus* (0.22%), *M. minutoides* (0.04%) and *C. cyanea* (0.04%) (Fig. 36). This community is clearly dominated by the rock-affiliated species, *M. namaquensis* and *E. myurus*.

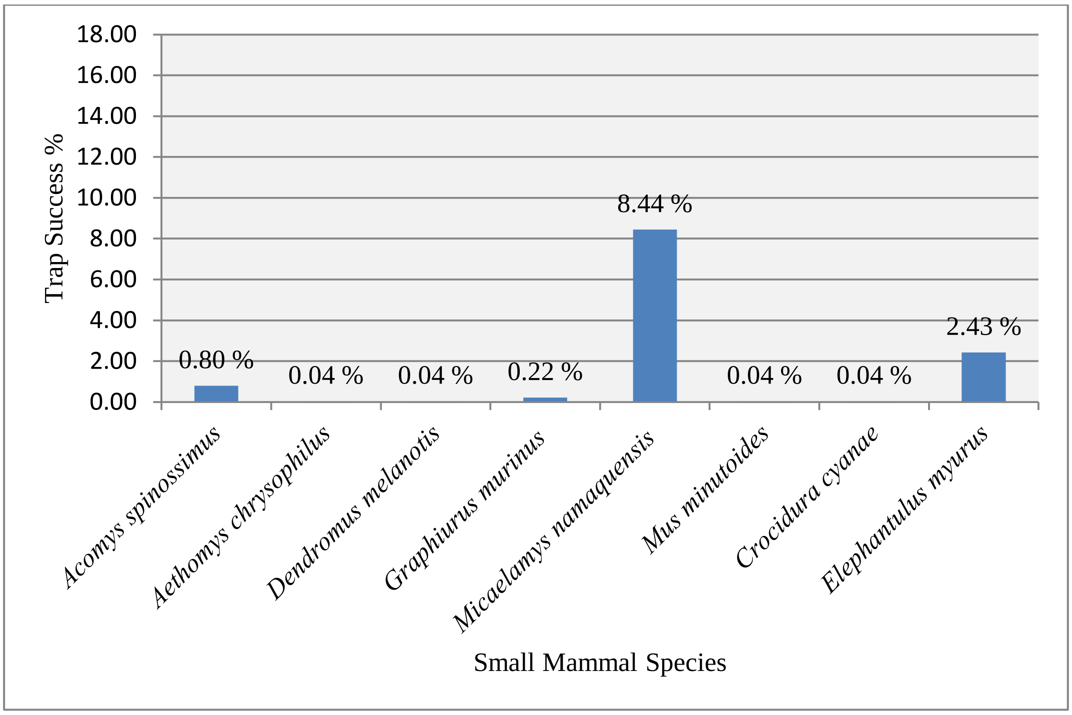

Figure 36. Graph illustrating small mammal trap success recorded in the Northern Slope Woodland community on Telperion.

The Northern Slope Woodland community is untransformed and intact from an ecological perspective. The site is dominated by *M. namaquensis* and *E. myurus* which are species with defined home ranges and are expected to occur evenly across this habitat type at the study site. This community had second highest trap success recorded during this study, superseded by the Rocky Open Shrub community (22.17%), with a higher recorded trap success of 10.14%. The Northern Slope Woodland contributed 20.09% to the trap success recorded during this study.

### 5.5.2. Trap success percentage recorded for small mammal species recorded in the Rocky Highveld Grassland community on Telperion

There was an insignificant difference ($\chi^2 = 0.020$; $df = 1$; $n = 393$; $p = 0.886$) between trap success recorded for Rocky Highveld Grassland community and other vegetation communities on the property, with a trap success of 7.17%, thus lower than the average trap success of 8.6% recorded for the study. Statistically there is an insignificant difference in trap success for the different species recorded for this vegetation community ($\chi^2 = 8.731$; $df = 9$; $n = 10$; $P = 0.462$). The highest percentage recorded in the Rocky Highveld Grassland community was for *M. namaquensis* (2.86%), followed by *E. myurus* (0.98%), however, however, this difference in trap success is insignificant ($\chi^2 = 0.932$; $df = 1$; $n = 2$; $P = 0.334$). A low trap success in this community was recorded for the remaining species, *D. melanotis* (0.80%), *G. leucogaster* (0.80%), *L. rosalia* (0.76%), *D. mystacalis* (0.36%), *S. pratensis* (0.25%), *M. minutoides* (0.22%), *A. chrysophilus* (0.11%), and *Mastomys* spp. (0.04%) (Fig. 37). Small mammal diversity within the community was high, although trap success was dominated by *M. namaquensis.*

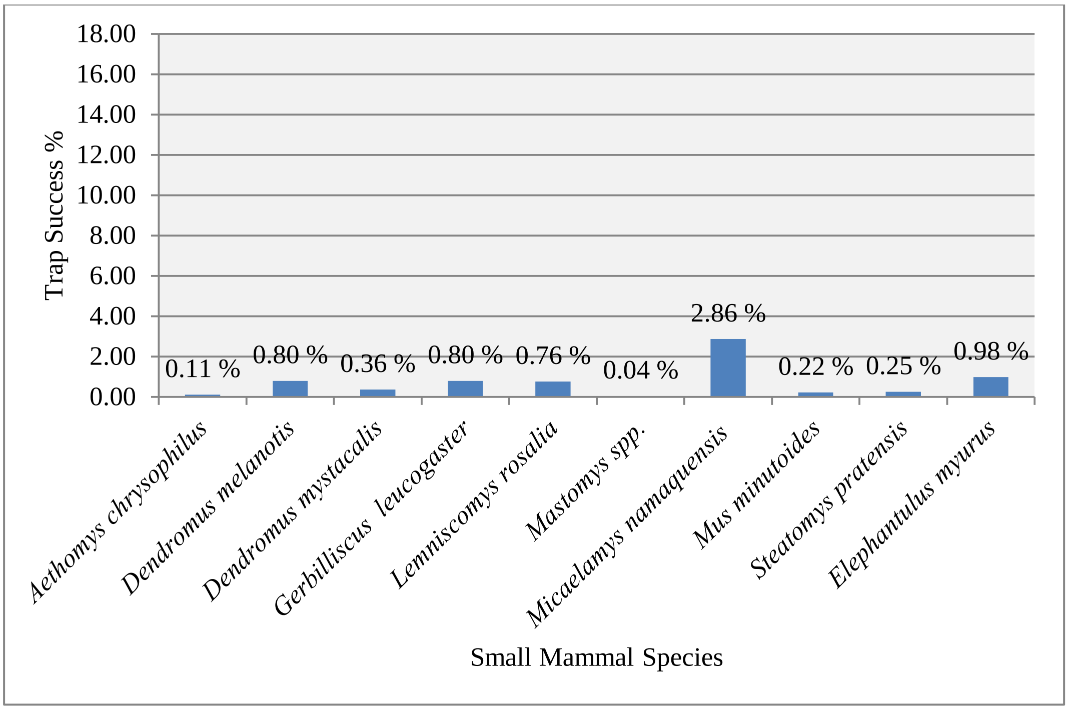

Figure 37. Graph illustrating small mammal trap success recorded in the Rocky Highveld Grassland community on Telperion.

The Rocky Highveld Grassland community is untransformed and intact from an ecological perspective. The site is dominated by *M. namaquensis* which is a species with a defined home range and is expected to be associated with areas at the study site with varying degrees of rock. The community has the highest diversity and had the 4th highest trap success recorded during this study, superseded by the Rocky Open Shrub community (22.17%), the Northern Slope Woodland community (12.03%) and Sheltered Woodland (8.69%). The Rocky Highveld Grassland contributed 11.98% to the trap success recorded for during this study.

### 5.5.3. Trap success percentage recorded for small mammal species recorded in the Degraded Grassland community on Telperion

The Degraded Grassland community had a significantly lower trap success ($\chi^2$ = 23.684; *df* = 1; *n* = 328; *P* = 0.000), with a trap success of 4.35%, lower than the average trap success of 8.6% recorded for the study. Statistically there is an insignificant difference in trap success for the different species recorded for this vegetation community ($\chi^2$ = 10.226; *df* = 7; *n* = 8; *P* = 0.176). The highest percentage recorded in the Degraded Grassland community was for *D. melanotis* (2.68%), followed by *L. rosalia* (0.69%), however, however, this difference in trap success is insignificant ($\chi^2 = 1.172$; $df = 1$; $n = 2$; $P = 0.279$). A low trap success in this community was recorded for the remaining species, *D. mystacalis* (0.11%), *G. leucogaster* (0.07%), *Mastomys* spp. (0.22%), *M. minutoides* (0.36%), *S. pratensis* (0.18%) and *C. cyanea* (0.04%) (Fig. 38). Small mammal diversity within the community was surprisingly high, although trap success was relatively low, except for *D. melanotis* in winter.

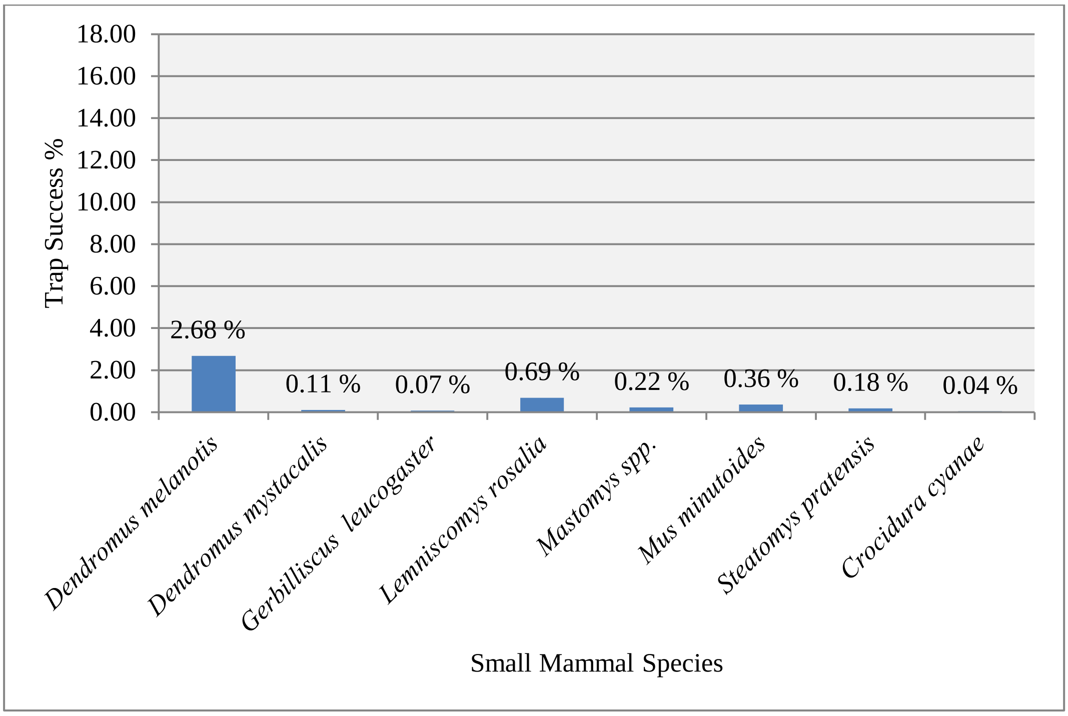

Figure 38. Graph illustrating small mammal trap success recorded in the Degraded Grassland community on Telperion.

The Degraded Grassland community is transformed and historically disturbed through overgrazing and past agricultural practices. The site is dominated by *D. melanotis* which is a species whose numbers fluctuated considerably as a result of individuals moving into the area due to a lack of sufficient cover in the surrounding areas. The community has had the 3rd lowest trap success recorded during this study, a slightly higher trap success than the Moist Degraded Grassland community (2.83%) and the Burkea Eragrostis Clumps community (2.63%). The Degraded Grassland contributed 7.25% to the trap success recorded during this study.

5.5.4. Trap success percentage recorded for small mammal species recorded in the Sheltered Woodland community on Telperion

There was an insignificant difference in trap success ($\chi^2 = 2.035$; $df = 1$; $n = 371$; $p = 0.154$), between the Sheltered Woodland community and the average trap success across other vegetation communities, with a trap success of 8.69%, which is slightly higher than the average trap success of 8.6% recorded for the study. Statistically there is a significant difference in trap success for the different species recorded for this vegetation community ($\chi^2 = 30.455$; $df = 7$; $n = 8$; $P = 0.000$).The highest percentage recorded in the Sheltered Woodland community was for *M. namaquensis* (6.36%), followed by *E. myurus* (1.36%), however, a significantly lower trap success for this species was recorded ($\chi^2 = 25.583$; $df = 1$; $n = 2$; $P = 0.000$). A low trap success in this community was recorded for the remaining species, *A. spinossimus* (0.10%), *D. melanotis* (0.20%), *M. minutoides* (0.45%), *C. cyanea* (0.05%), *C. mariquensis* (0.10%) and *S. infinitesimus* (0.05%) (Fig. 39). Small mammal diversity within the community is relatively high, and trap success is dominated by the rock affiliated species, *M. namaquensis* and *E. myurus*.

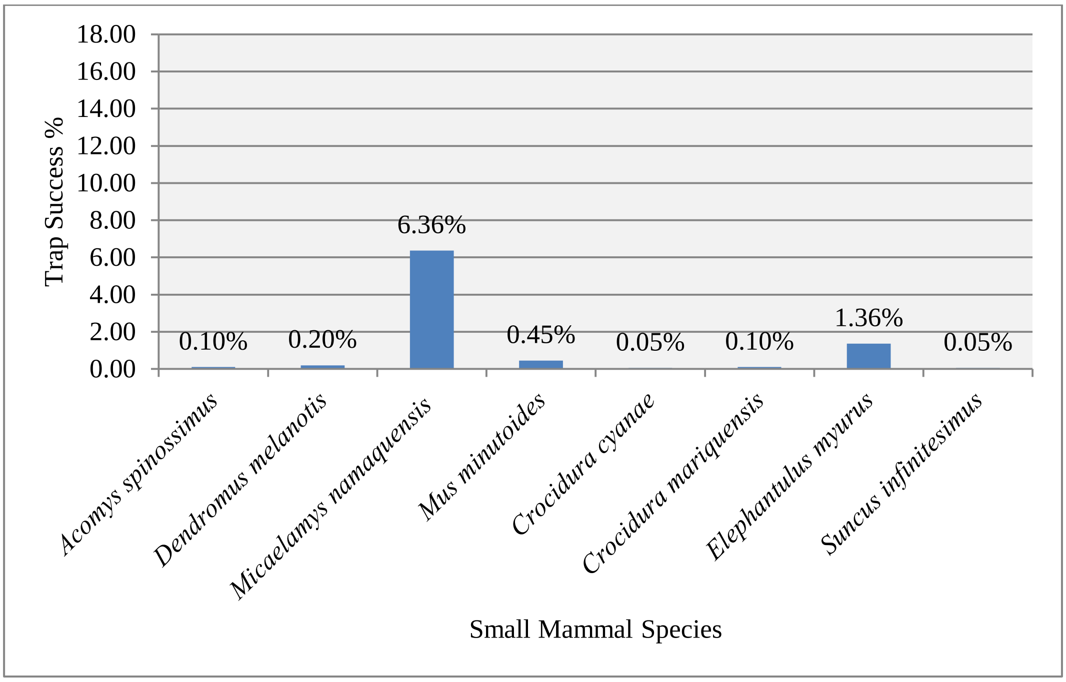

Figure 39. Graph illustrating small mammal trap success recorded in the Sheltered Woodland community on Telperion.

The Sheltered Woodland community is untransformed and intact from an ecological perspective. The site is dominated by *M. namaquensis*, a species associated with rocky habitats on the property. The community has a high diversity and the 3rd highest trap success recorded during this study, superseded by the Rocky Open Shrub community (22.17%) and the Northern Slope Woodland community (12.03%). The Sheltered Woodland community contributed 14.51% to the trap success recorded during this study.

### 5.5.5. Trap success percentage recorded for small mammal species recorded in the Burkea Eragrostis Clumps community on Telperion

The Burkea Eragrostis Clumps community had a significantly lower trap success ($\chi^2$ = 103.299; *df* = 1; *n* = 271; *p* = 0.000), 2.63% which was lower than the average trap success of 8.6% recorded for the study. Statistically there is an insignificant difference in trap success for the different species recorded for this vegetation community ($\chi^2$ = 1.828; *df* = 5; *n* = 6; *P* = 0.872). The highest percentage recorded in the Burkea Eragrostis Clumps community was for *G. brantsii* (1.06%), followed by *D. melanotis* (0.66%), however, this difference in trap success is insignificant ($\chi^2$ = 0.094; *df* = 1; *n* = 2; *P* = 0.758). A low trap success in this community was recorded for the remaining species, *L. rosalia* (0.10%), *Mastomys* spp. (0.10%), *M. minutoides* (0.61%) and *S. pratensis* (0.10%) (Fig. 40). Small mammal diversity within this community is relatively low, and trap success is dominated by species preferring bare, sandy soils.

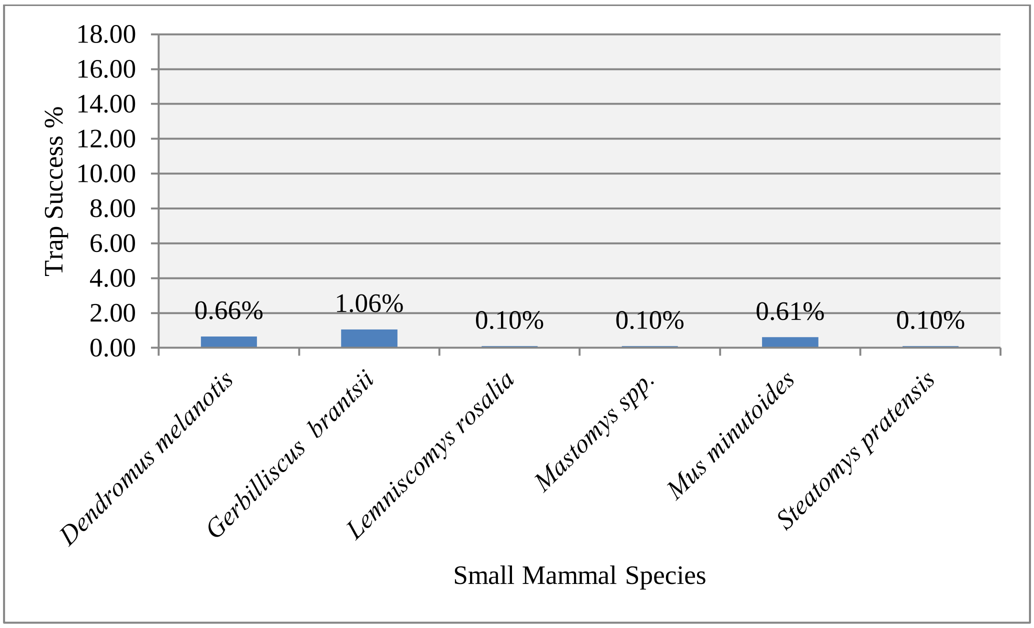

Figure 40. Graph illustrating small mammal trap success recorded in the Burkea Eragrostis Clumps community on Telperion.

The Burkea Eragrostis Clumps community is untransformed and intact from an ecological perspective. The site is dominated by *G. brantsii*, a species associated with low-lying sandy soils on the property. The community had the lowest trap success recorded during this study, followed by the Moist Degraded Grassland community (2.83%) and the Degraded Grassland community (4.35%). The Burkea Eragrostis Clumps community contributed 4.39% to the trap success recorded during this study.

### 5.5.6. Trap success percentage recorded for small mammal species recorded in the Moist Degraded Grassland community on Telperion

The Moist Degraded Grassland community had a significantly lower trap success ($\chi^2$ = 96.487; *df* = 1; *n* = 274; *p* = 0.000), 2.83% which is considerably lower than the average trap success of 8.6% recorded for the study. Statistically there is an insignificant difference in trap success for the different species recorded for this vegetation community ($\chi^2$ = 2.245; *df* = 7; *n* = 8; *P* = 0.945). The highest percentage recorded in the Burkea Eragrostis Clumps community was for *R. pumilio* (1.11%), followed by *C. mariquensis* (0.51%), however, this difference in trap success is insignificant ($\chi^2$ = 0.222; *df* = 1; *n* = 2; *P* = 0.637). A low trap success in this community was recorded for the remaining species, *D. melanotis* (0.05%), *D. mystacalis* (0.25%), *Mastomys* spp. (0.20%), *M. minutoides* (0.15%), *O. irroratus* (0.35%) and *S. infinitesimus* (0.20%) (Fig. 41). Small mammal diversity within this community is relatively high, although trap success was generally low, dominated by *R. pumilio*, a species whose numbers fluctuated considerably with extended periods of absence from this community.

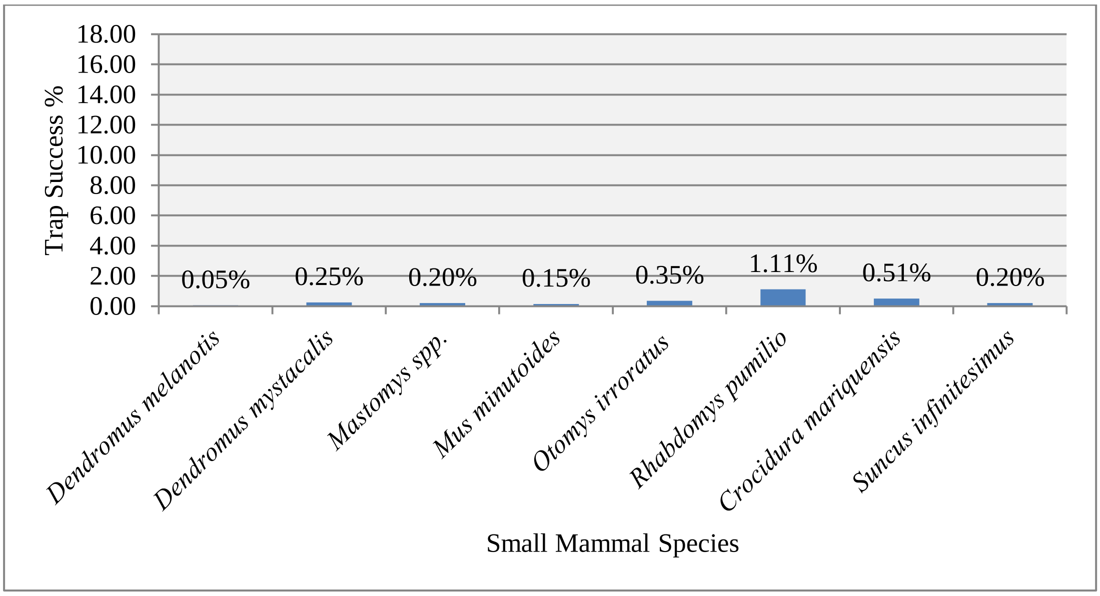

Figure 41. Graph illustrating small mammal trap success recorded in the Moist Degraded Grassland community on Telperion.

The Moist Degraded Grassland community is transformed and its fertile soils have been historically disturbed through overgrazing and past agricultural practices. The community has the second lowest trap success recorded during this study, a slightly higher trap success than the Burkea Eragrostis Clumps community (2.63%) and the Degraded Grassland community (4.35%). The Moist Degraded Grassland contributed 4.73% to the trap success recorded during this study. The sparse cover and seasonally wet soils possibly contribute to the low trap success recorded.

### 5.5.7. Trap success percentage recorded for small mammal species recorded in the Rocky Open Shrub community on Telperion

The Rocky Open Shrub community had a trap success of 22.17% which was significantly higher ($\chi^2 = 135.784$; $df = 1$; $n = 594$; $P = 0.000$) than the average trap success of 8.6% recorded for the study. Statistically there is a highly significant difference in trap success for the different species recorded for this vegetation community ($\chi^2 = 19.663$; $df = 2$; $n = 3$; $P = 0.000$). The highest percentage recorded for the Rocky Open Shrub community was *M. namaquensis* (16.87%); followed by *E. myurus* (4.95%), a significantly higher trap success for *M. namaquensis* species was recorded in comparison ($\chi^2 = 6.511$; $df = 1$; $n = 2$; $P = 0.010$), however, a significantly lower trap success was recorded for *A. chrysophilus* (0.35%) was recorded during the study ($\chi^2 = 15.83915$; $df = 1$; $n = 2$; $P = 0.000$) (Fig. 42). This community is clearly dominated by the rock affiliated species, *M. namaquensis* and *E. myurus*.

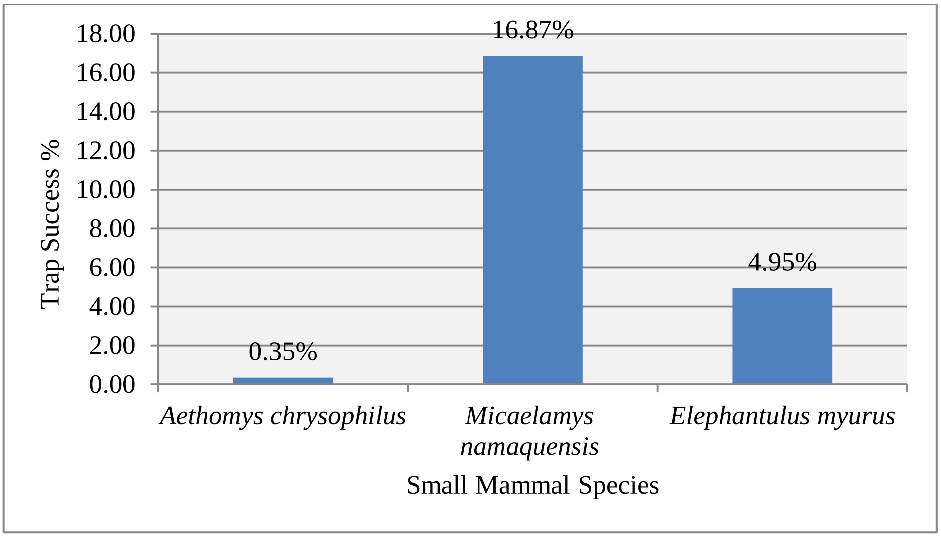

Figure 42. Graph illustrating small mammal trap success recorded in the Rocky Open Shrub community on Telperion.

The Rocky Open Shrub community is untransformed and intact from an ecological perspective. This community had the highest trap success recorded during this study, largely due to the trap success recorded for *M. namaquensis* and *E. myurus*, followed by the Northern Slope Woodland community (12.03%) and Sheltered Woodland (8.69%). This community contributed 37.03% to the trap success recorded for during this study.

## 5.6. Discussion

The objectives of this chapter were to assess the trap success of small mammals on Telperion in the Bankenveld grasslands of Mpumalanga Province, South Africa. Large differences in trap success were found between habitats, although similarities were also recorded. In areas which were previously under agriculture, a low trap success was recorded at certain times of the year, although generalist species such as *Mastomys* sp. and *Rhabdomys pumilio* were recorded, but these species occupied a low percentage of the trap success recorded.

Relatively few ruderal species dominate when disturbances are frequent, and relatively few highly competitive species dominate when disturbances are rare; intermediate levels of disturbance allow succession to proceed but limit the ability of competitive species to dominate the community (Valone & Kelt 1999). Past agricultural activities appeared to impact trap success at certain sites, and non-transformed communities had higher trap success than those previously cultivated. It is assumed that changes in vegetation species composition is a possible cause. The number of microhabitats and primary productivity is also high at the point of climax, and able to sustain a number of individuals from different species, which would influences trap success. Avenant & Watson (2002) found small mammal communities correlated with the abundance of pioneer plant species and their ecological value of the veld, indicating that a similar curve could be expected. Generalist species, those with a wide habitat tolerance, are generally found to dominate small mammal numbers on the lower part of the succession curve, with the opposite is expected to occur for specialist species, which increase in number towards the end of the curve. This correlates well with the Telperion study. Avenant (2005) felt that together, these finding support the idea that direct monitoring of small mammals could be used as a relatively effective and efficient method of indicating ecological disturbance, habitat health and integrity, and therefore a useful tool for reserve managers and ecologists.

High numbers of *Mastomys* spp. in all habitats indicates a level of disturbance at the study site; hence low numbers indicate a balanced system. A low trap success was recorded for *Mastomys* during this study, largely in previous disturbed areas. The relationships between small mammals and the environment in which they live is often complex in nature (Avenant 2000a; Birney *et al.* 1976). Small mammal trap success have been related to variables such as habitat structure and complexity (Rosenzweig & Winakur 1969; Brown 1973; French *et al.* 1976; Bond *et al.* 1980; Dueser & Brown 1980; Rowe-Rowe & Meester 1982a; Thompson 1982; Parmenter & MacMahon 1983; Kotler 1984; Abramsky 1988; Kerley 1992; Els & Kerley 1996), area (Abramsky *et al*. 1985; Fitzgibbon 1997), productivity (Abramsky 1978, 1988; Rosenweig 1992); predation (Kotler 1984; Norrdahl & Korpimäki 1995; Abramsky *et al.* 1998; trampling and grazing (Keesing 1998; Milchunas *et al*. 1998); surrounding landscape and the distance between similar habitats (Fitzgibbon 1997), and the maturity of the habitat and succession of the vegetation (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Rowe-Rowe 1995; Fitzgibbon 1997; Ferreira & van Aarde 1999). Trap success at the study site was low in trampled and overgrazed areas. The untransformed Rocky Open Shrub community had the highest trap success on the study site, due to the suitability of the habitat to *M. namaquensis* and *E. myurus*.

There appears to be a strong connection between disturbance in an ecosystem and the presence or absence of small mammal indicator species (Noss 1990; Armstrong & Van Hensbergen 1996; Avenant 1996; Leirs *et al.* 1996; Barreto *et al.* 1998. The objective of this study was to report on the trap success of the component species and diversity of small mammals present in specific habitats and plant communities on Telperion and Ezemvelo Nature Reserve. The three measures of abundance used in this study were trap success, species richness (or variety), and diversity (Nel 1975). The relative abundance or evenness of the component species was determined as the equitability index (Batten 1976). Trap success (or percentage success) is the number of small mammals captured over 100 trap nights. Generally, there were differences in small mammal trap success between different plant communities and habitat type. Owls and other predators are expected to have an influence on the number of small mammals recorded. Avanent (2005) found that the nocturnal species, *Mastomys coucha* and *Gerbilliscus leucogaster* contributed by far to the volume of prey ingested by barn owls (*Tylo alba*), although during spring and summer, the crepuscular species *Rhabdomys pumilio* and the diurnal species *Otomys irroratus* become more important as prey.

Makundi *et al*. (2007) found that reproduction and population fluctuations in *Mastomys natalensis* were linked to the duration and amount of rainfall in Tanzania. They also found that the distribution of these species indicates a broad habitat tolerance and makes it a generalist species in the colonization of disturbed habitats. The fact that few *Mastomys* spp. records were collected on Telperion and Ezemvelo Nature Reserve is indicative of the stable, in some cases, climax condition of the vegetation. In areas which showed signs of previous agricultural practices, sufficient time had progresses to allow these areas to recover. Ferreira & Van Aarde (1996) suggested that *Mastomys* spp. would be the first to colonize areas rehabilitated from mining operations, and it has been described as an opportunistic species, characteristically conforming to an r-selected strategist when conditions are favourable (Leirs *et al.* 1997). Makundi *et al.* (2007) found population densities were highest at the end of the rain season to the middle of the dry season, but rapid decline in population density occurred towards the end of the dry season in September. The *Mastomys* spp. recorded during this study were located in spring, although in low numbers. The conserving of biodiversity is one of the major goals justifying the presence of nature reserves and conservation areas. The ability of natural fire to rehabilitate flora in African savanna ecosystems has been well-documented (Swanepoel 1981; Manry & Knight 1986). We can therefore expect that the fauna which evolved in these habitats would also be well adapted (Rowe-Rowe & Meester 1982b).

Rowe-Rowe & Lowry (1982) for instance, found fewer small mammals in dense cover, compared to the same habitats frequently burned in a fire managed plan. According to Rowe-Rowe (1995), the season, size, pattern, and intensity of burning influences recolonization of small mammals in fire climax grasslands and must be incorporated when burning programs are planned. The lack of fire should be considered, as extensive areas of moribund sour grass occur at the study site, which had a low trap success.

It has been suggested that regenerating vegetation and availability of weed seeds create an attractive food resource for certain species of rodents (De Graaf 1981). According to Avenant (2000), the ecological role of predators in the maintenance of a balanced prey population and high prey diversity, ultimately affects the whole ecosystem, including the predator population (Kotler 1984; Norrdahl & Korpimäki 1995; Avenant & Nel 1997; McPeek 1998: Barreto *et al.* 1998; Ceballos *et al.* 1999). Makundi *et al.* (1999) examined farming practices and whether they affected the nature of habitat, shelter and population density of rodents in Tanzania. The questions raised through this study being do game farming practices influence trap success of rodent species in a “natural system”. The impact of herbivores on shelter and the availability of seed bearing plants are without question. The stocking rates of game farms and nature reserves directly and indirectly affect small mammal populations. In certain overgrazed areas, grass plants are not permitted to mature, therefore do not produce inflorescences, and ultimately do not produce food for certain species of rodents. Large areas with palatable grasses were overgrazed at the study site, and these areas had low trap success in the summer months due to overgrazing. Small mammal populations, whilst fluctuating through time are a constant influence within landscapes that contain suitable habitats. Stable ecosystems support a wide range of wildlife fauna in all niches. Control of large herbivores numbers is important in preventing further impacts of these animals, decreasing the potential of habitat to support certain small mammal species. Massawe *et al.* (2006) found an increase in rodent population in areas after seed emergence, although this trend was more evident in areas which has been slashed and burned through farming practices. Rainfall, timing, duration and amount, has a strong influence on the population dynamics of rodents as it indirectly affects availability of resources. According to Avenant (2000a,b), small mammal diversity relates to habitat structure, rainfall, state of vegetation succession, effects of overgrazing, predation and trampling. Such relationships appear complex in nature, impacting on basic habits of small mammals (Birney *et. al.* 1976).

The large differences in mammal trap success observed between the habitats on Telperion and Ezemvelo Nature Reserve are therefore expected. According to Avenant & Kuyler (2002), this agrees with the numerous studies that have demonstrated the casual relationship between disturbance, lack of disturbance, and diversity and abundance of small mammals (Wootton 1998; Trojan 2000, Hastwell & Huston 2001), and between the decrease in diversity and declines in ecosystem functioning, structure, and resilience (Grime 1998: Cardinale *et al.* 2000; Chaplin *et. al.* 2000; Johnson 2000; Loreau 2000; McCann 2000; Petchey 2000; Purvis & Hector 2000; Wilsey & Potvin 2000; Fonseca & Ganade 2001; Knops *et al.* 2001; Scheffer *et al.* 2001).

This study is important as it investigates the trap success of small mammal populations in the fire-climax grassland of the Bankenveld. Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Differential habitat use and the use of resources within these different systems, especially in space and time, may facilitate co-existence between species on a reserve, or specific habitat (M'Closkey 1976; Brown 1989; Yunger *et al.* 2002; Zhang 2003; Bonesi & Macdonald 2004; Harris *et al.* 2006). Spatial differences in small mammal communities are based on macro- and microhabitat selection. How small mammals choose an area is a result of cover availability, differences in micro-climate, substrate, predation risk and food availability (Chesson 1986).

Small Mammals are important components in Bankenveld grassland habitats ecosystems, as predators, consumers, dispersers of seed, burrowers and prey for carnivores, reptiles and raptors. Total biomass and density of small mammals should be taken into account when calculating carrying capacity on a reserve. More practically, their use should be maximised when monitoring ecosystems. During this study, the highest trap successes were found in spring and winter. Trap success were higher in the winter months, which were 4.7% higher than for spring, however trap success for *Micaelamys namaquensis* was higher in spring by 21%. The overall result is skewed by *Elephantulus myurus*, which were 55.7% more abundant in the winter months. In absence of *E. myurus*, spring would have the highest trap success in the Bankenveld Grassland's of Telperion and Ezemvelo Nature Reserve.

According to Avenant (2000a), homogeneous habitats should be selected and marginal areas (at the edge of habitats) should be avoided as the edges often house more species and can be seen as refugia where individuals can profit from the best of both habitats. Care was taken to ensure the habitats selected where "pure" representations of these habitat types, as although ecologically important, these edges often house more species and can be seen as refugia where individuals can profit from the best in two environments (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982a; Hansson 1998). For this reason they play an important role in the recolonization and species persistence of small mammals.

Certain vegetation communities appear more stable habitats for certain species of small mammal, for example, Northern Slope Woodland and Rocky Open Shrub for *Micaelamys namaquensis* and *Elephantulus myurus*, which are represented throughout the year, although the numbers fluctuate. Other communities such as Moist Degraded Grassland and Degraded Grassland differ seasonally in their suitability for harbor small mammals. Trap success varied for the different species recorded, *Dendromus melanotis* has a low trap success in the spring and summer months, while this species dominated in certain vegetation communities in the autumn and winter months. *Otomys irroratus* and *Rhabdomys pumilio* were only recorded in autumn and winter months at the study site, with 0% trap success during the spring and summer months. This is possibly due to local movements, spurred by changes in vegetation and lack of cover in other areas. Small mammals were 13.6% more abundant in year two (2009), when compared with year one (2008). This is due to the change in the methodology, reducing the number of transects, and increasing the number of consecutive trap nights per season.

Data were also recorded in communities at different areas according to vegetation community and historical agricultural influences on the property. The historical influence in certain areas on the property resulted in some differences in vegetation diversity, density and height. Trap success provided an indication of population abundance at the sites located within the different habitats. Inventories of species associations with habitat are valuable for aiding in conservation related decisions, since decisions are often made at local scales and small mammals can provide a rich source of data on environmental change (Kremen *et al.* 1993). These changes in habitat resulted in changes in plant communities, which consist of a combination of abiotic factors such as soil, rockiness and climate and biotic factors such as plant and animal composition with each element influencing the other. Therefore a vegetation community can be seen as an ecosystem and these should be managed effectively to ensure the future well-being of the organisms.

# CHAPTER 6

## CAPTURE FREQUENCY RECORDED FOR SMALL MAMMALS COUPLED WITH VEGETATION COMMUNITIES

### 6.1. Abstract

This chapter aims to determine the capture frequency of small mammals in seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. There are large differences in capture frequency recorded between these vegetation communities. The total capture frequency recorded include, Rocky Open Shrub (*n* = 439), Northern Slope Woodland (*n* = 332), Rocky Highveld Grassland (*n* = 198), Sheltered Woodland (*n* = 172), Degraded Grassland (*n* = 120), Moist Degraded Grassland (*n* = 56) and Burkea Eragrostis Clumps (*n* = 52). The placement of transects were based according to habitat structure, in some cases in areas influenced by past agricultural activities. The capture frequency percentage recorded for small mammals were different between transformed sites (12.9%) and non-transformed sites (87.1%). The vegetation communities with the highest capture frequencies for individual species included the Rocky Highveld Grassland for *Dendromus mystacalis* (*n* = 10), *Gerbilliscus leucogaster* (*n* = 22), *Lemniscomys rosalia* (*n* = 21), *Steatomys pratensis* (*n* = 7); Rocky Open Shrub for *Aethomys chrysophilus* (*n* = 7), *Micaelamys namaquensis* (*n* = 334), and *Elephantulus myurus* (*n* = 98); Moist Degraded Grassland for *Otomys irroratus* (*n* = 7), *Rhabdomys pumilio* (*n* = 22), *Crocidura mariquensis* (*n* = 10); Northern Slope Woodland for *Acomys spinosissimus* (*n* = 22), *Graphiurus murinus* (*n* = 6); Burkea Eragrostis Clumps for *Gerbilliscus brantsii* (*n* = 21) and *Mus minutoides* (*n* = 12); and Sheltered Woodland for *Crocidura cyanea* (*n* = 1). The untransformed Rocky Highveld Grassland, Northern Slope Woodland and Rocky Open Shrub are important vegetation communities for small mammal fauna in the Bankenveld grassland with high capture frequencies. The variety of vegetation communities in different successional states is important for diversity of species and show high capture frequencies for specific species.

**Keywords:** Capture frequency, Telperion, Ezemvelo Nature Reserve, untransformed, Bankenveld grassland, small mammals, vegetation, communities, South Africa

## 6.2. Introduction

The purpose of this chapter is to determine the capture frequency of small mammals in seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Capture frequency relates directly to abundance within populations, and may vary considerably over time and the cause of change in the trajectory of population growth is the central focus of population ecology (Sibly *et al.* 2005). Large differences in capture frequency are expected between the vegetation communities at the study site. The frequency of new and recaptured individuals will provide valuable information on this small mammal population. Due to the relatively small sample sizes of certain species, interpretation of recaptured data is restricted to individuals recaptured within transects during a particular survey. Rainfall, fire and grazing individually and in combination play a major role in shaping the vegetation dynamics of ecosystems around the globe. These are expected to directly and indirectly affect the capture frequency on a study site. Habitat preferences of rodents in Africa are determined primarily by the type of cover available to them and in general, dense plant covers supports a higher diversity of small mammal species and are lowest at intermediate values of plant cover (Monadjem 1997). Food supply is another factor that influences small mammal biomass (Doonan & Slade 1995). The quantity of natural food available to small mammals is expected to influence capture frequency recorded. In Africa, rainfall is regarded to have a primary influence on vegetation productivity (Bredenkamp *et al.* 2002), fire and herbivory are considered to be key factors determining vegetation structure and composition (Scholes & Walker 1993). Many small mammal communities are directly influenced by vegetation structure (Linzey & Kesner 1997; Ferreira & Van Aarde 1999; Fuller & Perrin 2001) and consequently are expected to be indirectly influenced by rainfall, fire and grazing, and can therefore be utilized to explore the interactions between these factors on ecosystem processes and biodiversity maintenance (Yarnell *et al.* 2007). The influence of these variables on capture frequency at the study site will be recorded. There appears to be a strong connection between disturbance in an ecosystem and the presence or absence of small mammal indicator species (Noss 1990; Armstrong & Van Hensbergen 1996; Avenant 1996; Leirs *et al.* 1996; Barreto *et al.* 1998). Massawe *et al.* (2006) found an increase in rodent population in areas after seed emergence, although this trend was more evident in areas which has been slashed and burned through farming practices. The presence of different species of small mammals within a community is often associated with grass cover, plant litter and vegetation density, and substrate with certain species in known to influence the assemblage recorded. Habitats are often related to foraging efficiencies (Bonesi & Macdonald 2004), often resulting in a specialist dominating over a generalist.

Temperature is expected to influence capture frequency, especially during exceptionally cold and wet periods. Timing of breeding in small mammal populations is often constrained, not only by the environment but also phylogenetically in terms of age of reproduction. The effects of population size fluctuations and species richness on trap success are due to differences in recruitment (movements into the population through birth and immigration) and emigration (movements out of the population through dispersal and death (Bronner 1986). The untransformed sites are expected to be important vegetation communities for small mammal fauna in the Bankenveld grassland with higher capture frequencies than sites previously under agriculture. The variety of vegetation communities in different successional states are important for diversity of species and show high capture frequencies for specific species. This chapter study is important as it investigates the capture frequency of small mammal populations in the fire-climax grassland of the Bankenveld.

## 6.3. Methodology

Transects were placed in different vegetation communities from which capture frequency was recorded. These included Northern Slope Woodland, Rocky Highveld Grassland, Degraded Grassland, Sheltered Woodland, Burkea Eragrostis Clumps, Moist Degraded Grassland and Rocky Open Shrub. Two transect lines in each transect were placed in a North-South and East-West direction. The frequency of new and recaptured individuals recorded during this study provides valuable information on the population dynamics and abundance of the population. Because of the relatively small samples sizes of certain species, interpretation of recaptured data was restricted to individuals recaptured within the same trap transect during a particular survey. Capture frequency was recorded over two to five nights. In year one (2008), ten transects each comprising 30 Sherman live-traps each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month. The starting-point was placing transects in the seven vegetation communities. In year one, two transects were placed in the dominant communities to obtain a greater sample size. In year one, 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. 10 m spacing was adopted at the study site with the available traps. In year two, three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per.

Chi-square ($\chi^2$) test to analyze capture frequencies were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 6.4. Results

Data were recorded between January 2008 and October 2009 from 17 sampling trips covering 16200 trap nights, with a trap success of 8.5% recorded for the study, with a capture frequency of 1369 representing 18 small mammal species. There is a highly significant difference in capture frequency of small mammals recorded between the seven vegetation communities ($\chi^2 = 633.862$; $df = 6$; $n = 1369$; $P = 0.000$). The total number of small mammal captures for the vegetation communities assessed were, Northern Slope Woodland ($n = 332$), Rocky Highveld Grassland ($n = 198$), Degraded Grassland ($n = 120$), Sheltered Woodland ($n = 172$), Burkea Eragrostis Clumps ($n = 52$), Moist Degraded Grassland ($n = 56$) and Rocky Open Shrub ($n = 439$). The placement of transects were based according to habitat structure, in some cases in areas influenced by past agricultural activities. The mean frequency of rodent captures was significantly different between transformed sites (12.9%), and non-transformed sites (87.1%) ($\chi^2 = 55.056$; $df = 1$; $n = 2$; $P = 0.000$). The overall capture percentage was recorded for small mammals in the different vegetation communities on Telperion (Fig. 43).

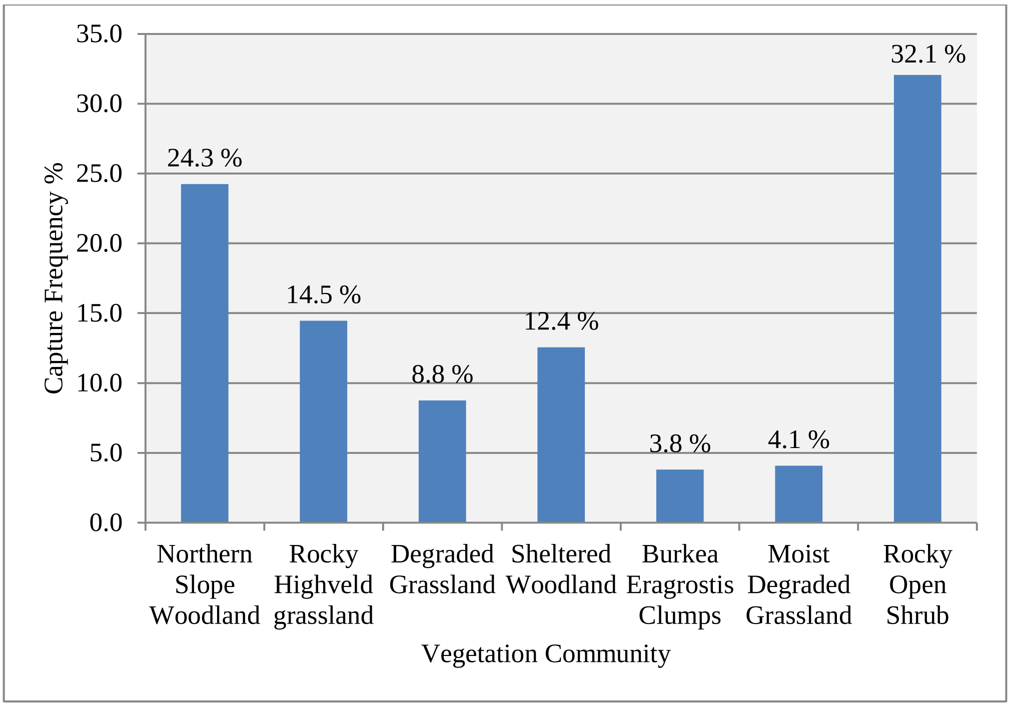

Figure 43. Graph illustrating the capture frequency percentage recorded for the different vegetation communities on Telperion.

The capture frequency for the Northern Slope Woodland community was recorded through trapping at two transects, NSW 1 and NSW 3. This community was a productive community and contributed 24.3% to the total small mammal capture frequency recorded during the study (Fig. 43). Statistically a significantly higher capture frequency was recorded in the Nothern Slope Woodland community compared with the average across all vegetation communities ($\chi^2$ = 35.030; *df* = 1; *n* = 529; *P* = 0.000). The number of small mammals recorded for the Northern Slope Woodland community (*n* = 332) was high in comparison to other vegetation communities at the study site.

The capture frequency for the Rocky Highveld Grassland community was recorded through trapping at two transects, RHG 2 and RHG 3. This community was a relatively productive community and contributed 14.5% to the total capture frequency recorded during the study (Fig. 43). Statistically an insignificant difference in capture frequency was recorded in the Rocky Highveld Grassland community compared with the average across all vegetation communities ($\chi^2$ = 0.010; *df* = 1; *n* = 394; *P* = 0.919). This community is relatively untransformed and in a balanced, stable ecological state which results in a high diversity of small mammal species. Statistically a higher frequency was recorded for the Rocky Highveld Grassland community (14.5%) in comparison with Moist Degraded Grassland (4.1%) and

Burkea Eragrostis Clumps (3.8%) communities on the property ($\chi^2$ = 307.563; *df* = 2; *n* = 440; *P* = 0.000).

The capture frequency for the Degraded Grassland community was recorded through trapping at two transects, DG 2 and DG 3. Statistically a significantly lower capture frequency was recorded in the Degraded Grassland community compared with the average across all vegetation communities ($\chi^2$ = 18.278; *df* = 1; *n* = 319; *P* = 0.000). This community was less productive than more stable habitats and contributed 8.8 % to the total capture frequency recorded during the study (Fig. 43). Statistically a significantly lower capture frequency in the Degraded Grassland community compared with the Rocky Open Shrub and Northern Slope Woodland communities ($\chi^2$ = 177.502; *df* = 2; *n* = 891; *P* = 0.000). The frequency recorded for the Degraded Grassland community (8.8%) was low in comparison with Rocky Open Shrub (31.8%) and Northern Slope Woodland (24.3%) on the property.

## 6.5. Capture frequency for small mammals recorded on Telperion

### 6.5.1. Capture frequency recorded for *Acomys spinosissimus* on Telperion

Statistically a significant difference in capture frequency was recorded for *Acomys spinosissimus* in the seven vegetation communities assessed during the study ($\chi^2$ = 119.329; *df* = 6; *n* = 7; *P* = 0.000). The highest capture recorded for *Acomys spinosissimus* was in the Northern Slope Woodland communities (*n* = 22), although the species was recorded in the Sheltered Woodland community (*n* = 2), however, in lower numbers (Fig 44). This species was found on the rocky ridges and outcrops on Telperion, preferring areas with large boulders for cover.

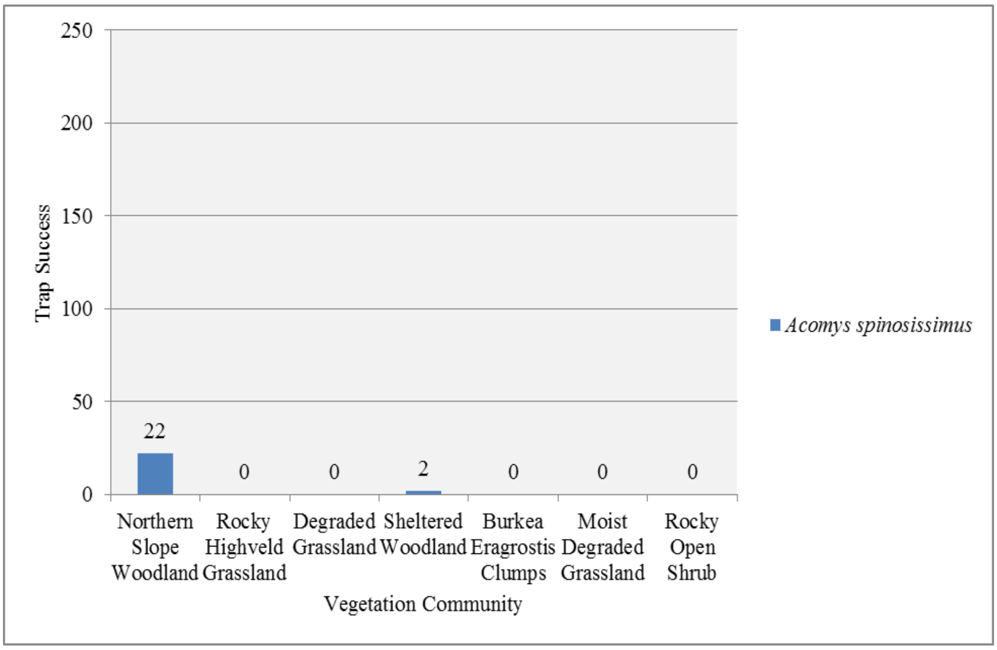

Figure 44. Graph illustrating the capture frequency for *Acomys spinosissimus* for the different vegetation communities on Telperion.

*Acomys spinosissimus* is a species which is not abundant anywhere at the study site, occurring in isolated pockets along the ridges. Statistically, the numbers of *A. spinossimus* were significantly lower than for other species recorded ($\chi^2 = 1274.683$; $df = 6$; $n = 1369$; $P = 0.000$). This species contributed 1.8% to the overall capture frequency recorded, 0.1% recorded in Sheltered Woodland, and 1.6% in Northern Slope Woodland. A significant percentage of individuals were recorded in the Northern Slope Woodland (91.7%), with a lower percentage (8.3%) in the Sheltered Woodland community ($\chi^2 = 69.556$; $df = 1$; $n = 24$; $P = 0.000$).

### 6.5.2. Capture frequency recorded for *Aethomys chrysophilus* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Aethomys chrysophilus* in the seven vegetation communities during the study ($\chi^2 = 26.569$; $df = 6$; $n = 7$; $P = 0.000$). The highest capture recorded for *Aethomys chrysophilus* was in the Rocky Open Shrub communities ($n = 7$), although the species was recorded in the Rocky Highveld Grassland community ($n = 3$) and Northern Slope Woodland ($n = 1$), however, in lower numbers (Fig. 45). This species was found in areas with sufficient grass cover on Telperion, preferring areas with patches of tall grass. It appears to co-inhabit in certain areas with *M. namaquensis* and *E. myurus*, however, this species extends further into open grassland.

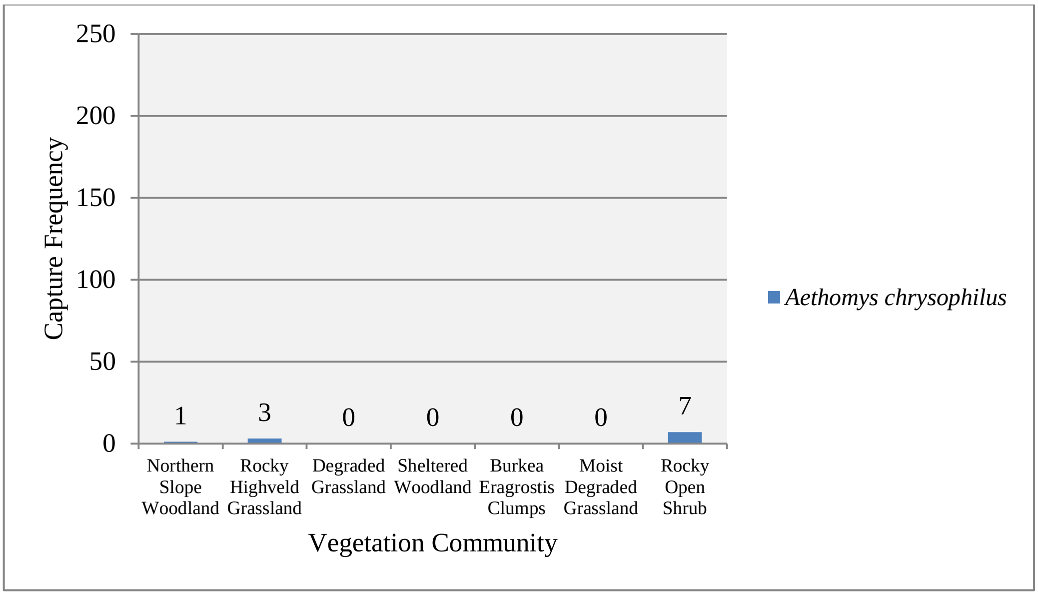

Figure 45. Graph illustrating the capture frequencies for *Aethomys chrysophilus* for the different vegetation communities on Telperion.

*Aethomys chrysophilus* is a species which was not abundant anywhere at the study site, occurring in areas with rock and dense grass. Statistically, the numbers of *A. chrysophilus* were significantly lower than other species recorded ($\chi^2 = 1325.35$; $df = 1$; $n = 1369$; $P = 0.000$). This species contributed 0.8% to the overall capture frequency recorded during the study, 0.5% in Rocky Open Shrub, 0.2% in Rocky Highveld Grassland, and 0.07% in Northern Slope Woodland. A significant percentage of individuals were recorded in the Rocky Open Shrub (63.6%), with a lower percentage (27.3%) in the Rocky Highveld Grassland, and (9.1%) in the Northern Slope Woodland community ($\chi^2 = 46.238$; $df = 2$; $n = 11$; $P = 0.000$).

### 6.5.3. Capture frequency recorded for *Dendromus melanotis* on Telperion

Statistically a significant difference in capture frequency was recorded for *Dendromus melanotis* in the seven vegetation communities during the study ($\chi^2 = 259.617$; $df = 6$; $n = 7$; $P = 0.000$). The highest capture recorded for *D. melanotis* was in the Degraded Grassland communities ($n = 74$), although the species was also recorded in the Rocky Highveld Grassland community ($n = 22$), Burkea Eragrostis Clumps ($n = 13$), Sheltered Woodland ($n = 4$), Moist Degraded Grassland ($n = 1$) and Northern Slope Woodland ($n = 1$), the later present in lower numbers (Fig 46). This species was found in areas with sufficient grass cover on

Telperion, moving into areas dense with *Seriphium plumosum*. It appears to inhabit areas with sufficient cover, moving out of an area when cover becomes insufficient.

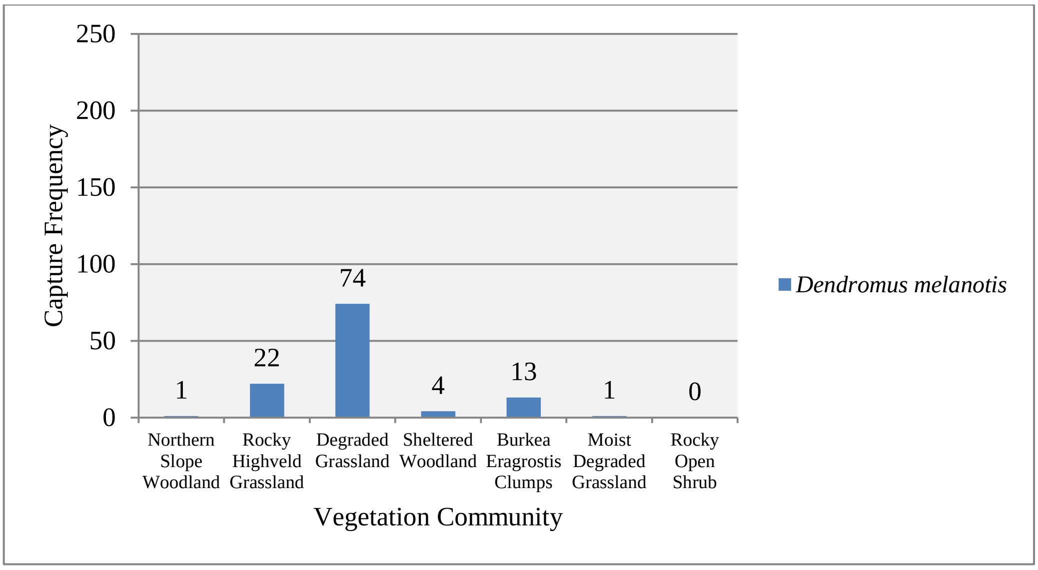

Figure 46. Graph illustrating the capture frequency for *Dendromus melanotis* for the different vegetation communities on Telperion.

*Dendromus melanotis* is a relatively common species, occurring in a wide range of habitats at the study site. Statistically, the numbers of *D. melanotis* were significantly lower than the numbers of *Micaelamys namaquensis* and *Elephantulus myurus* recorded ($\chi^2$ = 693.830; *df* = 1; *n* = 1106; *P* = 0.000). This species contributed 8.4 % to the total capture frequency recorded during the study, 5.4% recorded in Degraded Grassland, 1.6% in Rocky Highveld Grassland, 0.9% in Burkea Eragrostis Clumps, 0.3% in Sheltered Woodland, and 0.1% in Northern Slope Woodland and Moist Degraded Grassland respectively. A significant percentage of individuals were recorded in the Degraded Grassland (64.3%), with a lower percentage (19.1%) in the Rocky Highveld Grassland community, Burkea Eragrostis Clumps (11.3%), Sheltered Woodland (3.5%) and (0.9%) in Northern Slope Woodland and Moist Degraded Grassland community, respectively ($\chi^2$ = 206.433; *df* = 5; *n* = 115; *P* = 0.000).

### 6.5.4. Capture frequency recorded for *Dendromus mystacalis* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Dendromus mystacalis* in the seven vegetation communities during the study ($\chi^2$ = 34.130; *df* = 6; *n* = 7; *P* = 0.000). The highest capture recorded for *D. mystacalis* was in the Rocky

Highveld Grassland communities (*n* = 10), although the species was recorded in the Moist Degraded Grassland community (*n* = 5), and Degraded Grassland community (*n* = 3), present in relatively low numbers in all communities (Fig. 47). This species was found in areas with sufficient grass cover on Telperion, and is scarcer at the study site than *D. melanotis*. It appears to inhabit areas with sufficient cover, not recorded when cover becomes less dense.

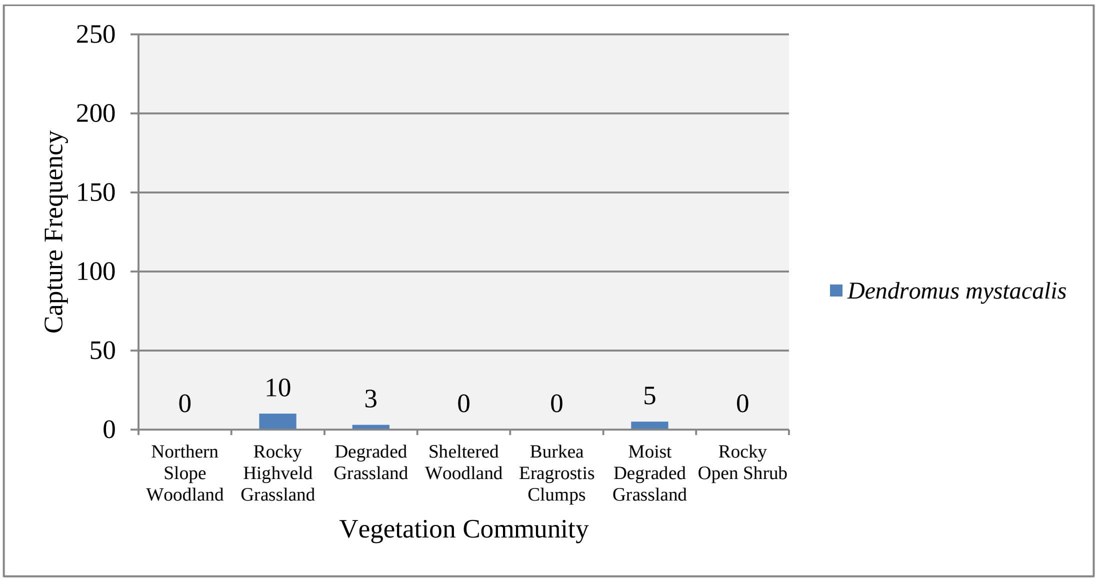

Figure 47. Graph illustrating the capture frequency for *Dendromus mystacalis* for the different vegetation communities on Telperion

*Dendromus mystacalis* is relatively scarce, only occurring in selected habitats on the property for short periods. Statistically, the numbers of *D. mystacalis* were significantly lower than the frequency of *D. melanotis* recorded ($\chi^2 = 70.744$; $df = 1$; $n = 133$; $P = 0.000$). This species contributed 1.3 % to the total small mammal capture frequency recorded during the study, 0.7% recorded in Rocky Highveld Grassland, 0.4% in Moist Degraded Grassland, 0.2% in Degraded Grassland. 55.6 % of *D. mystacalis* recorded during this study were found in Rocky Highveld Grassland, 27.8% in Moist Degraded Grassland, and 16.7% in Degraded Grassland, however, statistically these differences are insignificant ($\chi^2 = 4.333$; $df = 2$; $n = 18$; $P = 0.115$).

### 6.5.5. Capture frequency recorded for *Gerbilliscus brantsii* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Gerbilliscus brantsii* between the seven vegetation communities during the study ($\chi^2 = 126.000$; $df = 6$; $n = 7$; $P = 0.000$). *G. brantsii* was only recorded from the lower lying areas within the Burkea Eragrostis Clump community (*n* = 21) (Fig. 48). This species was found in areas with sparse grass cover and sandy soils on Telperion, and is scarcer on the property than *Gerbilliscus leucogaster*, preferring higher lying areas. This species inhabits areas with little cover, moving when the biomass becomes too high.

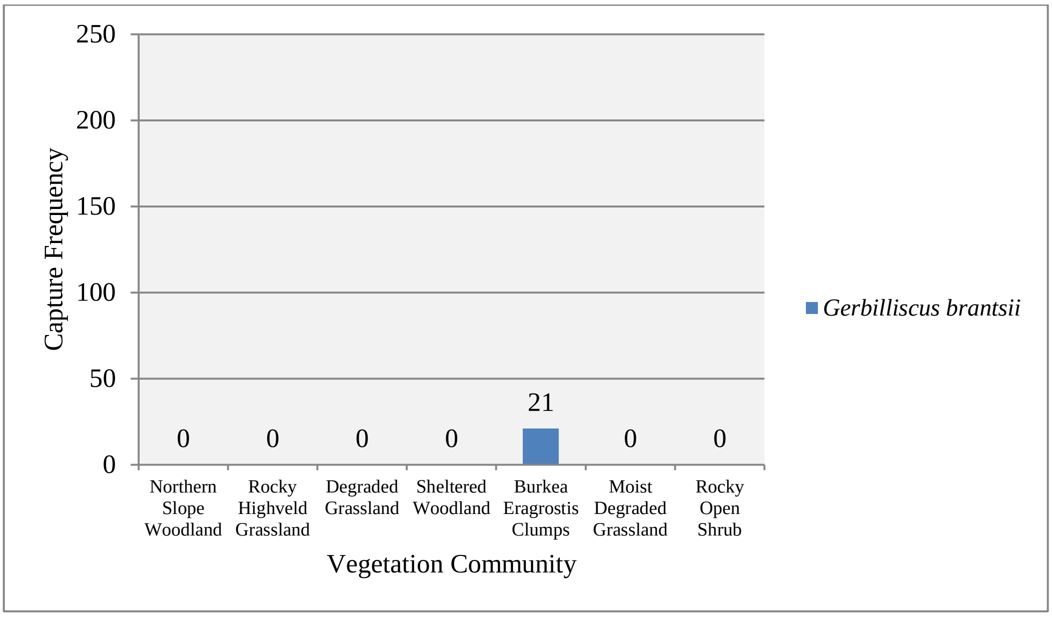

Figure 48. Graph illustrating the capture frequencies for *Gerbilliscus brantsii* for the different vegetation communities on Telperion

*Gerbilliscus brantsii* appears to be relatively scarce at the study site, only occurring in selected habitats in small family groups. Statistically, the numbers of *G. brantsii* were insignificantly different to the capture frequencies recorded for *Gerbilliscus leucogaster* ($\chi^2$ = 0.200; *df* = 1; *n* = 45; *P* = 0.655).This species contributed 1.5% to the total small mammal capture frequency recorded during the study. Statistically, this community is an important habitat for this species and should be conserved to maximize the study area's biodiversity. All individuals were recorded in the Burkea Eragrostis Clumps (100%) and this community is significant for this species ($\chi^2$ = 21.000; *df* = 1; *n* = 21; *P* = 0.000).

### 6.5.6. Capture frequency recorded for *Gerbilliscus leucogaster* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Gerbilliscus leucogaster* in the seven vegetation communities during the study ($\chi^2$ = 119.329; *df* = 6; *n* = 7; *P* = 0.000). The highest capture recorded for *G. leucogaster* was in the Rocky Highveld Grassland communities (*n* = 22), although the species was also recorded in the

Degraded Grassland community (*n* = 2), but in lower numbers (Fig. 49). This species was found in higher lying areas with short grass cover, with sandy soils. It appears to favour areas with sparse cover, avoiding dense grass.

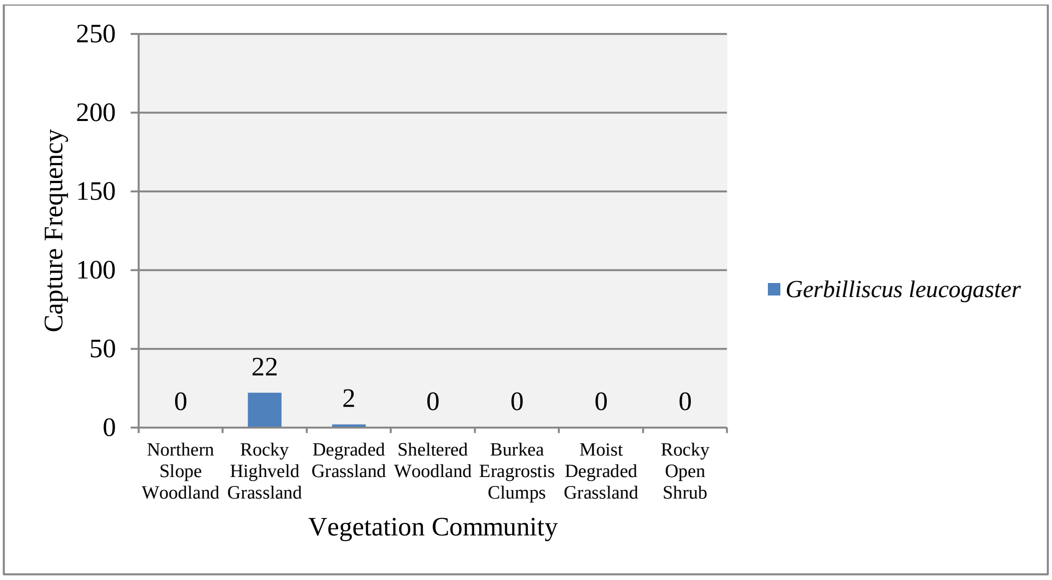

Figure 49. Graph illustrating the capture frequency for *Gerbilliscus leucogaster* for the different vegetation communities on Telperion.

*Gerbilliscus leucogaster* occurs in low densities on the property; however, this seems to fluctuate seasonally. Statistically, the capture frequency recorded for *G. leucogaster* was significantly lower than for *Micaelamys namaquensis* and *Elephantulus myurus* ($\chi^2$ = 921.270; *df* = 1; *n* = 1015; *P* = 0.000). This species contributed 1.8% to the total small mammal capture recorded during the study, 1.6% in Rocky Highveld Grassland and 0.2% in Degraded Grassland. A significant percentage of individuals were recorded in Rocky Highveld Grassland (91.7%), with a lower percentage (8.3%) in the Degraded Grassland community ($\chi^2$ = 16.667; *df* = 1; *n* = 24; *P* = 0.000).

### 6.5.7. Capture frequency recorded for *Graphiurus murinus* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Graphiurus murinus* in the seven vegetation communities during the study ($\chi^2$ = 36.303; *df* = 6; *n* = 7; *P* = 0.000). *G. murinus* were recorded from the rocky areas within the Northern Slope Woodland community (*n* = 6) (Fig. 50). This species was found in areas with a rocky substrate and boulders on Telperion, limited to certain areas with sufficient crevices. This species inhabit areas with little cover, with patches of woody vegetation.

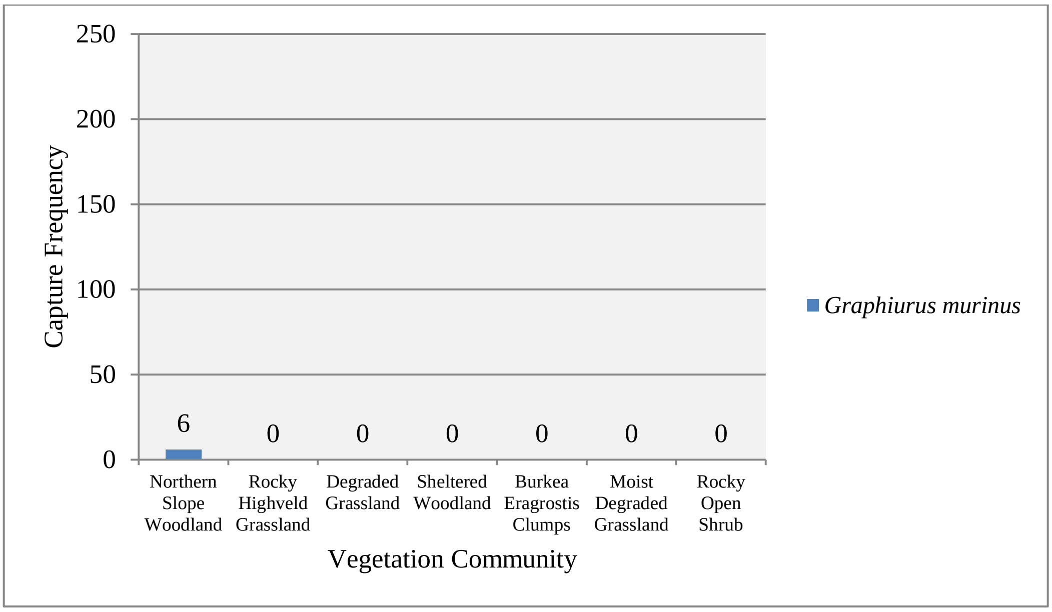

Figure 50. Graph illustrating the capture frequencies for *Graphiurus murinus* for the different vegetation communities on Telperion.

*Graphiurus murinus* is a species occurring in small family groups along the ridges, with large boulders of red sandstone. Statistically, the capture frequency of *G. murinus* was significantly lower than for *Acomys spinosissimus* ($\chi^2$ = 8.000; *df* = 1; *n* = 32; *P* = 0.005). This species only contributed 0.4% to the overall capture recorded during the study. All individuals were recorded in the Northern Slope Woodland (100%) and this community is significant for this species ($\chi^2$ = 6.000; *df* = 1; *n* = 6; *P* = 0.000). This species may be more abundant at the study site than recorded during this study due to it patchy habitat preference.

### 6.5.8. Capture frequency recorded for *Lemniscomys rosalia* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Lemniscomys rosalia* in the seven vegetation communities during the study ($\chi^2$ = 92.333; *df* = 6; *n* = 7; *P* = 0.000). The highest capture recorded for *Lemniscomys rosalia* was in the Rocky Highveld Grassland communities (*n* = 21), although the species was recorded in Degraded Grassland community (*n* = 19), and in low numbers in the Burkea Eragrostis Clump community (*n* = 2) (Fig. 51). This species was found in areas with dense or even moribund grass cover, recorded in areas with *Seriphium plumosum*.

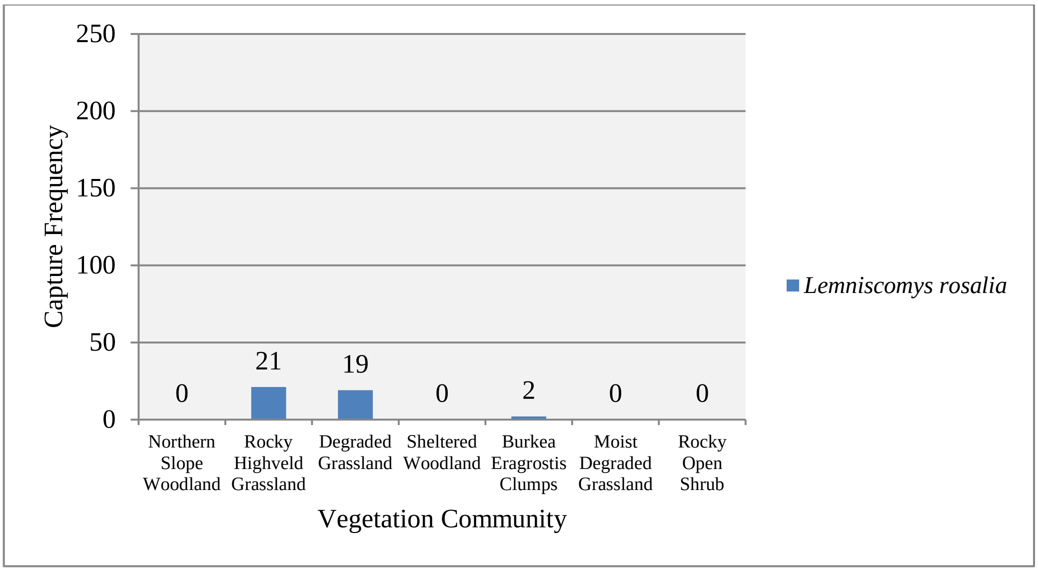

Figure 51. Graph illustrating the capture frequency for *Lemniscomys rosalia* for the different vegetation communities on Telperion.

*Lemniscomys rosalia* occurs in natural and altered grassland habitats at the study site. Statistically, the numbers of *L. rosalia* were significantly higher than *Rhabdomys pumilio* ($\chi^2 = 6.250$; $df = 1$; $n = 64$; $P = 0.012$). This species contributed 3.1% to the total small mammal capture recorded during the study, 1.5 % in Rocky Highveld Grassland, 1.4% in Degraded Grassland, and 0.2% in Burkea Eragrostis Clumps community. A significant percentage of individuals were recorded in the Rocky Highveld Grassland (50%), Degraded Grassland (48.2%), with a lower percentage (1.8%) in the Burkea Eragrostis Clumps community ($\chi^2 = 15.571$; $df = 2$; $n = 42$; $P = 0.000$). The species is a generalist, an important requirement being sufficient cover.

### 6.5.9. Capture frequency recorded for *Mastomys* spp. on Telperion

Statistically, a significant difference in capture frequency was recorded for *Mastomys* spp. in the seven vegetation communities during the study ($\chi^2 = 17.665$; $df = 6$; $n = 7$; $P = 0.007$). The highest capture recorded for *Mastomys* spp. was in the Degraded Grassland communities ($n = 6$), and Moist Degraded Grassland community ($n = 4$), although this species was also recorded in less degraded habitats such as Burkea Eragrostis Clump community ($n = 2$), and a single record in Rocky Highveld Grassland ($n = 1$) (Fig. 52). This is a generalist, often recorded in disturbed habitats. Surprisingly, this species was not abundant, recorded in both degraded habitats and pristine vegetation communities at the study site.

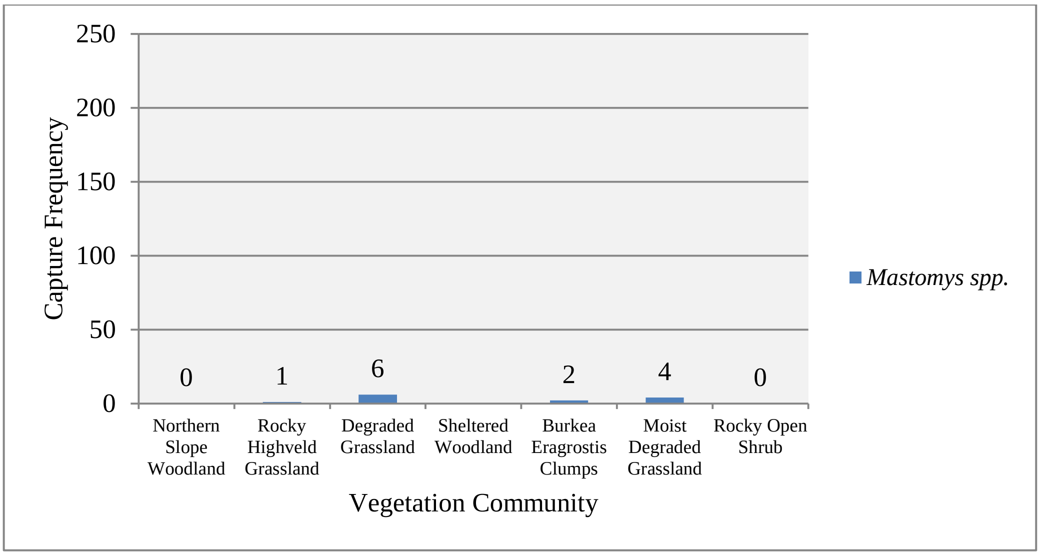

Figure 52. Graph illustrating the capture frequency for *Mastomys* spp. for the different vegetation communities on Telperion.

*Mastomys* spp. occurs in natural and altered grassland habitats at the study site. It is suspected that the population may fluctuate, and may be more abundant in certain years compared with others. Statistically, the capture frequency for *Mastomys* spp. were insignificantly different to *Rhabdomys pumilio* ($\chi^2 = 2.314$; $df = 1$; $n = 35$; $P = 0.128$). This species only contributed 0.9% to the total number of small mammals captured during the study, 0.5% in Degraded Grassland, 0.3% in Moist Degraded Grassland, 0.2% in Burkea Eragrostis Clumps and 0.1% in the Rocky Highveld Grassland community. The capture frequency recorded for *Mastomys* spp. was 46.2% in Degraded Grassland, 30.8% in Moist Degraded Grassland, 15.4% in Burkea Eragrostis Clumps, and 7.6 % in Rocky Highveld Grassland, although these differences are statistically insignificant ($\chi^2 = 4.538$; $df = 3$; $n = 13$; $P = 0.209$). This species is a generalist, able to survive in areas with low cover, even recently burnt veld.

### 6.5.10. Capture frequency recorded for *Micaelamys namaquensis* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Micaelamys namaquensis* across the seven vegetation communities during the study ($\chi^2$ = 933.044; *df* = 6; *n* = 7; *P* = 0.000). The highest capture recorded for *M. namaquensis* was in the Rocky Open Shrub communities (*n* = 334), although the species was abundant in Northern Slope Woodland (*n* = 233), Sheltered Woodland (*n* =126) and Rocky Highveld Grassland community (*n* = 79) (Fig. 53). This species is the most abundant small mammal species on the property and found in all areas with sufficient grass cover and rock for shelter and nesting. The presence of *M. namaquensis* is usually indicated by the presence of grass, stick and leaves protruding from rocky crevices.

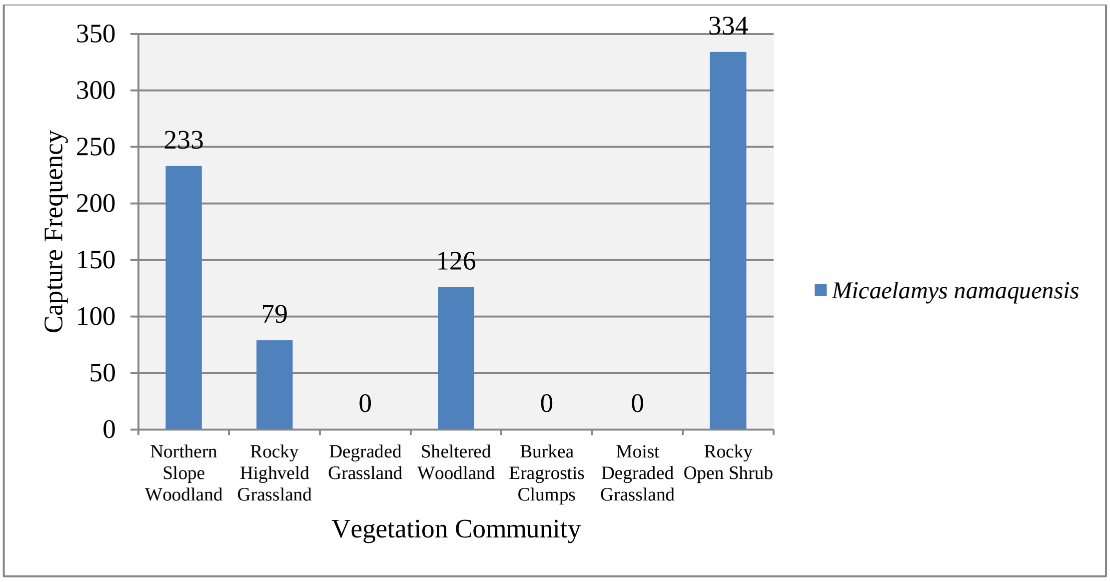

Figure 53. Graph illustrating the capture frequency for *Micaelamys namaquensis* for the different vegetation communities on Telperion.

*Micaelamys namaquensis* favors the untransformed rocky ridges at the study site. Statistically, the capture frequency of *M. namaquensis* is significantly higher than *Elephantulus myurus* ($\chi^2$ = 308.586; *df* = 1; *n* = 991; *P* = 0.000). This species recorded highest capture frequency percentage, contributing 56.4% to the total small mammal recorded during this study, 24.4% recorded in Rocky Open Shrub, 17% in Northern Slope Woodland, 9.2% in Sheltered Woodland and 5.8% in the Rocky Highveld Grassland community. A significant percentage of individuals were recorded in the Rocky Open Shrub (43.3%), Northern Slope Woodland (30.2%), Sheltered Woodland (16.3%), and Rocky Highveld

Grassland community (10.2%) ($\chi^2$ = 201.896; *df* = 3; *n* = 772; *P* = 0.000). This species was absent from Degraded Grassland, Moist Degraded Grassland, and Burkea Eragrostis Clumps due to a lack of rocky substrate in the communities. This species distribution is closely correlated with the presence of red sandstone at the study site. *Micaelamys namaquensis* and *Elephantulus myurus* occupy similar niches at the study site.

### 6.5.11. Capture frequency recorded for *Mus minutoides* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Mus minutoides* in the seven vegetation communities during the study ($\chi^2$ = 22.368; *df* = 6; *n* = 7; *P* = 0.001). The highest capture recorded for *M. minutoides* was in the Burkea Eragrostis Clumps communities (*n* = 12), although the species was also recorded in the Degraded Grassland community (*n* = 10), Sheltered Woodland (*n* = 9), Rocky Highveld Grassland (*n* = 6), Moist Degraded Grassland (*n* = 3) and Northern Slope Woodland (*n* = 1), present in the latter communities in lower numbers (Fig 54).

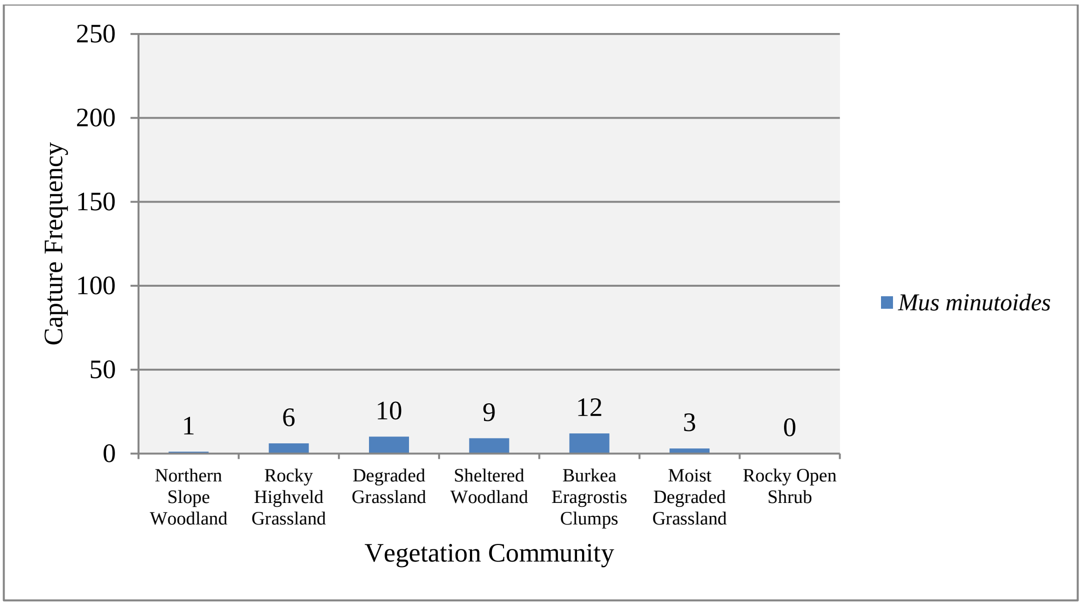

Figure 54. Graph illustrating the capture frequency for *Mus minutoides* in the different vegetation communities on Telperion.

*Mus minutoides* is a species which favors areas with sufficient grass and associated cover. Statistically, the numbers *M. minutoides* were significantly higher than for *Dendromus mystacalis* ($\chi^2$ = 8.966; *df* = 1; *n* = 59; *P* = 0.003). This species only contributed 3% of the total small mammal capture frequency recorded during the study, 0.9 % in Burkea Eragrostis

Clumps, 0.8 % in Degraded Grassland, 0.7 % in Sheltered Woodland, 0.4% in Rocky Highveld Grassland, 0.2% in Moist Degraded Grassland, and 0.1% in Northern Slope Woodland. A significant percentage of individuals were recorded in the Burkea Eragrostis Clumps (29.3%), Degraded Grassland (24.4%), Sheltered Woodland (22%), Rocky Highveld Grassland (14.6%), Moist Degraded Grassland (7.3%), with a lower percentage (2.4%) in the Northern Slope Woodland community ($\chi^2$ = 13.359; *df* = 5; *n* = 41; *P* = 0.021). This species was not recorded in Rocky Open Shrub, possibly due to a lack of sufficient cover.

### 6.5.12. Capture frequency recorded for *Otomys irroratus* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Otomys irroratus* in the seven vegetation communities during the study ($\chi^2$ = 42.000; *df* = 6; *n* = 7; *P* = 0.000). *Otomys irroratus* was recorded from the grassy patches of *Imperata cylindrica* in the Moist Degraded Grassland community (*n* = 7) (Fig. 55). This species was found in areas of dense grass cover and moist soils, restricted to the vlei's and marsh, low-lying areas of the study area.

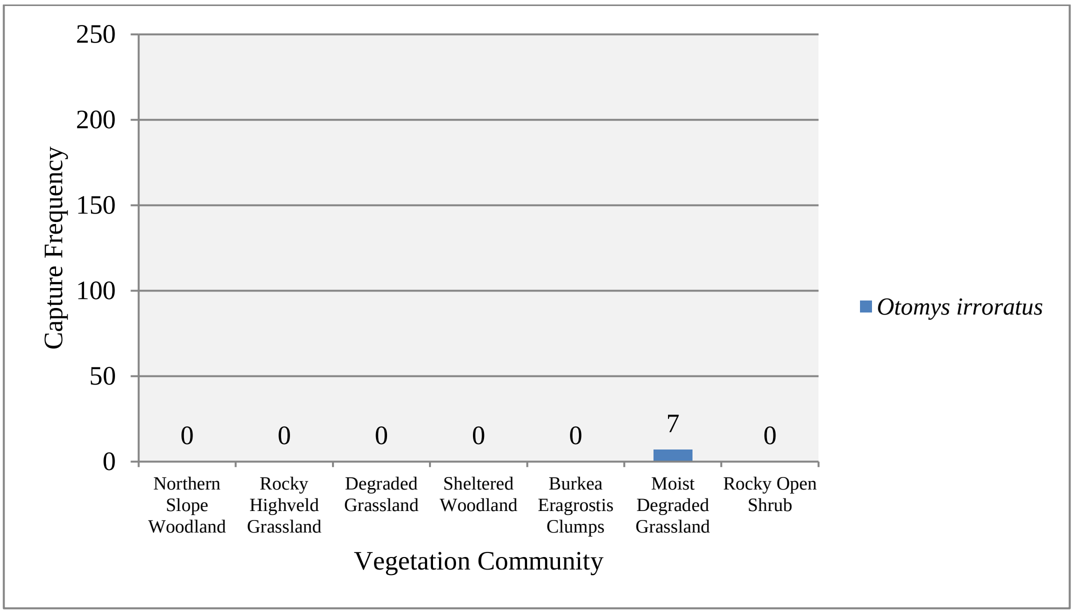

Figure 55. Graph illustrating the capture frequency for *Otomys irroratus* in the different vegetation communities on Telperion.

*Otomys irroratus* occurs in selected habitats at the study site and its presence in these areas was evident by the numerous "run-ways" in the dense, grassy patches of *Imperata* *cylindrica*. Statistically, the capture frequency of *O. irroratus* were significantly lower than for *Rhabdomys pumilio* ($\chi^2 = 7.759$; $df = 1$; $n = 29$; $P = 0.005$). This species only contributed 0.5 % of the total small mammal capture recorded during the study, of which 100% of *O. irroratus* were recorded in the Moist Degraded Grassland community. The Moist Degraded Grassland is significant and important for this species when compared to other vegetation communities assessed ($\chi^2 = 7.000$; $df = 1$; $n = 7$; $P = 0.008$). These vlei communities are important habitats for this species and should be conserved to maximize the biodiversity of the study site.

### 6.5.13. Capture frequency recorded for *Rhabdomys pumilio* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Rhabdomys pumilio* between the seven vegetation communities during the study ($\chi^2 = 133.829$; $df = 6$; $n = 7$; $P = 0.000$). *Rhabdomys pumilio* was recorded from the lower lying areas of the Moist Degraded Grassland community ($n = 22$) on Telperion (Fig. 56). This is a generalist, often recorded in habitats which are disturbed. This diurnal species was not recorded as frequently as was expected, however, fluctuations in abundance at the study site could occur.

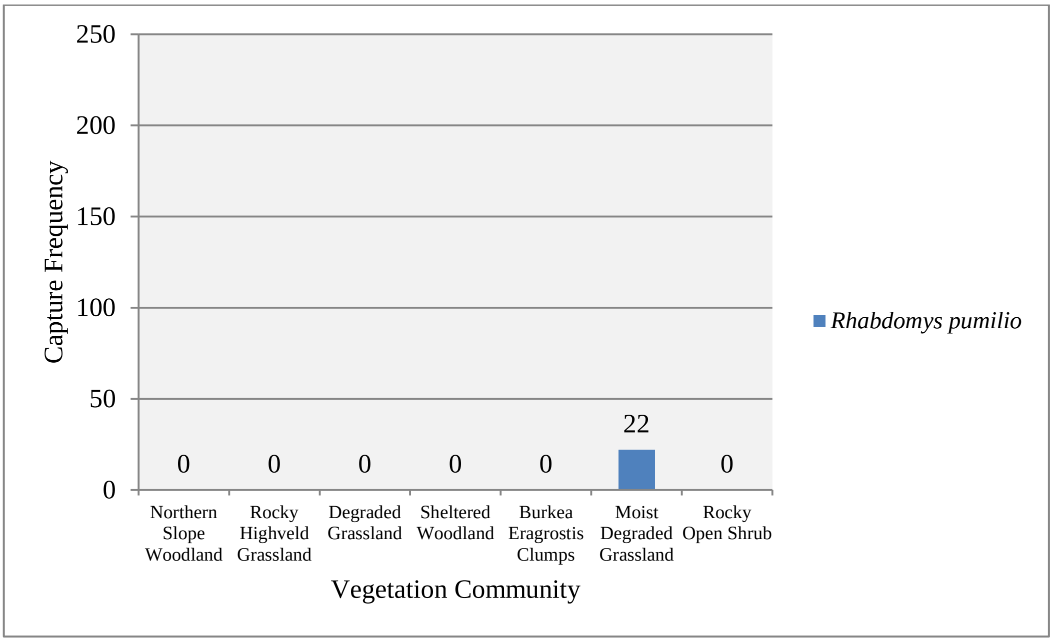

Figure 56. Graph illustrating the capture frequency for *Rhabdomys pumilio* in the different vegetation communities on Telperion.

*Rhabdomys pumilio* is a species which favors areas with a sufficient grass layer and associated cover. Statistically, the capture frequency of *R. pumilio* were significantly higher than was recorded for other species within this community ($\chi^2 = 44.000$; $df = 7$; $n = 56$; $P = 0.000$). This species often dominated small mammal numbers withing this specific community, however, during this study only contributed 1.6% to the total small mammal capture frequency recorded for the study. The Moist Degraded Grassland is significant and important for this species when compared to other vegetation communities assessed ($\chi^2 = 22.000$; $df = 1$; $n = 22$; $P = 0.000$).

### 6.5.14. Capture frequency recorded for *Steatomys pratensis* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Steatomys pratensis* between the seven vegetation communities during the study ($\chi^2 = 25.000$; $df = 6$; $n = 7$; $P = 0.000$). The highest capture recorded for *Steatomys pratensis* was in the Rocky Highveld Grassland ($n = 7$), as well as records from the Degraded Grassland ($n = 5$), and Burkea Eragrostis Clumps community ($n = 2$) (Fig. 57). This species inhabits open savanna, and is often recorded in habitats with sparse herbaceous cover. It is expected that the study area has marginally suitable habitat, and that this species prefers less dense, sweet veld.

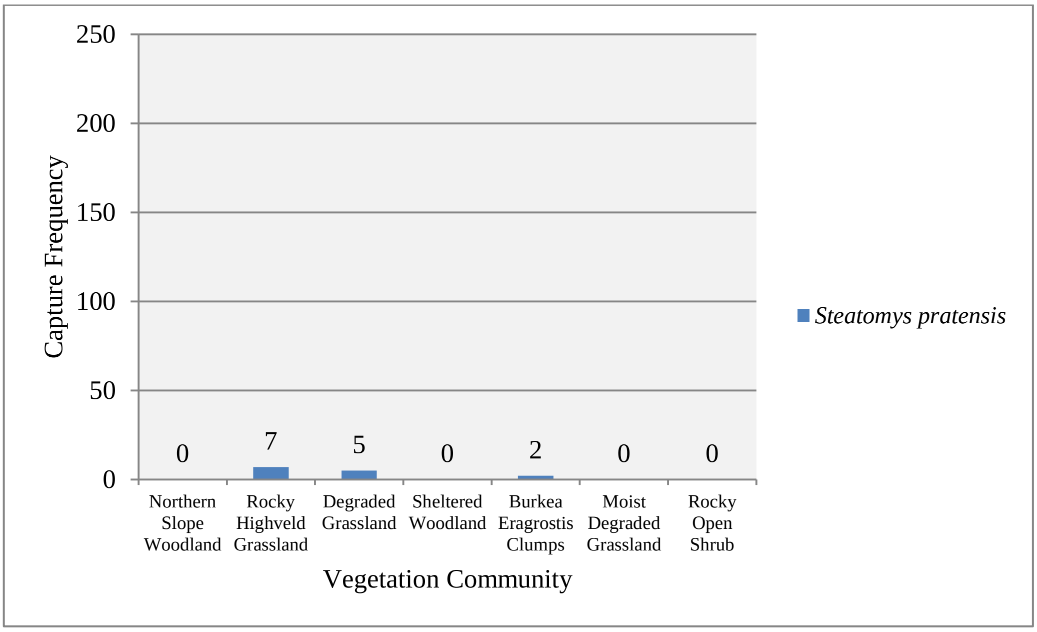

Figure 57. Graph illustrating the capture frequency for *Steatomys pratensis* in the different vegetation communities on Telperion.

*Steatomys pratensis* occurs in relatively low numbers in grassland habitats at the study site, appearing to avoid the rocky higher lying areas. No significant difference in capture frequency was found for *Steatomys pratensis* and *Mastomys* spp., both species recorded in the similar habitats ($\chi^2 = 0.037$; $df = 1$; $n = 27$; $P = 0.847$). This species contributed 1% to the total small mammal capture frequency recorded during the study, 0.5% in Rocky Highveld Grassland, 0.4% in Degraded Grassland, and 0.1% in the Burkea Eragrostis Clumps community. An insignificant difference in capture frequency was recorded between the Rocky Highveld Grassland (50%), Degraded Grassland (35.7%) and the Burkea Eragrostis Clumps (14.3%) communities ($\chi^2 = 2.756$; $df = 2$; $n = 24$; $P = 0.252$).

### 6.5.15. Capture frequency and trap success results recorded for *Crocidura cyanea* on Telperion

Statistically, there is an insignificant difference in capture frequency recorded for *Crocidura cyanea* between the seven vegetation communities assessed during the study ($\chi^2 = 4.300$; $df = 6$; $n = 7$; $P = 0.636$). A low capture frequency for *Crocidura cyanea* was recorded in three communities on Telperion, which included the Northern Slope Woodland community ($n = 1$), Degraded Grassland ($n = 1$) and Sheltered Woodland ($n = 1$) (Fig. 58). This species is found in low numbers in areas with sufficient grass cover, preferring areas with patches of dense grass extending further into areas with open grassland.

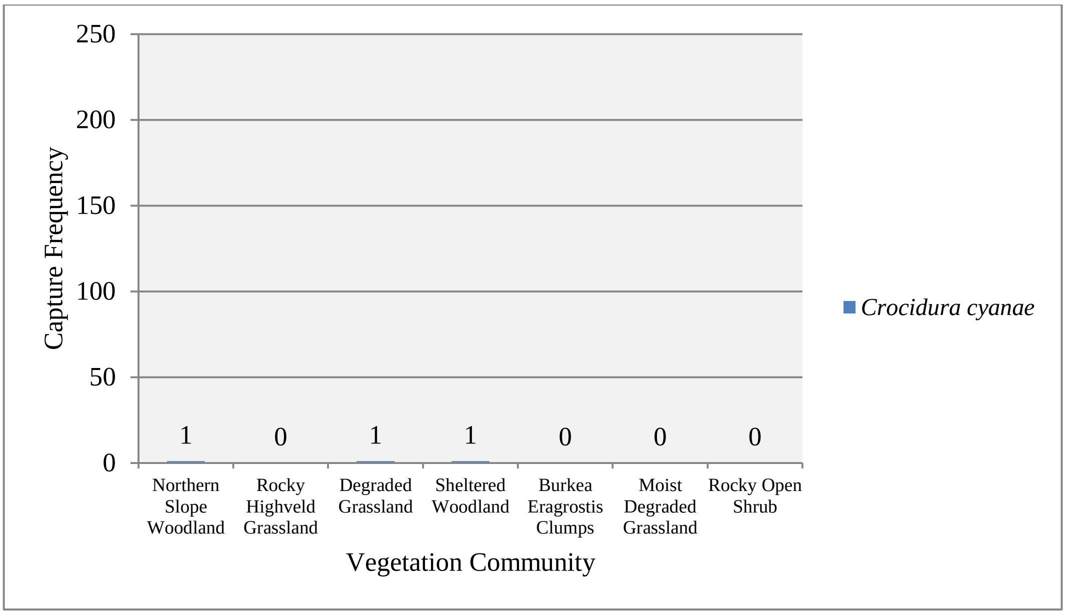

Figure 58. Graph illustrating the capture frequency for *Crocidura cyanea* for the different vegetation communities on Telperion

*Crocidura cyanea* occurs in low numbers in grassland habitats at the study site, while the record of a specimen in Northern Slope Woodland provides evidence of their presence in areas with a rocky substrate. Statistically, the capture frequency for *Crocidura cyanea* was significantly less than *Crocidura mariquensis* ($\chi^2 = 5.400$; $df = 1$; $n = 1369$; $P = 0.020$). This species contributed 0.3% to the total small mammal capture frequency recorded during the study, 0.1% in Northern Slope Woodland community, 0.1% in Degraded Grassland and 0.1% in Sheltered Woodland. There is an insignificant difference between capture frequency and vegetation communities, with 33% recorded in the Northern Slope Woodland community, 33.3% in Degraded Grassland, and 33.3% in the Sheltered Woodland community ($\chi^2 = 0.000$; $df = 2$; $n = 3$; $P = 1.000$).

### 6.5.16. Capture frequency recorded for *Crocidura mariquensis* on Telperion

Statistically, a significant difference in capture frequency was recorded for *Crocidura mariquensis* between the seven vegetation communities during the study ($\chi^2 = 49.076$; $df = 6$; $n = 7$; $P = 0.000$).The highest capture recorded for *Crocidura mariquensis* was in the Moist Degraded Grassland community ($n = 10$), although the species was recorded in vegetation along a drainage line in the Sheltered Woodland community ($n = 2$) (Fig. 59). This species is found on the fringes of seepage lines, marshes and vlei's on Telperion, preferring areas with suitable cover.

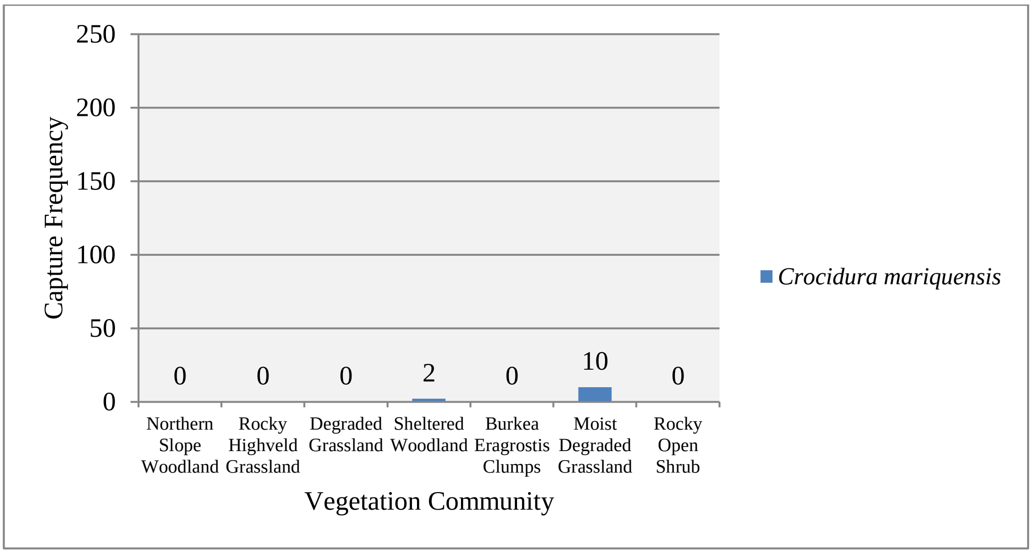

Figure 59. Graph illustrating the capture frequency for *Crocidura mariquensis* in the different vegetation communities on Telperion.

The difference in capture frequency between shrews *Crocidura mariquensis* and *Suncus infinitesimus* was insignificantly ($\chi^2$ = 2.882; *df* = 1; *n* = 17; *P* = 0.089). *Crocidura mariquensis* contributed 0.9% to the total small mammal capture frequency recorded during the study, 0.7% recorded in the Moist Degraded Grassland, and 0.2 % in Sheltered Woodland community. A significant percentage of individuals were recorded in the Moist Degraded Grassland (83.3%), with a lower percentage (16.7%) in the Sheltered Woodland community ($\chi^2$ = 5.333; *df* = 1; *n* = 12; *P* = 0.021). This species may be more abundant than recorded during this study as a result of a habitat bias. It is expected to be abundant in the rank vegetation along the rivers and tributaries at the study site.

### 6.5.17. Capture frequency recorded for *Elephantulus myurus* on Telperion

There is a significant difference in capture frequency recorded for *Elephantulus myurus* between the seven vegetation communities during the study ($\chi^2$ = 246.637; *df* = 5; *n* = 7; *P* = 0.000). The highest capture recorded for *Elephantulus myurus* was in the Rocky Open Shrub communities (*n* = 98), although the species was abundant in Northern Slope Woodland (*n* = 67), Sheltered Woodland (*n* = 27) and Rocky Highveld Grassland community (*n* = 27) (Fig. 60). This species was the most abundant insectivore at the study site and found in all areas with sufficient grass cover and rock for shelter. This species appears to have fixed territories as individuals were recorded repeatedly at set locations.

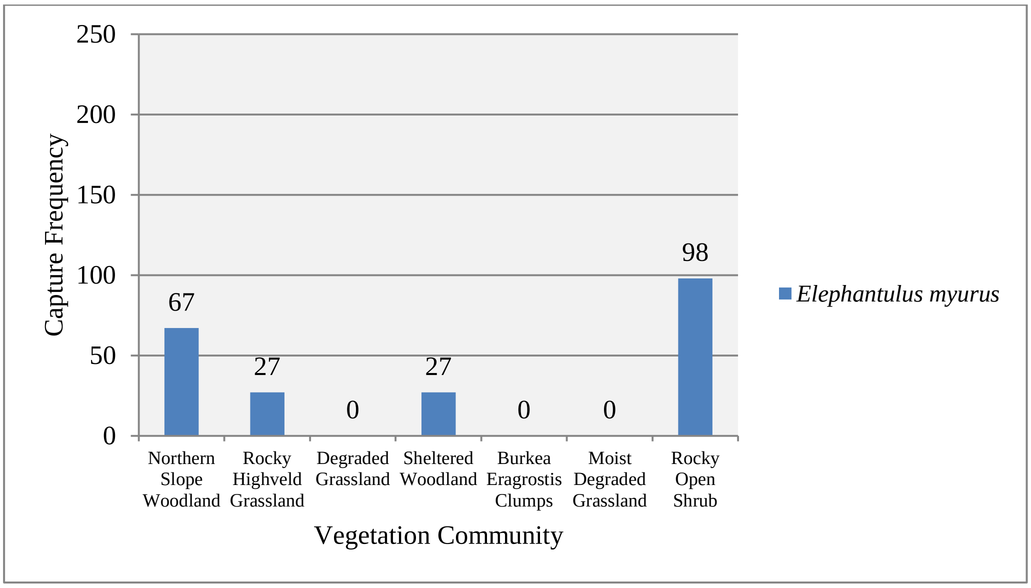

Figure 60. Graph illustrating the capture frequency for *Elephantulus myurus* in the different vegetation communities on Telperion

*Elephantulus myurus* frequented the untransformed rocky ridges at the study site. Statistically, the capture frequency for this species was significantly lower than *Micaelamys namaquensis* ($\chi^2$ = 308.586; *df* = 1; *n* = 991; *P* = 0.000). Second to *M. namaquensis*, *E. myurus* had the greatest recorded percentage, contributing 16% to the total small mammal recorded during this study, 7.2% recorded in Rocky Open Shrub, 4.9% in Northern Slope Woodland, 2% in Sheltered Woodland and 2% in the Rocky Highveld Grassland community. A significant percentage of individuals were recorded in the Rocky Open Shrub (44.7%), Northern Slope Woodland (30.6%), Sheltered Woodland (12.3%) and Rocky Highveld Grassland (12.2%) community ($\chi^2$ = 65.036; *df* = 3; *n* = 219; *P* = 0.000). This species was absent from Degraded Grassland, Moist Degraded Grassland, and Burkea Eragrostis Clumps due to a lack of rocky substrate in the communities. This species distribution is closely correlated with the presence of red sandstone at the study area, even occurring in communities with a few, scattered rocks.

### 6.5.18. Capture frequency recorded for *Suncus infinitesimus* on Telperion

There is significant difference in capture frequency recorded for *Suncus infinitesimus* between the seven vegetation communities during the study ($\chi^2$ = 18.486; *df* = 5; *n* = 7; *P* = 0.002). The highest capture recorded for *Suncus infinitesimus* was in the Moist Degraded Grassland community (*n* = 4), although the species was recorded in the Sheltered Woodland community (*n* = 1) (Fig. 61). This species was found on the fringes of seepage lines on Telperion, preferring areas with suitable grass cover.

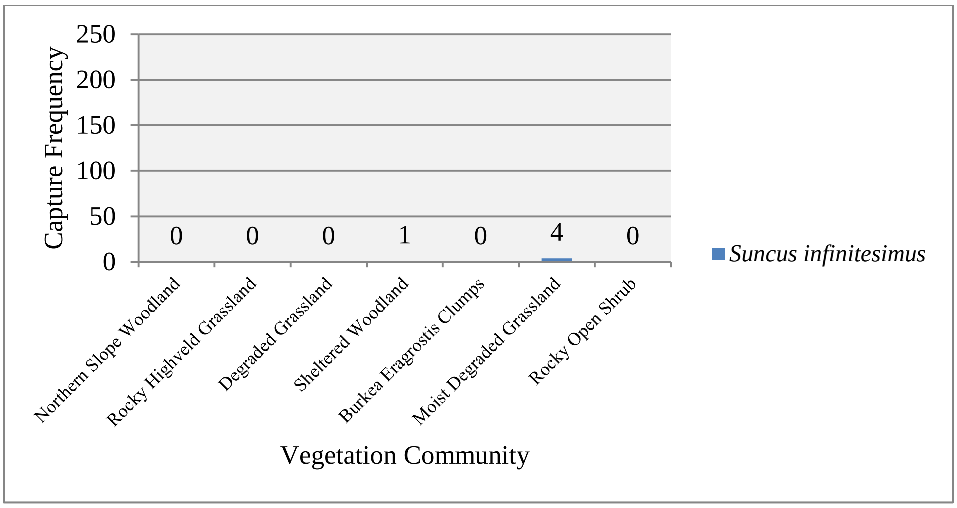

Figure 61. Graph illustrating the capture frequency for *Suncus infinitesimus* in the different vegetation communities on Telperion.

Statistically, the difference in capture frequency between *Suncus infinitesimus* and *Crocidura cyanea* are insignificantly ($\chi^2$ = 1.800; *df* = 1; *n* = 8; *P* = 0.479). *Suncus infinitesimus* contributed 0.4% to the total small mammal capture frequency recorded during the study, 0.3% recorded in the Moist Degraded Grassland, and 0.1% in Sheltered Woodland community. 80% of the *S. infinitesimus* recorded during the study were recorded in the Moist Degraded Grassland, and 20% in Sheltered Woodland community, although these differences in capture frequency are statisitcially insignificant ($\chi^2$ = 0.500; *df* = 1; *n* = 5; *P* = 0.179).

Capture frequency did not vary seasonally and with climatic conditions, as differences between seasons were insignificant ($\chi^2$ = 6.191; *df* = 3; *n* = 4; *P* = 0.103), with results for seasons similar, winter (27.5%), spring (25.1%), autumn (24.5%) and summer (22.9%). Capture frequency decreased (4.6%) over summer months, which could be a result increased activity by males in search of females. Eighteen species were sampled during this study: *Acomys spinosissimus*, *Aethomys chrysophilus*, *Dendromus melanotis*, *Dendromus mystacalis*, *Gerbilliscus brantsii*, *Gerbilliscus leucogaster*, *Graphiurus murinus*, *Lemniscomys rosalia*, *Mastomys* spp., *Micaelamys namaquensis*, *Mus minutoides*, *Otomys irroratus*, *Rhabdomys pumilio*, *Steatomys pratensis*, *Crocidura cyanea*, *Crocidura mariquensis*, *Elephantulus myurus* and *Suncus infinitesimus* (Table 29).

Table 29. Capture frequency for species recorded on Telperion over the duration of this study period.

| Species | Capture Frequency |
|---|---|
| *Micaelamys namaquensis* | 772 |
| *Elephantulus myurus* | 219 |
| *Dendromus melanotis* | 115 |
| *Lemniscomys rosalia* | 42 |
| *Mus minutoides* | 41 |
| *Acomys spinosissimus* | 24 |
| *Gerbilliscus leucogaster* | 24 |
| *Rhabdomys pumilio* | 22 |
| *Gerbilliscus brantsii* | 21 |
| *Aethomys chrysophilus* | 11 |
| *Dendromus mystacalis* | 18 |
| *Steatomys pratensis* | 14 |
| *Mastomys* spp. | 13 |
| *Crocidura mariquensis* | 12 |
| *Otomys irroratus* | 7 |
| *Graphiurus murinus* | 6 |
| *Suncus infinitesimus* | 5 |
| *Crocidura cyanea* | 3 |
| Total | 1369 |

*Micaelamys namaquensis* dominated the capture frequency (*n* = 772). Fluctuations in species diversity occurred monthly. The following frequencies were recorded during the study period *Micaelamys namaquensis* (n = 772), *Elephantulus myurus* (n = 219), *Dendromus melanotis* (*n* = 115), *Lemniscomys rosalia* (*n* = 42), *Mus minutoides* (n = 41), *Acomys spinosissimus* (*n* = 24), *Gerbilliscus leucogaster* (*n* = 24), *Rhabdomys pumilio* (n = 22), *Gerbilliscus brantsii* (*n* = 21), *Dendromus mystacalis* (*n* = 18), *Steatomys pratensis* (n = 14), *Mastomys* spp. (*n* = 13), *Crocidura mariquensis* (n = 12), *Aethomys chrysophilus* (*n* = 11), *Otomys irroratus* (n = 7), *Graphiurus murinus* (*n* = 6), *Suncus infinitesimus* (n = 5) and *Crocidura cyanea* (n = 3).

The capture percentage recorded during the study period are as follows *Micaelamys namaquensis* (56.4%), *Elephantulus myurus* (16.0 %), *Dendromus melanotis* (8.4%), *Lemniscomys rosalia* (3.1%), *Mus minutoides* (3.0%), *Acomys spinosissimus* (1.8%), *Gerbilliscus leucogaster* (1.8%), *Rhabdomys pumilio* (1.6%), *Gerbilliscus brantsii* (1.5%), *Dendromus mystacalis* (1.3%), *Steatomys pratensis* (1.0%), *Crocidura mariquensis* (0.9%), *Mastomys* spp. (0.9%), *Aethomys chrysophilus* (0.8%), *Otomys irroratus* (0.5%), *Graphiurus murinus* (0.4%), *Suncus infinitesimus* (0.4%), and *Crocidura cyanea* (0.2%) (Appendix K).

## 6.6. Discussion:

The aim of this chapter is to determine capture frequency of small mammal fauna recorded during the current study in the Bankenveld grasslands of Mpumalanga Province, South Africa. The frequency of new and recaptured individuals provides valuable information on the small mammal population at the study site. Because of the relatively small sample sizes of certain species, interpretation of recaptured data was restricted to individuals recaptured within transects during a particular survey. Eighteen species of small mammal were recorded during this study. Small mammals (= adults < 2kg) comprise quite a large percentage (> 60%) of all terrestrial mammal species in southern Africa (Skinner & Chimimba 2005). Small mammals have an important direct and indirect influence on ecosystem functioning.

Biodiversity of small mammals is used as an effective indicator of disturbance in natural ecosystems. A high capture frequency of *Mastomys* spp. in all habitats indicates a level of disturbance at the study site; hence low numbers indicate a balanced system. The relationships between small mammals and the environment in which they live is often complex in nature (Avenant 2000a; Birney *et al.* 1976). Small mammal community structure and species richness have been related to variables such as habitat structure and complexity (Rosenzweig & Winakur 1969; Brown 1973; French *et al.* 1976; Bond *et al.* 1980; Dueser & Brown 1980; Rowe-Rowe & Meester 1982a; Thompson 1982; Parmenter & MacMahon 1983; Kotler 1984; Abramsky 19878; Kerley 1992; Els & Kerley 1996), area (Abramsky *et al*. 1985; Fitzgibbon 1997), productivity (Abramsky 1978, 1988; Rosenweig 1992); predation (Kotler 1984; Norrdahl & Korpimäki 1995; Abramsky *et al.* 1998; trampling and grazing (Keesing 1998; Milchunas *et al*. 1998); surrounding landscape and the distance between similar habitats (Fitzgibbon 1997), and the maturity of the habitat and succession of the vegetation (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Rowe-Rowe 1995; Fitzgibbon 1997; Ferreira & van Aarde 1999). There appears to be a strong connection between disturbance in an ecosystem and the presence or absence of small mammal indicator species (Noss 1990; Armstrong & Van Hensbergen 1996; Avenant 1996; Leirs *et al.* 1996; Barreto *et al.* 1998.

The Rocky Open Shrub, Northern Slope Woodland, and Rocky Highveld Grassland communities had the highest capture frequency recorded for the study. This was due to high capture frequencies recorded for *Micaelamys namaquensis* and *Elephantulus myurus* in these vegetation communities. The Degraded Grassland and Moist Degraded Grassland communities had high diversity, but low capture frequencies. The reason for this capture frequency is the low numbers of small mammals in these communities in the summer months. The Burkea Eragrostis Clumps community had a low capture frequency in all seasons, possibly due to the lack of grass biomass in this community.

Massawe *et al.* (2006) found an increase in rodent population in areas after seed emergence, although this trend was more evident in areas which had been slashed and burned through farming practices. Rainfall, timing, duration and amount, has a strong influence on the population dynamics of rodents as it indirectly affects availability of resources. The results of this study support Avenant (2000a,b) that mid-autumn and mid-winter for certain species prove to be the best time to conduct small mammal sampling, although spring produced reasonable numbers of certain species. The summer months are less favourable, and produce significantly less animals and variety of species during this time of the year.

This study is important as it investigates the capture frequency of small mammal populations in the fire-climax grassland of the Bankenveld. In comparison, previously transformed communities had a lower capture frequency when compared to the historically non-transformed sites. The Rocky Highveld Grassland had the highest capture frequency for four species (*Dendromus mystacalis*, *Gerbilliscus leucogaster*, *Lemniscomys rosalia*, and *Steatomys pratensis*). These species favor areas with sufficient grass biomass, with sandy soils. The Rocky Open Shrub had the highest capture frequency for three species (*Aethomys chrysophilus*, *Micaelamys namaquensis* and *Elephantulus myurus*) recorded during the study. The highest capture frequency for *Otomys irroratus*, *Rhabdomys pumilio* and *Crocidura mariquensis* were recorded in the Moist Degraded Grassland community, *Acomys spinosissimus* and *Graphiurus murinus* in the Northern Slope Woodland, *Gerbilliscus brantsii* and, *Mus minutoides* in the Burkea Eragrostis Clumps and *Crocidura cyanea* in the Sheltered Woodland community. The habitat requirements for the different species recorded during the study determine the presence or absence of a species within a vegetation community.

Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Co-existence in a grassland habitat may also be promoted by mechanisms that reduce interspecific competition (Kinahan & Pillay 2008) and thus improve overall fitness. Differential habitat use and the use of resources within these different systems, especially in space and time, may facilitate co-existence between species on a reserve, or specific habitat (M'Closkey 1976; Brown 1989; Yunger *et al.* 2002; Zhang 2003; Bonesi & Macdonald 2004; Harris *et al.* 2006).

The competition theory assumes that at competitive equilibrium in densities are maintained (Ferreira & Van Aarde 1999), and may thus act to structure communities (Hughes *et al.* 1994; Manor & Saltz 2008). Demonstrating that different species of small mammals may use different parts of a resource, such as seeds as opposed to culms of grass, does not indicate the absence of competition between species, and thus competitive interactions, similarly, competition cannot be inferred in a variety of species occurring in the same resource (Conley 1976; Holbrook 1979; Schoener 1983).

Home range also gives an indication of the social structure of small mammal species (Schradin & Pillay 2006; Cooper & Randall 2007), and may influence capture frequency. Polygynous species tend to have a high degree of intraspecific overlap, especially between females and thus also tend to have higher densities (Ribble & Stanley 1998; Priotto *et al.* 2002). Promiscuous species within a community also tend to have high densities with a high degree of overlap between sexes, since males are unable to monopolise widespread females (Ostfeld 1990; Ribble & Stanley 1998; Jackson 1999). The increase in activity associated with promiscuity of these species may increase capture frequency.

The presence of different species of small mammals within a community is often associated with grass cover, plant litter and vegetation density, and substrate with certain species in known to influence the assemblage recorded. Habitats are often related to foraging efficiencies (Bonesi & Macdonald 2004), often resulting in a specialist dominating over a generalist. Although, a generalist has a wider scope in its feeding and habitat selection, being more flexible should it be required to change its optimal choice selection. Temperature could influence capture frequency, especially during exceptionally cold and wet periods. Timing of breeding in small mammal populations is often constrained, not only by the environment but also phylogenetically in terms of age of reproduction. Population size fluctuations and species richness are due to differences in recruitment (movements into the population through birth and immigration) and emigration (movements out of the population through dispersal and death (Bronner 1986). The fluctuations in capture frequency in the present study appear to correlate with the breeding season in certain species, and appeared cover driven in other species, such as *Dendromus melanotis*. Space use by small mammals in the Bankenveld may be influenced by variation in food distribution and abundance and the variety of acceptable food resources. This in unpredictable environments, or under high population density, home range size may be larger as distance travelled to find resources in order to meet energy requirements increases (Pasch & Koprowski 2006).

During this study, the highest capture frequencies were recorded in winter and spring, largely due to the high capture frequency of *E. myurus* in the winter months (See Chapter 10). According to Avenant (2000a), homogeneous habitats should be selected and marginal areas (at the edge of habitats) should be avoided as the edges often house more species and can be seen as refugia where individuals can profit from the best of both habitats. Care was taken to ensure the habitats selected where "pure" representations of these habitat types, as although ecologically important, these edges often house more species and can be seen as refugia where individuals can profit from the best in two environments (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Hansson 1998). For this reason they play an important role in the recolonization and species persistence of small mammals.

Petersen (2006) found small mammal abundance and diversity to be linked and correlated with grass biomass. Biomass appears to be linked to the foraging activity and concentration of mega-herbivores and anthropogenic management of the area (in the Telperion case study, previously disturbed areas and overgrazed areas). Small mammal populations, whilst fluctuating through time are a constant influence within landscapes that contain suitable habitats. Stable ecosystems support a wide range of wildlife fauna in all niches. Control of large herbivores numbers is important in preventing further impacts of these animals, decreasing the potential of habitat to support certain small mammal species.

The project has identified areas with a high capture frequency, assessing vegetation structure and taking in to consideration small mammal groups that reflect the species richness across a set of environments, thus acting as surrogates for the "wholesale" biodiversity (Gaston 1996a; McGeoch 1998). Data were also recorded in communities at different areas according to vegetation community and historical agricultural influences on the property. The historical influence in certain areas on the property resulted in some differences in vegetation diversity, density and height. In the current study, *M. namaquensis* had the highest capture frequency in four of the seven vegetation communities, followed by *E. myurus*. These two species were absent from Degraded Grassland, Moist Degraded Grassland and Burkea

Eragrostis Clumps. G. *murinus, S. infinitesimus* and *C. cyanea* were species with the lowest capture frequency recorded during the study. It is expected that these three species occur in low number at the study site.

# CHAPTER 7

# SMALL MAMMAL SPECIES RICHNESS AND COMPOSITION IN DIFFERENT VEGETATION COMMUNITIES

## 7.1. Abstract

This chapter aims to determine the species richness and composition for small mammal fauna in seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Species richness is defined as the number of different species represented in a vegetation community, and is simply a record of species, not taking abundances of the species or their relative distributions into account. Community structure is the structure of the assemblage or associations of populations of different species occupying a vegetation community or study area. Ten species were recorded for the Rocky Highveld Grassland community, a community consisting of *Micaelamys namaquensis* (37%), *Dendromus melanotis* (19.6%) and *Gerbilliscus leucogaster* (10.9%); nine species were recorded for the Degraded Grassland community, predominantly consisting of *Dendromus melanotis* (62.3) and *Mus minutoides* (10.4%); eight species recorded for the Northern Slope Woodland community, predominantly consisted of *Micaelamys namaquensis* (66.1%) and *Elephantulus myurus* (19.4%); eight species were recorded for the Sheltered Woodland community, dominated by *Micaelamys namaquensis* (63%) and *Elephantulus myurus* (16.4%); and eight species recorded in the Moist Degraded Grassland community, predominantly consisting of *Rhabdomys pumilio* (33.3%) and *Otomys irroratus* (15.4%). The Burkea Eragrostis Clump community was less productive than the other sites with six species recorded. The community structure dominated by *Gerbilliscus brantsii* (35.3%), *Dendromus melanotis* (26.9%) and *Mus minutoides* (26.9%). The Rocky Open Shrub community had a high abundance recorded; however, only three species of small mammal were recorded in the vegetation community. The community structure percentage predominantly consisted of *Micaelamys namaquensis* (75.8%) and *Elephantulus myurus* (21%). The untransformed Rocky Highveld Grassland had the highest species richness, followed by the transformed Degraded Grassland community. This provides evidence that study areas with high species richness require habitats of varying ecological state.

**Keywords:** Species richness, Telperion, Ezemvelo Nature Reserve, small mammals, ecological state, community structure, vegetation, communities, South Africa

## 7.2. Introduction

Species richness is defined as the number of different species represented in a vegetation community, and is simply a record of species, not taking abundances of the species or their relative distributions into account. Community composition is the structure of the assemblage or associations of populations of different species occupying a vegetation community or study area. The purpose of this chapter is to determine the species richness and composition of small mammal fauna within seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. These properties are situated to the extreme north of the grassland biome in South Africa, recognized by Acocks (1988) as Bankenveld, while Bredenkamp and Van Rooyen (1998) classified it as Rocky Highveld Grassland. Plant succession, condition of habitat, grass palatability, ecological status, geographic location and vegetation structure are recorded to have an impact on small mammal diversity and community composition (Els & Kerley 1996; Fitzgibbon 1997; Monadjem 1997; Abramsky *et al.* 1998; Ferreira & Van Aarde 1999; Monadjem 1999; Avenant 2000a). It is generally accepted that when there are changes in habitats through ecological disturbances, a decrease in the species richness of small mammals can be expected (Monadjem & Perrin 2003). Rainfall, fire and grazing individually and in combination play a major role in shaping the vegetation dynamics of ecosystems around the globe. The relative influence of density dependence in the dynamics of rodent populations is a matter of considerable debate (Krebs 2002; Berryman 2004). Nevertheless, population growth rates are often related negatively to density, in that population abundance is likely to decline when high and increase when low (Turchin 1999). Populations of short-lived organisms, such as rodents, appear more sensitive to changes in fecundity than adult survival (Oli & Dobson 2003; Gaillard *et al.* 2005). Density dependence affects the population dynamics of many species (Sibly *et al.* 2005), whereas seasonal changes in survival and fecundity appear to exert great influence on certain populations (Boonstra & Krebs 2006).

Habitat preferences of rodents in Africa are determined primarily by the type of cover available to them and in general, dense plant covers supports a higher diversity of small mammal species and are lowest at intermediate values of plant cover (Monadjem 1997). Food supply is another factor that influences small mammal biomass (Doonan & Slade 1995). Low level grazing and burning can help maintain small mammal biodiversity, if conducted under appropriate rainfall levels (Yarnell *et al.* 2007). Grazing is also thought to have negative impacts on the abundance and community structure of small mammals (Nyako-Lartey & Baxter 1995; Joubert & Ryan 1999) through the reduction in food quality (Keesing 1998) and cover (Kerley 1992). However, moderate levels of grazing may enhance small mammal diversity (Schmidt *et al.* 2005) by facilitating the creation of more ecological niches through heterogeneous habitat structuring (Kerley 1992). Small mammal communities have been used as indicators of habitat integrity (Avenant 2000a, 2003; Avenant & Kuyler 2002; Avenant and Watson 2002). Biodiversity of small mammals is used as an effective indicator of disturbance in natural ecosystems. In general, changes in small mammal habitats are associated with changes in species richness and ecological disturbance of these habitats is associated with a decrease in small mammal species richness.

Co-existence in a grassland habitat may also be promoted by mechanisms that reduce interspecific competition (Kinahan & Pillay 2008) and thus improve overall fitness. How small mammals choose an area is a result of cover availability, differences in micro-climate, substrate, predation risk and food availability (Chesson 1986). Certain vegetation communities at the site are expected to have higher species diversity of small mammals. This chapter aims to identify areas of high species richness, assess vegetation structure and taking in to consideration small mammal groups that reflect the species richness across a set of environments, thus acting as surrogates for the “wholesale” biodiversity (Gaston 1996a; McGeoch 1998). This chapter will provide evidence that high species richness occurs in habitats of varying ecological state.

## 7.3. Methodology

Species richness was calculated by caculating the number of species over the study period based on data recorded from 10 transects placed in seven broad vegetation communities, Northern Slope Woodland (NSW), Rocky Highveld Grassland (RHG), Degraded Grassland (DG), Sheltered Woodland (SW), Burkea Eragrostis Clumps (BEC), Moist Degraded Grassland (MDG) and Rocky Open Shrub (ROS). Data on small mammal species richness were recorded in each vegetation communities (Appendix L). The landscapes had significant differences in soil, geology, hydrology and associated vegetation. In year one (2008), 10 transects each comprising 30 live-traps Sherman each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month. The starting-point was placing transects in the seven vegetation communities. Species richness was recorded in the Northern Slope Woodland community from two transects, NSW 1 and NSW 3, in Rocky Highveld Grassland from two transects, RHG 2 and RHG 3, and from two transects in the Degraded Grassland community, DG 2 and DG 3. Data were collected from one transect for the remaining four vegetation communities, SW 1 in the Sheltered Woodland community, BEC 1 in the Burkea Eragrostis Clumps, MDG 3 in the Moist Degraded Grassland and ROS 1 in the Rocky Open Shrub community.

In year one, two transects were placed in the dominant communities to obtain a greater sample size. In year one, 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. 10 m spacing was adopted at the study site with the available traps. In year two, three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per site. Analysis of variance (ANOVA) was used to test for significant differences between species richness and vegetation communities (Fowler *et al.* 1998). Tukey's test was undertaken when the result from ANOVA indicated a significant difference between the variables. Tukey's test provides an indication of where significant differences occur.

Other statistical methods used included Chi-square ($\chi^2$) test to analyze frequencies. All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 7.4. Results

Small mammal species richness was recorded in the different vegetation communities included Rocky Highveld Grassland ($n$ = 10), Degraded Grassland ($n$ = 9), Northern Slope Woodland ($n$ = 8), Sheltered Woodland ($n$ = 8), Moist Degraded Grassland ($n$ = 8), Burkea Eragrostis Clumps ($n$ = 6), and Rocky Open Shrub ($n$ = 3) (Fig. 62). ANOVA revealed a highly significant differences between species richness and vegetation community ($F_{1.6}$ = 6.78; $n$ = 18; $P$ = 0.000). Significant differences in species richness occured between Rocky Highveld Grassland and Northern Slope Woodland (Tukey's: $P$ = 0.04), Sheltered Woodland (Tukey's: $P$ = 0.02), Rocky Open Shrub (Tukey's: $P$ = 0.00), Burkea Eragrostis Clumps (Tukey's: $P$ = 0.00) and Moist Degraded Grassland (Tukey's: $P$ = 0.02), with an insignificant (Tukey's: $P$ = 0.37) difference in species richness when compared with Degraded Grassland.

There was also a significant difference recorded between Degraded Grassland and Rocky Open Shrub (Tukey's: $P = 0.02$).

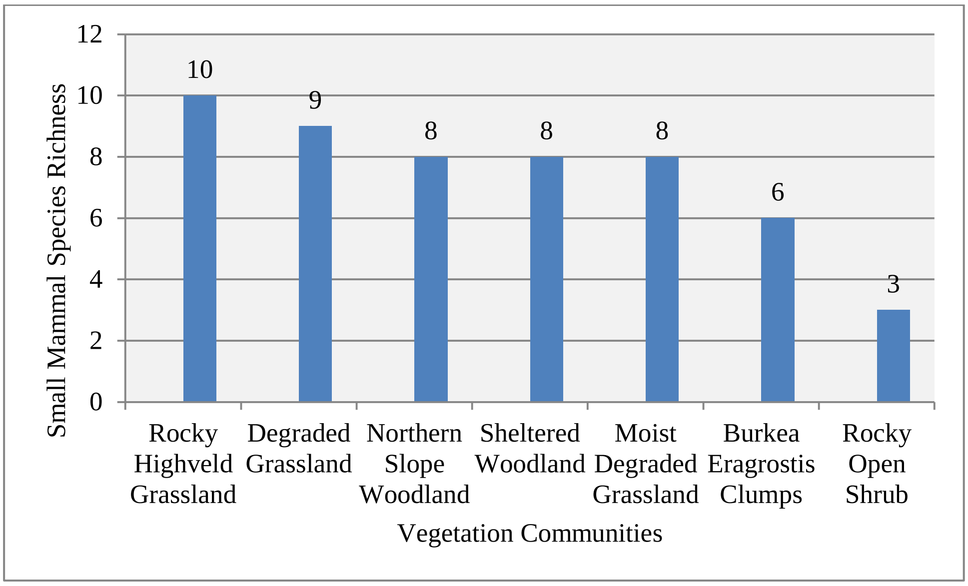

Figure 62. Graph illustrating the comparison of small mammal species richness between the seven vegetation communities on Telperion.

Community structure is calculated by recording individual animals trapped over the study period. The number of individual captured between different vegetation communities included, Northern Slope Woodland ($n = 124$), and Rocky Open Shrub, ($n = 124$), Rocky Highveld Grassland ($n = 92$), Degraded Grassland ($n = 77$), Sheltered Woodland ($n = 73$), Moist Degraded Grassland ($n = 39$), and Burkea Eragrostis Clumps ($n = 34$). The previous veld management practice was noted. ANOVA revealed significant differences between community structure and vegetation community ($F_{1.6} = 3.79$; $n = 663$; $P = 0.010$). Significant differences in species richness occured between Rocky Open Shrub and Moist Degraded Grassland (Tukey's: $P = 0.01$) and Burkea Eragrostis Clumps (Tukey's: $P = 0.01$),

## 7.5. Assessment of small mammal species richness and community structure in the vegetation communities on Telperion

### 7.5.1 Assessment of small mammal species richness and community structure in the Northern Slope Woodland (NSW) vegetation community on Telperion

This community had high species richness and eight species of small mammals from this community were recorded during the study (Fig. 64). The following species were recorded in the Northern Slope Woodland community, *Acomys spinosissimus, Aethomys chrysophilus, Dendromus melanotis, Graphiurus murinus, Micaelamys namaquensis, Mus minutoides, Elephantulus myurus* and *Crocidura cyanea.* Statistically there is an insignificant difference between species richness within the Northern Slope Woodland community and the average recorded in other vegetation communities assessed during this study ($\chi^2 = 0.021$; $df = 1$; $n = 15.4$; $P = 0.884$). The species richness of small mammals recorded for the Northern Slope Woodland community ($n = 8$) was high in comparison with other vegetation communities at the study site.

*Graphiurus murinus* was recorded exclusively in the Northern Slope Woodland community during this study. This species favours areas with suitable rocky outcrops and woodland, both represented in this community. 44.4% of the species recorded during this study were represented in the Northern Slope Woodland community. A total of 124 individual small mammals were recorded in the Northern Slope Woodland community (Fig. 63). This site consists of rocky ridges and outcrops on Telperion, areas with scattered large boulders. Statistically there is a highly significant difference between species community assessed within the Northern Slope Woodland ($\chi^2 = 354.064$; $df = 7$; $n = 124$; $P = 0.000$). The numbers per species recorded for the Northern Slope Woodland community were *Micaelamys namaquensis* ($n = 82$), *Elephantulus myurus* ($n = 24$), *Acomys spinosissimus* ($n = 9$), *Graphiurus murinus* ($n = 5$), *Aethomys chrysophilus* ($n = 1$), *Dendromus melanotis* ($n = 1$), *Mus minutoides* ($n = 1$), and *Crocidura cyanea* ($n = 1$). Statistically there is a significant difference between community structure within the Northern Slope Woodland community and the average between all other vegetation communities assessed during this study ($\chi^2 = 3.924$; $df = 1$; $n = 218.7$; $P = 0.047$).

The community structure percentage recorded in the Northern Slope Woodland community consists of *Micaelamys namaquensis* (66.1%), *Elephantulus myurus* (19.4%), *Acomys spinosissimus* (7.3%), *Graphiurus murinus* (4%), *Aethomys chrysophilus* (0.8%), *Dendromus melanotis* (0.8%), *Mus minutoides* (0.8%), and *Crocidura cyanea* (0.8) (Fig. 63). The Northern Slope Woodland community is dominated by *M. namaquensis* and *E. myurus,* with *A. spinossimus* and *G. murinus* worth noting, although their numbers were recorded in low densities this vegetation community is an important habitat for these species due to the abundance of suitable boulders and rock crevices.

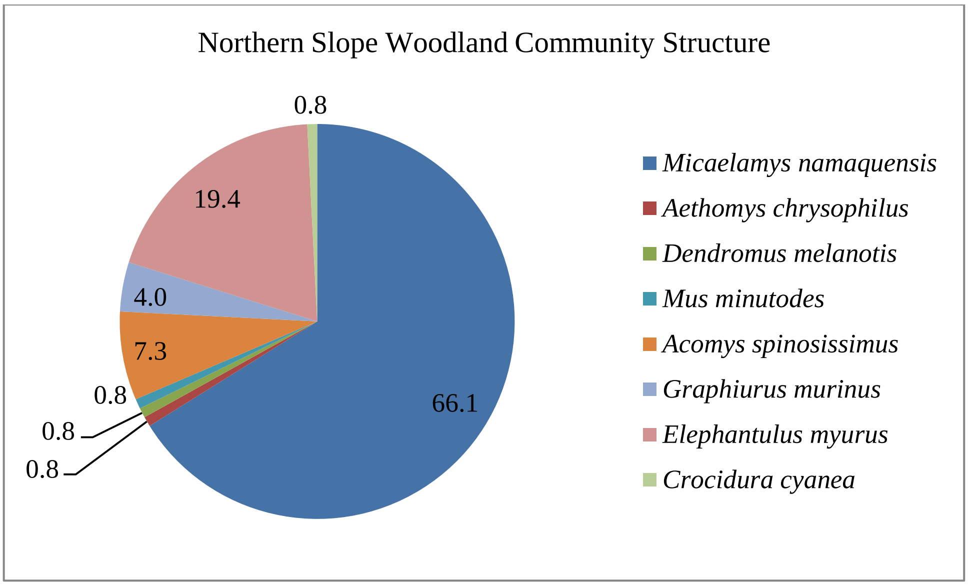

Figure 63. The community structure of small mammals recorded in the Northern Slope Woodland community on Telperion.

### 7.5.2. Assessment of small mammal species richness and community structure in the Rocky Highveld Grassland (RHG) vegetation community on Telperion

This community was the most productive community with 10 species recorded during the study period. The following species were recorded in the Rocky Highveld Grassland community: *Aethomys chrysophilus*, *Dendromus melanotis*, *Dendromus mystacalis*, *Gerbilliscus leucogaster*, *Lemniscomys rosalia*, *Mastomys* spp., *Micaelamys namaquensis*, *Mus minutoides*, *Steatomys pratensis*, and *Elephantulus myurus*. (Fig. 65). This community is relatively untransformed and is balanced, stable ecological state and therefore had a high species richness of small mammal species. Statistically there is an insignificant difference between species richness within the Rocky Highveld Grassland community and the average recorded in other vegetation communities assessed during this study ($\chi^2 = 0.380$; $df = 1$; $n = 17.4$; $P = 0.537$). The species richness for the Rocky Highveld Grassland community ($n = 10$) was high in comparison with other communities at the study site. No species were recorded exclusively in the Rocky Highveld Grassland community during this study, although species richness was high. 55.6% of the species richess recorded during this study was represented in the Rocky Highveld Grassland.

A total number of 92 individual small mammals were recorded in the Rocky Highveld Grassland community were recorded (Fig. 64). The rockiness of the study site varies considerably with sparse to dense surface rocks, varying in size from boulders to flat rocky ridges. Statistically there is a highly significant difference between species community structure assessed within the Rocky Highveld Grassland ($\chi^2 = 98.435$; $df = 9$; $n = 92$; $P = 0.000$). The abundance of individual species recorded in Rocky Highveld Grassland community was: *Micaelamys namaquensis* ($n = 34$), *Dendromus melanotis* ($n = 18$), *Gerbilliscus leucogaster* ($n = 10$), *Elephantulus myurus* ($n = 8$), *Dendromus mystacalis* ($n = 6$), *Lemniscomys rosalia* ($n = 6$), *Mus minutoides* ($n = 5$), *Steatomys pratensis* ($n = 3$), *Aethomys chrysophilus* ($n = 1$), and *Mastomys* spp. ($n = 1$). Statistically there is an insignificant difference between community structure within the Rocky Highveld Grassland community and the average between all other vegetation communities assessed during this study ($\chi^2 = 0.039$; $df = 1$; $n = 186.7$; $P = 0.843$).

The community structure percentage recorded in the Rocky Highveld Grassland community consists of *Micaelamys namaquensis* (37%), *Dendromus melanotis* (19.6%), *Gerbilliscus leucogaster* (10.9%), *Elephantulus myurus* (8.7%), *Dendromus mystacalis* (6.5%), *Lemniscomys rosalia* (6.5%), *Mus minutoides* (5.4%), *Steatomys pratensis* (3.3%), *Aethomys chrysophilus* (1.1%) and *Mastomys* spp. (1.1%) (Fig. 64). The Rocky Highveld Grassland community is dominated by *M. namaquensis* and *D. melanotis*, with *G. leucogaster* and *E. myurus* worth noting although their numbers were recorded in low densities this vegetation community is an important habitat for these species due to the abundance of suitable sandy soils, boulders and rock crevices.

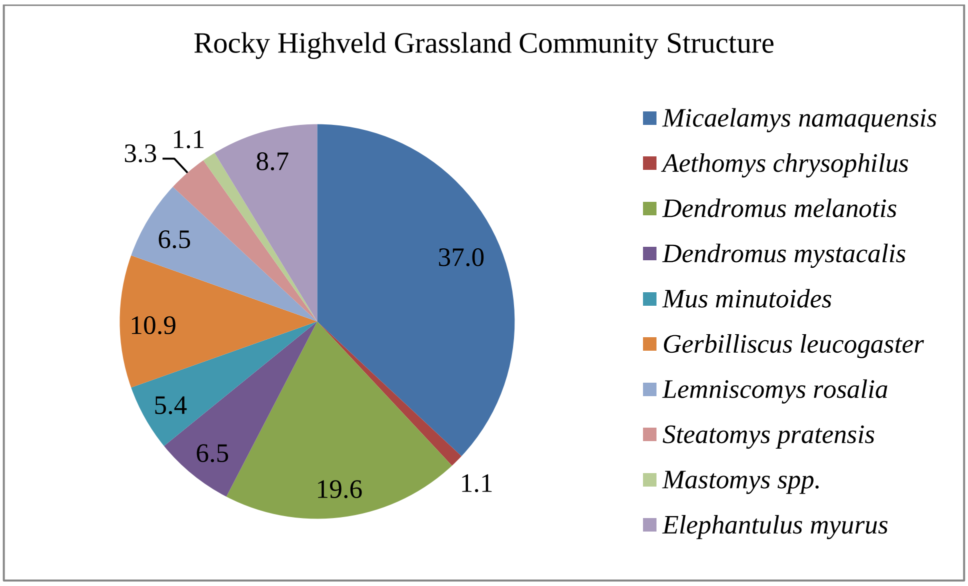

Figure 64. The community structure of small mammals recorded in the Rocky Highveld Grassland community on Telperion.

### 7.5.3. Assessment of small mammal species richness and community structure in the Degraded Grassland (DG) vegetation community on Telperion

This community was surprisingly productive and nine species of small mammal were recorded during the study. The following species were recorded in the Degraded Grassland community, *Dendromus melanotis, Dendromus mystacalis, Gerbilliscus leucogaster, Lemniscomys rosalia, Mastomys spp., Mus minutoides, Steatomys pratensis* and *Crocidura cyanea* (Fig. 65). Statistically there is an insignificant difference between species richness within the Degraded Grassland community and the average recorded in other vegetation communities assessed during this study ($\chi^2 = 0.151$; $df = 1$; $n = 16.4$; $P = 0.698$). The species richness for the Degraded Grassland community ($n = 9$) was high, possibly due to generalist and specialized species been recorded in this community. No species were recorded only in the Degraded Grassland community during this study, although species richness was high. 50% of the species recorded during this study were represented in the Degraded Grassland community.

A total number of 77 individual small mammals for the Degraded Grassland community were recorded (Fig. 65). This site is situated on nutrient-poor sandy soils derived from sandstone and is predominantly old cultivated lands disturbed by plough action in the past. Statistically there is a highly significant difference between species community structure assessed within the Degraded Grassland ($\chi^2 = 178.803$; $df = 7$; $n = 77$; $P = 0.000$). The abundance of individual species recorded for the Degraded Grassland community were; *Dendromus melanotis* ($n = 48$), *Mus minutoides* ($n = 8$), *Lemniscomys rosalia* ($n = 6$), *Mastomys* spp. ($n = 5$), *Steatomys pratensis* ($n = 5$), *Dendromus mystacalis* ($n = 2$), *Gerbilliscus leucogaster* ($n = 2$), and *Crocidura cyanea* ($n = 1$). Statistically there is an insignificant difference between community structure within the Degraded Grassland community and the average between all other vegetation communities assessed during this study ($\chi^2 = 1.824$; $df = 1$; $n = 171.7$; $P = 0.177$).

The community structure percentage recorded in the Degraded Grassland community consists of *Dendromus melanotis* (62.3%), *Mus minutoides* (10.4%), *Lemniscomys rosalia* (7.8%), *Mastomys* spp. (6.5%), *Steatomys pratensis* (6.5%), *Dendromus mystacalis* (2.6%), *Gerbilliscus leucogaster* (2.6%), and *Crocidura cyanea* (1.3%) (Fig. 65). The Degraded Grassland community is dominated by *D. melanotis*, with *M. minutoides* and *L. rosalia* worth noting although their numbers were recorded in low densities this vegetation community is an important habitat for these species due to the abundance of suitable grass cover.

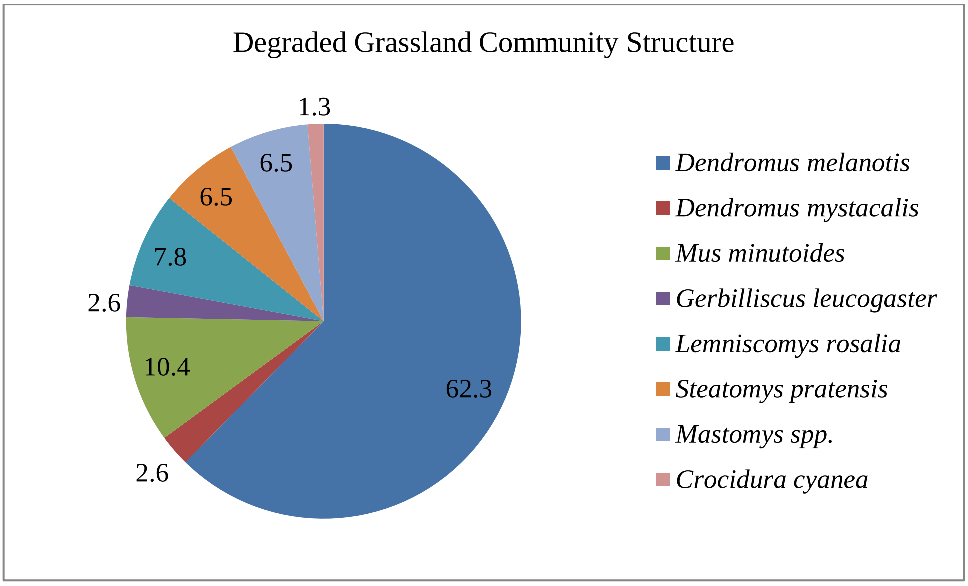

Figure 65. The community structure of small mammals recorded in the Degraded Grassland community on Telperion.

### 7.5.4. Assessment of small mammal species richness and community structure in the Sheltered Woodland (SW) vegetation community on Telperion

This community had high species richness and 8 species of small mammals were recorded during the study. The following species were recorded in the Sheltered Woodland community: *Acomys spinosissimus*, *Dendromus melanotis*, *Micaelamys namaquensis*, *Mus minutoides*, *Crocidura cyanea*, *Crocidura mariquensis*, *Elephantulus myurus* and *Suncus infinitesimus* (Fig. 66). Statistically there is an insignificant difference between species richness within the Sheltered Woodland community and the average recorded in other vegetation communities assessed during this study ($\chi^2 = 0.021$; $df = 1$; $n = 15.4$; $P = 0.884$). The species richness for the Sheltered Woodland community ($n = 8$) was high, possibly due to the variety is habitats between the rocks. The Sheltered Woodland community had the highest species richness of insectivores recorded during this study. No species were recorded only in the Sheltered Woodland community, although species richness was high. 44.4% of the species recorded during this study were represented in the Sheltered Woodland community.

A total number of 73 individual small mammals for the Sheltered Woodland community were recorded (Fig. 66). This site consists of the extremely rocky areas adjacent to the Wilge River and incorporates sections of the study site which remain in a natural state. Statistically there is a highly significant difference between species community structure assessed within the Sheltered Woodland ($\chi^2$ = 180.162; *df* = 7; *n* = 73; *P* = 0.000). The abundance of individual species recorded for the Sheltered Woodland community was: *Micaelamys namaquensis* (*n* = 46), *Elephantulus myurus* (*n* = 12), *Mus minutoides* (*n* = 5), *Dendromus melanotis* (*n* = 4), *Acomys spinosissimus* (*n* = 2), *Crocidura mariquensis* (*n* = 2), *Crocidura cyanea* (*n* = 1), and *Suncus infinitesimus* (*n* = 1). Statistically there is an insignificant difference between community structure within the Sheltered Woodland community and the average between all other vegetation communities assessed during this study ($\chi^2$ = 2.806; *df* = 1; *n* = 167.7; *P* = 0.094).

The community structure percentage recorded in the Sheltered Woodland community consists of *Micaelamys namaquensis* (63%), *Elephantulus myurus* (16.4%), *Mus minutoides* (6.8%), *Dendromus melanotis* (5.5%), *Acomys spinosissimus* (2.7%), *Crocidura mariquensis* (2.7%), *Crocidura cyanea* (1.4%), and *Suncus infinitesimus* (1.4%) (Fig. 66). The Sheltered Woodland community is dominated by *M. namaquensis* and *E. myurus*, with the presence of *M. minutoides, A. spinossimus* and *C. mariquensis* worth noting.

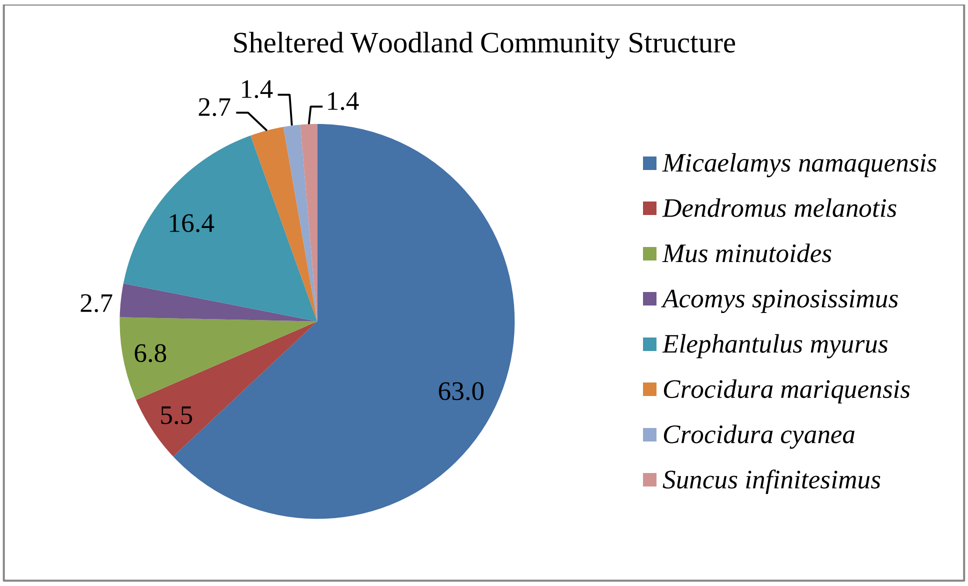

Figure 66. The community structure of small mammals recorded in the Sheltered Woodland community on Telperion.

### 7.5.5. Assessment of small mammal species richness and community structure in the Burkea Eragrostis Clumps (BEC) vegetation community on Telperion

This community was less productive than most other sites and six species of small mammal were recorded during the study. The following species were recorded in the Burkea

Eragrostis Clumps community: *Dendromus melanotis*, *Gerbilliscus brantsii*, *Lemniscomys rosalia*, *Mastomys* spp., *Mus minutoides* and *Steatomys pratensis* (Fig. 67). Statistically there is an insignificant difference between species richness within the Burkea Eragrostis Clumps community and the average recorded in other vegetation communities assessed during this study ($\chi^2 = 0.146$; $df = 1$; $n = 13.4$; $P = 0.702$). The species richness for the Burkea Eragrostis Clump community ($n = 6$) was average, possibly due to a lack of sufficient cover at certain times of the year. *Gerbilliscus brantsii* was only recorded in the Burkea Eragrostis Clump community during this study, possibly due to the low-lying altitude and sandy soils present within this community. 33.3% of the species recorded during this study were represented in the Burkea Eragrostis Clumps community.

A total of 34 individual small mammals for the Burkea Eragrostis Clumps community were recorded (Fig. 67). This site is characterized by noticeable clumps of tall stands of *Burkea africana* trees and deep sandy soils. Statistically there is a significant difference between species community structure assessed within the Burkea Eragrostis Clumps ($\chi^2 = 20.937$; $df = 5$; $n = 34$; $P = 0.001$). The abundance of individual species recorded for the Burkea Eragrostis Clumps community was: *Gerbilliscus brantsii* ($n = 12$), *Mus minutoides* ($n = 9$), *Dendromus melanotis* ($n = 9$), *Mastomys* spp. ($n = 2$), *Lemniscomys rosalia* ($n = 1$), and *Steatomys pratensis* ($n = 1$). Statistically there is a significant difference between community structure within the Burkea Eragrostis Clumps community and the average between all other vegetation communities assessed during this study ($\chi^2 = 28.606$; $df = 1$; $n = 128.7$; $P = 0.000$).

The community structure percentage recorded in the Burkea Eragrostis Clumps community consists of *Gerbilliscus brantsii* (35.3%), *Dendromus melanotis* (26.9%), *Mus minutoides* (26.9%), *Mastomys* spp. (5.9%), *Lemniscomys rosalia* (2.9%), and *Steatomys pratensis* (2.9%) (Fig. 67). The Burkea Eragrostis Clumps community is dominated by *G. brantsii*, with *M. minutoides* and *D. melanotis* worth noting although their numbers were recorded in low densities this vegetation community is an important habitat for these species due to the abundance of suitable grass cover and sandy soils.

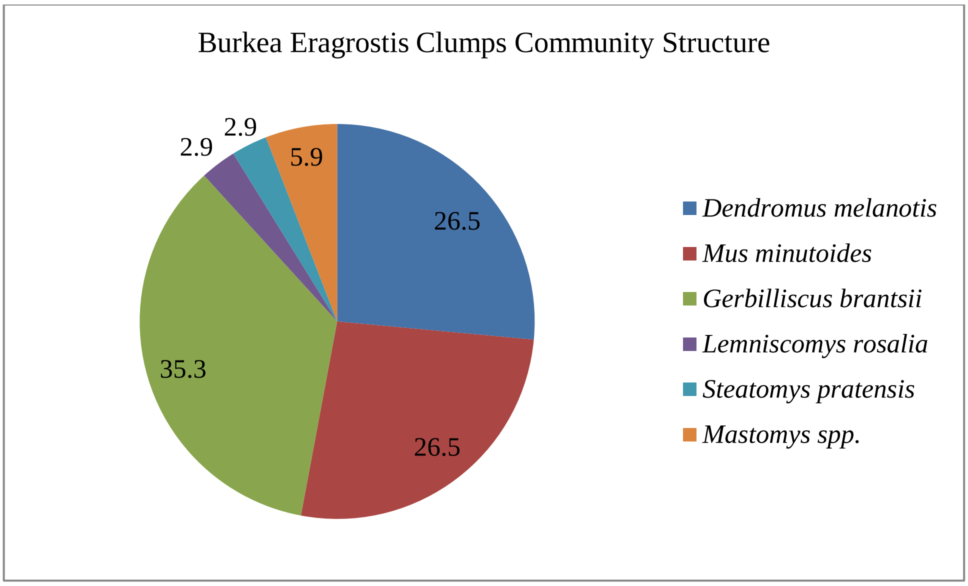

Figure 67. The community structure of small mammals recorded in the Burkea Eragrostis Clumps community on Telperion

### 7.5.6. Assessment of small mammal species richness in the Moist Degraded Grassland (MDG) vegetation community on Telperion

This community had high species richness and 8 species of small mammal were recorded within this community during the study. The following species were recorded in the Moist Degraded Grassland community: *Dendromus melanotis, Dendromus mystacalis, Mastomys* spp., *Mus minutoides, Rhabdomys pumilio, Otomys irroratus, Crocidura mariquensis,* and *Suncus infinitesimus* (Fig. 68). Statistically there is an insignificant difference between species richness within the Moist Degraded Grassland community and the average recorded in other vegetation communities assessed during this study ($\chi^2 = 0.023$; $df = 1$; $n = 15.4$; $P = 0.878$). The species richness for the Moist Degraded Grassland ($n = 8$) was high, possibly due the wet nature of the community creating a habitat for species not recorded at other sites. *Rhabdomys pumilio* and *Otomys irroratus* were only recorded in Moist Degraded Grassland community during the study. 44.4% of the species recorded during this study were represented in the Moist Degraded Grassland community. A total number of 39 individual small mammals for the Moist Degraded Grassland community were recorded (Fig. 68). This site is characterized by either historically cultivated or extensively disturbed areas with some degree of moist soil condition.

There is a significant difference between species community structure assessed within the Moist Degraded Grassland ($\chi^2 = 19.771$; $df = 5$; $n = 39$; $P = 0.006$). The abundance of individual species recorded for the Moist Degraded Grassland community was: *Rhabdomys pumilio* (*n* = 13), *Crocidura mariquensis* (n = 6), *Otomys irroratus* (*n* = 6), *Suncus infinitesimus* (*n* = 4), *Dendromus mystacalis* (*n* = 4), *Mus minutoides* (*n* = 3), *Mastomys* spp. (*n* = 2) and *Dendromus melanotis* (*n* = 1). Statistically there is a significant difference between community structure within the Moist Degraded Grassland community and the average between all other vegetation communities assessed during this study ($\chi^2 = 23.187$; *df* = 1; *n* = 133.7; *P* = 0.000). The community structure percentage recorded in the Moist Degraded Grassland consists of: *Rhabdomys pumilio* (33.3%), *Otomys irroratus* (15.4%), *Crocidura mariquensis* (15.4%), *Dendromus mystacalis* (10.3%), *Suncus infinitesimus* (10.3%), *Mus minutoides* (7.7%), *Mastomys* spp. (5.1%), and *Dendromus melanotis* (2.6%) (Fig. 68). The Moist Degraded Grassland community is dominated by *R. pumilio*, although the presence of this species fluctuates, and at times, this species was not recorded. *O. irroratus* and *C. mariquensis* are worth noting although their numbers were recorded in low densities this vegetation community is an important habitat for these species due to the available vlei areas.

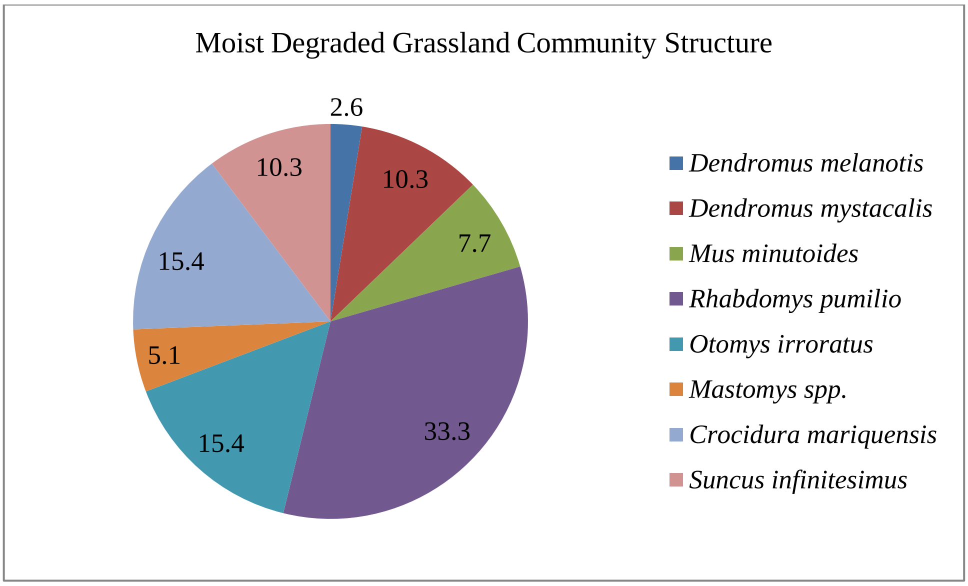

Figure 68. The community structure of small mammals recorded in the Moist Degraded Grassland community on Telperion.

### 7.5.7. Assessment of small mammal species richness in the Rocky Open Shrub (ROS) vegetation community on Telperion

This community was dominated by two dominant species, although only three species of small mammal were recorded in the vegetation community during the study. The following species were recorded in the Rocky Open Shrub community: *Aethomys chrysophilus, Micaelamys namaquensis,* and *Elephantulus myurus* (Fig. 69). Statistically there is an insignificant difference between species richness within the Rocky Open Shrub community and the average recorded in other vegetation communities assessed during this study ($\chi^2$ = 1.862; *df* = 1; *n* = 10.4; *P* = 0.172). The species richness in the Rocky Open Shrub community (*n* = 3) was low, possibly due to the abundance of *M. namaquensis* and *E. myurus* and possibly lack of sufficient phytomass. No species were recorded exclusively in the Rocky Open Shrub community during this study, and species richness was low. 16.7% of the species recorded during this study were represented in the Rocky Open Shrub community.

A total number of 124 individual small mammals for the Rocky Open Shrub community were recorded (Fig. 69). The site is located on a slightly elevated plateau and is characterized by very rocky, red sandstone formations and a sparse herbaceous component. Statistically there is a significant difference between species community structure assessed within the Rocky Open Shrub ($\chi^2$ = 106.602; *df* = 2; *n* = 124; *P* = 0.000). The abundance of individual species recorded for the Rocky Open Shrub community was: *Micaelamys namaquensis* (*n* = 94), *Elephantulus myurus* (*n* = 26), and *Aethomys chrysophilus* (*n* = 4). Statistically there is a highly significant difference between community structure within the Rocky Open Shrub community and the average between all other vegetation communities assessed during this study ($\chi^2$ = 52.442; *df* = 1; *n* = 318.7; *P* = 0.000). The community structure percentage recorded in the Moist Degraded Grassland consists of *Micaelamys namaquensis* (75.8%), *Elephantulus myurus* (21%) and *Aethomys chrysophilus* (3.2%) (Fig. 69). The Rocky Open Shrub community is dominated by *M. namaquensis* and *E. myurus* and the habitat is ideal for these species. A few records of *A. chrysophilus* in the grassy saddles between outcrops were observed.

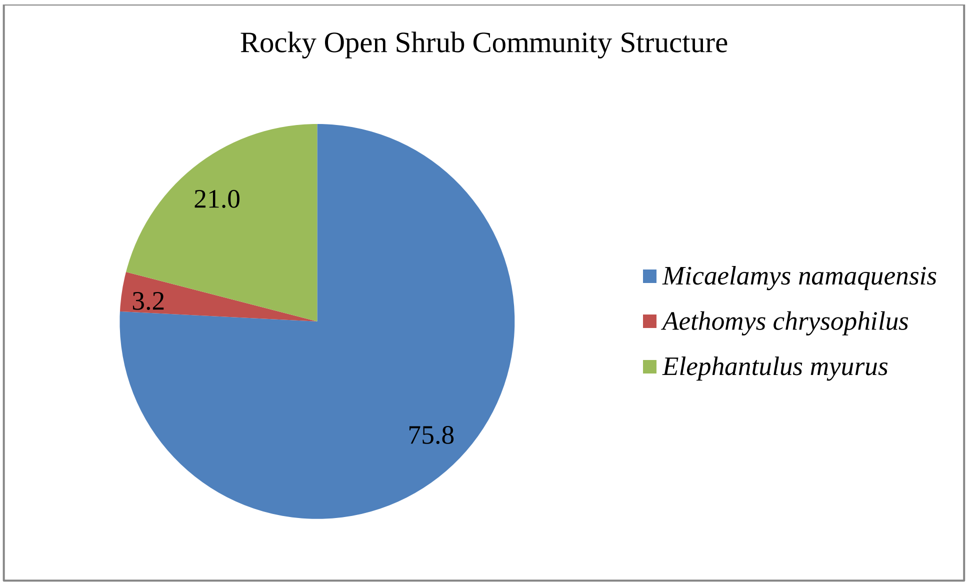

Figure 69. The community structure of small mammals recorded in the Rocky Open Shrub community on Telperion.

## 7.6. Discusion:

The primarily objectives of this chapter is to assess small mammal species richness (variety) and community structure on Telperion and Ezemvelo Nature Reserve in the Bankenveld grasslands, South Africa. Large differences in small mammal composition, and species richness were recorded between habitats, although similarities were also noted. In areas which were previously under agriculture, surprisingly high species richness was recorded at certain times of the year, with generalists such as *Mastomys* spp. and *Rhabdomys pumilio* also recorded.  The species richness of  small mammal fauna in an area indicate ecosystem integrity and, together, they support a proposal by Avenant (2000 a,b) in that direct monitoring of small mammals as a relatively efficient and inexpensive method of determining disturbance in an ecosystem.  Eighteen species of small mammal were recorded during this study. Small mammals (= adults < 2kg) comprise quite a large percentage (> 60%) of all terrestrial mammal species in southern Africa (Skinner & Chimimba 2005). Small mammals have an important direct and indirect influence on ecosystem functioning.

Species richness was highest in the untransformed Rocky Highveld Grassland community. This community, characterized by *Protea welwitchii*, was historically unsuitable for agriculture due to its rocky nature. 10 species were recorded within this community during this study, including *Micaelamys namaquensis and Elephantulus myurus*, species which dominated the rocky outcrops at the study site. Other species, preferring sandy soils were also recorded. The variety of habitats within this community is largely responsible for this community richness. *M. namaquensis* dominated within this community, and appears abundant across the reserve in areas with scattered red sandstone. *Dendromus melanotis* and *Gerbilliscus leucogaster* were also regularly recorded the former preferring long, dense grass, and the later sandy soils. Dry savanna specialists such as *Steatomys pratensis* were also represented within this community structure. The Degraded Grassland community has a surprisingly high species richness recorded. A possible explanation for this is the cover provided by bush encroacher, *Seriphium plumosum*. This community was dominated by *Dendromus melanotis* is winter, however a poor community structure in summer was recorded. These areas are important refugia for small mammals in the winter months when the biomass in surrounding areas is reduced through grazing. It is expected that movement occurs into the surrounding areas with a higher quality grass seed in the summer months. *Mus minutoides* and *G. leucogaster* were also recorded in reasonable numbers in the community. The Rocky Open Shrub had the highest trap success recorded, although species richness was low. The community structure largely consisted of two species, *M. namaquensis* and *E. myurus*. These species occurred in large numbers, and the possibly exists that they out compete other species.

Small mammal community composition and structure have been used as indicators of habitat integrity (Avenant 2000a, 2003; Avenant & Cavallini 2007; Avenant & Kuyler 2002; Avenant and Watson 2002). Tilman (1982) developed a growth curve for animal and plant groups whereby highest species richness increased with succession up to a point of climax, when they decreased to a point where equilibrium is reached. Species number is expected to fluctuate around this point until disturbance occurs (Avenant 2005). Relatively few ruderal species dominate when disturbances are frequent, and relatively few highly competitive species dominate when disturbances are rare; intermediate levels of disturbance allow succession to proceed but limit the ability of competitive species to dominate the community (Valone & Kelt 1999). The number of microhabitats and primary productivity is also high at the point of climax, and able to sustain a number of individuals from different species. Avenant & Watson (2002) found small mammal communities correlated with the abundance of pioneer plants species and their ecological value of the veld, indicating that a similar curve could be expected. Generalist species, those with a wide habitat tolerance, are generally found to dominate small mammal numbers on the lower part of the succession curve, with the opposite is expected to occur for specialist species, which increase in number towards the end of the curve. Avenant (2005) felt that together, these finding support the idea that direct monitoring of small mammals could be used as a relatively effective and efficient method of indicating ecological disturbance, habitat health and integrity, and therefore a useful tool for reserve managers and ecologists.

Biodiversity of small mammals is used as an effective indicator of disturbance in natural ecosystems. High numbers of *Mastomys* spp. in all habitats indicates a level of disturbance at the study site; hence low numbers indicate a balanced system. The relationships between small mammals and the environment in which they live is often complex in nature (Avenant 2000a; Birney *et al.* 1976). Small mammal community structure and species richness have been related to biotic and abiotic variables such as habitat structure and complexity (Rosenzweig & Winakur 1969; Brown 1973; French *et al.* 1976; Bond *et al.* 1980; Dueser & Brown 1980; Rowe-Rowe & Meester 1982a; Thompson 1982; Parmenter & MacMahon 1983; Kotler 1984; Abramsky 1988; Kerley 1992; Els & Kerley 1996), area (Abramsky *et al*. 1985; Fitzgibbon 1997), productivity (Abramsky 1978, 1988; Rosenweig 1992); predation (Kotler 1984; Norrdahl & Korpimäki 1995; Abramsky *et al.* 1998; trampling and grazing (Keesing 1998; Milchunas *et al*. 1998); surrounding landscape and the distance between similar habitats (Fitzgibbon 1997), and the maturity of the habitat and succession of the vegetation (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Rowe-Rowe 1995; Fitzgibbon 1997; Ferreira & van Aarde 1999). In general, changes in small mammal habitats are associated with changes in species richness and ecological disturbance of these habitats is associated with a decrease in small mammal species richness.

The large differences in mammal community structure and species richness observed between the habitats on Telperion and Ezemvelo Nature Reserve are therefore expected. According to Avenant & Kuyler (2002), this agrees with the numerous studies that have demonstrated the casual relationship between disturbance, lack of disturbance, and diversity and abundance of small mammals (Wootton 1998; Trojan 2000, Hastwell & Huston 2001), and between the decrease in diversity and declines in ecosystem functioning, structure, and resilience (Grime 1998: Cardinale *et al.* 2000; Chaplin *et. al.* 2000; Johnson 2000; Loreau 2000; McCann 2000; Petchey 2000; Purvis & Hector 2000; Wilsey & Potvin 2000; Fonseca & Ganade 2001; Knops *et al.* 2001; Scheffer *et al.* 2001). As stated by Avenant (2000a,b), the lack of domination by *Mastomys*, species richness and diversity are all small mammal community characteristics that indicate ecosystem integrity.

Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Co-existence in a grassland habitat may also be promoted by mechanisms that reduce interspecific competition (Kinahan & Pillay 2008) and thus improve overall fitness. Differential habitat use and the use of resources within these different systems, especially in space and time, may facilitate co-existence between species on a reserve, or specific habitat (M'Closkey 1976; Brown 1989; Yunger *et al.* 2002; Zhang 2003; Bonesi & Macdonald 2004; Harris *et al.* 2006). Spatial differences in small mammal communities are based on macro- and micro-habitat selection. How small mammals choose an area is a result of cover availability, differences in micro-climate, substrate, predation risk and food availability (Chesson 1986). Temporal differences on the other hand involve variations that act on a daily basis, such as resource renewal and availability, lunar, an increase in predation, and annual, rainfall, and temperature (Chesson 1986). Therefore, for community structure of small mammals, there needs to be an axis of environmental heterogeneity and a trade-off between interacting species, resulting in each species having a place on that axis where it is the superior competitor (Kotler & Brown 1988; Brown 1989; Abramsky *et al.* 1990; Perrin & Kotler 2005).

Species within a community may be able to inhabit the same habitat as they respond differently to environmental fluctuations (Moro & Morris 2000; Stilmant *et al.* 2008). Thus, Bankenveld small mammal communities may be composed of species that vary from having narrow habitat requirements, referred to as specialists, to those with very broad habitat requirements, or generalists (Ben-Natan *et al.* 2004; Manor & Saltz 2008). Generalists however, may have a variety of accessible and profitable options; they often have clear resource preferences and will rank these depending on availability, whereas specialists tend to be more efficient at using specific resources (Stilmant *et al.* 2008), although this may have costs in terms of habitat, time or energy constraints (Townsend *et al.* 2000). It therefore found that specialists and generalists are often able to co-exist as generalists can exploit resources not used by specialist, and it is therefore expected that specialists should be able to out-compete less well-adapted species (Manor & Saltz 2008). Demonstrating that different species of small mammals may use different parts of a resource, such as seeds as opposed to culms of grass, does not indicate the absence of competition between species, and thus competitive interactions, similarly, competition cannot be inferred in a variety of species occurring in the same resource (Conley 1976; Holbrook 1979; Schoener 1983).

In the present study, the domination of indicator species, high species richness and high diversity are useful tools in highlighting the variability of the habitats found at the study site. During this study, the highest species richness was found in summer (Appendix O). According to Avenant (2000a), homogeneous habitats should be selected and marginal areas (at the edge of habitats) should be avoided as the edges often house more species and can be seen as refugia where individuals can profit from the best of both habitats. Care was taken to ensure the habitats selected where "pure" representations of these habitat types, as although ecologically important, these edges often house more species and can be seen as refugia where individuals can profit from the best in two environments (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Hansson 1998). For this reason they play an important role in the recolonization and species persistence of small mammals. Certain vegetation communities appear more stable habitats for some species of small mammal, for example, Northern Slope Woodland and Rocky Open Shrub for *Micaelamys namaquensis* and *Elephantulus myurus*, which were represented throughout the year, although the numbers did fluctuate. Other communities such as Moist Degraded Grassland and Degraded Grassland differed seasonally in their suitability for small mammals.

This chapter has identified areas of high species richness, assessing vegetation structure and taking in to consideration small mammal groups that reflect the species richness across a set of environments, thus acting as surrogates for the "wholesale" biodiversity (Gaston 1996a; McGeoch 1998). The conservation value of an area is typically judged using a measure of species richness, or some variant of it (Gaston 1996b; Angermeier & Winston 1997). Petersen (2006) describes the removal of small mammal species through habitat alteration, alongside fire, overgrazing, climate change and other factors are complicit in the increasing of densification of woody shrubs and trees in southern African savannas. This is difficult to quantify, however, should not be ruled out when discussing plant cover and density in the changes in habitat structure of the Bankenveld grasslands. The variety of vegetation communities in different stages of succession provide suitable habitat for diverse and integrated small mammal populations, catering for specialists and generalist species.

# CHAPTER 8

# SEX RATIO OF SMALL MAMMAL SPECIES RECORDED ON TELPERION

## 8.1. Abstract

This chapter aims to determine the sex ratio for small mammals species recorded in seven different vegetation communities of Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Sex ratio is defined as the ratio of males to females in a population. Understanding the sex ratio within a population provides insight into behaviour, breeding, aggression, home range use, emigration and immigration as well as population growth. It is assumed that the ratio of males to females to be equal. Over the study period a higher male to female ratio was recorded for *Acomys spinosissimus* (♂ = 81.8%; ♀ = 18.2%); *Aethomys chrysophilus* (♂ = 66.7%; ♀ = 33.3%), *Dendromus melanotis* (♂ = 61.7%; ♀ = 38.3%), *Lemniscomys rosalia* (♂ = 61.5%; ♀ = 38.5%), *Mastomys* (♂ = 100%; ♀ = 0%), *Otomys irroratus* (♂ = 100%; ♀ = 0%), *Rhabdomys pumilio* (♂ = 69.2%; ♀ = 30.8%), *Elephantulus myurus* (♂ = 51.4%; ♀ = 48.6%); and *Suncus infinitesimus* (♂ = 60%; ♀ = 40%). While a higher female to male ratio was recorded for *Dendromus mystacalis* (♀ = 58.3%; ♂ = 41.7%), *Gerbilliscus leucogaster* (♀ = 75%; ♂ = 25%), *Graphiurus murinus* (♀ = 60%; ♂ = 40%), *Mus minutoides* (♀ = 56.7%; ♂ = 43.3%), *Steatomys pratensis* (♀ = 66.6%; ♂ = 33.3%), *Crocidura cyanea* (♀ = 100%; (♂ = 0%); and *Crocidura mariquensis* were recorded (♀ = 62.5%; (♂ = 37.5%). An equal number of female to male animals were recorded for *Gerbilliscus brantsii* (♂ = 50%; ♀ = 50%). Higher ratios of male individuals recorded may be linked to home range use and increased activity in searching for a mate. Higher ratios of female individuals may be breeding and increased demand on energy reserves associated with lactating.

**Keywords:** Sex ratio, Telperion, Ezemvelo Nature Reserve, small mammals, female, male, home range, breeding, South Africa.

## 8.2. Introduction

Sex ratio is defined as the ratio of males to females in a population. Understanding the sex ratio within a population provides insight into behaviour, breeding, aggression, home range use, emigration and immigration as well as population growth. The purpose of this chapter being to determine the sex ratio for small mammals in seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. These properties are situated to the extreme north of the grassland biome in South Africa, recognized by Acocks (1988) as Bankenveld, while Bredenkamp and Van Rooyen (1998) classified it as Rocky Highveld Grassland. Polygynous species tend to have a high degree of intraspecific home range overlap, especially between females and thus also tend to have higher densities (Ribble & Stanley 1998; Priotto *et al.* 2002). The sex ratio of these species tends to be skewed towards male dominance. Promiscuous species within a community also tend to have high densities with a high degree of overlap between sexes, since males are unable to monopolise widespread females (Ostfeld 1990; Ribble & Stanley 1998; Jackson 1999). Both abiotic and biotic factors have been proposed as regulators of breeding in different species and density in small mammal communities (Perrin & Boyer 2000). These factors indirectly influence the sex ratio recorded. Many small mammal species in southern Africa have a sex ratio that approximates 1:1 (Bronner 1986; Perrin & Swanepoel 1987; Ostfeld & Manson 1996; Monadjem 1999; Yarnell & Scott 2006). It is expected that equal numbers of male to female animals will be recorded during the study, however, there are periods when sex capture bias is likely. Male individuals of certain species of rodents are expected to be captured in spring and summer as they become more active in search of females to mate with, while females could be captured more readily when they become more active in search of food as energy requirements are increased during lactation and post-breeding.

## 8.3. Methodology

In year one (2008), ten transects each comprising 30 live-traps Sherman each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month. The starting-point was placing transects in the seven vegetation communities. In year one, two transects were placed in the dominant communities to obtain a greater sample size. In year one, 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. The 10 m spacing was adopted at the study site with the available traps. In year two, three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per site. The sex of individual species was recorded during the duration of the study.

Analysis of variance (ANOVA) was used to test for significant differences between sex ratio within different seasons (Fowler *et al.* 1998). Tukey’s test was undertaken when the result from ANOVA indicated a significant difference between the variables. Tukey’s test provides an indication of where significant differences occur.

Other statistical methods used include Chi-square ($\chi^2$) test to analyze sex ratio frequencies and t-tests ($t$), analyzing variance when samples were small, using the mean difference between the two samples and dividing these by the standard error of the difference.

All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 8.4. Results

Differences in sex ratio occurred seasonally and between species. ANOVA however revealed an insignificant difference between sex ratio and season ($F_{1.3} = 1.69$; $n = 560$; $P > 0.001$). The assessment of sex ratio is important in determining increases in population, community structure and dynamics. ANOVA revealed a highly significant differences between male and female animals recorded ($F_{1.17} = 2.17$; $n = 560$; $P < 0.001$). Disproportional sex ratios can result in increased competition for mates and ultimately affect breeding performance. The abundance of one sex over another may be indicative of territoriality, mate selection and parental care. The following ratios were recorded during the study period: *Acomys spinosissimus* (♂ = 9; ♀= 2), *Aethomys chrysophilus* (♂ = 4; ♀= 2), *Dendromus melanotis* (♂ = 50; ♀= 31), *Dendromus mystacalis* (♂ = 5; ♀= 7), *Gerbilliscus brantsii* (♂ = 6; ♀= 6), *Gerbilliscus leucogaster* (♂ = 3; ♀= 9), *Graphiurus murinus* (♂ = 2; ♀= 3), *Lemniscomys rosalia* (♂ = 8; ♀= 5), *Mastomys* spp. (♂ = 8; ♀= 0), *Micaelamys namaquensis* (♂ = 146; ♀= 107; unknown = 2), *Mus minutoides* (♂ = 13; ♀= 17), *Otomys irroratus* (♂ = 6; ♀= 0), *Rhabdomys pumilio* (♂ = 9; ♀= 4), *Steatomys pratensis* (♂ = 3; ♀= 6), *Crocidura cyanea* (♂ = 0; ♀= 3), *Crocidura mariquensis* (♂ = 3; ♀= 5), *Elephantulus myurus* (♂ = 34; ♀= 36), and *Suncus infinitesimus* (♂ = 2; ♀= 3). The sex ratio for the individual species was recorded per species (Appendix M).

## 8.5. Sex ratio of the population sample of the species recorded on Telperion

### 8.5.1. Sex ratio of the population sample of *Acomys spinosissimus* recorded on Telperion

The seasonal sex ratio data for *Acomys spinosissimus* were recorded. The frequency of male animals (n = 9) to female animals (n = 2) differed insignificantly ($t_{(20)} = 0.00$; $n = 11$; $P = 0.001$) due to low numbers of specimens recorded. The following seasonal frequencies between male and female specimens were recorded for *Acomys spinosissimus*: Autumn (♂ = 2; ♀ = 0), Spring (♂ = 2; ♀ = 1), Summer (♂ = 5; ♀ = 0), Winter (♂ = 0; ♀ = 1) (Fig 70). ANOVA revealed an insignificant difference between recorded sex and season ($F_{1.3} = 3.39$; $n = 11$; $P > 0.001$).

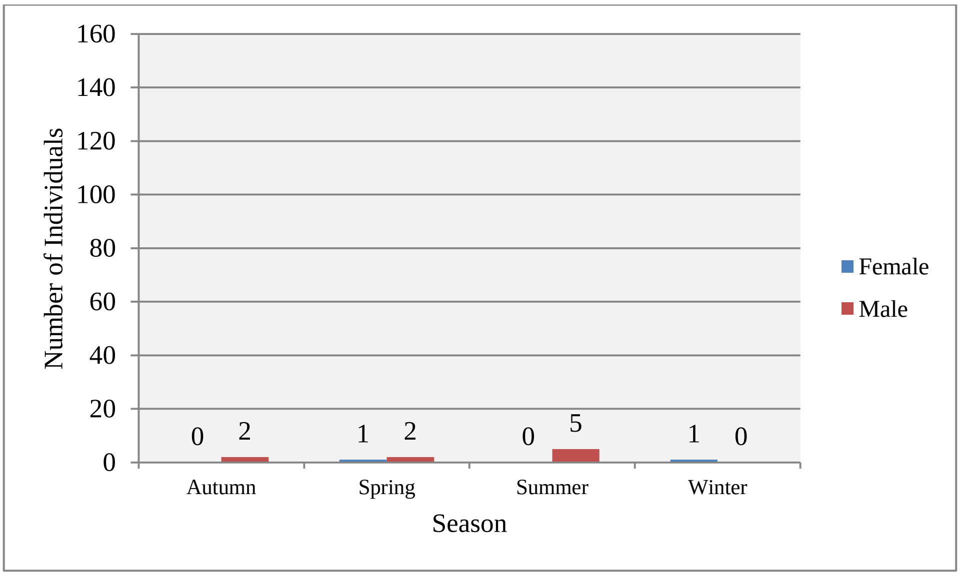

Figure 70. Graph illustrating the seasonal recorded sex ratio of *Acomys spinosissimus* collected on Telperion.

No large differences occurred between the frequencies recorded for male and female specimens during this study. The habitat requirement for this species is limited to the specific rocky outcrops at the study site which limited the number of animals was recorded. Male animals were recorded during autumn (March – May), spring (September – November) and summer (December – February), possibly due to breeding and increased food requirement. Female animals were recorded in spring and winter months (June – August), but in low numbers. Over the study period a higher male to female ratio was recorded (♂ = 81.8%; ♀ =

18.2%). Interestingly, *A. spinossimus* were only collected in two habitat types, in Northern Slope Woodland (♂ = 7; ♀ = 2) and Sheltered Woodland (♂ = 2; ♀ = 0, but in low numbers (Appendix N).

### 8.5.2. Sex ratio of the population sample of *Aethomys chrysophilus* recorded on Telperion

The seasonal sex ratio data for *Aethomys chrysophilus* were recorded. The frequency of male animals ($n = 4$) to female animals ($n = 2$) differed insignificantly ($t_{(10)} = 0.00$; $n = 6$; $P > 0.001$) due to low numbers of specimens recorded. The following seasonal frequencies between male and female specimens were recorded for *A. chrysophilus*: Autumn (♂ = 1; ♀ = 0), Spring (♂ = 0; ♀ = 0), Summer (♂ = 3; ♀ = 2), Winter (♂ = 0; ♀ = 0) (Fig. 71). ANOVA revealed an insignificant difference between recorded sex and season ($F_{1.4} = 0.44$; $n = 6$; $P > 0.001$).

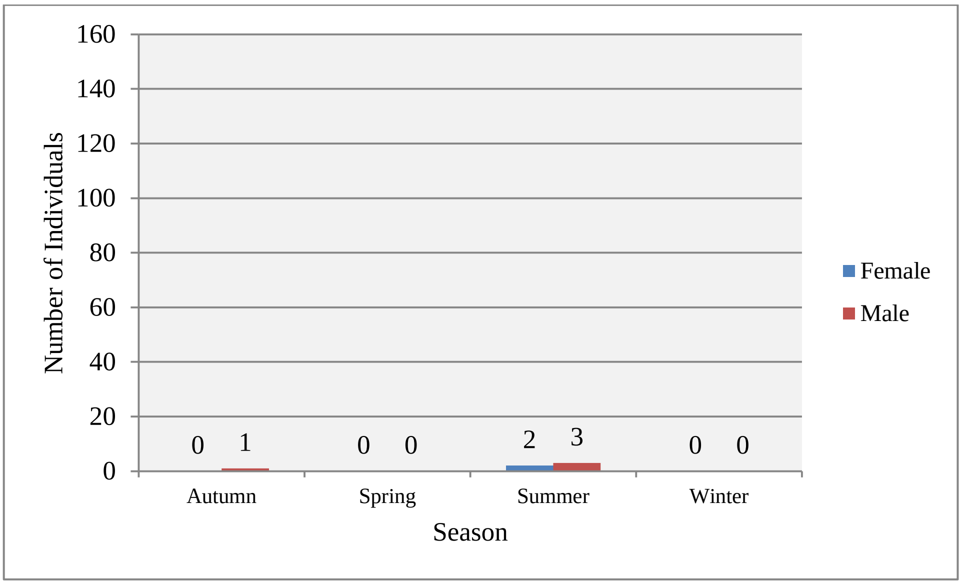

Figure 71. Graph illustrating the seasonal recorded sex ratio of *Aethomys chrysophilus* collected on Telperion.

No large differences occurred between the frequencies recorded for male and female specimens during this study. It is suspected that this species occurs at the study site in generally low numbers and few animals were recorded. Male animals were recorded during autumn (March – May and summer (December – February). Female animals were recorded in summer only, but in low numbers. Over the study period, a higher male to female ratio was recorded (♂ = 66.7%; ♀ = 33.3%). Interestingly, *A. chrysophilus* were only collected in three habitat types, in Northern Slope Woodland (♂ = 1; ♀ = 0), Rocky Highveld Grassland (♂ = 0; ♀ = 1) and Rocky Open Shrub (♂ = 3; ♀ = 1) but in low numbers compared to *Micaelamys namaquensis* (Appendix N).

### 8.5.3. Sex ratio of the population sample of *Dendromus melanotis* recorded on Telperion

The seasonal sex ratio data for *Dendromus melanotis* were recorded. The frequency of male animals ($n = 50$) to female animals ($n = 31$) and differed significantly ($t_{(81)} = 25.57$; $n = 82$; $P < 0.001$) with almost double the number of males being recorded. The following seasonal frequencies between male and female specimens were recorded for *D. melanotis*: Autumn (♂ = 27; ♀ = 13), Spring (♂ = 3; ♀ = 3), Summer (♂ = 3; ♀ = 6), Winter (♂ = 17; ♀ = 9) (Fig. 72). ). ANOVA revealed an insignificant difference between recorded sex and season ($F_{1.3} = 1.01$; $n = 82$; $P > 0.001$).

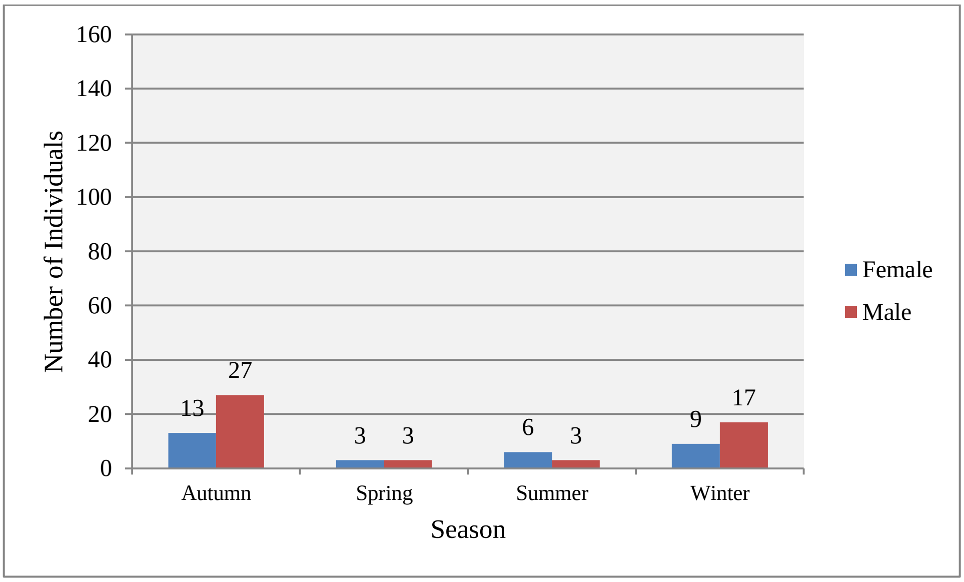

Figure 72. Graph illustrating the seasonal recorded sex ratio of *Dendromus melanotis* collected on Telperion.

The ratio between male and female specimens differed in that large sample sizes of male animals were recorded during this study. The veld type appears favorable to the species and large sample sizes of animals were recorded. Male and female animals were recorded during all months. Higher numbers were recorded in the autumn and summer months, possibly due to animals taking shelter in certain habitat types. Over the study period, a higher male to female ratio was recorded (♂ = 61.7%; ♀ = 38.3%). *Dendromus melanotis* was collected in all but one habitat type, Northern Slope Woodland (♂ = 0 ; ♀ = 1 ), Rocky Highveld Grassland (♂ = 12; ♀ = 6), Degraded Grassland (♂ = 26 ; ♀ = 17 ), Burkea Eragrostis Clumps (♂ = 6; ♀ = 3), Sheltered Woodland (♂ = 2; ♀ = 2) and Moist Degraded Grassland (♂ = 4; ♀ = 2 ) (Appendix N). This species was however, not recorded in Rocky Open Shrub, possibly due to the habitat requirement, preferring more vegetated areas.

### 8.5.4. Sex ratio of the population sample of *Dendromus mystacalis* recorded on Telperion

The seasonal sex ratio data for *Dendromus mystacalis* were recorded. The frequency of male animals ($n$ = 5) to female animals ($n$ = 7) differed significantly ($t_{(11)} = 10.65$; $n = 12$; $P < 0.001$) even though numbers of specimens recorded were low. The following seasonal frequencies between male and female specimens were recorded for *D. mystacalis*: Autumn (♂ = 4; ♀ = 5), Spring (♂ = 0; ♀ = 0), Summer (♂ = 0; ♀ = 0), Winter (♂ = 1; ♀ = 2). (Fig. 73). ANOVA revealed an insignificant difference between recorded sex and season ($F_{1.1} = 0.10$; $n = 12$; $P > 0.001$).

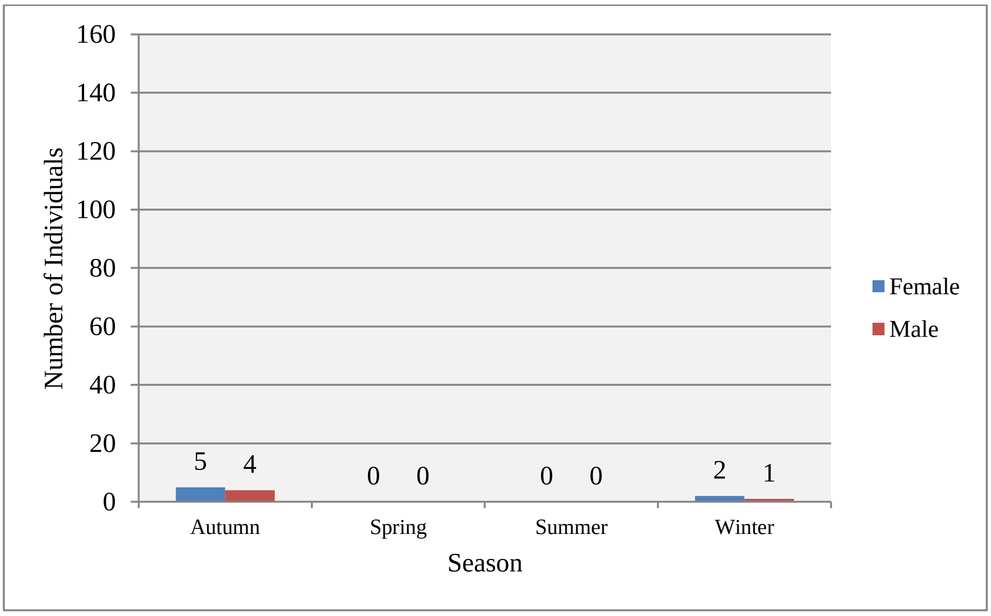

Figure 73. Graph illustrating the seasonal recorded sex ratio of *Dendromus mystacalis* collected on Telperion.

No large differences occurred between the frequencies recorded for male and female specimens during this study. It is suspected that this species occurs on the property in generally low numbers and thus few animals were recorded. Male and female animals were only recorded during autumn (March – May and winter (June – August) months. Over the study period a slightly higher female to male ratio was recorded (♂ = 41.7%; ♀ = 58.3%). *D. mystacalis* were only collected in three habitat types, in Rocky Highveld Grassland (♂ = 3; ♀ = 3), Degraded Grassland (♂ = 1; ♀ = 1) and Moist Degraded Grassland (♂ = 1; ♀ = 3) but recorded in low numbers in these habitat types (Appendix N).

### 8.5.5. Sex ratio of the population sample of *Gerbilliscus brantsii* recorded on Telperion

The seasonal sex ratio data for *Gerbilliscus brantsii* were recorded. The frequency of male animals (*n* = 6) to female animals (*n* = 6) differed insignificantly ($t_{(22)} = 0.00$; $n = 6$; $P > 0.001$) due to low numbers of specimens recorded, with an equal number of male to female animals been recorded. The following seasonal frequencies between male and female specimens were recorded for *G. brantsii*: Autumn (♂ = 0; ♀ = 0), Spring (♂ = 4; ♀ = 1), Summer (♂ = 2; ♀ = 4), Winter (♂ = 0; ♀ = 1) (Fig. 74). Statistically there is no significant relationship between sex and season $\chi^2 = 1.733333$; $df = 2$; $n = 12$; $p = 0.420351$.

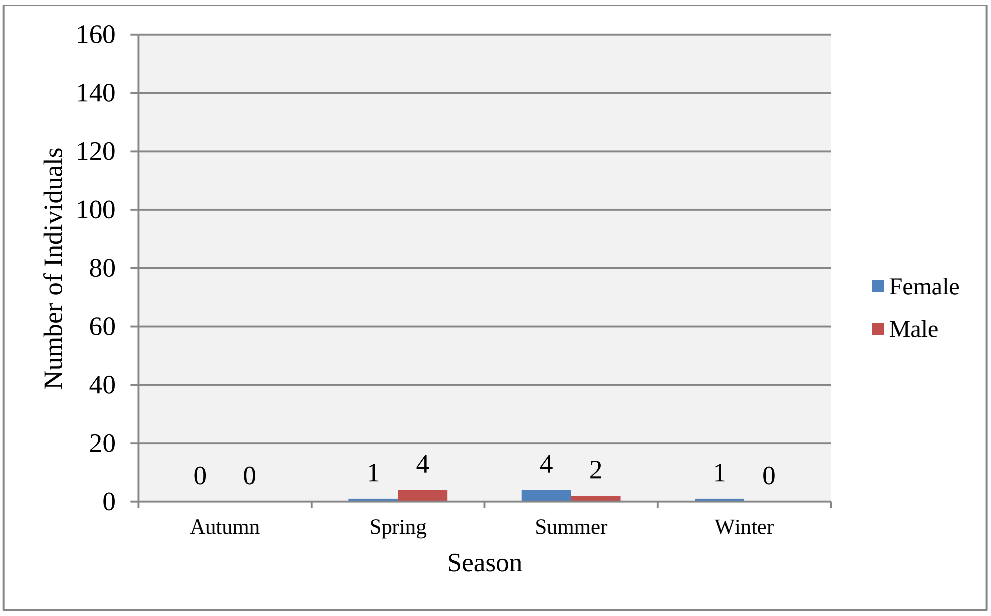

Figure 74. Graph illustrating the seasonal recorded sex ratio of *Gerbilliscus brantsii* collected on Telperion.

It is suspected that this species occurs at the study site in generally low numbers in the low-lying sandy grassland areas of the study site and therefore only a few animals were recorded. Male and female animals were recorded primarily in the spring (September – November) and summer (December – February) months. Over the study period, an equal number of female to male ratio was recorded (♂ = 50%; ♀ = 50%). *Gerbilliscus brantsii* was only sampled on one habitat type in Burkea Eragrostis Clumps (♂ = 6; ♀ = 6), although it is suspected that they may overlap with *Gerbilliscus leucogaster* in certain areas, which appears to occupy higher lying areas at the study site (Appendix N).

### 8.5.6. Sex ratio of the population sample of *Gerbilliscus leucogaster* recorded on Telperion

The seasonal sex ratio data for *Gerbilliscus leucogaster* were recorded. The frequency of male animals ($n = 3$) to female animals ($n = 9$) differed significantly ($t_{(10)} = -2.449$; $n = 12$; $P = 0.034$), with three times more female to male animals recorded. The following seasonal frequencies between male and female specimens were recorded for *G. leucogaster*: Autumn (♂ = 0; ♀ = 4), Spring (♂ = 1; ♀ = 1), Summer (♂ = 1; ♀ = 2), Winter (♂ = 1; ♀ = 2) (Fig. 75). Statistically there is no significant relationship between sex and season $\chi^2 = 2.666$; $df = 5$; $n = 12$; $p = 0.751$.

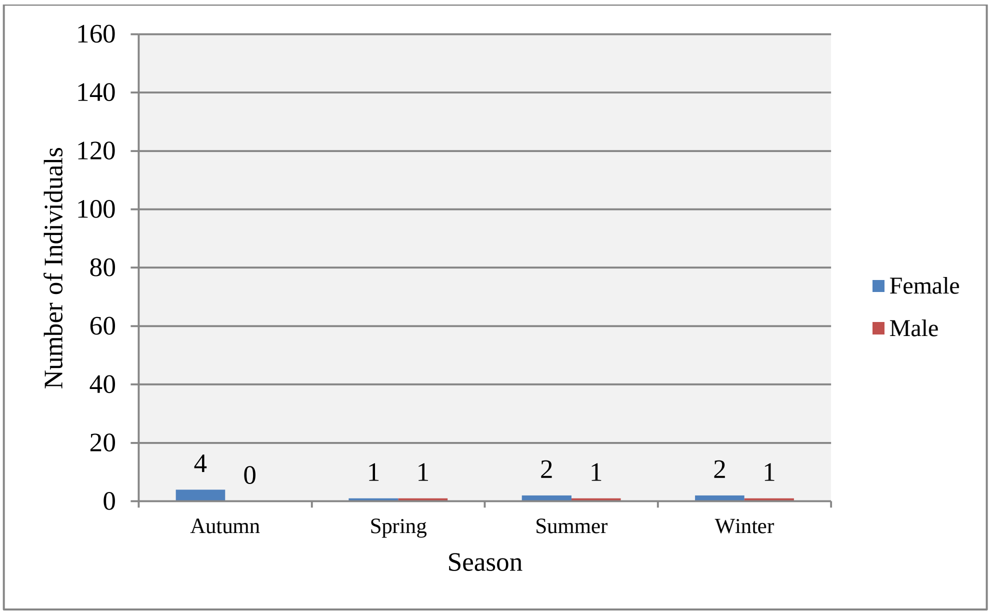

Figure 75. Graph illustrating the seasonal recorded sex ratio of *Gerbilliscus leucogaster* collected on Telperion.

Higher frequencies of female compared to male animals were recorded during this study. It is suspected that this species occurs at the study site in low numbers, preferring the open, sandy areas in the higher lying areas of the study site. Both male and female animals were recorded during all seasons, except for no males recorded in autumn. Over the study period, a higher female to male ratio was recorded (♂ = 25%; ♀ = 75%). *Gerbilliscus leucogaster* was only sampled in two habitat types: the Rocky Highveld Grassland (♂ = 3; ♀ = 7), and Degraded Grassland (♂ = 0; ♀ = 2) (Appendix N). A large percentage of females were recorded at the beginning of autumn, however, these were juvenile animals from the previous breeding season.

### 8.5.7. Sex ratio of the population sample of *Graphiurus murinus* recorded on Telperion

The seasonal sex ratio data for *Graphiurus murinus* were recorded. The frequency of male animals (*n* = 2) to female animals (*n* = 3) were insignificant ($t_{(2)}$ = -1.000; *n* = 5; *P* = 1.000) and low numbers of specimens were recorded, although more female than male animals were recorded. The following seasonal frequencies between male and female specimens were recorded for *G. murinus*: Autumn (♂ = 1; ♀ = 1), Spring (♂ = 0; ♀ = 0), Summer (♂ = 1; ♀ = 2), Winter (♂ = 0; ♀ = 0) (Fig. 76). Statistically there is no significant relationship between sex and season $\chi^2$ = 0.166; *df* = 3; *n* = 12; *P* = 0.983.

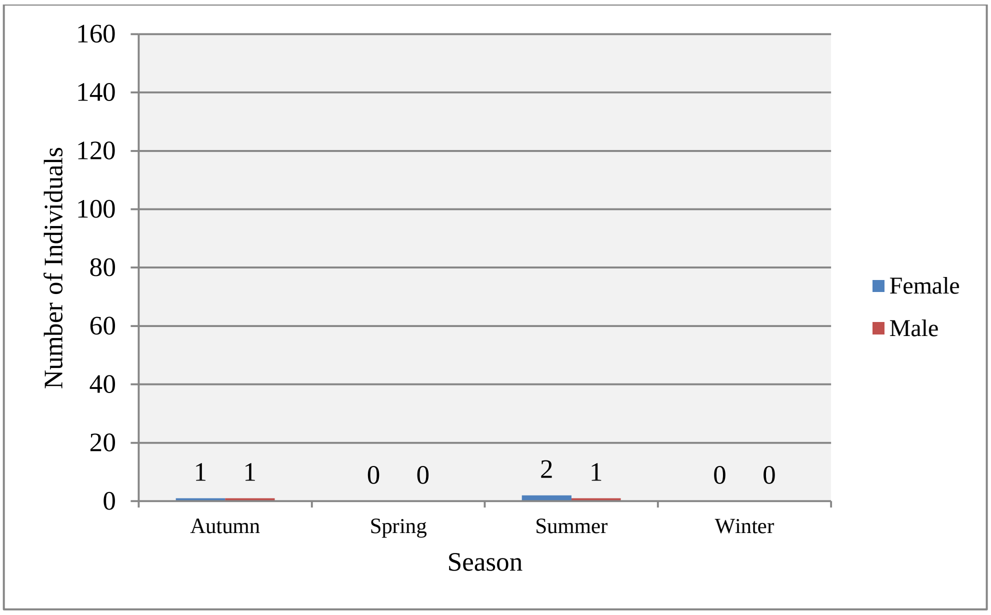

Figure 76. Graph illustrating the seasonal recorded sex ratio of *Graphiurus murinus* collected on Telperion.

No large differences occurred between the frequencies recorded for male and female specimens during this study. The habitat requirement for this species is limited to the specific rocky outcrops at the study site which limited the number of animals was recorded. Male and female animals were recorded during autumn (March – May) and summer (December – February), possibly due to an increased activity due breeding and increased food requirement. Over the study period, a slightly higher female to male ratio was recorded (♂ = 40%; ♀ = 60%). *Graphiurus murinus* was only collected in one habitat type, in Northern Slope Woodland (♂ = 2; ♀ = 3), but in low numbers (Appendix N).

### 8.5.8. Sex ratio of the population sample of *Lemniscomys rosalia* recorded on Telperion

The seasonal sex ratio data for *Lemniscomys rosalia* were recorded. The frequency of male animals (*n* = 8) to female animals (*n* = 5) were insignificant ($t_{(8)} = 0.647$; $n = 13$; $P = 0.536$) and low numbers of specimens were recorded, although more male than female animals were recorded. The following seasonal frequencies between male and female specimens were recorded for *L. rosalia*: Autumn (♂ = 0; ♀ = 0), Spring (♂ = 1; ♀ = 1), Summer (♂ = 6; ♀ = 4), Winter (♂ = 1; ♀ = 0) (Fig. 77). Statistically there is no significant relationship between sex and season $\chi^2 = 2.500$; $df = 4$; $n = 12$; $P = 0.645$.

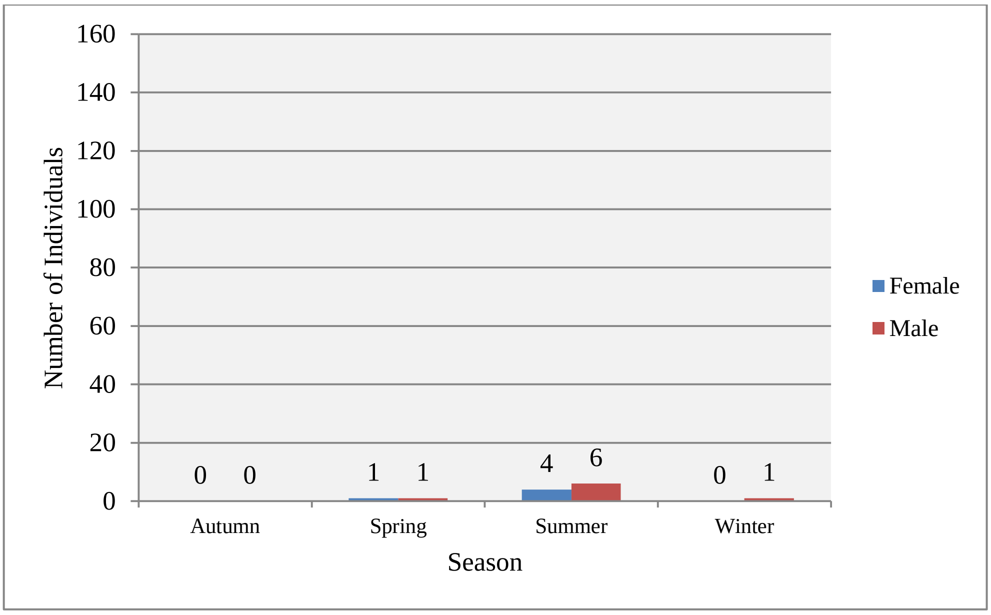

Figure 77. Graph illustrating the seasonal recorded sex ratio of *Lemniscomys rosalia* collected on Telperion.

No large differences occurred between the frequencies recorded for male and female specimens during this study. The habitat requirement for this species is rank grassland with sufficient cover. Male and female animals were recorded during spring (September – November) and summer (December – February), with an individual male specimen being recorded in winter (June – August). Over the study period, a slightly higher male to female ratio was recorded (♂ = 61.5%; ♀ = 38.5%). *Lemniscomys rosalia* was collected in three habitat types, in Rocky Highveld Grassland (♂ = 5; ♀ = 1), Degraded Grassland (♂ = 3; ♀ = 3), and Burkea Eragrostis Clumps (♂ = 0; ♀ = 1) but in low numbers (Appendix N).

### 8.5.9. Sex ratio of the population sample of *Mastomys* spp. recorded on Telperion

*Mastomys* spp. may have a recorded litter size of 24 young with three to four litters per season. The proportion of females to males is therefore important in determining population growth. Monthly sex ratio data were recorded for *Mastomys* spp. on Telperion. The frequency of male animals ($n = 8$) to female animals ($n = 0$) were significantly higher ($t_{(8)} = 6.324$; $n = 8$; $P = 0.000$), even though low numbers of specimens were recorded. The following seasonal frequencies between male and female specimens were recorded for *Mastomys* spp.: Autumn (♂ = 0; ♀ = 0), Spring (♂ = 7; ♀ = 0), Summer (♂ = 1; ♀ = 0), Winter (♂ = 0; ♀ = 0) (Fig. 78). Statistically there is no significant relationship between sex and season $\chi^2 = 5.000$; $df = 3$; $n = 8$; $P = 0.172$.

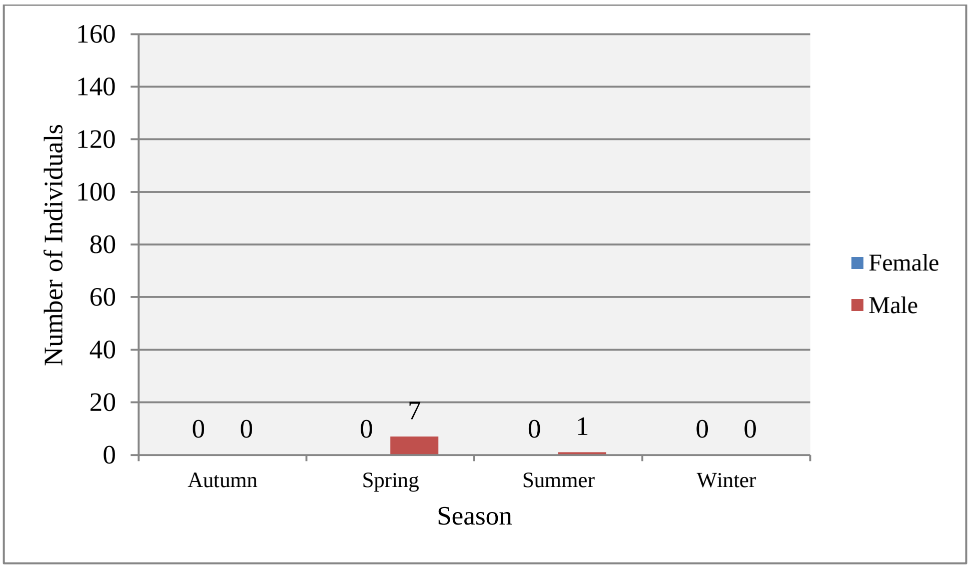

Figure 78. Graph illustrating the seasonal recorded sex ratio of *Mastomys* spp. collected on Telperion.

The ratio between male and female specimens differed in that no female animals were recorded during this study. The habitat appeared marginal for the species and a limited number of animals were recorded. Male animals were recorded during spring (September – November) and summer (December – February), possibly due to breeding and increased food requirement. The autumn (March – May) and winter months (June – August) resulted in no male or female animals being collected. Over the study period, a higher male to female ratio was recorded (♂ = 100%; ♀ = 0%). Interestingly, *Mastomys* were collected in four habitat types, Moist Degraded Grassland (♂ = 1; ♀ = 0), Degraded Grassland (♂ = 4; ♀ = 0), Burkea Eragrostis Clumps (♂ = 2; ♀ = 0) and Rocky Highveld Grassland (♂ = 1; ♀ = 0), with low numbers recorded (Appendix N).

### 8.5.10. Sex ratio of the population sample of *Micaelamys namaquensis* recorded on Telperion

The seasonal sex ratio data for *Micaelamys namaquensis* were recorded. The frequency of male animals ($n$ = 146) to female animals ($n$ = 107) were insignificant ($t_{(6)} = 0.864$; $n = 253$; $P = 0.421$), although differed with a higher number of males ($n$ = 39) being recorded. The following seasonal frequencies between male and female specimens were recorded for *M. namaquensis*: Autumn (♂ = 37; ♀ = 24), Spring (♂ = 59; ♀ = 40), Summer (♂ = 38; ♀ = 31), Winter (♂ = 12; ♀ = 12) (Fig. 79). Statistically there is no significant relationship between sex and season $\chi^2 = 2.994$; $df = 3$; $n = 4$; $P = 0.393$.

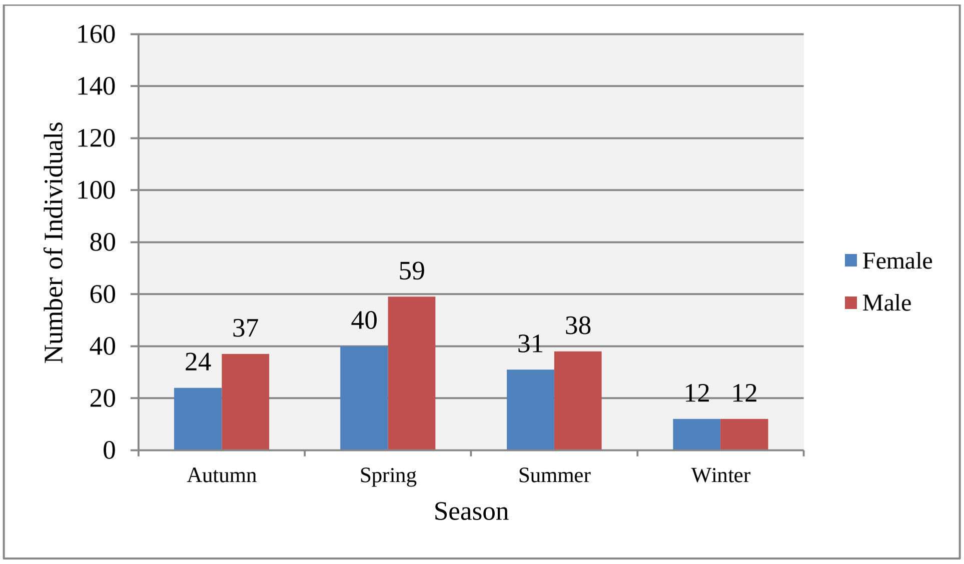

Figure 79. Graph illustrating the seasonal recorded sex ratio of *Micaelamys namaquensis* collected on Telperion.

No large differences occurred between the frequencies recorded for male and female specimens during this study, with the largest variance occurring in spring with more males (*n* = 59) recorded, 19 specimens greater than recorded for females. This is the most abundance species occurring at the study site and thus the species most frequently recorded. Male and female animals were recorded in all seasons on the property, with lowest frequencies recorded in winter. Over the study period a higher male to female ratio was recorded (♂ = 57.7%; ♀ = 42.3%). *Micaelamys namaquensis* was collected in four habitat types, in Northern Slope Woodland (♂ = 41; ♀ = 42), Rocky Highveld Grassland (♂ = 24; ♀ = 10), Sheltered Woodland (♂ = 27; ♀ = 18) and Rocky Open Shrub (♂ = 54; ♀ = 37), all habitats with a varying degree of rocky red sandstone substrate, the species appearing to avoid sandy or grassy habitats without the presence of rock (Appendix N).

### 8.5.11. Sex ratio of the population sample of *Mus minutoides* recorded on Telperion

The seasonal sex ratio data for *Mus minutoides* were recorded. The frequency of male animals (*n* = 13) to female animals (*n* = 17) were insignificant ($t_{(6)} = -0.617$; *n* = 30; *P* = 0.559), and narrowly differed with a higher number of females (*n* = 4) recorded. The following seasonal frequencies between male and female specimens were recorded for *M. minutoides*: Autumn (♂ = 2; ♀ = 5), Spring (♂ = 2; ♀ = 2), Summer (♂ = 5; ♀ = 8), Winter (♂ = 4; ♀ = 2) (Fig 80). Statistically there is no significant relationship between sex and season $\chi^2 = 1.322$; *df* = 3; *n* = 4; *P* = 0.724.

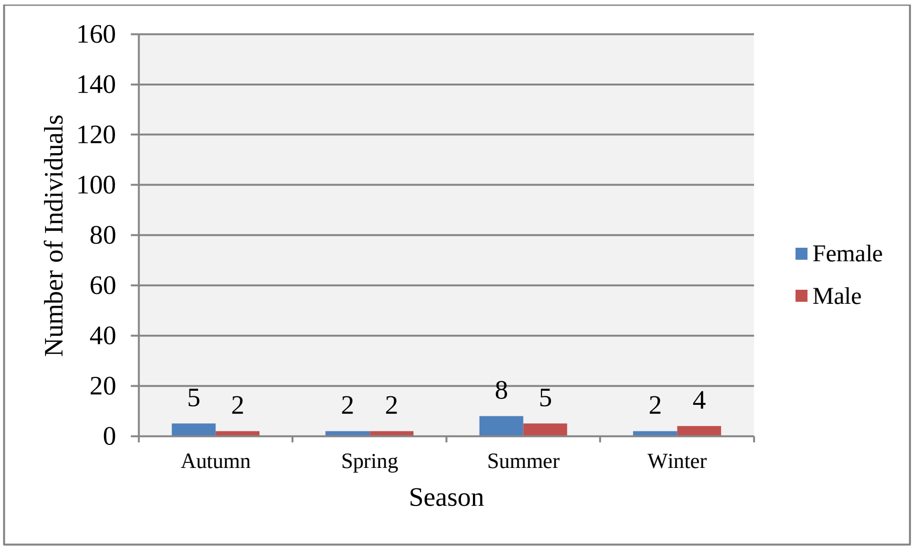

Figure 80. Graph illustrating the seasonal recorded sex ratio of *Mus minutoides* collected on Telperion.

No large differences occurred between frequencies recorded for male and female specimens during this study, with the largest variance occurring in autumn and summer with more females recorded than males. This species was recorded in all habitat types, except for Rocky Open Shrub. Male and female animals were recorded in all seasons at the study site, with lowest frequencies recorded in spring. Over the study period, a higher female to male ratio was recorded (♂ = 43.3%; ♀ = 56.7%). *Mus minutoides* was collected in six of the seven habitat types: Northern Slope Woodland (♂ = 0; ♀ = 1), Rocky Highveld Grassland (♂ = 3; ♀ = 2), Degraded Grassland (♂ = 2; ♀ = 5), Sheltered Woodland (♂ = 2; ♀ = 3), Burkea Eragrostis Clumps (♂ = 5; ♀ = 4) and Moist Degraded Grassland (♂ = 1; ♀ = 2), this species appearing to be more of a generalist in habitat requirement than other species recorded at the study site (Appendix N).

### 8.5.12. Sex ratio of the population sample of *Otomys irroratus* recorded on Telperion

The seasonal sex ratio data for *Otomys irroratus* were recorded. The frequency of male animals ($n$ = 6) to female animals ($n$ = 0) was insignificant ($t_{(6)}$ = 1.566; $n$ = 6; $P$ = 0.168), and low numbers of individuals were recorded, with no female animals recorded. The following seasonal frequencies between male and female specimens were recorded for *O. irroratus*: Autumn (♂ = 2; ♀ = 0), Spring (♂ = 0; ♀ = 0), Summer (♂ = 0; ♀ = 0), Winter (♂ = 4; ♀ = 0) (Fig. 81). Statistically there is no significant relationship between sex and season $\chi^2$ = 3.000; $df$ = 3; $n$ = 4; $P$ = 0.392.

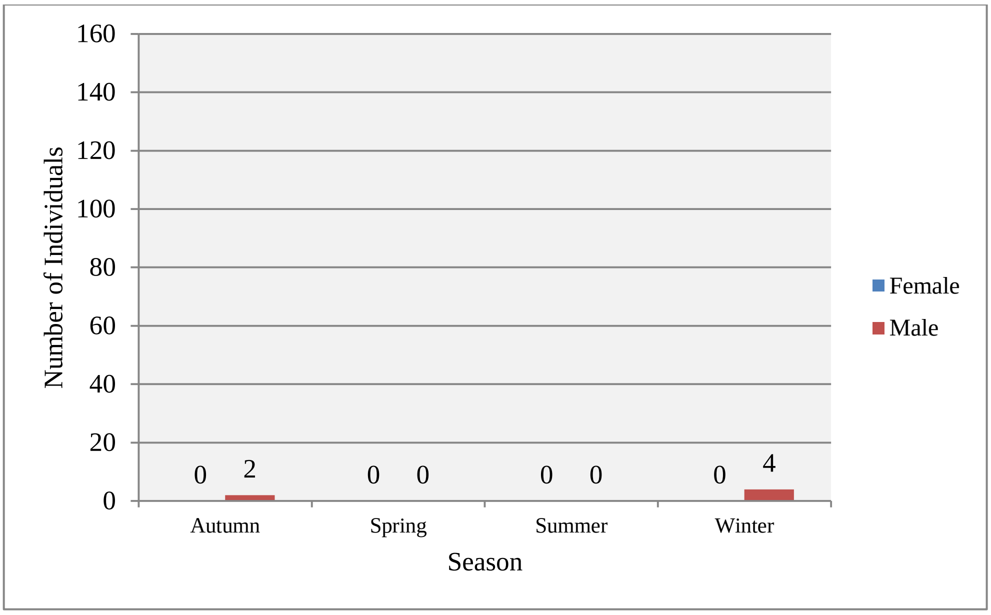

Figure 81. Graph illustrating the seasonal recorded sex ratio of *Otomys irroratus* collected on Telperion.

The ratio between male and female specimens differed in that no female animals were recorded during this study. This species has specific habitat requirements, preferring seasonally wet patches of *Imperata cylindrica*, only present in the Moist Degraded Grassland habitat and therefore, only a few animals were recorded. The male animals were recorded during autumn (March – May) and winter (June – August), possibly due to a greater willingness to enter baited traps as a result of general food shortage in these areas. No animals were collected during the spring (September – November) and summer months (December – February). Over the study period, a higher male to female ratio was recorded (♂ = 100%; ♀ = 0%). *Otomys irroratus* was only collected in one habitat type on the property, Moist Degraded Grassland (♂ = 6; ♀ = 0), with low numbers recorded.

### 8.5.13. Sex ratio of the population sample of *Rhabdomys pumilio* recorded on Telperion

The seasonal sex ratio data for *Rhabdomys pumilio* were recorded. The frequency of male animals ($n$ = 9) to female animals ($n$ = 4) was insignificant ($t_{(6)} = 0.696$; $n$ = 6; $P$ = 0.513), and low numbers of specimens were recorded, however a higher number of male animals were recorded. The following seasonal frequencies between male and female specimens were recorded for *R. pumilio*: Autumn (♂ = 2; ♀ = 1), Spring (♂ = 0; ♀ = 0), Summer (♂ = 0; ♀ = 0), Winter (♂ = 7; ♀ = 3) (Fig. 82). Statistically there is no significant relationship between sex and season $\chi^2 = 0.966$; $df = 3$; $n = 4$; $P = 0.809$.

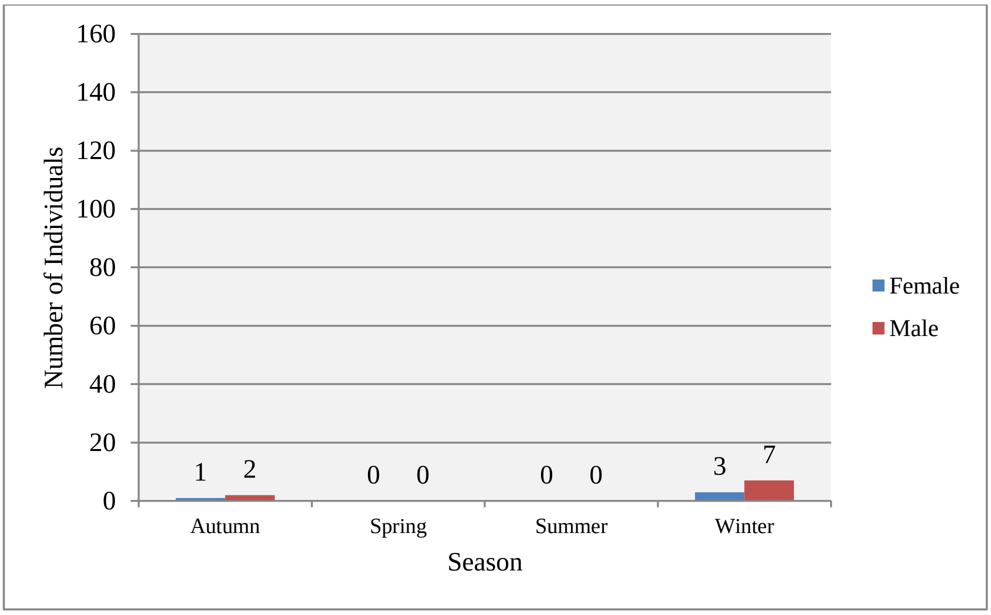

Figure 82. Graph illustrating the seasonal recorded sex ratio of *Rhabdomys pumilio* collected on Telperion.

The ratio between male and female specimens differed with twice as many male animals recorded during this study. The male and female animals were recorded during autumn (March – May) and winter (June – August), possibly due to a lack of cover in other habitat types. No animals were collected during the spring (September – November) and summer months (December – February). Over the study period, a higher male to female ratio was recorded (♂ = 69.2%; ♀ = 30.8%). *Rhabdomys pumilio* was only collected in only one habitat type at the study site, Moist Degraded Grassland (♂ = 9; ♀ = 4) (Appendix N). Interestingly, this species was only recorded in the last two field trips in 2009.

### 8.5.14. Sex ratio of the population sample of *Steatomys pratensis* recorded on Telperion

The seasonal sex ratio data for *Steatomys pratensis* were recorded. The frequency of male animals ($n = 3$) to female animals ($n = 6$) was insignificant ($t_{(3)} = -0.816$; $n = 9$; $P = 0.474$), and low numbers of specimens were recorded, although a higher number of female animals were recorded. The following seasonal frequencies between male and female specimens were recorded for *S. pratensis*: Autumn (♂ = 0; ♀ = 2), Spring (♂ = 1; ♀ = 0), Summer (♂ = 2; ♀ = 4), Winter (♂ = 0; ♀ = 0) (Fig. 83). Statistically there is no significant relationship between sex and season $\chi^2 = 3.333$; $df = 3$; $n = 4$; $P = 0.343$.

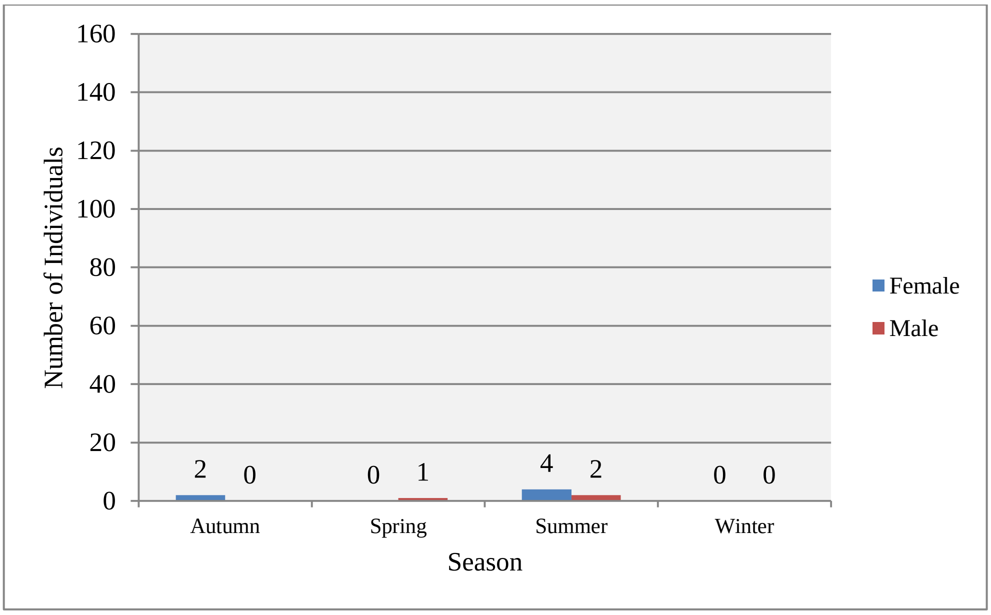

Figure 83. Graph illustrating the seasonal recorded sex ratio of *Steatomys pratensis* collected on Telperion.

The ratio between male and female specimens differed with more female animals recorded during this study. Male and female animals were recorded during summer (December – February), with female animals been recorded in autumn (March – May), and a single male animal been recorded in spring (September – November). No animals were collected during winter (June - August). Over the study period, a higher female to male ratio was recorded (♂ = 33.3%; ♀ = 66.6%). *Steatomys pratensis* was only collected in three habitat type at the study site, namely, Rocky Highveld Grassland (♂ = 1; ♀ = 2), Degraded Grassland (♂ = 2; ♀ = 3), and Burkea Eragrostis Clumps (♂ = 0; ♀ = 1) (Appendix N). This species preferred the short, open grassland of these habitat types, avoiding rocky and areas with dense, tall stands of grass.

### 8.5.15. Sex ratio of the population sample of *Crocidura cyanea* recorded on Telperion

The seasonal sex ratio data for *Crocidura cyanea* were recorded. The frequency of male animals ($n = 0$) to female animals ($n = 3$) was insignificant ($t_{(6)} = -1.566$; $n = 3$; $P = 0.168$), with low numbers of specimens were recorded, although no male animals were recorded. The following seasonal frequencies between male and female specimens were recorded for *C. cyanea*: Autumn (♂ = 0; ♀ = 0), Spring (♂ = 0; ♀ = 0), Summer (♂ = 0; ♀ = 2), Winter (♂ = 0; ♀ = 1) (Fig. 84). Statistically there is no significant relationship between sex and season $\chi^2 = 1.500$; $df = 3$; $n = 4$; $P = 0.682$.

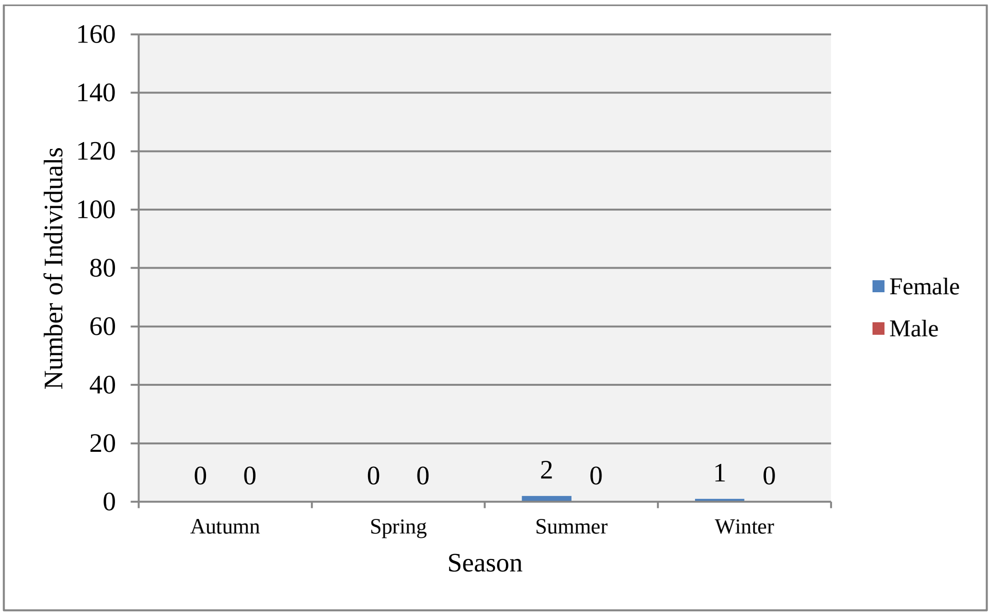

Figure 84. Graph illustrating the seasonal recorded sex ratio of *Crocidura cyanea* collected on Telperion.

The ratio between male and female specimens differed in that no male animals were recorded during this study. The female animals were recorded during summer (December – February) and winter (June– August). No animals were collected during autumn (March - May) and spring months (September – November). Over the study period, a higher female to male ratio was recorded (♂ = 0%; ♀ = 100%). *Crocidura cyanea* were collected in three habitat types on the property, Northern Slope Woodland (♂ = 0; ♀ = 1), Degraded Grassland (♂ = 0; ♀ = 1), and Sheltered Woodland (♂ = 0; ♀ = 1) (Appendix R), but not recorded frequently and in low numbers.

### 8.5.16. Sex ratio of the population sample of *Crocidura mariquensis* recorded on Telperion

The seasonal sex ratio data for *Crocidura mariquensis* were recorded. The frequency of male animals ($n = 3$) to female animals ($n = 5$) is insignificant ($t_{(6)} = -0.510$; $n = 8$; $P =$

0.627), with low numbers of specimens recorded, although a greater frequency of female animals were recorded. The following seasonal frequencies between male and female specimens were recorded for *C. mariquensis*: Autumn (♂ = 0; ♀ = 0), Spring (♂ = 1; ♀ = 0), Summer (♂ = 1; ♀ = 1), Winter (♂ = 1; ♀ = 4) (Fig. 85). Statistically there is no significant relationship between sex and season $\chi^2 = 1.400$; $df = 3$; $n = 4$; $P = 0.705$.

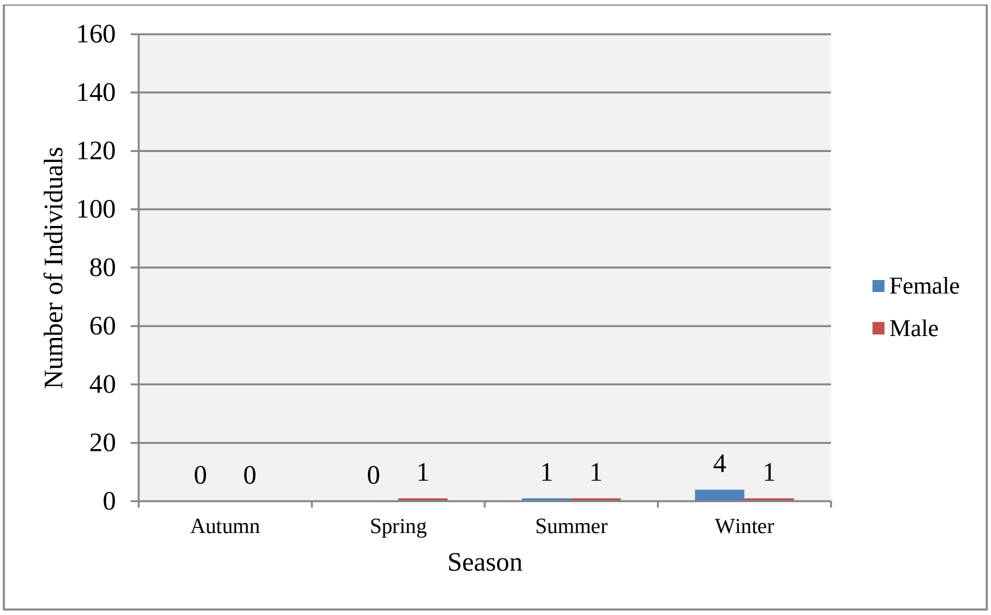

Figure 85. Graph illustrating the seasonal recorded sex ratio of *Crocidura mariquensis* collected on Telperion.

The ratio between male and female specimens differed in that greater frequencies of female animals were recorded during this study. The animals were recorded during spring (September – November), summer (December – February) and winter (June– August). No animals were collected during autumn (March - May). Higher frequencies of female animals were recorded in winter. Over the study period, a higher female to male ratio was recorded (♂ = 37.5%; ♀ = 62.5%). *Crocidura mariquensis* was collected in two habitat types at the study area, Moist Degraded Grassland (♂ = 3; ♀ = 3), and Sheltered Woodland (♂ = 0; ♀ = 2) (Appendix N), a species which appears to associate with moist, spongy areas.

### 8.5.17. Sex ratio of the population sample of *Elephantulus myurus* recorded on Telperion

The seasonal sex ratio data for *Elephantulus myurus* were recorded. The frequency of male animals ($n = 34$) to female animals ($n = 36$) is insignificant ($t_{(6)} = -0.134$; $n = 70$; $P =$

0.898), with only a slightly higher number of females recorded. The following seasonal frequencies between male and female specimens were recorded for *E. myurus*: Autumn (♂ = 12; ♀ = 15), Spring (♂ = 2; ♀ = 2), Summer (♂ = 7; ♀ = 11), Winter (♂ = 13; ♀ = 8) (Fig. 86). Statistically there is no significant relationship between sex and season $\chi^2 = 1.206$; $df = 3$; $n = 4$; $P = 0.751$.

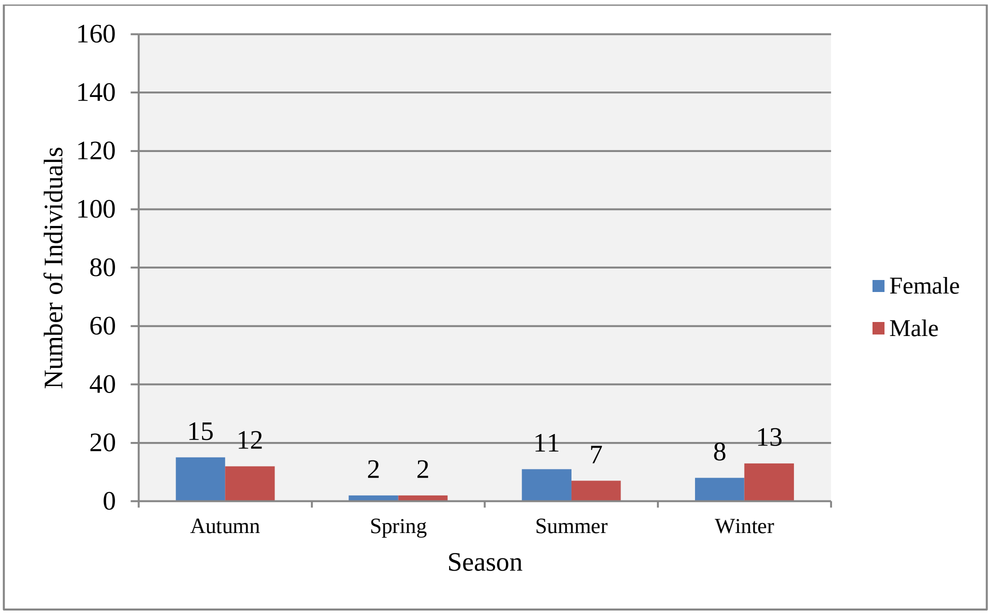

Figure 86. Graph illustrating the seasonal recorded sex ratio of *Elephantulus myurus* collected on Telperion.

No large differences occurred between the frequencies recorded for male and female specimens during this study, with the largest variance occurring in winter with more males ($n$ = 13) recorded, five specimens greater than recorded for females. This is the most abundant insectivore occurring at the study site and thus the insectivore species most frequently recorded. Male and female animals were recorded in all seasons at the study site, with lowest frequencies recorded in spring. Over the study period, a slightly higher male to female ratio was recorded (♂ = 51.4%; ♀ = 48.6%). *Elephantulus myurus* was collected in four habitat types, in Northern Slope Woodland (♂ = 13; ♀ = 11), Rocky Highveld Grassland (♂ = 4; ♀ = 4), Sheltered Woodland (♂ = 6; ♀ = 6) and Rocky Open Shrub (♂ = 11; ♀ = 15), all habitats with a varying degree of rocky red sandstone substrate, the species appearing to avoid either sandy or grassy habitats without the presence of rock and occupies the same ecological niche as *M. namaquensis* (Appendix N).

### 8.5.18. Sex ratio of the population sample of *Suncus infinitesimus* recorded on Telperion

The seasonal sex ratio data for *Suncus infinitesimus* were recorded. The frequency of male animals ($n$ = 2) to female animals ($n$ = 3) is insignificant ($t_{(6)}$ = -0.361; $n$ = 6; $P$ = 0.730), with low numbers of specimens recorded. The following seasonal frequencies between male and female specimens were recorded for *S. infinitesimus*: Autumn (♂ = 1; ♀ = 0), Spring (♂ = 0; ♀ = 0), Summer (♂ = 3; ♀ = 2), Winter (♂ = 0; ♀ = 0) (Fig. 87). Statistically there is no significant relationship between sex and season $\chi^2$ = 1.166; $df$ = 3; $n$ = 4; $P$ = 0.761.

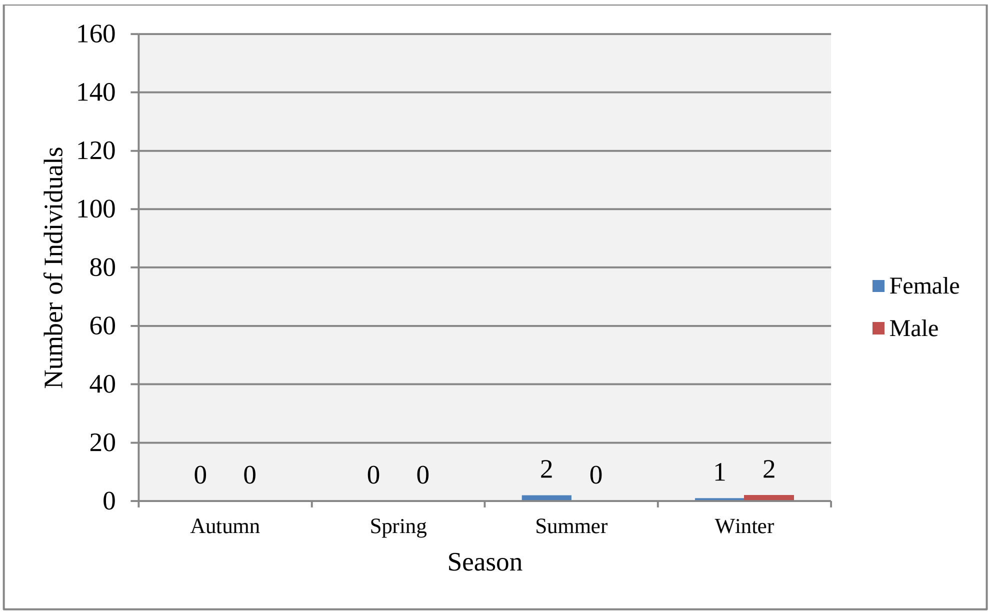

Figure 87. Graph illustrating the seasonal recorded sex ratio of *Suncus infinitesimus* collected on Telperion.

No large differences occurred between the frequencies recorded for male and female specimens during this study. It is suspected that this species occurs at the study site in generally low numbers and few animals were recorded. Male animals were recorded during winter (June - August). Female animals were recorded in summer (December - February) and winter, also in low numbers. Over the study period, a higher male to female ratio was recorded (♂ = 60%; ♀ = 40%). Interestingly, *S. infinitesimus* were collected in three habitat types, in Degraded Grassland (♂ = 0; ♀ = 1), Sheltered Woodland (♂ = 0; ♀ = 1) and Moist Degraded Grassland (♂ = 2; ♀ = 1) (Appendix N).

## 8.6. Discussion

The objectives of the chapter were to identify and quantify differences in the sex ratio of small mammal fauna in the fire climax Bankenveld grasslands of Telperion, Mpumalanga Province and Ezemvelo Nature Reserve, Gauteng Province, South Africa. Small mammals (= adults < 2kg) comprise quite a large percentage (> 60%) of all terrestrial mammal species in southern Africa (Skinner & Chimimba 2005). It is expected that equal numbers of male to female animals will be recorded during the study, however, there are period when sex capture bias is likely.

Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Intraspecific competition between small mammal species should occur at a higher density than interspecific competition since resource use is essentially the same within a species (Perri & Randall 1999; Perrin *et al.* 2001; Zhang 2003; Dammhahn & Kappeler 2008). Mutually exclusive home ranges provide evidence of avoidance rather than aggression as a behavioural mechanism promoting community structure and coexistence. However, the presence of a variety of species is just one factor influencing home range overlap. Other biological factors include population density, abundance, and sex, while ecological factors may include season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Ribble *et al.* 2002; Priotto *et al.* 2002; Schradin & Pillay 2006; Pasch & Koprowski 2006; Copper & Randall 2007). Polygynous species tend to have a high degree of intraspecific overlap, especially between females and thus also tend to have higher densities (Ribble & Stanley 1998; Priotto *et al.* 2002). The sex ratio of these species tends to be skewed towards male dominance. Promiscuous species within a community also tend to have high densities with a high degree of overlap between sexes, since males are unable to monopolise widespread females (Ostfeld 1990; Ribble & Stanley 1998; Jackson 1999).

Both abiotic and biotic factors have been proposed as regulators of breeding in different species and density in small mammal communities (Perrin & Boyer 2000). These factors indirectly influence the sex ratio recorded. The seasonal reproductive change sometimes recorded within these small mammal communities is often associated with changes in the diet (Perrin & Boyer 2000). Mechanisms that reduce interspecific competition and improve overall fitness promote coexistence in communities (Kinahan & Pillay 2008). Three main cues, or a combination, are expected to influence reproduction in small mammals, namely abiotic factors (such as food availability), internal factors (endogenous rhythms) and social cues between individuals (Neal 1986; Ims 1990). Abiotic factors, such as rain are not likely to affect breeding directly as there is usually a lag time of two or three months between rainfall and the evidence of breeding (Bronner 1986), but rather affects breeding indirectly through food availability (Neal 1982). Rainfall therefore may still contribute to the timing of the reproductive seasonality and could explain inter-year variation in population numbers and demography (Willan & Meester 1989; Monadjem & Perrin 2003). Temperature could influence breeding success, especially during exceptionally cold and wet periods. Timing of breeding in small mammal populations is often constrained, not only by the environment but also phylogenetically in terms of age of reproduction. Population size fluctuations and species richness are due to differences in recruitment (movements into the population through birth and immigration) and emigration (movements out of the population through dispersal and death (Bronner 1986). Many small mammal species in southern Africa have a sex ratio that approximates 1:1 (Bronner 1986; Perrin & Swanepoel 1987; Ostfeld & Manson 1996; Monadjem 1999; Yarnell & Scott 2006).

Male individuals of certain species of rodents appear more readily captured in spring and summer as they become more active in search of females to mate with. Higher numbers of male *Acomys spinosissimus* were recorded during summer months and all appeared reproductively active.  Similarly, male *Micaelamys namaquensis* were more regularly caught in spring, at the beginning of the species breeding season. Another theory explains why in certain cases, more female animals are recorded in late summer and autumn. Larger numbers of female *Mus minutoides* were recorded in late summer and autumn during the study. This could result as females become more active in search of food as energy requirements are increased during lactation and post-breeding. Female *Elephantulus myurus* were more regularly recorded in summer and autumn, while male animals dominated in winter during this study.

# CHAPTER 9

## CAPTURE-RECAPTURE OF SMALL MAMMAL SPECIES RECORDED ON TELPERION

### 9.1. Abstract

This chapter aims to determine the capture-recapture ratio for small mammal fauna in seven different vegetation communities of Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. A portion of the population was captured, marked, and released. Later, another portion was captured and the number of marked individuals within the sample was counted. The frequency of new and recaptured animals recorded during this study provided valuable information regarding the population dynamics and abundance. The frequency of new to recaptured animals differed seasonally as well as between species. As trapping at each transect was performed over two to five nights, recaptures occurred after marking an individual. The following results were recorded, *Acomys spinosissimus* (*New* = 11; *Recaptures* = 13), *Aethomys chrysophilus* (*New* = 6; *Recaptures* = 5), *Dendromus melanotis* (*New* = 81; *Recaptures* = 34), *Dendromus mystacalis* (*New* = 12; *Recaptures* = 6), *Gerbilliscus brantsii* (*New* = 12; *Recaptures* = 9), *Gerbilliscus leucogaster* (*New* = 12; *Recaptures* = 12), *Graphiurus murinus* (*New* = 5; *Recaptures* = 1) *Lemniscomys rosalia* (*New* = 13; *Recaptures* = 29), *Mastomys* spp. (*New* = 10; *Recaptures* = 3), *Micaelamys namaquensis* (*New* = 256; *Recaptures* = 516), *Mus minutoides* (*New* = 31; *Recaptures* = 10), *Otomys irroratus* (*New* = 6; *Recaptures* = 1), *Rhabdomys pumilio* (*n* = 13; *Recaptures* = 9), *Steatomys pratensis* (*New* = 9; *Recaptures* = 5), *Crocidura mariquensis* (*New* = 4; *Recaptures* = 4) and *Elephantulus myurus* (*New* = 70; *Recaptures* = 149). Two species of insectivores, *Crocidura cyanea* (*New* = 3) and *Suncus infinitesimus* (*New* = 5) were not recaptured during the study. The population of small mammals appears to be resident, with defined home ranges, although some local movements tended to occur. Species such as *Gerbilliscus brantsii*, *Gerbilliscus leucogaster* and *Elephantulus myurus* have fixed colonies, and recapture rates are high.

**Keywords:** Capture, recapture, Telperion, Ezemvelo Nature Reserve, insectivores, small mammals, marked individuals, South Africa.

## 9.2. Introduction

The chapter investigates a portion of the population captured, marked, and released. Later, another portion is captured and the numbers of marked individuals within the sample are counted. The frequency of new and recaptured animals recorded during this study will provide valuable information regarding the population dynamics and abundance. This chapter aims to determine the capture-recapture ratio for small mammal fauna in seven different vegetation communities of Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Information on territories and home ranges of small mammals may be assessed through capture-recapture studies. The relative influence of density dependence in the dynamics of rodent populations is a matter of considerable debate (Krebs 2002; Berryman 2004). Density dependence affects the population dynamics of many species (Sibly *et al.* 2005), whereas seasonal changes in survival and fecundity appear to exert great influence on certain populations (Boonstra & Krebs 2006).

Capture-recapture studies assess a known number of marked individuals within a population and determine whether the second sample is proportional to the number of marked individuals in the whole population, thus providing an estimate of the total population size by dividing the number of marked individuals by the proportion of marked individuals in the second sample. The method is useful when it is not practical to count all of the individuals in the population. Small mammal community structure and species richness is related to variables such as habitat structure and complexity (Rosenzweig & Winakur 1969; Brown 1973; French *et al.* 1976; Bond *et al.* 1980; Dueser & Brown 1980; Rowe-Rowe & Meester 1982a; Thompson 1982; Parmenter & MacMahon 1983; Kotler 1984; Abramsky 1988; Kerley 1992; Els & Kerley 1996), area (Abramsky *et al.* 1985; Fitzgibbon 1997), productivity (Abramsky 1978, 1988; Rosenweig 1992); predation (Kotler 1984; Norrdahl & Korpimäki 1995; Abramsky et al. 1998; trampling and grazing (Keesing 1998; Milchunas *et al.* 1998); surrounding landscape and the distance between similar habitats (Fitzgibbon 1997), and the maturity of the habitat and succession of the vegetation (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Rowe-Rowe 1995; Fitzgibbon 1997; Ferreira & van Aarde 1999). Mutually exclusive home ranges provide evidence of avoidance rather than aggression as a behavioural mechanism promoting community structure and coexistence. However, the presence of a variety of species is just one factor influencing home range overlap.

Other biological factors include population density, abundance, sex and age structure, and body size, while ecological factors may include season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Ribble *et al.* 2002; Priotto *et al.* 2002; Schradin & Pillay 2006; Pasch & Koprowski 2006; Copper & Randall 2007). Home range also gives an indication of the social structure of small mammal species (Schradin & Pillay 2006; Cooper & Randall 2007). Polygynous species tend to have a high degree of intraspecific overlap, especially between females and thus also tend to have higher densities (Ribble & Stanley 1998; Priotto *et al.* 2002). Promiscuous species within a community also tend to have high densities with a high degree of overlap between sexes, since males are unable to monopolise widespread females (Ostfeld 1990; Ribble & Stanley 1998; Jackson 1999). These factors are expected to influence recapture success and influence the habits of certain species. Population size fluctuations and species richness are due to differences in recruitment (movements into the population through birth and immigration) and emigration (movements out of the population through dispersal and death (Bronner 1986). Capture-recapture is expected to differ between habitats, over seasons, between species, and with trap method. The population of small mammals is expected to be resident, with defined home ranges, although some local movements are expected to occur. Space use by small mammals in the Bankenveld may be influenced by variation in food distribution and abundance and the variety of acceptable food resources. This in unpredictable environments, or under high population density, home range size may be larger as distance travelled to find resources in order to meet energy requirements increases (Pasch & Koprowski 2006).

Those small mammal species with fixed territories or home ranges may be more readily recaptured to species with local movements. These species may utilize fixed areas, and will there therefore be recaptured in these transects until they perish. Interpretation of capture-recapture results is complicated by the fact that many rodents could potentially be trapped even if only part of their home range fell into a survey area, which could give rise to biases in population estimates based on trapping rates (Bowers *et al.* 1996).

## 9.3. Methodology:

In year one (2008), ten transects each comprising 30 live-traps Sherman each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month. The starting-point was placing transects in the seven vegetation communities. In year one, two transects were placed in the dominant communities to obtain a greater sample size. In year one, 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. 10 m spacing was adopted at the study site with the available traps. In year two (2009), three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per site. Of the eighteen specie recorded during this study, sixteen species were recaptured.

Chi-square ($\chi^2$) tests were used to analyze capture-recapture frequencies and season, and t-tests ($t$) to analyze the variance between new individuals and recaptures, using the mean difference between the two variables and dividing these by the standard error of the difference.

All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 9.4. Results

Eighteen species were recorded during this study which include *Acomys spinosissimus* (*n* = 11), *Aethomys chrysophilus* (*n* = 6), *Dendromus melanotis* (*n* = 81), *Dendromus mystacalis* (*n* = 12), *Gerbilliscus brantsii* (*n* = 12), *Gerbilliscus leucogaster* (*n* = 12), *Graphiurus murinus* (*n* = 5), *Lemniscomys rosalia* (*n* = 13), *Mastomys* spp. (*n* = 10), *Micaelamys namaquensis* (*n* = 256), *Mus minutoides* (*n* = 31), *Otomys irroratus* (*n* = 6), *Rhabdomys pumilio* (*n* = 13), *Steatomys pratensis* (*n* = 9), *Crocidura cyanea* (*n* = 3), *Crocidura mariquensis* (*n* = 4), *Elephantulus myurus* (*n* = 70), and *Suncus infinitesimus* (*n* = 5).

Sixteen species were recaptured, these include *Acomys spinosissimus* (*n* = 13), *Aethomys chrysophilus* (*n* = 5), *Dendromus melanotis* (*n* = 34), *Dendromus mystacalis* (*n* = 6), *Gerbilliscus brantsii* (*n* = 9), *Gerbilliscus leucogaster* (*n* = 12), *Graphiurus murinus* (*n* = 1) *Lemniscomys rosalia* (*n* = 29), *Mastomys* spp. (*n* = 3), *Micaelamys namaquensis* (*n* = 516), *Mus minutoides* (*n* = 10), *Otomys irroratus* (*n* = 1), *Rhabdomys pumilio* (*n* = 9), *Steatomys pratensis* (*n* = 5), *Crocidura mariquensis* (*n* = 4) and *Elephantulus myurus* (*n* = 149).

## 9.5. Capture-recapture ratio recorded for the small mammal species recorded on Telperion

### 9.5.1. Capture-recapture ratio recorded for *Acomys spinosissimus* on Telperion

Capture - recapture data were recorded for *Acomys spinosissimus* from two sites on Telperion. The frequencies recorded of new captures ($n$ = 11) to recaptures ($n$ = 13) were insignificant ($t_{(6)} = -0.510$; $n = 24$; $P = 0.627$), with a similar number of new animals to recaptures recorded (Fig. 88).

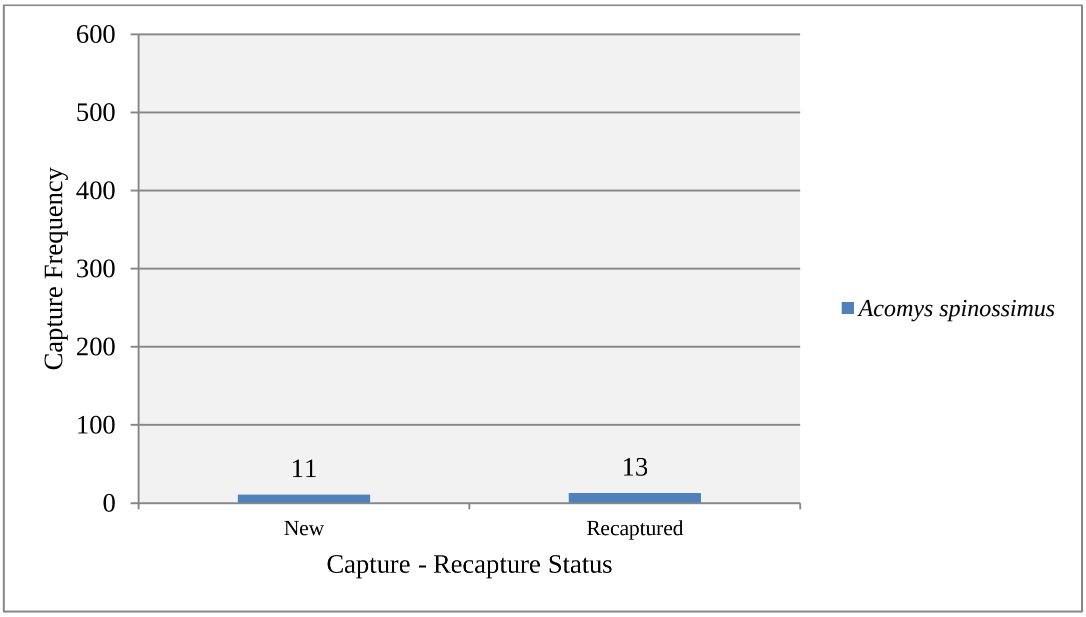

Figure 88. Graph illustrating the capture-recapture ratio of *Acomys spinosissimus* recorded from two vegetation communities on Telperion

The percentage of new captures (45.8%) to recaptures (54.2%) were similar, however as a result of low numbers recorded this does not necssilarily provide an accurate representation. Statistically there is no significant relationship between capture-recapture status and season $\chi^2 = 1.221$; $df = 3$; $n = 4$; $P = 0.748$. The representative percentage of 1.6% of the total recaptures and 2.0% of new captures recorded during this study were *A. spinossimus*. This species was recorded at two sites at the study site and is closely associated with large boulders.

### 9.5.2 Capture-recapture ratio recorded for *Aethomys chrysophilus* on Telperion

Capture-recapture data were recorded for *Aethomys chrysophilus* from three sites on Telperion. The frequencies recorded of new captures ($n$ = 6) to recaptures ($n$ = 5) were insignificant ($t_{(6)} = 0.195$; $n = 11$; $P = 0.852$), and similar numbers were recorded (Fig. 89).

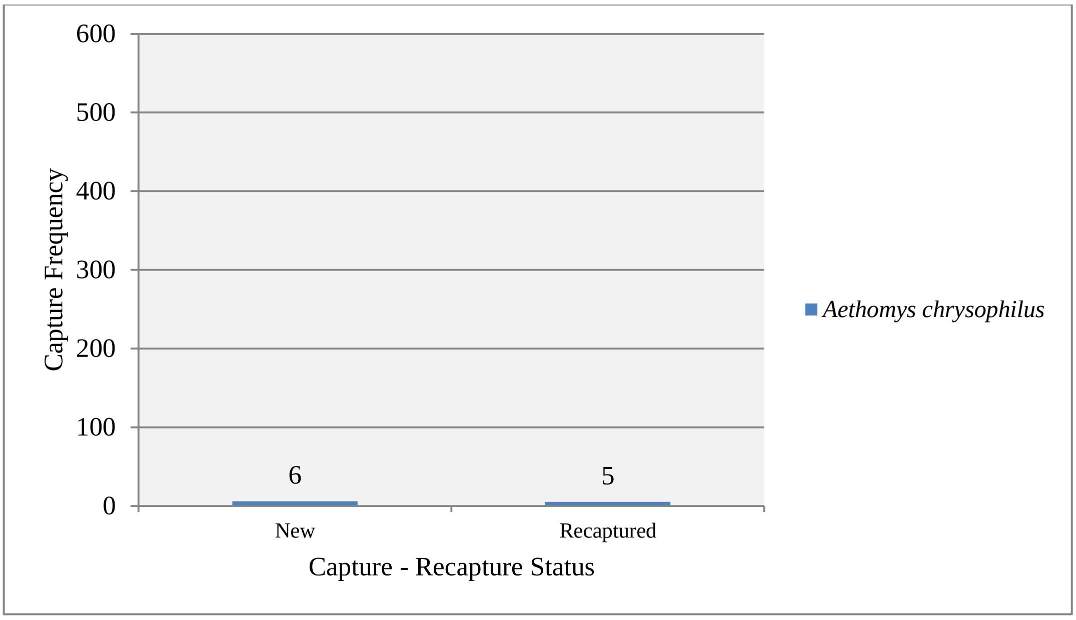

Figure 89. Graph illustrating the capture-recapture ratio of *Aethomys chrysophilus* recorded from three transects on Telperion.

The percentage of new captures (54.5%) to recaptures (45.5%) were similar, however as a result of low numbers recorded does not provide an accurate representation. Statistically there is no significant relationship between capture-recapture status and season $\chi^2 = 1.643$; $df = 3$; $n = 4$; $P = 0.649$. The representative percentage to the overall recaptures (0.6%) and overall new captures (1.1%) recorded during this study were *A. chrysophilus*. This species was not regularly encountered at the study site and abundance appears sporadic in nature.

### 9.5.3 Capture-recapture ratio recorded for *Dendromus melanotis* on Telperion

Capture-recapture data were recorded for *Dendromus melanotis* on Telperion. The frequency of new captures ($n = 81$) to recaptures ($n = 34$) indicate that significantly more new animals $\chi^2 = 19.862$; $df = 1$; $n = 115$; $P = 0.000$ were recorded during this study compared with recaptures (Fig. 90).

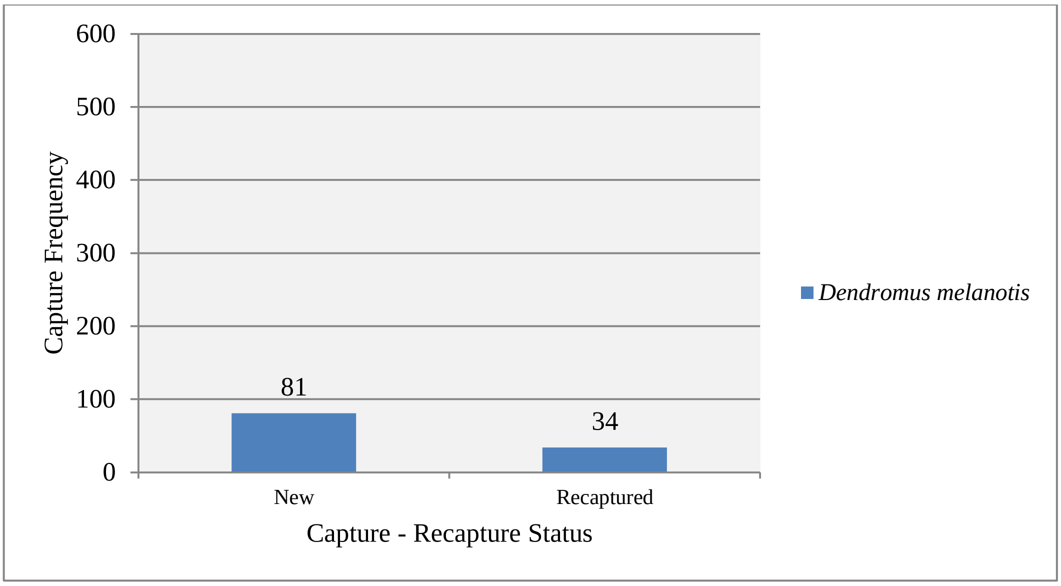

Figure 90. Graph illustrating the capture-recapture ratio of *Dendromus melanotis* recorded from six transects on Telperion.

This result indicated by the percentage of new captures (70.4%) to recaptures (29.6%), shows that a large percentage of the population was not recaptured during the study period. Statistically there is a significant relationship between capture-recapture status and season $\chi^2 = 13.352$; $df = 3$; $n = 4$; $P = 0.004$, with more new animals being recorded in autumn and winter. The representative percentage of the overall recaptures (4.2%) and overall new captures (14.4%) during this study were recorded for *D. melanotis.*

### 9.5.4 Capture-recapture ratio recorded for *Dendromus mystacalis* on Telperion

Capture - recapture data were recorded for *Dendromus mystacalis* from three sites on Telperion. Disproportional frequencies of new captures ($n = 12$) to recaptures ($n = 6$) were recorded (Fig. 91). In comparison, insignificantly ($t_{(6)} = 0.655$; $n = 18$; $P = 0.537$) fewer recaptures compared with new animals were recorded during the study, although fewer animals were recaptured, possibly as a result of this species sporadic distribution at the study site.

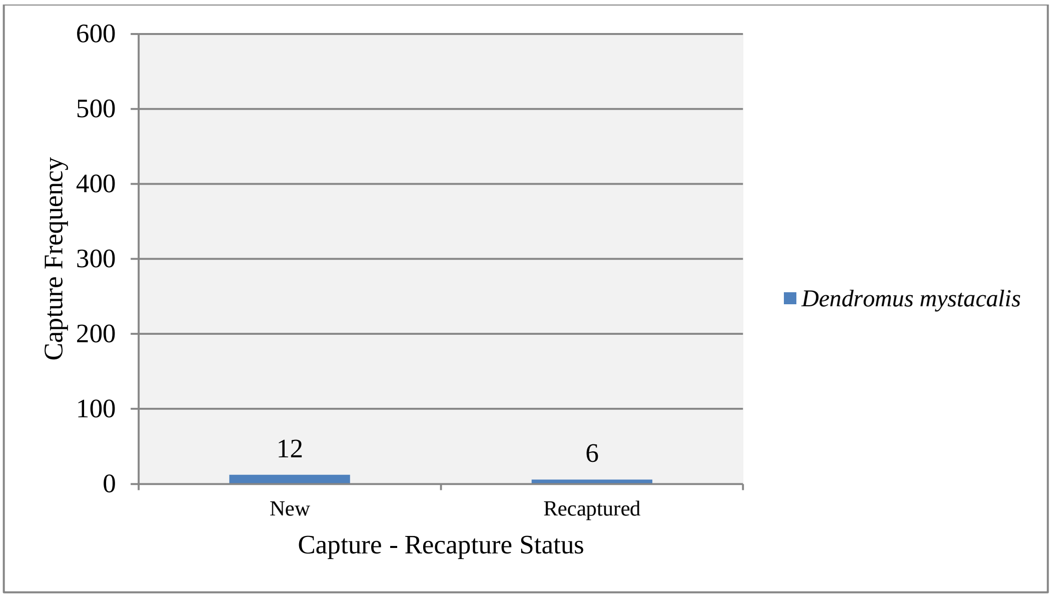

Figure 91. Graph illustrating the capture-recapture ratio of *Dendromus mystacalis* recorded from three vegetation types on Telperion.

The percentage of new captures (66.7%) to recaptures (33.3%) indicates this species appears to be less resident and is possibly nomadic in habits. Statistically there is no significant differece between capture-recapture status and season $\chi^2 = 1.500$; $df = 3$; $n = 4$; $P = 0.682$. The representative percentage of the overall recaptures (0.7%) and overall new captures (2.1%) during this study were recorded for *D. mystacalis.*

### 9.5.5 Capture-recapture ratio recorded for *Gerbilliscus brantsii* on Telperion

Capture - recapture data were recorded for *Gerbilliscus brantsii* from one sites on Telperion. An insignificant ($t_{(6)} = 0.379$; $n = 21$; $P = 0.717$) difference occurred between the frequency of new captures ($n = 12$) to recaptures ($n = 9$) were recorded (Fig. 92). In comparison however, fewer recaptures were recorded. Low numbers of animals were recorded, possibly as a result of a specific habitat requirement and limited distribution at the study site.

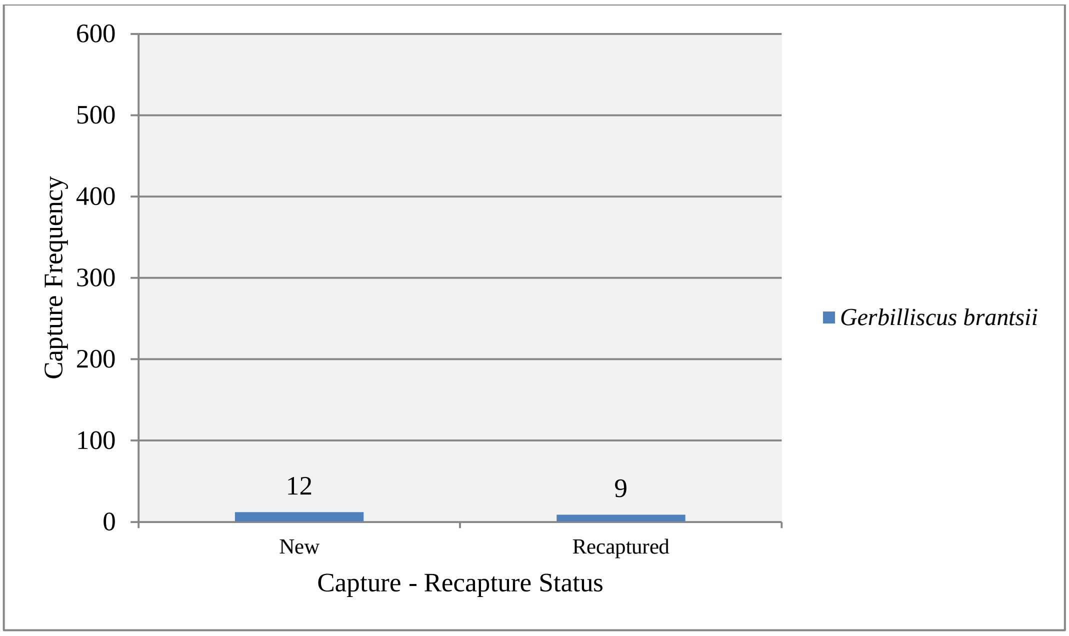

Figure 92. Graph illustrating the capture-recapture ratio of *Gerbilliscus brantsii* recorded from one vegetation community on Telperion.

The percentage of new captures (57.1%) to recaptures (42.9%) indicates this species is resident, living in colonies and occupies distinct home ranges. Statistically there is no significant difference between capture-recapture status and season $\chi^2 = 0.642$; $df = 3$; $n = 4$; $P = 0.886$, although more new animals were recorded in spring. The representative percentage of the overall recaptures (1.1%) and overall new captures (2.1%) during this study were recorded for *G. brantsii.*

### 9.5.6 Capture-recapture ratio recorded for *Gerbilliscus leucogaster* on Telperion

Capture-recapture data were recorded for *Gerbilliscus leucogaster* from two vegetation communities on Telperion. The frequency of new captures ($n$ = 12) to recaptures ($n$ = 12) indicated the animal is resident in an area for a prolonged period of time resulting in this species being repeatedly captured during this study (Fig. 93). Statistically there is an insignificant ($t_{(6)} = 0.00$; $n = 24$; $P = 1.000$) difference between new captures and recaptures.

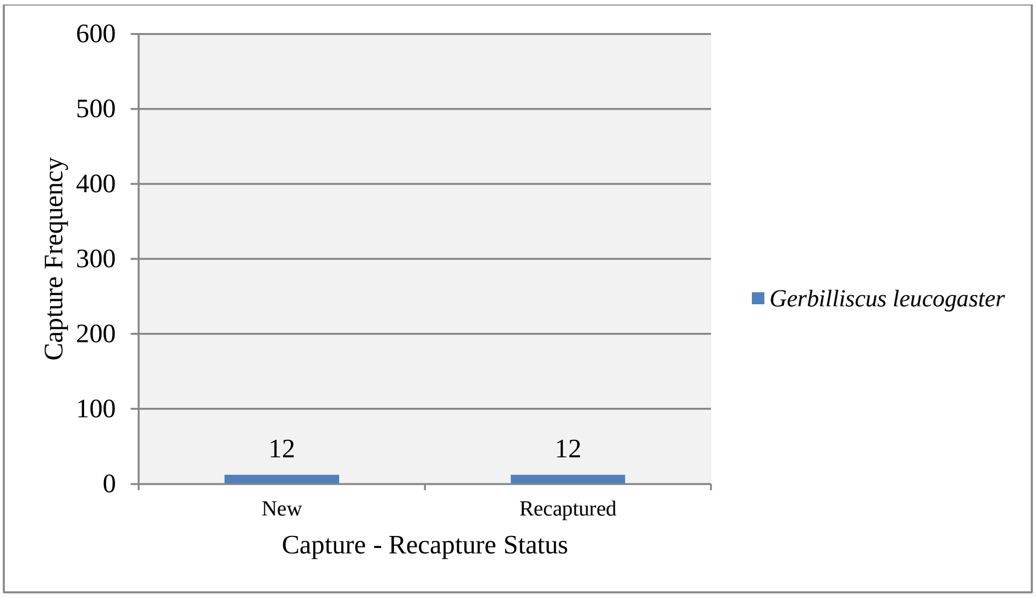

Figure 93. Graph illustrating the capture-recapture ratio of *Gerbilliscus leucogaster* recorded from two vegetation communities on Telperion.

The percentage of new captures (50%) to recaptures (50%) indicates this species is less nomadic than other species. Statistically there is no significant difference between capture-recapture status and season $\chi^2 = 1.406$; $df = 3$; $n = 4$; $P = 0.704$. The representative percentage of 1.5% of the total recaptures and 2.1% of the total new captures were recorded for *Gerbilliscus leucogaster* during this study.

### 9.5.7 Capture-recapture ratio recorded for *Graphiurus murinus* on Telperion

Capture-recapture data were recorded for *Graphiurus murinus* from one site on Telperion. The frequencies recorded of new captures ($n = 5$) to recaptures ($n = 3$) were insignificant ($t_{(6)} = 0.562$; $n = 8$; $P = 0.595$), although this species was not recaptured frequently (Fig. 94).

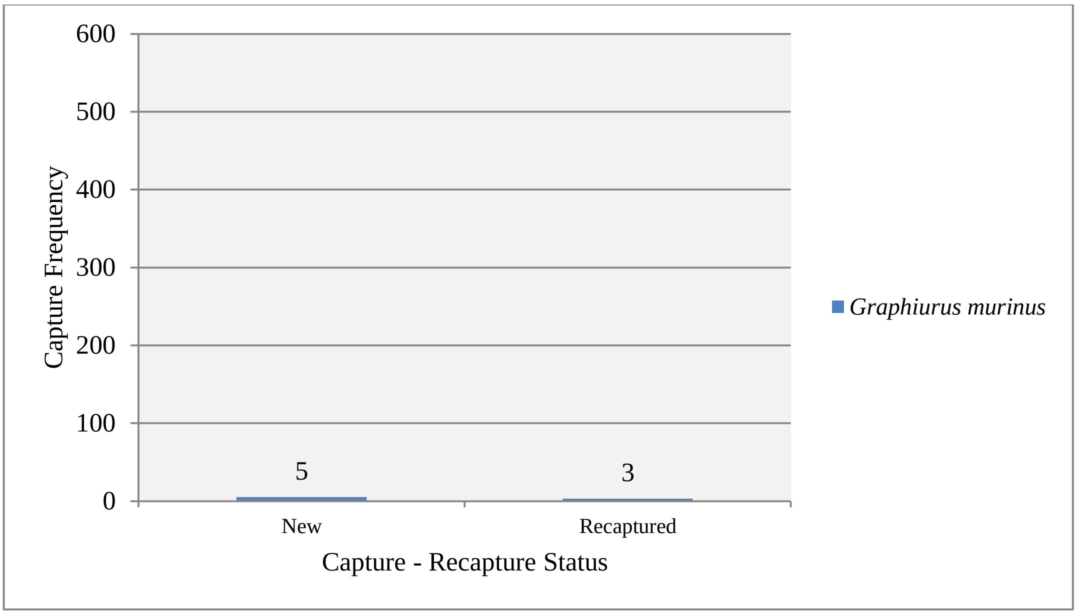

Figure 94. Graph illustrating the capture-recapture ratio of *Graphiurus murinus* recorded from two vegetation communities on Telperion.

The percentage of new captures (62.5%) to recaptures (37.5%) indicates this species is resident, occupying distinct home ranges, although not frequently recorded at the study site. Statistically there is no significant difference between capture-recapture status and season $\chi^2 = 0.266$; $df = 3$; $n = 4$; $P = 0.966$. The representative percentage of 0.1% of total recaptures and 0.9% for total new captures were recorded for *G. murinus* during this study.

### 9.5.8 Capture-recapture ratio recorded for *Lemniscomys rosalia* on Telperion

Capture-recapture data were recorded for *Lemniscomys rosalia* on Telperion. There is a statistically $\chi^2 = 6.095$; $df = 1$; $n = 42$; $P = 0.0135$ higher frequency of recaptures ($n = 29$) to new captures ($n = 13$), with a larger number of animals recaptured in comparison with new animals recorded during this study (Fig. 95).

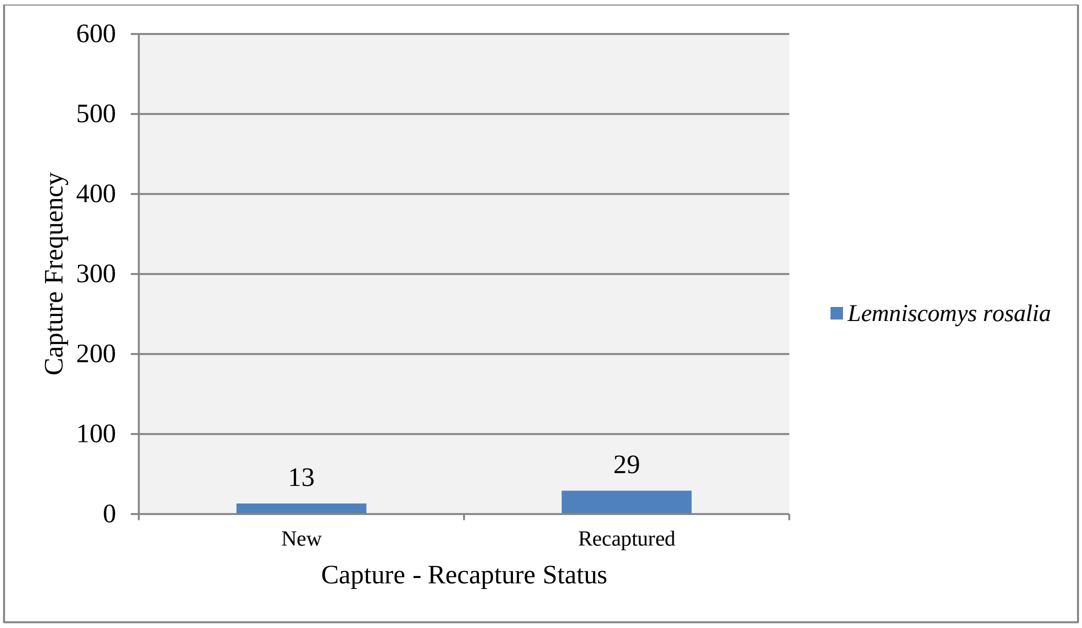

Figure 95. Graph illustrating the capture-recapture ratio of *Lemniscomys rosalia* recorded from three vegetation communities on Telperion.

The percentage of new captures (31%) to recaptures (69%) indicates this species is resident, occupying distinct home ranges. Statistically there is a significant difference between capture-recapture status and season $\chi^2 = 9.419$; $df = 3$; $n = 4$; $P = 0.024$, with a greater number of recaptures being recorded to new animals in all month except for summer. The representative percentage of 3.6% of the total recaptures and 2.3% of new captures recorded during this study were *L. rosalia*. This species was recorded in three vegetation communities at the study site and is closely associated vegetation cover.

### 9.5.9 Capture-recapture ratio recorded for *Mastomys* spp. on Telperion

Capture-recapture data were recorded for *Mastomys* spp. from three vegetation communities on Telperion. The differences in frequencies recorded for new captures ($n = 10$) to recaptures ($n = 5$) were insignificant ($t_{(6)} = 0.614$; $n = 15$; $P = 0.561$), an indication of the nomadic nature of this species (Fig. 96).

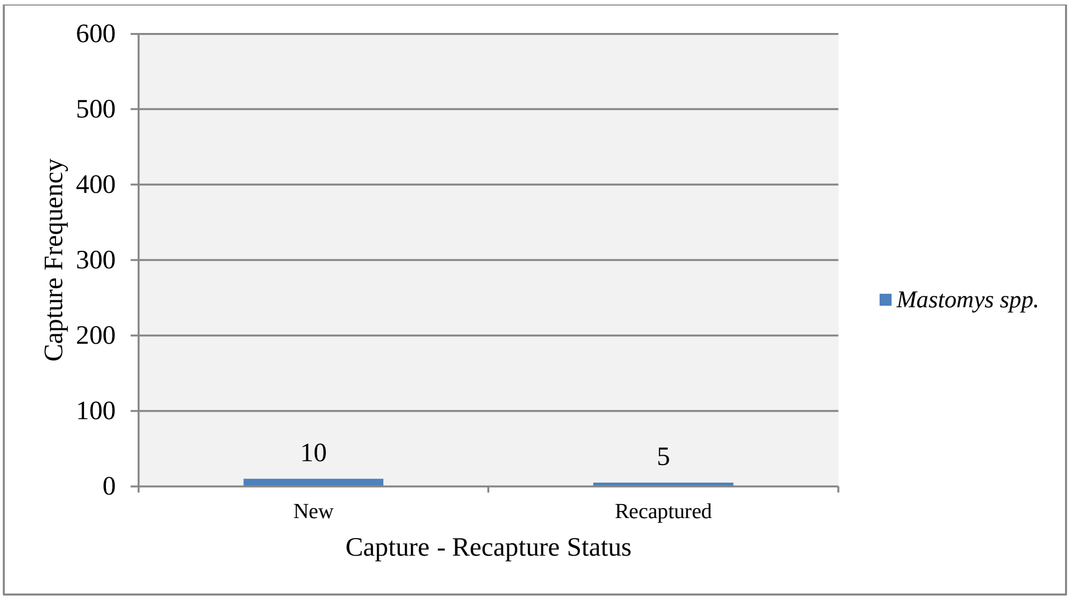

Figure 96. Graph illustrating the capture-recapture ratio of *Mastomys* spp. recorded from three vegetation communities on Telperion.

The percentage of new captures (66.6%) to recaptures (33.4%) differed greatly, however as a result of low numbers recorded does not provide an accurate representation. Statistically there is an insignificant difference between capture-recapture status and season $\chi^2 = 1.136$; *df* = 3; *n* = 4; *P* = 0.768. The representative percentage of 0.4% of the total recaptures and 1.8% of total new captures were recorded for *Mastomys* spp. during this study. This species was not regularly encountered during the study, largely due to its sporadic distribution and seasonal fluctuation in the abundance.

### 9.5.10 Capture-recapture ratio recorded for *Micaelamys namaquensis* on Telperion

Capture-recapture data were recorded for *Micaelamys namaquensis* from four vegetation communities on Telperion. The frequency of new captures (*n* = 256) to recaptures (*n* = 493) differed significantly ($t_{(6)} = -2.588$; *n* = 749; *P* = 0.041). Furthermore, this species appears to have fixed territories as individuals were recaptured frequently in the same trap or in adjacent traps on subsequent trapping sessions. Results indicate that many individuals recaptured were caught more than once (Fig. 97).

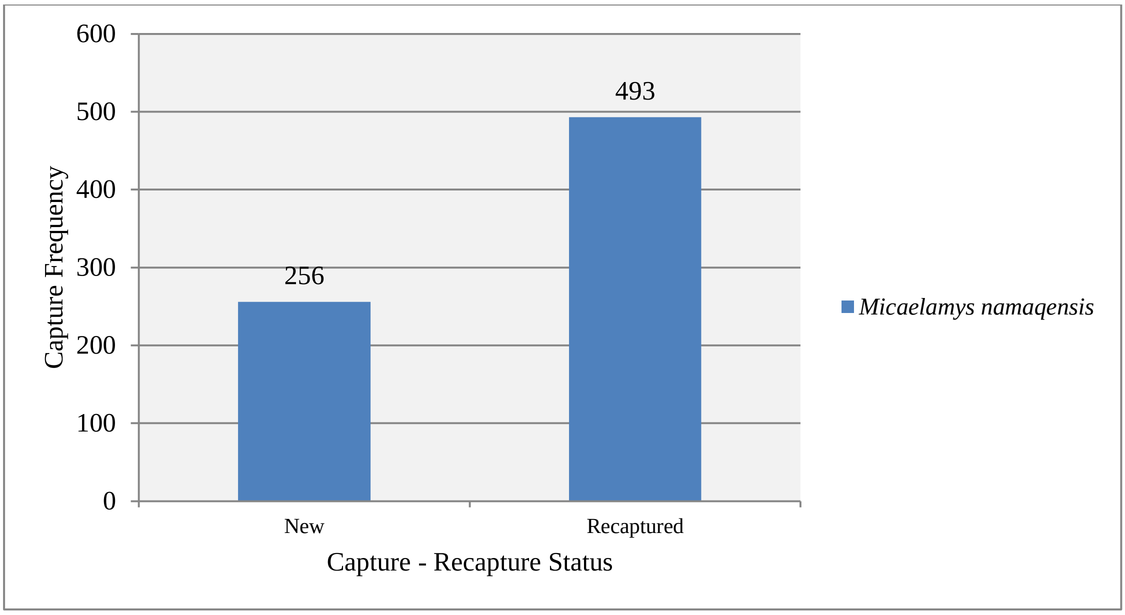

Figure 97. Graph illustrating the capture-recapture ratio of *Micaelamys namaquensis* recorded from four transects on Telperion.

These results are clearly indicated by the percentage of new captures (34.2%) to recaptures (65.8%). Statistically there is a significant difference between capture-recapture status and season $\chi^2 = 54.161$; $df = 3$; $n = 4$; $P = 0.000$, with recaptures dominating in all seasons. The large percentage of 64% of total recaptures and 45.4% of new individuals were recorded for *M. namquensis* during this study.

### 9.5.11 Capture-recapture ratio recorded for *Mus minutoides* on Telperion

Capture-recapture data were recorded for *Mus minutoides* from six vegetation types Telperion. Significantly $\chi^2 = 9.523$; $df = 1$; $n = 42$; $P = 0.002$ higher frequencies of new captures ($n = 31$) were recorded compared to recaptures ($n = 11$) (Fig. 98). *Mus minutoides* appears to be more difficult to recapture than other species and it is possibly more nomadic than other species. This species could also be more difficult to trap as a result of their light weight.

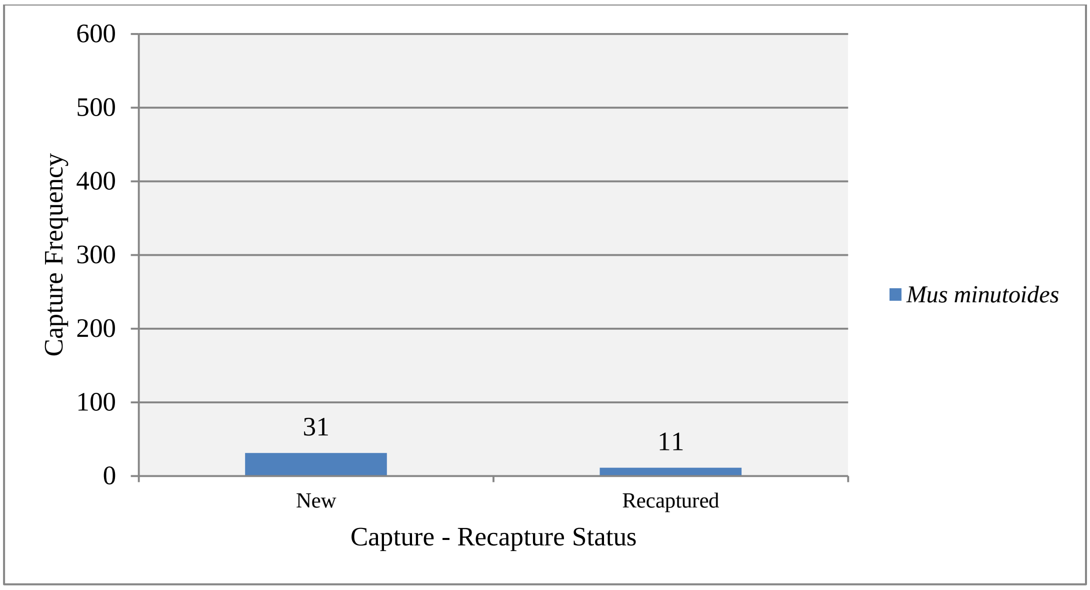

Figure 98. Graph illustrating the capture-recapture ratio of *Mus minutoides* recorded from six vegetation types on Telperion.

This result indicates a higher percentage of new captures (73.8%) to recaptures (26.2%). Statistically there is a no significant difference between capture-recapture status and season $\chi^2 = 6.729$; *df* = 3; *n* = 4; *P* = 0.081, however a greater number of new animals were recorded in summer. The representative percentage to the overall recaptures (1.2%) and overall new captures (5.5%) during this study were recorded for *M. minutoides.*

### 9.5.12 Capture-recapture ratio recorded for *Otomys irroratus* on Telperion

Capture-recapture data for *Otomys irroratus* were recorded from one site on Telperion. The difference in frequencies recorded between new captures (*n* = 6) to recaptures (*n* = 1) were marginally significant $\chi^2 = 3.571$; *df* = 1; *n* = 7; *P* = 0.059, with this species not being recaptured frequently (Fig. 99).

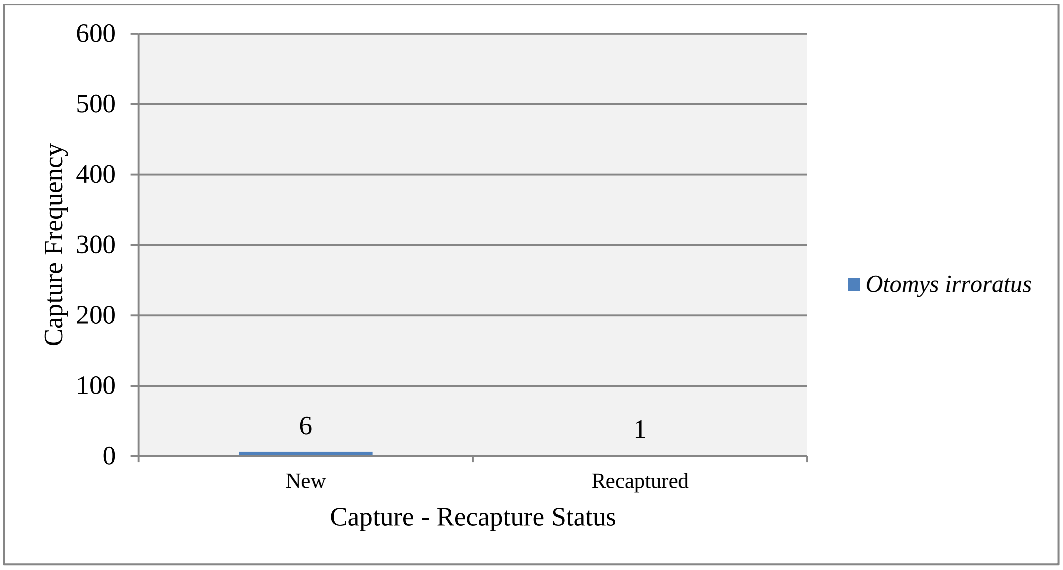

Figure 99. Graph illustrating the capture-recapture ratio of *Otomys irroratus* recorded from one vegetation type on Telperion.

The percentage of new captures (85.7%) to recaptures (14.3%) differed, however as a result of low numbers recorded does not provide an accurate representation. Statistically there is a no significant difference between capture-recapture status and season $\chi^2 = 1.900$; $df = 3$; $n = 4$; $P = 0.593$. The representative percentage to the overall recaptures (0.1%) and overall new captures (1.1%) recorded during this study were *Otomys irroratus*. This species was not regularly encountered during the study, largely due to this species favoured habitat not being well-represented in the majority of the survey sites.

### 9.5.13 Capture-recapture ratio recorded for *Rhabdomys pumilio* on Telperion

Capture-recapture data for *Rhabdomys pumilio* were recorded from one site on Telperion. The difference in frequency recorded for new captures (n = 13) to recaptures (n = 9) were insignificant ($t_{(6)} = 0.307$; $n = 22$; $P = 0.769$) (Fig. 100).

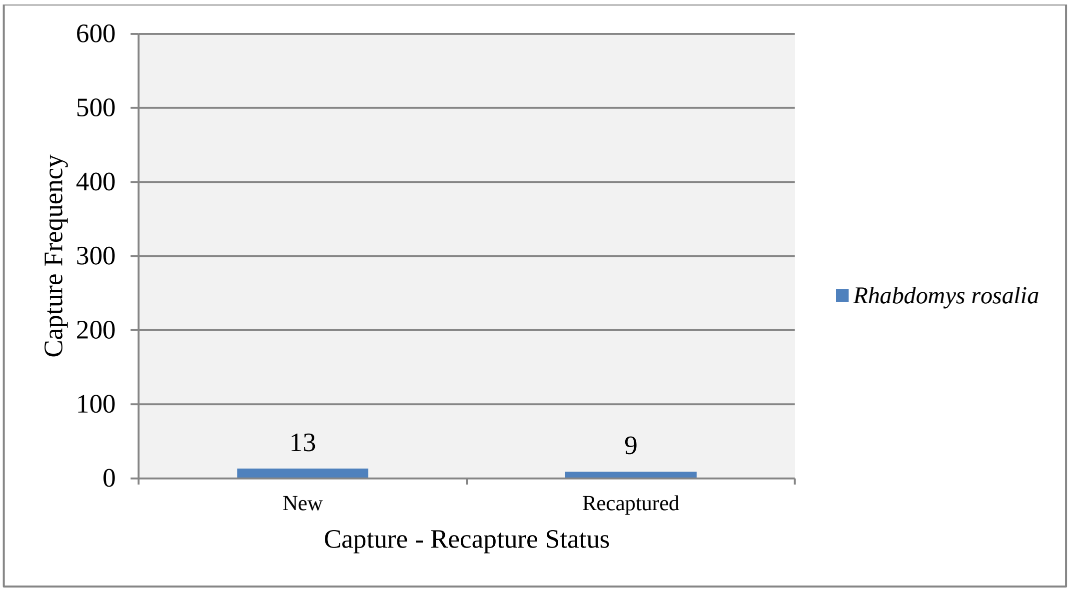

Figure 100. Graph illustrating the capture-recapture ratio of *Rhabdomys rosalia* recorded from one vegetation type on Telperion.

The percentage of new captures (59.1%) to recaptures (40.9%) differed marginally, however as a result of low numbers recorded does not provide an accurate representation. Statistically there is a no significant difference between capture-recapture status and season $\chi^2 = 1.526$; $df = 3$; $n = 4$; $P = 0.676$. The representative percentage of 1.1% of the total recaptures and 2.3% of total new captures were recorded for *R. rosalia* during this study. This species was not regularly encountered during the study, largely due to its sporadic distribution and seasonal fluctuation in the abundance.

### 9.5.14 Capture-recapture ratio recorded for *Steatomys pratensis* on Telperion

Capture-recapture data for *Steatomys pratensis* were recorded from three vegetation communities on Telperion. The difference in frequency recorded for new captures ($n = 9$) to recaptures ($n = 5$) were insignificant ($t_{(6)} = 0.617$; $n = 14$; $P = 0.559$) (Fig. 101).

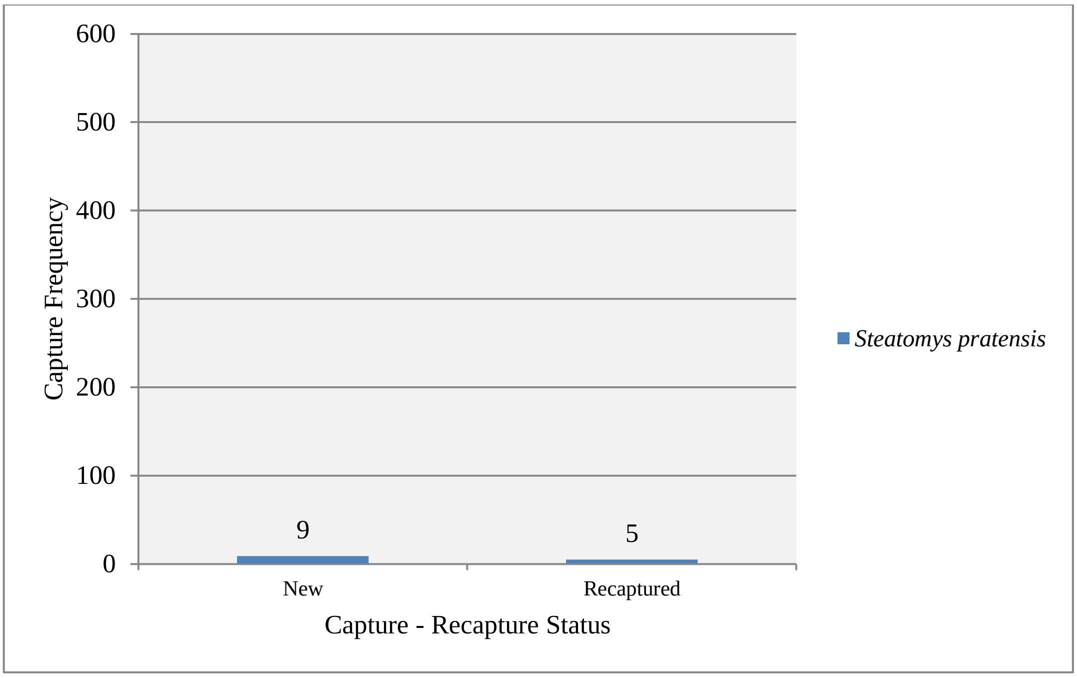

Figure 101. Graph illustrating the capture-recapture ratio of *S. pratensis* recorded from three vegetation types on Telperion.

The percentage of new captures (64.3%) to recaptures (35.7%) differ, however as a result of low numbers recorded does not provide an accurate representation. Statistically there is a no significant difference between capture-recapture status and season $\chi^2 = 2.200$; $df = 3$; $n = 4$; $P = 0.532$. The representative percentage of 0.6% of the total recaptures and 1.6% of total new captures were recorded for *S. pratensis* during this study. This species was randomly encountered during the study, largely due to its sporadic distribution.

### 9.5.15 Capture-recapture ratio recorded for *Crocidura cyanea* on Telperion

Only three individuals of *Crocidura cyanea* were recorded at the study site, however none of these animals were recaptured during the study period.

### 9.5.16 Capture-recapture ratio recorded for *Crocidura mariquensis* on Telperion

Capture-recapture data for *Crocidura mariquensis* were recorded from two sites on Telperion. The difference in frequency recorded for new captures ($n = 8$) to recaptures ($n = 4$) were insignificant $\chi^2 = 0.775$; $df = 6$; $n = 12$; $P = 0.468$ (Fig. 102).

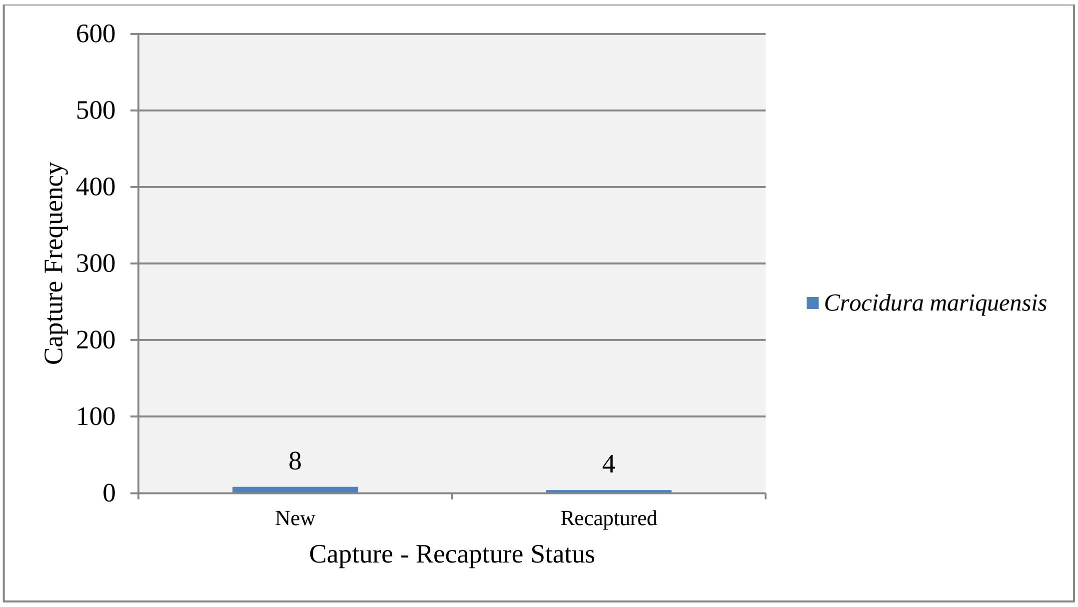

Figure 102. Graph illustrating the capture-recapture ratio of *Crocidura mariquensis* recorded from three vegetation types on Telperion.

The percentage of new captures (66.7%) to recaptures (33.3%) differed, however as a result of low numbers recorded does not provide an accurate representation. Statistically there is a no significant difference between capture-recapture status and season $\chi^2 = 0.917$; $df = 3$; $n = 4$; $P = 0.821$. The representative percentage of 0.5% of the total recaptures and 1.4% of total new captures were recorded for *C. mariquensis* during this study. This species was not regularly encountered during the study, largely due to its specialized habitat requirement.

### 9.5.17 Capture-recapture ratio recorded for *Elephantulus myurus* on Telperion

Capture-recapture data were recorded for *Elephantulus myurus* from four vegetation communities on Telperion. The frequency of new captures ($n = 70$) to recaptures ($n = 149$) differed significantly $\chi^2 = 27.908$; $df = 1$; $n = 219$; $P = 0.000$. Furthermore, this species appears to have fixed territories as individuals were recaptured frequently in the same trap or in adjacent traps on subsequent trapping sessions. Results indicate that many individuals recaptured were caught more than once (Fig.103).

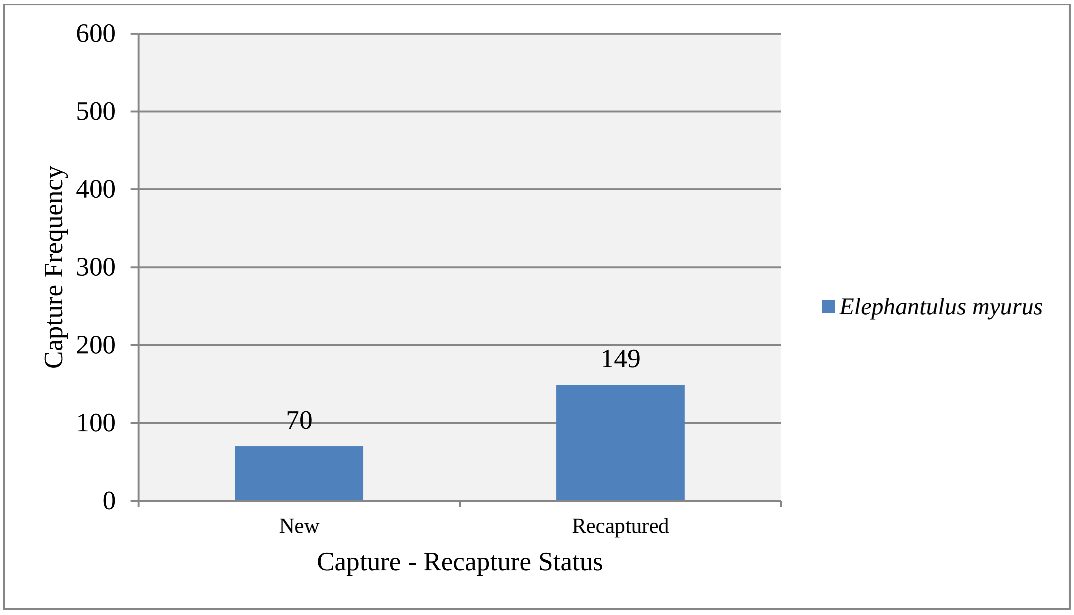

Figure 103. Graph illustrating the capture-recapture ratio of *Elephantulus myurus* recorded from four vegetation types on Telperion.

This result indicates a higher percentage of new captures (32%) to recaptures (68%). Statistically there is a significant difference between capture-recapture status and season $\chi^2$ = 27.051; *df* = 3; *n* = 4; *P* = 0.000, with the number of recaptured animals dominating in all month except for summer. The large percentage of 18.5% of total recaptures and 12.4% of new individuals were recorded for *E. myurus* during this study.

### 9.5.18 Capture-recapture ratio recorded for *Suncus infinitesimus* on Telperion

Although five individuals of *Suncus infinitesimus* were recorded at the study site, none of these were recaptured during the study period.

## 9.6. Discusion

The primary aim of this chapter is to analyze capture-recapture data recorded for small mammal fauna within vegetation communities in the Bankenveld grasslands of Mpumalanga and Gauteng Provinces, South Africa. Eighteen species of small mammal were recorded, sixteen species were recaptured during this study. Small mammals (= adults < 2kg) comprise quite a large percentage (> 60%) of all terrestrial mammal species in southern Africa (Skinner & Chimimba 2005). Capture-recapture studies assess a known number of marked individuals within a population and determine whether the second sample is proportional to the number of marked individuals in the whole population, thus providing an estimate of the total population size by dividing the number of marked individuals by the proportion of marked individuals in the second sample. The method is useful when it is not practical to count all of the individuals in the population.

Small mammal communities have been used as indicators of habitat integrity (Avenant 2000a, 2003; Avenant & Kuyler 2002; Avenant & Watson 2002). Tilman (1982) developed a growth curve for animal and plant groups whereby highest species richness increased with succession up to a point of climax, when they decreased to a point where equilibrium is reached. Species number is expected to fluctuate around this point until disturbance occurs (Avenant 2005).

Biodiversity of small mammals is used as an effective indicator of disturbance in natural ecosystems. Small mammal community structure and species richness have been related to biotic and abiotic variables such as habitat structure and complexity (Rosenzweig & Winakur 1969; Brown 1973; French *et al.* 1976; Bond *et al.* 1980; Dueser & Brown 1980; Rowe-Rowe & Meester 1982a; Thompson 1982; Parmenter & MacMahon 1983; Kotler 1984; Abramsky 1988; Kerley 1992; Els & Kerley 1996), area (Abramsky *et al.* 1985; Fitzgibbon 1997), productivity (Abramsky 1978, 1988; Rosenweig 1992); predation (Kotler 1984; Norrdahl & Korpimäki 1995; Abramsky *et al.* 1998; trampling and grazing (Keesing 1998; Milchunas *et al.* 1998); surrounding landscape and the distance between similar habitats (Fitzgibbon 1997), and the maturity of the habitat and succession of the vegetation (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Rowe-Rowe 1995; Fitzgibbon 1997; Ferreira & van Aarde 1999).

There appears to be a strong connection between disturbance in an ecosystem and the presence or absence of small mammal indicator species (Noss 1990; Armstrong & Van Hensbergen 1996; Avenant 1996; Leirs *et al.* 1996; Barreto *et al.* 1998.

Massawe *et al.* (2006) found an increase in rodent population in areas after seed emergence, although this trend was more evident in areas which has been slashed and burned through farming practices. Rainfall, timing, duration and amount, has a strong influence on the population dynamics of rodents as it indirectly affects availability of resources.

Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Co-existence in a grassland habitat may also be promoted by mechanisms that reduce interspecific competition (Kinahan & Pillay 2008) and thus improve overall fitness. Differential habitat use and the use of resources within these different systems, especially in space and time, may facilitate co-existence between species on a reserve, or specific habitat (M'Closkey 1976; Brown 1989; Yunger *et al.* 2002; Zhang 2003; Bonesi & Macdonald 2004; Harris *et al.* 2006). Spatial differences in small mammal communities are based on macro- and micro-habitat selection. How small mammals choose an area is a result of cover availability, differences in micro-climate, substrate, predation risk and food availability (Chesson 1986). Temporal differences on the other hand involve variations that act on a daily basis, such as resource renewal and availability, lunar, an increase in predation, and annual, rainfall, and temperature (Chesson 1986). Therefore, for community structure of small mammals, there needs to be an axis of environmental heterogeneity and a trade-off between interacting species, resulting in each species having a place on that axis where it is the superior competitor (Kotler & Brown 1988; Brown 1989; Abramsky *et al.* 1990; Perrin & Kotler 2005).

Species within a community may be able to inhabit the same habitat as they respond differently to environmental fluctuations (Moro & Morris 2000; Stilmant *et al.* 2008). Thus, Bankenveld small mammal communities may be composed of species that vary from having narrow habitat requirements, referred to as specialists, to those with very broad habitat requirements, or generalists (Ben-Natan *et al.* 2004; Manor & Saltz 2008).

Competitive co-existence may be emphasized when there is spatial or temporal variation in resource abundance or non-equilibrium between resource and consumer dynamics (Chesson 1986). Demonstrating that different species of small mammals may use different parts of a resource, such as seeds as opposed to culms of grass, does not indicate the absence of competition between species, and thus competitive interactions, similarly, competition cannot be inferred in a variety of species occurring in the same resource (Conley 1976; Holbrook 1979; Schoener 1983). Competitive release is well-understood in grassland environments, and occurs when in the absence of one species, another species increases its home range, density or range of food eaten (Chesson 1986). Intraspecific competition between small mammal species should occur at a higher density than interspecific competition since resource use is essentially the same within a species (Perri & Randall 1999; Perrin *et al.* 2001; Zhang 2003; Dammhahn & Kappeler 2008). Mutually exclusive home ranges provide evidence of avoidance rather than aggression as a behavioural mechanism promoting community structure and coexistence. However, the presence of a variety of species is just one factor influencing home range overlap. Other biological factors include population density, abundance, sex and age structure, and body size, while ecological factors may include season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld

1990; Ribble *et al.* 2002; Priotto *et al.* 2002; Schradin & Pillay 2006; Pasch & Koprowski 2006; Copper & Randall 2007). Home range also gives an indication of the social structure of small mammal species (Schradin & Pillay 2006; Cooper & Randall 2007). Polygynous species tend to have a high degree of intraspecific overlap, especially between females and thus also tend to have higher densities (Ribble & Stanley 1998; Priotto *et al.* 2002). Promiscuous species within a community also tend to have high densities with a high degree of overlap between sexes, since males are unable to monopolise widespread females (Ostfeld 1990; Ribble & Stanley 1998; Jackson 1999). These factors also influence recapture success and influence the habits of certain species.

Life history characteristics such as fecundity, longevity and dispersal that allow species to minimise or avoid competition however promote coexistence between species (Brown & Zeng 1989; Dammhahn & Kappeler 2008), since these traits may be an adaptive response to the environment (Neal 1986). Population size fluctuations and species richness are due to differences in recruitment (movements into the population through birth and immigration) and emigration (movements out of the population through dispersal and death (Bronner 1986). Studies of spatial organisation may also contribute to understanding patterns of coexistence between similar species (Ferreira & Van Aarde 1999; Priotto *et al.* 2002; Ribble *et al.* 2002). Since ecological and resource portioning may be the underlying mechanisms of coexistence (Rosenzweig 1981; Kalcounis-Ruppell & Millar 2002; Bonesi & Macdonald 2004; Jorgensen 2004), it would be expected that ecologically-similar species would occupy adjacent, non-overlapping home ranges (Bleich & Price 1995; Christopher & Barrett 2006), but that these may vary depending on resource availability (Orland & Kelt 2007). Space use by small mammals in the Bankenveld may be influenced by variation in food distribution and abundance and the variety of acceptable food resources. This in unpredictable environments, or under high population density, home range size may be larger as distance travelled to find resources in order to meet energy requirements increases (Pasch & Koprowski 2006). Those small mammal species with fixed territories or home ranges are more readily recaptured to species with local movements. These species utilize fixed areas, and are therefore repeatedly recaptured in these transects. The two dominant species at the study site, *Micaelamys namaquensis* and *Elephantulus myurus*, were regularly recaptured. This is a clear indication of the resident nature of these two species. *M. namaquensis* were recaptured 65.8% more than new individuals were recorded, while *E. myurus* were recaptured 68% more. *M. namaquensis* was recaptured more regularly during spring and summer, which appears to be related to an increased activity in the breeding season. *Mastomys* spp. and

*Rhabdomys pumlio* were recaptures for a fixed period of time, before disappearing from the transect. This could be an indication of their local seasonal movements at certain periods. *Dendromus melanotis*, *Mus minutoides* and *Steatomys pratensis* appear to move more readily and seldom recaptured. If recaptures were recorded, they usually occurred within the current week of surveying. Species, such as *Gerbilliscus leucogaster* and *Gerbilliscus brantsii* living in small family groups or colonies were regularly recaptured in close proximity to their burrows. This could give a skewed projection on abundance as trap success varies depending on proximity of transect to such a colony.

Interpretation of capture-recapture results of small mammals in the Bankenveld grasslands of Telperion and Ezemvelo Nature Reserve is complicated by the fact that many rodents could potentially be trapped even if only part of their home range fell into a survey area, which could give rise to biases in population estimates based on trapping rates (Bowers *et al.* 1996). Certain vegetation communities appear more stable habitats for certain species of small mammal, for example, Northern Slope Woodland and Rocky Open Shrub for *M. namaquensis* and *E. myurus*, which are represented throughout the year, although the number of recaptures recorded varied. Other communities such as Moist Degraded Grassland and Degraded Grassland differ seasonally in their suitability to small mammals. Indigenous rodent populations are limited by fluctuating resources availability which includes food and shelter (Monadjem & Perrin 1998). Combined with the influence of predation, rodent communities need a specialized set of conditions if they are to persist in viable numbers. Capture-recapture data provides useful information on the habits of small mammal species, providing a clear indication as to whether species are resident, have local movements, or highly mobile in nature. Whether a species is permanently or temporarily resident also appears to depend on intraspecies competition, suitable habitat and food resources.

# CHAPTER 10

# POPULATION ESTIMATES RECORDED FOR NON-VOLANT SMALL MAMMAL COMMUNITIES COUPLED WITH VEGETATION ON TELPERION

## 10.1. Abstract

This chapter aims to calculate the population estimates of small mammal species in seven different vegetation communities of Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Different species are expected to inhabit different vegetation communities and areas subjected to various passed land management practices. Density dependent and independent factors have an impact on densities and the population. An estimated population estimate calculated for the Northern Slope Woodland community is 41 animals per ha, and with a total community calculated at 1968 ha, the estimated population estimate of 80 688 is expected. Estimated population estimates calculated for small mammals in the Rocky Highveld Grassland is 34 animals per ha, with a community of 1944 ha at the study site, the population estimate of 66 096 animals is calculated. Population estimates for the Degraded Grassland estimate 72 animals per ha. The community covers 2604 ha of the study area, and a population estimate of 187 488 animals is calculated. In the Sheltered Woodland community, an estimated 34 small mammals per ha is calculated. The community covers 219 ha of the study area, and 7 446 animals are estimated to occur this community. In the Burkea Eragrostis Clumps community 10 animals per ha are calculated. This community covers 116 ha, and it is calculated that 1 160 animals inhabit this community. Population estimates in the Moist Degraded Grassland are calculated at 13 small mammals per ha. The community covers 894 ha, therefore a population estimate of 11 622 animals is calculated. The Rocky Open Shrub community is calculated to have 85 small mammals per ha. The community cover 272 ha of the study area, and a population estimate of 23 120 animals is calculated. Telperion and Ezemvelo Nature Reserve are estimated to have a population estimate of 377 620 small mammals on these properties.

**Keywords:** Population estimate, small mammals, community, Telperion, Ezemvelo Nature Reserve, vegetation, density dependent, density independent, South Africa

## 10.2. Introduction

The purpose of this chapter is to calculate the population estimates of small mammal species in seven different vegetation communities of Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. The population estimate of small mammals within a broad habitat or vegetation community is influenced by habitat structure and complexity, region, grazing value, maturity of habitat and succession of the vegetation. These properties are situated to the extreme north of the grassland biome in South Africa, recognized by Acocks (1988) as Bankenveld, and by Bredenkamp and Van Rooyen (1998) as Rocky Highveld Grassland. South Africa's grassland biome has been identified as critically endangered based on total habitat loss, degree of fragmentation and taking into account future threats (Reyers *et al.* 2001). It is in need of conservation attention as little protection is given to this biome, despite its multiple sources and severity of threats to this biologically important resource (Neke & Du Plessis 2004).

This chapter is important as it investigates the population estimates of small mammal populations in fire-climax grassland. Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Small Mammals are important components in grassland habitat ecosystems, as predators, consumers, dispersers of seed, burrowers and prey for carnivores, reptiles and raptors. Different species are expected to inhabit different vegetation communities and areas subjected to various passed land management practices. Density dependent and independent factors have an impact on densities and the population. The relative influence of density dependence in the dynamics of rodent populations is a matter of considerable debate (Krebs 2002; Berryman 2004). Nevertheless, population growth rates are often related negatively to density, in that population abundance is likely to decline when high and increase when low (Turchin 1999). Rodents may reach high densities, particularly in agro-ecosystems (Leirs & Verheyen 1995; Julliard *et al.* 1999; Vibe-Petersen. *et al.* 2006; Sluydts *et al.* 2007). Population estimates of small mammal populations are expected vary considerably over time and the cause of change in the trajectory of population growth is the central focus of population ecology (Sibly *et al.* 2005). Food supply is another factor that influences small mammal density (Doonan & Slade 1995). In Africa, rainfall is regarded to have a primary influence on vegetation productivity (Bredenkamp *et al.* 2002), fire and herbivory are considered to be key factors determining vegetation structure and composition (Scholes & Walker 1993). Yarnell *et al.* (2007) found heavy grazing negatively affected overall density of small mammals in general and *Mastomys* in particular; in contrast, fire alone had little immediate impact on small mammal diversity. Densities of small mammals in an area are expected to be impacted by predation.

According to Avenant (2000), the ecological role of predators in the maintenance of a balanced prey population and high prey diversity, ultimately affects the whole ecosystem, including the predator population (Kotler 1984; Norrdahl & Korpimäki 1995; Avenant & Nel 1997; McPeek 1998: Barreto *et al.* 1998; Ceballos *et al.* 1999). Small mammal density has been related to biotic and abiotic variables such as habitat structure and complexity (Rosenzweig & Winakur 1969; Brown 1973; French *et al.* 1976; Bond *et al.* 1980; Dueser & Brown 1980; Rowe-Rowe & Meester 1982a; Thompson 1982; Parmenter & MacMahon 1983; Kotler 1984; Abramsky 1988; Kerley 1992; Els & Kerley 1996), area (Abramsky *et al.* 1985; Fitzgibbon 1997), productivity (Abramsky 1978, 1988; Rosenweig 1992); predation (Kotler 1984; Norrdahl & Korpimäki 1995; Abramsky *et al.* 1998; trampling and grazing (Keesing 1998; Milchunas *et al.* 1998); surrounding landscape and the distance between similar habitats (Fitzgibbon 1997), and the maturity of the habitat and succession of the vegetation (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Rowe-Rowe 1995; Fitzgibbon 1997; Ferreira & van Aarde 1999). Makundi *et al.* (2007) found population densities were highest at the end of the rain season to the middle of the dry season, but rapid decline in population density occurred towards the end of the dry season in September. Managers of nature reserves and conservation areas readily burn areas of moribund grass to stimulate growth of early grasses. This new growth may provide better nutrition for rodents and requirements of breeding, growth and survival of young, provided sufficient shelter remains.

The question raised through this study is do game farming practices influence the population densities of rodent species in a “natural system”. Densities of small mammals in these grasslands may be influenced by variation in food distribution and abundance and the variety of acceptable food resources. Thus in unpredictable environments, or under high population density, home range size may be larger as distance travelled to find resources in order to meet energy requirements increases (Pasch & Koprowski 2006).

## 10.3. Methodology

Population estimate calculations provide an indication of the lowest possible densities recorded for a species or a population in a vegetation community, or ultimately over the entire study area. The months were categorized according to season, with September, October and November falling within Spring, December, January and February in Summer, March, April and May in Autumn, and June, July and August in Winter. Capture frequency data was ustilised for the analysis, including new and recaptured indivduals. In year one (2008), ten transects each comprising 30 live-traps Sherman each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month. The starting-point was placing transects in the seven vegetation communities. In year one, two transects were placed in the dominant communities to obtain a greater sample size. In year one, 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. 10m spacing was adopted at the study site with the available traps. In year two, three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per site. The population estimate of small mammals recorded in the Northern Slope Woodland is calculated by averaging the seasonal population estimate figures recorded.

It is accepted that the average home range diameter for small mammals is estimated at 20 m; therefore, in calculating the total area sampled as 10m on both sides of each trap, these estimates are considered “population estimates”. In year one, the length of area which equals the transect length was 290 m of which 10m was added to both ends of the transect resulting in a total length of 310 m. The width of the area is calculated as 10 m on either side of the trap, calculated as 20 m. Therefore, the area size is calculated as 310 m x 20 m, which equals 6200 $m^2$. Density is calculated as number of small mammals recorded/area size in $m^2$. The area size is calculated to number per hectare (1ha = 100 m x 100 m = 10 000 $m^2$). The population estimate of small mammals per ha is therefore calculated as the number of small mammals recorded x 10 000/6 200.

In year two, transects of 60 traps were spaced 5 m apart over 5 consecutive days seasonally. In year two, the length of area which equals the transect length was 295 m of which 10 m was added to both ends of the transect resulting in a total length of 315 m. The width of the area is calculated as 10 m on either side of the trap, calculated as 20 m. Therefore, the area size is calculated as 315 m x 20 m, which equals 6300 $m^{2.}$ Then density is then calculated as number of small mammals recorded/area size in $m^2$. The area size is then calculated to number per hectare (1ha = 100 m x 100 m = 10 000 $m^2$). The population estimate of small mammals per ha is therefore calculated as the number of small mammals recorded x 10 000/6 300. Population estimates were recorded from ten transects in year one, and seven transects in year two for small mammal communities within seven vegetation communities on Telperion and Ezemvelo Nature Reserve.

Analysis of variance (ANOVA) was used to test for significant differences between population estimates and vegetation community within different seasons (Fowler *et al.* 1998). Tukey's test was undertaken when the result from ANOVA indicated a significant difference between the variables. Tukey's test provides an indication of where significant differences occur. All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 10.4. Results

### 10.4. Population estimates recorded for non-volant small mammal assemblages in the Northern Slope Woodland vegetation community

The Northern Slope Woodland community occupies 25% of the study area and covers an area of 1968 ha (Fig. 104).

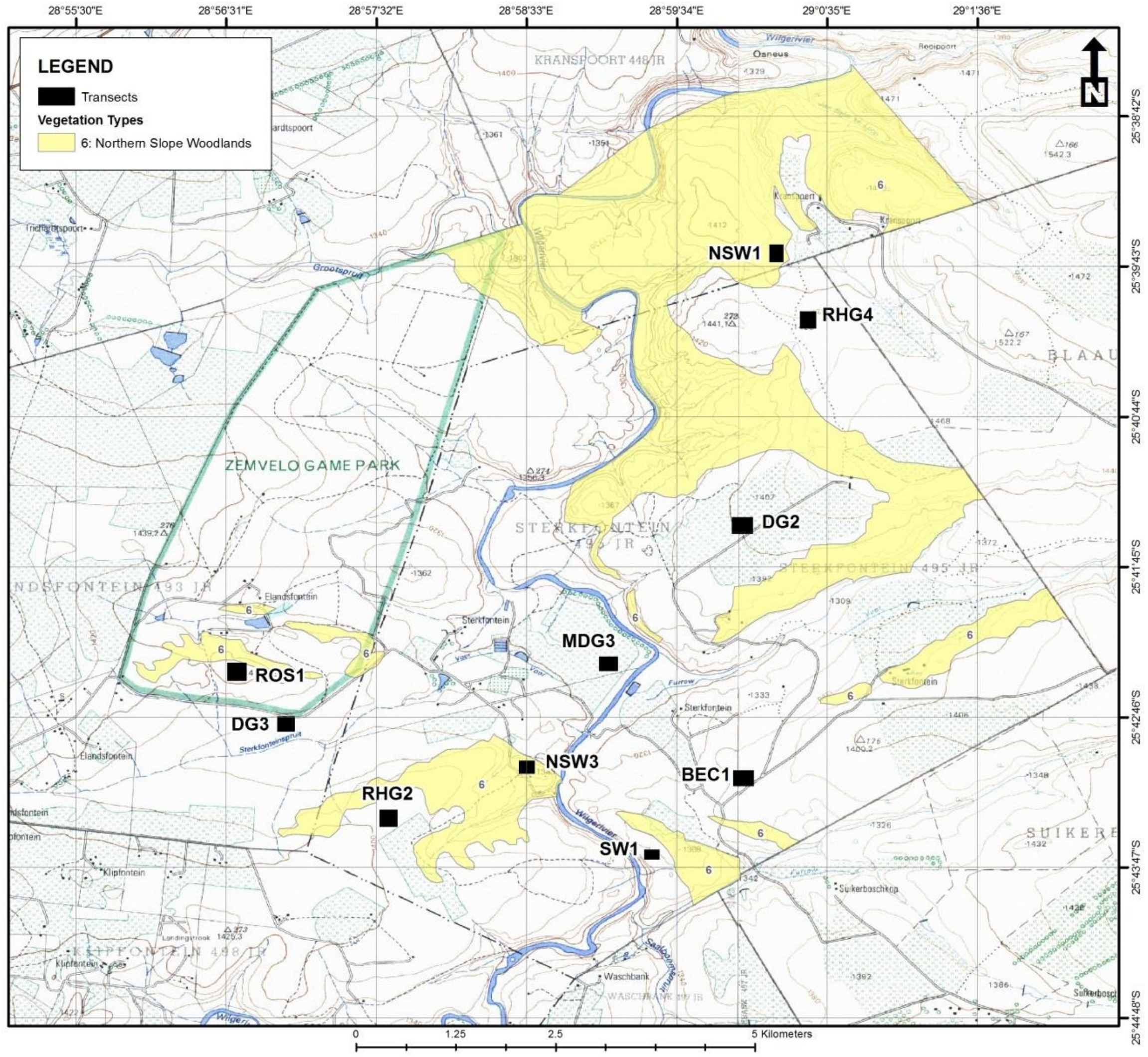

Figure 104. Map of Telperion and Ezemvelo Nature Reserve depicting the areas covered by Northern Slope Woodland habitat on the property.

ANOVA revealed an insignificant difference between population estimate and season ($F_{1.3}$ = 0.609; $n$ = 212; $P$ = 0.622) for transect Northern Slope Woodland 1 (NSW 1). The population estimates recorded for transect NSW 1 indicate a highest density per ha in autumn (59 animals per ha), followed by winter (57 animals per ha) and summer and spring equal number (48 animals per ha) (Fig. 105).

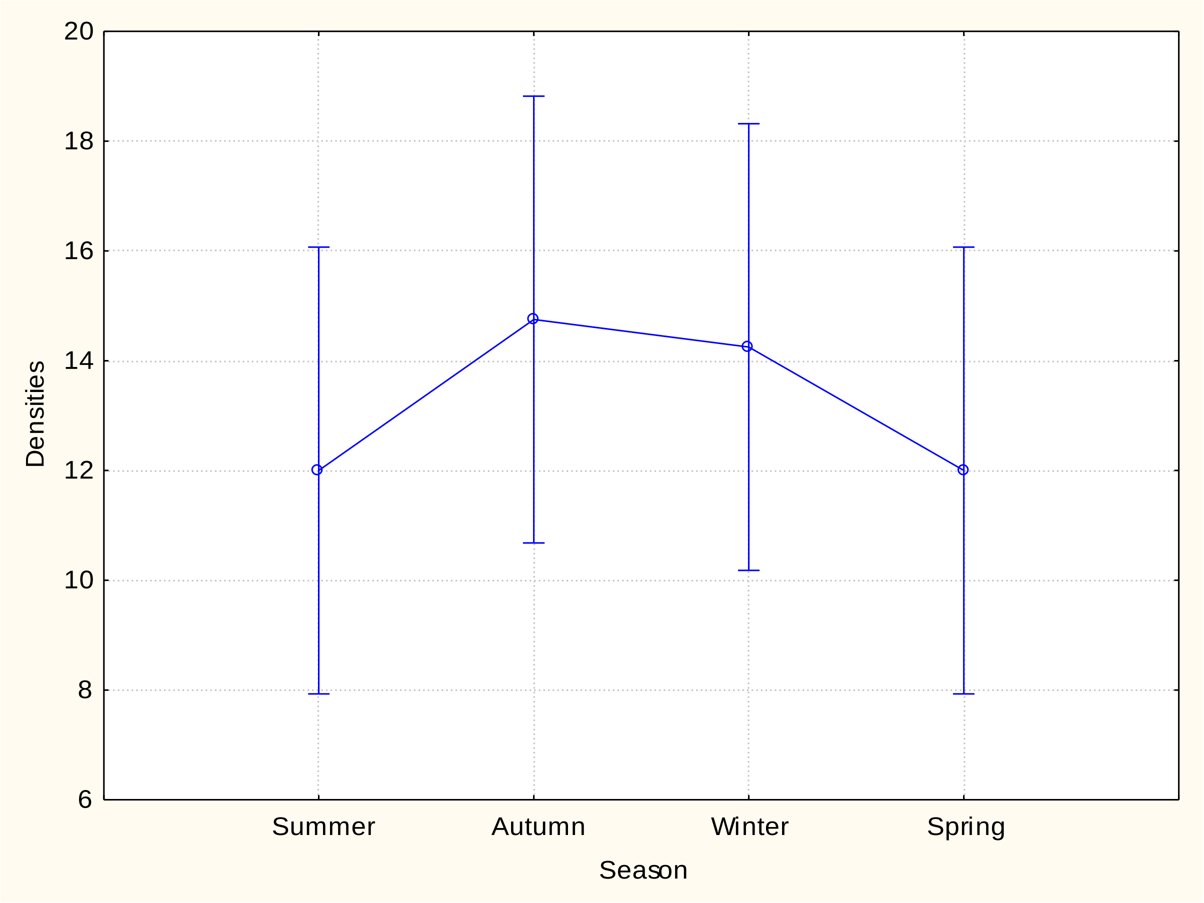

Figure 105. Graph depicting small mammal population estimates in 2008 recorded at Northern Slope Woodland 1.

The population estimates appear similar seasonally, and large fluctuation within this transect do not appear to occur. ANOVA revealed a significant difference between population estimate and season ($F_{1.3} = 6.267$; $n = 105$; $P = 0.008$) for transect Northern Slope Woodland 3 (NSW 3). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P = 0.04$), winter (Tukey's: $P = 0.00$) and spring (Tukey's: $P = 0.03$). The population estimates recorded for transect NSW 3 in year one indicate the highest density per ha in winter (36 animals per ha), followed by spring (30 animals per ha), autumn (29 animals per ha) and the lowest number in summer (10 animals per ha) (Fig. 106a).

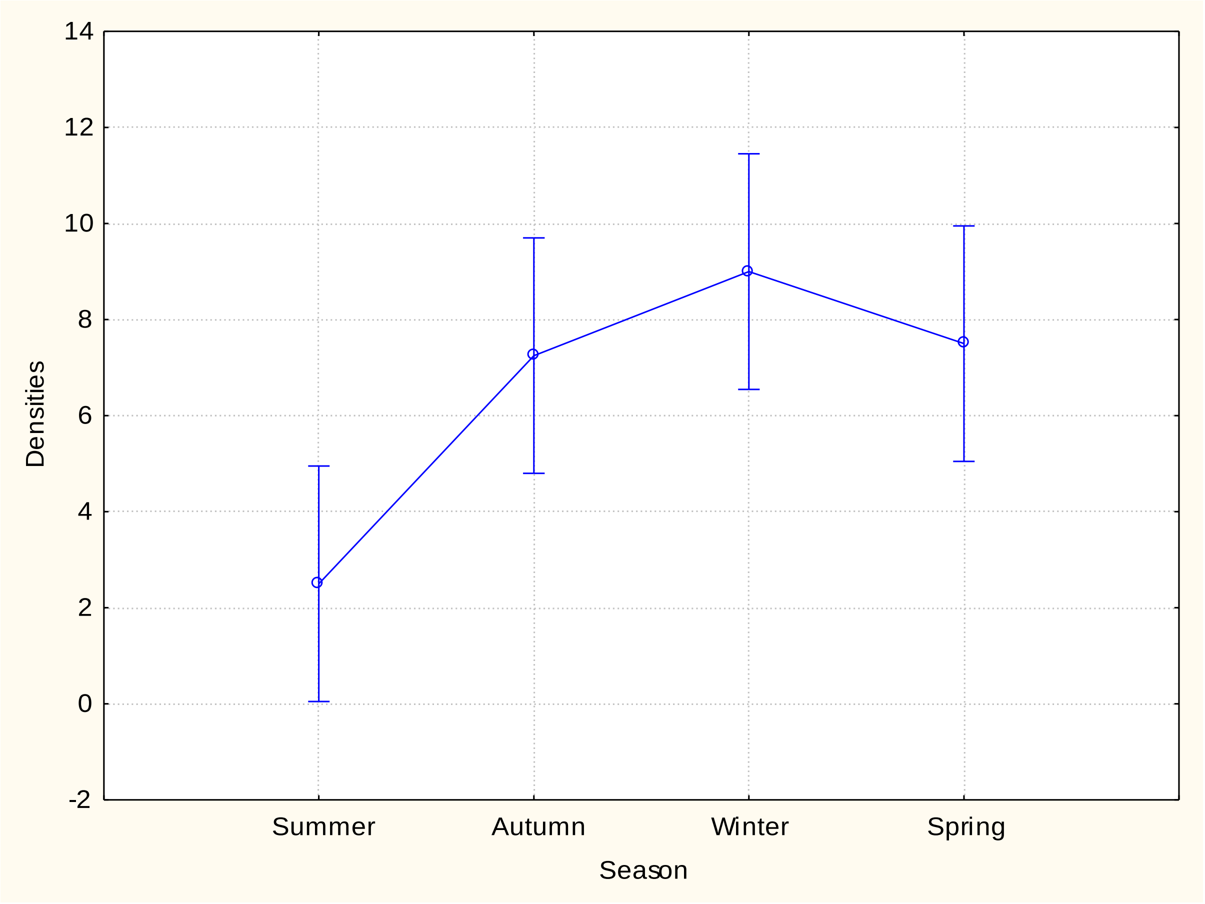

Figure 106a. Graph depicting small mammal population estimates in 2008 recorded at Northern Slope Woodland 3

ANOVA revealed a significant difference between population estimate and season ($F_{1.3}$ = 60.852; *n* = 165; *P* = 0.000) for transect Northern Slope Woodland 3 (NSW 3) in year two. Statistically population estimates are significantly different in summer and winter (Tukey's: *P* = 0.00), summer and spring (Tukey's: *P* = 0.00); autumn and winter (Tukey's: *P* = 0.00), autumn and spring (Tukey's: *P* = 0.00). The population estimates recorded for transect NSW 3 in year two indicate the highest density per ha in spring (54 animals per ha), followed by winter (48 animals per ha), autumn (34 animals per ha) and summer having the lowest number recorded (29 animals per ha) (Fig. 106b).

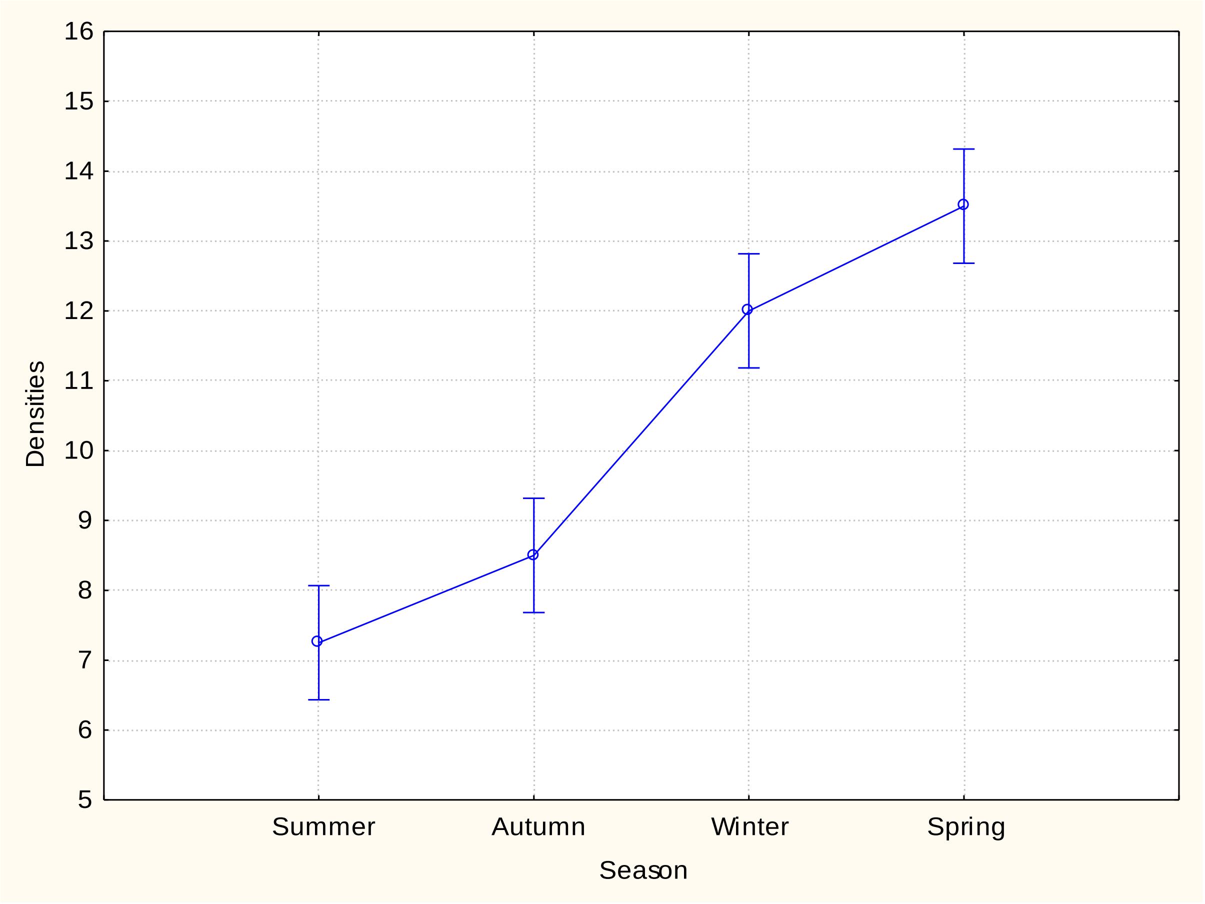

Figure 106b. Graph depicting small mammal population estimates in 2009 recorded at Northern Slope Woodland 3

Statistically ANOVA revealed a significant difference between mean population estimate and season ($F_{1.6}$ = 0.713; $n$ = 163; $P$ = 0.562) for the Northern Slope Woodland community. The seasonal mean population estimates recorded indicate that winter has marginally the highest densities (48 animals per ha), followed by spring (47 animals per ha), autumn (39 animals per ha) and summer with the lowest recorded number (29 animals per ha) (Figure 107).

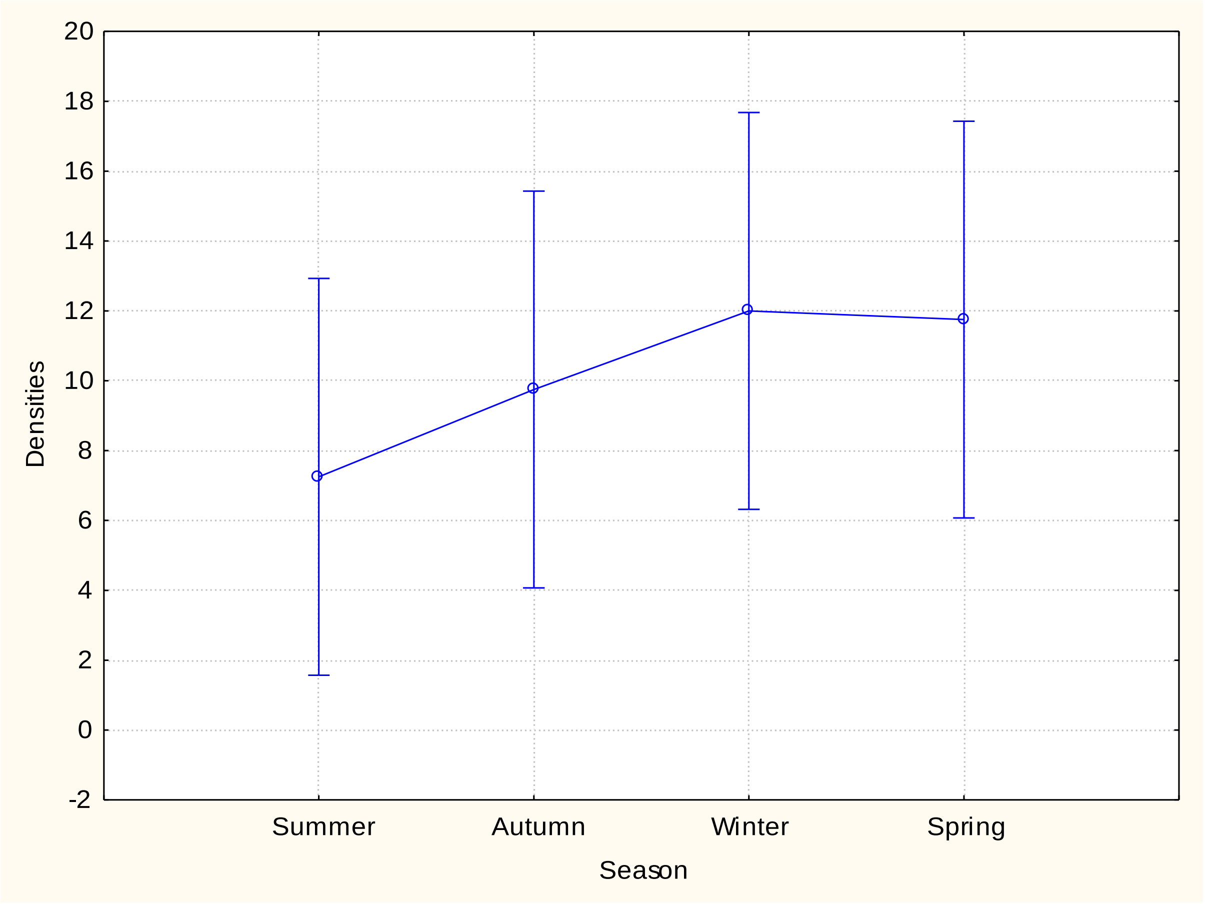

Figure 107. Graph depicting mean small mammal population estimates recorded at Northern Slope Woodland during the study period.

The mean population estimate of small mammals recorded for Northern Slope Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 41 small mammals per ha. The community is recorded to cover 1968 ha of the property, therefore a population estimate of 80 688 small mammals are estimated to occur in the Northern Slope Woodland community at the study site. The population estimates were recorded for the following small mammal species seasonally in Northern Slope Woodland on the property during this study.

### 10.4.1. Seasonal population estimates recorded for *Micaelamys namaquensis* in the Northern Slope Woodland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *M. namaquensis* in Northern Slope Woodland in year 1 indicate the highest density per ha in spring (32 animals per ha), followed by winter

(22 animals per ha), autumn (21 animals per ha) and the lowest number in summer (14 animals per ha) (Fig. 109). ANOVA revealed an insignificant difference in population estimate of *M. namaquensis* and season ($F_{1.3} = 0.732$; $n = 89$; $P = 0.561$) for the Northern Slope Woodland community in year 1. The population estimates recorded in Northern Slope Woodland in year 2 indicate the highest density per ha in spring (46 animals per ha), followed by winter (38 animals per ha), autumn (30 animals per ha) and summer having the lowest number recorded (14 animals per ha) (Fig. 108). ANOVA revealed an insignificant difference in population estimate of *M. namaquensis* and season ($F_{1.3} = 1.179$; $n = 128$; $P = 0.377$) for the Northern Slope Woodland community in year 2.

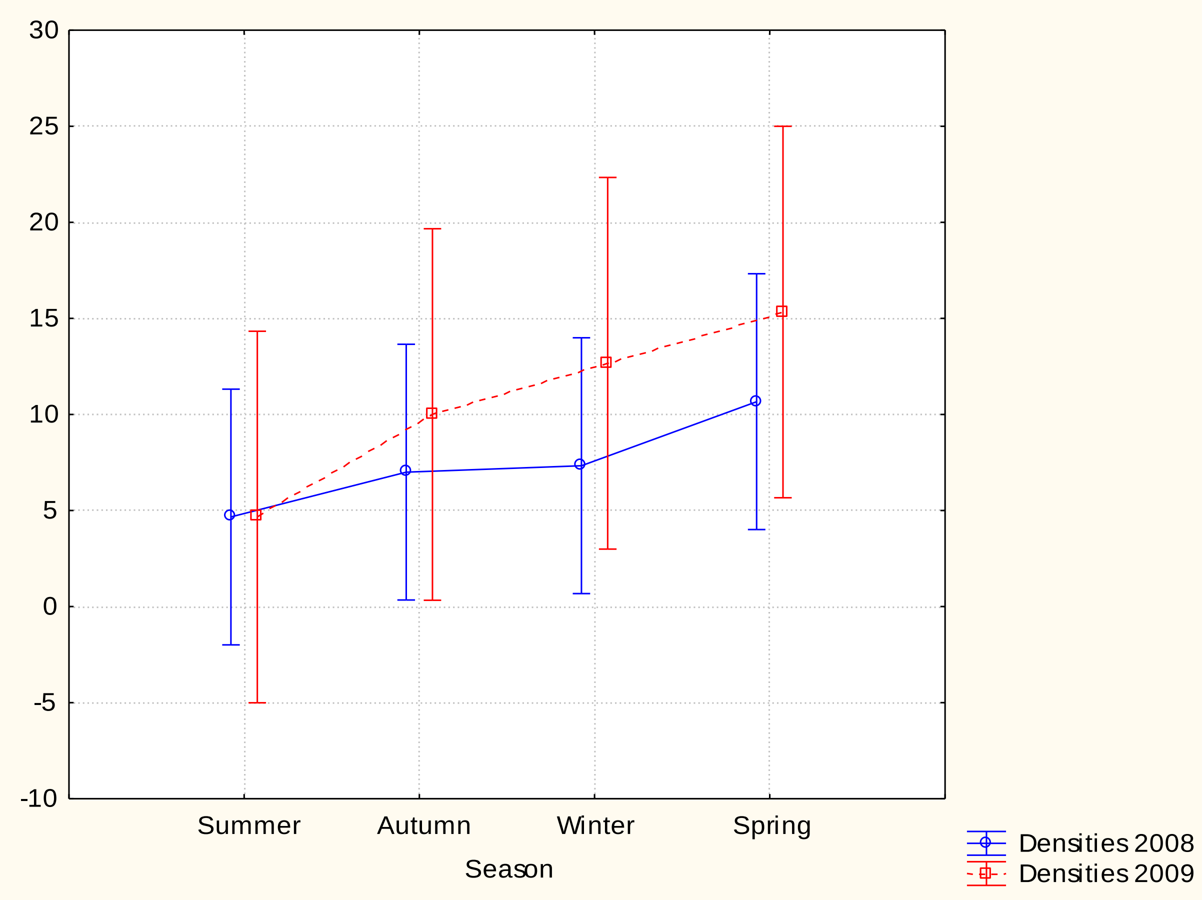

Figure 108. Graph depicting seasonal *Micaelamys namaquensis* population estimates in 2008 and 2009 recorded in the Northern Slope Woodland vegetation community.

The seasonal mean population estimate for *M. namaquensis* recorded in the Northern Slope Woodland community indicate that spring has the highest population estimates (39 animals per ha), followed by winter (30 animals per ha), autumn (26 animals per ha) and summer with the lowest recorded number (18 animals per ha) (Figure 109). ANOVA revealed an insignificant difference in mean population estimate of *M. namaquensis* and season ($F_{1.3}$ = 0.461; $n$ = 113; $P$ = 0.717) for the Northern Slope Woodland community.

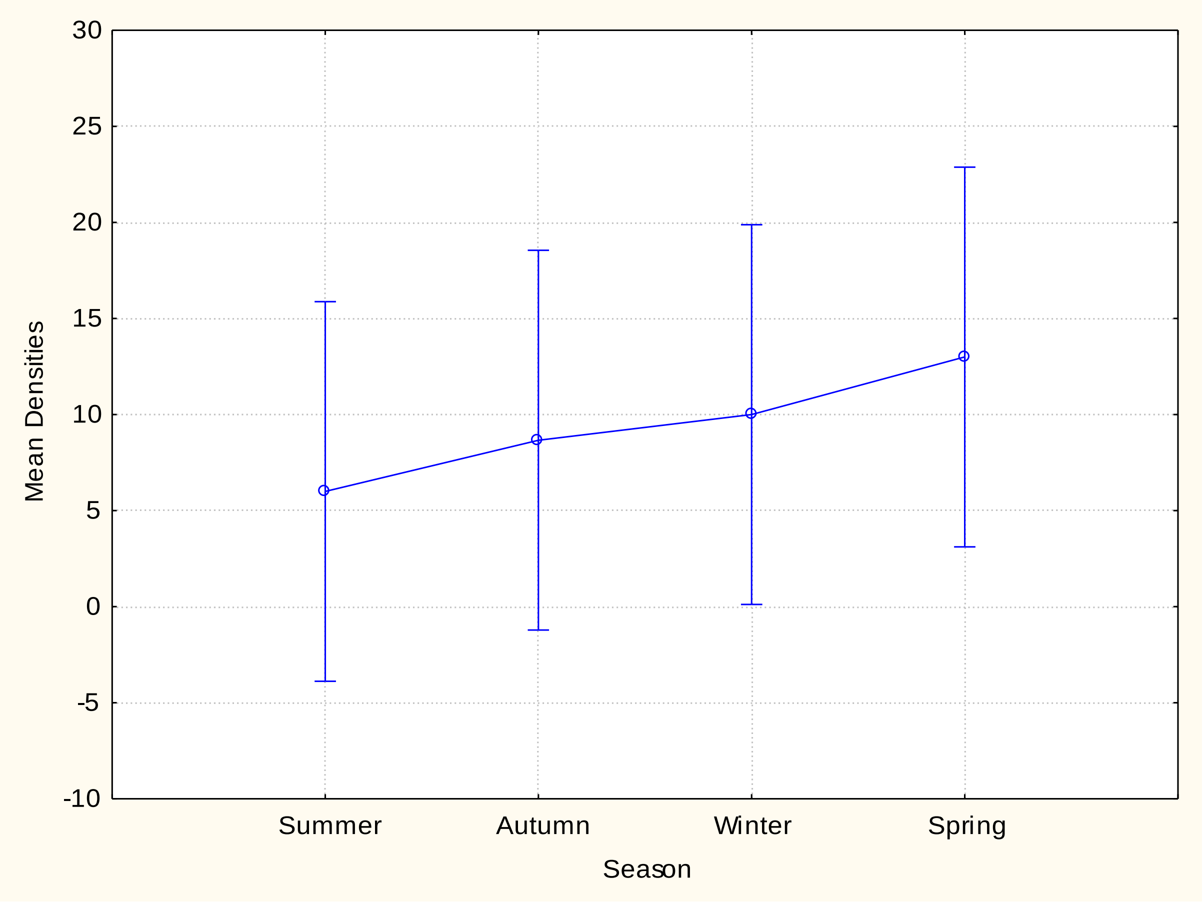

Figure 109. Graph depicting mean *Micaelamys namaquensis* population estimates recorded in Northern Slope Woodland during the study period.

The mean population estimate of *M. namaquensis* recorded for Northern Slope Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 28 small mammals per ha. The community is recorded to cover 1968 ha of the property, therefore a population estimate of 55 104 *M. namaquensis* are estimated to occur in the Northern Slope Woodland community at the study site.

### 10.4.2. Seasonal population estimates recorded for *Graphiurus murinus Graphiurus murinus* in the Northern Slope Woodland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *G. murinus* in Northern Slope Woodland in year 1 indicate the highest density per ha in autumn (5 animals per ha), followed by summer (2 animals per ha) (Fig. 110). ANOVA revealed a significant difference between population estimate of *G. murinus* and season ($F_{1.3}$ = 11.167; *n* = 7; *P* = 0.003) for the Northern Slope Woodland community in year 1. Statistically population estimates are significantly different in autumn and spring (Tukey's: *P* = 0.00), and autumn and winter (Tukey's: *P* = 0.00). The population estimates recorded in Northern Slope Woodland in year 2 indicate the highest density of *G. murinus* per ha in summer (5 animals per ha), with no individuals recorded during winter and spring during the study (Fig. 110). ANOVA revealed an insignificant difference in population estimate of *G. murinus* and season ($F_{1.3}$ = 3.571; *n* = 5; *P* = 0.067) in the Northern Slope Woodland community in year 2.

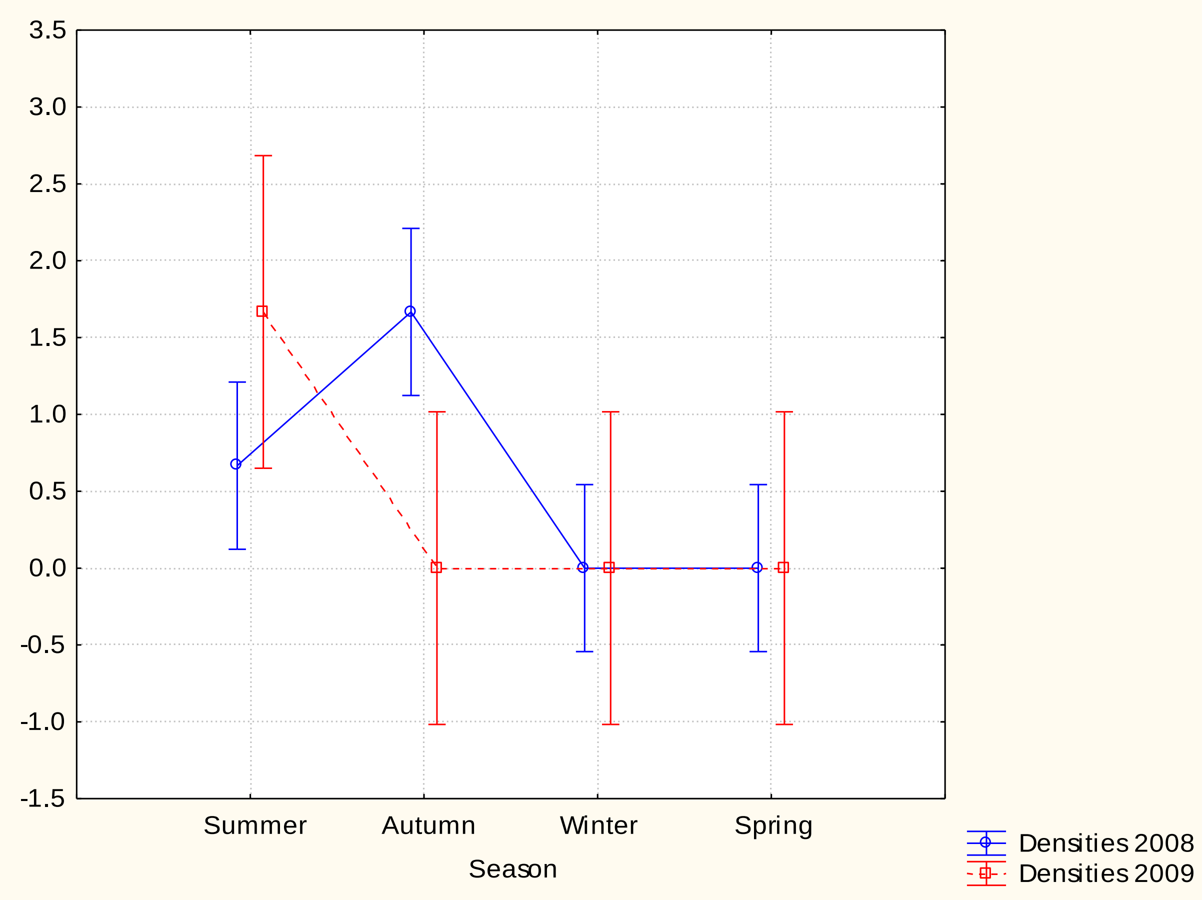

Figure 110. Graph depicting seasonal *Graphiurus murinus* minimm densities in 2008 and 2009 recorded in the Northern Slope Woodland vegetation community.

The seasonal mean population estimate for *G. murinus* recorded in the Northern Slope Woodland community indicate that summer and autumn have highest population estimates (4 animals per ha) (Fig. 111). ANOVA revealed a significant difference between population estimate of *G. murinus* and season ($F_{1.3}$ = 6.268; *n* = 105; *P* = 0.008) for the Northern Slope Woodland community. Statistically population estimates are significantly different in summer and winter (Tukey's: *P* = 0.01), summer and spring (Tukey's: *P* = 0.01), and autumn and winter (Tukey's: *P* = 0.01), and autumn and spring (Tukey's: *P* = 0.01).

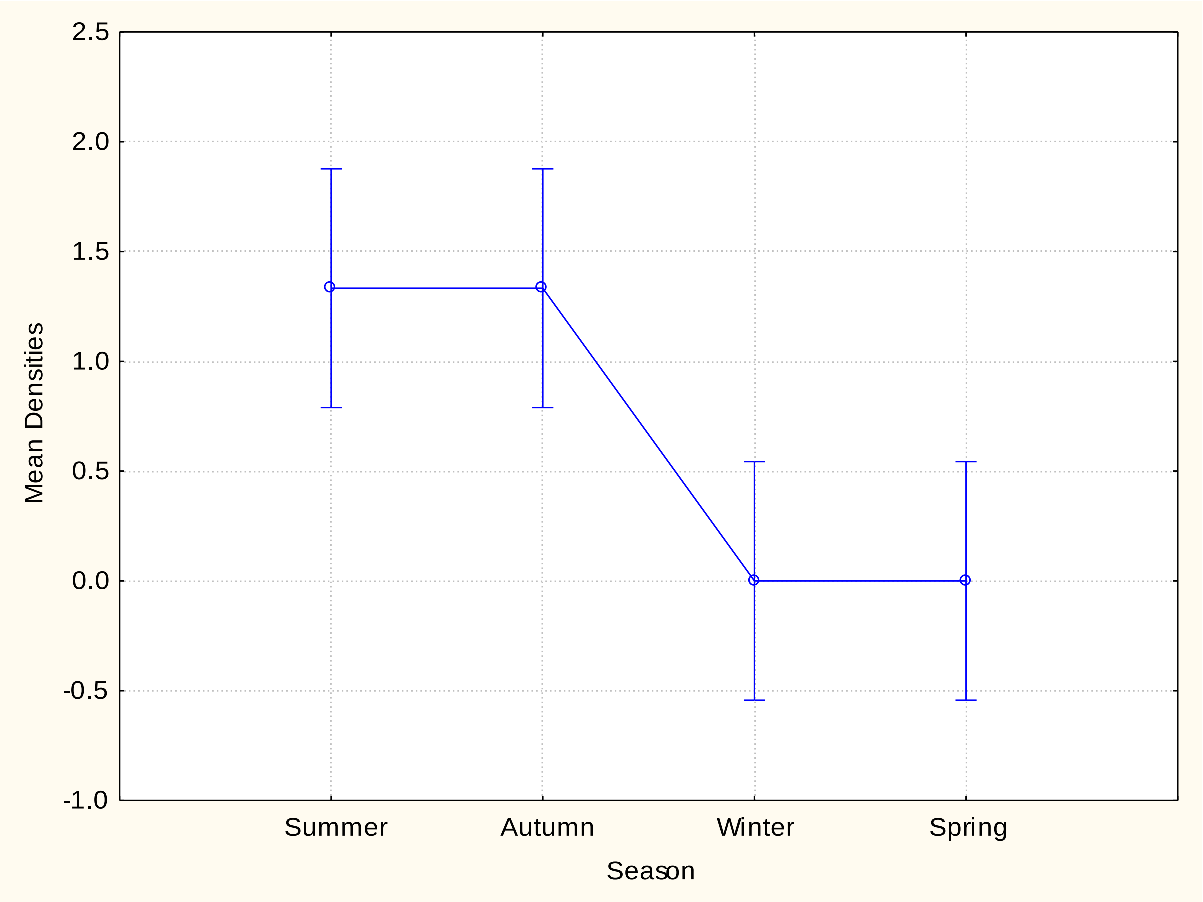

Figure 111. Graph depicting mean *Graphiurus murinus* population estimates recorded in Northern Slope Woodland during the study period.

The mean population estimate of *Graphirus murinus* recorded for Northern Slope Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 2 small mammals per ha. The community covers 1968 ha of the property, therefore a population estimate of 3 936 *G. murinus* are estimated to occur in the Northern Slope Woodland community on the property. *G. murinus* was solely collected in this habitat type and therefore the expected population estimate for this species at the study site.

### 10.4.3. Seasonal population estimates recorded for *Acomys spinosissimus* in the Northern Slope Woodland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *A. spinossimus* in Northern Slope Woodland in year one indicate an equal density per ha in autumn, winter and spring (4 animals per ha), followed by summer (2 animals per ha) (Fig. 112). ANOVA revealed an insignificant difference in population estimate of *A. spinossimus* and season ($F_{1.3}$ = 1.000; $n$ = 14; $P$ = 0.441) for the Northern Slope Woodland community in year 1. The population estimates recorded in Northern Slope Woodland in year two indicate the highest density of *A. spinossimus* per ha in summer (10 animals per ha), followed by spring (3 animals per ha), winter (2 animals per ha), with no individuals recorded during autumn in year two of the study (Fig. 112). ANOVA revealed a significant difference between population estimate of *A. spinossimus* and season ($F_{1.3}$ = 6.879; $n$ = 15; $P$ = 0.013) for the Northern Slope Woodland community. Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.01), and summer and winter (Tukey's: $P$ = 0.03).

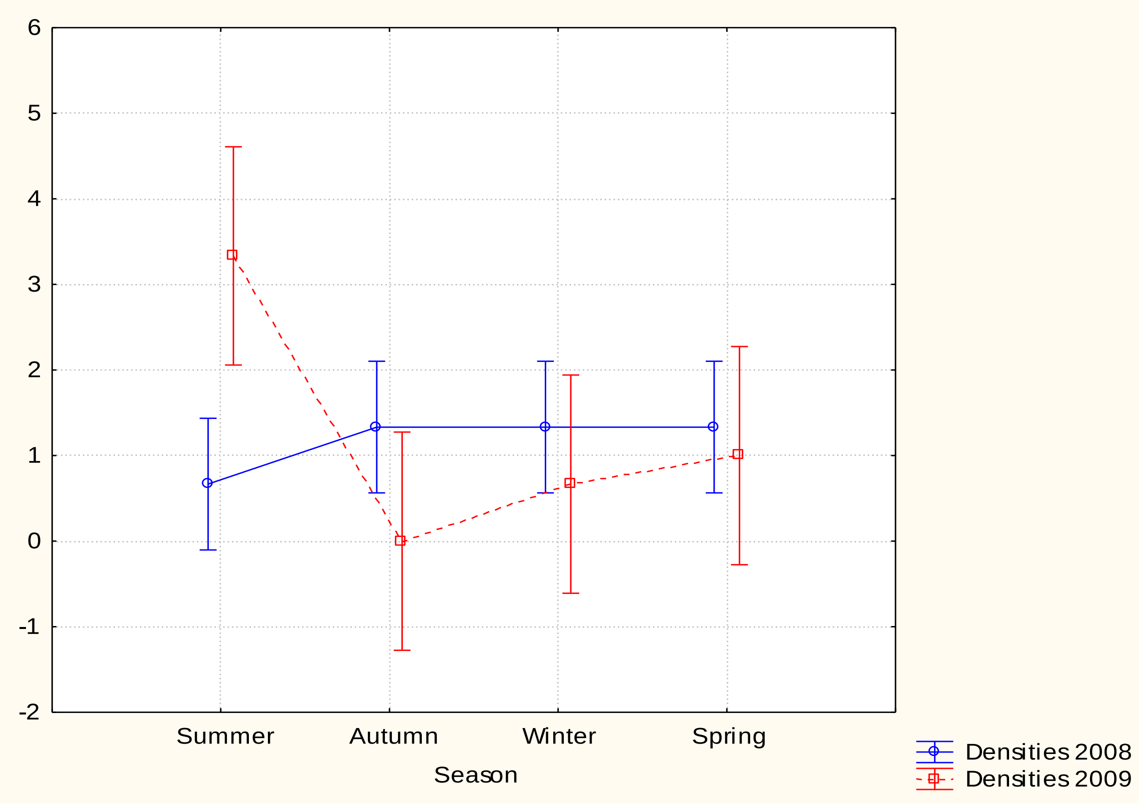

Figure 112. Graph depicting seasonal *Acomys spinosissimus* population estimates in 2008 and 2009 recorded in the Northern Slope Woodland vegetation community

The seasonal mean population estimate for *A. spinossimus* recorded in the Northern Slope Woodland community indicate that summer has the highest population estimates (6 animals per ha), followed by winter, autumn and spring with equal densities (4 animals per ha) (Fig. 113). ANOVA revealed an insignificant difference in the mean population estimate of *A. spinossimus* and season ($F_{1.3}$ = 1.333; $n$ = 18; $P$ = 0.330) for the Northern Slope Woodland community.

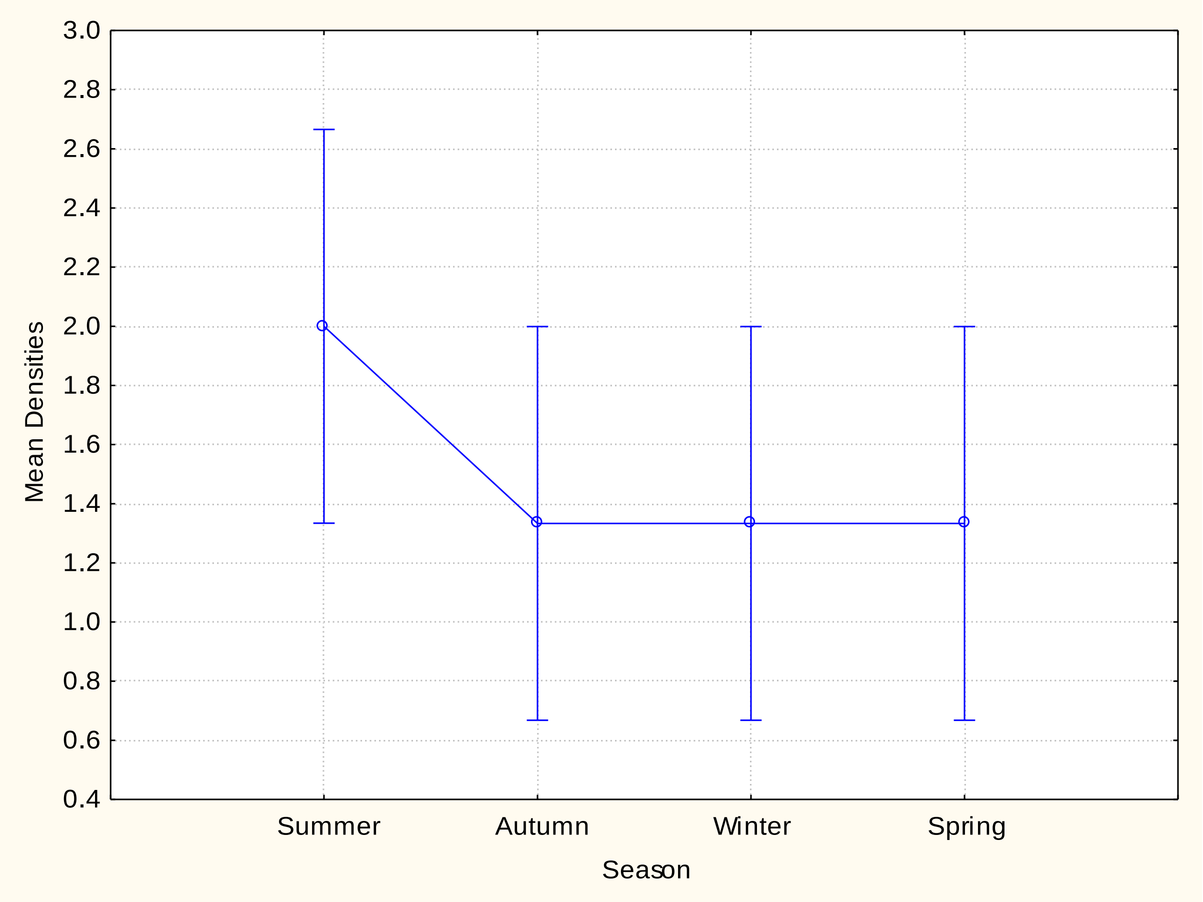

Figure 113. Graph depicting mean *A. spinossimus* population estimates recorded in Northern Slope Woodland during the study period.

The mean population estimate of *Acomys spinosissimus* recorded for Northern Slope Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 5 small mammals per ha. The community is recorded to cover 1968 ha at the study site; therefore a population estimate of 9840 *A. spinossimus* is estimated to occur in the Northern Slope Woodland community on the property.

### 10.4.4. Seasonal population estimates recorded for *Aethomys chrysophilus* in the Northern Slope Woodland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *Aethomys chrysophilus* in Northern Slope Woodland in year 1 with only one record in autumn (2 animals per ha) (Fig. 114). No individuals were recorded during year 2 of the study. ANOVA revealed a weak significant difference between population estimate of *G. murinus* and season ($F_{1.3} = 4.000$; $n = 2$; $P = 0.052$) for the Northern Slope Woodland community.

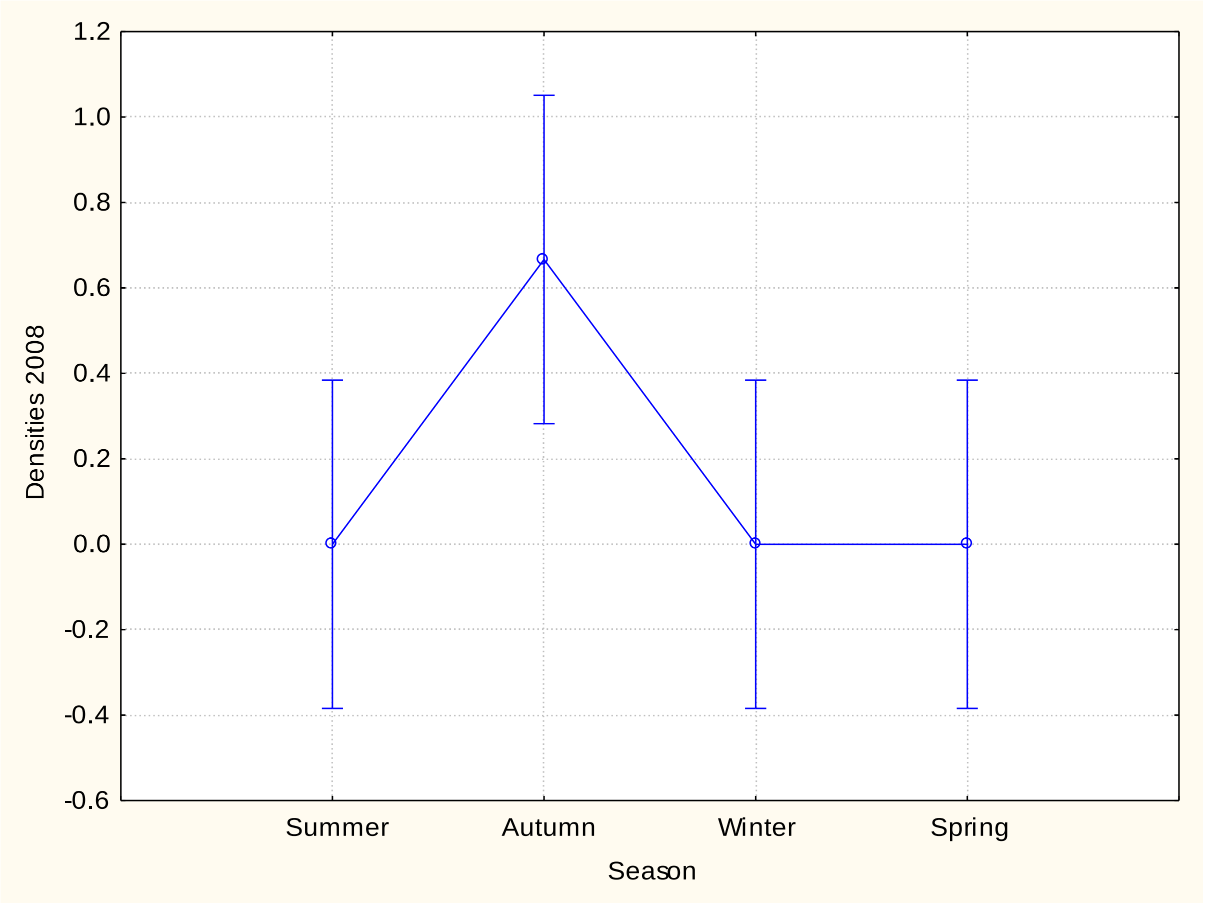

Figure 114. Graph depicting mean *Aethomys chrysophilus* population estimates recorded in Northern Slope Woodland during the study period.

The mean population estimate of *A. chrysophilus* recorded for Northern Slope Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammals every two hectares. The community is recorded to cover 1968 ha of the property; therefore a population estimate of 984 *A. chrysophilus* is estimated to occur in the Northern Slope Woodland community on the property.

### 10.4.5. Seasonal population estimates recorded for *Dendromus melanotis* in the Northern Slope Woodland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *D. melanotis* in Northern Slope Woodland in year 1 with only one record in winter (2 animals per ha) (Fig. 115). No individuals were recorded during year 2 of the study. ANOVA revealed a weak significant difference between population estimate of *D. melanotis* and season ($F_{1.3}$ = 4.000; $n$ = 2; $P$ = 0.052) for the Northern Slope Woodland community.

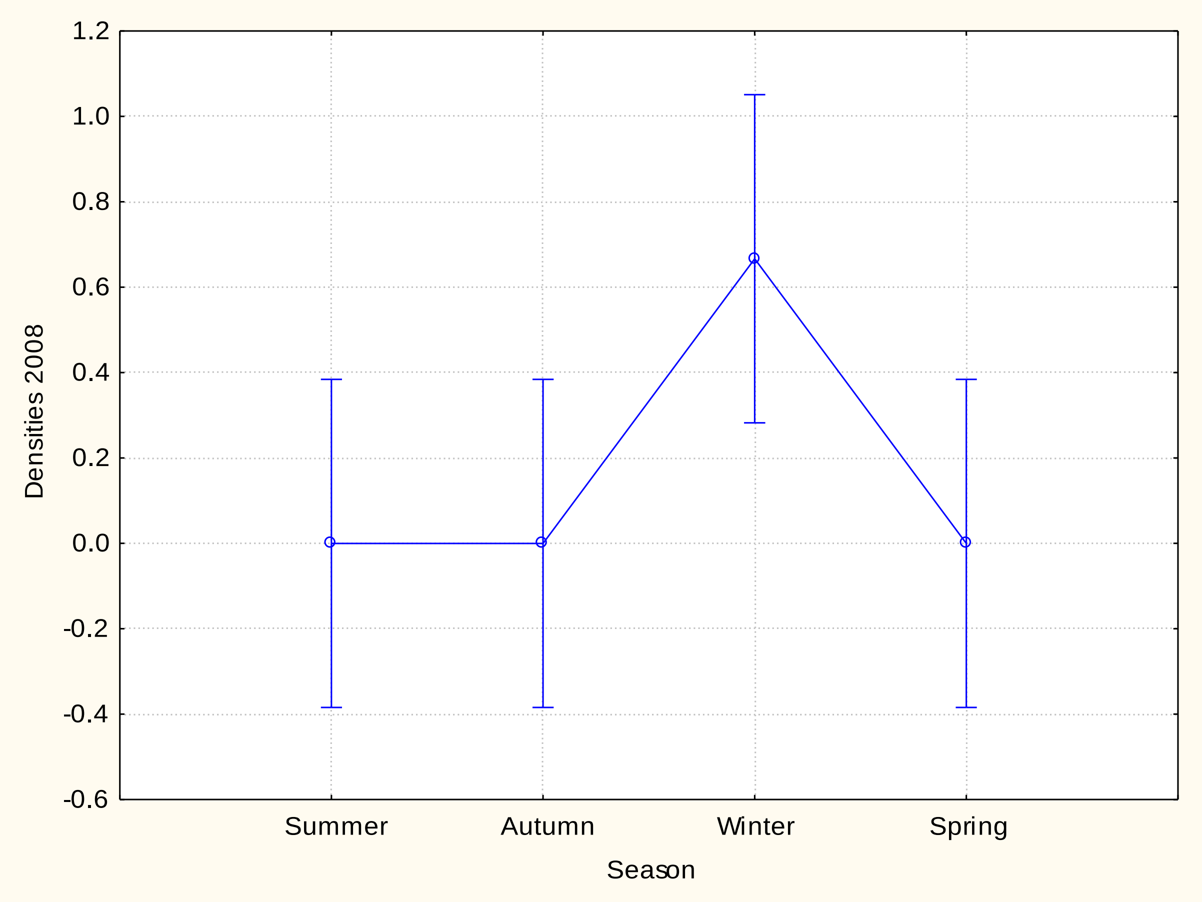

Figure 115. Graph depicting mean *Dendromus melanotis* population estimates recorded in Northern Slope Woodland during the study period

The mean population estimate of *D. melanotis* recorded for Northern Slope Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal for every two hectares. The community is recorded covers 1968 ha at the study site; therefore a population estimate of 984 *D. melanotis* is estimated to occur in the Northern Slope Woodland community at the study site.

### 10.4.6. Seasonal population estimates recorded for *Elephantulus myurus* in the Northern Slope Woodland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *E. myurus* in Northern Slope Woodland in year 1 indicate the highest density per ha in winter (20 animals per ha), followed by autumn (16 animals per ha), summer (5 animals per ha) and the lowest number in spring (4 animals per ha) (Fig. 116). ANOVA revealed an insignificant difference in population estimate of *E. myurus* and season ($F_{1.3}$ = 1.223; $n$ = 45; $P$ = 0.363) for the Northern Slope Woodland community in year 1. The population estimates recorded in Northern Slope Woodland in year two indicate the highest density per ha in winter (8 animals per ha), followed by spring (5 animals per ha), autumn (2 animals per ha) and no record in summer (Fig. 116). ANOVA revealed a significant difference between population estimate of *E. myurus* and season ($F_{1.3}$ = 8.167; $n$ = 15; $P$ = 0.008) for the Northern Slope Woodland community. Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.00), and autumn and winter (Tukey's: $P$ = 0.03).

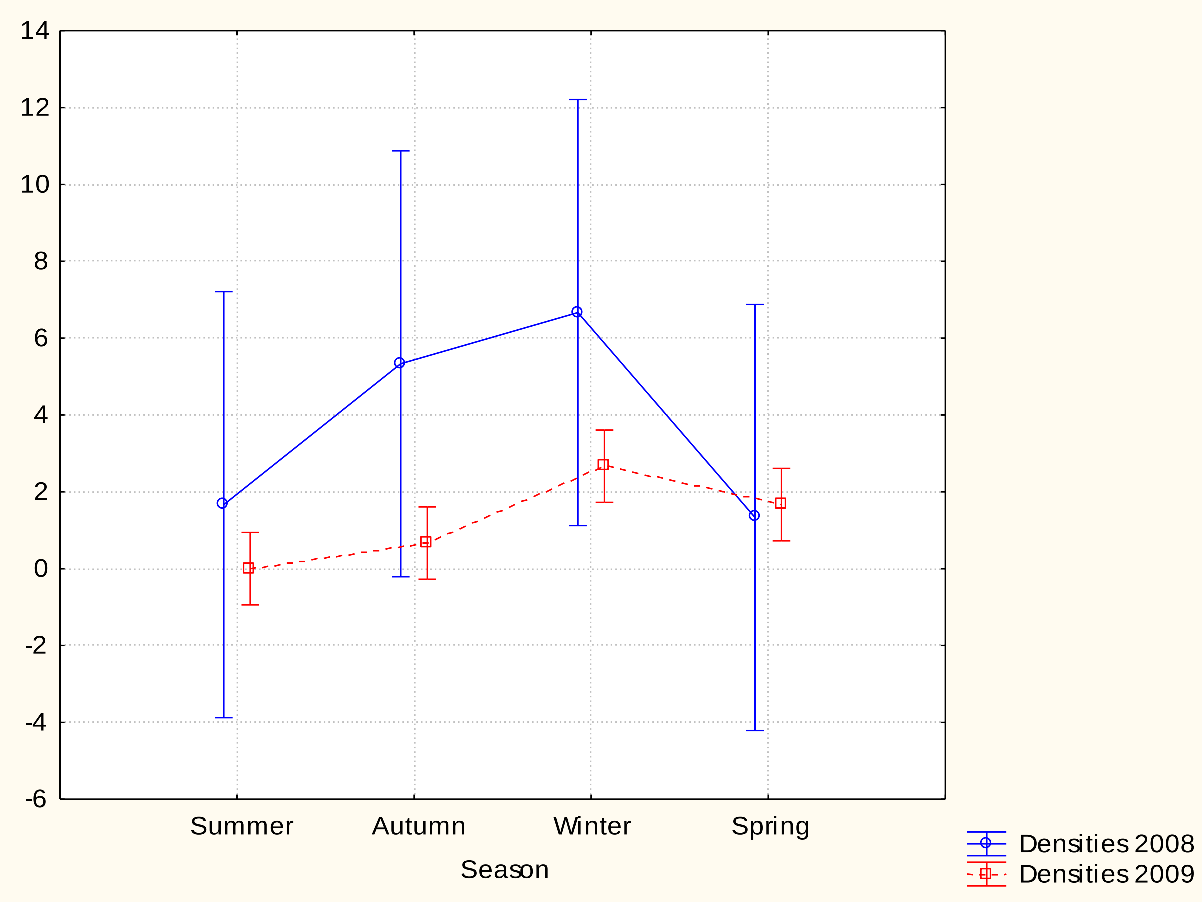

Figure 116. Graph depicting seasonal *Elephantulus myurus* population estimates in 2008 and 2009 recorded in the Northern Slope Woodland vegetation community.

The seasonal mean population estimate for *E. myurus* recorded in the Northern Slope Woodland community indicate that winter has the highest population estimates (14 animals per ha), followed by autumn (9 animals per ha), spring (5 animals per ha) and summer with the lowest recorded number (4 animals per ha) (Figure 117). ANOVA revealed a weak but significant difference between population estimate of *E. myurus* and season ($F_{1.3} = 3.937$; $n = 32$; $P = 0.054$) for the Northern Slope Woodland community. Statistically population estimates are significantly different in summer and winter (Tukey's: $P = 0.05$).

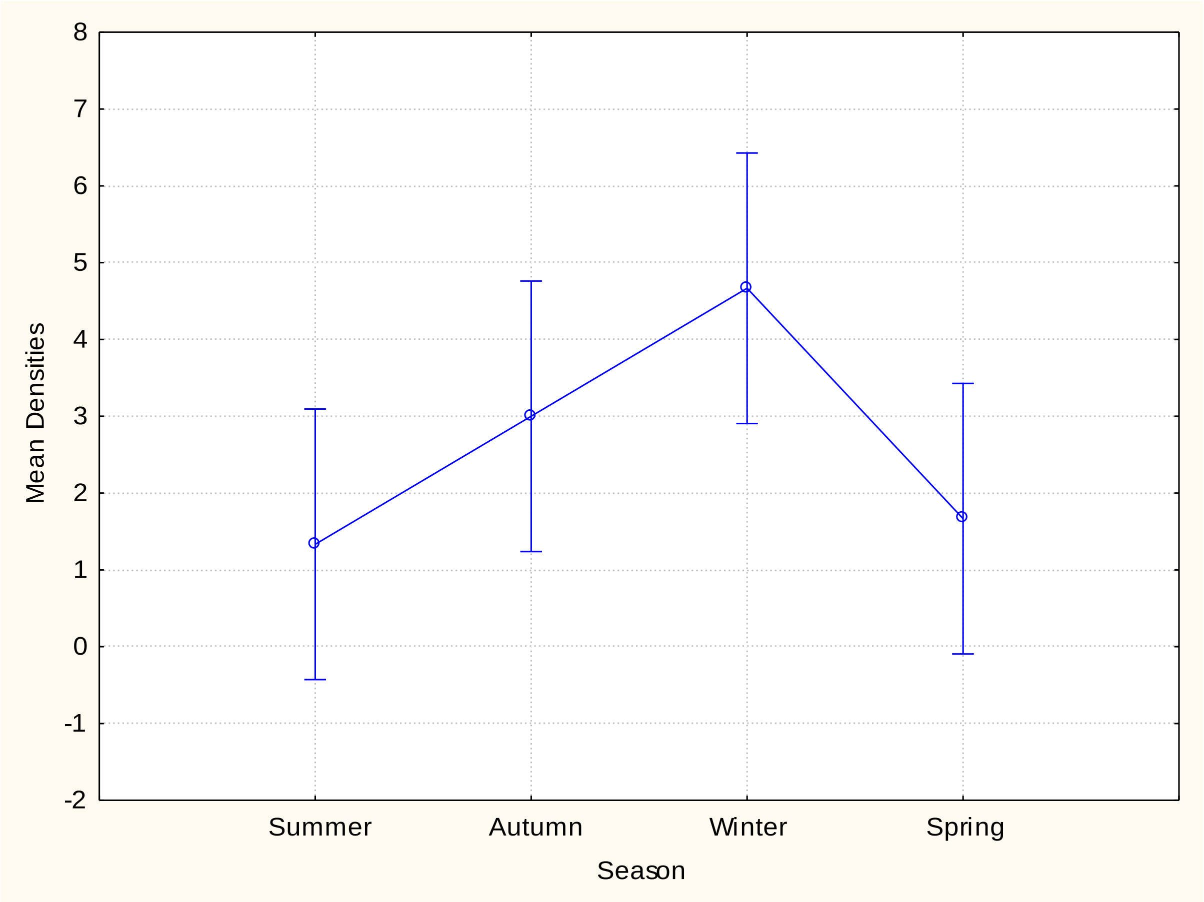

Figure 117. Graph depicting mean *Elephantulus myurus* population estimates recorded in Northern Slope Woodland during the study period.

The mean population estimate of *E. myurus* recorded for Northern Slope Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 8 small mammals per hectare. The community is recorded to cover 1968 ha of the property, therefore a population estimate of 15 744 *E. myurus* are estimated to occur in the Northern Slope Woodland community on the property.

### 10.4.7. Seasonal population estimates recorded for *Crocidura cyanea* in the Northern Slope Woodland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *C. cyanea* in Northern Slope Woodland in year 1 with only one record in summer (2 animals per ha) (Fig. 118). No individuals were recorded during year 2 of the study. ANOVA revealed a weak but significant difference between population estimate of *C. cyanea* and season ($F_{1.3}$ = 4.000; $n$ = 2; $P$ = 0.052) for the Northern Slope Woodland community.

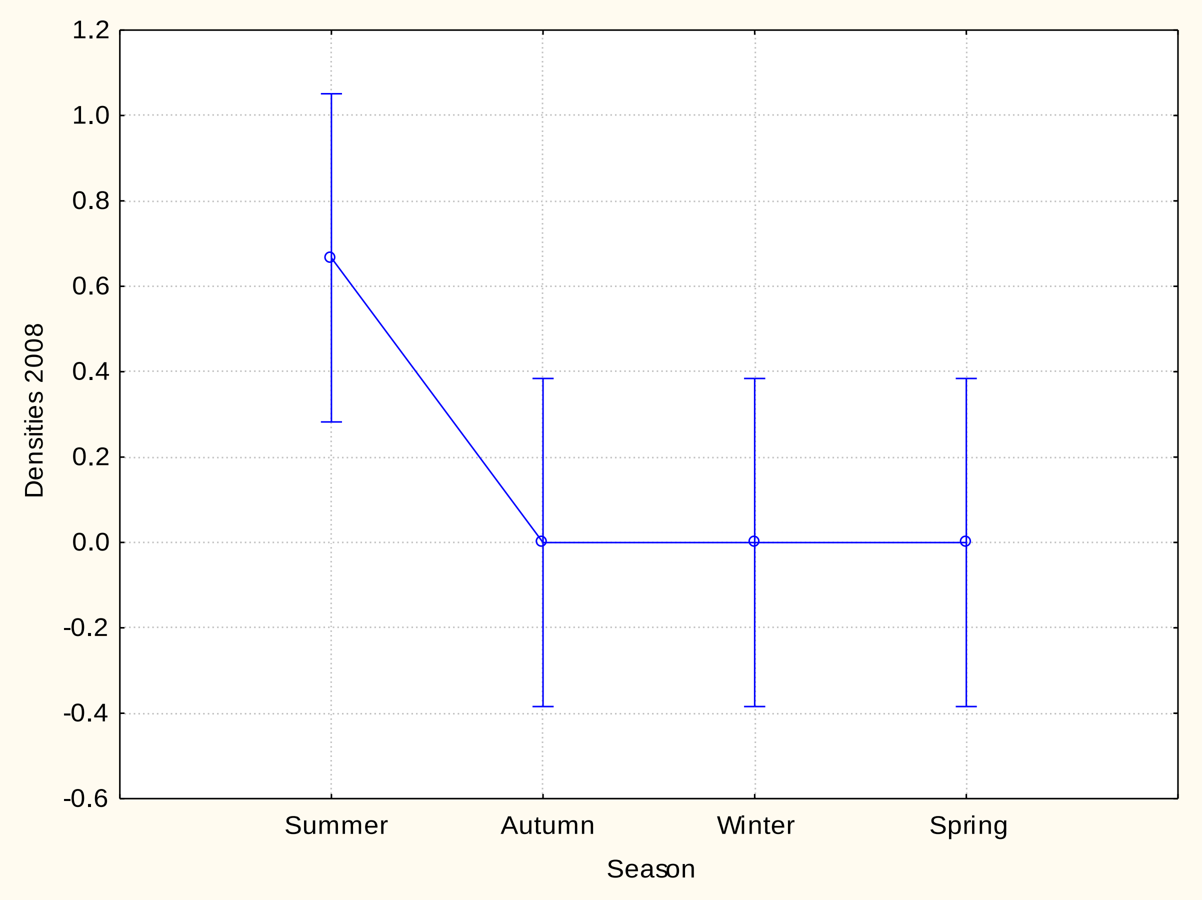

Figure 118. Graph depicting mean *Crocidura cyanea* population estimates recorded in Northern Slope Woodland during the study period.

The mean population estimate of *C. cyanea* recorded for Northern Slope Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammals every two hectares. The community is recorded covers 1968 ha of the property; therefore a population estimate of 984 *C. cyanea* is estimated to occur in the Northern Slope Woodland community at the study site.

## 10.5. Population estimates recorded for non-volant small mammal assemblages in the Rocky Highveld Grassland vegetation community.

The Rocky Highveld Grassland community occupies 15% of the study site and covers an area of 1944 ha, primarily on areas where cultivation was excluded in the past by the rockiness of such areas (Fig. 119).

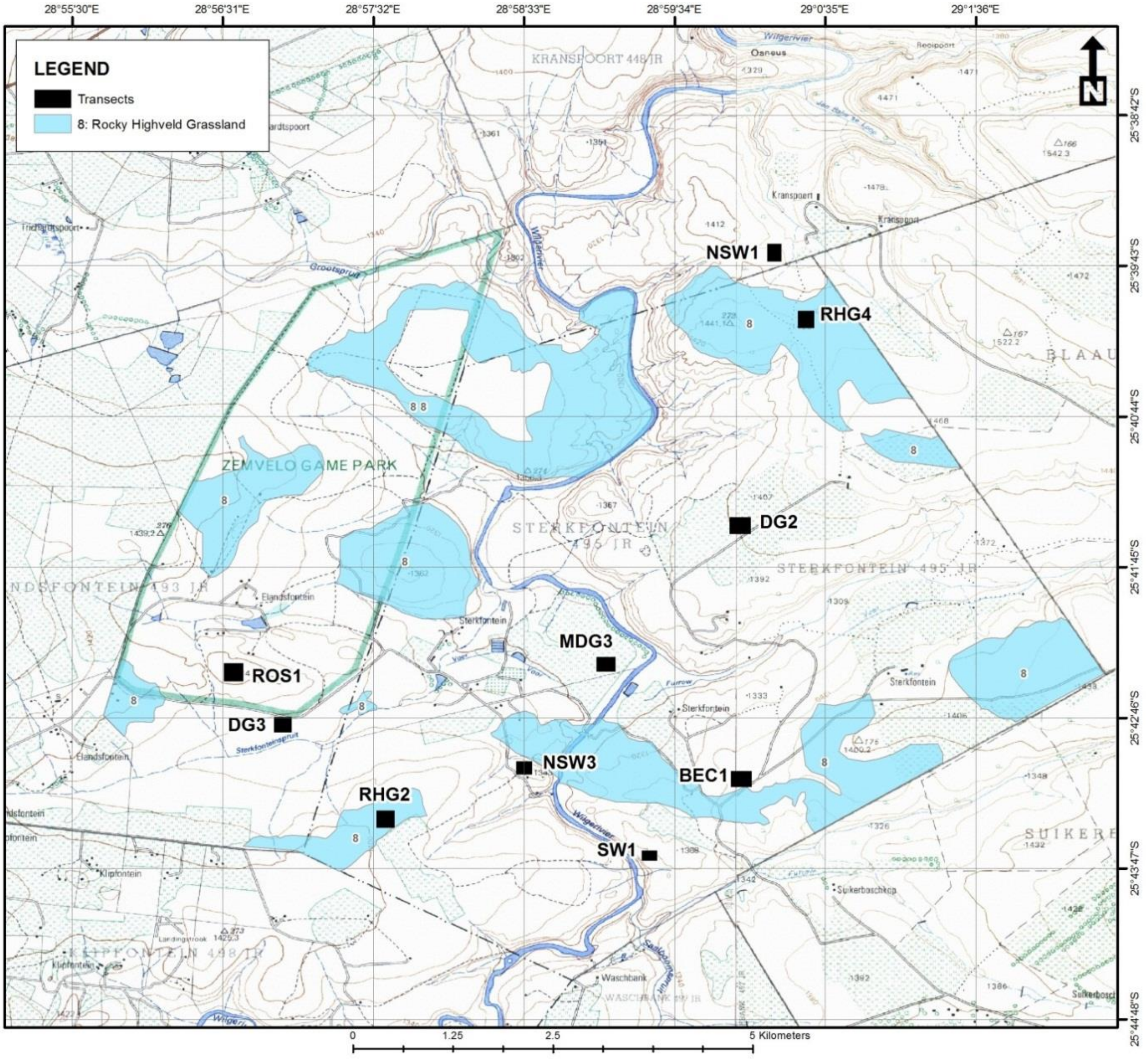

Figure 119. Map of Telperion and Ezemvelo Nature Reserve depicting the areas covered by Rocky Highveld Grassland habitat at the study site.

Statistically ANOVA revealed a significant difference between population estimate and season ($F_{1.6}$ = 69.19; $n$ = 12900; $P$ < 0.001) for transect Rocky Highveld Grassland (RHG 4). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.00), summer and winter (Tukey's: $P$ = 0.02); and autumn and spring (Tukey's: $P$ = 0.01). The population estimates recorded for transect RHG 4 indicate a highest density per ha in autumn (13 animals per ha), followed by winter (10 animals per ha), spring (6 animals per ha) and the lowest number recorded in summer (4 animals per ha) (Fig. 120).

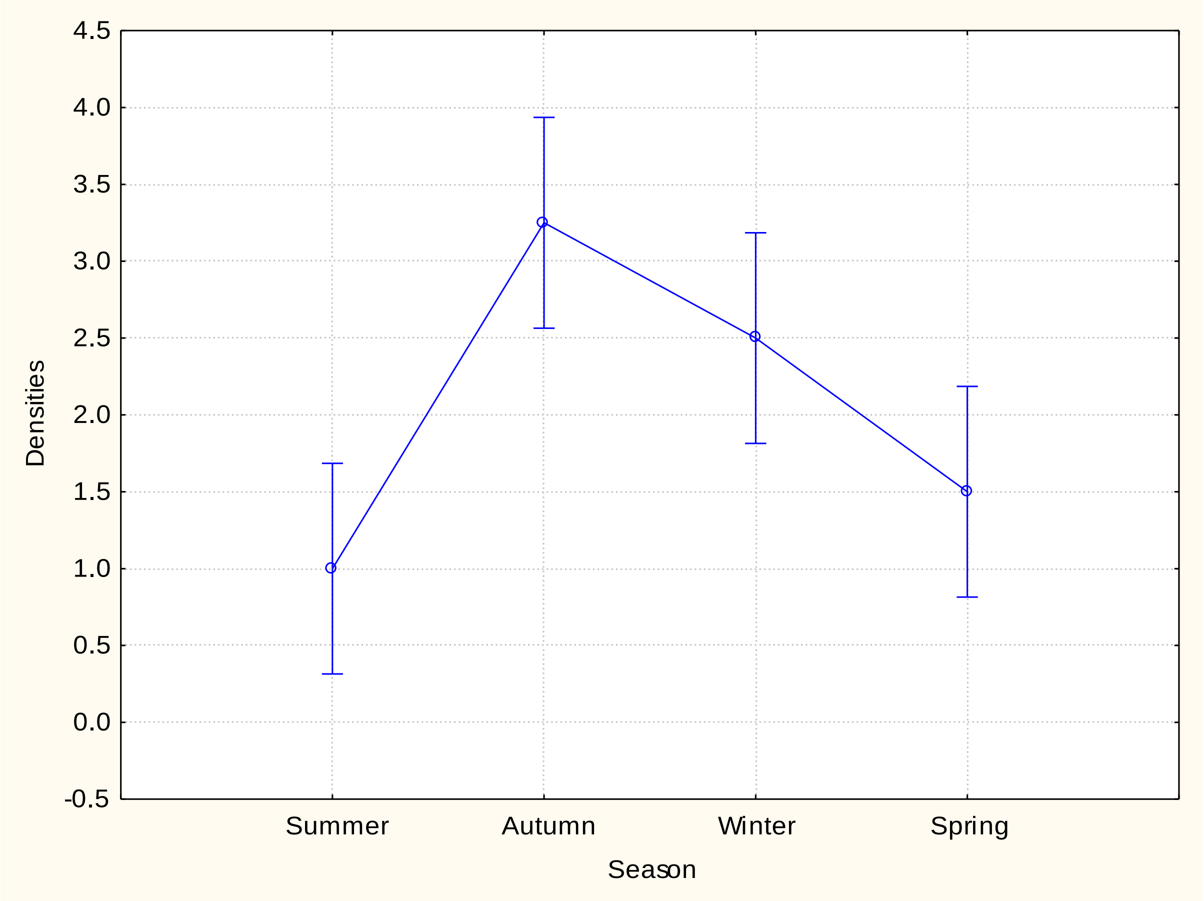

Figure 120. Graph depicting small mammal population estimates in 2008 recorded Rocky Highveld Grassland 4.

The population estimates appear similar seasonally, and large fluctuation within this transect appear not to occur, although autumn and winter indicate higher numbers. Statistically ANOVA revealed an insignificant difference between population estimate and season ($F_{1.3}$ = 1.731; $n$ = 73; $P$ = 0.214) in transect Rocky Highveld Grassland 2 in year one. The population estimates recorded in year 1 for transect RHG 2 indicate the highest density per ha in autumn (25 animals per ha), followed by spring (17 animals per ha), winter (16 animals per ha) and the lowest number in summer (15 animals per ha) (Fig. 121a).

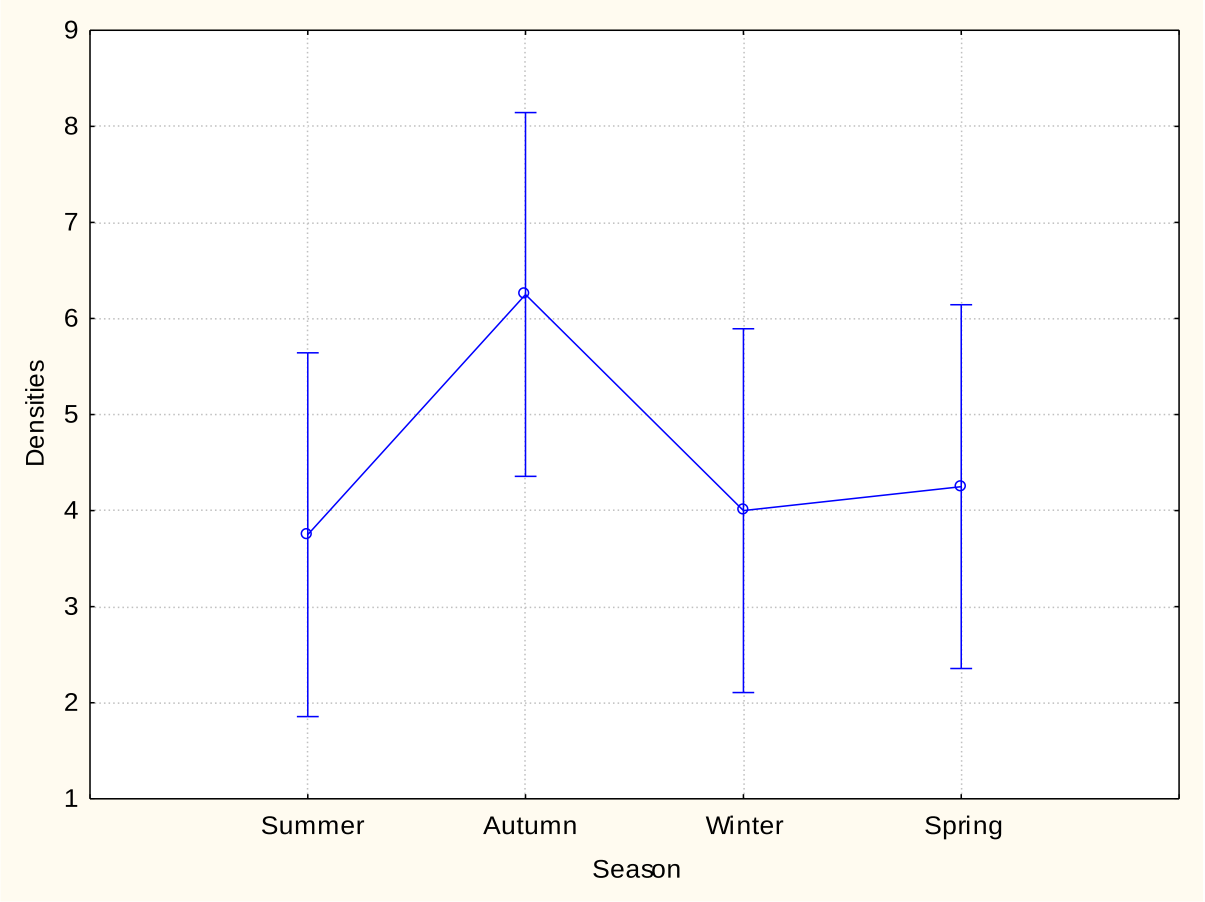

Figure 121a. Graph depicting small mammal population estimates in 2008 recorded at Rocky Highveld Grassland 2.

Statistically ANOVA revealed an insignificant difference between population estimate and season ($F_{1.3} = 0.681$; $n = 210$; $P = 0.580$) in Rocky Highveld Grassland 2 (RHG 2) in year 2. The population estimates recorded for transect RHG 2 in year two indicate the highest density per ha also in autumn (66 animals per ha), followed by winter (50 animals per ha), with summer and spring having equal numbers recorded (47 animals per ha) (Fig. 121b).

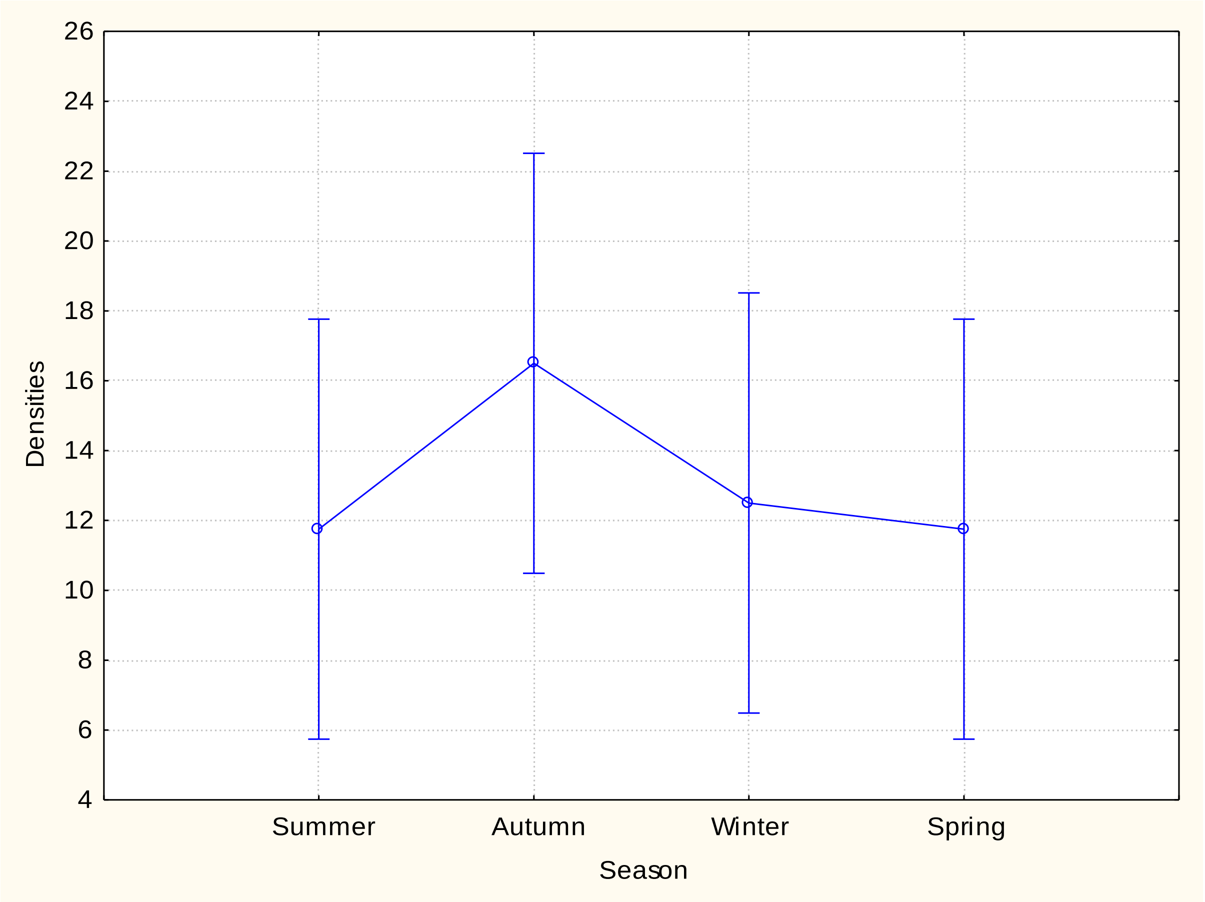

Figure 121b. Graph depicting small mammal population estimates in 2009 recorded at Rocky Highveld Grassland 2.

Statistically ANOVA revealed an insignificant difference between population estimate and season ($F_{1.3}$ = 0.491; $n$ = 134; $P$ = 0.695) in Rocky Highveld Grassland community. The seasonal mean population estimate for small mammals recorded in the community indicate that autumn has the highest densities (43 animals per ha), followed by winter (32 animals per ha), spring (30 animals per ha) and summer with the lowest recorded number (29 animals per ha) (Fig. 122).

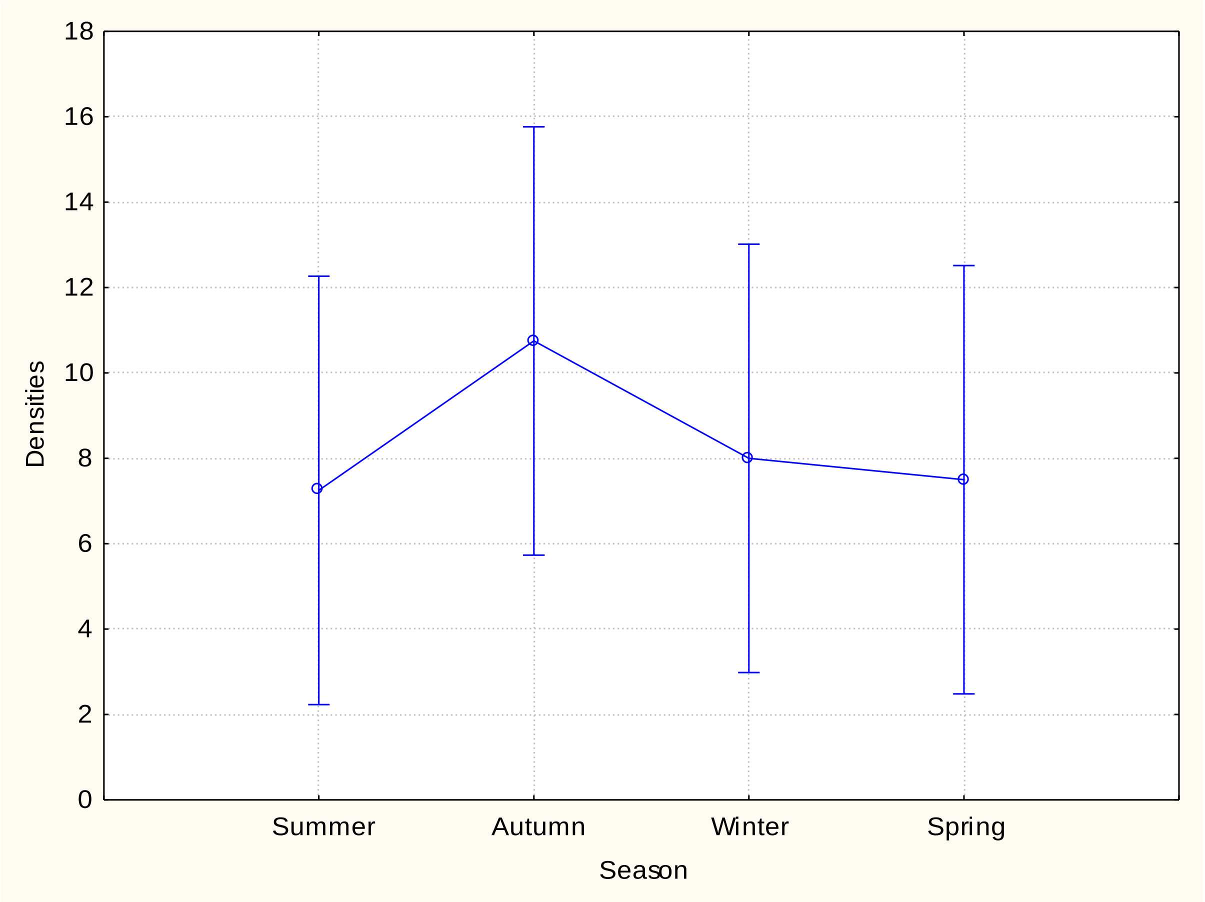

Figure 122. Graph depicting mean small mammal population estimates recorded at Rocky Highveld Grassland during the study period.

The mean population estimate of small mammals recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 34 small mammals per ha. The community is recorded to cover 1944 ha at the study site, therefore a population estimate of 66 096 small mammals are estimated to occur in the Rocky Highveld Grassland community on the property. The population estimates were recorded for the following small mammal species seasonally in Rocky Highveld Grassland at the study site during this study.

### 10.5.1. Seasonal population estimates recorded for *Micaelamys namaquensis* in Rocky Highveld Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *M. namaquensis* in Rocky Highveld Grassland in year 1 indicate the highest density per ha in autumn (10 animals per ha), followed by winter and spring (8 animals per ha) and the lowest number in summer (4 animals per ha) (Fig. 123). ANOVA revealed an insignificant difference in population estimate of *M. namaquensis* and season ($F_{1.3}$ = 1.013; $n$ = 30; $P$ = 0.436) for the Rocky Highveld Grassland community in year 1. The population estimates recorded in Rocky Highveld Grassland in year 2 indicate the highest density per ha in spring (30 animals per ha), followed by summer (16 animals per ha), autumn (13 animals per ha) and winter having the lowest number recorded (6 animals per ha) (Fig. 123). ANOVA revealed an insignificant difference in population estimate of *M. namaquensis* and season ($F_{1.3}$ = 2.879; $n$ = 63; $P$ = 0.103) for the Rocky Highveld Grassland community in year 2.

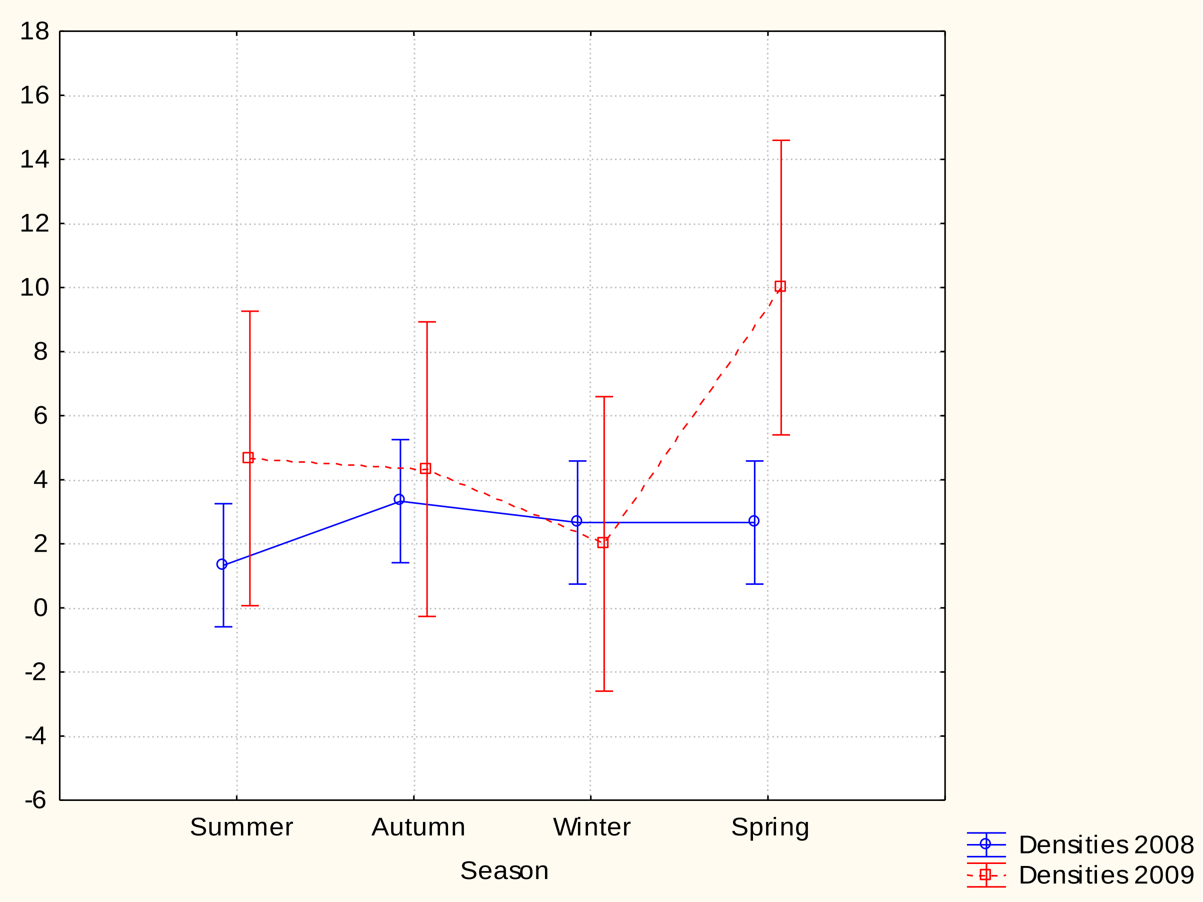

Figure 123. Graph depicting seasonal *M. namaquensis* population estimates in 2008 and 2009 recorded in the Rocky Highveld Grassland vegetation community.

The seasonal mean population estimate for *M. namaquensis* recorded in the Rocky Highveld Grassland community indicate that spring has the highest population estimates (19 animals per ha), followed by autumn (12 animals per ha), summer (10 animals per ha) and winter with the lowest recorded number (7 animals per ha) (Fig 124). ANOVA revealed an insignificant difference in mean population estimate of *M. namaquensis* and season ($F_{1.3}$ = 0.990; $n$ = 48; $P$ = 0.445) for the Rocky Highveld Grassland community.

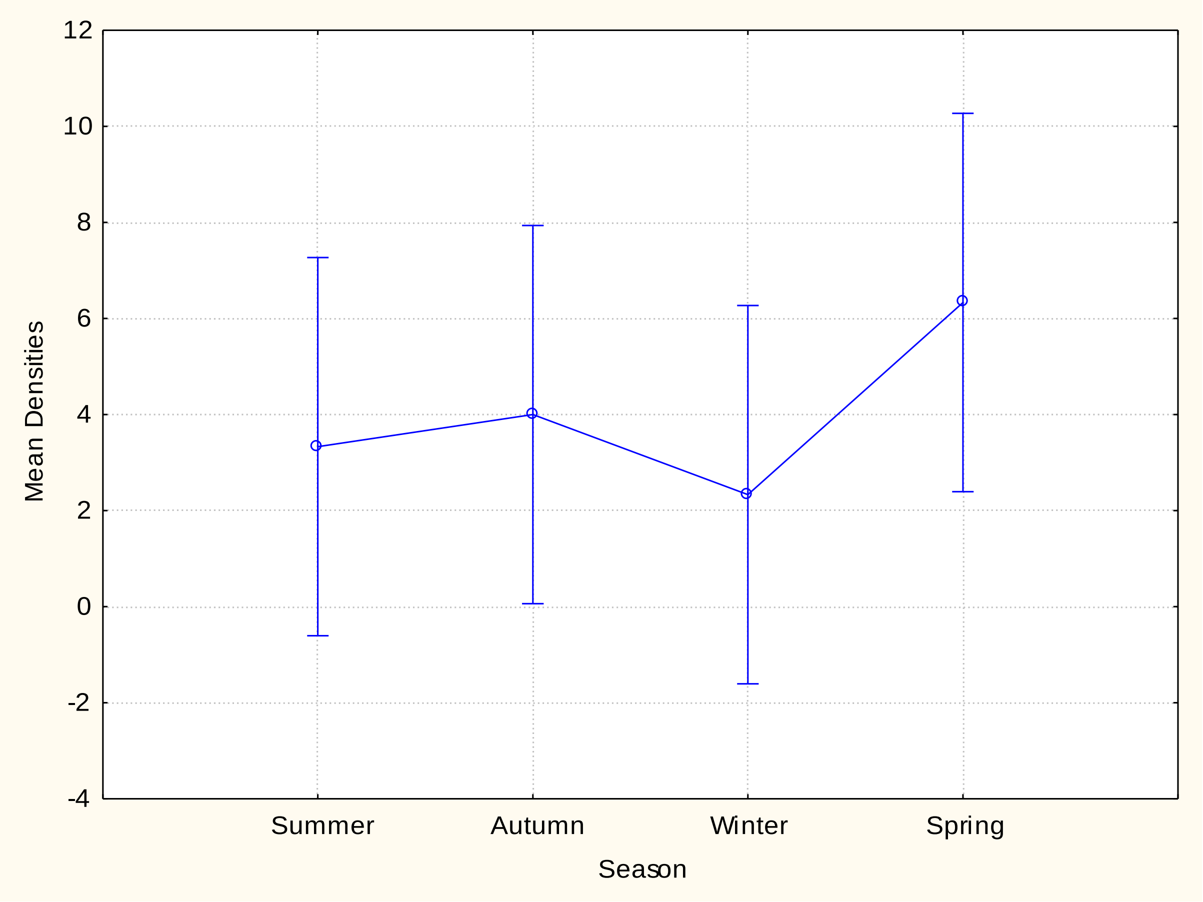

Figure 124. Graph depicting mean *M. namaquensis* population estimates recorded in Rocky Highveld Grassland during the study period.

The mean population estimate of *M. namaquensis* recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 12 small mammals per ha. The community covers 1944 ha of the property, therefore a population estimate of 23 328 *M. namaquensis* are estimated to occur in the Rocky Highveld Grassland community at the study site.

### 10.5.2. Seasonal population estimates recorded for *Aethomys chrysophilus* in the Rocky Highveld Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *Aethomys chrysophilus* in Rocky Highveld Grassland in year 1 with three records, 2 animals in summer (4 animals per ha) and 1 in autumn (2 animals per ha) (Fig. 125). No individuals were recorded during year 2 of the study. ANOVA revealed an insignificant difference in population estimate of *A. chrysophilus* and season ($F_{1.3} = 2.429$; $n = 7$; $P = 0.140$) for the Rocky Highveld Grassland community.

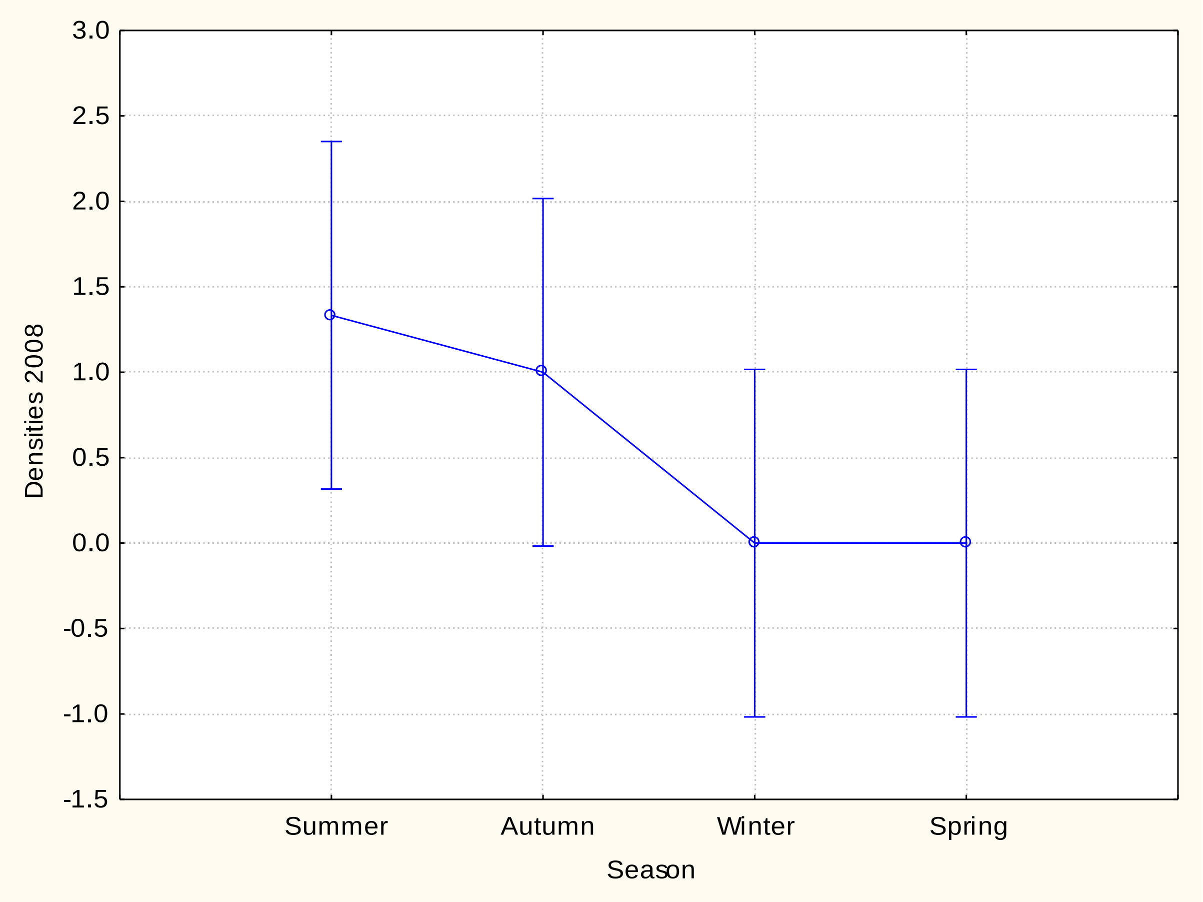

Figure 125. Graph depicting mean *Aethomys chrysophilus* population estimates recorded in Rocky Highveld Grassland during the study period.

The mean population estimate of *A. chrysophilus* recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammals per ha. The community covers 1 944 ha of the study site; therefore a population estimate of 1 944 *A. chrysophilus* is estimated to occur in the Rocky Highveld Grassland community on the property.

10.5.3. Seasonal population estimates recorded for *Dendromus melanotis* in Rocky Highveld Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *D. melanotis* in Rocky Highveld Grassland in year 1 indicate the highest density per ha in winter and spring (2 animals per ha), with no individuals recorded in summer and autumn (Fig 126). ANOVA revealed an insignificant difference in population estimate between *D. melanotis* and season ($F_{1.3}$ = 0.667; $n$ = 4; $P$ = 0.596) for the Rocky Highveld Grassland community in year 1. The population estimates recorded in Rocky Highveld Grassland in year 2 indicate the highest density per ha in autumn (21 animals per ha), followed by winter (8 animals per ha), with equal densities recorded in summer and spring (2 animals per ha) (Fig. 126). ANOVA revealed an insignificant difference in population estimate between *D. melanotis* and season ($F_{1.3}$ = 1.698; $n$ = 33; $P$ = 0.244) for the Rocky Highveld Grassland community in year 2.

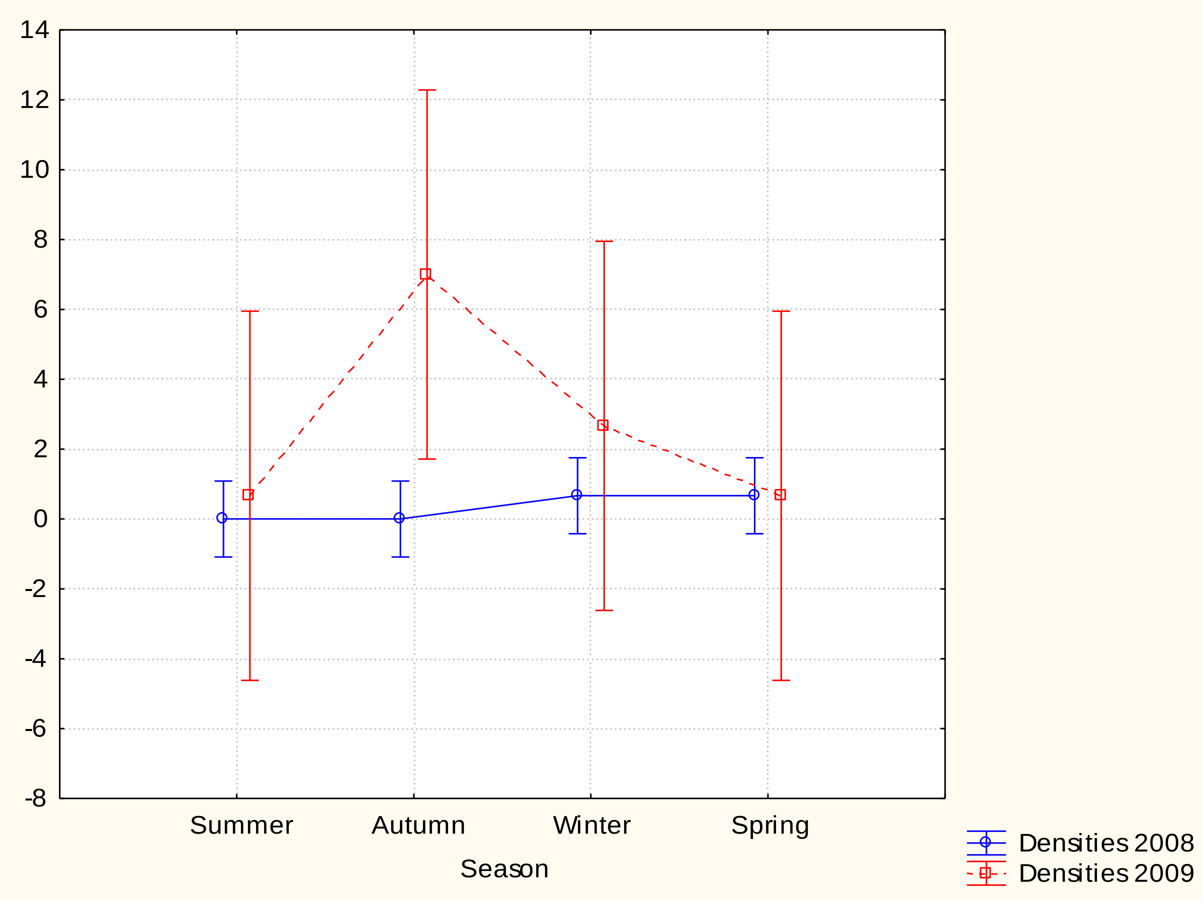

Figure 126. Graph depicting seasonal *Dendromus melanotis* population estimates in 2008 and 2009 recorded in the Rocky Highveld Grassland vegetation community.

The seasonal mean population estimate for *D. melanotis* recorded in the Rocky Highveld Grassland community indicate that autumn has the highest population estimates (11 animals per ha), followed by winter (5 animals per ha), and summer and spring with an equal population estimate (2 animals per ha) (Fig. 127). ANOVA revealed an insignificant difference in mean population estimate between *D. melanotis* and season ($F_{1.3} = 0.911$; $n = 20$; $P = 0.477$) for the Rocky Highveld Grassland community.

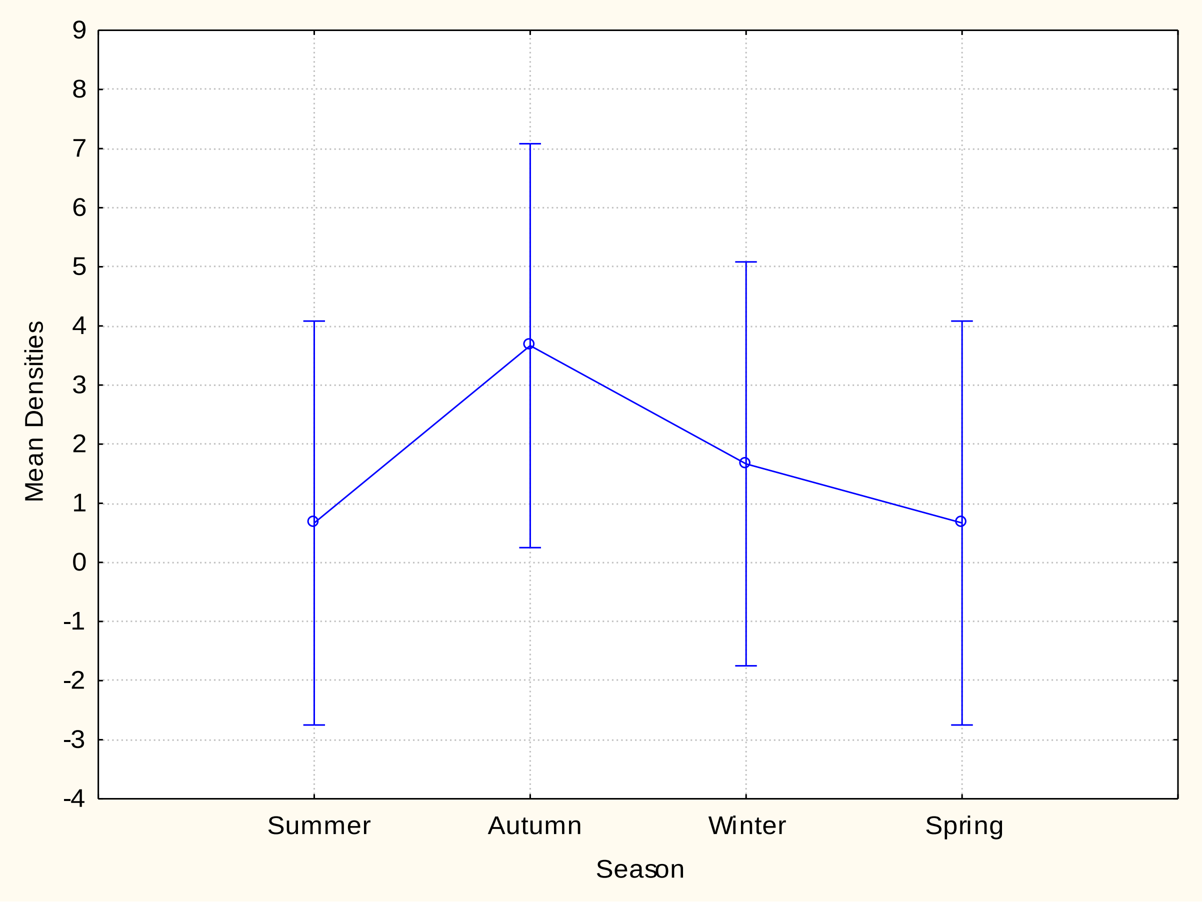

Figure 127. Graph depicting mean *Dendromus melanotis* population estimates recorded in Rocky Highveld Grassland during the study period.

The mean population estimate of *D. melanotis* recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 5 small mammals per ha. This community covers 1944 ha of the property, therefore a population estimate of 9 720 *D. melanotis* are estimated to occur in the Rocky Highveld Grassland community at the study site.

### 10.5.4. Seasonal population estimates recorded for *Dendromus mystacalis* in Rocky Highveld Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *D. mystacalis* in Rocky Highveld Grassland in year 1 indicate the highest density per ha in autumn (4 animals per ha), with no individuals recorded in summer, winter and spring (Fig 128). ANOVA revealed an insignificant difference in population estimate between *D. mystacalis* and season ($F_{1.3}$ = 2.286; $n$ = 4; $P$ = 0.156) for the Rocky Highveld Grassland community in year 1. The population estimates recorded in Rocky Highveld Grassland in year 2 indicate the highest density per ha in autumn (8 animals per ha), followed by winter (5 animals per ha), with no individuals recorded in summer and spring (Fig. 128). ANOVA revealed a significant difference between population estimate between *D. mystacalis* and season ($F_{1.3}$ = 7.792; $n$ = 13; $P$ = 0.009) for the Rocky Highveld Grassland community in year 2. Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.01), and autumn and spring (Tukey's: $P$ = 0.01).

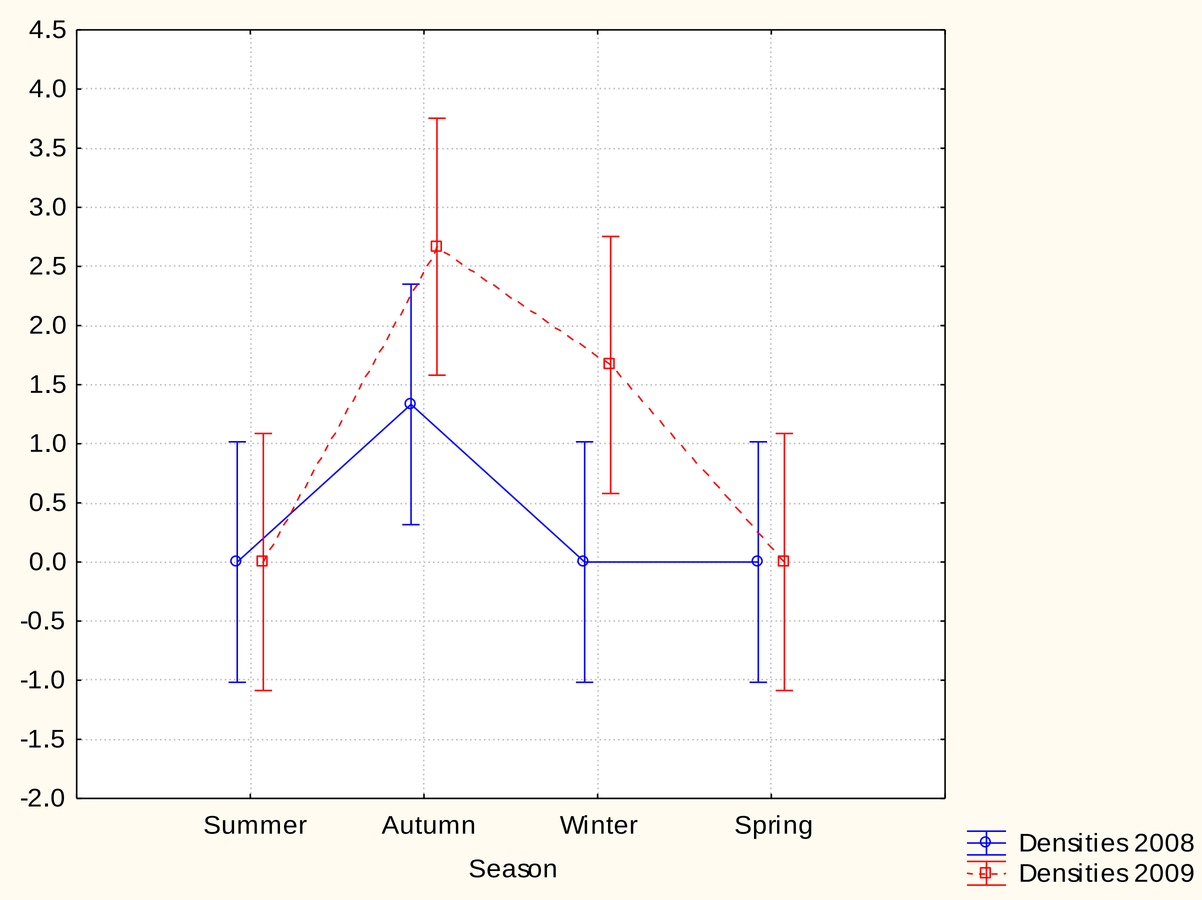

Figure 128. Graph depicting seasonal *Dendromus mystacalis* population estimates in 2008 and 2009 recorded in the Rocky Highveld Grassland vegetation community.

The seasonal mean population estimate for *D. mystacalis* recorded in the Rocky Highveld Grassland community indicate that autumn has the highest population estimates (11 animals per ha), followed by winter (5 animals per ha), and summer and spring with 0 densities (Fig. 129). ANOVA revealed a significant difference in mean population estimate between *D. mystacalis* and season ($F_{1.3}$ = 4.754; $n$ = 16; $P$ = 0.035) for the Rocky Highveld Grassland community. Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.04), and autumn and spring (Tukey's: $P$ = 0.04).

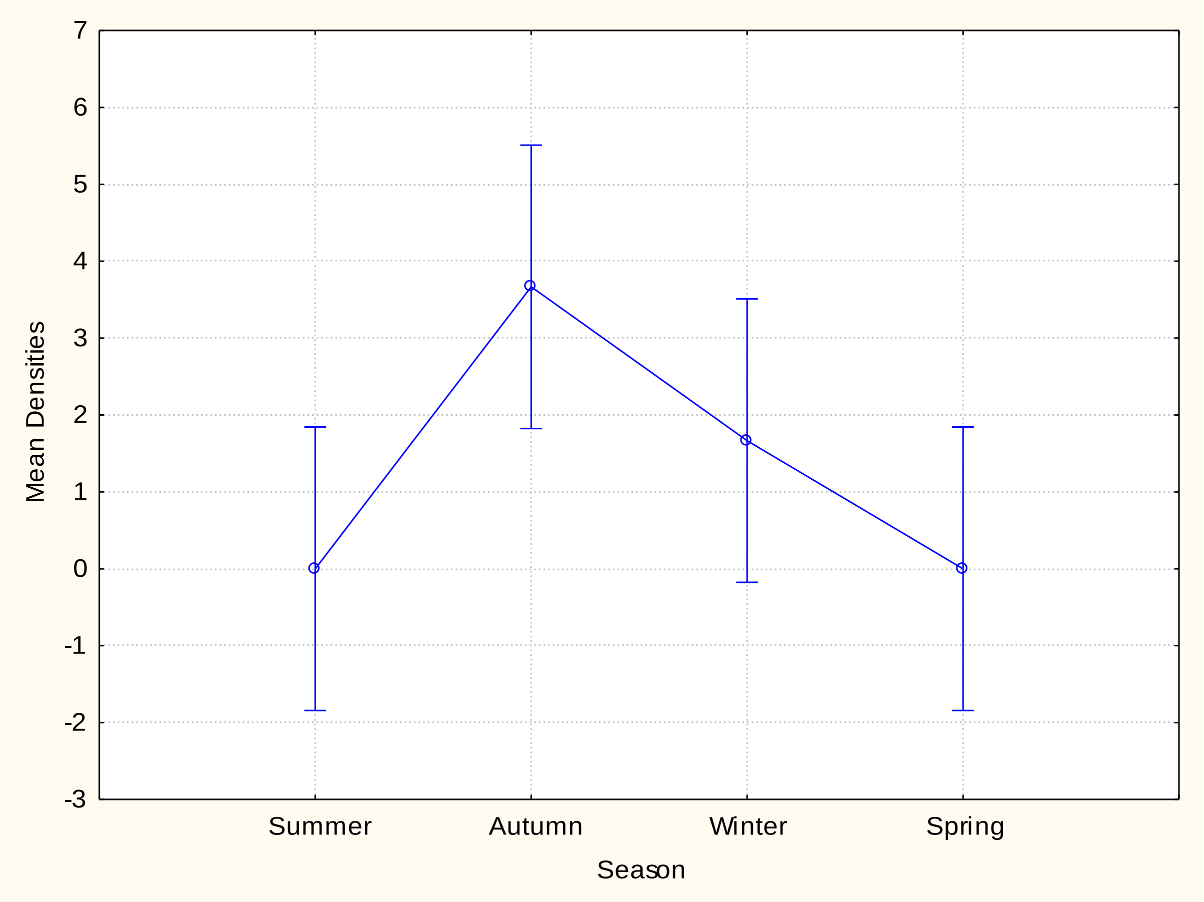

Figure 129. Graph depicting mean *Dendromus mystacalis* population estimates recorded in Rocky Highveld Grassland during the study period

The mean population estimate of *D. mystacalis* recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 2 small mammals per ha. This community covers 1944 ha of the property, therefore a population estimate of 3 888 *D. mystacalis* are estimated to occur in the Rocky Highveld Grassland community at the study site.

### 10.5.5. Seasonal population estimates recorded for *Steatomys pratensis* in Rocky Highveld Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *S. pratensis* in Rocky Highveld Grassland in year one indicate the highest density per ha in summer (10 animals per ha), with no animals recorded in autumn, winter and spring (Fig. 130). ANOVA revealed an insignificant difference in population estimate between *S. pratensis* and season ($F_{1.3} = 1.923$; $n = 10$; $P = 0.204$) for the Rocky Highveld Grassland community in year 1. The population estimates recorded in Rocky Highveld Grassland in year two indicate lower densities per ha, with one animal recorded in summer (2 animals per ha), and no records in autumn, winter and spring (Fig. 130). ANOVA revealed an insignificant difference in population estimate between *S. pratensis* and season ($F_{1.3} = 1.000$; $n = 2$; $P = 0.441$) for the Rocky Highveld Grassland community in year 1.

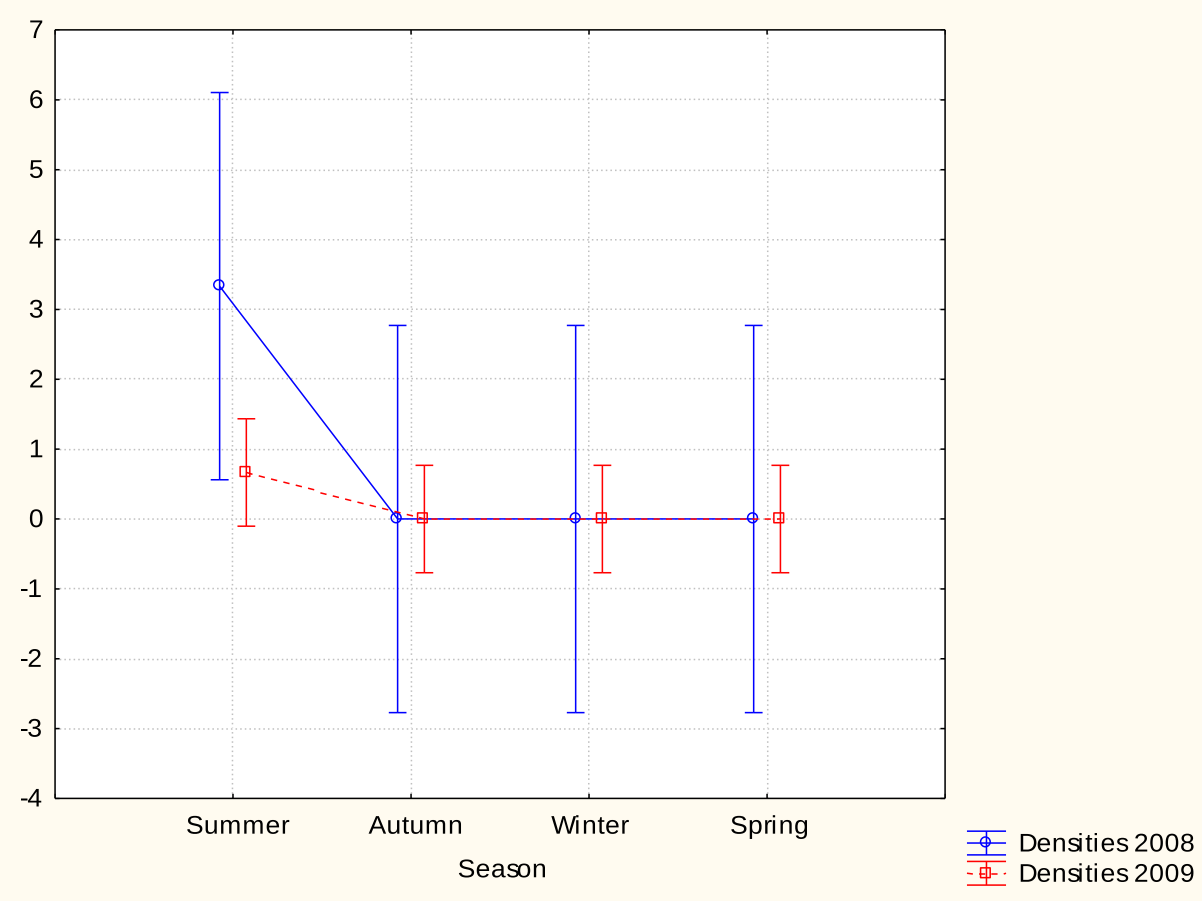

Figure 130. Graph depicting seasonal *Steatomys pratensis* population estimates in 2008 and 2009 recorded in the Rocky Highveld Grassland vegetation community.

The seasonal mean population estimate for *S. pratensis* recorded in the Rocky Highveld Grassland community indicate that summer has the highest population estimates (6 animals per ha), with no animals recorded in autumn, winter and spring (Fig. 131). ANOVA revealed a weak but significant difference between population estimate between *S. pratensis* and season ($F_{1.3} = 4.000$; $n = 6$; $P = 0.052$) for the Rocky Highveld Grassland community.

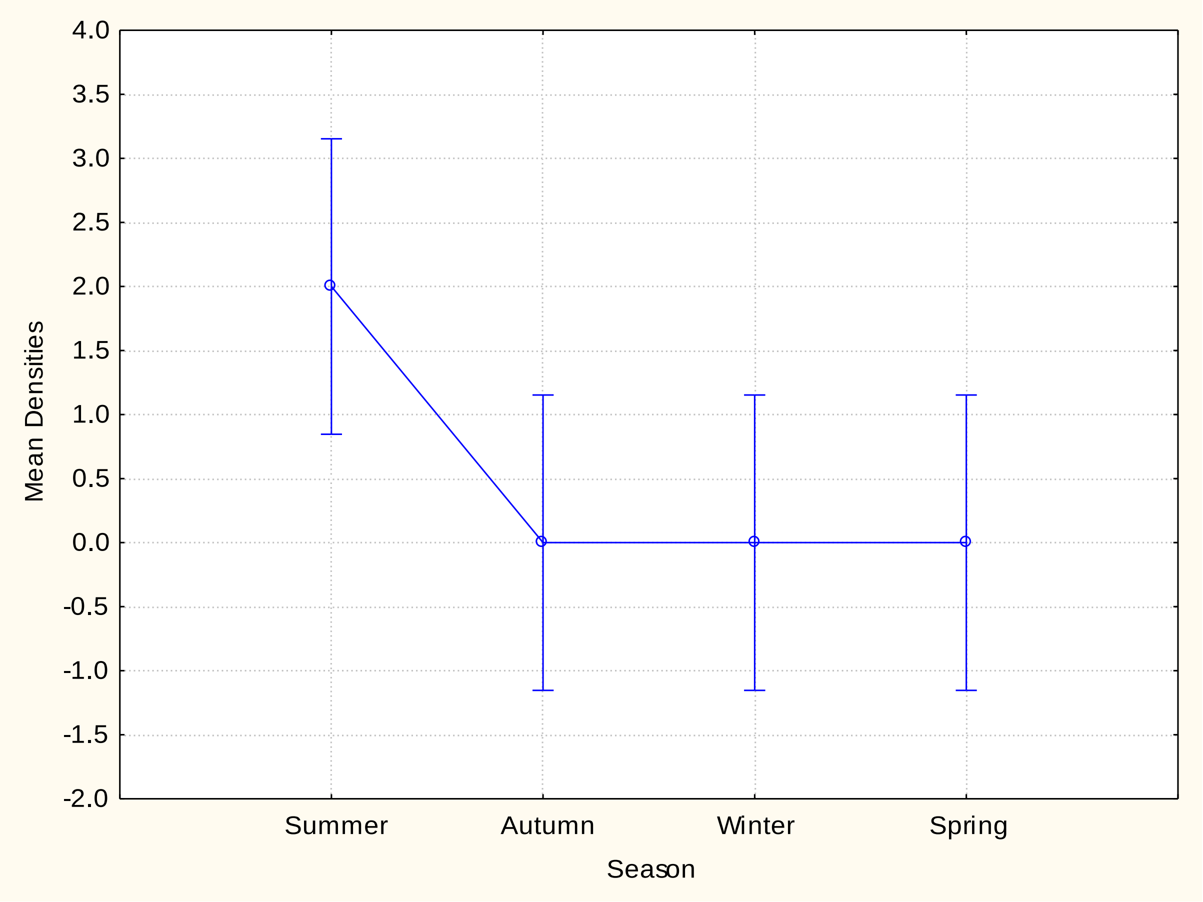

Figure 131. Graph depicting mean *Steatomys pratensis* population estimates recorded in Rocky Highveld Grassland during the study period.

The mean population estimate of *S. pratensis* recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 2 small mammals per ha. This community covers 1944 ha of the property, therefore a population estimate of 3 888 *S. pratensis* are estimated to occur in the Rocky Highveld Grassland community at the study site.

### 10.5.6. Seasonal population estimates recorded for *Gerbilliscus leucogaster* in Rocky Highveld Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *G. leucogaster* in Rocky Highveld Grassland in year 1 indicate the highest density per ha in autumn (8 animals per ha), followed by summer

(5 animals per ha), spring (2 animals per ha), with no animals recorded in winter (Fig. 132). ANOVA revealed an insignificant difference in population estimate between *G. leucogaster* and season ($F_{1.3}$ = 0.527; *n* = 15; *P* = 0.676) for the Rocky Highveld Grassland community in year 1. The population estimates recorded in Rocky Highveld Grassland in year 2 indicate the opposite to year 1, with the highest density per ha in winter (11 animals per ha), followed by autumn (5 animals per ha), summer (3 animals per ha), with the lowest population estimate recorded in spring (2 animals per ha) (Fig. 132). ANOVA revealed an insignificant difference in population estimate between *G. leucogaster* and season ($F_{1.3}$ = 0.409; *n* = 21; *P* = 0.751) for the Rocky Highveld Grassland community in year 2.

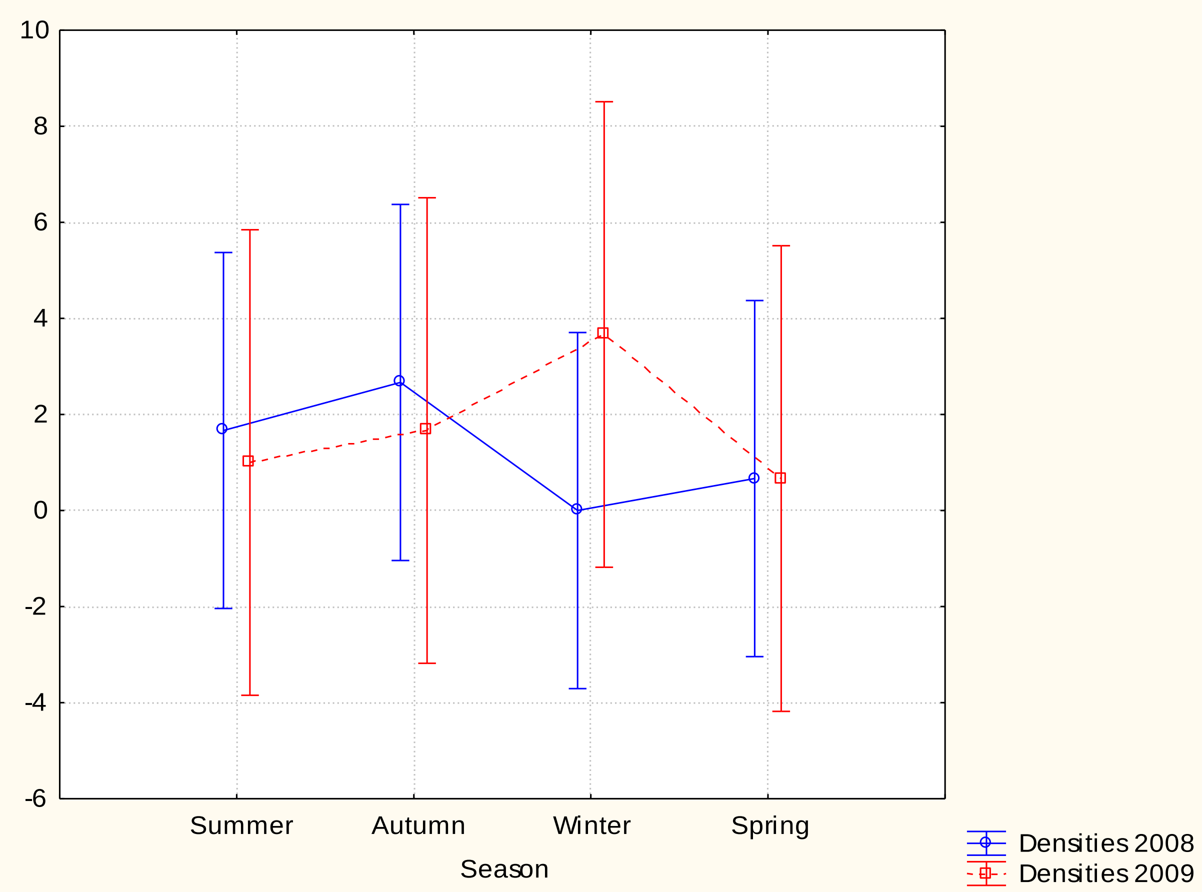

Figure 132. Graph depicting seasonal *Gerbilliscus leucogaster* population estimates in 2008 and 2009 recorded in the Rocky Highveld Grassland vegetation community.

The seasonal mean population estimate for *G. leucogaster* recorded in the Rocky Highveld Grassland community indicate that autumn has the highest population estimates (7 animals per ha), followed by winter (6 animals per ha), summer (4 animals per ha), and spring with the lowest density (2 animals per ha) (Fig 133). ANOVA revealed an insignificant difference in mean population estimate between *G. leucogaster* and season ($F_{1.3}$ = 0.187; $n$ = 19; $P$ = 0.902) for the Rocky Highveld Grassland community.

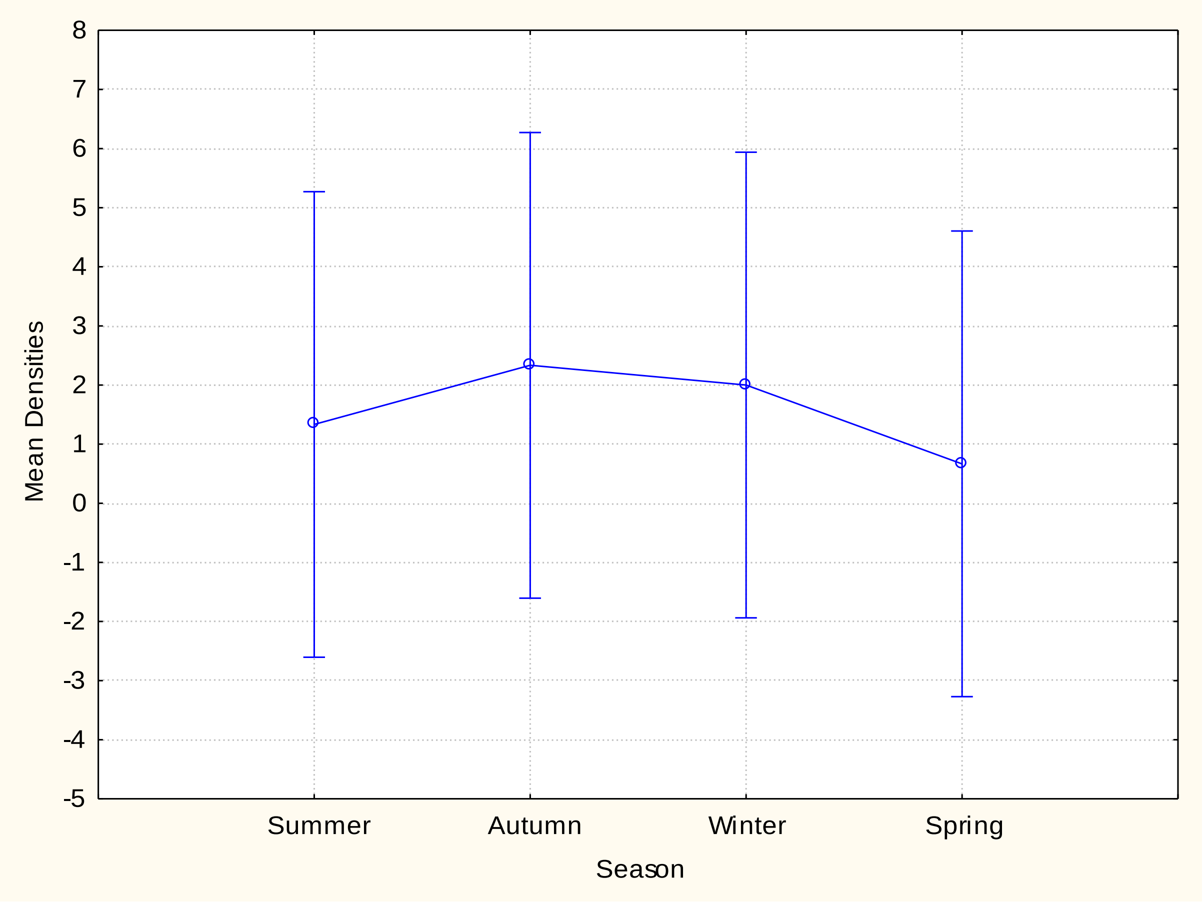

Figure 133. Graph depicting mean *Gerbilliscus leucogaster* population estimates recorded in Rocky Highveld Grassland during the study period.

The mean population estimate of *G. leucogaster* recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 5 small mammals per ha. This community covers 1944 ha of the property, therefore a population estimate of 9 720 *G. leucogaster* are estimated to occur in the Rocky Highveld Grassland community at the study site.

### 10.5.7. Seasonal population estimates recorded for *Mastomys* spp. in the Rocky Highveld Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *Mastomys* spp. in Rocky Highveld Grassland in year 1 with only one record in spring (2 animals per ha) (Fig. 134). No individuals were recorded during year 2 of the study. ANOVA revealed a weak but significant difference between population estimate between *Mastomys* spp. and season ($F_{1.3}$ = 4.000; $n$ = 2; $P$ = 0.052) for the Rocky Highveld Grassland community.

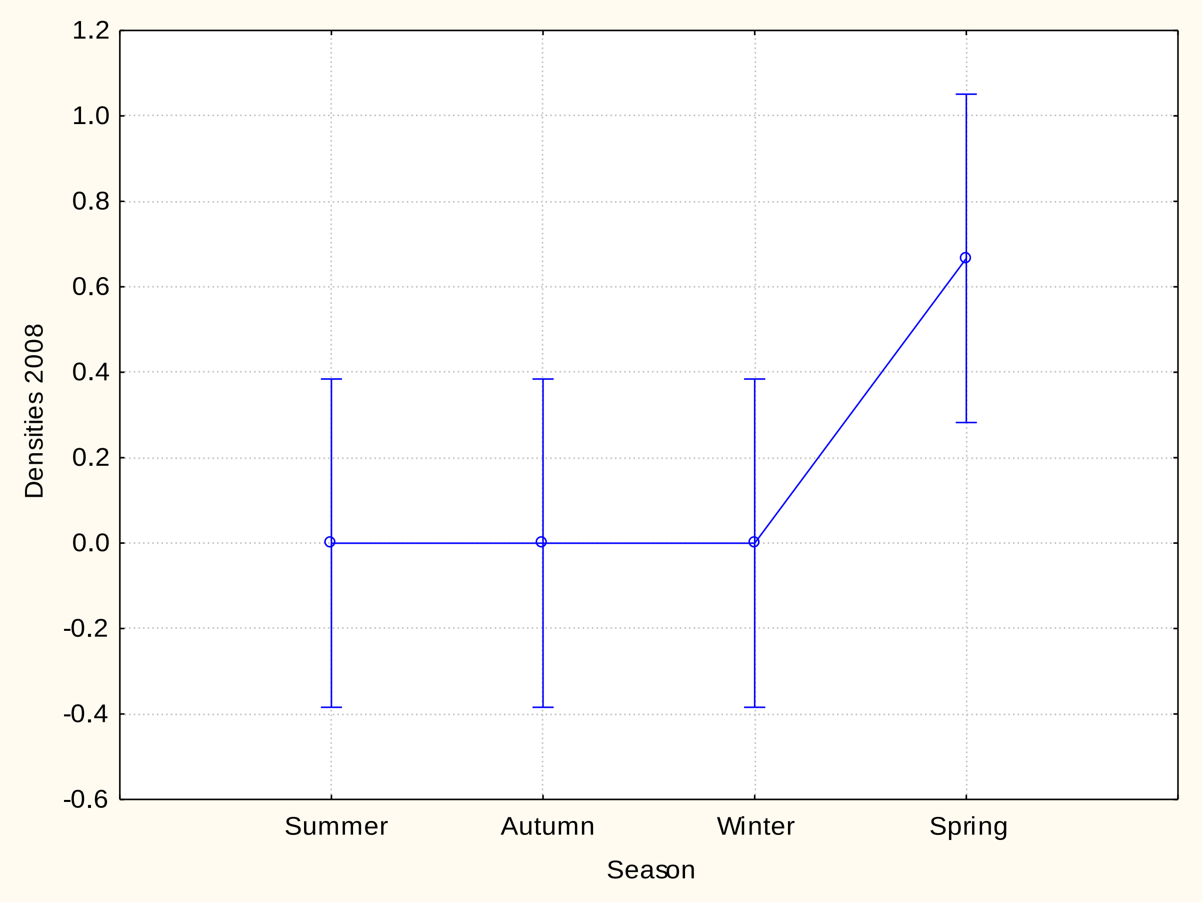

Figure 134. Graph depicting mean *Mastomys* spp. population estimates recorded in Rocky Highveld Grassland during the study period

The mean population estimate of *Mastomys* spp. recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal for every two hectares. This community covers 1944 ha of the property; therefore population estimates of 972 *Mastomys* spp. are estimated to occur in the Rocky Highveld Grassland community on the property.

### 10.5.8. Seasonal population estimates recorded for *Lemniscomys rosalia* in the Rocky Highveld Grassland community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded during year 1 of the study. The population estimates for *L. rosalia* in Rocky Highveld Grassland in year 2 had the highest densities recorded in summer (7 animals per ha), followed by autumn (5 animals per ha), spring (4 animals per ha), and the lowest densities in winter (2 animals per ha) (Fig. 135). Large fluctuation in densities in this species in year 2 did not appear to occur. ANOVA revealed an insignificant difference in population estimate between *L. rosalia* and season ($F_{1.3} = 0.619$; $n = 18$; $P = 0.622$) for the Rocky Highveld Grassland community.

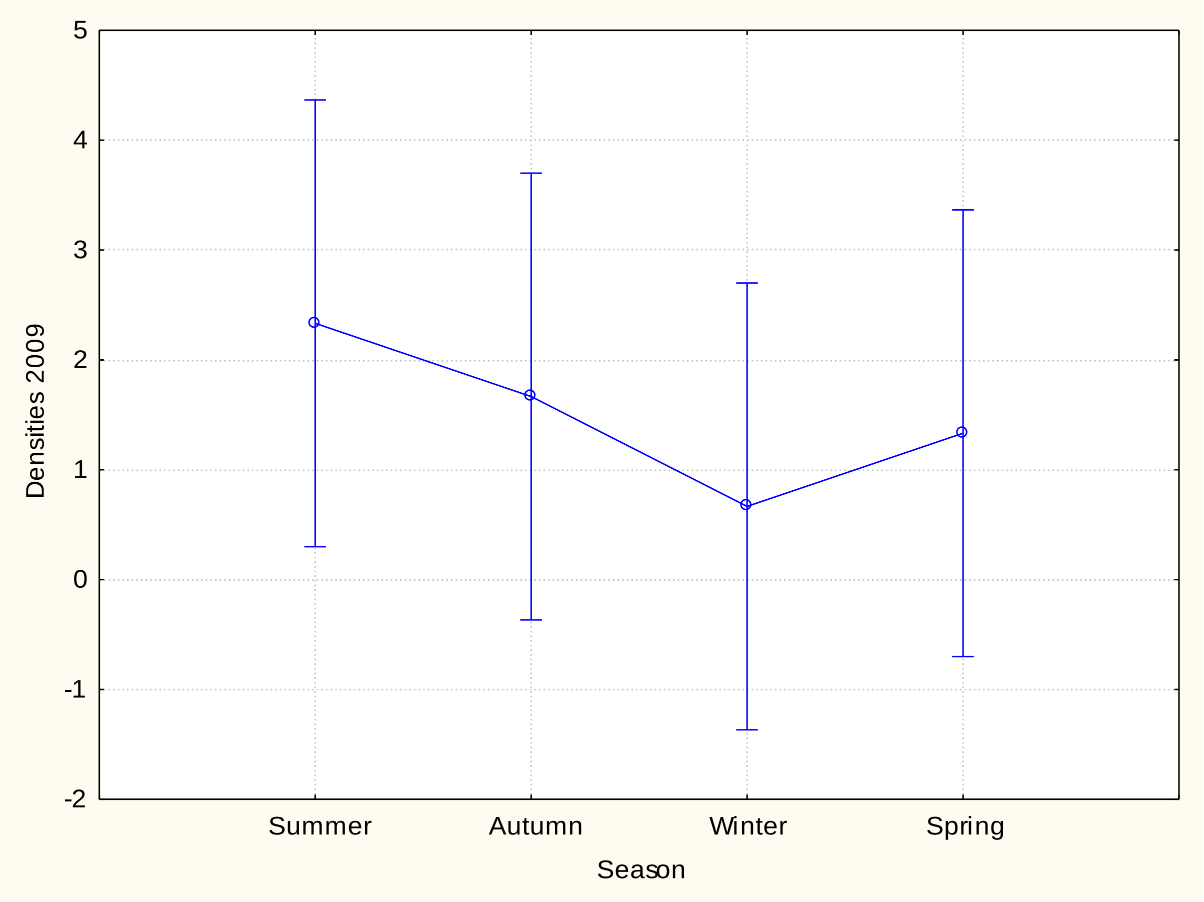

Figure 135. Graph depicting mean *Lemniscomys rosalia* population estimates recorded in Rocky Highveld Grassland during the study period.

The mean population estimate of *L. rosalia* recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 5 small mammals per ha. This community covers 1944 ha at the study site, therefore a population estimate of 9 720 *L. rosalia* are estimated to occur in the Rocky Highveld Grassland community on the property.

### 10.5.9. Seasonal population estimates recorded for *Mus minutoides* in the Rocky Highveld Grassland community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded during year 1 of the study. The population estimates for *M. minutoides* in Rocky Highveld Grassland in year 2 had equal densities recorded in summer, autumn and winter (2 animals per ha), with no animals being recorded in spring (Fig. 136). ANOVA revealed an insignificant difference in population estimate between *M. minutoides* and season ($F_{1.3}$ = 0.333; $n$ = 6; $P$ = 0.802) for the Rocky Highveld Grassland community. Large fluctuation in densities in this species in year two did not appear to occur.

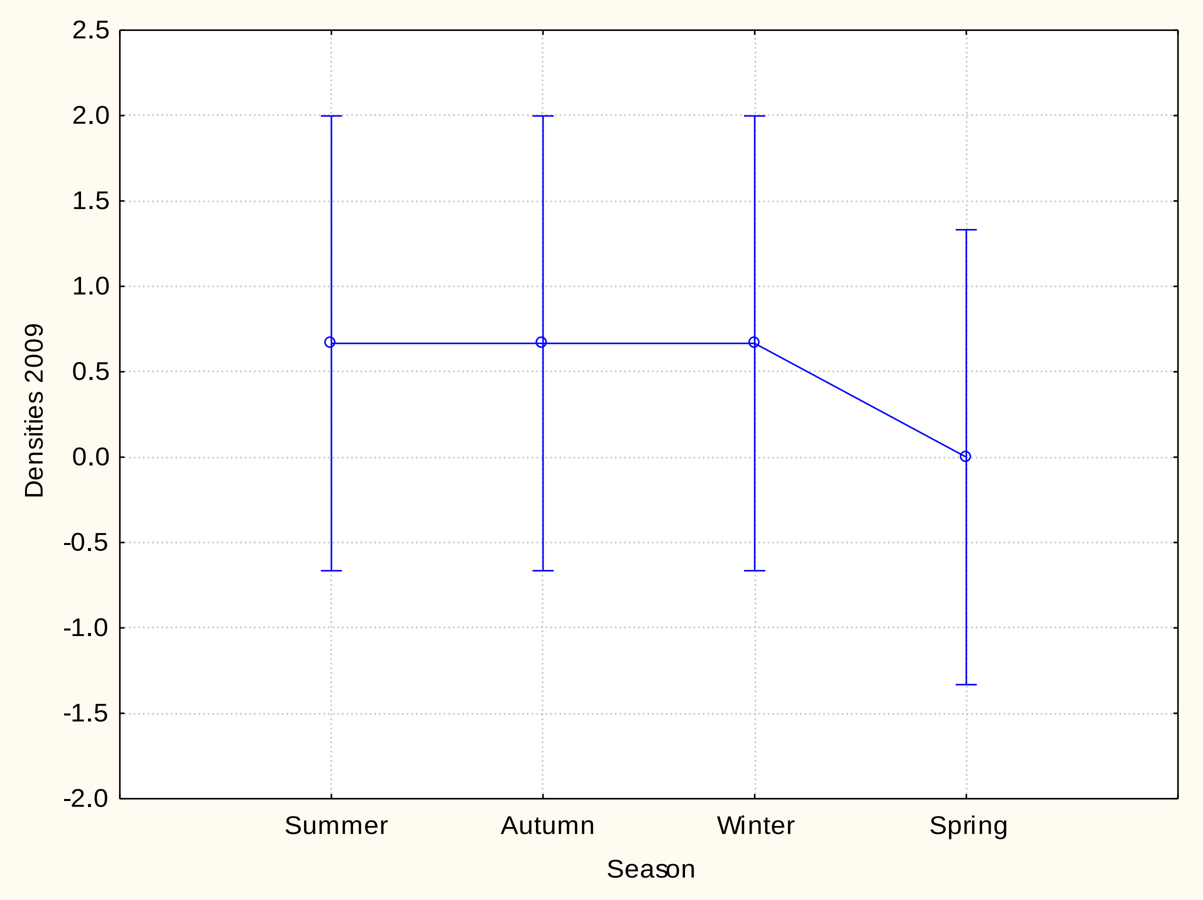

Figure 136. Graph depicting mean *Mus minutoides* population estimates recorded in Rocky Highveld Grassland during the study period.

The mean population estimate of *M. minutoides* recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 2 small mammals per ha. This community covers 1944 ha of the study site, therefore a population estimate of 3 888 *M. minutoides* are estimated to occur in the Rocky Highveld Grassland community at the study site.

### 10.5.10. Seasonal population estimates recorded for *Elephantulus myurus* in the Rocky Highveld Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *Elephantulus myurus* in Rocky Highveld Grassland in year 1 indicate the highest density per ha in winter (5 animals per ha), with equal densities recorded in summer, autumn and spring (2 animals per ha) (Fig. 137). ANOVA revealed an insignificant difference in population estimate between *E. myurus* and season ($F_{1.3} = 0.321$; $n = 11$; $P = 0.810$) for the Rocky Highveld Grassland community in year 1. The population estimates recorded in Rocky Highveld Grassland in year 2 also indicate the highest density per ha in winter (14 animals per ha), followed by autumn (6 animals per ha), spring (5 animals per ha) and summer having the lowest number recorded (2 animals per ha) (Fig. 137). ANOVA revealed an insignificant difference in population estimate between *E. myurus* and season ($F_{1.3} = 2.667$; $n = 21$; $P = 0.119$) for the Rocky Highveld Grassland community in year 2.

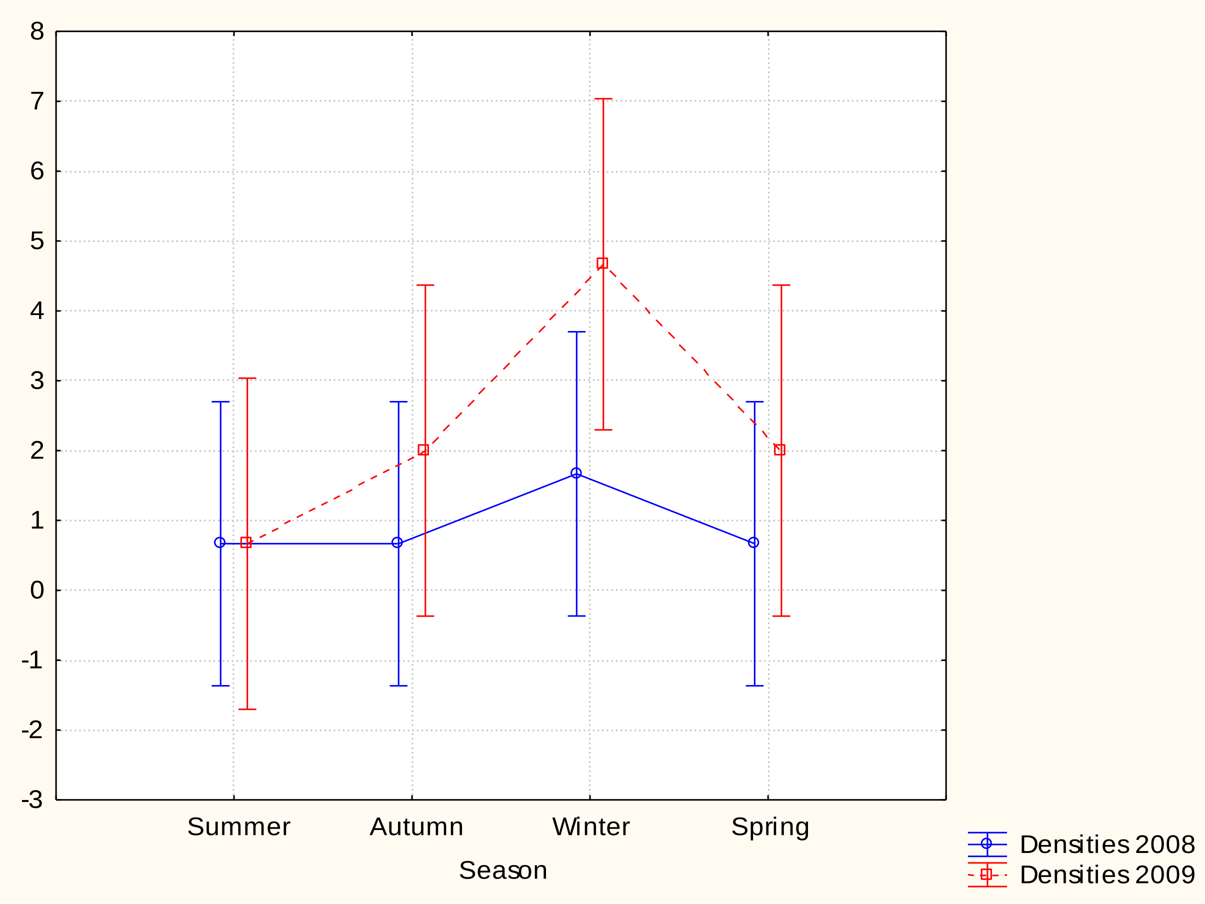

Figure 137. Graph depicting seasonal *E. myurus* population estimates in 2008 and 2009 recorded in the Rocky Highveld Grassland vegetation community.

The seasonal mean population estimate for *E. myurus* recorded in the Rocky Highveld Grassland community indicate that winter has the highest population estimates (10 animals per ha), followed by autumn and spring (4 animals per ha) and summer with the lowest recorded number (2 animals per ha) (Fig 138). ANOVA revealed an insignificant difference in mean population estimate between *E. myurus* and season ($F_{1.3}$ = 1.92; $n$ = 20; $P$ = 0.205) in the Rocky Highveld Grassland community.

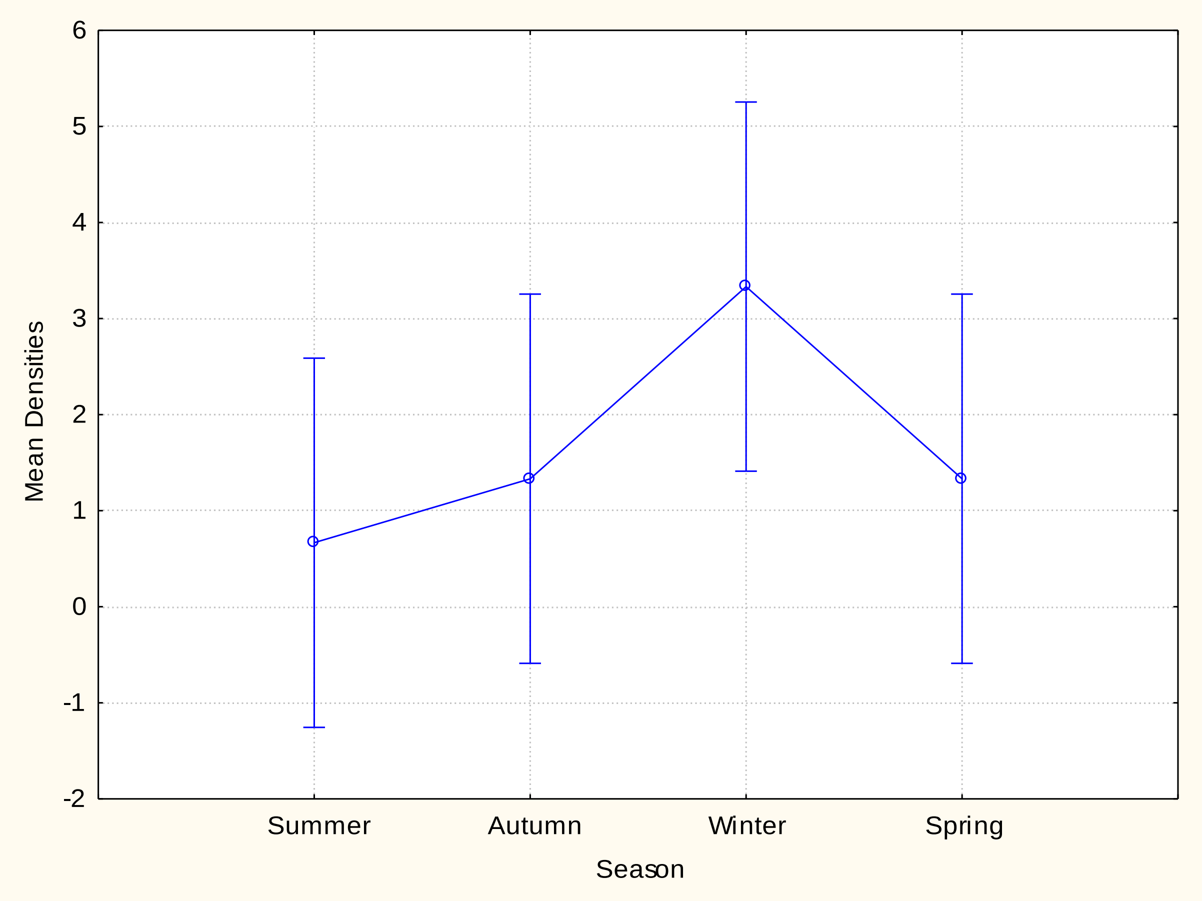

Figure 138. Graph depicting mean *E. myurus* population estimates recorded in Rocky Highveld Grassland during the study period.

The mean population estimate of *E. myurus* recorded for Rocky Highveld Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 5 small mammals per ha. The community covers 1944 ha of the property, therefore a population estimate of 9 720 *E. myurus* are estimated to occur in the Rocky Highveld Grassland community at the study site.

### 10.6. Population estimates recorded for non-volant small mammal assemblages in the Degraded Grassland vegetation community.

The Degraded Grassland community is a transformed plant community which occupies 45% of the study site and constitutes the largest portion covering an area of 2604 ha (Fig. 139).

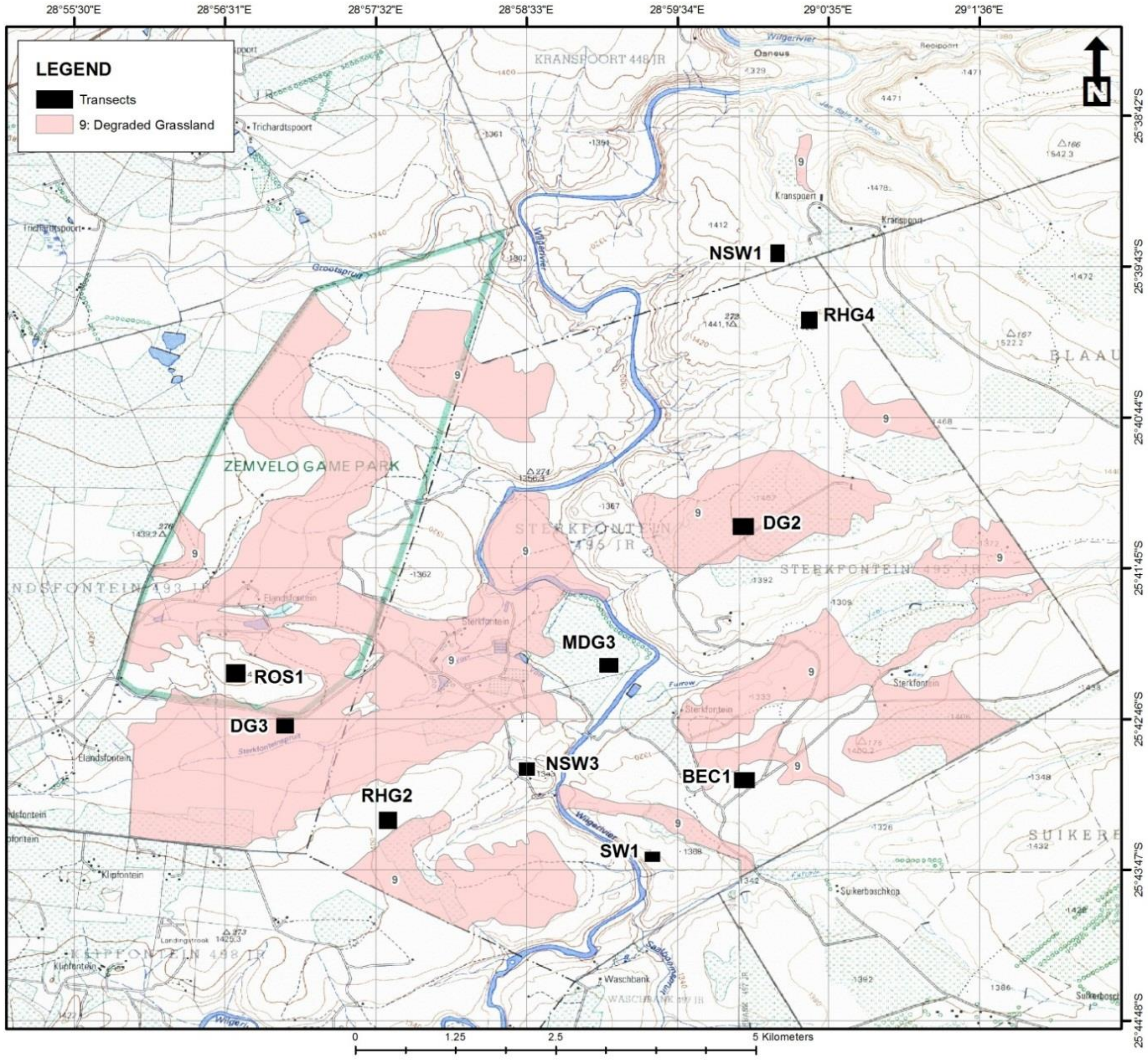

Figure 139. Map of Telperion and Ezemvelo Nature Reserve depicting the areas covered by Degraded Grassland habitat on the study site.

Statistically ANOVA revealed a significant difference between population estimate and season ($F_{1.3} = 4.880$; $n = 30$; $P = 0.019$) in transect Degraded Grassland 3 (DG 3). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P = 0.03$), summer and winter (Tukey's: $P = 0.02$. The population estimates recorded for transect DG 3 indicate a highest density per ha in summer (14 animals per ha), followed by spring (7 animals per ha), autumn (5 animals per ha) and the lowest number recorded in winter (4 animals per ha) (Fig. 140).

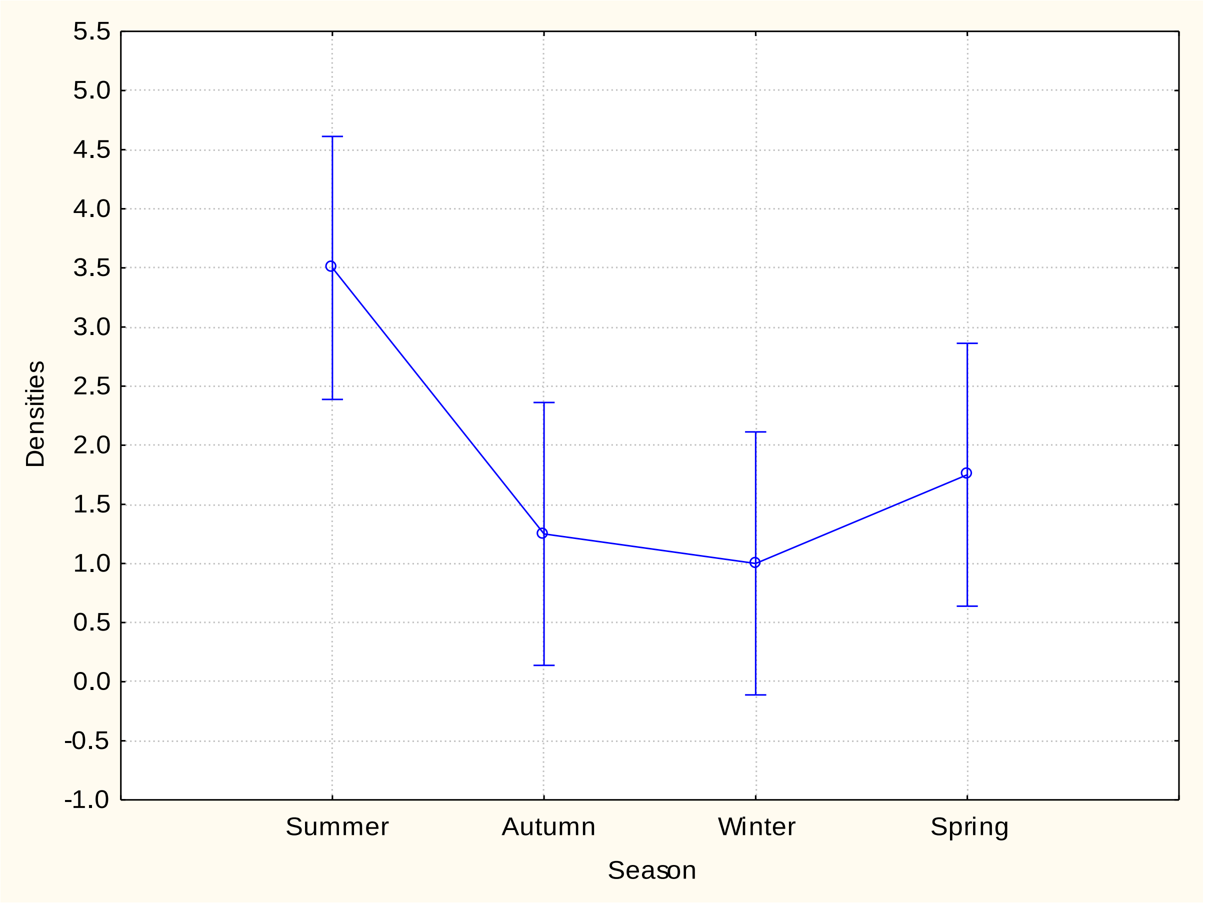

Figure 140. Graph depicting small mammal population estimates in 2008 recorded at Degraded Grassland 3.

The seasonally low population estimates appear similar, although results for summer months indicate higher numbers recorded. Statistically ANOVA revealed a significant difference between population estimate and season in transect Degraded Grassland 2 in year one ($F_{1.3}$ = 4.278; *n* = 57; *P* = 0.029). Statistically population estimates are significantly different in autumn and winter (Tukey’s: *P* = 0.02). The population estimates recorded for transect DG 2 in year one indicate the highest density per ha in winter (29 animals per ha), followed by summer (13 animals per ha), spring (11 animals per ha) and the lowest number in autumn (4 animals per ha) (Fig. 141a).

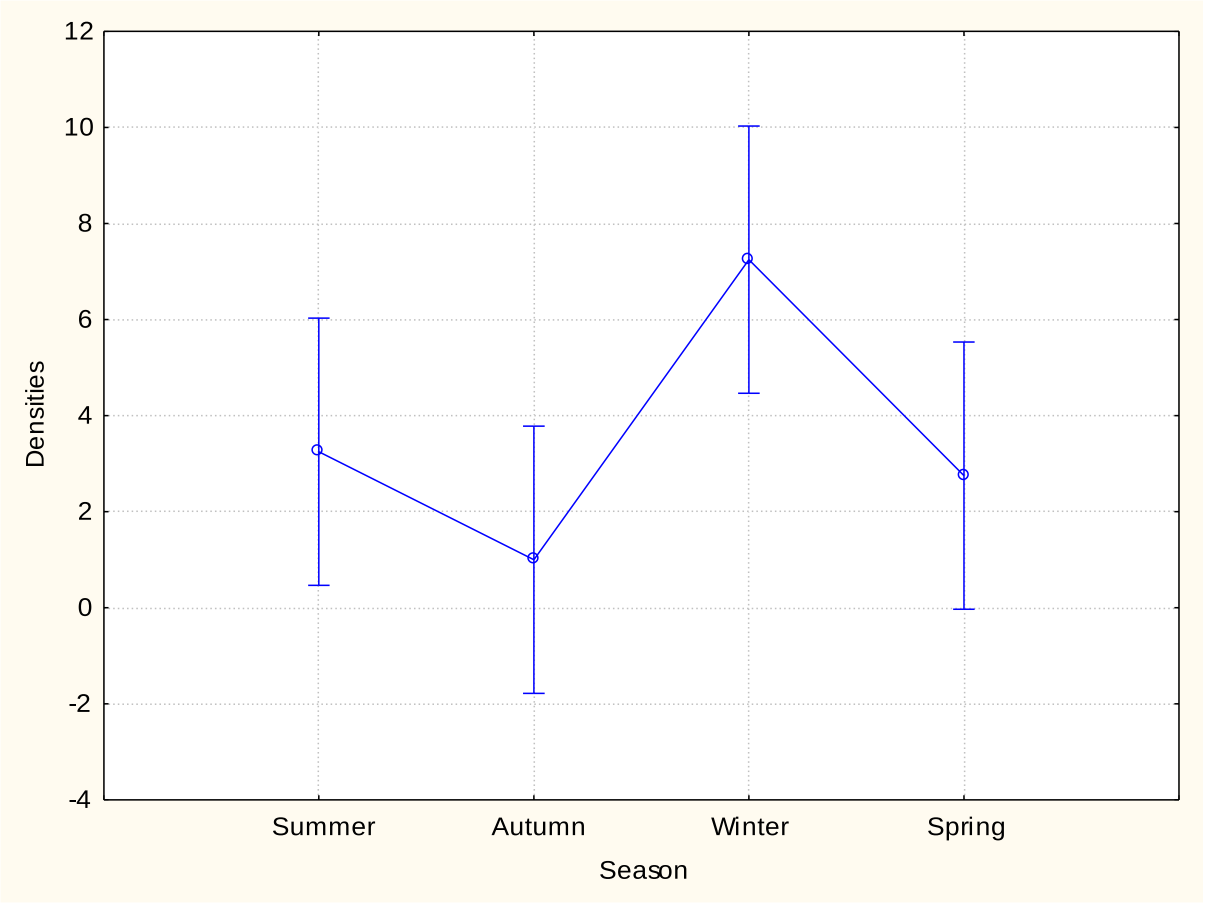

Figure 141a. Graph depicting small mammal population estimates in 2008 recorded at Degraded Grassland 2.

Statistically ANOVA revealed a highly significant difference between population estimate and season ($F_{1.3}$ = 18.667; *n* = 96; *P* = 0.000) in Degraded Grassland 2 in year two. Statistically population estimates are significantly different in summer and autumn (Tukey's: *P* = 0.00); autumn and winter (Tukey's: *P* = 0.00), and autumn and spring (Tukey's: *P* = 0.00). The population estimates recorded for transect DG 2 in year two indicate the highest density per ha also in autumn (58 animals per ha), followed by summer (22 animals per ha), summer (10 animals per ha), with spring having the lowest recorded densities (6 animals per ha) (Fig. 141b).

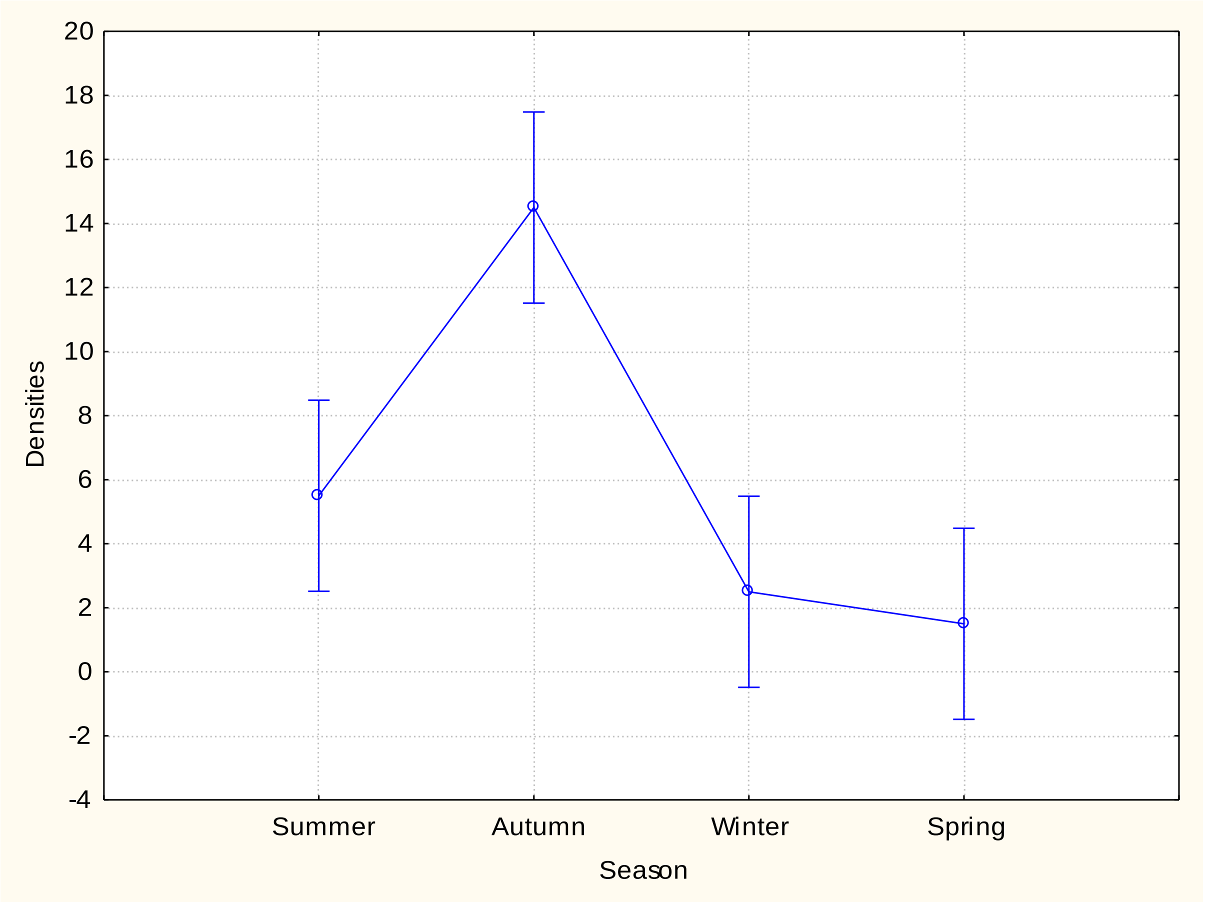

Figure 141b. Graph depicting small mammal population estimates in 2009 recorded at Degraded Grassland 2.

Statistically ANOVA revealed a significant difference between population estimate and season ($F_{1.3}$ = 5.379; $n$ = 72; $P$ = 0.014) in the Degraded Grassland community. Statistically population estimates are significantly different in autumn and spring (Tukey's: $P$ = 0.01). The seasonal mean population estimate for small mammals recorded in the Degraded Grassland community indicate that autumn has the highest densities (32 animals per ha), followed by summer (18 animals per ha), winter (14 animals per ha) and spring with the lowest recorded number (8 animals per ha) (Figure 142).

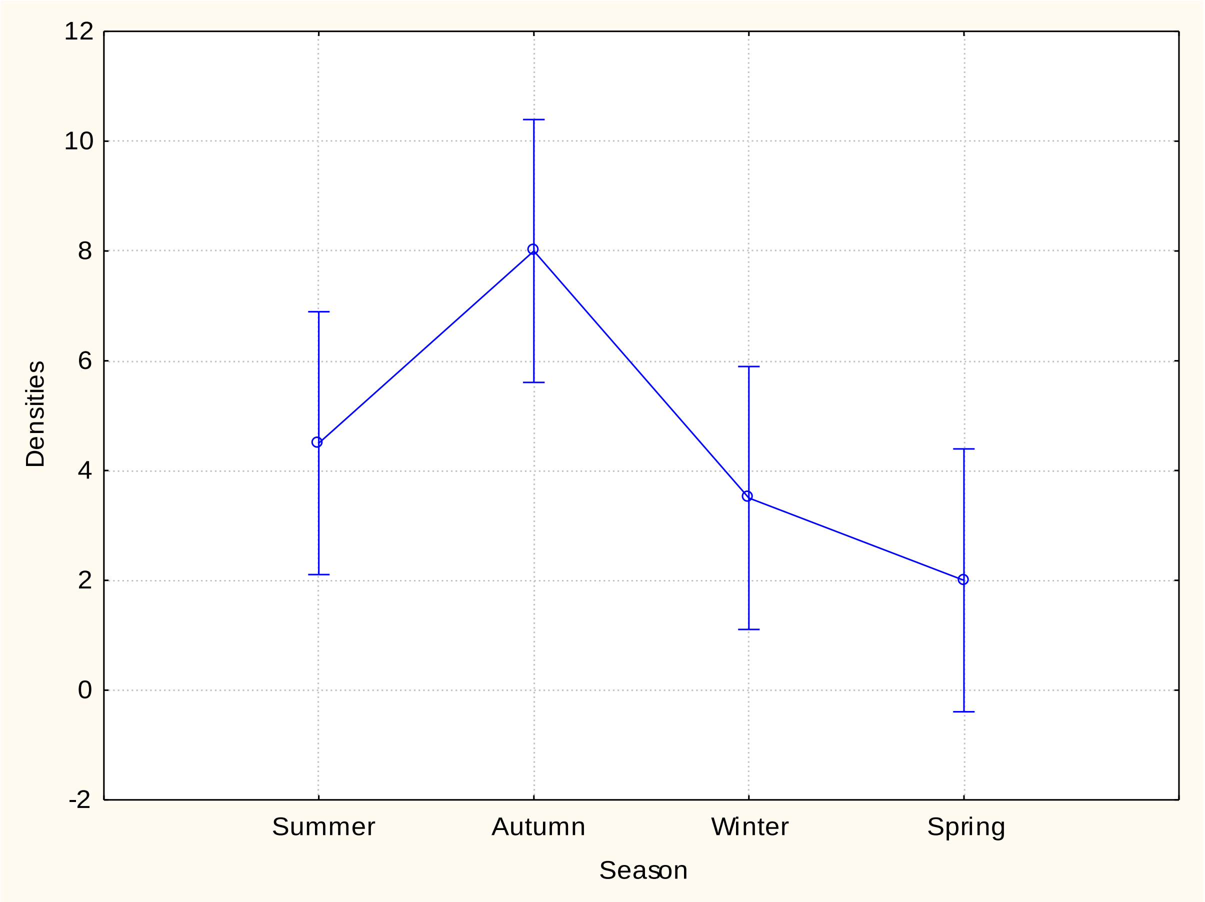

Figure 142. Graph depicting mean small mammal population estimates recorded in Degraded Grassland during the study period.

The mean population estimate of small mammals recorded for Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 72 small mammals per ha. The community is recorded to cover 2604 ha of the property, therefore a population estimate of 187 488 small mammals are estimated to occur in the Degraded Grassland community on the property. The population estimates were recorded for the following small mammal species seasonally in Degraded Grassland on the property during this study.

### 10.6.1. Seasonal population estimates recorded for *Gerbilliscus leucogaster* in Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates for *G. leucogaster* in Degraded Grassland in year 1 had equal densities recorded in autumn and winter (2 animals per ha), with no animals being recorded in summer and spring (Fig. 143). ANOVA revealed an insignificant difference in population estimate between *G. leucogaster* and season ($F_{1.3}$ = 1.067; $n$ = 4; $P$ = 0.416) for the Degraded Grassland community in year 1. Large fluctuation in densities in this species in year one did not appear to occur. No individuals were recorded in the community during year 2 of the study.

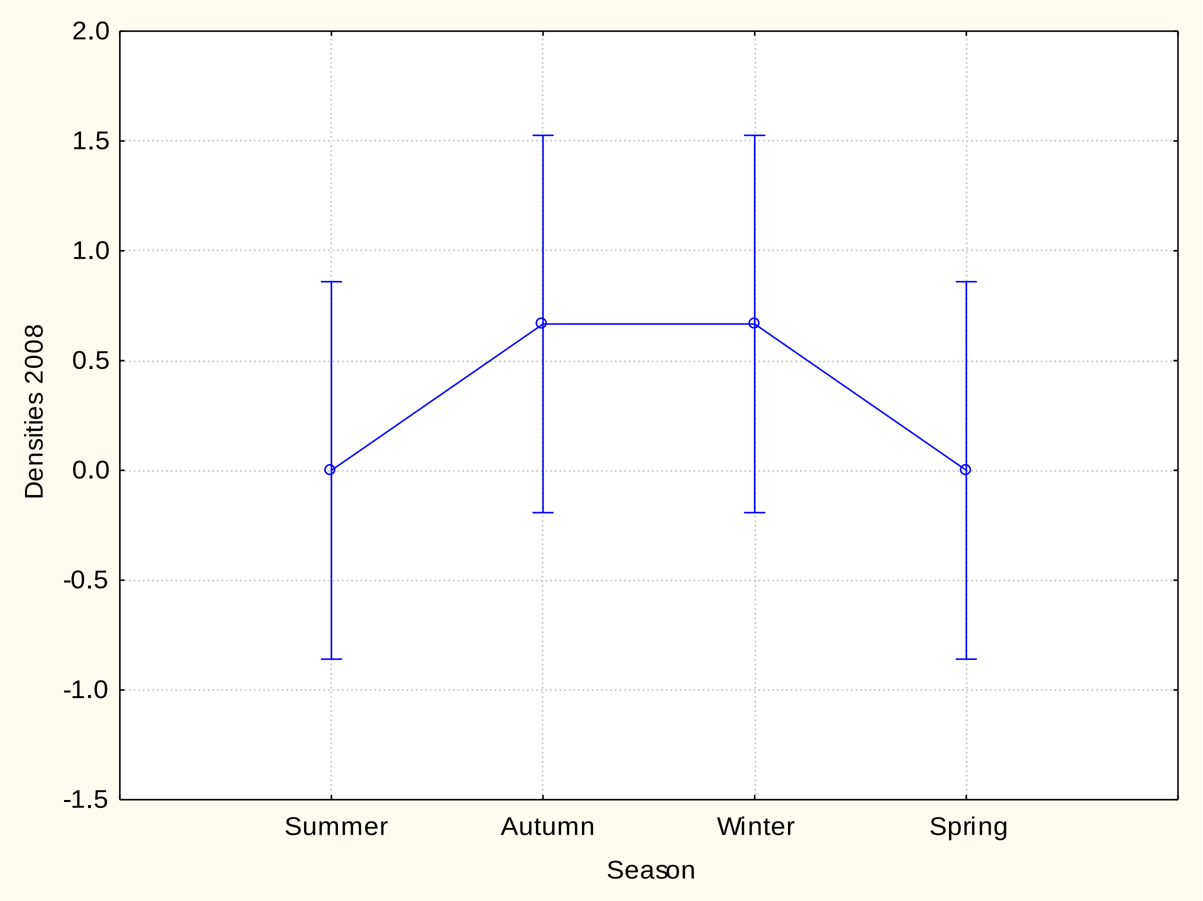

Figure 143. Graph depicting mean *Gerbilliscus leucogaster* population estimates recorded in Degraded Grassland during the study period.

The mean population estimate of *G. leucogaster* recorded for Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammals per ha. This community covers 2 604 ha of the property, therefore a population estimate of 2 604 *G. leucogaster* are estimated to occur in the Degraded Grassland community on the property.

### 10.6.2 Seasonal population estimates recorded for *Dendromus melanotis* in the Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *D. melanotis* in Degraded Grassland in year 1 indicate the highest density per ha in winter (12 animals per ha), followed by summer (4 animal per ha), with equal densities recorded in autumn and spring (3 animals per ha) (Fig. 144). ANOVA revealed an insignificant difference in population estimate between *D. melanotis* and season ($F_{1.3}$ = 1.900; $n$ = 22; $P$ = 0.208) for the Degraded Grassland community in year 1. The population estimates recorded in Degraded Grassland in year 2 also indicate the highest density per ha in autumn (51 animals per ha), followed by summer (14 animals per ha), winter (5 animals per ha), with no animals recorded in spring (Fig. 144). ANOVA revealed a significant difference between population estimate between *D. melanotis* and season ($F_{1.3}$ = 51.935; $n$ = 70; $P$ = 0.000) for the Degraded Grassland community. Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.00), autumn and winter (Tukey's: $P$ = 0.00), autumn and spring (Tukey's: $P$ = 0.00).

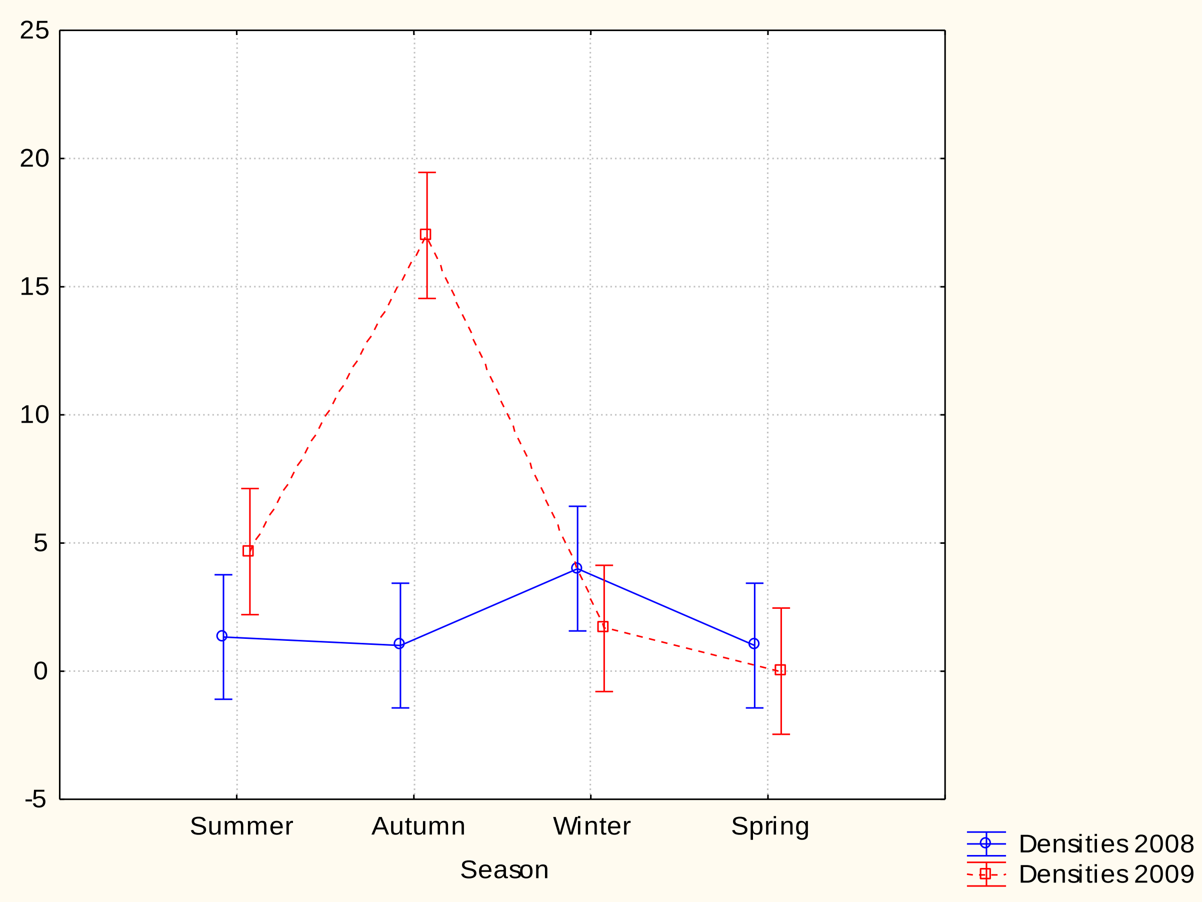

Figure 144. Graph depicting seasonal *Dendromus melanotis* population estimates in 2008 and 2009 recorded in the Degraded Grassland vegetation community.

The seasonal mean population estimate for *D. melanotis* recorded in the Degraded Grassland community indicate that autumn has the highest population estimates (27 animals per ha), followed by winter and summer (9 animals per ha), and spring with the lowest recorded number (2 animals per ha) (Fig 145). ANOVA revealed a significant difference between mean population estimate of *D. melanotis* and season ($F_{1.3}$ = 40.667; $n$ = 44; $P$ = 0.000) in the Degraded Grassland community. Statistically mean population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.00), summer and winter (Tukey's: $P$ = 0.01), summer and spring (Tukey's: $P$ = 0.00); autumn and winter (Tukey's: $P$ = 0.0), autumn and spring (Tukey's: $P$ = 0.00).

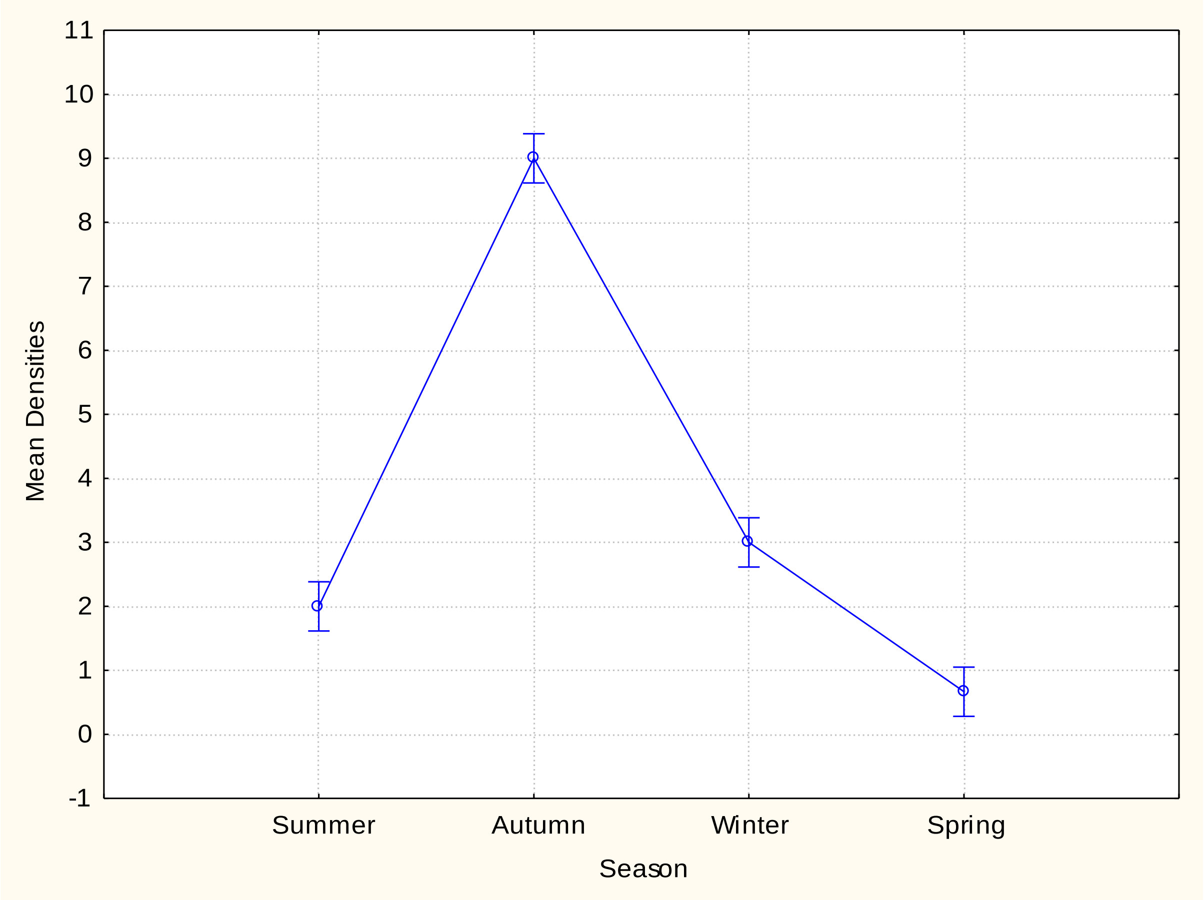

Figure 145. Graph depicting mean *Dendromus melanotis* population estimates recorded in Degraded Grassland during the study period.

The mean population estimate of *D. melanotis* recorded for Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 12 small mammals per ha. The community covers 2 604 ha of the property, therefore a population estimate of 31 248 *D. melanotis* are estimated to occur in the Degraded Grassland community on the property.

### 10.6.3. Seasonal population estimates recorded for *Lemniscomys rosalia* in the Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *L. rosalia* in Degraded Grassland in year 1indicate an equal density per ha in summer, winter and spring (2 animals per ha), with no animals recorded in autumn (Fig. 146). ANOVA revealed an insignificant difference in population estimate between *L. rosalia* and season ($F_{1.3}$ = 1.333; $n$ = 6; $P$ = 0.330) in the Degraded Grassland community in year 1. The population estimates recorded in Degraded Grassland in year 2 also indicate low density per ha, with the highest population estimate recorded in spring (8 animals per ha), followed by summer (6 animals per ha), with equal numbers recorded in autumn and winter (5 animals per ha) (Fig. 146). ANOVA revealed an insignificant difference in population estimate between *L. rosalia* and season ($F_{1.3}$ = 2.667; $n$ = 22; $P$ = 0.119) in the Degraded Grassland community in year 2.

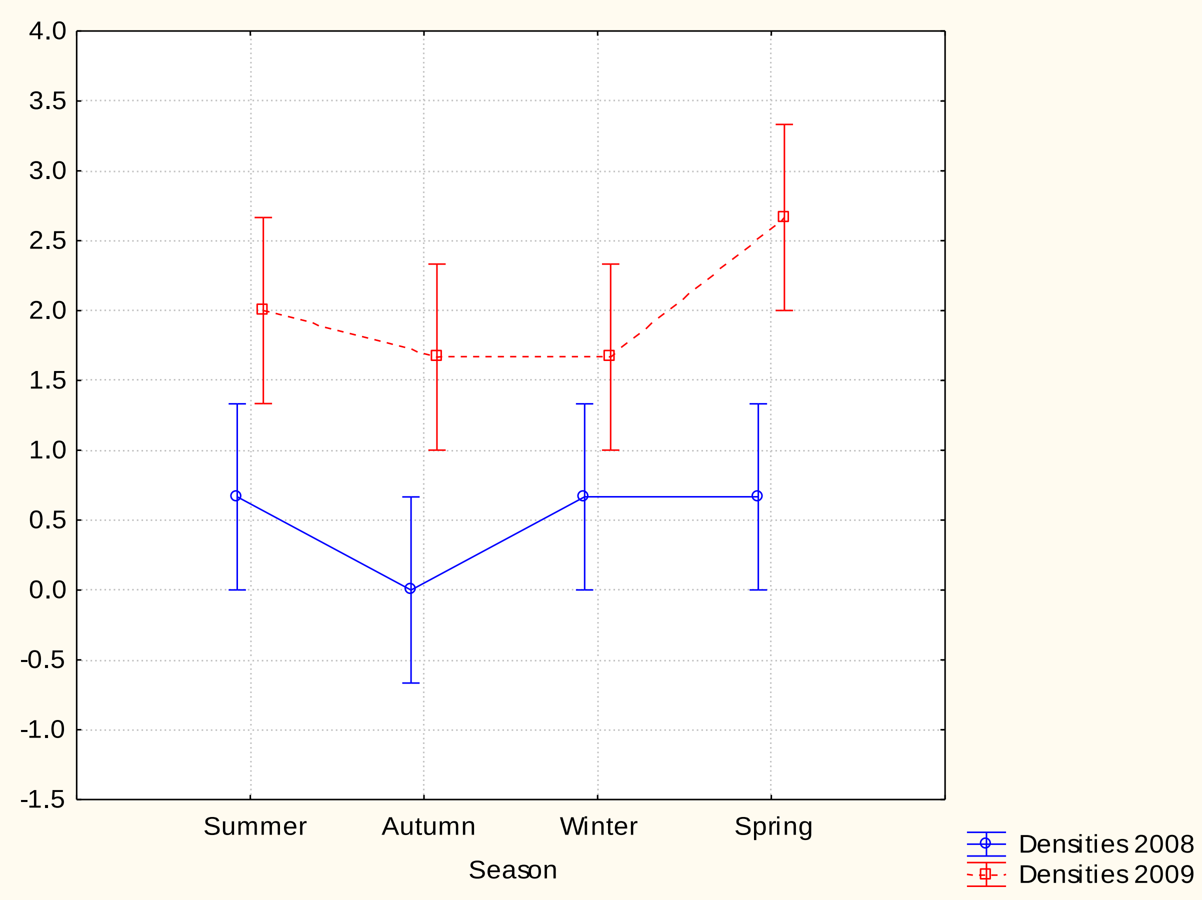

Figure 146. Graph depicting seasonal *Lemniscomys rosalia* population estimates in 2008 and 2009 recorded in the Degraded Grassland vegetation community.

The seasonal mean population estimate for *L. rosalia* recorded in the Degraded Grassland community indicate that spring has moderately the highest densities (5 animals per ha), with summer, autumn and winter having equal densities estimates (4 animals per ha) (Fig. 147). ANOVA revealed an insignificant difference in mean population estimate between *L. rosalia* and season ($F_{1.3}$ = 6.268; $n$ = 105; $P$ = 0.008) in the Degraded Grassland community.

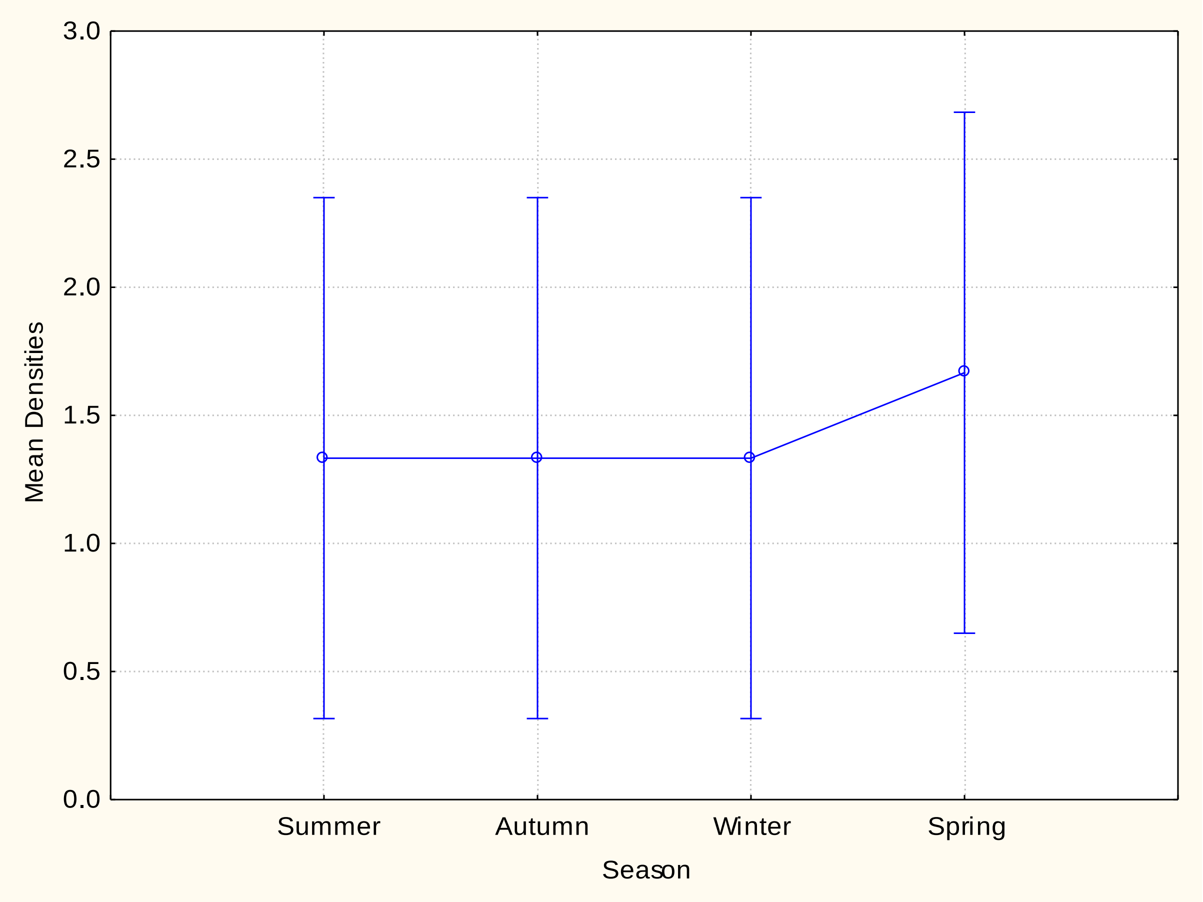

Figure 147. Graph depicting mean *L. rosalia* population estimates recorded in Degraded Grassland during the study period.

The mean population estimate of *L. rosalia* recorded for Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 4 small mammals per ha. The community covers 2 604 ha of the property, therefore a population estimate of 10 416 *L. rosalia* are estimated to occur in the Degraded Grassland community on the property.

### 10.6.4. Seasonal population estimates recorded for *Mus minutoides* in the Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *M. minutoides* in Degraded Grassland in year 1 indicate low densities in autumn (2 animals per ha), with no animals recorded in summer, winter or spring (Fig. 148). ANOVA revealed an insignificant difference in population estimate between *M. minutoides* and season ($F_{1,3} = 1.000$; $n = 2$; $P = 0.441$) in the Degraded Grassland community in year 1. The population estimates recorded in Degraded Grassland in year 2 also indicate low density per ha, with the highest population estimate recorded in summer (4 animals per ha), with equal numbers recorded in winter and spring (2 animals per ha), and no animals recorded in autumn (Fig. 148). ANOVA revealed an insignificant difference in population estimate between *M. minutoides* and season ($F_{1,3} = 1.778$; $n = 8$; $P = 0.008$) in the Degraded Grassland community in year 2.

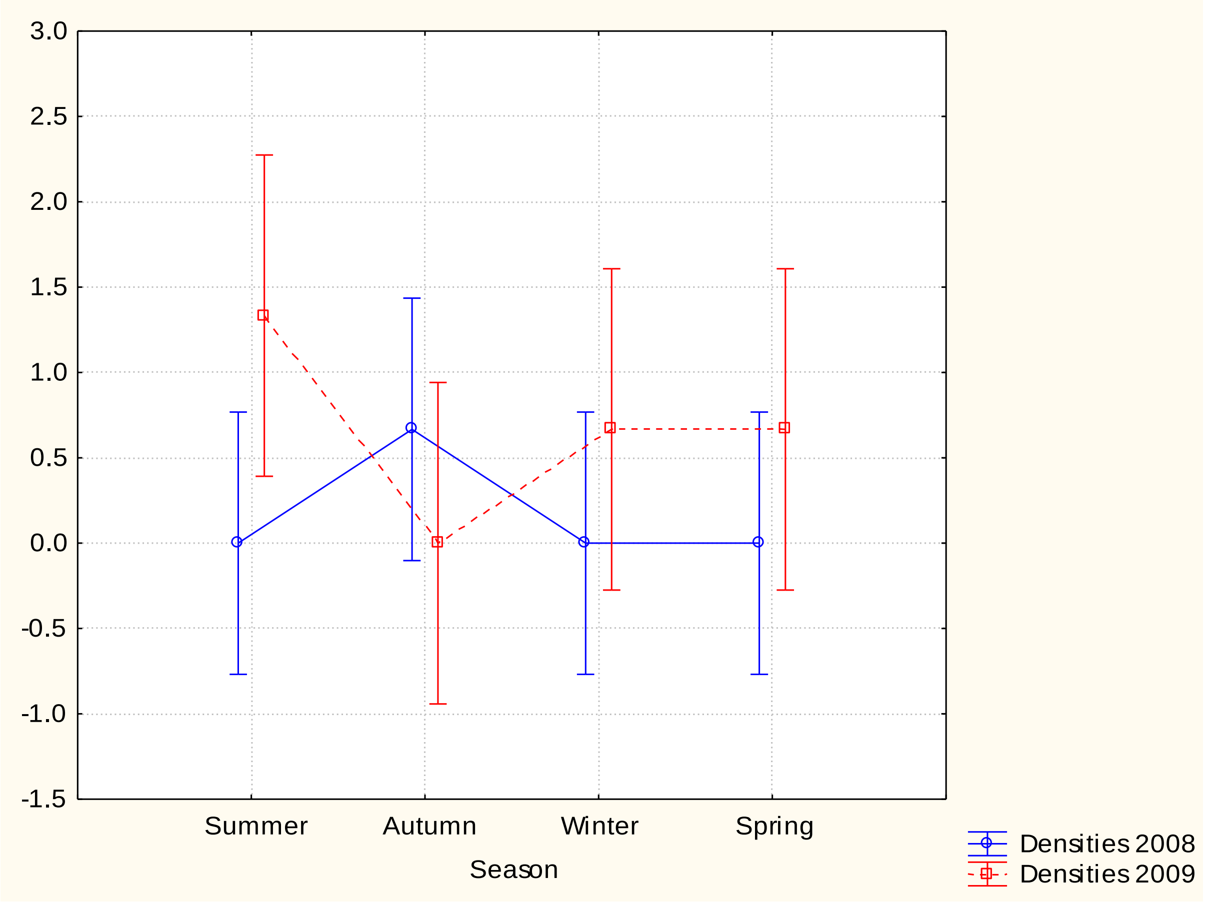

Figure 148. Graph depicting seasonal *Mus minutoides* population estimates in 2008 and 2009 recorded in the Degraded Grassland vegetation community.

The seasonal mean population estimate for *M. minutoides* recorded in the Degraded Grassland community indicate that summer has moderately the highest densities (3 animals per ha), with autumn, winter and spring having equal densities estimates (2 animals per ha)

(Fig 149). ANOVA revealed an insignificant difference in mean population estimate between *M. minutoides* and season ($F_{1.3}$ = 0.333; $n$ = 9; $P$ = 0.802) for the Degraded Grassland community.

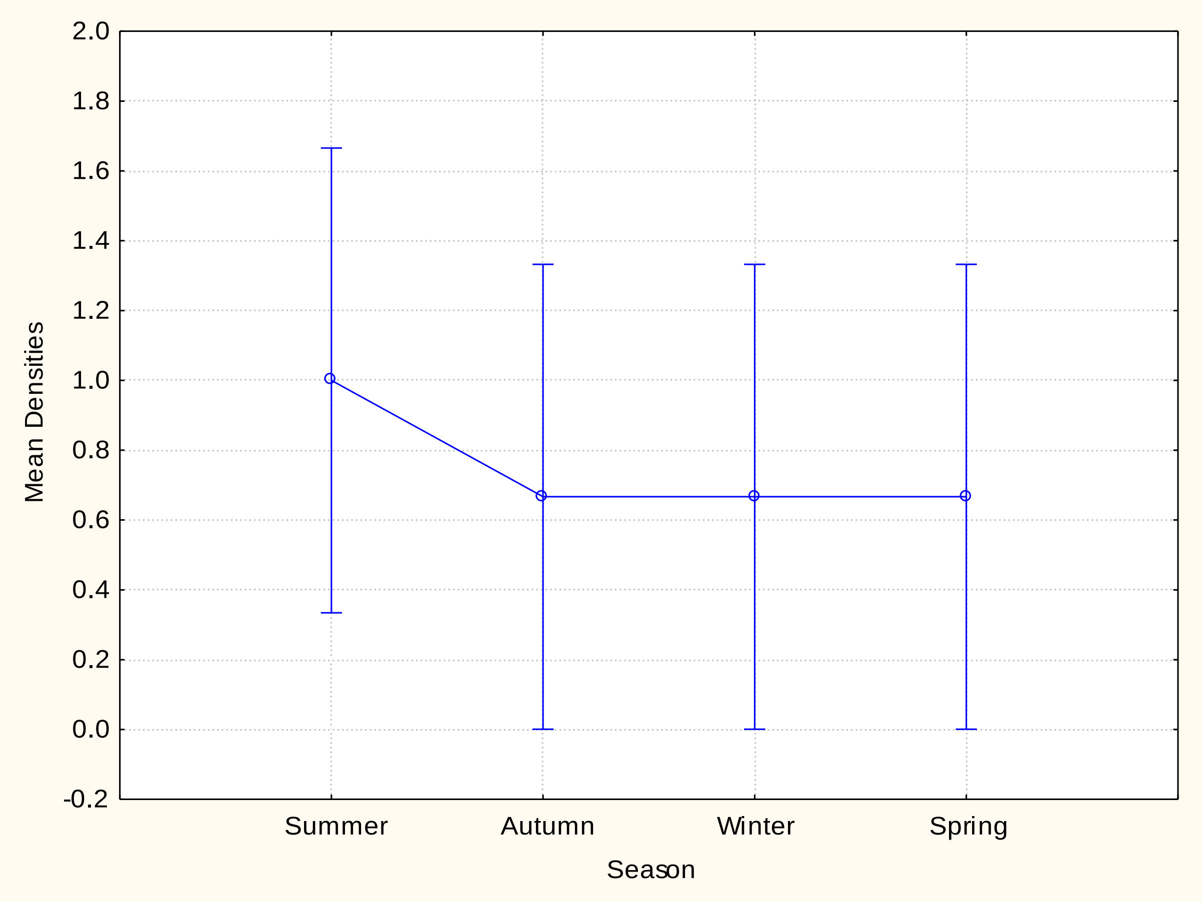

Figure 149. Graph depicting mean *Mus minutoides* population estimates recorded in Degraded Grassland during the study period.

The mean population estimate of *M. minutoides* recorded for Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 2 small mammals per ha. The community covers 2 604 ha of the property, therefore a population estimate of 5 208 *M. minutoides* are estimated to occur in the Degraded Grassland community on the property.

10.6.5. Seasonal population estimates recorded for *Mastomys* spp. in Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates for *Mastomys* spp. in Degraded Grassland in year 1 had equal densities recorded in summer and spring (2 animals per ha), with no animals being recorded in autumn and winter (Fig. 150). ANOVA revealed an insignificant difference in population estimate between *Mastomys* spp. and season ($F_{1.3} = 2.667$; $n = 4$; $P = 0.119$) for the Degraded Grassland community in year 1. Large fluctuation in densities in this species in year 1 did not appear to occur. No individuals were recorded in the community during year 2 of the study.

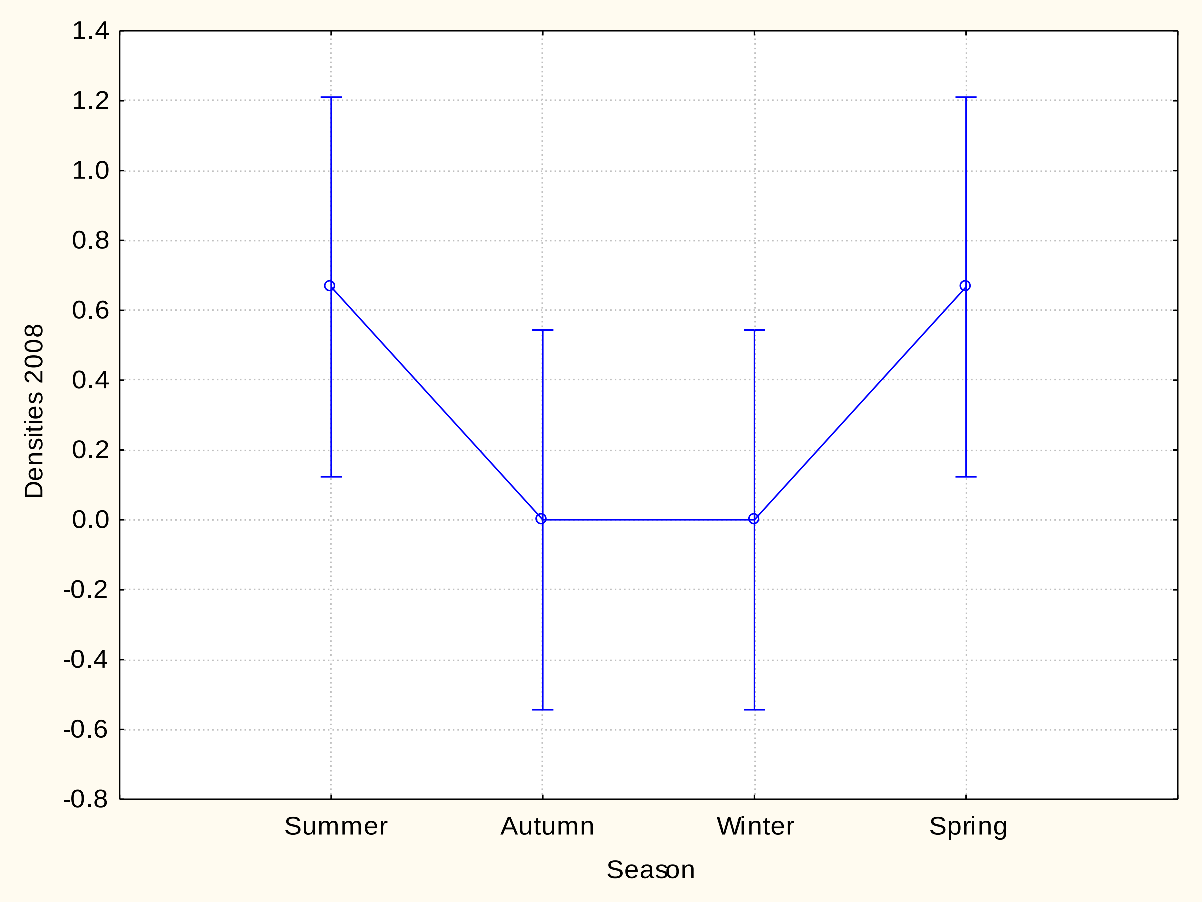

Figure 150. Graph depicting mean *Mastomys* spp. population estimates recorded in Degraded Grassland during the study period.

The mean population estimate of *Mastomys* spp. recorded for Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammals per ha. This community covers 2 604 ha of the property, therefore a population estimate of 2 604 *Mastomys* spp. are estimated to occur in the Degraded Grassland community on the property. There appear to be fluctuations in the population, and may be absent at certain time of the year.

### 10.6.6 Seasonal population estimates recorded for *Steatomys pratensis* in the Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *S. pratensis* in Degraded Grassland in year 1 indicate an equal density per ha recorded in summer, autumn and spring (2 animals per ha), with no animals recorded in winter (Fig. 151). ANOVA revealed an insignificant difference in population estimate between *S. pratensis* and season ($F_{1.3}$ = 1.333; $n$ = 6; $P$ = 0.330) in the Degraded Grassland community in year 1. The population estimates recorded in Degraded Grassland in year 2 also indicate low density per ha, with one individual recorded in summer (2 animals per ha), and no records in autumn, winter and spring. ANOVA revealed a weak, but significant difference between population estimate between *S. pratensis* and season ($F_{1.3}$ = 4.000; $n$ = 2; $P$ = 0.05) in the Degraded Grassland community.

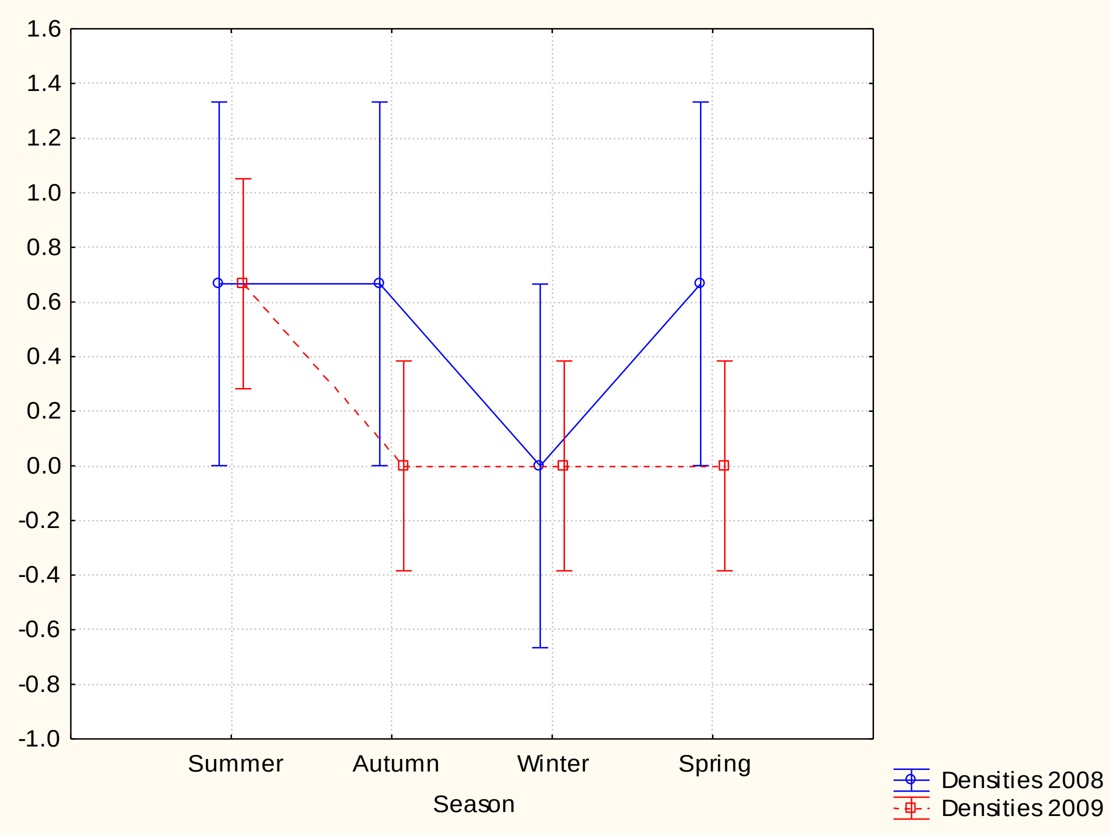

Figure 151. Graph depicting seasonal *Steatomys pratensis* population estimates in 2008 and 2009 recorded in the Degraded Grassland vegetation community.

The seasonal mean population estimate for *S. pratensis* recorded in the Degraded Grassland community indicate equal densities in summer, autumn and spring (2 animals per ha), with no animals recorded in winter (Fig 152). ANOVA revealed an insignificant difference in mean population estimate between *S. pratensis* and season ($F_{1.3}$ = 1.333; $n$ = 6; $P$ = 0.330) in the Degraded Grassland community.

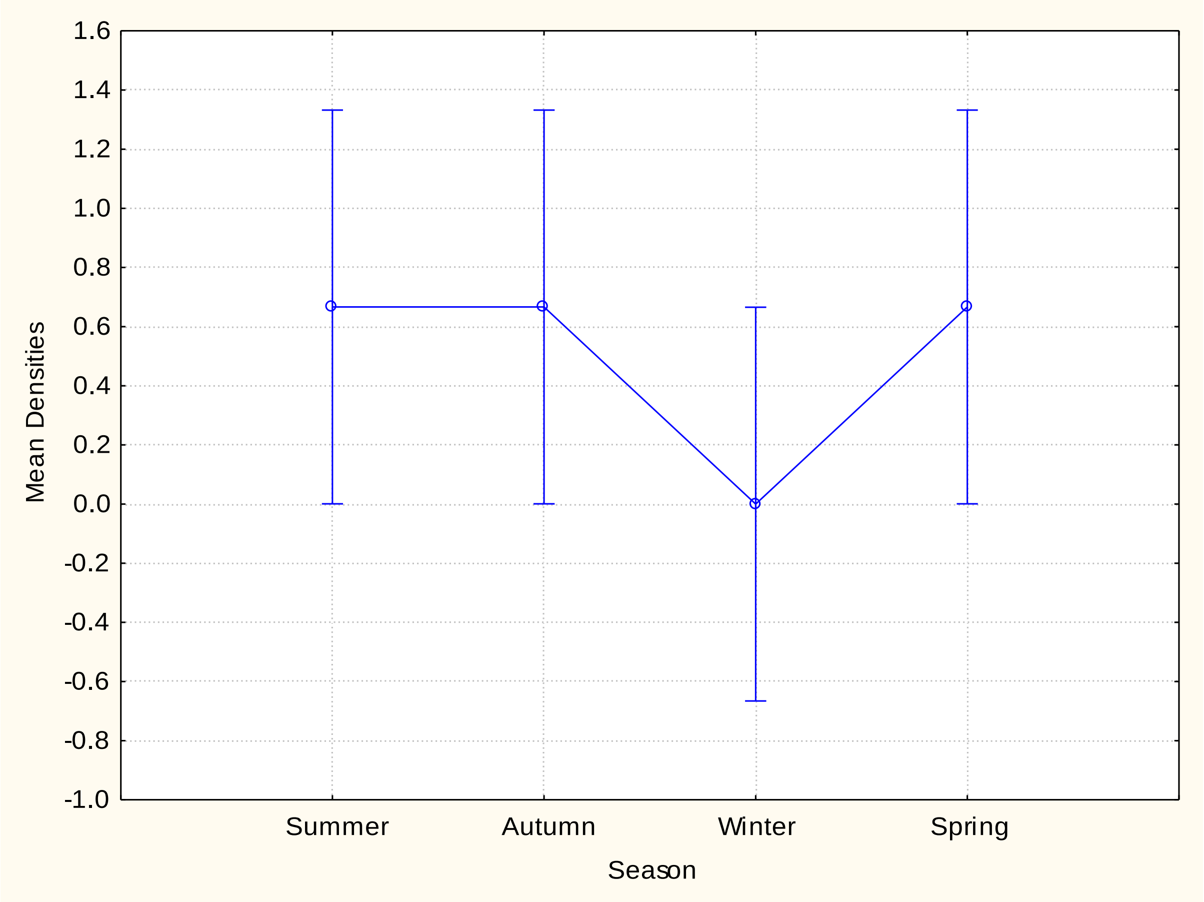

Figure 152. Graph depicting mean *Steatomys pratensis* population estimates recorded in Degraded Grassland during the study period.

The mean population estimate of *S. pratensis* recorded for Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 2 small mammals per ha. The community covers 2 604 ha of the property, therefore a population estimate of 5 208 *S. pratensis* are estimated to occur in the Degraded Grassland community on the property.

### 10.6.7. Seasonal population estimates recorded for *Suncus infinitesimus* in Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

One individual *S. infinitesimus* was recorded in Degraded Grassland in year 1 in summer (2 animals per ha), with no animals being recorded in autumn, winter and spring (Fig. 153). This species appear to occur in very low densities in this vegetation community. ANOVA revealed a weak, but significant difference between population estimate between *Suncus infinitesimus* and season ($F_{1.3} = 4.000$; $n = 2$; $P = 0.052$) for the Degraded Grassland community. No individuals were recorded in the community during year 2 of the study.

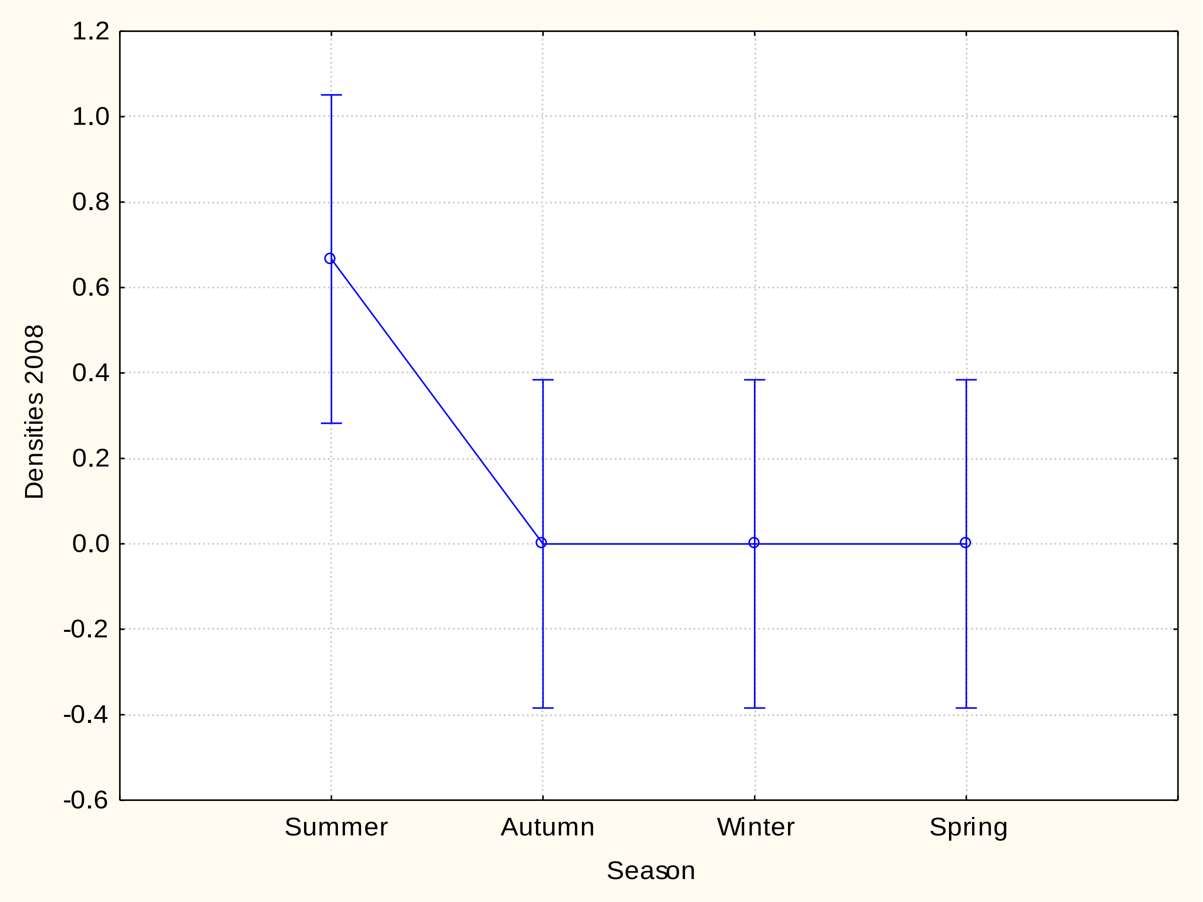

Figure 153. Graph depicting mean *Suncus infinitesimus* population estimates recorded in Degraded Grassland during the study period.

The mean population estimate of *S. infinitesimus* recorded for Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal for every 2 hectares. This community covers 2 604 ha of the property, therefore a population estimate of 1 302 *S. infinitesimus* are estimated to occur in the Degraded Grassland community on the property.

## 10.7. Population estimates recorded for non-volant small mammal assemblages in the Sheltered Woodland vegetation community.

The Sheltered Woodland community occupies a limited portion of 8% of the property and covers an area of 219 ha, consisting of extremely rocky areas adjacent to the Wilge River (Fig. 154).

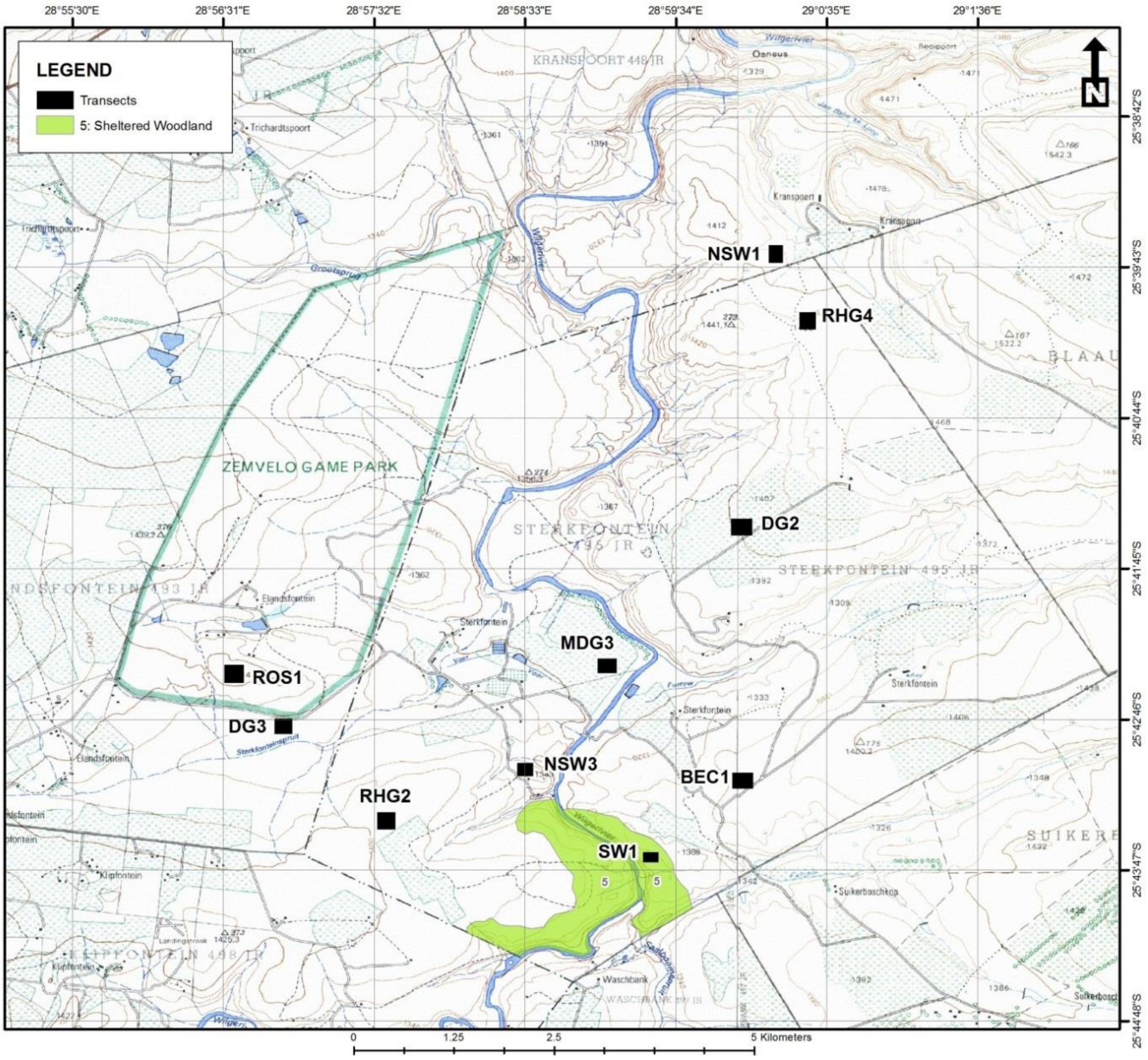

Figure 154. Map of Telperion and Ezemvelo Nature Reserve depicting the areas covered by Sheltered Woodland habitat at the study site.

ANOVA revealed a significant difference between population estimate and season in the Sheltered Woodland (SW 1) community in year 1 ($F_{1.3}$ = 22.444; *n* = 110; *P* = 0.0003). Statistically population estimates are significantly different in summer and winter (Tukey's: *P* = 0.01), summer and spring (Tukey's: *P* = 0.03); autumn and spring (Tukey's: *P* = 0.00); winter and spring (Tukey's: *P* = 0.00). The population estimates recorded for Sheltered Woodland in year one indicate the highest density per ha in winter (33 animals per ha), followed by autumn (31 animals per ha), summer (26 animals per ha) and the lowest number in spring (20 animals per ha) (Fig. 155a).

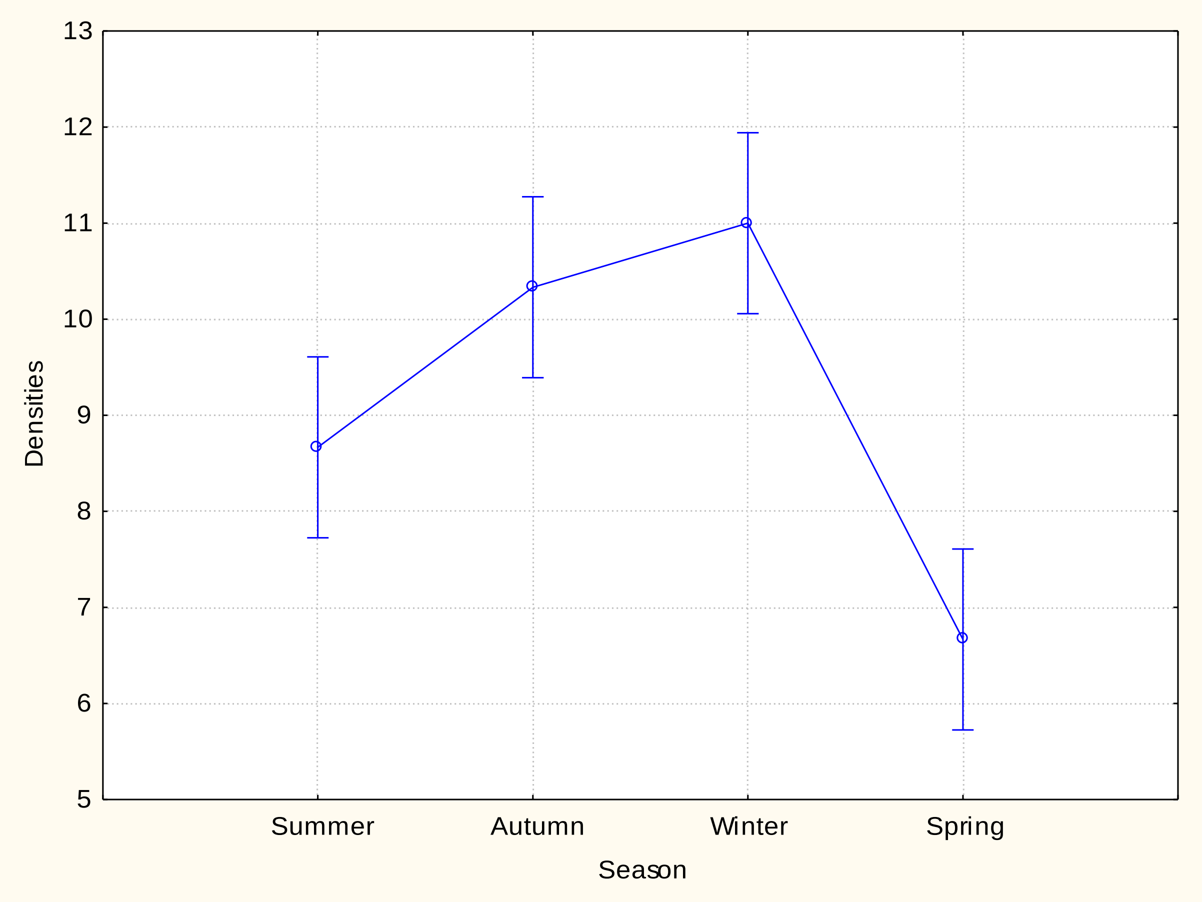

Figure 155a. Graph depicting small mammal population estimates in 2008 recorded in the Sheltered Woodland community.

ANOVA revealed a significant difference between population estimate and season in the Sheltered Woodland (SW 1) community in year 2 ($F_{1.3}$ = 42.800; *n* = 158; *P* = 0.000). Statistically population estimates are significantly different in summer and winter (Tukey's: *P* = 0.01), summer and spring (Tukey's: *P* = 0.00); autumn and winter (Tukey's: *P* = 0.00), autumn and spring (Tukey's: *P* = 0.00); winter and spring (Tukey's: *P* = 0.00). The population estimates recorded for Sheltered Woodland in year 2 indicate the highest density per ha in spring (53 animals per ha), followed by winter (42 animals per ha), summer (33 animals per ha) and autumn having the lowest number recorded (30 animals per ha) (Fig. 155b).

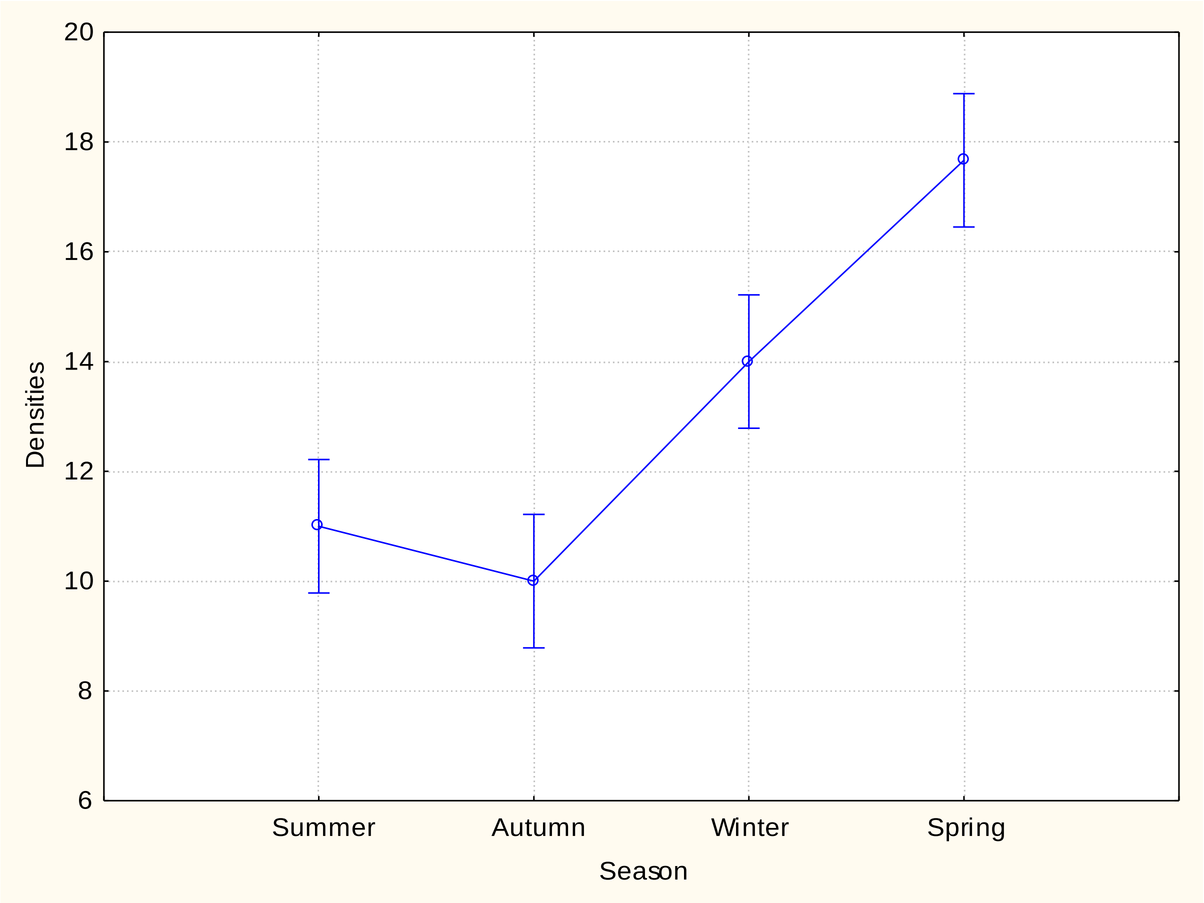

Figure 155b. Graph depicting small mammal population estimates in 2009 recorded in the Sheltered Woodland community.

ANOVA revealed a significant difference between population estimate and season in the Sheltered Woodland (SW 1) community ($F_{1.3}$ = 11.111; $n$ = 136; $P$ = 0.003). Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.01), summer and spring (Tukey's: $P$ = 0.01); autumn and winter (Tukey's: $P$ = 0.01), and autumn and spring (Tukey's: $P$ = 0.03). The seasonal mean population estimate for small mammals recorded in the Sheltered Woodland community indicate that winter has marginally the highest densities (38 animals per ha), followed by spring (37 animals per ha), autumn (31 animals per ha) and summer with the lowest recorded number (30 animals per ha) (Fig. 156).

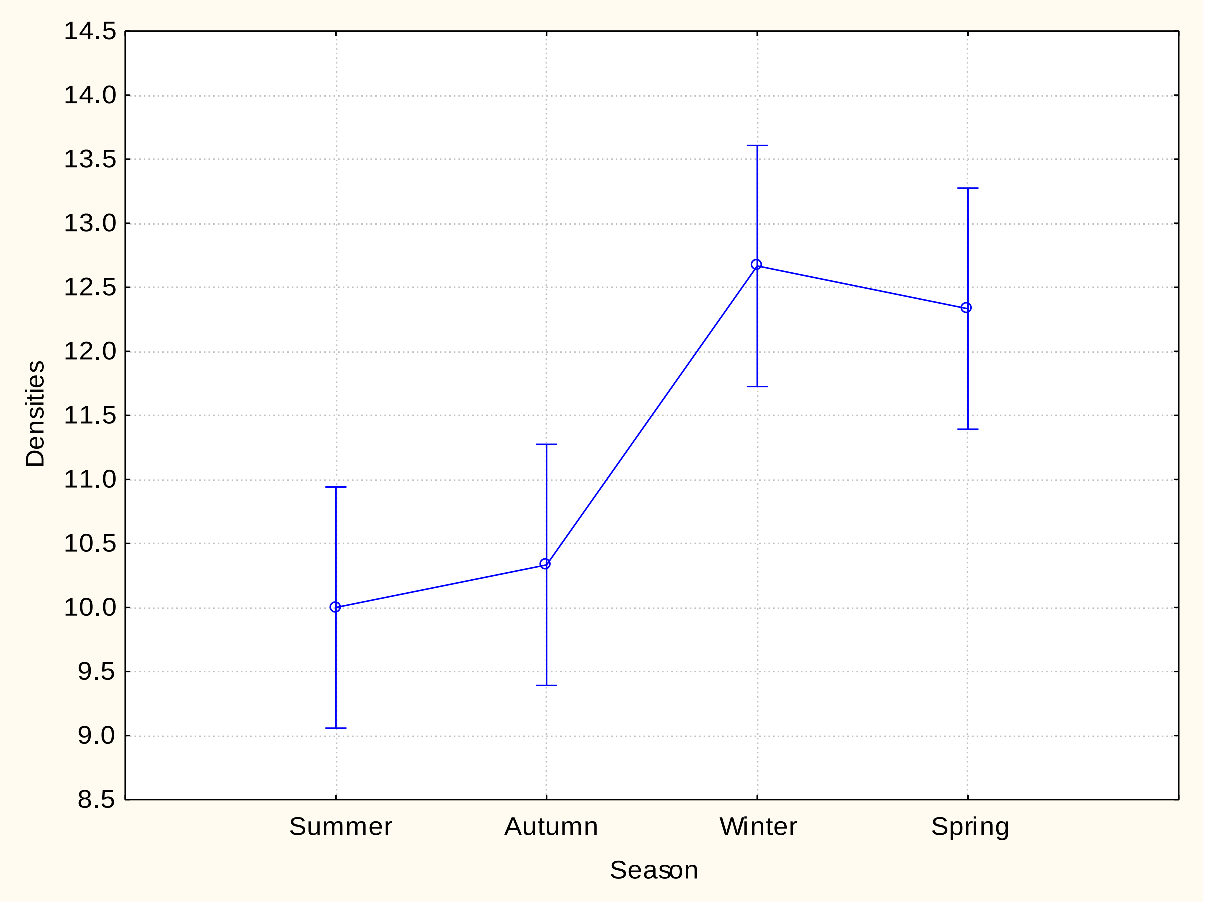

Figure 156. Graph depicting mean small mammal population estimates recorded in the Sheltered Woodland community during the study period.

The mean population estimate of small mammals recorded for Sheltered Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 34 small mammals per ha. The community is recorded to cover 219 ha of the property, therefore a population estimate of 7 446 small mammals are estimated to occur in the Sheltered Woodland community on the property. The population estimates were recorded for the following small mammal species seasonally in Sheltered Woodland during the study.

### 10.7.1. Seasonal population estimates recorded for *Micaelamys namaquensis* in the Sheltered Woodland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *M. namaquensis* in Sheltered Woodland in year 1 indicate the highest density per ha in summer and autumn (26 animals per ha), followed by winter (18 animals per ha) and the lowest number in spring (13 animals per ha) (Fig. 157).

ANOVA revealed a significant difference between population estimate and season in the Sheltered Woodland (SW 1) community in year 1 ($F_{1.3}$ = 27.278; $n$ = 83; $P$ = 0.000). Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.00), summer and spring (Tukey's: $P$ = 0.00); autumn and winter (Tukey's: $P$ = 0.00); autumn and spring (Tukey's: $P$ = 0.00). The population estimates recorded in Sheltered Woodland in year 2 indicate the highest density per ha in spring (48 animals per ha), followed by winter (24 animals per ha), autumn (22 animals per ha) and summer having the lowest number recorded (19 animals per ha) (Fig. 157). Statistically ANOVA revealed a significant difference between population estimate and season in the Sheltered Woodland (SW 1) community in year 2 ($F_{1.3}$ = 27.278; $n$ = 83; $P$ = 0.000). Statistically population estimates are significantly different in summer and spring (Tukey's: $P$ = 0.00); autumn and spring (Tukey's: $P$ = 0.00); and winter and spring (Tukey's: $P$ = 0.00).

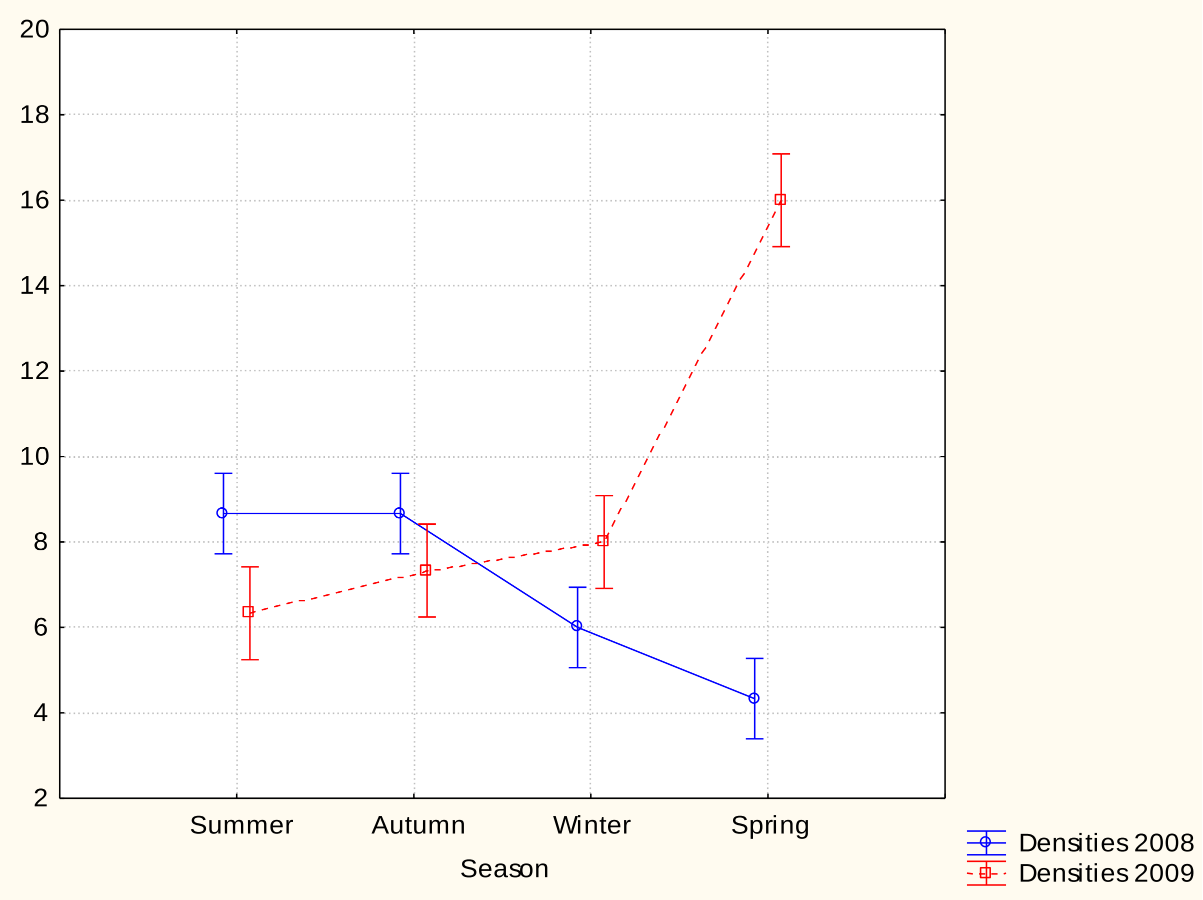

Figure 157. Graph depicting seasonal *Micaelamys namaquensis* population estimates in 2008 and 2009 recorded in the Sheltered Woodland vegetation community.

The seasonal mean population estimate for *M. namaquensis* recorded in the Sheltered Woodland community indicate that spring has the highest population estimates (31 animals per ha), followed by autumn (24 animals per ha), summer (23 animals per ha) and winter with the lowest recorded number (21 animals per ha) (Figure 158). Statistically ANOVA revealed a significant difference between mean population estimate and season in the Sheltered Woodland (SW 1) community ($F_{1.3}$ = 9.944; $n$ = 101; $P$ = 0.004). Statistically population estimates are significantly different in summer and spring (Tukey's: $P$ = 0.00); autumn and spring (Tukey's: $P$ = 0.01); and winter and spring (Tukey's: $P$ = 0.00).

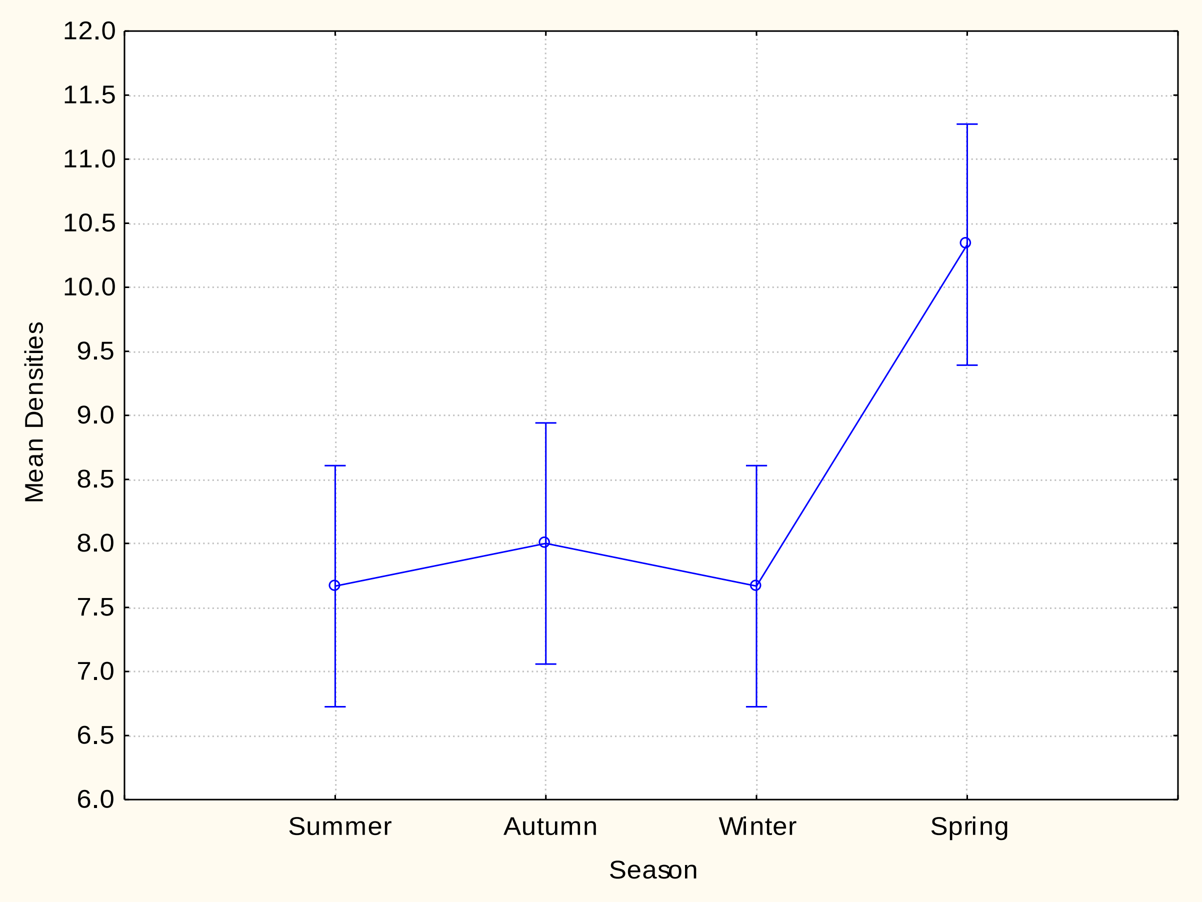

Figure 158. Graph depicting mean *Micaelamys namaquensis* population estimates recorded in Sheltered Woodland during the study period.

The mean population estimate of *M. namaquensis* recorded for Sheltered Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 25 small mammals per ha. The community is recorded to cover 219 ha of the property, therefore a population estimate of 5 475 *M. namaquensis* are estimated to occur in the Sheltered Woodland community at the study site.

### 10.7.2. Seasonal population estimates recorded for *Dendromus melanotis* in the Sheltered Woodland community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded in the Sheltered Woodland community during year 1 of the study. The population estimates for *D. melanotis* in Sheltered Woodland in year 2 harboured equal densities recorded in autumn and winter (2 animals per ha), with no animals being recorded in summer and spring (Fig. 159). ANOVA revealed an insignificant difference in population estimate between *D. melanotis* and season ($F_{1.3} = 2.667$; $n = 4$; $P = 0.119$) in the Sheltered Woodland community in year 2.

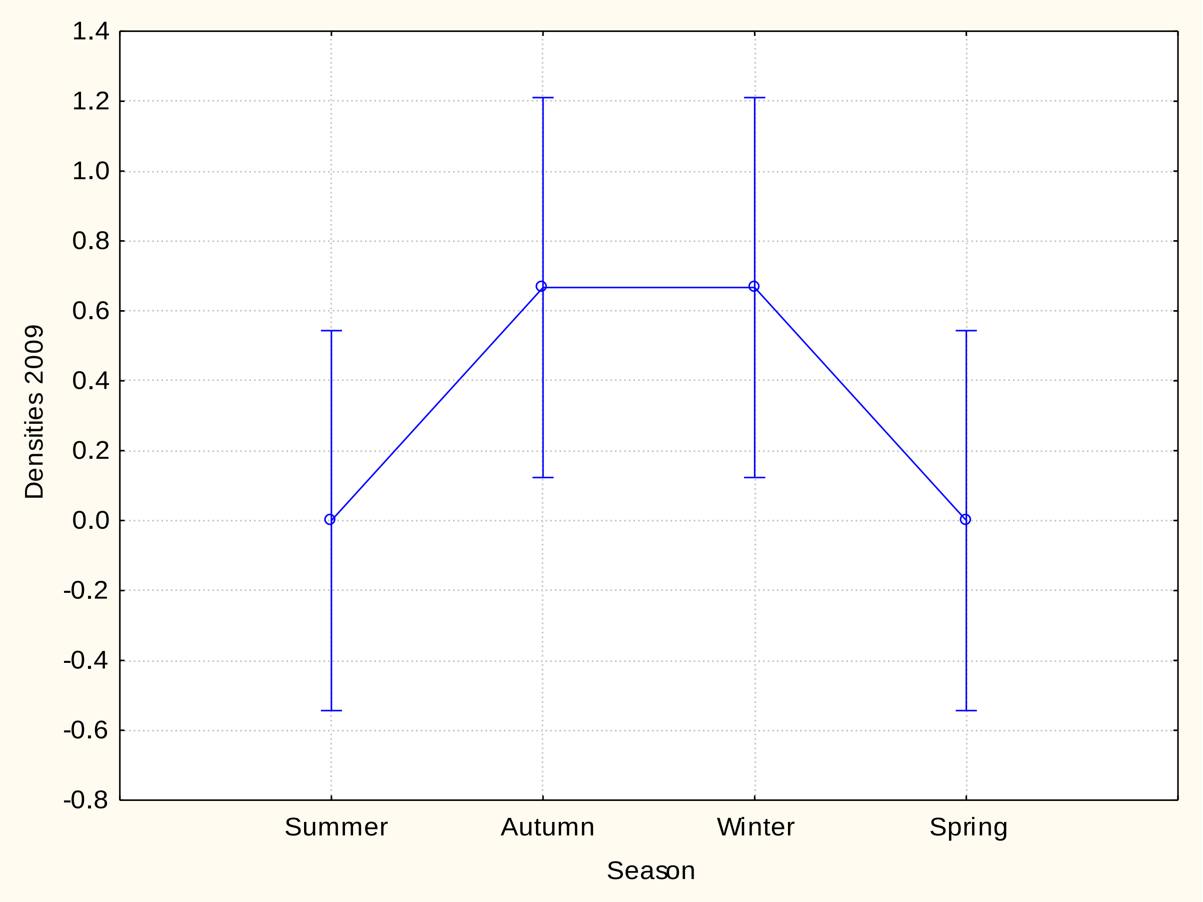

Figure 159. Graph depicting mean *Dendromus melanotis* population estimates recorded in Sheltered Woodland during the study period.

The mean population estimate of *D. melanotis* recorded in the Sheltered Woodland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammals per ha. This community covers 219 ha of the property, therefore a population estimate of 219 *D. melanotis* are estimated to occur in the Sheltered Woodland community on the property.

### 10.7.3. Seasonal population estimates recorded for *Acomys spinosissimus* in the Sheltered Woodland community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded in the Sheltered Woodland community during year 1 of the study. The population estimates for *A. spinossimus* in Sheltered Woodland in year 2 harboured equal densities recorded in summer and spring (2 animals per ha), with no animals being recorded in autumn and winter (Fig. 160). ANOVA revealed an insignificant difference in population estimate between *A. spinossimus* and season ($F_{1.3} = 2.667$; $n = 4$; $P = 0.119$) in the Sheltered Woodland community in year 2.

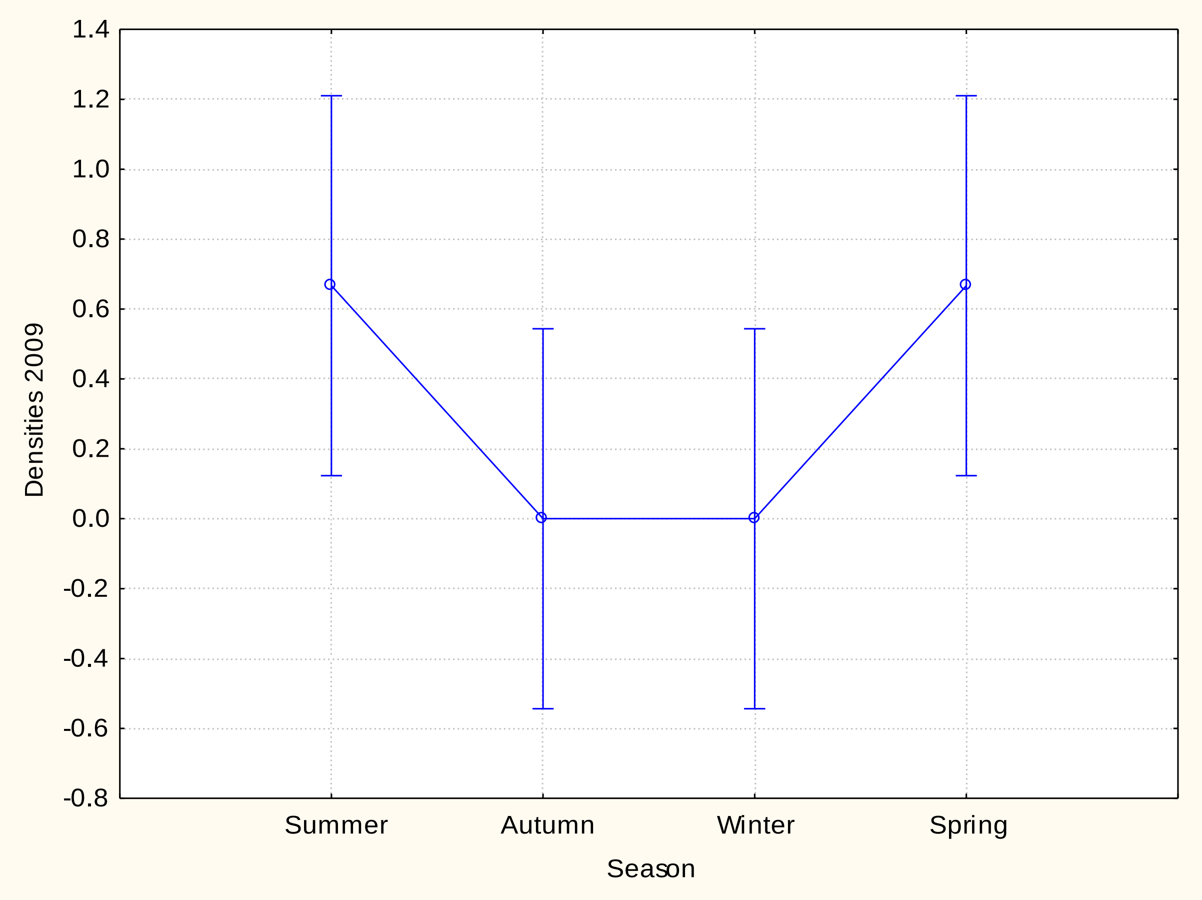

Figure 160. Graph depicting mean *Acomys spinosissimus* population estimates recorded in Sheltered Woodland during the study period.

The mean population estimate of *A. spinossimus* recorded in the Sheltered Woodland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal per ha. This community covers 219 ha of the property, therefore a population estimate of 219 *A. spinossimus* are estimated to occur in the Sheltered Woodland community at the study site.

### 10.7.4. Seasonal population estimates recorded for *Mus minutoides* in the Sheltered Woodland community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded in the Sheltered Woodland community during year 1 of the study. The population estimates for *M. minutoides* in Sheltered Woodland in year 2 harboured highest densities in summer (4 animals per ha), followed by autumn (2 animals per ha), with no animals being recorded in winter and spring (Fig. 161). Statistically ANOVA revealed a significant difference between population estimates of *M. minutoides* and season in the Sheltered Woodland (SW 1) community in year 2 ($F_{1.3}$ = 7.333; $n$ = 6; $P$ = 0.011). Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.01), summer and spring (Tukey's: $P$ = 0.01).

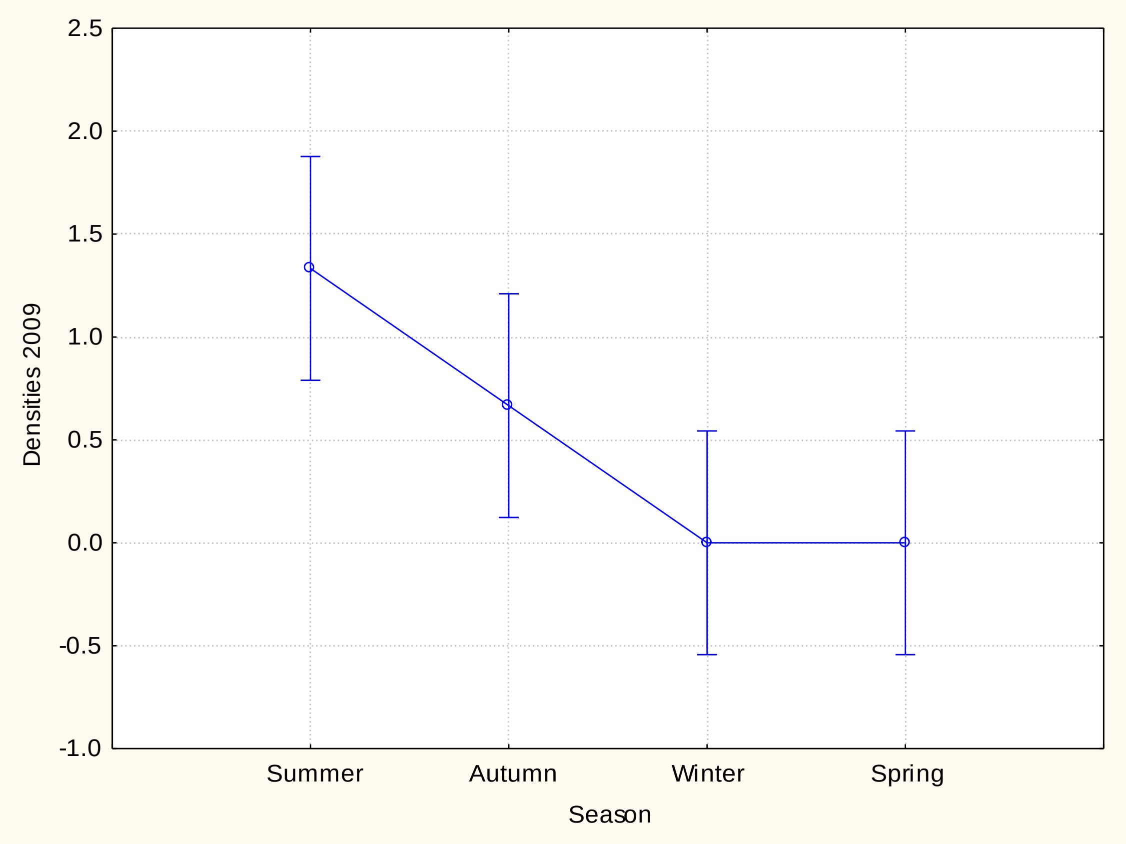

Figure 161. Graph depicting mean *Mus minutoides* population estimates recorded in Sheltered Woodland during the study period.

The mean population estimate of *M. minutoides* recorded in the Sheltered Woodland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 2 small mammals per ha. This community covers 219 ha of the property, therefore a population estimate of 438 *M. minutoides* are estimated to occur in the Sheltered Woodland community on the property.

### 10.7.5. Seasonal population estimates recorded for *Elephantulus myurus* in the Sheltered Woodland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *E. myurus* in Sheltered Woodland in year 1 indicate the highest density per ha in winter (11 animals per ha), followed by spring (7 animals per ha), autumn (5 animals per ha) and no animals recorded in summer (Fig. 162). Statistically ANOVA revealed a significant difference between population estimates of *E. myurus* and season in the Sheltered Woodland (SW 1) community in year 1 ($F_{1.3} = 27.889$; $n = 23$; $P = 0.000$). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P = 0.01$), summer and winter (Tukey's: $P = 0.00$), summer and spring (Tukey's: $P = 0.00$); autumn and winter (Tukey's: $P = 0.00$); and winter and spring (Tukey's: $P = 0.04$).

The population estimates recorded in Sheltered Woodland in year 2 indicate the highest density per ha in winter (13 animals per ha), with equal numbers being recorded in autumn and spring (3 animals per ha), and summer with the lowest number recorded (2 animals per ha) (Fig. 162). Statistically ANOVA revealed a significant difference between population estimates of *E. myurus* and season in the Sheltered Woodland (SW 1) community in year 2 ($F_{1.3} = 53.833$; $n = 21$; $P = 0.000$). Statistically population estimates are significantly different in summer and winter (Tukey's: $P = 0.00$); autumn and winter (Tukey's: $P = 0.00$); and winter and spring (Tukey's: $P = 0.00$).

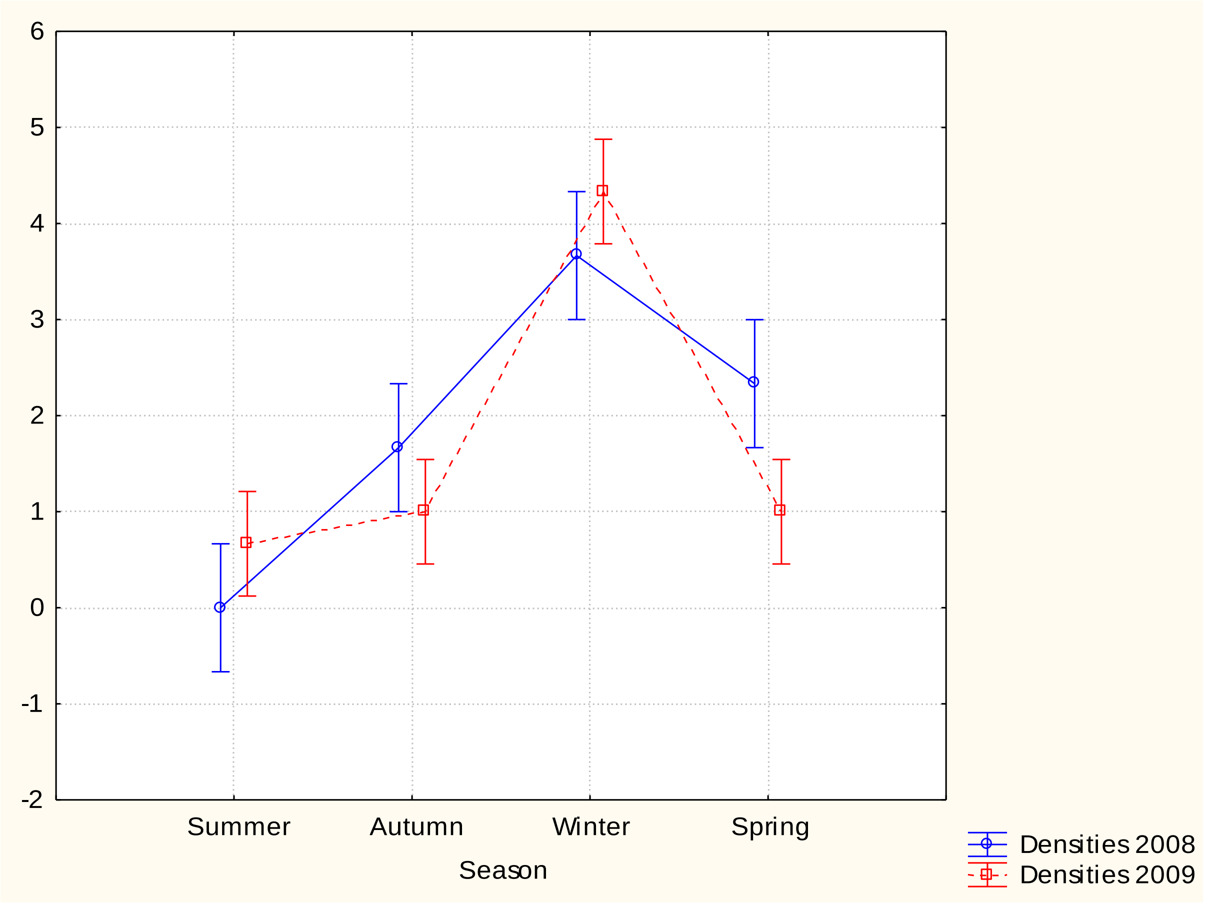

Figure 162. Graph depicting seasonal *Elephantulus myurus* population estimates in 2008 and 2009 recorded in the Sheltered Woodland vegetation community.

The seasonal mean population estimate for *E. myurus* recorded in the Sheltered Woodland community indicate that winter has the highest population estimates (12 animals per ha), followed by spring (5 animals per ha), autumn (4 animals per ha) and summer with the lowest recorded number (2 animals per ha) (Fig. 163). Statistically ANOVA revealed a significant difference between mean population estimate and season in the Sheltered Woodland (SW 1) community ($F_{1.3}$ = 12.611; *n* = 23; *P* = 0.002). Statistically population estimates are significantly different in summer and winter (Tukey's: *P* = 0.00): autumn and winter (Tukey's: *P* = 0.00); winter and spring (Tukey's: *P* = 0.01).

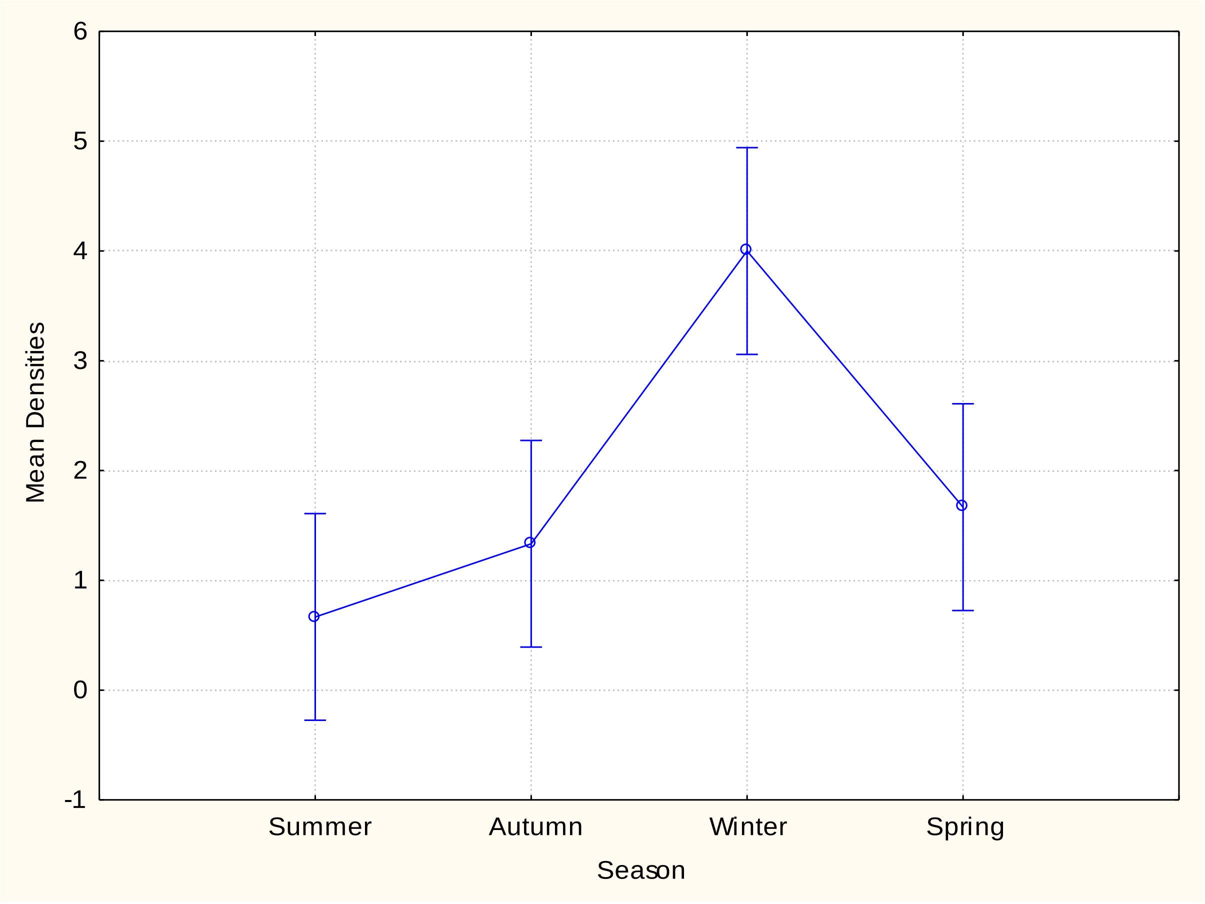

Figure 164. Graph depicting mean *Elephantulus myurus* population estimates recorded in Sheltered Woodland during the study period.

The mean population estimate of *E. myurus* recorded for Sheltered Woodland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 6 small mammals per ha. The community is recorded to cover 219 ha of the property, therefore a population estimate of 1 314 *E. myurus* are estimated to occur in the Sheltered Woodland community on the property.

### 10.7.6. Seasonal population estimates recorded for *Crocidura cyanea* in the Sheltered Woodland community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded in the Sheltered Woodland community during year 1 of the study. The population estimates for *C. cyanea* in Sheltered Woodland in year 2 harboured highest densities in summer (2 animals per ha), with no animals being recorded in autumn, winter and spring (Fig. 164). ANOVA revealed an insignificant difference in population estimate between *C. cyanea* and season ($F_{1,3}$ = 1.000; $n$ = 2; $P$ = 0.441) in the Sheltered Woodland community in year 2.

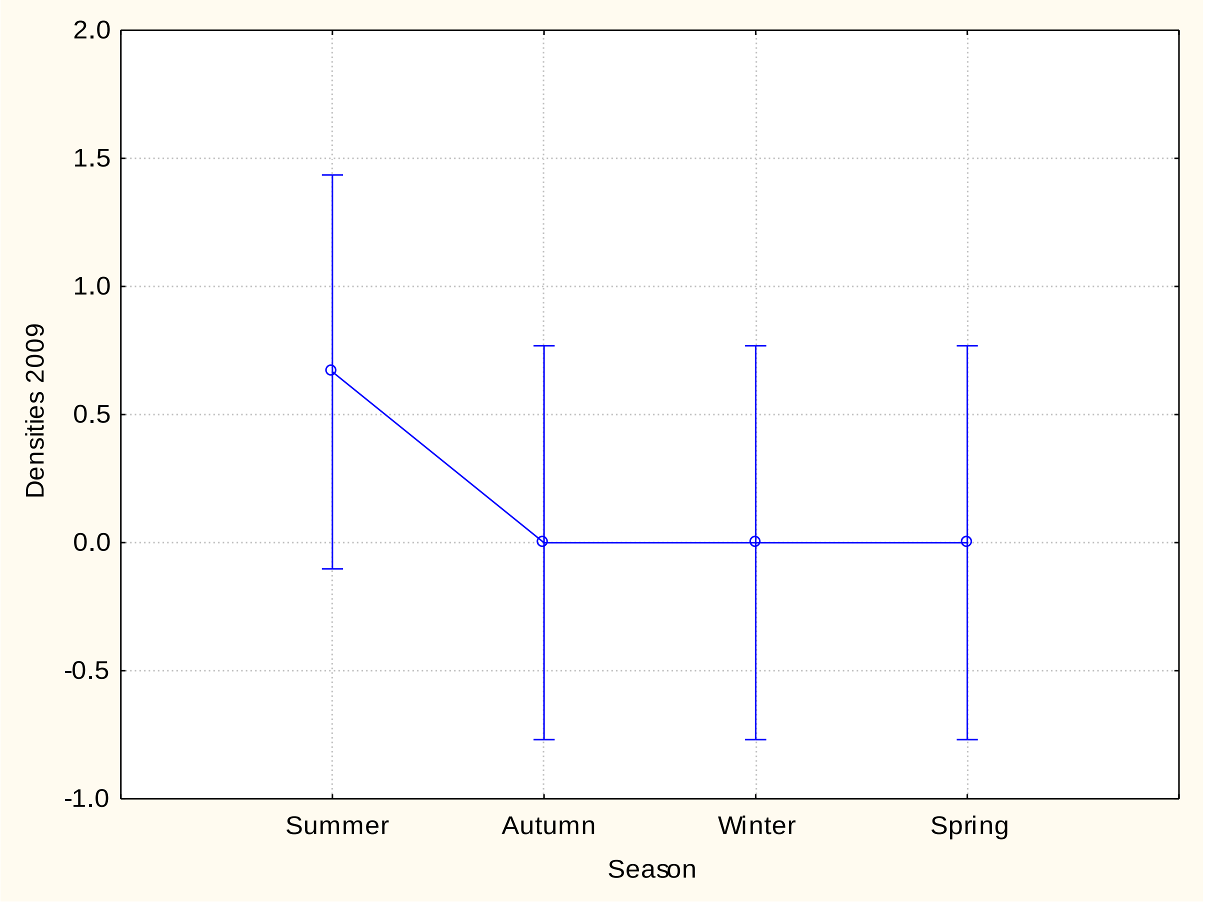

Figure 164. Graph depicting mean *Crocidura cyanea* population estimates recorded in Sheltered Woodland during the study period.

The mean population estimate of *C. cyanea* recorded in the Sheltered Woodland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal for every two hectares. This community covers 219 ha of the property, therefore a population estimate of 110 *C. cyanea* are estimated to occur in the Sheltered Woodland community on the property.

### 10.7.7. Seasonal population estimates recorded for *Crocidura mariquensis* in the Sheltered Woodland community on Telperion and Ezemvelo Nature Reserve

The population estimates for *C. mariquensis* in Sheltered Woodland in year 1 harboured highest densities in winter (2 animals per *C. mariquensis* ha), with no animals being recorded in summer, autumn and spring (Fig. 165). No individuals were recorded in the Sheltered Woodland community during year 2 of the study. ANOVA revealed an insignificant difference in population estimate between *C. mariquensis* and season ($F_{1.3}$ = 1.000; $n = 2$; $P = 0.441$) in the Sheltered Woodland community in year 1.

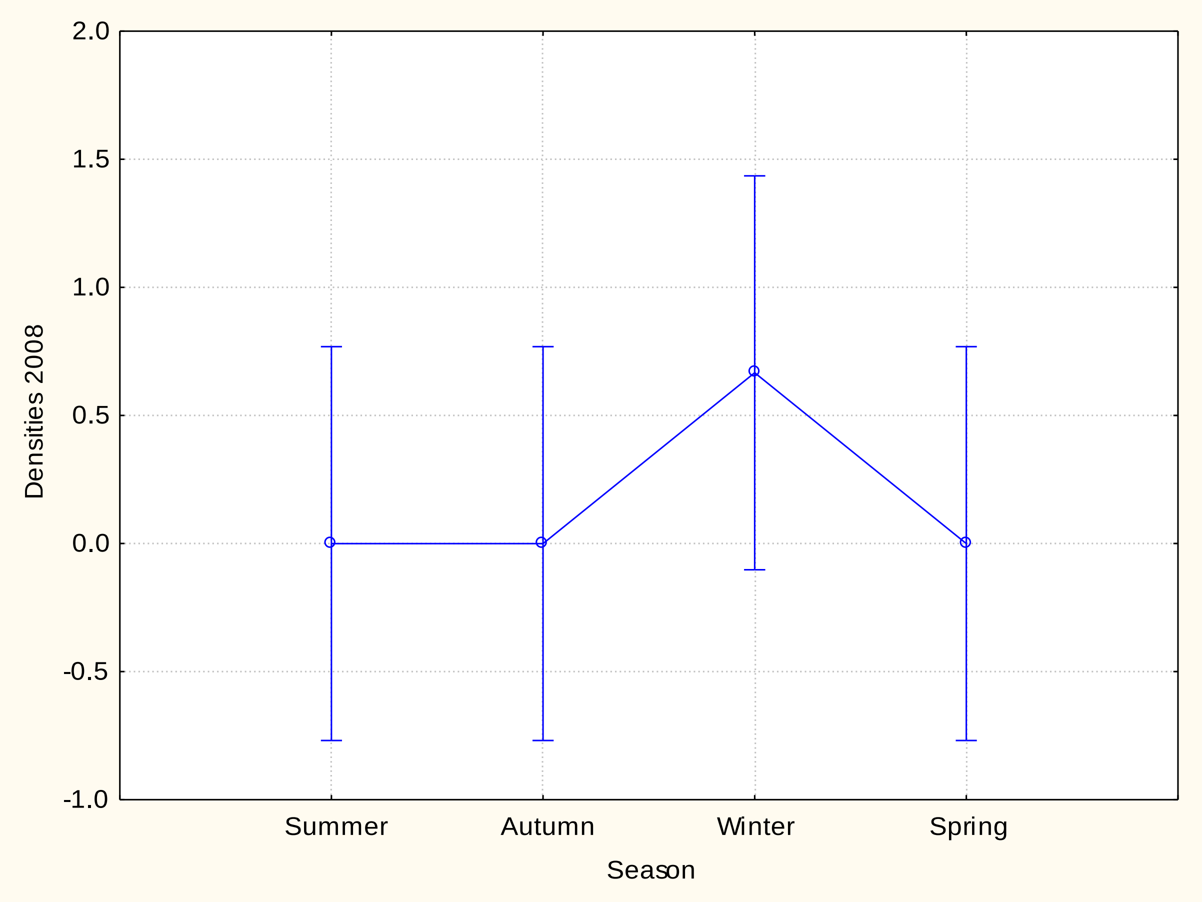

Figure 165. Graph depicting mean *Crocidura mariquensis* population estimates recorded in Sheltered Woodland during the study period.

The mean population estimate of *C. mariquensis* recorded in the Sheltered Woodland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal for every two hectares. This community covers 219 ha of the property, therefore a population estimate of 110 *C. mariquensis* are estimated to occur in the Sheltered Woodland community on the property.

10.7.8. Seasonal population estimates recorded for *Suncus infinitesimus* in the Sheltered Woodland community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded in the Sheltered Woodland community during year 1 of the study. The population estimates for *S. infinitesimus* in Sheltered Woodland in year 2 harboured highest densities in winter (2 animals per ha), with no animals being recorded in summer, autumn and spring (Fig. 166). ANOVA revealed an insignificant difference in population estimate between *S. infinitesimus* and season ($F_{1.3} = 1.000$; $n = 2$; $P = 0.441$) in the Sheltered Woodland community in year 2.

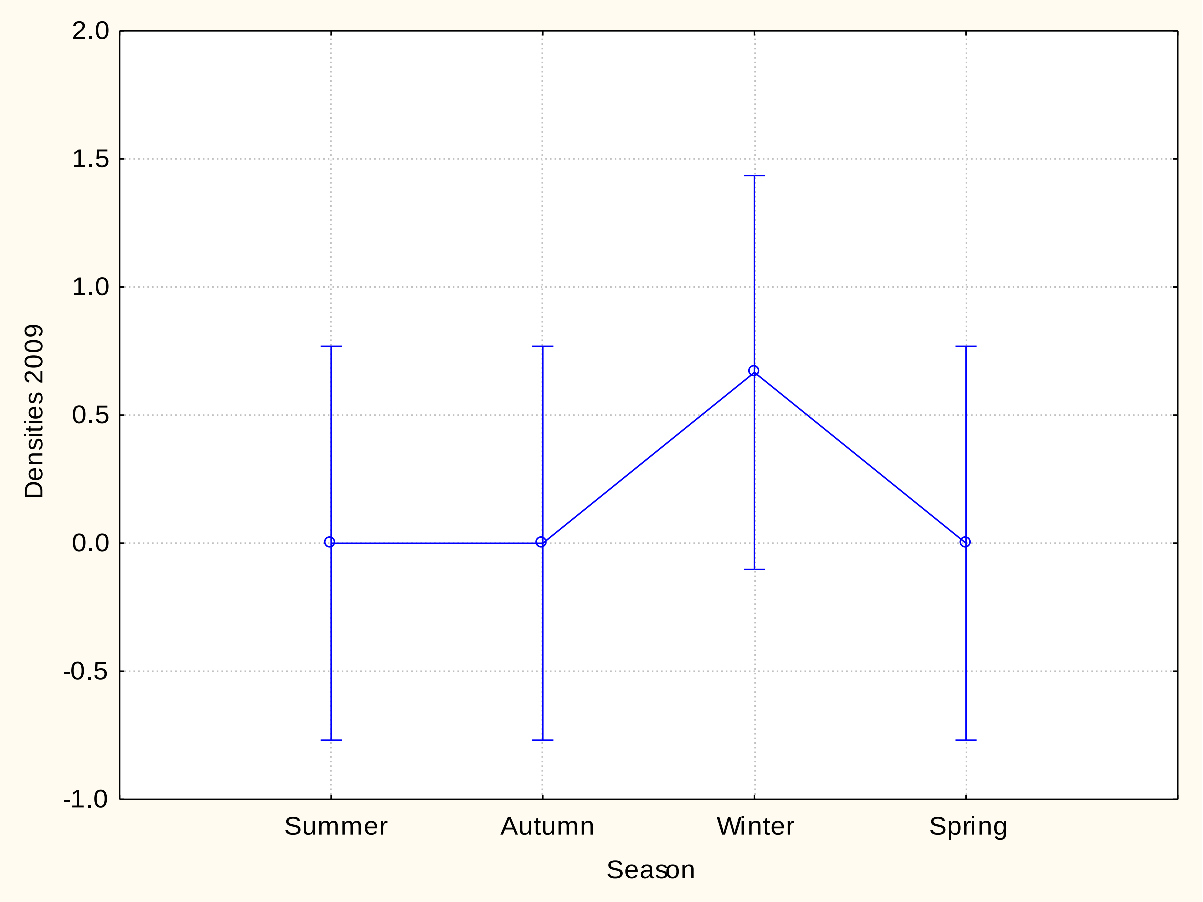

Figure 166. Graph depicting mean *Suncus infinitesimus* population estimates recorded in Sheltered Woodland during the study period.

The mean population estimate of *S. infinitesimus* recorded in the Sheltered Woodland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal for every two hectares. This community covers 219 ha of the property, therefore a population estimate of 110 *S. infinitesimus* are estimated to occur in the Sheltered Woodland community during the study.

## 10.8. Population estimates recorded for non-volant small mammal assemblages in the Burkea Eragrostis Clumps vegetation community.

The Burkea Eragrostis Clumps community occurs in relatively small clumps and occupies 4% of the property and covers an area of 116 ha (Fig. 167).

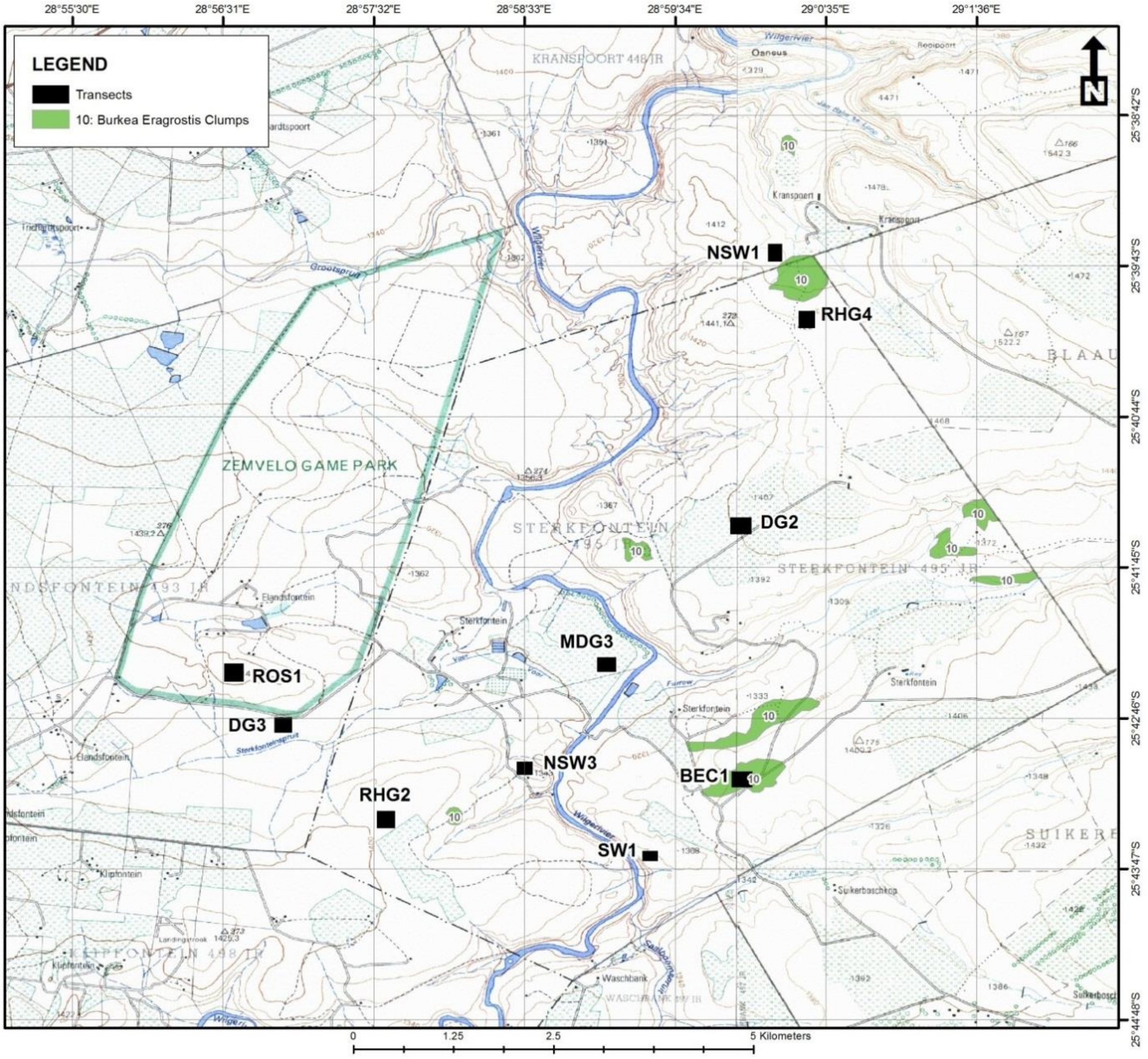

Figure 167. Map of Telperion and Ezemvelo Nature Reserve depicting the areas covered by Burkea Eragrostis Clumps habitat at the study site.

ANOVA revealed a significant difference between population estimate and season in year one in the Burkea Eragrostis Clumps community (BEC 1) ($F_{1.3} = 6.324$; $n = 38$; $P = 0.008$). Statistically population estimates are significantly different in autumn and winter (Tukey's: $P = 0.03$), and autumn and spring (Tukey's: $P = 0.00$). The population estimates recorded for Burkea Eragrostis Clumps in year one indicate the highest density per ha in spring (16 animals per ha), followed by winter (13 animals per ha), summer (7 animals per ha) and the lowest number in autumn (2 animals per ha) (Fig. 168a).

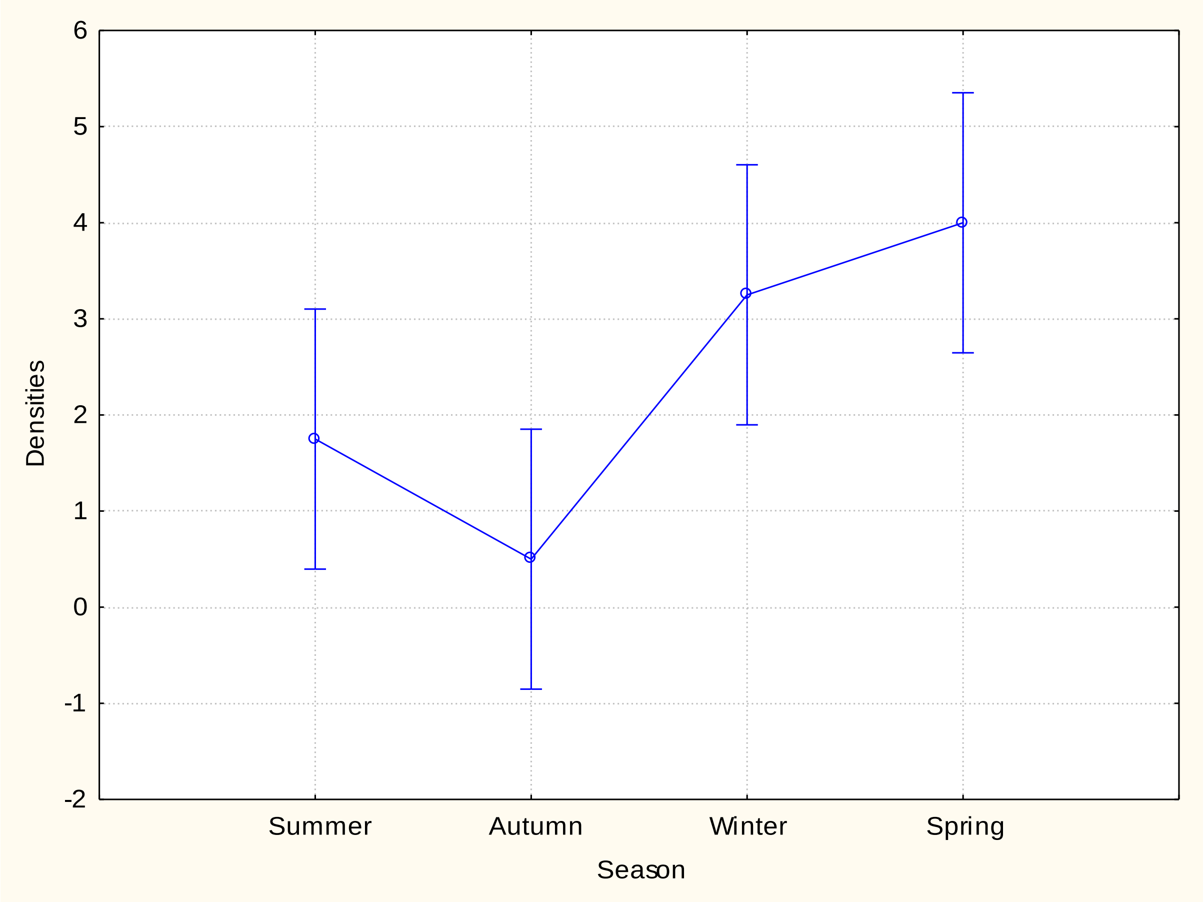

Figure 168a. Graph depicting small mammal population estimates in 2008 recorded in the Burkea Eragrostis Clumps community.

ANOVA revealed a significant difference between population estimate and season in Burkea Eragrostis Clumps (BEC 1) in year 2 ($F_{1.3}$ = 110.143; $n$ = 39; $P$ = 0.000). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.00), summer and winter (Tukey's: $P$ = 0.00), and summer and spring (Tukey's: $P$ = 0.00); autumn and winter (Tukey's: $P$ = 0.00), and autumn and spring (Tukey's: $P$ = 0.00). The population estimates recorded for Burkea Eragrostis Clumps in year 2 indicate the highest density per ha in summer (21 animals per ha), followed by winter and spring (8 animals per ha), and autumn having the lowest number recorded (2 animals per ha) (Fig. 168b).

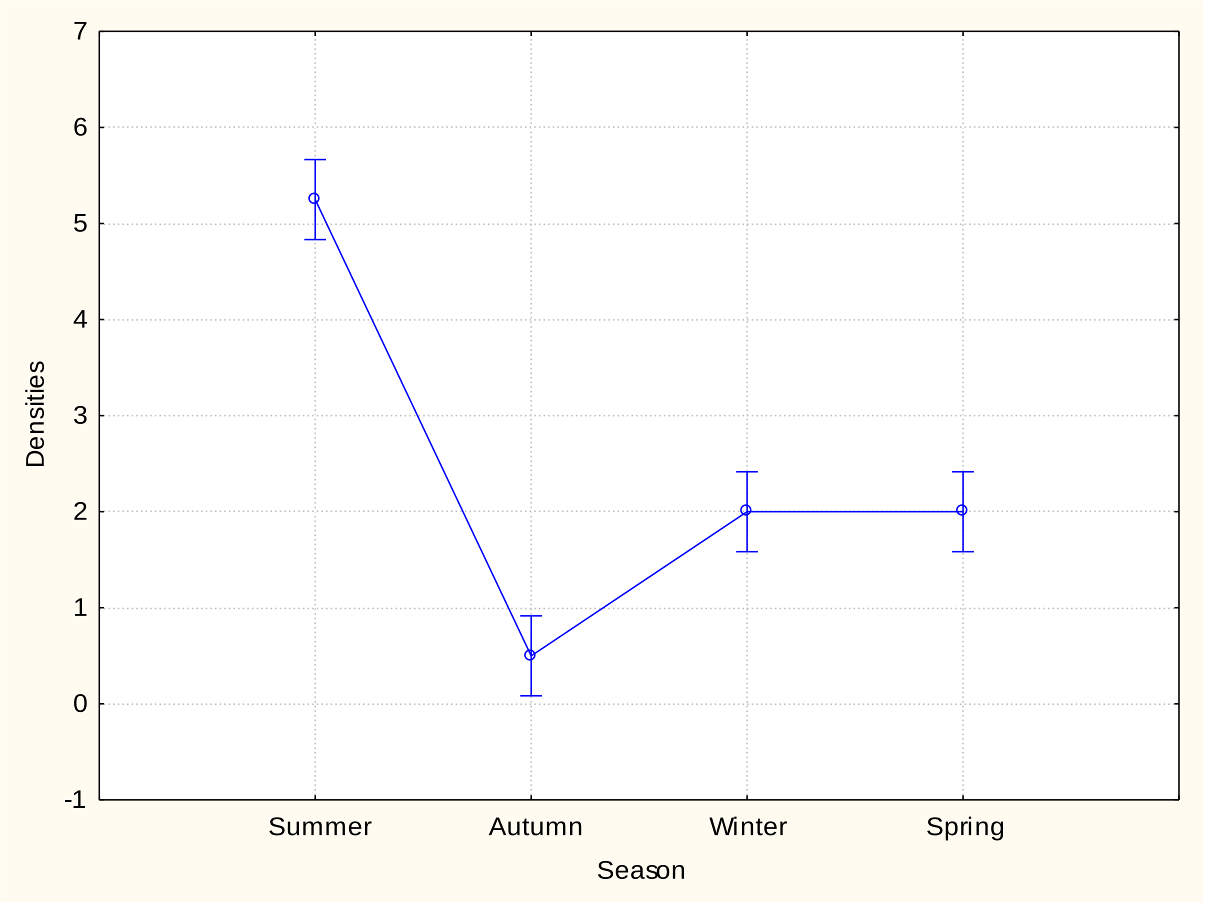

Figure 168b. Graph depicting small mammal population estimates in 2009 recorded in the Burkea Eragrostis Clumps community.

ANOVA revealed a significant difference between population estimate and season in the Sheltered Woodland community ($F_{1.3}$ = 3.725; $n$ = 39; $P$ = 0.042). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.04). The seasonal mean population estimate for small mammals recorded in the Burkea Eragrostis Clumps community indicate that summer has marginally the highest densities (14 animals per ha), followed by spring (12 animals per ha), winter (31 animals per ha) and autumn with the lowest recorded number (2 animals per ha) (Figure 169).

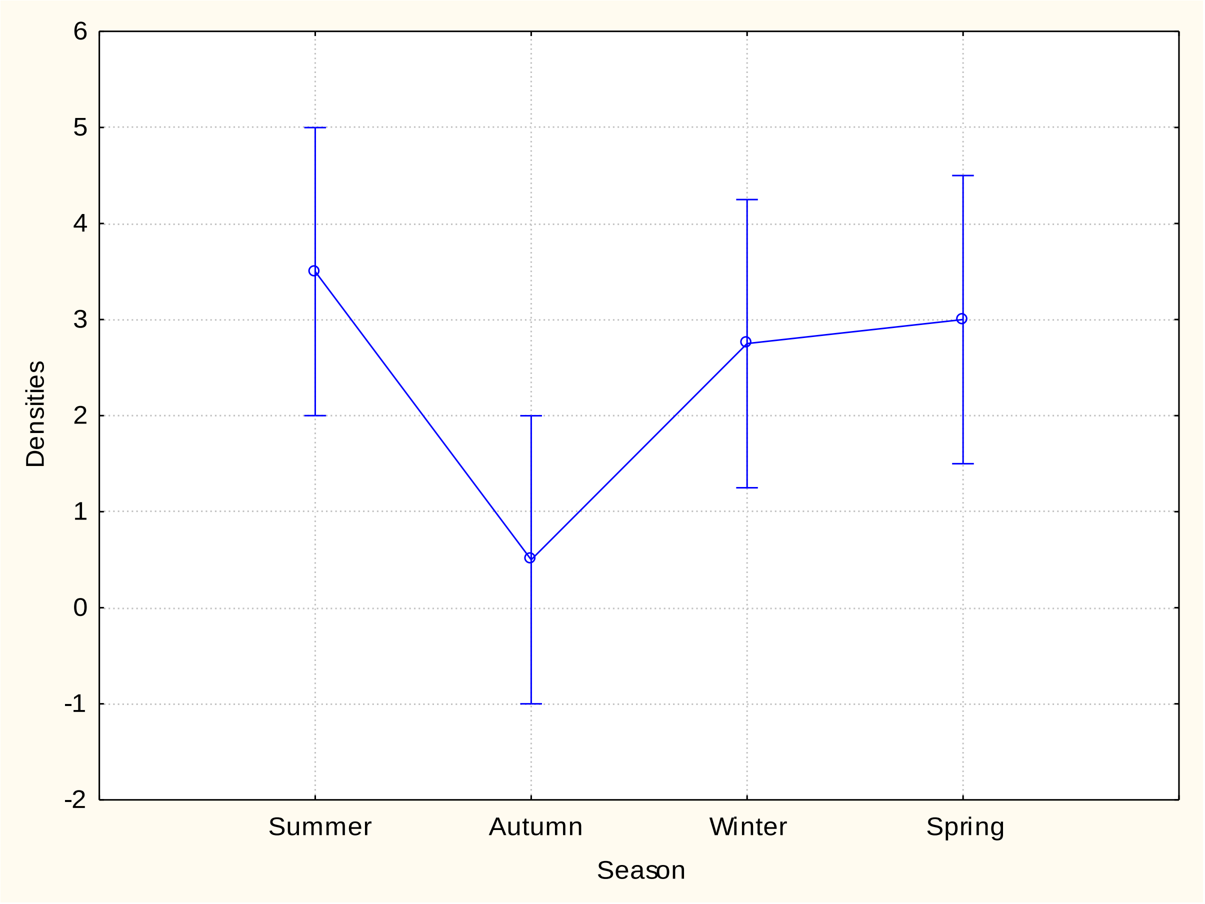

Figure 169. Graph depicting mean small mammal population estimates recorded in the Burkea Eragrostis Clumps community during the study period.

The mean population estimate of small mammals recorded for Burkea Eragrostis Clumps is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 10 small mammals per ha. The community is recorded to cover 116 ha of the property, therefore a population estimate of 1 160 small mammals are estimated to occur in the Burkea Eragrostis Clumps community on the property. The population estimates were recorded for the following small mammal species seasonally in Burkea Eragrostis Clumps during the study.

### 10.8.1. Seasonal population estimates recorded for *Gerbilliscus brantsii* in the Burkea Eragrostis Clumps community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *G. brantsii* in Burkea Eragrostis Clumps in year 1 indicate the highest density per ha in spring (11 animals per ha), followed by summer

(7 animals per ha), winter (4 animals per ha), with no animals being recorded in autumn. (Fig. 170).

ANOVA revealed a significant difference between population estimate of *G. brantsii* and season in the Burkea Eragrostis Clumps (BEC 1) community in year 1 ($F_{1.3}$ = 28.889; *n* = 22; *P* = 0.000). Statistically population estimates are significantly different in summer and autumn (Tukey's: *P* = 0.01), summer and spring (Tukey's: *P* = 0.04); autumn and winter (Tukey's: *P* = 0.04); autumn and spring (Tukey's: *P* = 0.00) winter and spring (Tukey's: *P* = 0.00). The population estimates recorded in Burkea Eragrostis Clumps in year 2 indicate the highest density per ha in summer (11 animals per ha), with no animals being recorded in autumn, winter and spring (Fig. 170). Statistically ANOVA revealed a significant difference between population estimate of *G. brantsii* and season in the Burkea Eragrostis Clumps (BEC 1) community in year 2 ($F_{1.3}$ = 121.000; *n* = 11; *P* = 0.000). Statistically population estimates are significantly different in summer and autumn (Tukey's: *P* = 0.00), summer and spring (Tukey's: *P* = 0.00); summer and winter (Tukey's: *P* = 0.00).

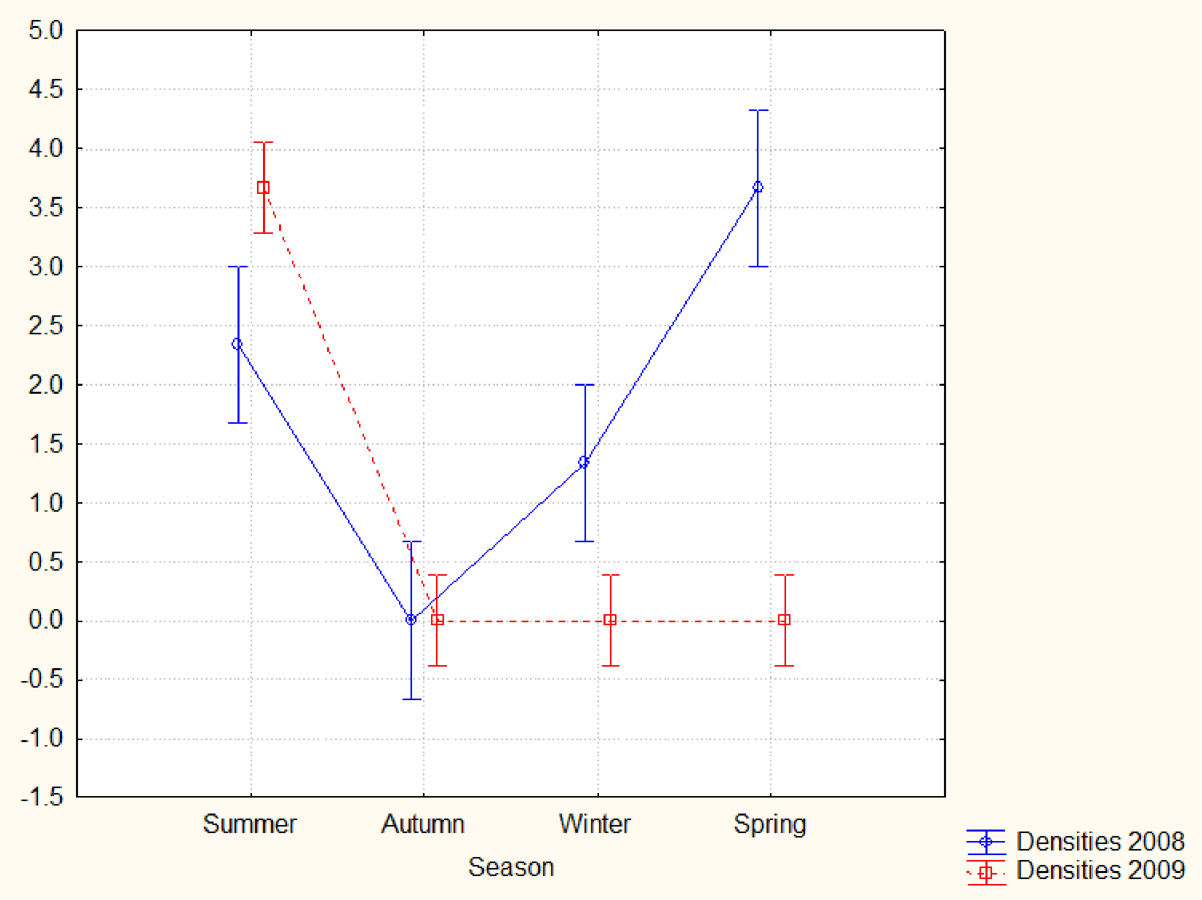

Figure 170. Graph depicting seasonal *Gerbilliscus brantsii* population estimates in 2008 and 2009 recorded in the Burkea Eragrostis Clumps vegetation community.

The seasonal mean population estimate for *G. brantsii* recorded in the Burkea Eragrostis Clumps community indicate that summer has the highest population estimates (9 animals per ha), followed by spring (6 animals per ha), winter (2 animals per ha), with no animals recorded in autumn (Figure 171).

ANOVA revealed a significant difference between population estimate of *G. brantsii* and season in the Burkea Eragrostis Clumps (BEC 1) community ($F_{1.3} = 9.286$; $n = 17$; $P = 0.006$). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P = 0.00$), summer and winter (Tukey's: $P = 0.02$); autumn and spring (Tukey's: $P = 0.04$).

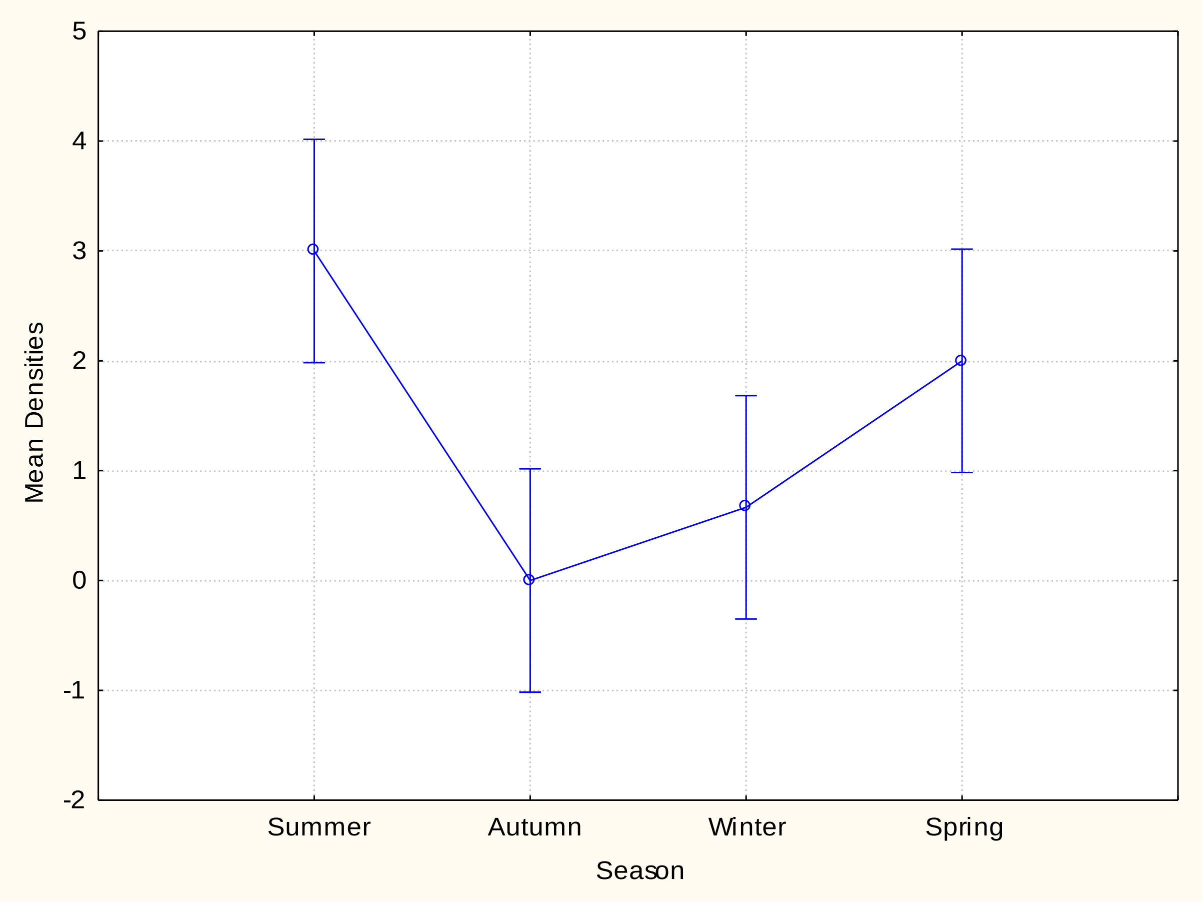

Figure 171. Graph depicting mean *Gerbilliscus brantsii* population estimates recorded in Burkea Eragrostis Clumps during the study period.

The mean population estimate of *G. brantsii* recorded for Burkea Eragrostis Clumps is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 4 small mammals per ha. The community is recorded to cover 116 ha of the property, therefore a population estimate of 464 *G. brantsii* are estimated to occur in the Burkea Eragrostis Clumps community on the property.

### 10.8.2. Seasonal population estimates recorded for *Mus minutoides* in the Burkea Eragrostis Clumps community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *M. minutoides* in Burkea Eragrostis Clumps in year 1 indicate the highest density per ha in summer (3 animals per ha), with no animals being recorded in autumn, winter and spring (Fig. 172).

ANOVA revealed an insignificant difference in population estimate between *M. minutoides* and season ($F_{1.3}$ = 1.000; $n$ = 3; $P$ = 0.441) in the Burkea Eragrostis Clumps community in year 1. The population estimates recorded in Burkea Eragrostis Clumps in year 2 indicate the highest density per ha in summer and spring (5 animals per ha), followed by winter (3 animals per ha), with no animals being recorded in autumn (Fig. 172). Statistically ANOVA revealed a significant difference between population estimate for *M. minutoides* and season in the Burkea Eragrostis Clumps (BEC 1) community in year 2 ($F_{1.3}$ = 11.167; $n$ = 13; $P$ = 0.003). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.0); autumn and spring (Tukey's: $P$ = 0.00).

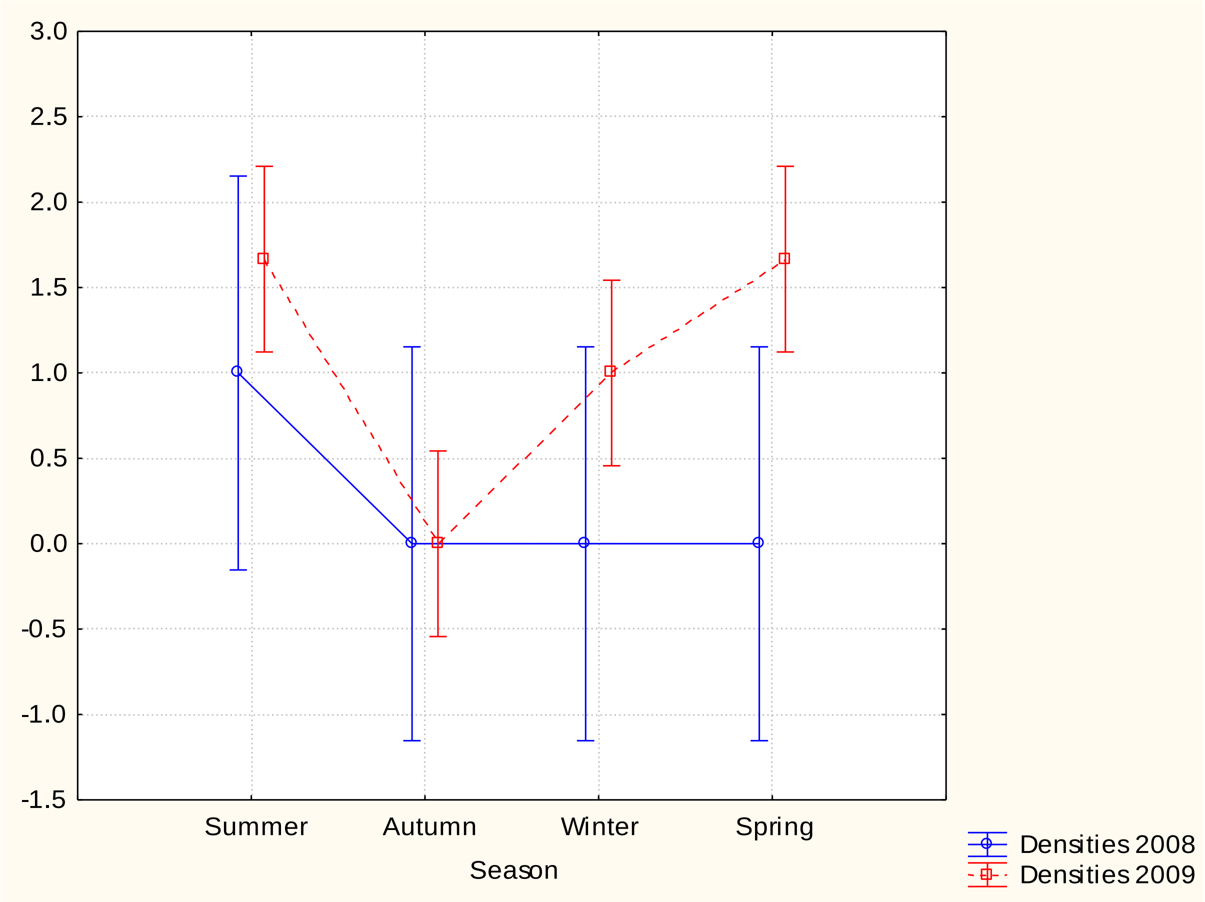

Figure 172. Graph depicting seasonal *Mus minutoides* population estimates in 2008 and 2009 recorded in the Burkea Eragrostis Clumps vegetation community.

The seasonal mean population estimate for *M. minutoides* recorded in the Burkea Eragrostis Clumps community indicate that summer has the highest population estimates (6 animals per ha), followed by spring (3 animals per ha), winter (2 animals per ha), with no animals recorded in autumn (Figure 173). ANOVA revealed an insignificant difference in population estimate between *M. minutoides* and season ($F_{1.3}$ = 6.268; $n$ = 105; $P$ = 0.008) in the Burkea Eragrostis Clumps community.

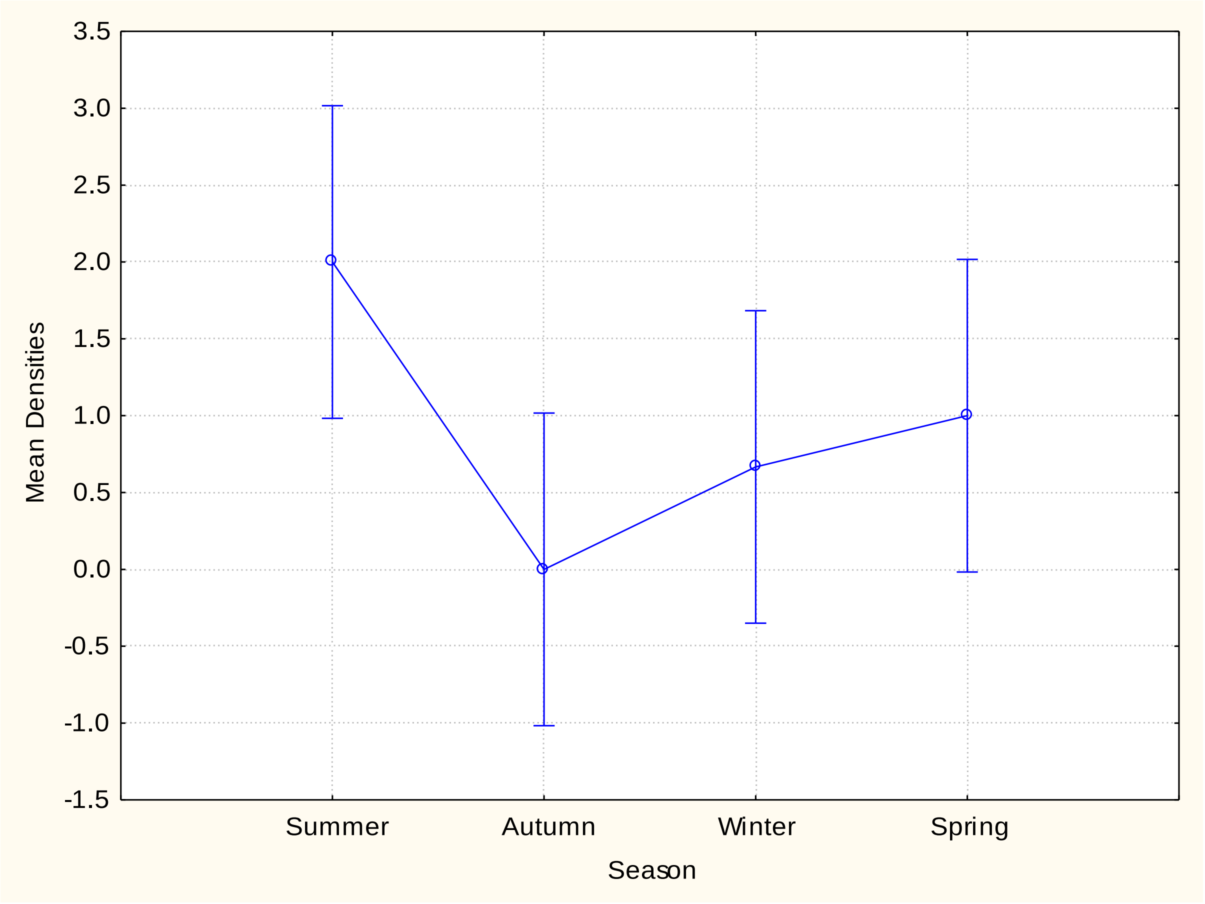

Figure 173. Graph depicting mean *Mus minutoides* population estimates recorded in Burkea Eragrostis Clumps during the study period.

The mean population estimate of *M. minutoides* recorded for Burkea Eragrostis Clumps is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 3 small mammals per ha. The community is recorded to cover 116 ha of the property, therefore a population estimate of 348 *M. minutoides* are estimated to occur in the Burkea Eragrostis Clumps community on the property. The possible cause for animals frequenting the spring and summer months in this vegetation community is due to the lack of cover in autumn and winter.

### 10.8.3. Seasonal population estimates recorded for *Dendromus melanotis* in the Burkea Eragrostis Clumps community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *D. melanotis* in Burkea Eragrostis Clumps in year 1 indicate the highest density per ha in winter (7 animals per ha), followed by spring (5 animals per ha), with no animals being recorded in summer and autumn (Fig. 174).

ANOVA revealed a significant difference between *D. melanotis* population estimate and season in the Burkea Eragrostis Clumps (BEC 1) community in year 1 ($F_{1.3}$ = 25.333; *n* = 12; *P* = 0.000). Statistically population estimates are significantly different in summer and winter (Tukey's: *P* = 0.00), summer and spring (Tukey's: *P* = 0.00); autumn and winter (Tukey's: *P* = 0.00); autumn and spring (Tukey's: *P* = 0.00). The population estimates recorded in Burkea Eragrostis Clumps in year 2 indicate the highest density per ha in winter (5 animals per ha), followed by summer (3 animals per ha), with no animals being recorded in autumn and spring (Fig. 174). ANOVA revealed a significant difference between population estimate of *D. melanotis* and season in the Burkea Eragrostis Clumps (BEC 1) community in year 2 ($F_{1.3}$ = 24.000; *n* = 8; *P* = 0.000). Statistically population estimates are significantly different in summer and autumn (Tukey's: *P* = 0.01), summer and spring (Tukey's: *P* = 0.01); autumn and winter (Tukey's: *P* = 0.00); winter and spring (Tukey's: *P* = 0.00).

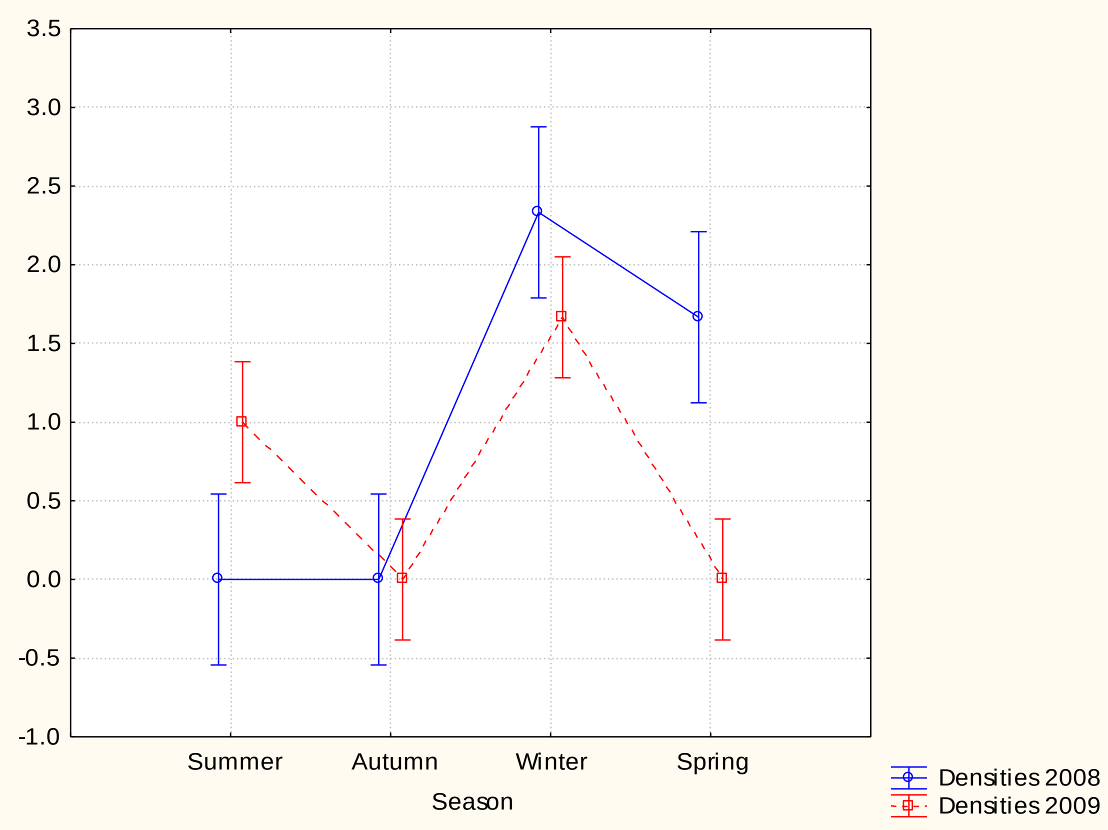

Figure 174. Graph depicting seasonal *Dendromus melanotis* population estimates in 2008 and 2009 recorded in the Burkea Eragrostis Clumps vegetation community.

The seasonal mean population estimate for *D. melanotis* recorded in the *Burkea Eragrostis* Clumps community indicate that winter has the highest population estimates (6 animals per ha), followed by spring (3 animals per ha), summer (2 animals per ha), with no animals recorded in autumn (Figure 175). ANOVA revealed a significant difference between population estimates of *D. melanotis* and season in the Burkea Eragrostis Clumps (BEC 1) community in year 1 ($F_{1.3}$ = 25.000; $n$ = 11; $P$ = 0.00). Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.00), autumn and winter (Tukey's: $P$ = 0.03); autumn and spring (Tukey's: $P$ = 0.01); winter and spring (Tukey's: $P$ = 0.01).

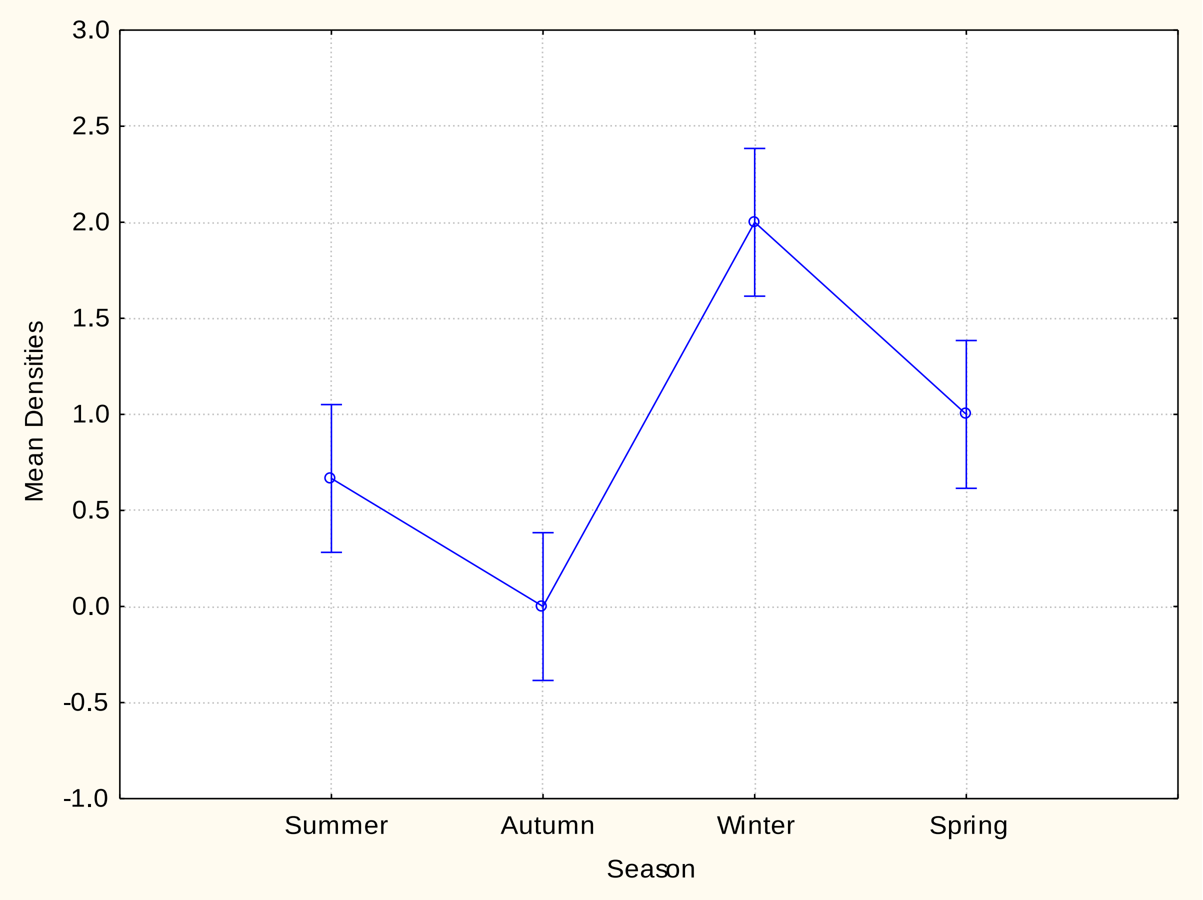

Figure 175. Graph depicting mean *Dendromus melanotis* population estimates recorded in Burkea Eragrostis Clumps during the study period.

The mean population estimate of *D. melanotis* recorded for Burkea Eragrostis Clumps is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 3 small mammals per ha. The community is recorded to cover 116 ha of the property, therefore a population estimate of 348 *D. melanotis* are estimated to occur in the Burkea Eragrostis Clumps community on the property. The possible cause for animals frequenting the spring and summer months in this vegetation community is due to the lack of cover in autumn and winter.

### 10.8.4. Seasonal population estimates recorded for *Steatomys pratensis* in the Burkea Eragrostis Clumps community on Telperion and Ezemvelo Nature Reserve

The population estimates for *S. pratensis* in Burkea Eragrostis Clumps in year 1 harboured highest densities in autumn and winter (2 animals per ha), with no animals being recorded in summer and spring (Fig. 176). ANOVA revealed an insignificant difference in population estimate between *S. pratensis* and season ($F_{1.3}$ = 0.667; $n$ = 4; $P$ = 0.596) in the Burkea Eragrostis Clumps community in year 1. No individuals were recorded in the Burkea Eragrostis Clumps community during year 2 of the study.

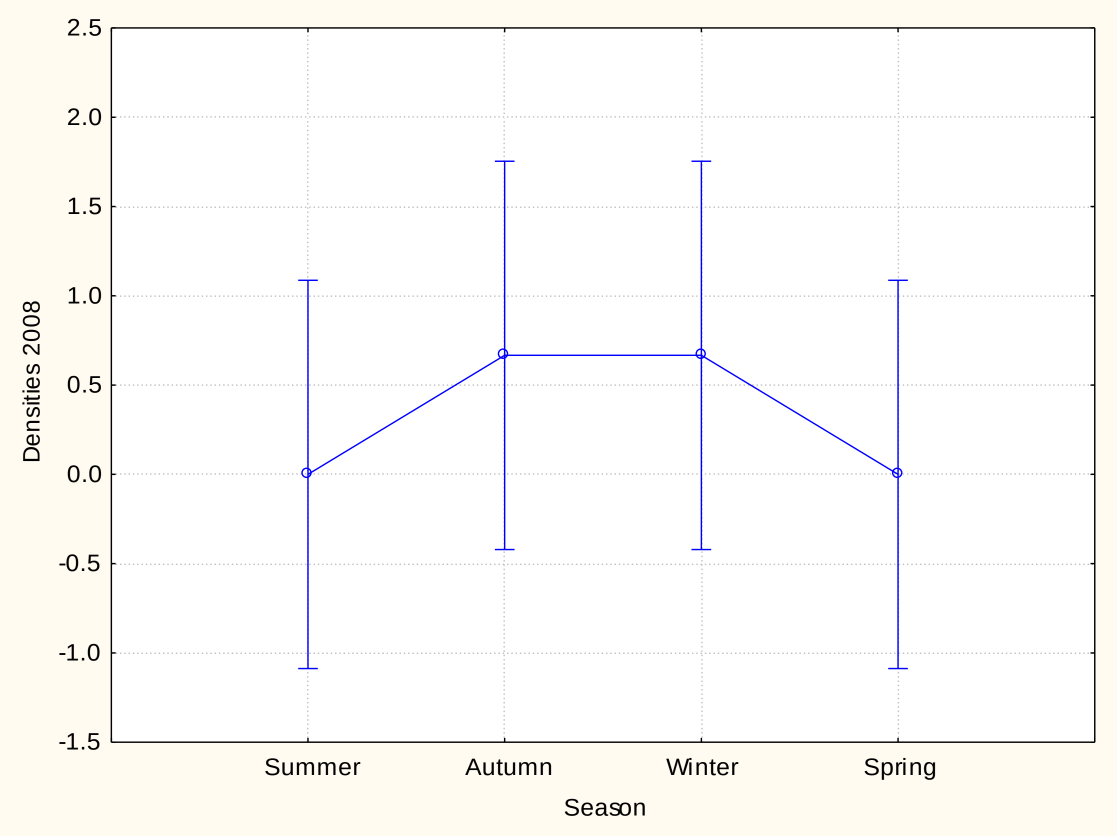

Figure 176. Graph depicting mean *Steatomys pratensis* population estimates recorded in Burkea Eragrostis Clumps during the study period.

The mean population estimate of *S. pratensis* recorded in the Burkea Eragrostis Clumps community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal per ha. This community covers 116 ha of the property, therefore a population estimate of 116 *S. pratensis* are estimated to occur in the Burkea Eragrostis Clumps community at the study site.

### 10.8.5. Seasonal population estimates recorded for *Mastomys* spp. in the Burkea Eragrostis Clumps community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded in the Burkea Eragrostis Clumps community during year 1 of the study. The population estimates for *Mastomys* spp. in Burkea Eragrostis Clumps in year 2 harboured highest densities in spring (2 animals per ha), with no animals being recorded in summer, autumn and winter (Fig. 177). ANOVA revealed an insignificant difference in population estimate between *Mastomys* spp. and season ($F_{1.3}$ = 1.000; $n$ = 2; $P$ = 0.441) in the Burkea Eragrostis Clumps community in year 2.

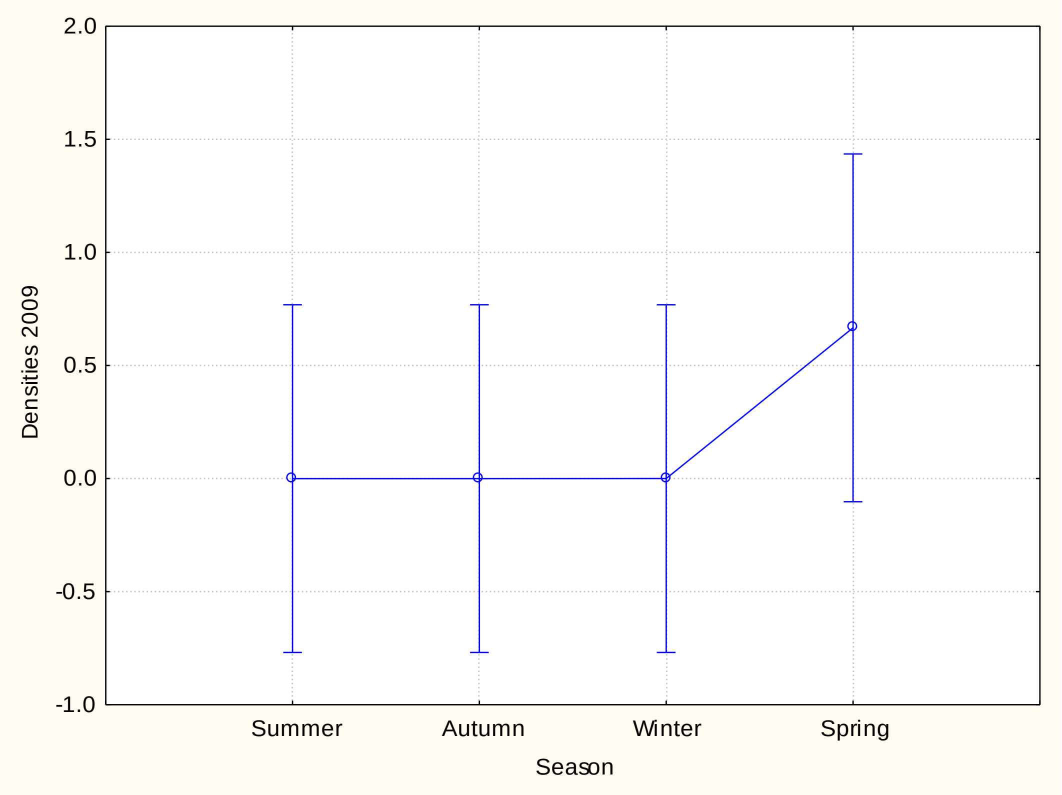

Figure 177. Graph depicting mean *Mastomys* spp. population estimates recorded in Burkea Eragrostis Clumps during the study period.

The mean population estimate of *Mastomys* spp. recorded in the Burkea Eragrostis Clumps community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal for every two hectares. This community covers 116 ha of the property, therefore a population estimate of 58 *Mastomys* spp. is estimated to occur in the Burkea Eragrostis Clumps community on the property.

### 10.8.6. Seasonal population estimates recorded for *Lemniscomys rosalia* in the Burkea Eragrostis Clumps community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded in the Burkea Eragrostis Clumps community during year 1 of the study. The population estimates for *L. rosalia* in Burkea Eragrostis Clumps in year 2 harboured highest densities in summer and autumn (2 animals per ha), with no animals being recorded in winter and spring (Fig. 178). ANOVA revealed an insignificant difference in population estimate between *L. rosalia* and season ($F_{1.3}$ = 0.667; $n$ = 4; $P$ = 0.596) in the Burkea Eragrostis Clumps community in year 2.

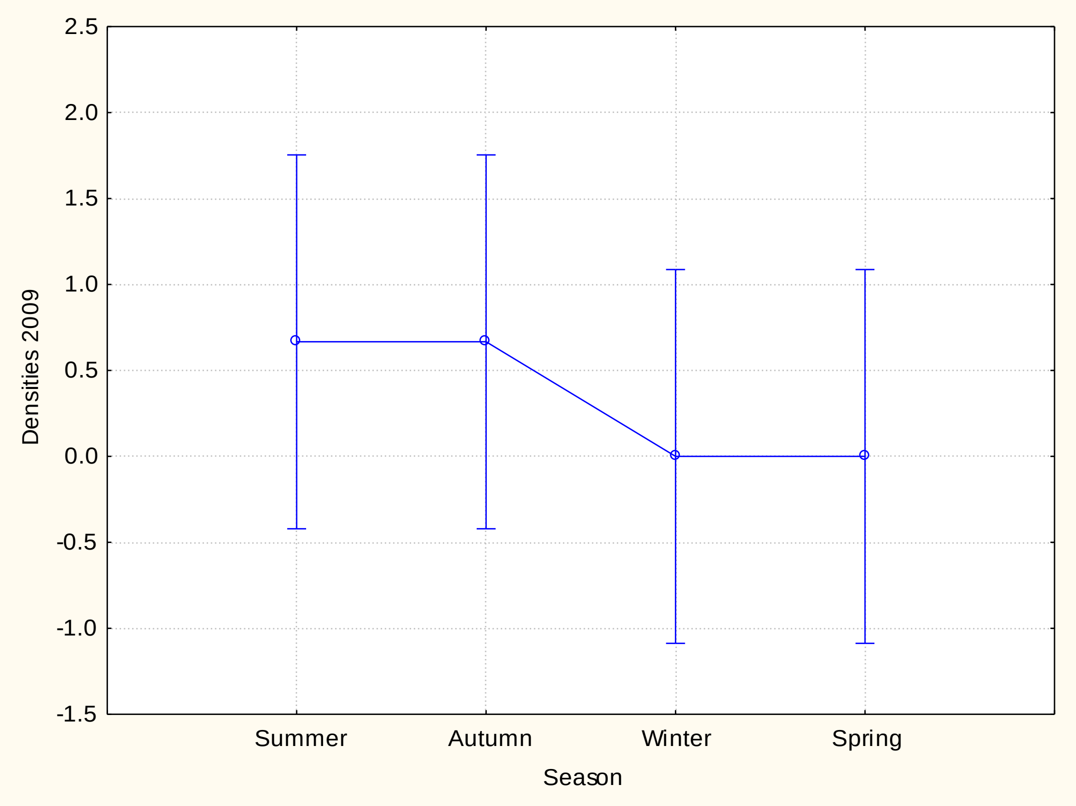

Figure 178. Graph depicting mean *Lemniscomys rosalia* population estimates recorded in Burkea Eragrostis Clumps during the study period.

The mean population estimate of *L. rosalia* recorded in the Burkea Eragrostis Clumps community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal per ha. This community covers 116 ha of the property, therefore a population estimate of 116 *L. rosalia* are estimated to occur in the Burkea Eragrostis Clumps community on the property.

### 10.9. Population estimates recorded for non-volant small mammal assemblages in the Moist Degraded Grassland vegetation community.

The Moist Degraded Grassland community occupies a significant 10% of the property and covers an area of 894 ha (Fig. 179).

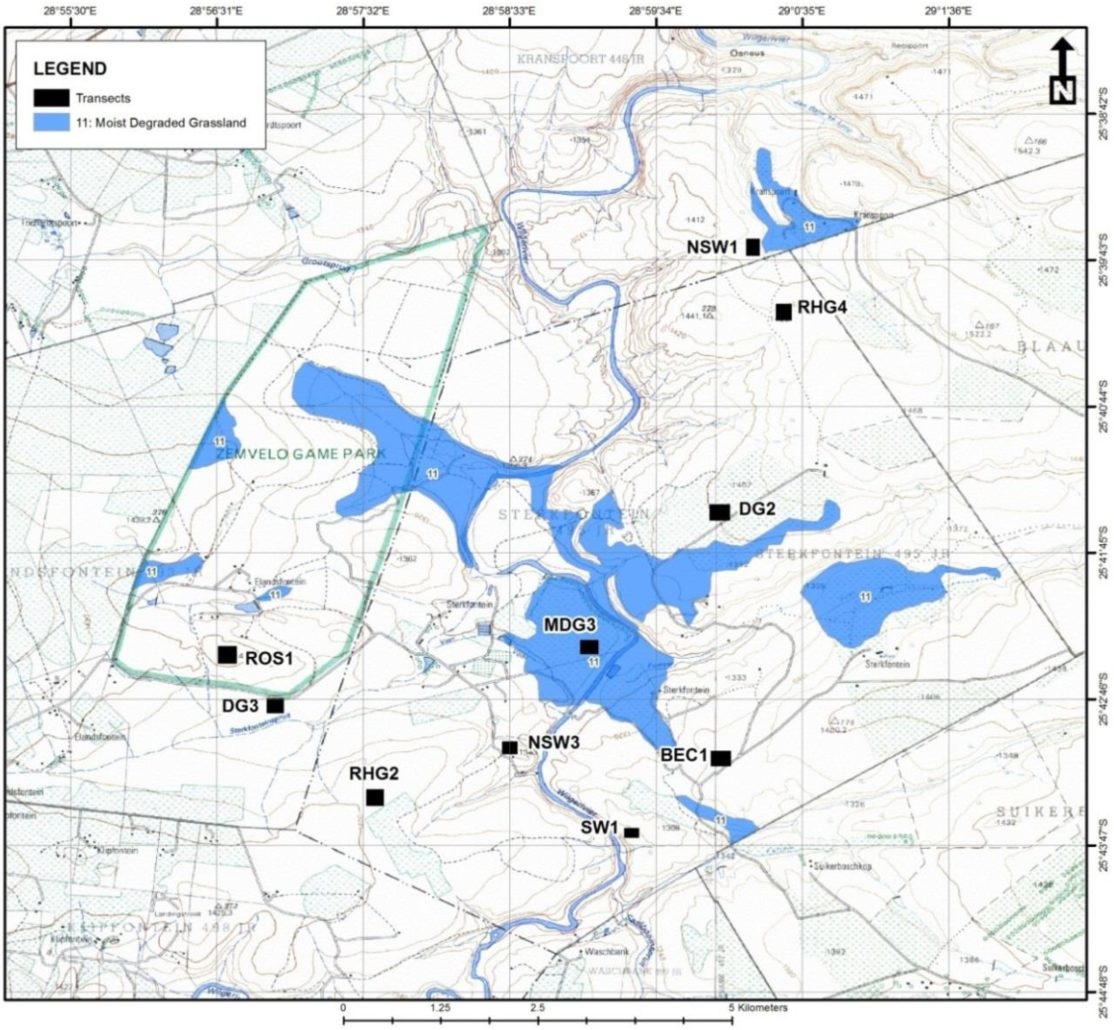

Figure 179. Map of Telperion and Ezemvelo Nature Reserve depicting the areas covered by Moist Degraded Grassland habitat on the property.

ANOVA revealed a significant difference between population estimate and season Moist Degraded Grassland (MDG3) community in year 1 ($F_{1.3}$ = 4.566; $n$ = 19; $P$ = 0.024). Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.05); and autumn and winter (Tukey's: $P$ = 0.05). The population estimates recorded for Moist Degraded Grassland in year 1 indicate the highest density per ha in winter (11 animals per ha), followed by spring (8 animals per ha), with no animals recorded during summer and autumn (Fig. 180a).

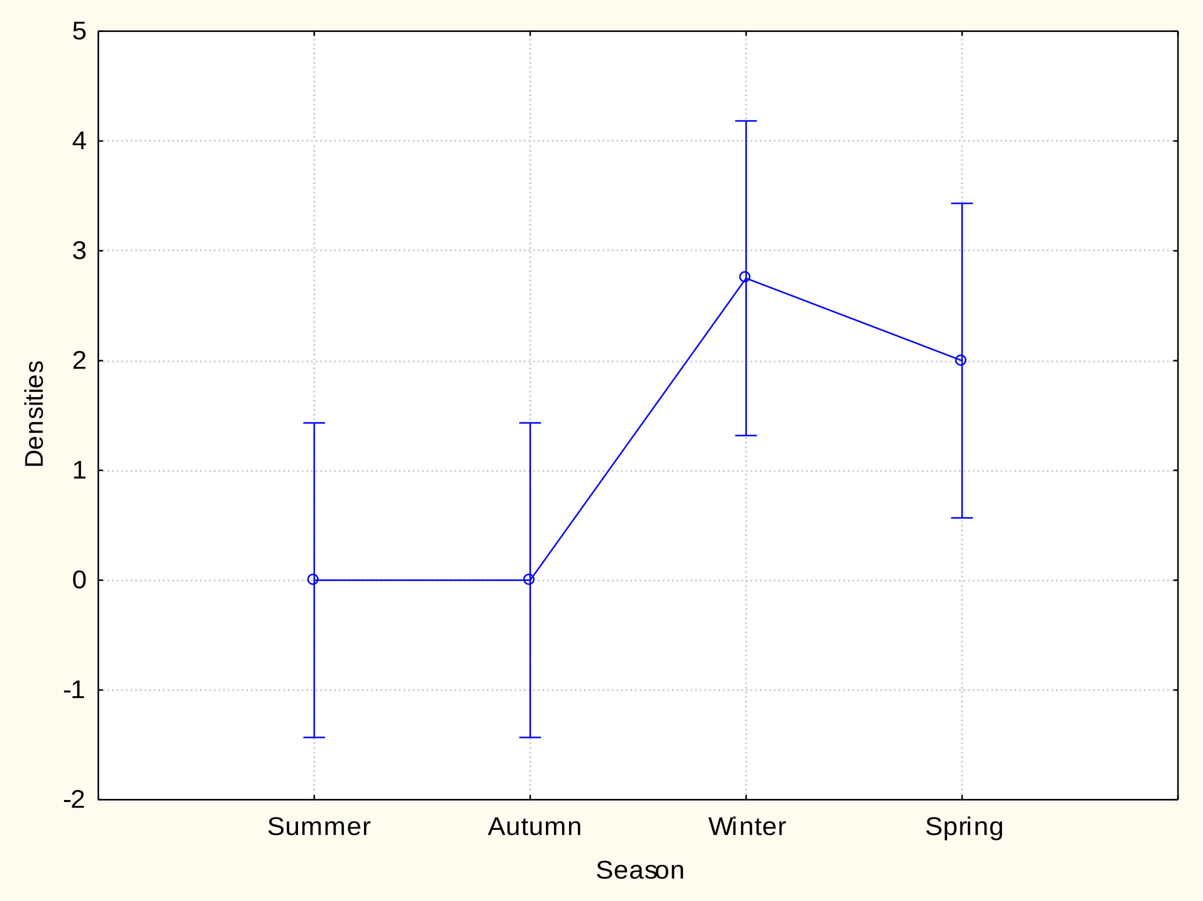

Figure 180a. Graph depicting small mammal population estimates in 2008 recorded in the Moist Degraded Grassland community.

ANOVA revealed a significant difference between population estimate and season in Moist Degraded Grassland community in year 2 ($F_{1.3}$ = 20.167; $n$ = 83; $P$ = 0.000). Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.00); autumn and winter (Tukey's: $P$ = 0.00). The population estimates recorded for Moist Degraded Grassland in year 2 indicate the highest density per ha in winter (52 animals per ha), followed by autumn (19 animals per ha), summer (5 animals per ha) and the lowest number recorded in spring (5 animals per ha) (Fig. 180b).

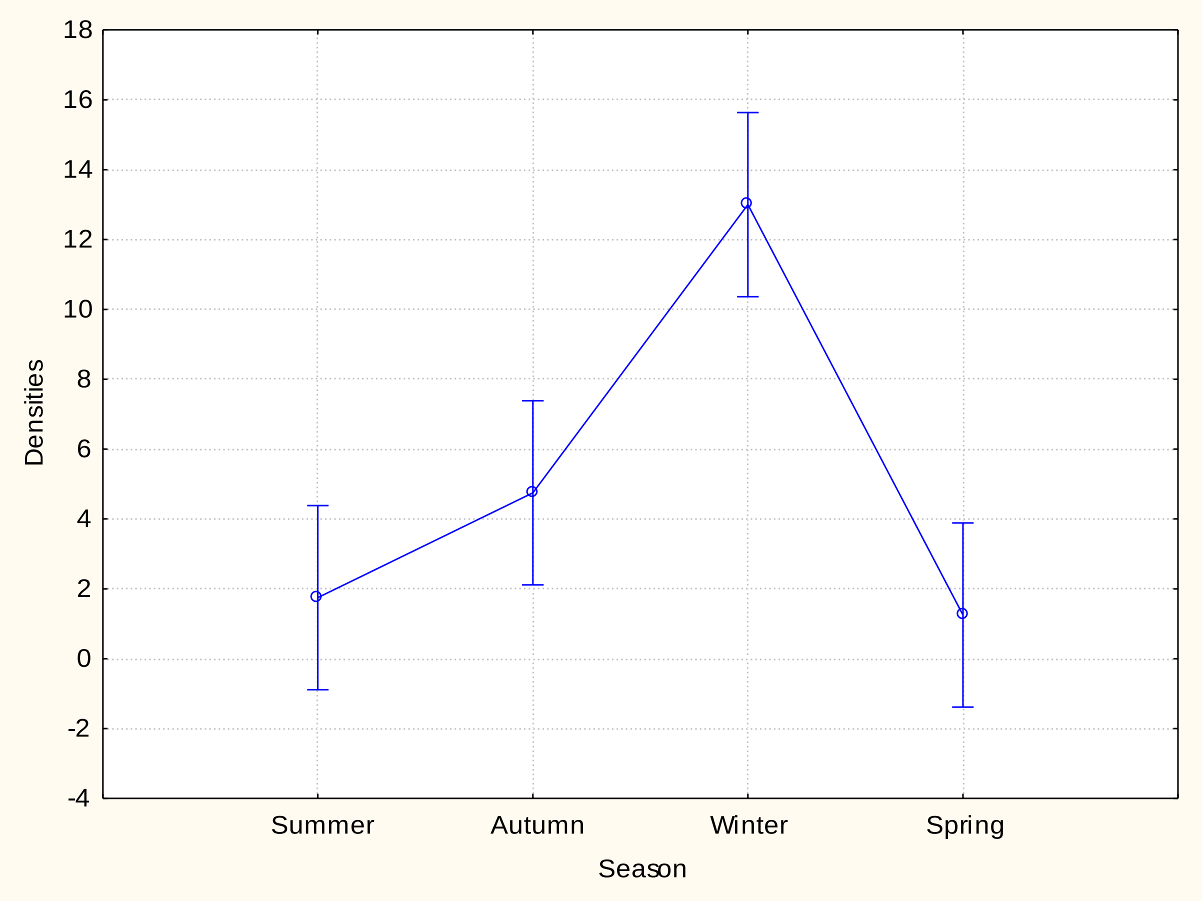

Figure 180b. Graph depicting small mammal population estimates in 2009 recorded in the Moist Degraded Grassland community.

ANOVA revealed a significant difference between population estimate and season in the Moist Degraded Grassland community ($F_{1.3}$ = 9.784; *n* = 53; *P* = 0.002). Statistically population estimates are significantly different in summer and winter (Tukey's: *P* = 0.00); autumn and winter (Tukey's: *P* = 0.01); and winter and spring (Tukey's: *P* = 0.00). The seasonal mean population estimate for small mammals recorded in the Moist Degraded Grassland community indicate that winter the highest densities (32 animals per ha), followed by autumn (10 animals per ha), spring (7 animals per ha) and summer with the lowest recorded number (4 animals per ha) (Figure 181).

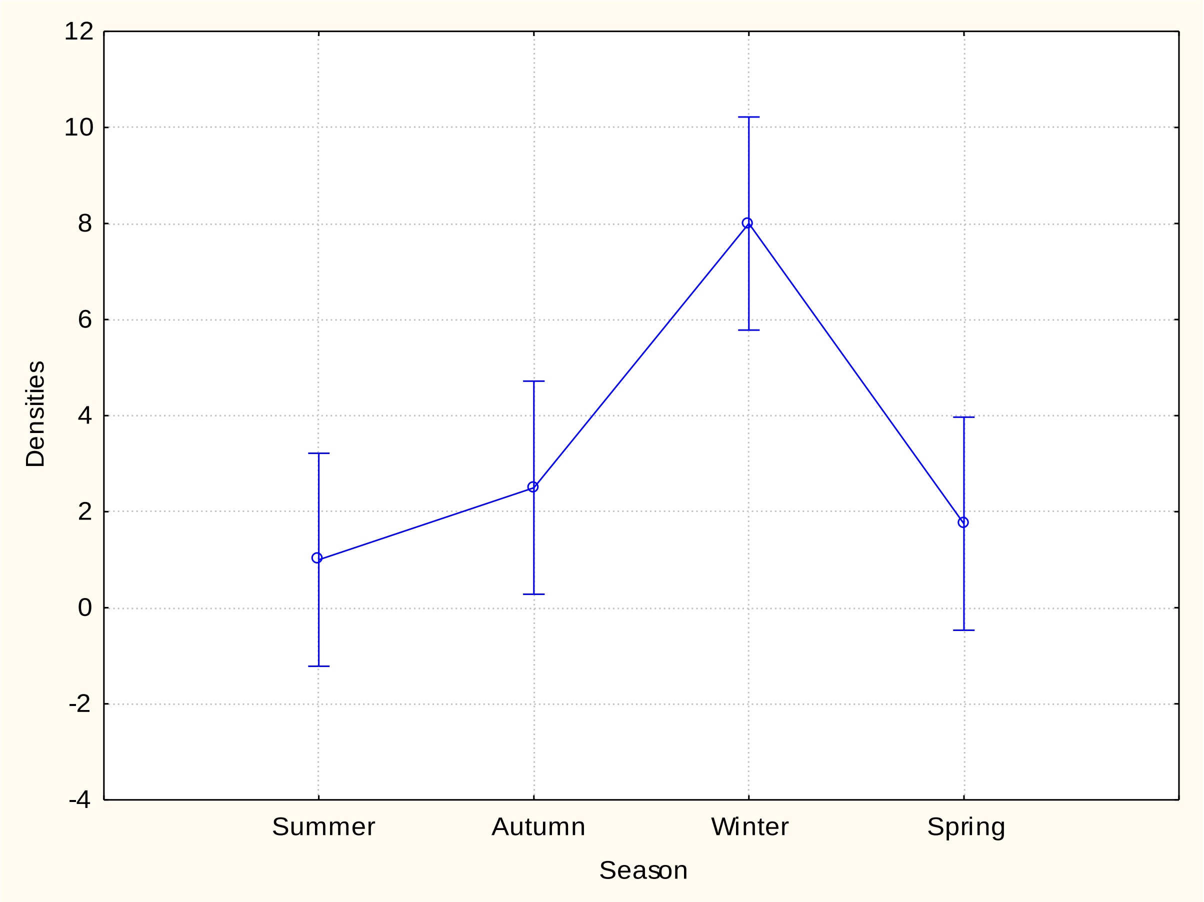

Figure 181. Graph depicting mean small mammal population estimates recorded in the Moist Degraded Grassland community during the study period.

The mean population estimate of small mammals recorded for Moist Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 13 small mammals per ha. The community is recorded to cover 894 ha of the property, therefore a population estimate of 11 622 small mammals are estimated to occur in the Moist Degraded Grassland community at the study site. The population estimates were recorded for the following small mammal species seasonally in Moist Degraded Grassland during the study.

### 10.9.1. Seasonal population estimates recorded for *Dendromus melanotis* in the Moist Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *D. melanotis* in Moist Degraded Grassland in year 1 indicate the highest density per ha in winter (6 animals per ha), followed by spring (3 animals per ha), with no animals being recorded in summer and autumn (Fig. 182).

ANOVA revealed a significant difference between population estimate of *D. melanotis* and season in the Moist Degraded Grassland community in year 1 ($F_{1.3}$ = 24.000; *n* = 8; *P* = 0.000). Population estimates are significantly different in summer and winter (Tukey's: *P* = 0.00); summer and spring (Tukey's: *P* = 0.01); autumn and winter (Tukey's: *P* = 0.00), autumn and spring (Tukey's: *P* = 0.01). The population estimates recorded in Moist Degraded Grassland in year 2 indicate the highest density per ha in winter (2 animals per ha), with no animals being recorded in summer, autumn and spring (Fig. 182). ANOVA revealed an insignificant difference in population estimate between *D. melanotis* and season ($F_{1.3}$ = 2.667; *n* = 4; *P* = 0.119) in the Moist Degraded Grassland community in year 2.

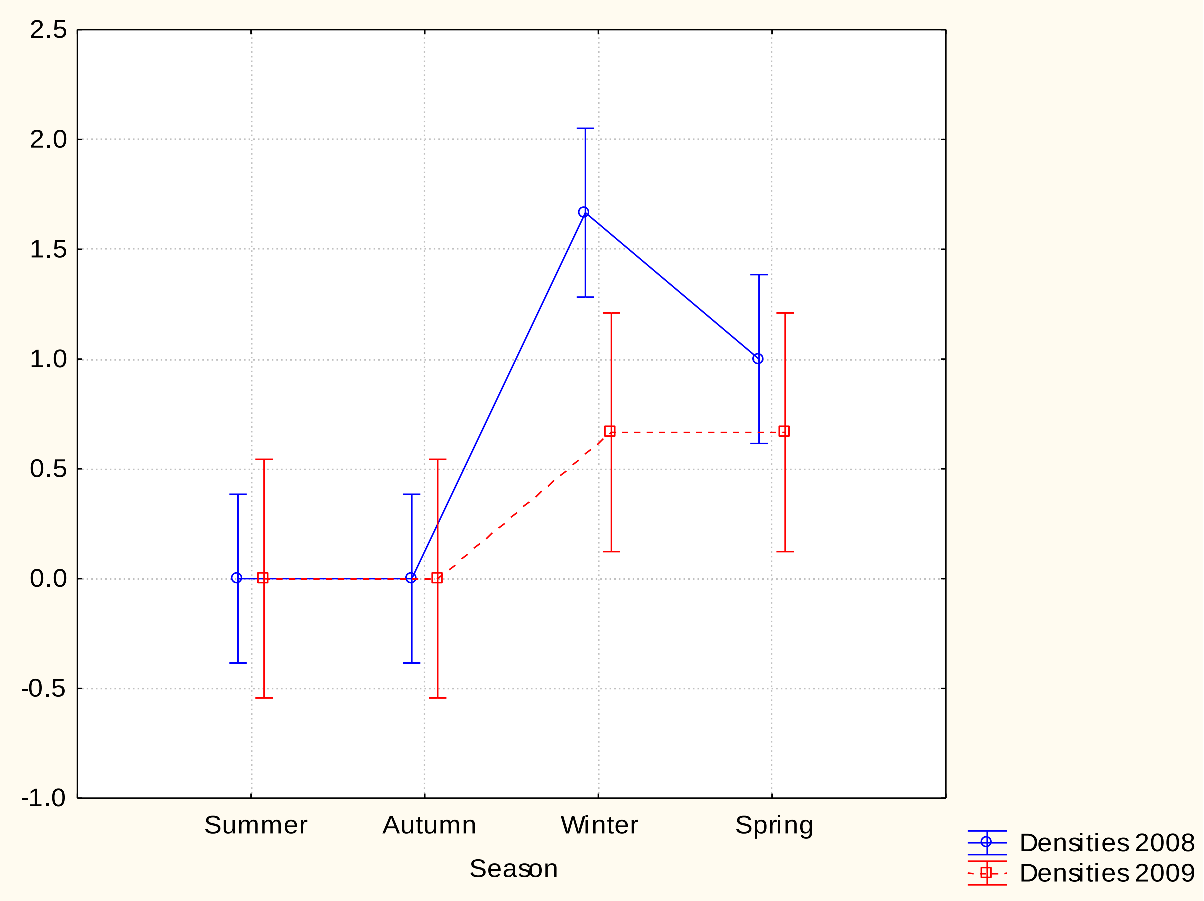

Figure 182. Graph depicting seasonal *Dendromus melanotis* population estimates in 2008 and 2009 recorded in the Moist Degraded Grassland vegetation community.

The seasonal mean population estimate for *D. melanotis* recorded in the Moist Degraded Grassland community indicate that winter has the highest population estimates (4 animals per ha), followed by spring (2 animals per ha), with no animals recorded in summer and autumn (Figure 183). ANOVA revealed a significant difference between in the mean population estimate and season in the Moist Degraded Grassland community ($F_{1.3}$ = 7.333; $n$ = 6; $P$ = 0.011). Population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.01); autumn and winter (Tukey's: $P$ = 0.010.

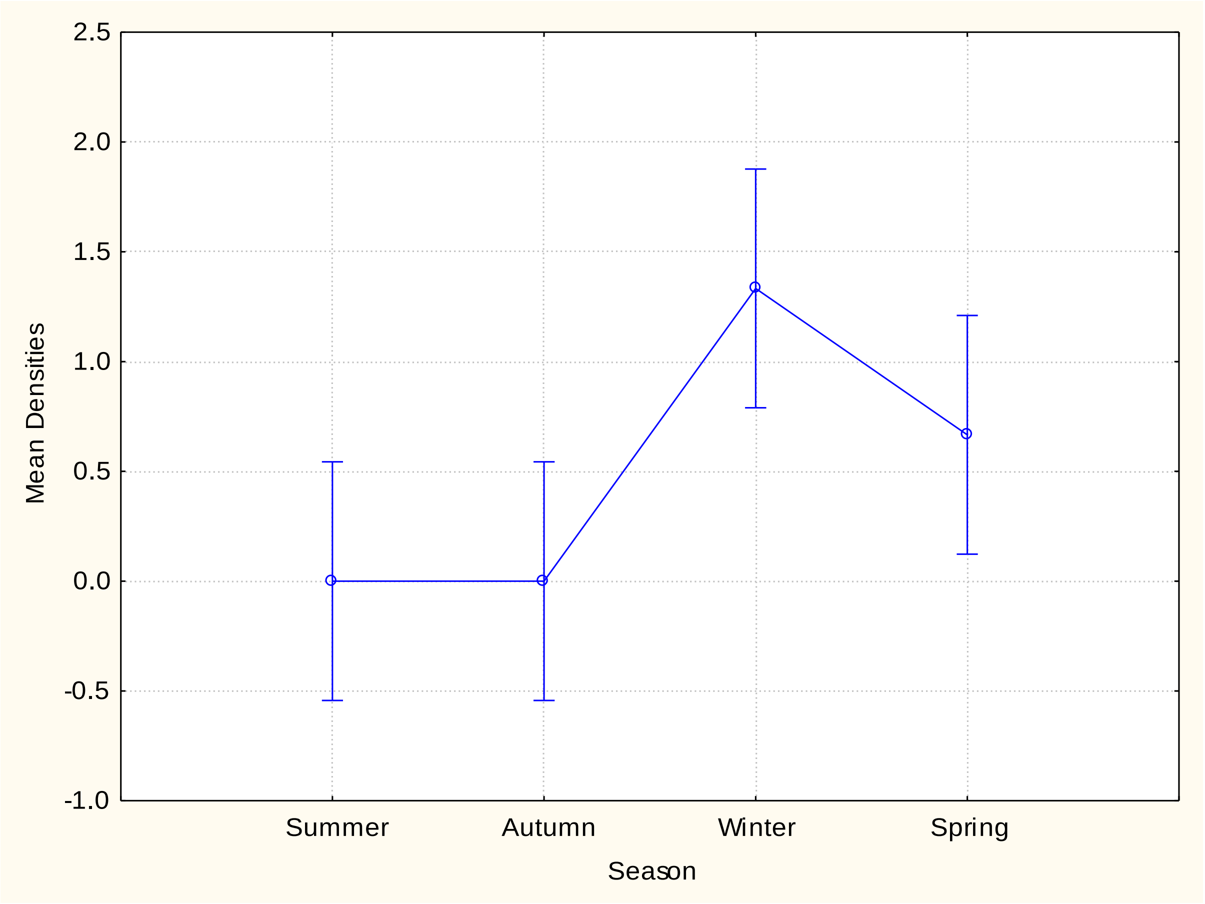

Figure 183. Graph depicting mean *Dendromus melanotis* population estimates recorded in Moist Degraded Grassland during the study period.

The mean population estimate of *D. melanotis* recorded for Moist Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 2 small mammals per ha. The community is recorded to cover 894 ha of the property, therefore a population estimate of 1 788 *D. melanotis* are estimated to occur in the Moist Degraded Grassland community at the study site.

10.9.2. Seasonal population estimates recorded for *Dendromus mystacalis* in the Moist Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates for *D. mystacalis* in Moist Degraded Grassland in year 1 harboured highest densities in winter (2 animals per ha), with no animals being recorded in summer, autumn and spring (Fig. 184). ANOVA revealed an insignificant difference in population estimate between *S. pratensis* and season ($F_{1.3}$ = 1.000; $n$ = 2; $P$ = 0.441) in the Moist Degraded Grassland community in year 1. No individuals were recorded in the Moist Degraded Grassland community during year 2 of the study.

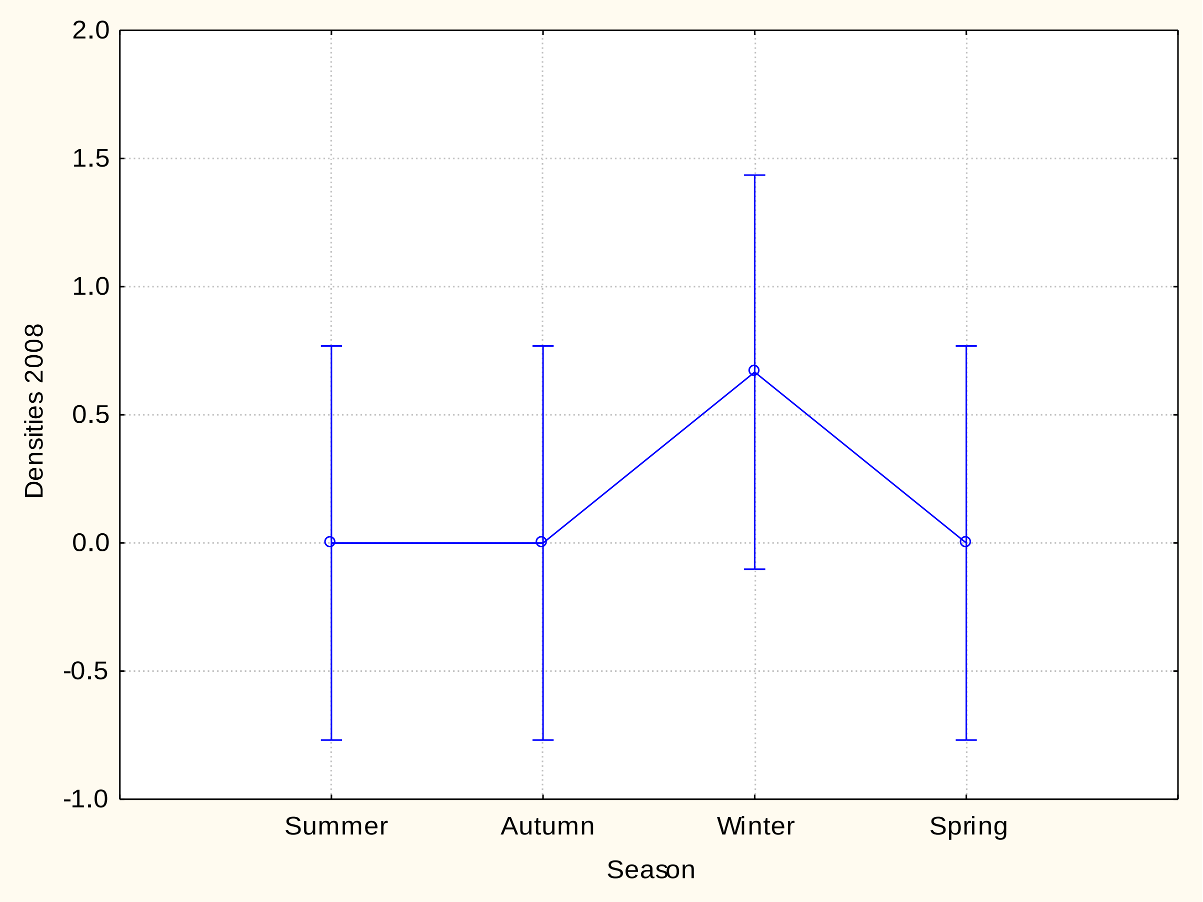

Figure 184. Graph depicting mean *Dendromus mystacalis* population estimates recorded in Moist Degraded Grassland during the study period.

The mean population estimate of *D. mystacalis* recorded in the Moist Degraded Grassland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal per ha. This community covers 894 ha of the property, therefore a population estimate of 894 *D. mystacalis* are estimated to occur in the Moist Degraded Grassland community on the property.

### 10.9.3. Seasonal population estimates recorded for *Mastomys* spp. in the Moist Degraded Grassland community on Telperion

The population estimates recorded for *Mastomys* spp. in Moist Degraded Grassland in year 1 indicate the highest density per ha in spring (3 animals per ha), with no animals being recorded in summer, autumn and winter (Fig. 185). ANOVA revealed an insignificant difference in population estimate between *S. pratensis* and season ($F_{1.3}$ = 3.000; $n$ = 3; $P$ = 0.095) in the Moist Degraded Grassland community in year 1. The population estimates recorded in Moist Degraded Grassland in year 2 indicate the highest density per ha in spring (5 animals per ha), with no animals being recorded in summer, autumn and winter (Fig. 185). ANOVA revealed a significant difference between population estimate for *Mastomys* spp. and season in the Moist Degraded Grassland community ($F_{1.3}$ = 25.000; $n$ = 5; $P$ = 0.000). Population estimates are significantly different in summer and spring (Tukey's: $P$ = 0.00); autumn and spring (Tukey's: $P$ = 0.00); and winter and spring (Tukey's: $P$ = 0.00).

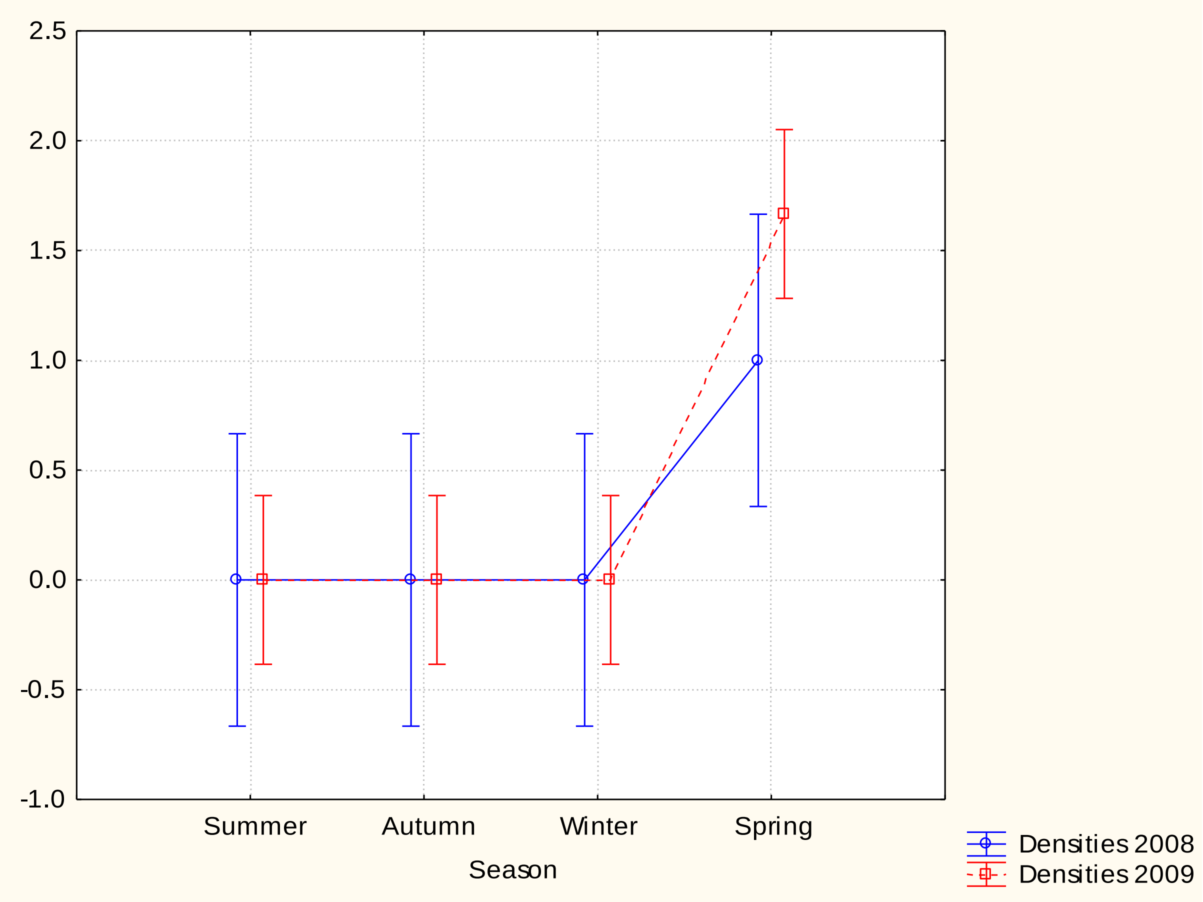

Figure 185. Graph depicting seasonal *Mastomys* spp. population estimates in 2008 and 2009 recorded in the Moist Degraded Grassland vegetation community.

The seasonal mean population estimate for *Mastomys* spp. recorded in the Moist Degraded Grassland community indicate that spring has the highest population estimates (4 animals per ha), with no animals recorded in summer, autumn and winter (Figure 186). ANOVA revealed a weak, but significant difference between mean minimum *Mastomys* spp. density and season in the Moist Degraded Grassland community ($F_{1.3}$ = 4.000; $n$ = 4; $P$ = 0.052).

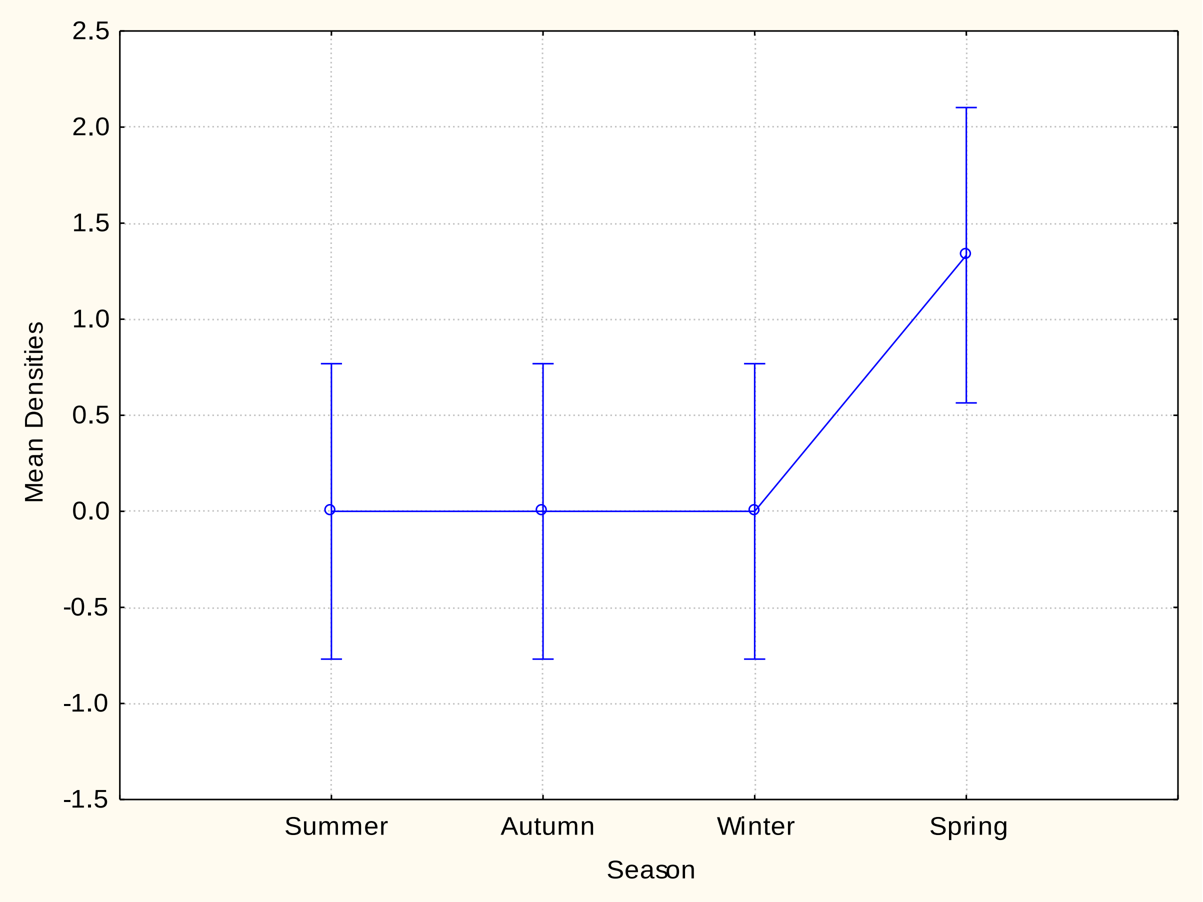

Figure 186. Graph depicting mean *Mastomys* spp. population estimates recorded in Moist Degraded Grassland during the study period.

The mean population estimate of *Mastomys* spp. recorded for Moist Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammals per ha. The community is recorded to cover 894 ha of the property, therefore a population estimate of 894 *Mastomys* spp. is estimated to occur in the Moist Degraded Grassland community at the study site.

10.9.4. Seasonal population estimates recorded for *Mus minutoides* in the Moist Degraded Grassland community on Telperion

No individuals were recorded in the Moist Degraded Grassland community during year 1 of the study. The population estimates for *M. minutoides* in Moist Degraded Grassland in year 2 harboured highest densities in autumn and winter (2 animals per ha), with no animals being recorded in summer and spring (Fig. 187). ANOVA revealed an insignificant difference in population estimate between *S. pratensis* and season ($F_{1.3}$ = 0.667; $n$ = 4; $P$ = 0.596) in the Moist Degraded Grassland community in year 2.

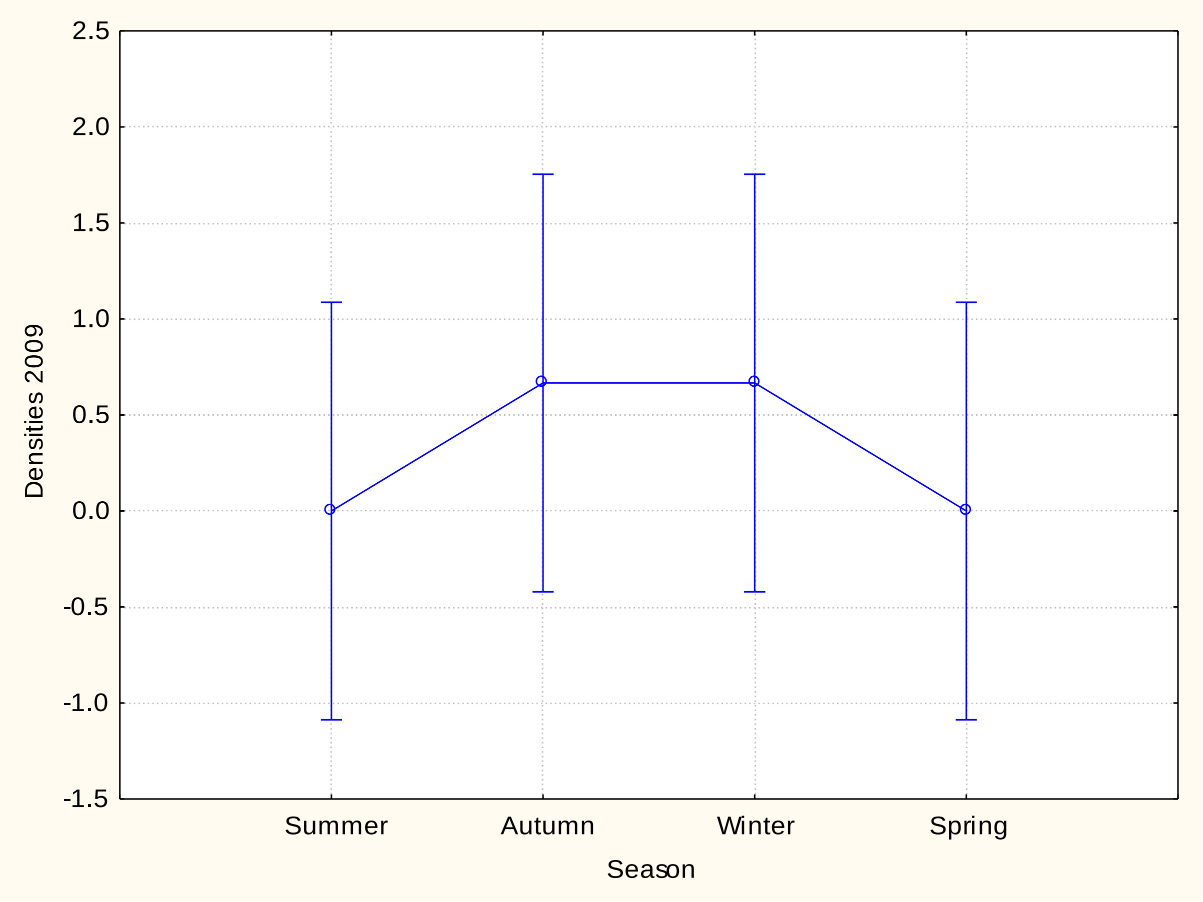

Figure 187. Graph depicting mean *Mus minutoides* population estimates recorded in Moist Degraded Grassland during the study period.

The mean population estimate of *M. minutoides* recorded in the Moist Degraded Grassland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal per ha. This community covers 894 ha of the property, therefore a population estimate of 894 *M. minutoides* are estimated to occur in the Moist Degraded Grassland community on the property.

### 10.9.5. Seasonal population estimates recorded for *Otomys irroratus* in the Moist Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded in the Moist Degraded Grassland community during year 1 of the study. The population estimates for *O. irroratus* in Moist Degraded Grassland in year 2 harboured highest densities in winter (4 animals per ha), followed by autumn (2 animals per ha), with no animals being recorded in summer and spring (Fig. 188). ANOVA revealed a significant difference between population estimate of *O. irroratus* and season in the Moist Degraded Grassland community ($F_{1.3}$ = 7.333; $n$ = 6; $P$ = 0.011). Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.01); and winter and spring (Tukey's: $P$ = 0.01).

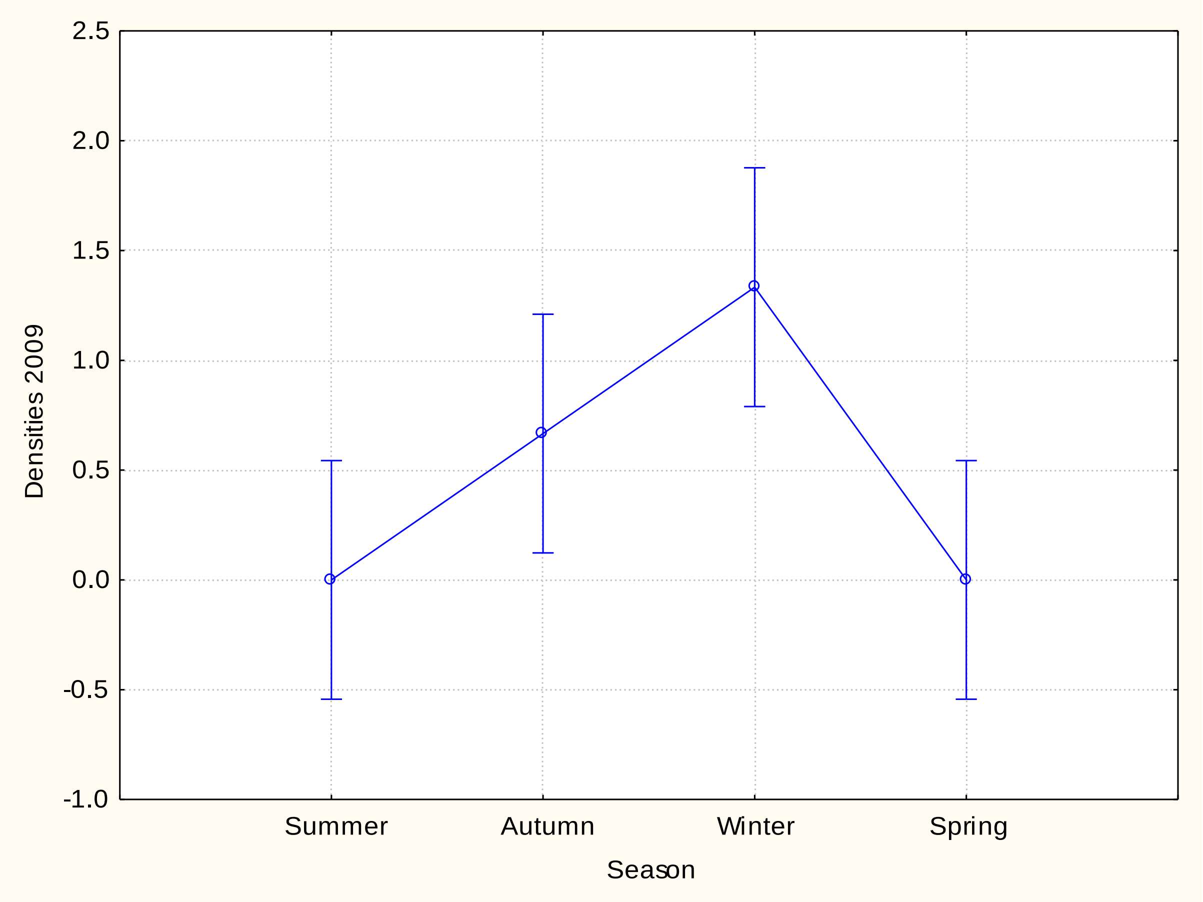

Figure 188. Graph depicting mean *Otomoys irroratus* population estimates recorded in Moist Degraded Grassland during the study period.

The mean population estimate of *O. irroratus* recorded in the Moist Degraded Grassland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 2 small mammal per ha. This community covers 894 ha of the property, therefore a population estimate of 1 788 *O. irroratus* are estimated to occur in the Moist Degraded Grassland community at the study site.

### 10.9.6. Seasonal population estimates recorded for *Rhabdomys pumilio* in the Moist Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

No individuals were recorded in the Moist Degraded Grassland community during year 1 of the study. The population estimates for *R. pumilio* in Moist Degraded Grassland in year 2 harboured highest densities in winter (15 animals per ha), followed by autumn (3 animals per ha), with no animals being recorded in summer and spring (Fig. 189). ANOVA revealed a significant difference between population estimate and season in the Moist Degraded Grassland community in year 2 ($F_{1.3}$ = 68.000; $n$ = 18; $P$ = 0.000). Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.00); autumn and winter (Tukey's: $P$ = 0.00); and winter and spring (Tukey's: $P$ = 0.00).

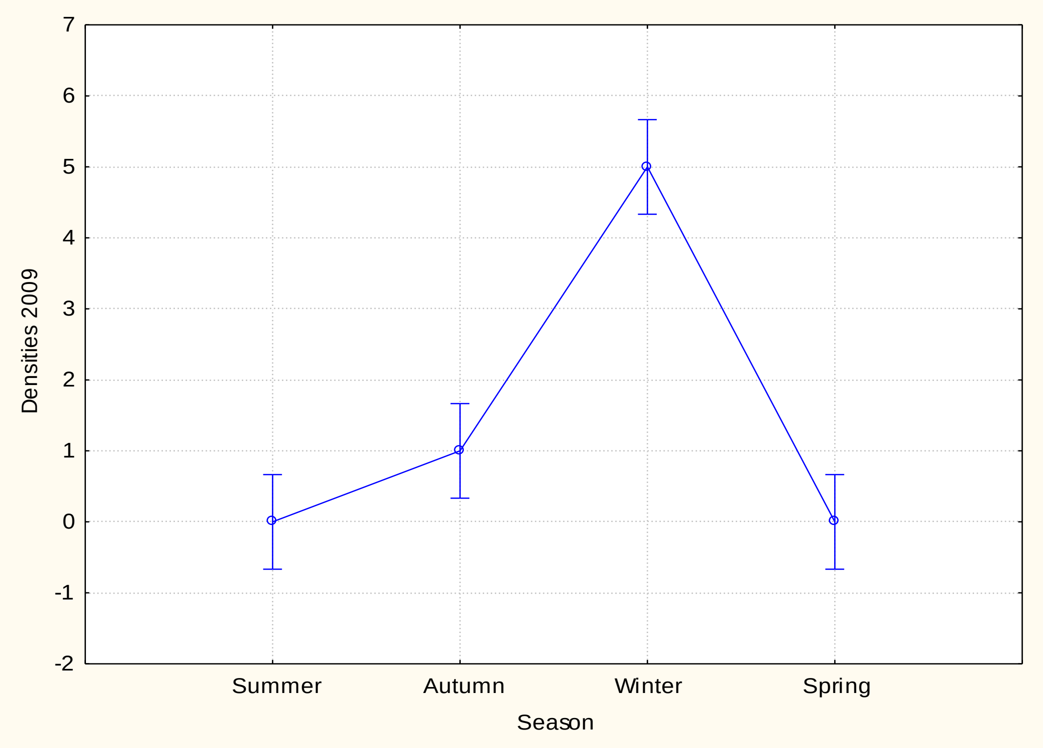

Figure 189. Graph depicting mean *Rhabdomys pumilio* population estimates recorded in Moist Degraded Grassland during the study period.

The mean population estimate of *R. pumilio* recorded in the Moist Degraded Grassland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 5 small mammal per ha. This community covers 894 ha of the property, therefore a population estimate of 4 470 *R. pumilio* are estimated to occur in the Moist Degraded Grassland community at the study site.

### 10.9.7. Seasonal population estimates recorded for *Crocidura mariquensis* in the Moist Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *C. mariquensis* in Moist Degraded Grassland in year 1 indicate the highest density per ha in spring (2 animals per ha), with no animals being recorded in summer, autumn and winter (Fig. 190). ANOVA revealed an insignificant difference in population estimate between *between S. pratensis* and season ($F_{1.3}$ = 1.000; $n$ = 2; $P$ = 0.441) in the Moist Degraded Grassland community in year 1. The population estimates recorded in Moist Degraded Grassland in year 2 indicate the highest density per ha in winter (10 animals per ha), followed by summer (5 animals per ha), with no animals being recorded in autumn and spring (Fig. 190). ANOVA revealed a significant difference between population estimate of *C. mariquensis* and season in the Moist Degraded Grassland community ($F_{1.3}$ = 45.833; $n$ = 15; $P$ = 0.000). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.00), summer and winter (Tukey's: $P$ = 0.00), summer and spring (Tukey's: $P$ = 0.00); autumn and winter (Tukey's: $P$ = 0.00); and winter and spring (Tukey's: $P$ = 0.00).

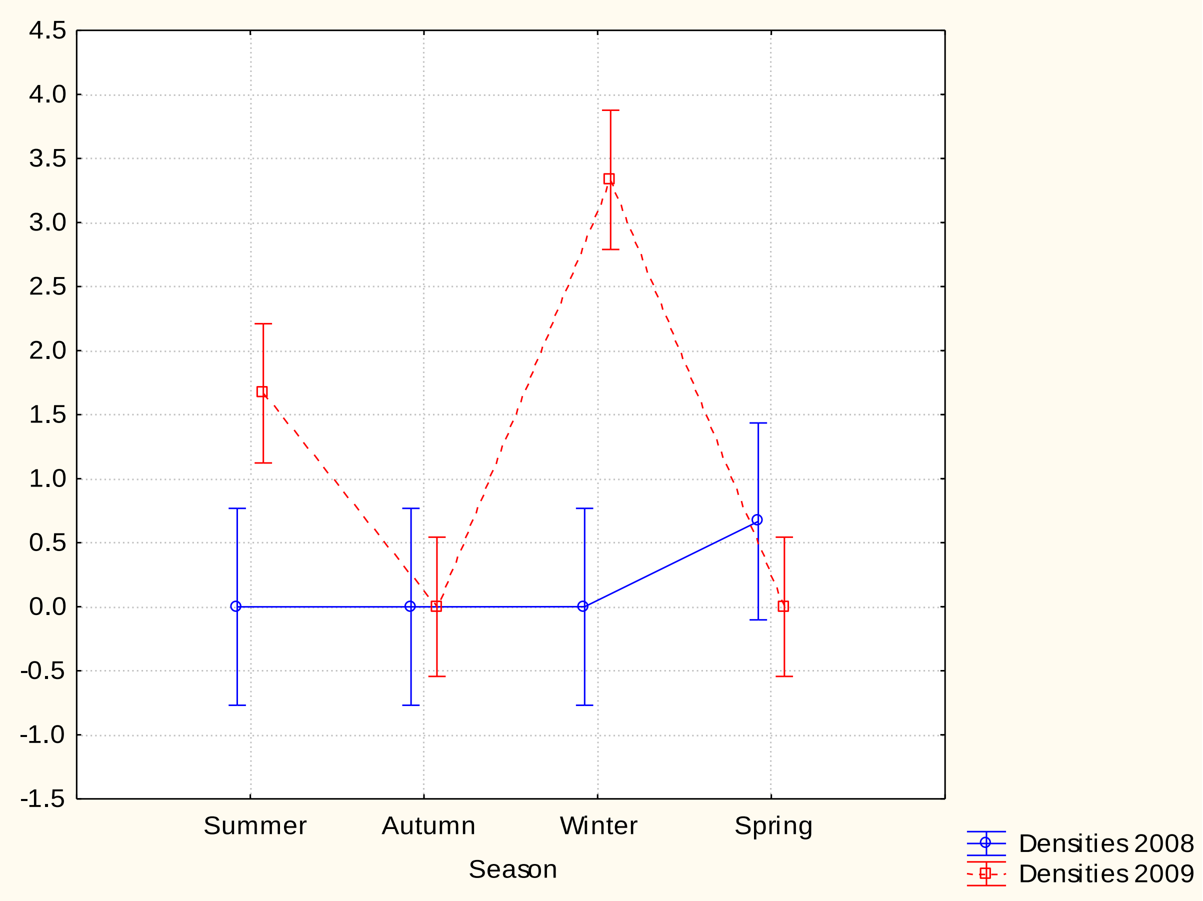

Figure 190. Graph depicting seasonal *Crocidura mariquensis* population estimates in 2008 and 2009 recorded in the Moist Degraded Grassland vegetation community.

The seasonal mean population estimate for *C. mariquensis* recorded in the Moist Degraded Grassland community indicate that winter has the highest population estimates (5 animals per ha), followed by summer (3 animals per ha), spring (2 animals per ha), with no animals recorded in autumn (Figure 191). ANOVA revealed a significant difference between population estimate for *C. mariquensis* and season in the Moist Degraded Grassland community ($F_{1.3} = 8.667$; $n = 10$; $P = 0.007$). Population estimates are significantly different in autumn and winter (Tukey's: $P = 0.00$).

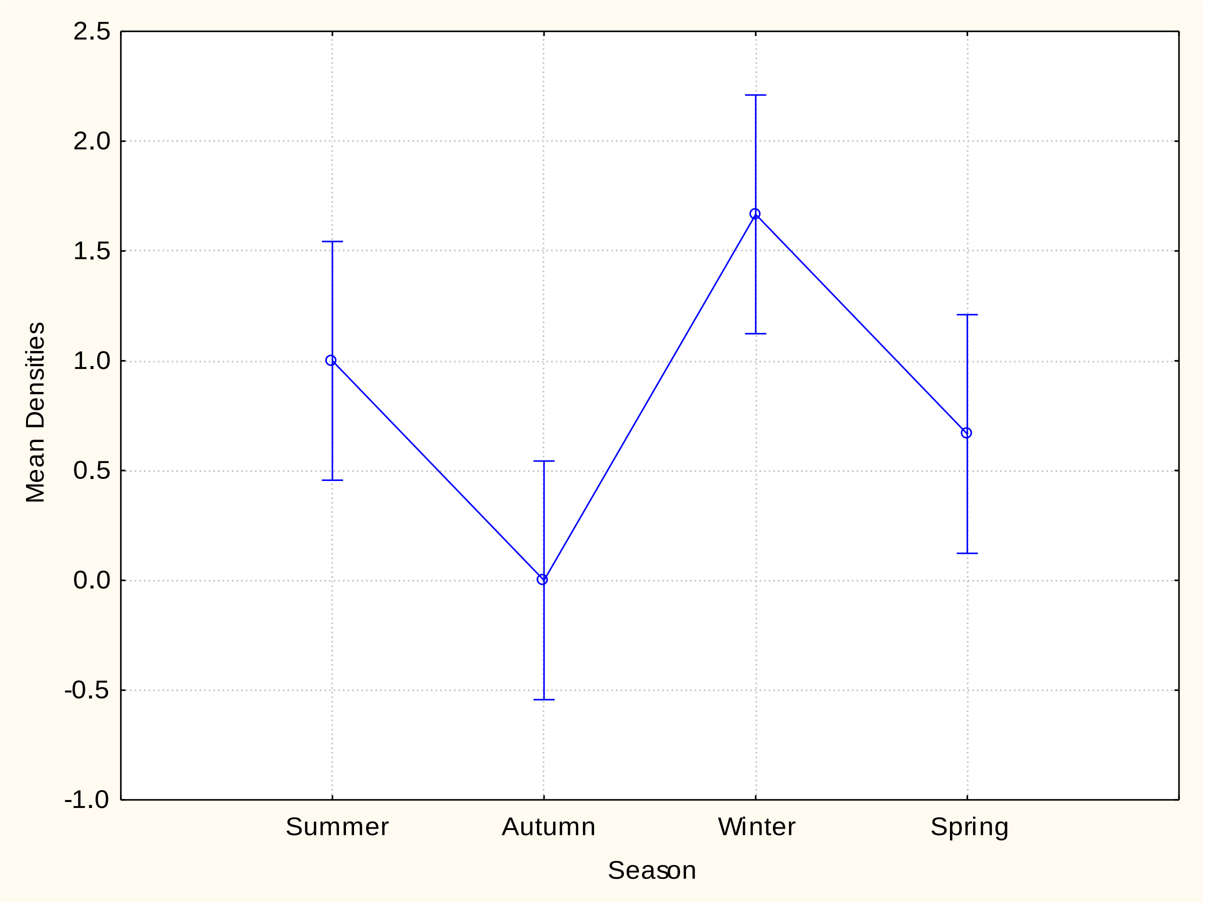

Figure 191. Graph depicting mean *Crocidura mariquensis* population estimates recorded in Moist Degraded Grassland during the study period.

The mean population estimate of *C. mariquensis* recorded for Moist Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 3 small mammals per ha. The community is recorded to cover 894 ha of the property, therefore a population estimate of 2 682 *C. mariquensis* are estimated to occur in the Moist Degraded Grassland community at the study site.

10.9.8. Seasonal population estimates recorded for *Crocidura cyanea* in the Moist Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates for *C. cyanea* in Moist Degraded Grassland in year 1 harboured highest densities in winter (2 animals per ha), with no animals being recorded in summer, autumn and spring (Fig. 192). ANOVA revealed an insignificant difference in population estimate between *C. cyanea* and season ($F_{1.3}$ = 1.000; $n$ = 2; $P$ = 0.441) in the

Moist Degraded Grassland community in year 1. No individuals were recorded in the Moist Degraded Grassland community during year 2 of the study.

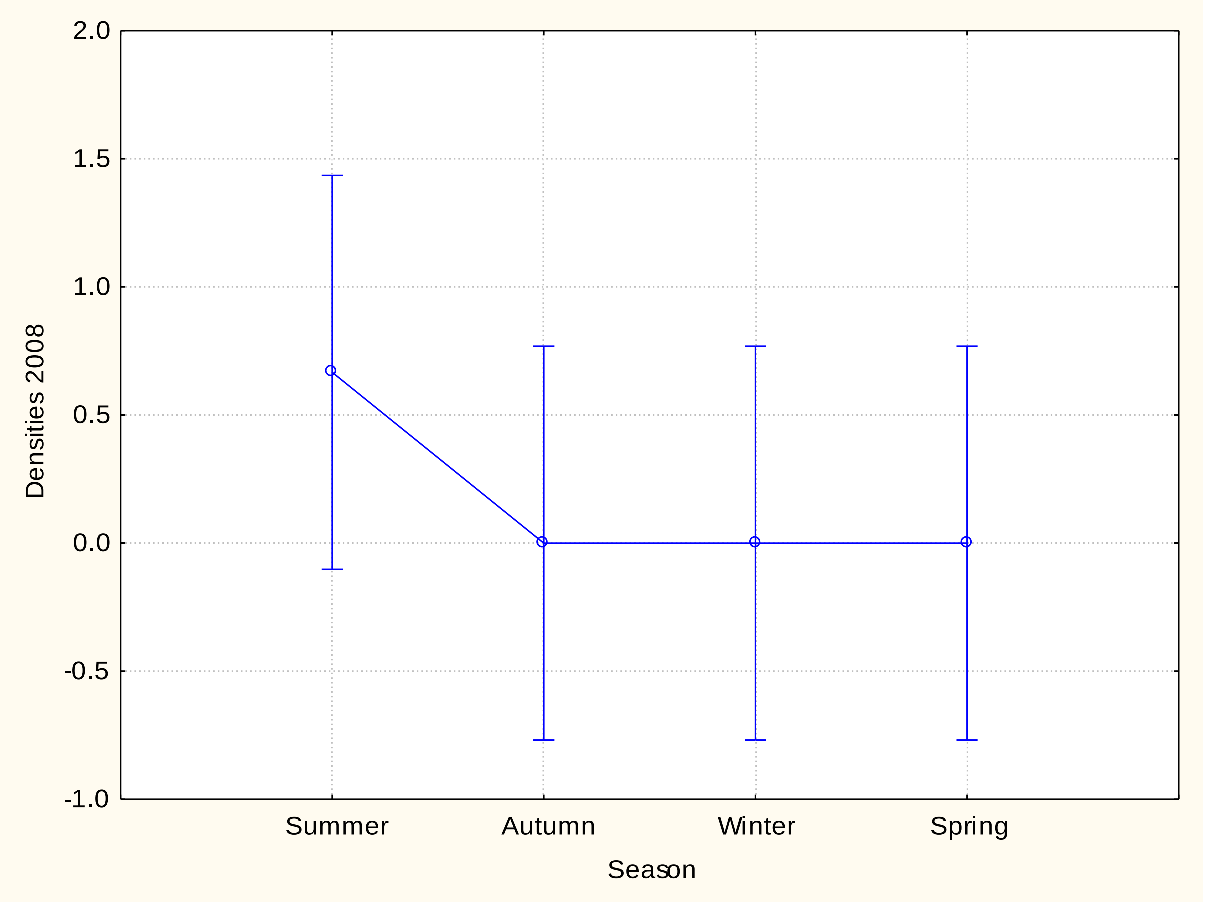

Figure 192. Graph depicting mean *Crocidura cyanea* population estimates recorded in Moist Degraded Grassland during the study period.

The mean population estimate of *C. cyanea* recorded in the Moist Degraded Grassland community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 1 small mammal for every 2 hectares. This community covers 894 ha of the property, therefore a population estimate of 447 *C. cyanea* are estimated to occur in the Moist Degraded Grassland community on the property.

10.9.9. Seasonal population estimates recorded for *Suncus infinitesimus* in the Moist Degraded Grassland community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *S. infinitesimus* in Moist Degraded Grassland in year 1 indicate the highest density per ha in winter (3 animals per ha), with no animals being recorded in summer, autumn and spring (Fig. 193). ANOVA revealed an insignificant difference in population estimate between *S. infinitesimus* and season ($F_{1.3} = 3.000$; $n = 3$; $P = 0.095$) in the Moist Degraded Grassland community in year 1. The population estimates recorded in Moist Degraded Grassland in year 2 indicate the highest density per ha in summer (2 animals per ha), with no animals being recorded in autumn, winter and spring (Fig. 194). ANOVA revealed an insignificant difference in population estimate between *S. infinitesimus* and season ($F_{1.3} = 1.000$; $n = 2$; $P = 0.441$) in the Moist Degraded Grassland community in year 2.

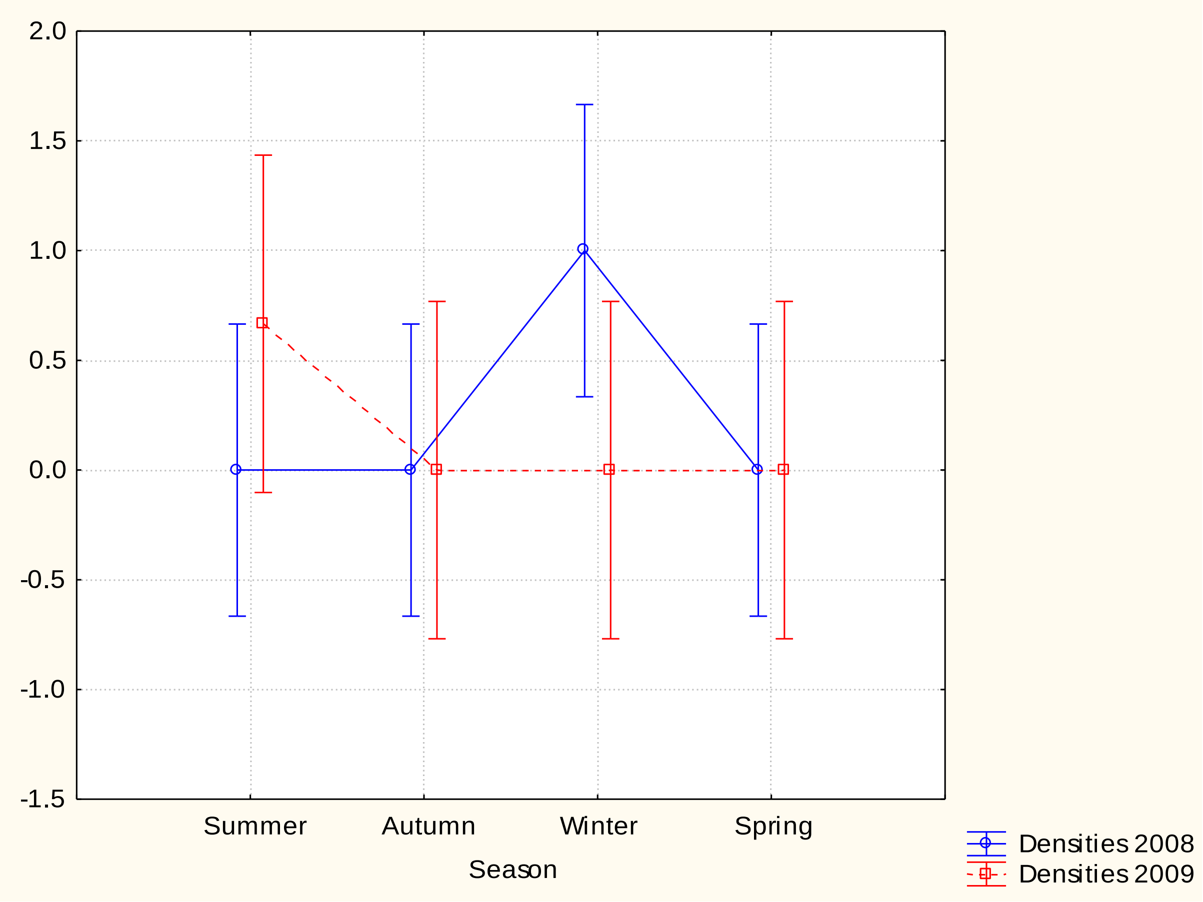

Figure 193. Graph depicting seasonal *Suncus infinitesimus* population estimates in 2008 and 2009 recorded in the Moist Degraded Grassland vegetation community.

The seasonal mean population estimate for *S. infinitesimus* recorded in the Moist Degraded Grassland community indicate that winter and summer have the highest population estimates (2 animals per ha), with no animals recorded in autumn and spring (Figure 194).

ANOVA revealed an insignificant difference between mean population estimate between *S. infinitesimus* and season ($F_{1.3}$ = 0.667; $n$ = 4; $P$ = 0.596) in the Moist Degraded Grassland community.

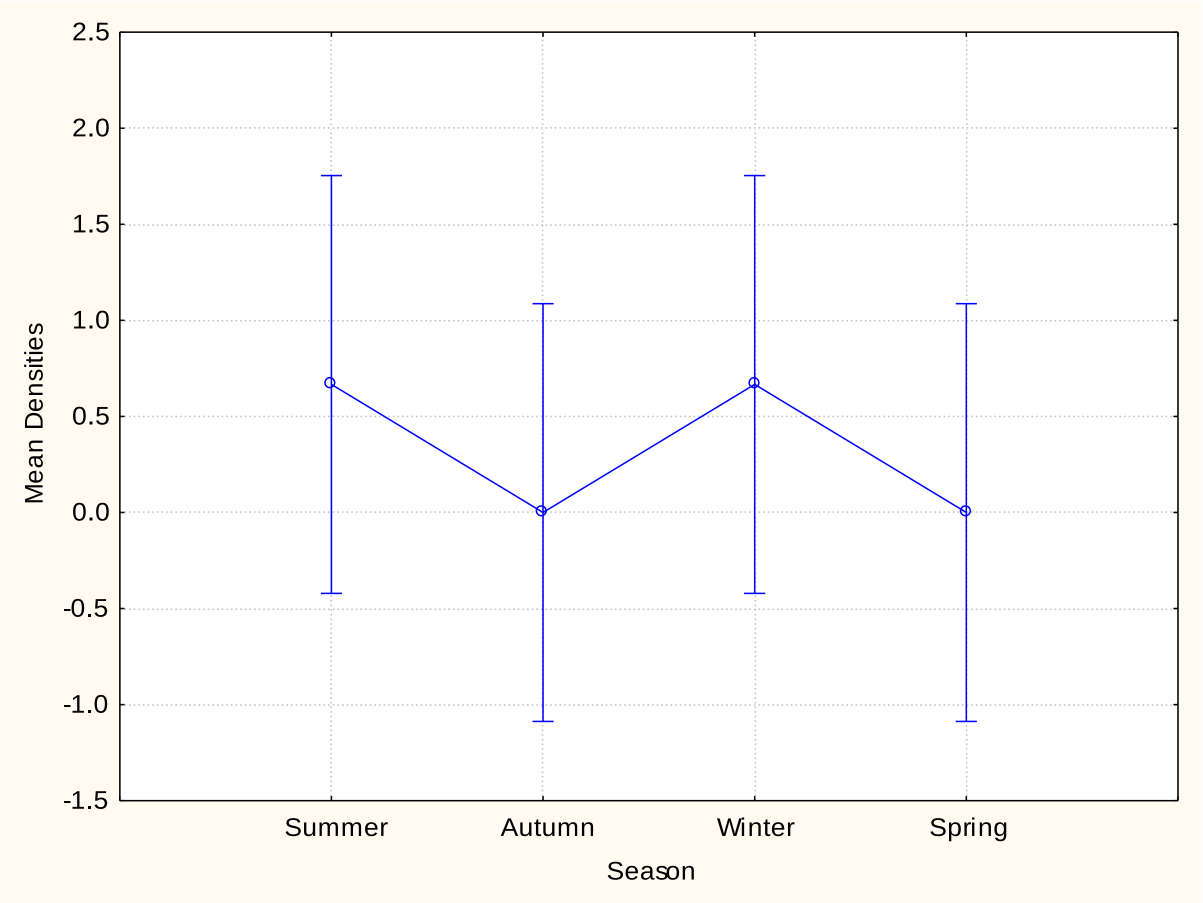

Figure 194. Graph depicting mean *Suncus infinitesimus* population estimates recorded in Moist Degraded Grassland during the study period.

The mean population estimate of *S. infinitesimus* recorded for Moist Degraded Grassland is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 3 small mammals per ha. The community is recorded to cover 894 ha of the property, therefore a population estimate of 2 682 *S. infinitesimus* are estimated to occur in the Moist Degraded Grassland community at the study site.

## 10.10. Population estimates recorded for non-volant small mammal assemblages in the Rocky Open Shrub vegetation community.

The Rocky Open Shrub community occupies community occupies a relatively small portion of the property of 7 % and covers an area of 272 ha (Fig. 195).

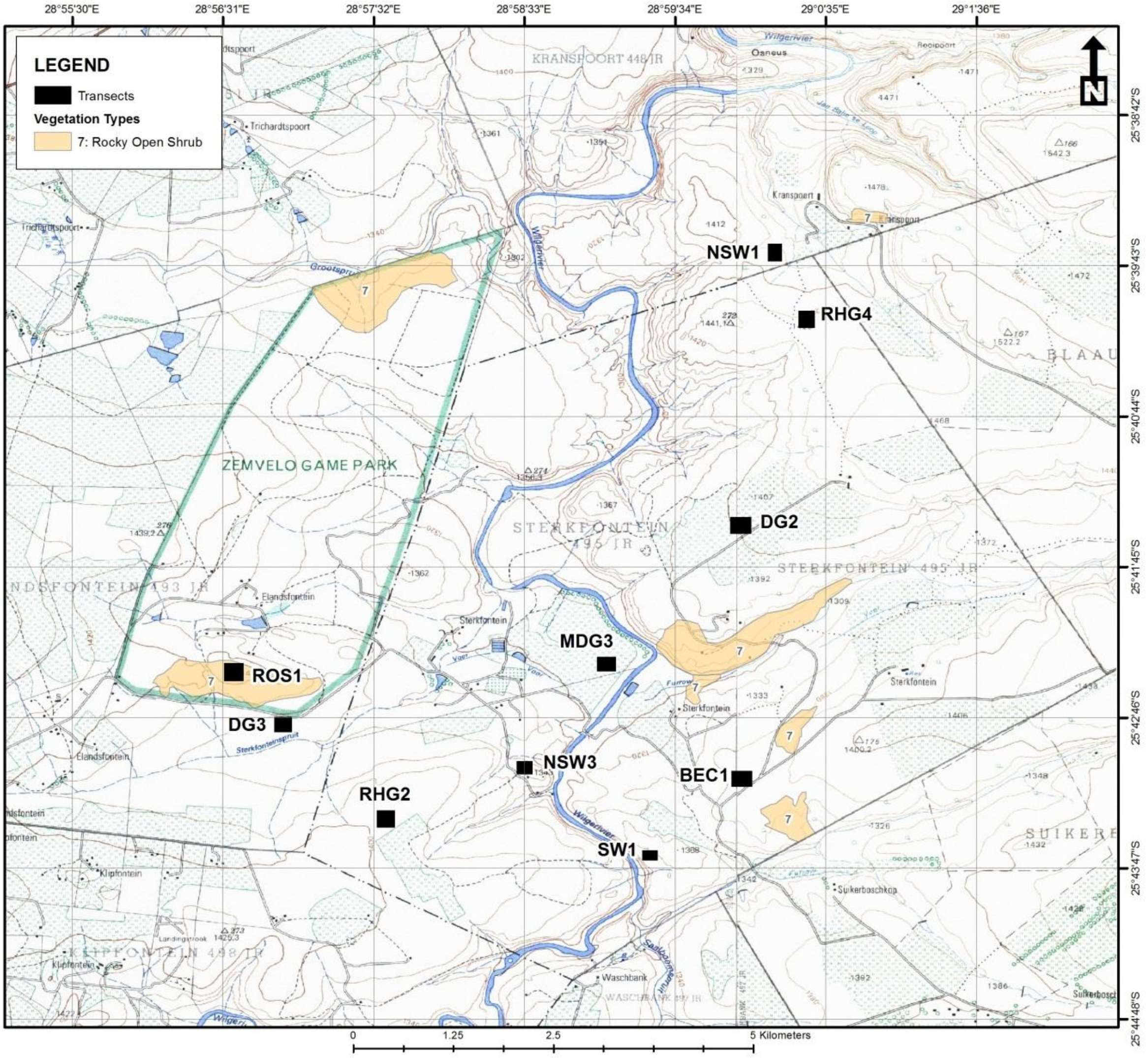

Figure 195. Map of Telperion and Ezemvelo Nature Reserve depicting the areas covered by Rocky Open Shrub (ROS1) habitat at the study site.

ANOVA revealed a significant difference between population estimate and season in the Rocky Open Shrub community in year 1 ($F_{1.3} = 107.267$; $n = 291$; $P = 0.000$). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P = 0.00$), summer and winter (Tukey's: $P = 0.00$), summer and spring (Tukey's: $P = 0.00$); autumn and winter (Tukey's: $P = 0.04$); and winter and spring (Tukey's: $P = 0.04$). The population estimates recorded for Rocky Open Shrub in year 1 indicate the highest density per ha in winter (100 animals per ha), followed by spring (72 animals per ha), autumn (67 animals per ha), and the lowest number recorded in summer (52 animals per ha) (Fig. 196a).

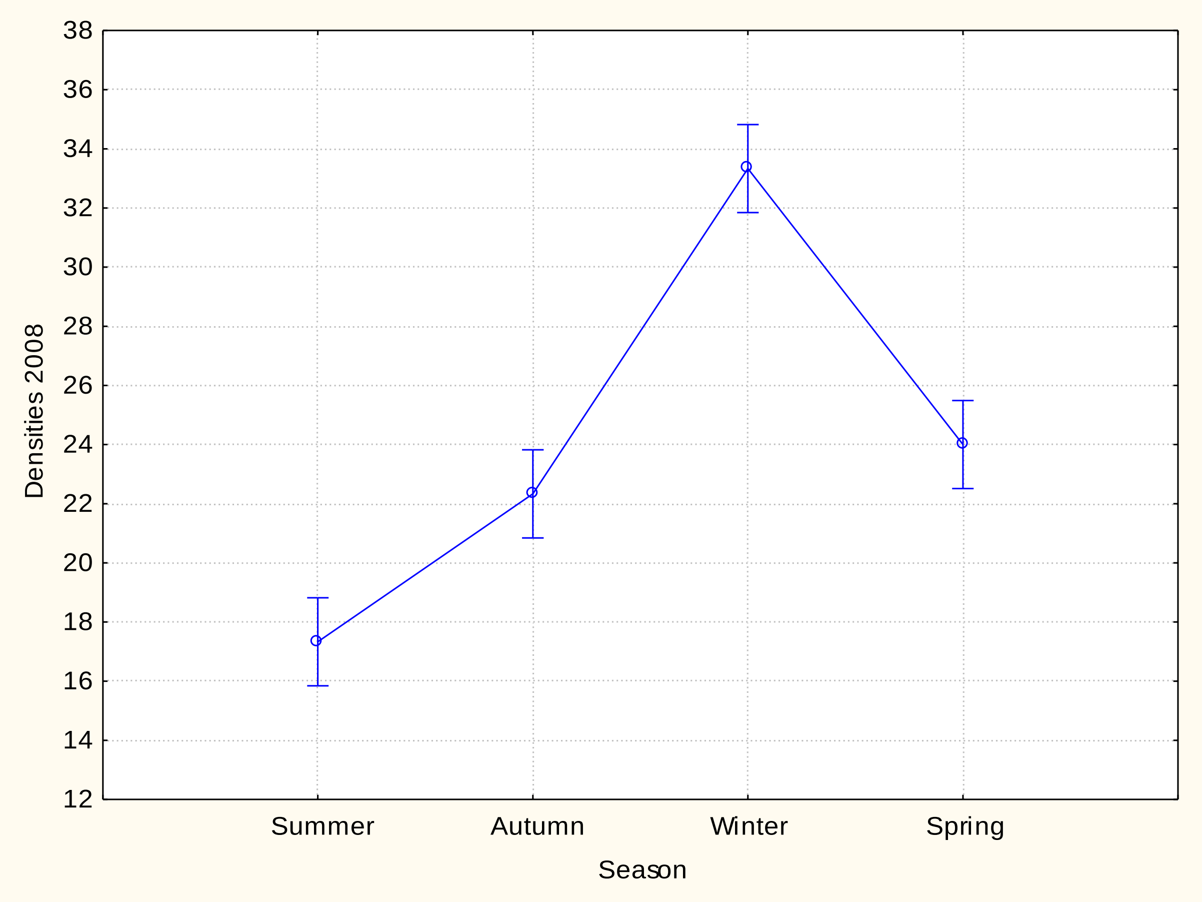

Figure 196a. Graph depicting small mammal population estimates in 2008 recorded in the Rocky Open Shrub community.

ANOVA revealed a highly significant difference between population estimate and season in the Rocky Open Shrub community in year 2 ($F_{1.3}$ = 732.57; $n$ = 388; $P$ = 0.000). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.00), summer and winter (Tukey's: $P$ = 0.00), summer and spring (Tukey's: $P$ = 0.00); autumn and winter (Tukey's: $P$ = 0.00), autumn and spring (Tukey's: $P$ = 0.00); and winter and spring (Tukey's: $P$ = 0.00). The population estimates recorded for Rocky Open Shrub in year 2 indicate the highest density per ha in spring (148 animals per ha), followed by winter (92 animals per ha), summer (83 animals per ha) and the lowest number recorded in autumn (65 animals per ha) (Fig. 196b).

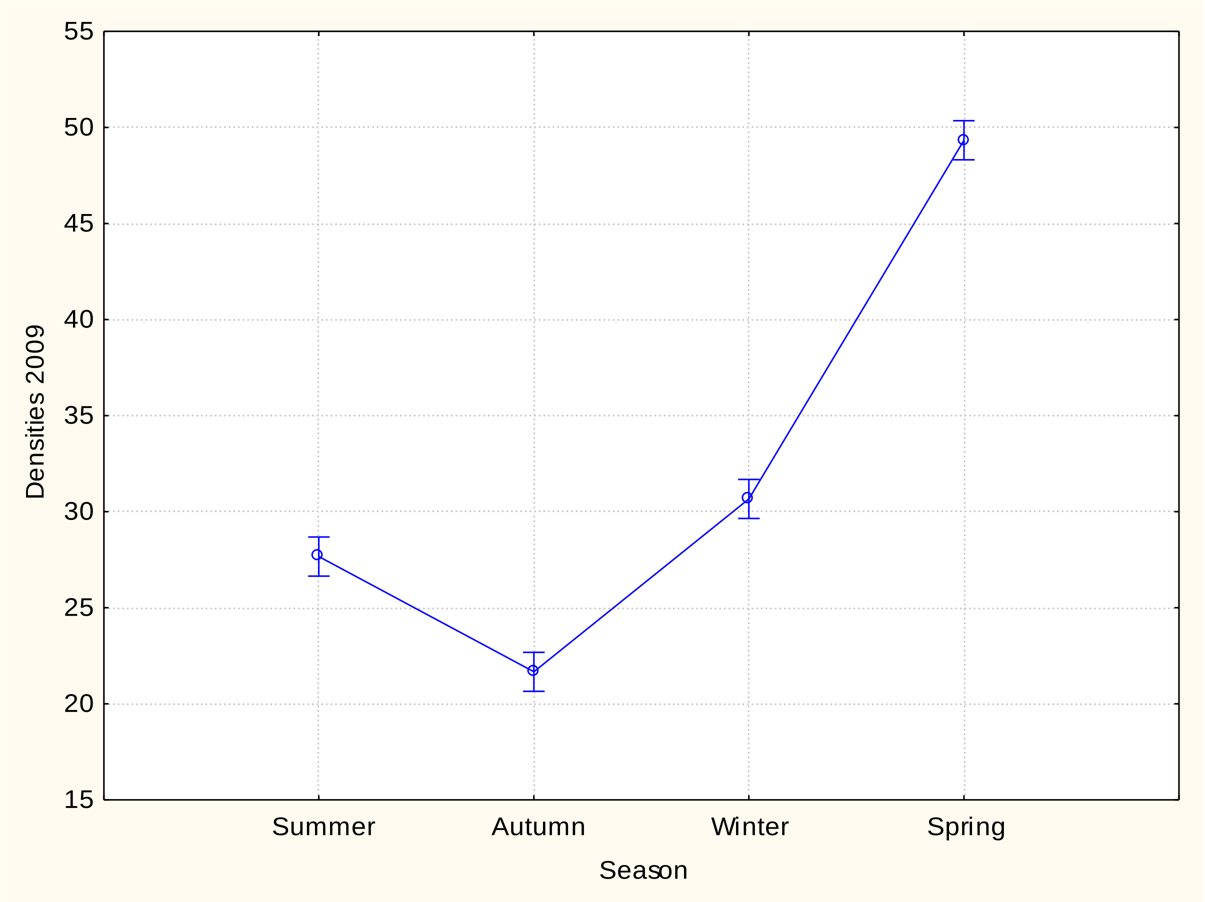

Figure 196b. Graph depicting small mammal population estimates in 2009 recorded in the Rocky Open Shrub community.

ANOVA revealed a highly significant difference between mean population estimate and season in the Rocky Open Shrub community ($F_{1.3}$ = 232.67; $n$ = 340; $P$ = 0.000). Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.00), summer and spring (Tukey's: $P$ = 0.00); autumn and winter (Tukey's: $P$ = 0.00), autumn and spring (Tukey's: $P$ = 0.00); and winter and spring (Tukey's: $P$ = 0.00). The seasonal mean population estimate for small mammals recorded in the Rocky Open Shrub community indicate that spring has the highest densities (110 animals per ha), followed by winter (96 animals per ha), summer (68 animals per ha) and autumn with the lowest recorded number (66 animals per ha) (Figure 197).

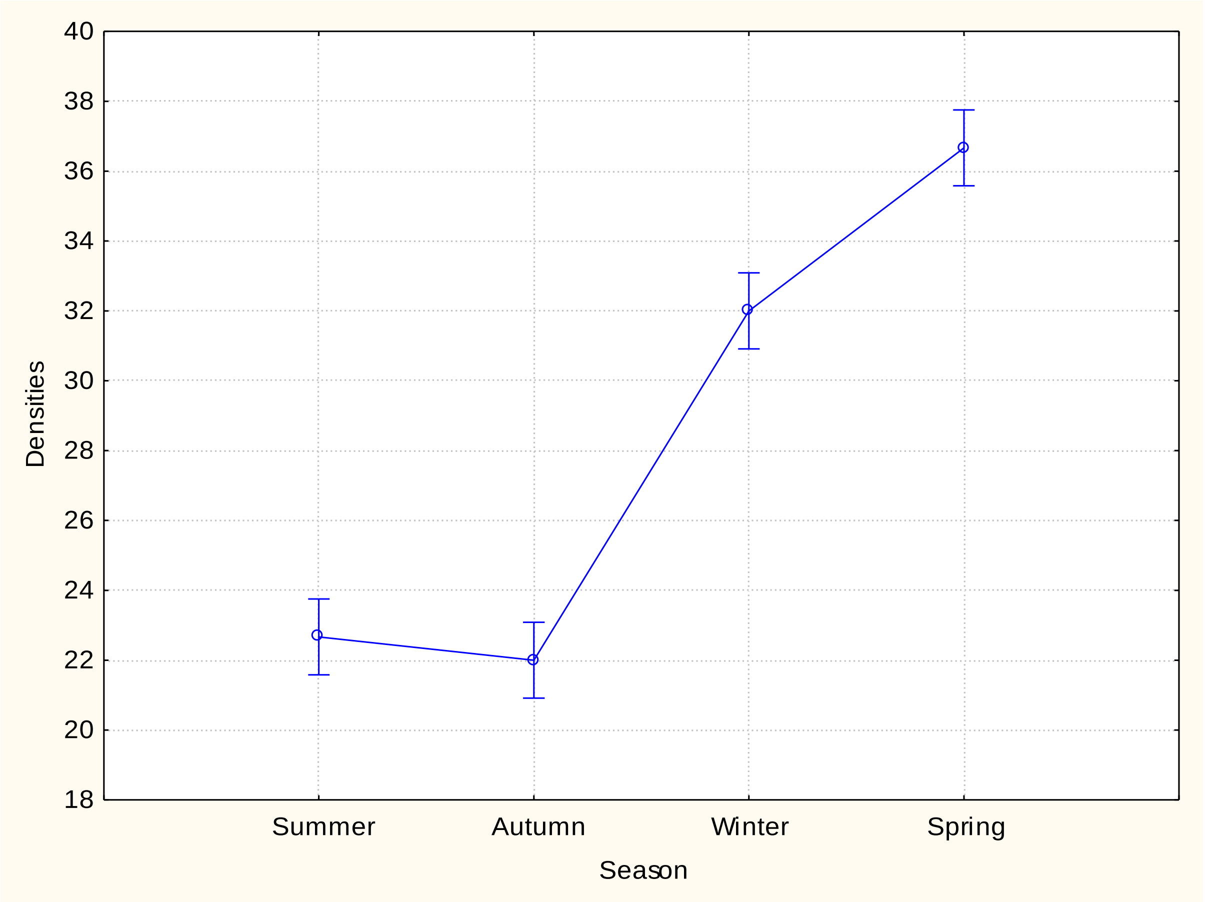

Figure 197. Graph depicting mean small mammal population estimates recorded in the Rocky Open Shrub community during the study period.

The mean population estimate of small mammals recorded for Rocky Open Shrub is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 85 small mammals per ha. The community is recorded to cover 272 ha of the property, therefore a population estimate of 23 120 small mammals are estimated to occur in the Rocky Open Shrub community on the property. Spring and winter often report the highest densities recorded due to the fact that food is less readily available which results in animals been captured more readily. The population estimates were recorded for the following small mammal species seasonally in Rocky Open Shrub during the study.

### 10.10.1. Seasonal population estimates recorded for *Micaelamys namaquensis* in the Rocky Open Shrub community on Telperion and Ezemvelo Nature Reserve

ANOVA revealed a significant difference between population estimate and season in the Rocky Open Shrub community in year 1 ($F_{1.3}$ = 177.111; *n* = 202; *P* = 0.000). The population estimates recorded for *M. namaquensis* in Rocky Open Shrub in year 1 indicate the highest density per ha in winter (67 animals per ha), followed by spring (61 animals per ha), autumn (42 animals per ha), and summer with the lowest recorded density (32 animals per ha) (Fig. 198). Statistically population estimates are significantly different in summer and autumn (Tukey's: *P* = 0.00), summer and winter (Tukey's: *P* = 0.00), summer and spring (Tukey's: *P* = 0.00); autumn and winter (Tukey's: *P* = 0.00), autumn and spring (Tukey's: *P* = 0.00); winter and spring (Tukey's: *P* = 0.03). The population estimates recorded in Rocky Open Shrub in year 2 indicate the highest density per ha in spring (137 animals per ha), followed by summer (70 animals per ha), winter (59 animals per ha) and autumn the lowest recorded density (48 animals per ha) (Fig. 198). ANOVA revealed a significant difference between population estimate and season in the Rocky Open Shrub community in year 2 ($F_{1.3}$ = 1067.78; *n* = 314; *P* = 0.000). Statistically population estimates are significantly different in summer and autumn (Tukey's: *P* = 0.00), summer and winter (Tukey's: *P* = 0.00), summer and spring (Tukey's: *P* = 0.00); autumn and winter (Tukey's: *P* = 0.00), autumn and spring (Tukey's: *P* = 0.00); winter and spring (Tukey's: *P* = 0.00).

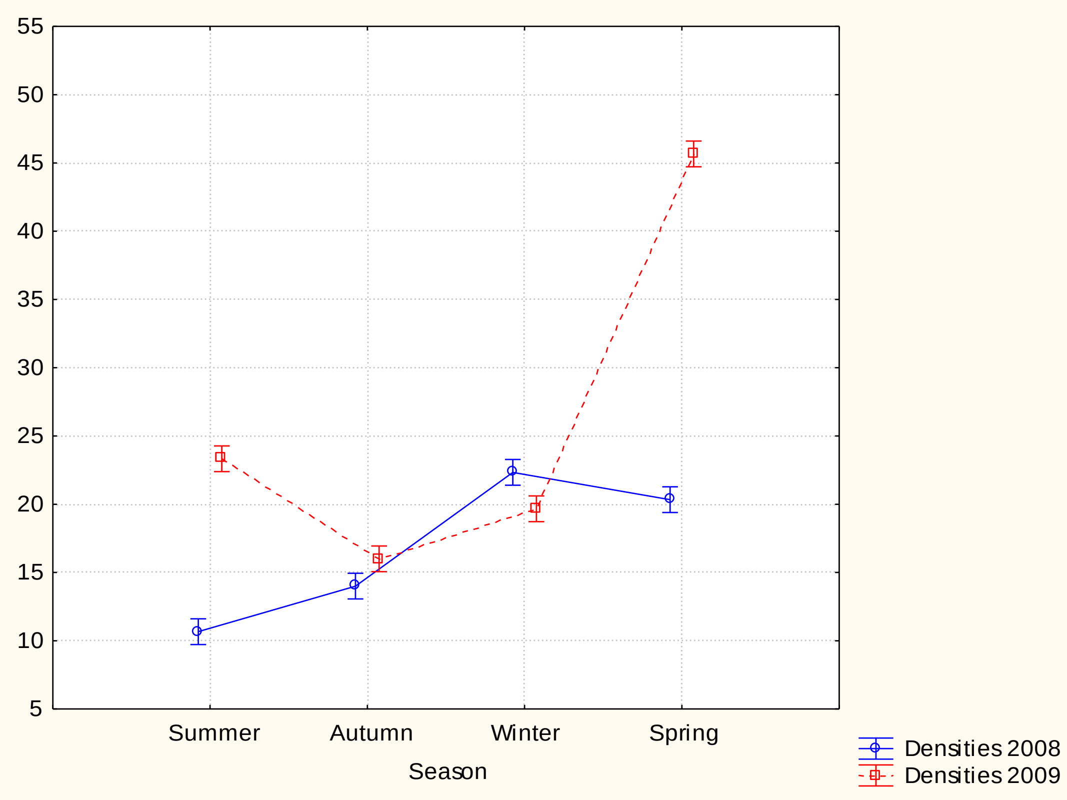

Figure 198. Graph depicting seasonal *Micaelamys namaquensis* population estimates in 2009 recorded in the Rocky Open Shrub vegetation community.

ANOVA revealed a significant difference between mean population estimate and season in the Rocky Open Shrub community ($F_{1.3}$ = 130.000; $n$ = 258; $P$ = 0.000). Statistically population estimates are significantly different in summer and winter (Tukey's: $P$ = 0.01), summer and spring (Tukey's: $P$ = 0.00); autumn and winter (Tukey's: $P$ = 0.00), autumn and spring (Tukey's: $P$ = 0.00); winter and spring (Tukey's: $P$ = 0.00). The seasonal mean population estimate for *M. namaquensis* recorded in the Rocky Open Shrub community indicate that spring has the highest population estimates (99 animals per ha), followed by winter (63 animals per ha), summer (51 animals per ha), and autumn with the lowest recorded density (45 animals per ha) (Fig. 199).

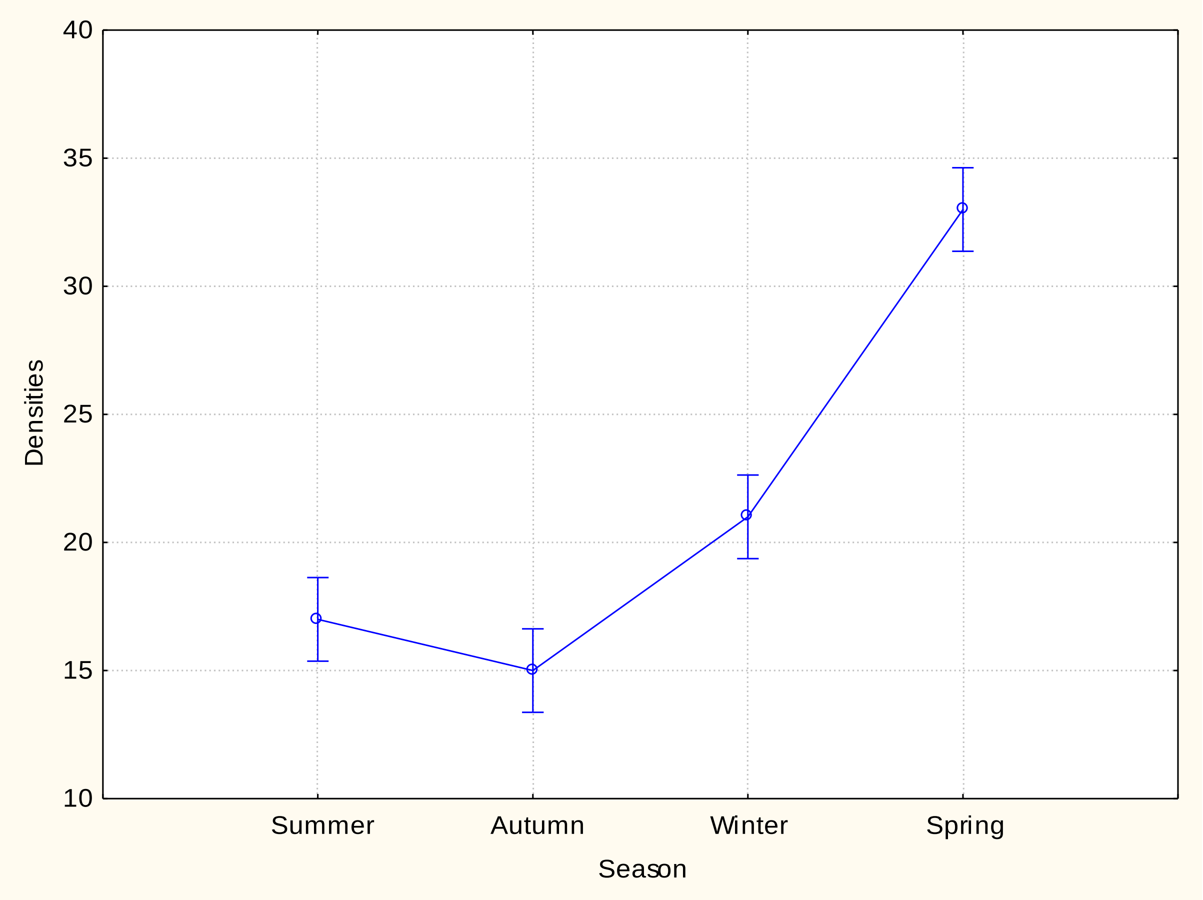

Figure 199. Graph depicting mean *Micaelamys namaquensis* population estimates recorded in Rocky Open Shrub during the study period.

The mean population estimate of *M. namaquensis* recorded for Rocky Open Shrub is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 65 small mammals per ha. The community is recorded to cover 272 ha of the property, therefore a population estimate of 17 680 *M. namaquensis* are estimated to occur in the Rocky Open Shrub community at the study site. Autumn regularly reports that lowest densities due to sufficient food being available after the summer rains and subsequent plant growth and seed production.

### 10.10.2. Seasonal population estimates recorded for *Aethomys chrysophilus* in the Rocky Open Shrub community on Telperion and Ezemvelo Nature Reserve

The population estimates for *A. chrysophilus* in Rocky Open Shrub in year 1 harboured highest densities in summer (4 animals per ha), followed by spring (2 animals per ha), with no animals being recorded in autumn and winter (Fig. 200). ANOVA revealed a significant difference between population estimate between *A. chrysophilus* and season ($F_{1.3}$ = 7.333; $n$ = 6; $P$ = 0.011) in the Rocky Open Shrub community. Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.01), and summer and winter (Tukey's: $P$ = 0.01). No individuals were recorded in the Rocky Open Shrub community during year 2 of the study.

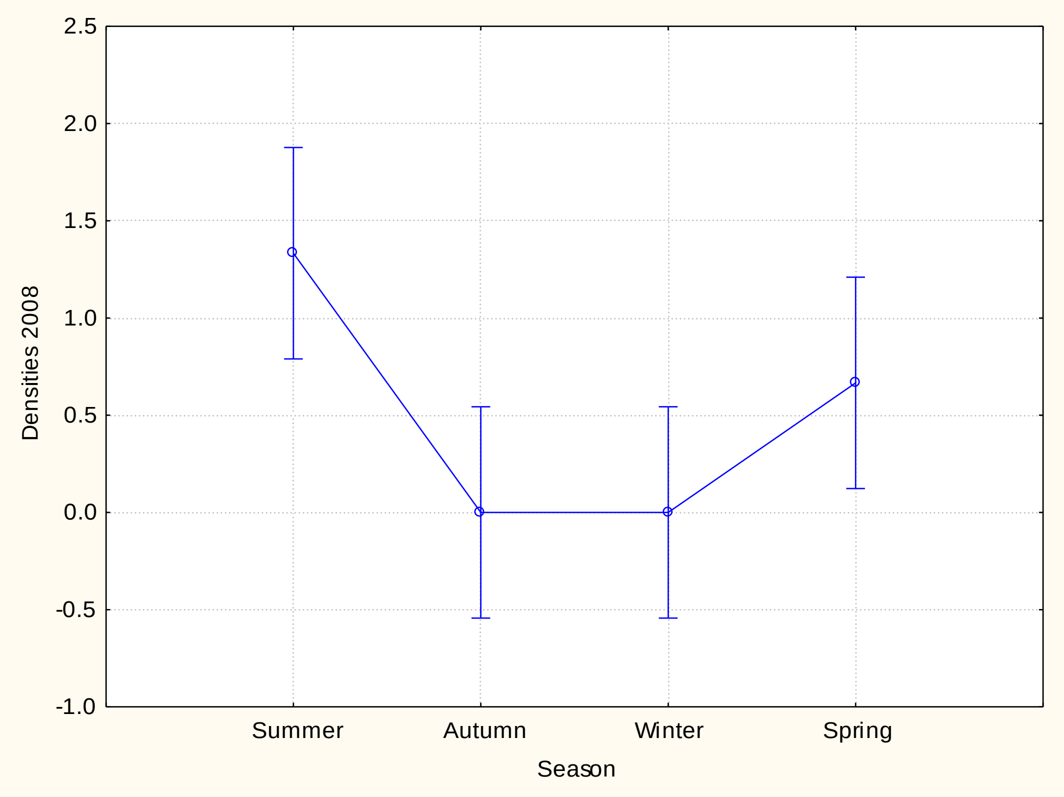

Figure 200. Graph depicting mean *Aethomys chrysophilus* population estimates recorded in Rocky Open Shrub during the study period.

The mean population estimate of *A. chrysophilus* recorded in the Rocky Open Shrub community is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 2 small mammal per ha. This community covers 272 ha of the property, therefore a population estimate of 544 *A. chrysophilus* are estimated to occur in the Rocky Open Shrub community at the study site. This habitat appears marginal for this species, which appeared to frequent the grassy saddles between rock sets.

### 10.10.3. Seasonal population estimates recorded for *Elephantulus myurus* in the Rocky Open Shrub community on Telperion and Ezemvelo Nature Reserve

The population estimates recorded for *E. myurus* in Rocky Open Shrub in year 1 indicate the highest density per ha in winter (33 animals per ha), followed by autumn (25 animals per ha), summer (12 animals per ha), and spring with the lowest recorded density (8 animals per ha) (Fig. 201). ANOVA revealed a significant difference between population estimate and season in the Rocky Open Shrub community in year 1 ($F_{1.3} = 106.933$; $n = 78$; $P = 0.000$). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P = 0.00$), summer and winter (Tukey's: $P = 0.00$), autumn and winter (Tukey's: $P = 0.00$), and autumn and spring (Tukey's: $P = 0.00$). The population estimates recorded in Rocky Open Shrub in year 2 indicate the highest density per ha in winter (33 animals per ha), followed by autumn (17 animals per ha), summer (13 animals per ha) and spring the lowest recorded density (11 animals per ha) (Fig. 201). ANOVA revealed a significant difference between population estimate and season in the Rocky Open Shrub community in year 2 ($F_{1.3} = 66.444$; $n = 74$; $P = 0.000$). Statistically population estimates are significantly different in summer and winter (Tukey's: $P = 0.00$), autumn and winter (Tukey's: $P = 0.00$), and autumn and spring (Tukey's: $P = 0.03$).

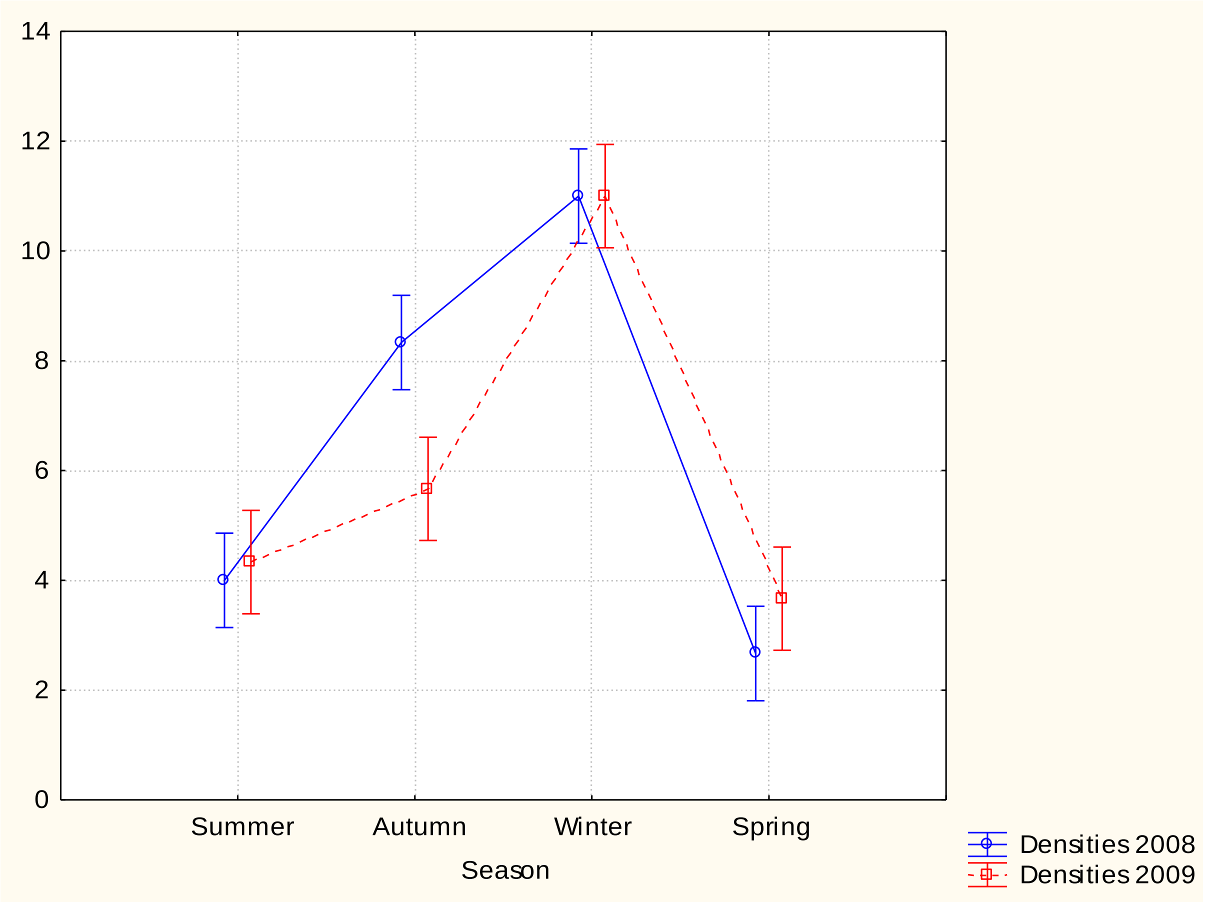

Figure 201. Graph depicting seasonal *Elephantulus myurus* population estimates in 2008 and 2009 recorded in the Rocky Open Shrub vegetation community.

The seasonal mean population estimate for *E. myurus* recorded in the Rocky Open Shrub community indicate that winter has the highest population estimates (33 animals per ha), followed by autumn (21 animals per ha), summer (13 animals per ha), and spring with the lowest recorded density (10 animals per ha) (Figure 202). ANOVA revealed a significant difference between mean population estimate of *E. myurus* and season in the Rocky Open Shrub community ($F_{1.3}$ = 52.792; $n$ = 77; $P$ = 0.000). Statistically population estimates are significantly different in summer and autumn (Tukey's: $P$ = 0.01), summer and winter (Tukey's: $P$ = 0.00), autumn and winter (Tukey's: $P$ = 0.00), autumn and spring (Tukey's: $P$ = 0.00); and winter and spring (Tukey's: $P$ = 0.00).

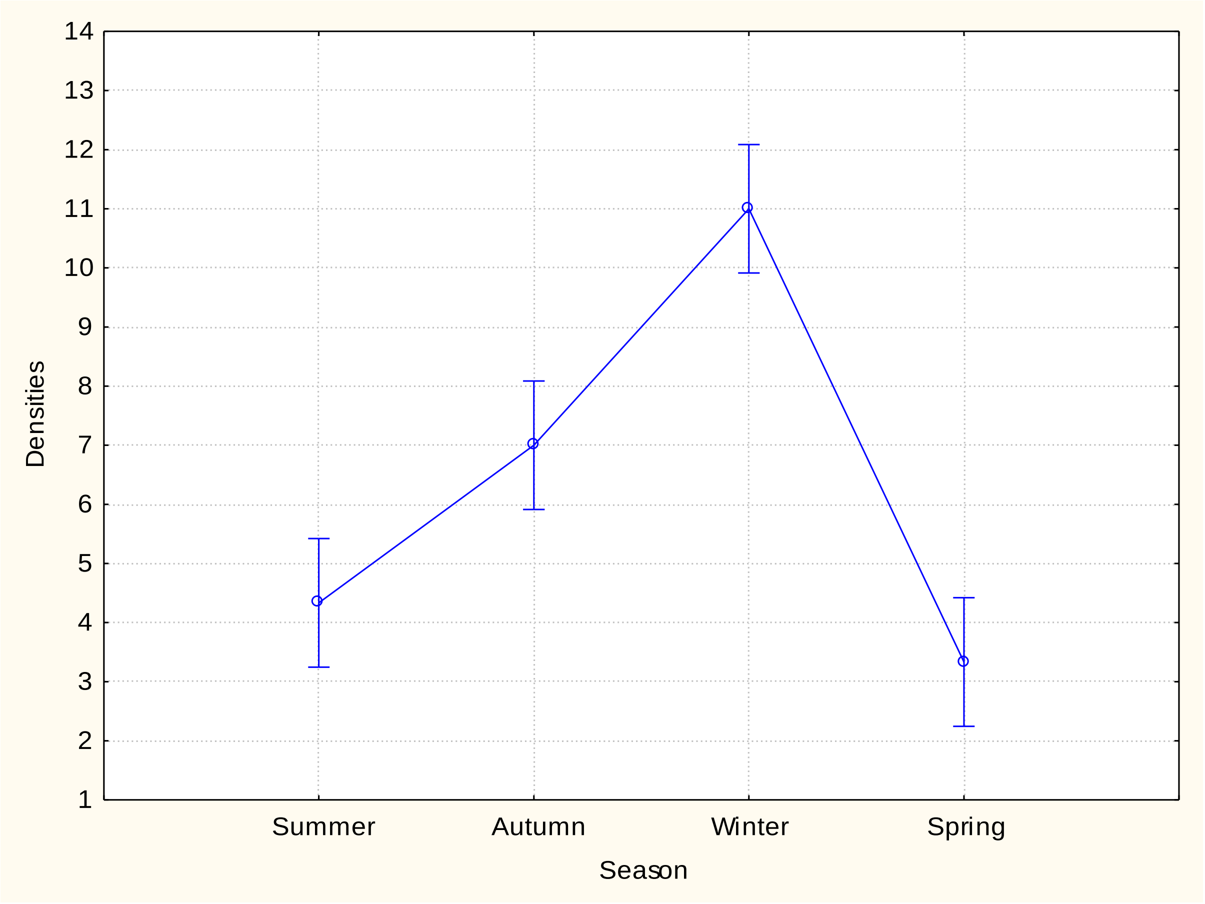

Figure 202. Graph depicting mean *Elephantulus myurus* population estimates recorded in Rocky Open Shrub during the study period.

The mean population estimate of *E. myurus* recorded for Rocky Open Shrub is calculated by averaging the mean seasonal population estimate figures recorded. The estimated population estimate recorded for this vegetation community is 19 small mammals per ha. The community is recorded to cover 272 ha of the property, therefore a population estimate of 5 168 *E. myurus* are estimated to occur in the Rocky Open Shrub community on the property.

## 10.11. Discussion:

The primary objective of this chapter is to quantify the population estimate of small mammal fauna in the Bankenveld grasslands of Telperion in Mpumalanga Province, and Ezemvelo Nature Reserve, in Gauteng Province, South Africa. Small mammal populations are expected to vary on a seasonally basis reflecting seasonal changes in reproduction and emigration. Density dependent and independent factors have an impact on population densities. In areas which were previously under agriculture, low densities were recorded at certain times of the year, and generalists such as *Mastomys* sp. and *Rhabdomys pumilio* were recorded. Small mammals (= adults < 2kg) comprise quite a large percentage (> 60%) of all terrestrial mammal species in southern Africa (Skinner & Chimimba 2005). Small mammals have an important direct and indirect influence on ecosystem, functioning.

Densities of small mammals in an area are expected to be impacted by predation. Small mammals are also a major natural prey of both caracal *Caracal caracal* and the black-backed jackal *Canis mesomelas*. According to Avenant (2000), the ecological role of predators in the maintenance of a balanced prey population and high prey diversity, ultimately affects the whole ecosystem, including the predator population (Kotler 1984; Norrdahl & Korpimäki 1995; Avenant & Nel 1997; McPeek 1998: Barreto *et al.* 1998; Ceballos *et al.* 1999). Makundi *et al.* (1999) examined farming practices and whether they affected the nature of habitat, shelter and population density of rodents in Tanzania. According to Avenant & du Plessis (2008), these predators change their diet according to decreases in small mammal densities at times when their energy needs are high, resulting in an increase in stock losses. Small mammal densities therefore could impact the number of losses experienced by farmers in South Africa. Small mammal communities have been used as indicators of habitat integrity (Avenant 2000a, 2003; Avenant & Kuyler 2002; Avenant and Watson 2002). Avenant & Watson (2002) found small mammal communities correlated with the abundance of pioneer plants species and their ecological value of the veld, indicating that a similar curve could be expected. Generalist species, those with a wide habitat tolerance, are generally found to dominate small mammal numbers on the lower part of the succession curve, with the opposite is expected to occur for specialist species, which increase in density towards the end of the curve. Avenant (2005) felt that together, these finding support the idea that direct monitoring of small mammals could be used as a relatively effective and efficient method of indicating ecological disturbance, habitat health and integrity, and therefore a useful tool for reserve managers and ecologists.

High densities of *Mastomys* spp. in all habitats indicate a level of disturbance at the study site; hence low numbers indicate a balanced system. The relationships between small mammals and the environment in which they live is often complex in nature (Avenant 2000a; Birney *et al.* 1976). Small mammal density has been related to biotic and abiotic variables such as habitat structure and complexity (Rosenzweig & Winakur 1969; Brown 1973; French *et al.* 1976; Bond *et al.* 1980; Dueser & Brown 1980; Rowe-Rowe & Meester 1982a; Thompson 1982; Parmenter & MacMahon 1983; Kotler 1984; Abramsky 1988; Kerley 1992;

Els & Kerley 1996), area (Abramsky *et al*. 1985; Fitzgibbon 1997), productivity (Abramsky 1978, 1988; Rosenweig 1992); predation (Kotler 1984; Norrdahl & Korpimäki 1995; Abramsky *et al.* 1998; trampling and grazing (Keesing 1998; Milchunas *et al*. 1998); surrounding landscape and the distance between similar habitats (Fitzgibbon 1997), and the maturity of the habitat and succession of the vegetation (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Rowe-Rowe 1995; Fitzgibbon 1997; Ferreira & van Aarde 1999).

The Rocky Open Shrub community had the highest densities during the study, with an estimated 85 small mammals per ha. It is expected that the highest densities will occur in spring, followed by winter, with summer and autumn with the lowest small mammal densities. This result is influenced by high numbers of *Micaelamys namaquensis* recorded in spring and *Elephantulus myurus* in winter. The Degraded Grassland community had the second highest densities with an estimated 72 animals per ha. Highest densities are expected in the autumn months, followed by summer, and winter and spring with the lowest densities. This result is influenced by large numbers of *Dendromus melanotis* in the community in autumn. The Northern Slope Woodland community had densities of 41 animals per ha recorded. The highest densities are expected in winter, then spring, and autumn and summer with the lowest densities. This result is influenced by the high number of *E. myurus* in the community in winter. The Rocky Highveld Grassland community had densities of 34 animals per ha recorded. The highest densities are expected in autumn, followed by winter; spring and summer are expected to have the lowest densities. The high densities experienced in autumn appear related to an increase in numbers from breeding summer. The Sheltered Woodland community had an estimated 34 small mammals per estimated. Winter had marginally highest densities of small mammals, followed by spring, with autumn and summer with the lowest densities recorded number in this community. The Moist Degraded Grassland community had densities of 13 small mammals per ha recorded. The winter months had the highest densities in this community, followed by autumn, with spring and summer with the lowest densities recorded. This community remains wet into the winter months, and good biomass of vegetation is maintained. The Burkea Eragrostis Clumps community had the lowest densities recorded at the study site with 10 animals per ha recorded. Results indicate summer had marginally higher densities than spring, with winter and autumn having the lowest recorded densities. Vegetation is sparse in the community during autumn and winter, and cover and food is limited.

Makundi *et al.* (2007) found population densities were highest at the end of the rain season to the middle of the dry season, but rapid decline in population density occurred towards the end of the dry season in September. Fire is often excluded from nature reserves due to its perceived danger to wildlife, infrastructure and human life, fire is however important in maintaining natural balances in an ecosystem, especially evident in fire climax grasslands and the species which inhabit them. Beck & Vogl (1972) suggested that some of the mortality associated with fire on small mammals might be caused by predation. Burned areas are left open and therefore, the lack of cover improves accessibility to avian and mammalian predators (Motobu 1978). MacFadyen (2007) found that high *Mastomys* spp. densities in the Kruger National Park persisted months after such a burn without a drastic decrease in abundance. There has been some evidence which suggests that unburnt seeds on the ground attract rodents (Makundi *et al.* 1999). Managers of nature reserves and conservation areas readily burn areas of moribund grass to stimulate growth of early grasses. This new growth presumably provides better nutrition for rodents and the requirements of breeding, growth and survival of young, provided sufficient shelter remains.

The questions raised through this study being do game farming practices influence the population densities and species richness of rodent species in a “natural system”. The impact of herbivores on shelter and the availability of seed bearing plants are without question. The stocking rates of game farms and nature reserves directly and indirectly affect small mammal densities. In certain overgrazed areas, grass plants are not permitted to mature, therefore do not produce inflorescences, and ultimately do not produce food for certain species of rodents. Massawe *et al.* (2006) found an increase in rodent densities in areas after seed emergence, although this trend was more evident in areas which has been slashed and burned through farming practices. Rainfall, timing, duration and amount, has a strong influence on the population dynamics of rodents as it indirectly affects availability of resources.

This study is important as it investigates the population estimates of small mammal populations in the fire-climax grassland of the Bankenveld. Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Co-existence in a grassland habitat may also be promoted by mechanisms that reduce interspecific competition (Kinahan & Pillay 2008) and thus improve overall fitness. Differential habitat use and the use of resources within these different systems, especially in space and time, may facilitate co-existence between species on a reserve, or specific habitat (M’Closkey 1976; Brown 1989; Yunger *et al.* 2002; Zhang 2003; Bonesi & Macdonald 2004; Harris *et al.* 2006).

The competition theory assumes that at competitive equilibrium in densities are maintained (Ferreira & Van Aarde 1999), and may thus act to structure communities (Hughes *et al.* 1994; Manor & Saltz 2008). Competitive co-existence may be emphasized when there is spatial or temporal variation in resource abundance or non-equilibrium between resource and consumer dynamics (Chesson 1986). Demonstrating that different species of small mammals may use different parts of a resource, such as seeds as opposed to culms of grass, does not indicate the absence of competition between species, and thus competitive interactions, similarly, competition cannot be inferred in a variety of species occurring in the same resource (Conley 1976; Holbrook 1979; Schoener 1983).

Intraspecific competition between small mammals should occur at a higher density than interspecific competition since resource use is essentially the same within a species (Perri & Randall 1999; Perrin *et al.* 2001; Zhang 2003; Dammhahn & Kappeler 2008). Other biological factors include abundance, sex and age structure, and body size, while ecological factors may include season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Ribble *et al.* 2002; Priotto *et al.* 2002; Schradin & Pillay 2006; Pasch & Koprowski 2006; Copper & Randall 2007). Home range also gives an indication of the social structure of small mammal species (Schradin & Pillay 2006; Cooper & Randall 2007). Polygynous species tend to have a high degree of intraspecific overlap, especially between females and thus also tend to have higher densities (Ribble & Stanley 1998; Priotto *et al.* 2002). Promiscuous species within a community also tend to have high densities with a high degree of overlap between sexes, since males are unable to monopolise widespread females (Ostfeld 1990; Ribble & Stanley 1998; Jackson 1999).

As natural environments are dynamic, the processes promoting similarities and differences in population variables may change over space and time (Brown & Zeng 1989; Chesson 2003). This is evident when examining patterns of density in small mammal communities. Changes in recoded small mammal densities are dependent on a variety of factors, method used, season, climate and temperature. Three main cues, or a combination, are expected to influence reproduction in small mammals, namely abiotic factors (such as food availability), internal factors (endogenous rhythms) and social cues between individuals (Neal 1986; Ims 1990). Abiotic factors, such as rain are not likely to affect breeding directly as there is usually a lag time of two or three months between rainfall and the evidence of breeding (Bronner 1986), but rather affects breeding indirectly through food availability (Neal 1982). Population size fluctuations are due to differences in recruitment (movements into the population through birth and immigration) and emigration (movements out of the population through dispersal and death (Bronner 1986).

Home range overlap is influenced by several biological factors, such as population density, sex, age, body size and ecological factors, such as season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Priotto *et al.* 2002; Ribble *et al.* 2002; Schradin & Pillay 2006; Cooper & Randall 2007). Studies of spatial organisation may also contribute to understanding patterns of coexistence between similar species (Ferreira & Van Aarde 1999; Priotto *et al.* 2002; Ribble *et al.* 2002). Since ecological and resource portioning may be the underlying mechanisms of coexistence (Rosenzweig 1981; Kalcounis-Ruppell & Millar 2002; Bonesi & Macdonald 2004; Jorgensen 2004), it would be expected that ecologically-similar species would occupy adjacent, non-overlapping home ranges (Bleich & Price 1995; Christopher & Barrett 2006), but that these may vary depending on resource availability (Orland & Kelt 2007). Densities of small mammals in the Bankenveld may be influenced by variation in food distribution and abundance and the variety of acceptable food resources. This in unpredictable environments, or under high population density, home range size may be larger as distance travelled to find resources in order to meet energy requirements increases (Pasch & Koprowski 2006).

Small Mammals are important components in Bankenveld grassland habitats ecosystems, as predators, consumers, dispersers of seed, burrowers and prey for carnivores, reptiles and raptors. Total density of small mammals should be taken into account when calculating carrying capacity on a reserve. More practically, their use should be maximised when monitoring ecosystems. During this study, the highest densities of small mammals were recorded in the rocky areas. According to Avenant (2000a), homogeneous habitats should be selected and marginal areas (at the edge of habitats) should be avoided as the edges often house more species and can be seen as refugia where individuals can profit from the best of both habitats. Care was taken to ensure the habitats selected where "pure" representations of these habitat types, as although ecologically important, these edges often house more species and can be seen as refugia where individuals can profit from the best in two environments (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Hansson 1998). Certain vegetation communities had higher densities of small mammal, for example, Northern Slope Woodland and Rocky Open Shrub for *Micaelamys namaquensis* and *Elephantulus myurus*, which are represented throughout the year, although the numbers fluctuate. Other communities such as Moist Degraded Grassland and Degraded Grassland differ seasonally in their suitability for harbor small mammals.

According to Bronner *et al.* (1988), Brooks (1982), Davis & Meester (1981) rodent population densities in perennial grasslands of the South African highveld are highly seasonal, with reproduction largely occurring between November and March, reaching peaks in population numbers during March and April. During winter (May-September) vegetation becomes less dense due to frost, and rodent populations decrease substantially (Davis 1973; Smithers 1983). Telperion and Ezemvelo Nature Reserve are estimated to have a minimum number of 377 620 small mammals inhabiting the different vegetation communities on the properties.

# CHAPTER 11:

# SHORT TERM SEASONAL CLIMATIC EFFECTS ON SMALL MAMMAL ASSEMBLAGES IN THE BANKENVELD GRASSLANDS

## 11.1. Abstract

This aim of this chapter is to determine the short term seasonal climatic effects on small mammal species richness and abundance in seven vegetation communities of Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Climate has a direct impact on small mammal fauna, influencing food availability, abundance, home range size and breeding. These climate fluctuations have temporary and long-lasting effects on species richness and abundance. Each species or assemblage of small mammal has a unique set of preferences or requirements. These requirements are affected by climate, temperature, aridity, resource availability, habitat requirements and competition. Since the factors of habitat requirement for more specialized species can be complex and interconnected, the habitat of certain species are affected by local and seasonal climate fluctuations. Marginally a greater number of new individuals were recorded when the maximum temperature was moderate, and there appears to be no relationship between average maximum temperature and the number of new individuals recorded. There appears to be no relationship between average minimum temperature and the number of new individuals recorded, although marginally higher numbers of new individuals were recorded in autumn after the summer rains. The summer months appear to harbour the highest species diversity, possibly due to the fact that animals are reproductively active and therefore more readily recorded, while maximum temperature does not appear to impact species richness, possibly due to the fact that the majority of the species recorded are nocturnal in habits. Data suggests low species richness in spring and autumn, although minimum temperature does not appear to impact species richness, even though higher species richness was recorded when minimum temperatures were higher.

**Keywords:** Climate, temperature, rainfall, small mammal fauna, Telperion, Ezemvelo Nature Reserve South Africa.

## 11.2. Introduction

The purpose of this chapter is to determine short term seasonal climatic effects on small mammal species richness and abundance in seven vegetation communities of Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Temperature and rainfall are expected to influence home range size and population densities of small mammals. The short term effect of climate on the extent and cause of small mammal diversity and movement in an area is well-documented (Yarnell *et.al*. 2007). Rodents are a very successful group forming the largest Order of mammals, although rainfall and temperature affect the abundance, community structure and species richness, especially when a population is influenced by the associated changes in vegetation structure and food availability. Plants are influenced by climate, influencing the amount of seed produced, often determined by the amount of rainfall and water availability for plants (Kent & Coker 2000; Bredenkamp 2001).

The climate of an area indicates the prevailing weather conditions over a long period of time, including the daily, seasonal and annual variations. Climate shapes the vegetation patterns by influencing the plant's life cycle with factors such as light, temperature and moisture (Schulze 2003), which in turn influences the small mammal population recorded. In Africa, rainfall is regarded as the primary influence on vegetation productivity (Bredenkamp *et al.* 2002), fire and herbivory are considered being key factors determining vegetation structure and composition (Scholes & Walker 1993). Many small mammal communities are directly influenced by vegetation structure (Linzey & Kesner 1997; Ferreira & Van Aarde 1999; Fuller & Perrin 2001) and consequently will be indirectly influenced by rainfall, fire and grazing, and can therefore be utilized to explore the interactions between these factors on ecosystem processes and biodiversity maintenance (Yarnell *et al* 2007). When climatic conditions change, in time resources are often insufficient to maintain these large populations, and populations' crash. Makundi *et al.* (2007) found that reproduction and population fluctuations in *Mastomys natalensis* were linked to the duration and amount of rainfall in Tanzania.

Abiotic factors, such as rain are not likely to affect breeding directly as there is usually a lag time of two or three months between rainfall and the evidence of breeding (Bronner 1986), but rather affects breeding indirectly through food availability (Neal 1982). Rainfall therefore may still contribute to the timing of the reproductive seasonality and could explain inter-year variation in population numbers and demography (Willan & Meester 1989;

Monadjem & Perrin 2003). Climate is expected to have a direct impact on small mammal fauna, influencing food availability, abundance, home range size and breeding. These climate fluctuations have temporary and long-lasting effects on species richness and abundance. Each species or assemblage of small mammal has a unique set of preferences or requirements. These requirements are affected by climate, temperature, aridity, resource availability, habitat requirements and competition. Since the factors of habitat requirement for more specialized species can be complex and interconnected, the habitat of certain species may be affected by local and seasonal climate fluctuations. Changes in small mammal assemblages recorded in a vegetation community are often as a result of the changes in plant communities associated with the changing season and the associated changes in temperature and rainfall. Temperature and rainfall are expected to influence trap success, the number of new individuals, and species richness recorded, having specific responses to these fluctuations in temperature and rainfall.

## 11.3. Methodology

In year one (2008), ten transects each comprising 30 live-traps Sherman each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month.  The starting-point was placing transects in the seven vegetation communities. Two transects were placed in the dominant communities to obtain a greater sample size. 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. 10 m spacing was adopted at the study site with the available traps. In year two, three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per site. Climate data was recorded and accessed via the weather station in Witbank.

Variance between climatic conditions and small mammal data were assessed using t-tests (*t*), using the mean difference between the two variables and dividing these by the standard error of the difference. The strength between relationships or correlations between climate and small mammal data were analyzed using the coefficient of determination $r^2$. All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 11.4. Results

The temperature data measured at the weather station at Witbank, approximately 45 km to the east of Telperion, and from Bronhkhorstspruit, approximately 30 km west of Telperion, indicate that the average maximum and minimum temperatures are relatively similar in 2008 and 2009 (Fig. 203). There is a significant relationship ($r^2 = 0.790$; $df = 1,10$; $n = 12$; $P < 0.000$) between maximum temperature recorded in 2008 and 2009. Similarly, there is a positive correlation ($r^2 = 0.927$; $df = 1,10$; $n = 12$; $P < 0.000$) between minimum temperatures in 2008 and 2009. There is a significant relationship between maximum temperature and minimum temperature ($r^2 = 0.774$; $df = 2, 9$; $n = 12$; $P < 0.001$).

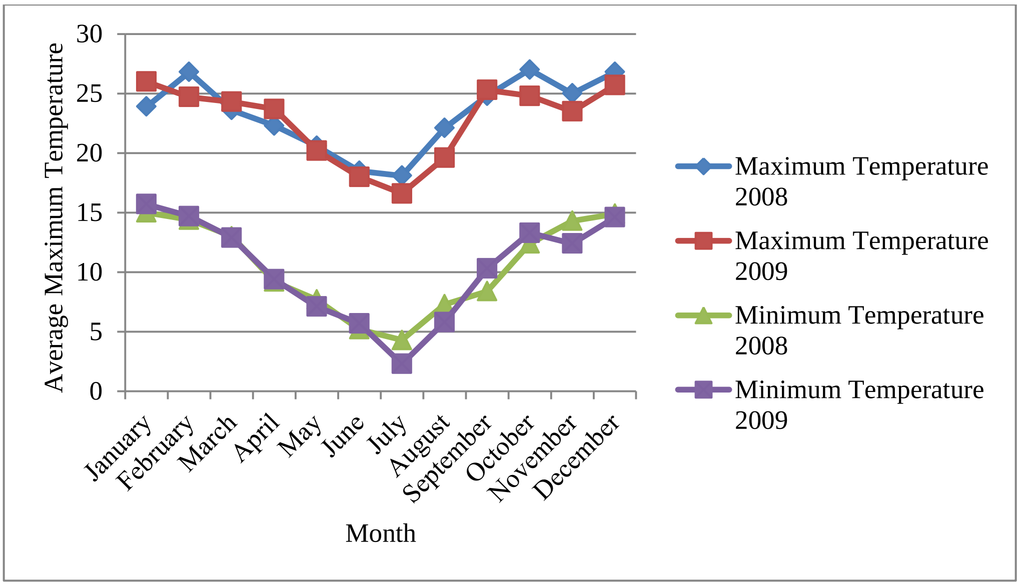

Figure 203. Graph illustrating the comparison between average maximum and minimum temperature in 2008 and 2009 on Telperion.

Statistically there is an insignificant difference between maximum temperatures ($t_{(22)} = 0.460$; $n = 12$; $P = 0.650$), and minimum temperatures ($t_{(22)} = 0.094$; $n = 12$; $P = 0.650$) in 2008 and 2009. According to data the highest temperatures occur during December, January and February when the average daily maximum temperature is 25.5° C and the average daily minimum temperature ranges between 14 and 15° C. The lowest temperatures occur during July where the daily maximum temperature averages around 16° C and the daily minimum temperature 2.3° C. Tropical anticyclones bring dry subsiding air to the interior plateau of southern Africa which causes a seasonal drought between April and September. From October to March the continental high weakens and is replaced by a shallow surface low which allows moist maritime air from the east and northeast to reach the interior and cause summer rain (Buckle 1996). Therefore, Telperion receives its rainfall during summer. Rainfall data for 2008 and 2009 was obtained from the weather station at Witbank. The rainy season peaks from October to February, while the driest months are in winter, between June and August. The annual rainfall received during this study is 751.6 mm in 2008 and 916.6 mm in 2009 (Fig. 204). There is a significant relationship ($r^2 = 0.642$; $df = 1,10$; $n = 12$; $P = 0.001$) between average rainfall recorded in 2008 and 2009.

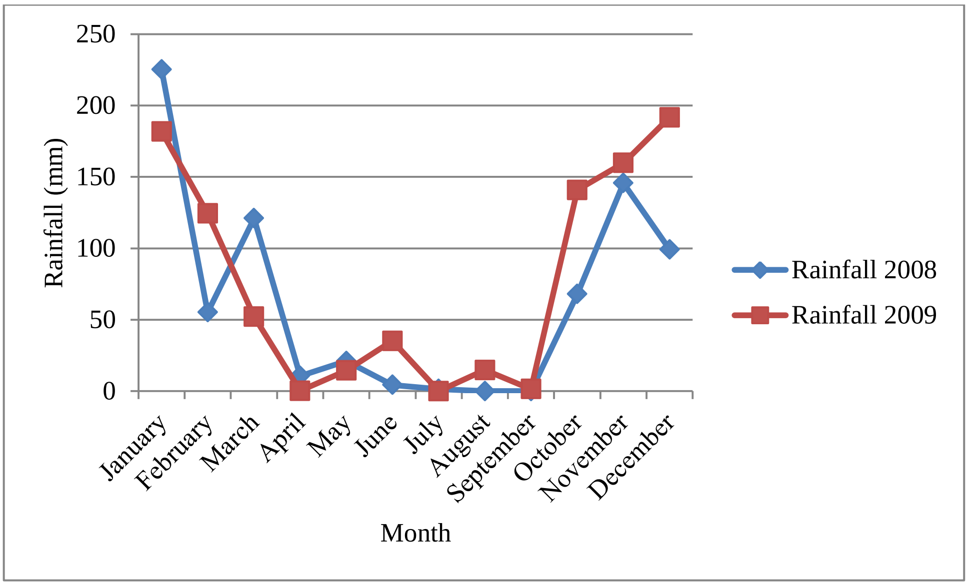

Figure 204. Graph illustrating the comparison between monthly rainfall in 2008 and 2009 on Telperion.

Statistically there is an insignificant difference between maximum temperatures ($t_{(22)} = 0.460$; $n = 12$; $P = 0.650$), and minimum temperatures ($t_{(22)} = 0.094$; $n = 12$; $P = 0.650$) in 2008 and 2009. The structure of a small mammal community is influenced by of a combination of abiotic factors such as rockiness and climate and biotic factors such as plant cover and the predator species present, with each element influencing another.

## 11.5. The effects of climate on small mammal trap success recorded on Telperion in 2008 and 2009

### 11.5.1. The influence of average maximum temperature on the trap success recorded on Telperion

Trap success recorded was compared to average maximum temperature during 2008 and 2009. In 2008, monthly trap success was compared with monthly calculated average maximum temperature. The highest monthly trap success percentage recorded in 2008 was in

August ($n$ = 70) and average maximum temperature was 22.1° C, while the lowest trap success recorded was in January ($n$ = 25), when average maximum temperature was 23.9° C (Fig. 205). There is insignificant relationship ($r^2$ = 0.097; $df$ = 1,10; $n$ = 12; $P$ = 0.325) between trap success and average monthly maximum temperature recorded in 2008.

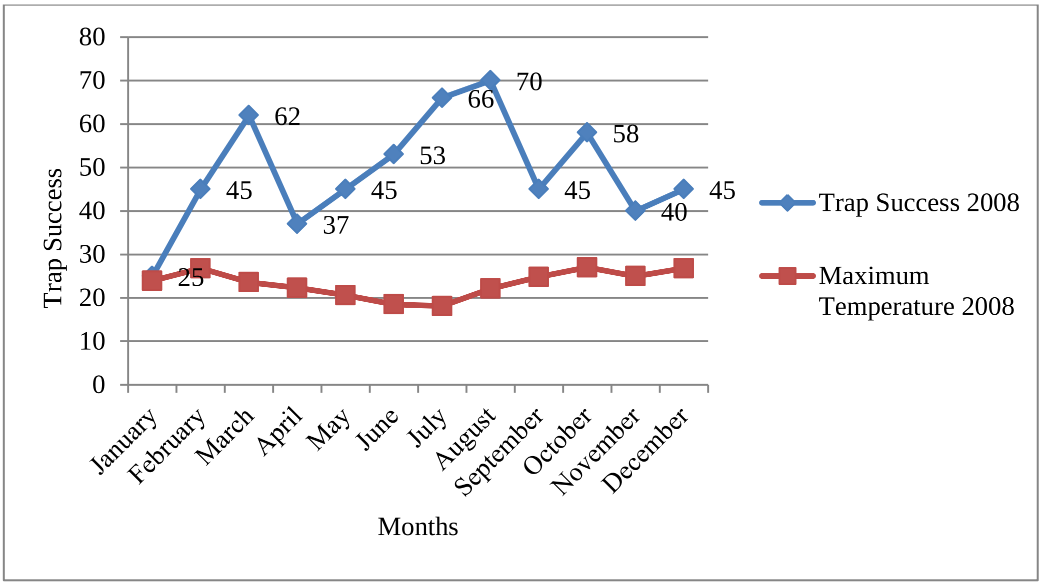

Figure 205. Graph illustrating the monthly trap success compared with average maximum temperature in 2008.

Seasonal trap success was recorded in 2008 and 2009, and compared with average seasonal maximum temperature (Fig. 206)

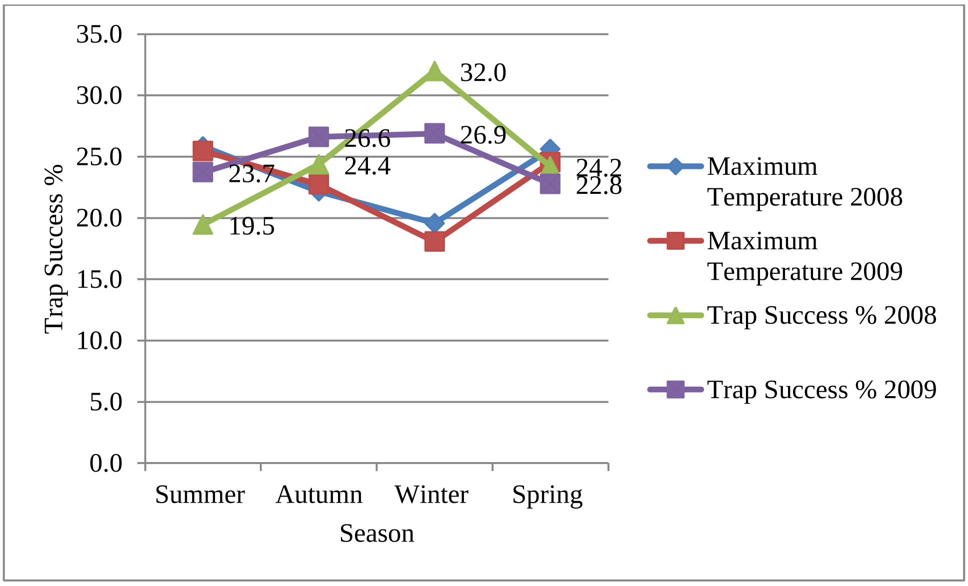

Figure 206. Graph illustrating the small mammal trap success percentage compared with average maximum temperature in 2008 and 2009.

Results in 2008 indicates that the lowest trap success was recorded in summer (19.5%), when average maximum temperature were 25.8º C; followed by spring (24.2%) with an average maximum temperature of 25.6º C, autumn (24.4%) with a temperature of 22.2º C, and winter (32%) with the highest trap success in 2008 with an average maximum temperature of 19.6º C. There is an insignificant relationship ($r^2 = 0.750$; *df* = 1,2; *n* = 4; *P* = 0.114) between average seasonal maximum temperature and trap success in in 2008. Results recorded in 2009 indicates that the lowest trap success was recorded in spring (22.8%), when average maximum temperature was 24.5º C, followed by summer (23.7%) with an average maximum temperature of 25.5º C, autumn (26.6%) with a temperature of 22.7º C, and winter with a marginally higher trap success (26.9%), with the lowest maximum temperature of 18.1º C. There is an insignificant relationship ($r^2 = 0.641$; *df* = 1,2; *n* = 4; *P* = 0.199) between seasonal average maximum temperature and trap success recorded in 2009. The combined trap success recorded during the study suggests that small mammals are least abundant in summer, when the combined traps success was lowest (21.8%), when average maximum temperature for the both years was highest at 25.7º C, followed by spring (23.4%), with a temperature of 25.1º C, autumn (25.6%) with a temperature of 22.5º C, and the highest trap success recorded for the study being in winter, when maximum average temperature was lowest at 18.8º C. There is an insignificant relationship ($r^2 = 0.947$; *df* = 2,1; *n* = 12; $P < 0.229$) between combined average seasonal maximum temperature and trap success in 2008 (*P* = 0.630) and 2009 (*P* = 0.328) , although higher numbers of animals were recorded when the maximum temperature is low.

### 11.5.2. The influence of average minimum temperature on the trap success recorded on Telperion

Trap success recorded was compared to minimum temperature in 2008 and 2009. In 2008 monthly trap success was compared with monthly calculated average minimum temperature. There is an insignificant relationship ($r^2 = 0.256$; *df* = 1,10; *n* = 12; *P* = 0.093) between minimum temperature and trap success recorded in 2008. The highest monthly trap success percentage recorded in 2008 was in August (n = 70) and average minimum temperature was 7.3º C, while the lowest trap success recorded was in January (n = 25), when average minimum temperature was 15 ºC (Fig. 207).

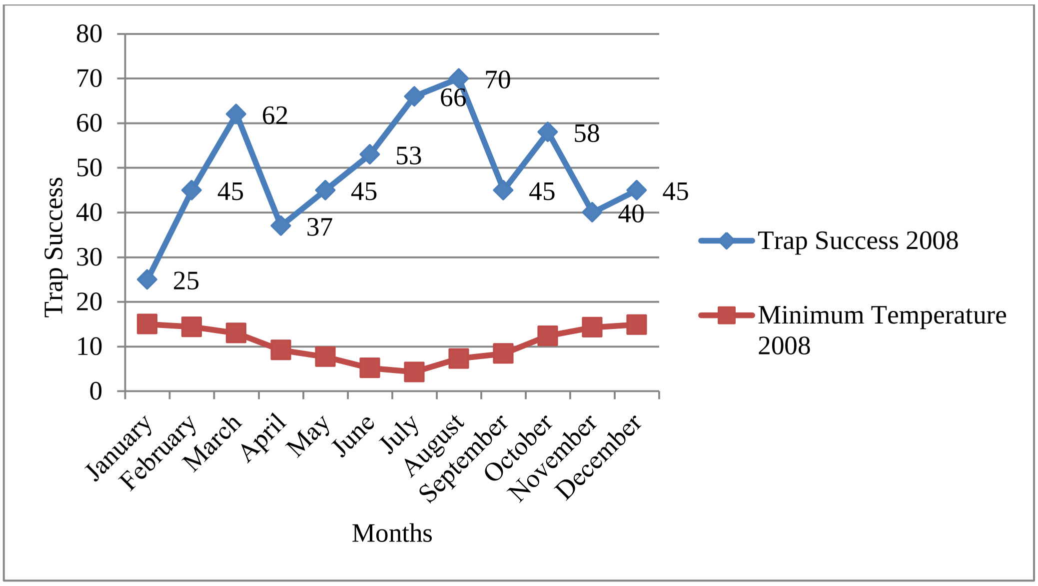

Figure 207. Graph illustrating the monthly trap success compared with average minimum temperature in 2008.

Seasonal trap success was recorded in 2008 and 2009, and compared with average seasonal minimum temperature (Fig. 208)

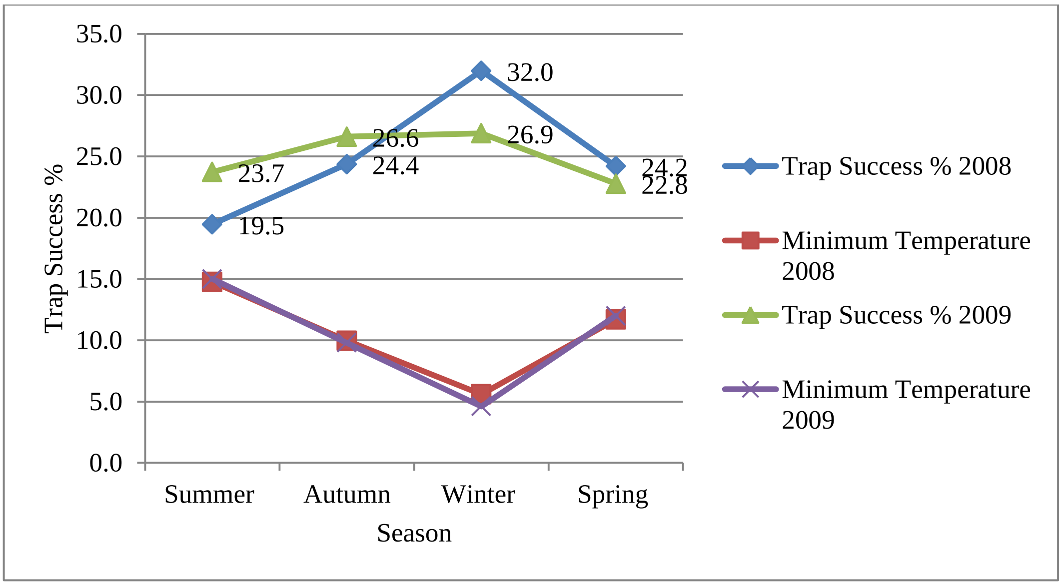

Figure 208. Graph illustrating the small mammal trap success percentage compared with average minimum temperature in 2008 and 2009.

Trap success data recorded in 2008 indicates that the lowest trap success was recorded in summer (19.5%), when average minimum temperature was 14.8º C; followed by spring (24.2%) with an average minimum temperature of 11.7º C, autumn (24.4%) with a temperature of 10º C, and winter (32%) with the highest trap success in 2008 and an average minimum temperature of 5.6º C. There is a strong positive statistical relationship ($r^2 = 0.967$; $df = 1,2$; $n = 12$; $P = 0.017$) between average seasonal minimum temperature and trap success recorded in 2008. Trap success recorded in 2009 indicates that the lowest trap success was recorded in spring (22.8%), when average minimum temperature was 12º C, followed by summer (23.7%) with an average minimum temperature of 15º C, autumn (26.6%) with a temperature of 9.8º C, and winter with a marginally higher trap success (26.9%), with the lowest minimum temperature of 4.6º C. There is an insignificant relationship ($r^2 = 0.618$; $df = 1,2$; $n = 4$; $P = 0.214$) between average seasonal minimum temperature and trap success recorded for 2009. The combined trap success recorded during the study suggests that small mammals are least abundant in summer, when the combined traps success was lowest (21.8%), when average minimum temperature recorded between both years was highest at 14.9º C, followed by spring (23.4%), with a temperature of 11.9º C, autumn (25.6%) with a temperature of 9.9º C, and the highest trap success recorded for the study being in winter (29.2%), when minimum average temperature was lowest at 5.1º C. There insignificant relationship ($r^2 = 0.967$; $df = 2,1$; $n = 4$; $P < 0.182$) between the combined average seasonal minimum temperature and trap success in 2008 ($P = 0.788$) and 2009 ($P = 0.959$), although a higher trap success was recorded when morning and evening temperatures were low.

### 11.5.3. The influence of average rainfall on the trap success recorded on Telperion

Trap success recorded on Telperion was compared to average rainfall in 2008 and 2009. In 2008, monthly trap success was compared with the monthly average rainfall. The highest monthly trap success percentage recorded in 2008 was in August (n = 70) and average rainfall was 0 mm, while the lowest trap success recorded was in January (n = 25), when average rainfall was the highest 225.2 mm (Fig. 209). There is an insignificant relationship ($r^2 = 0.283$; $df = 1,10$; $n = 12$; $P = 0.075$) between average monthly rainfall and trap success recorded in 2008.

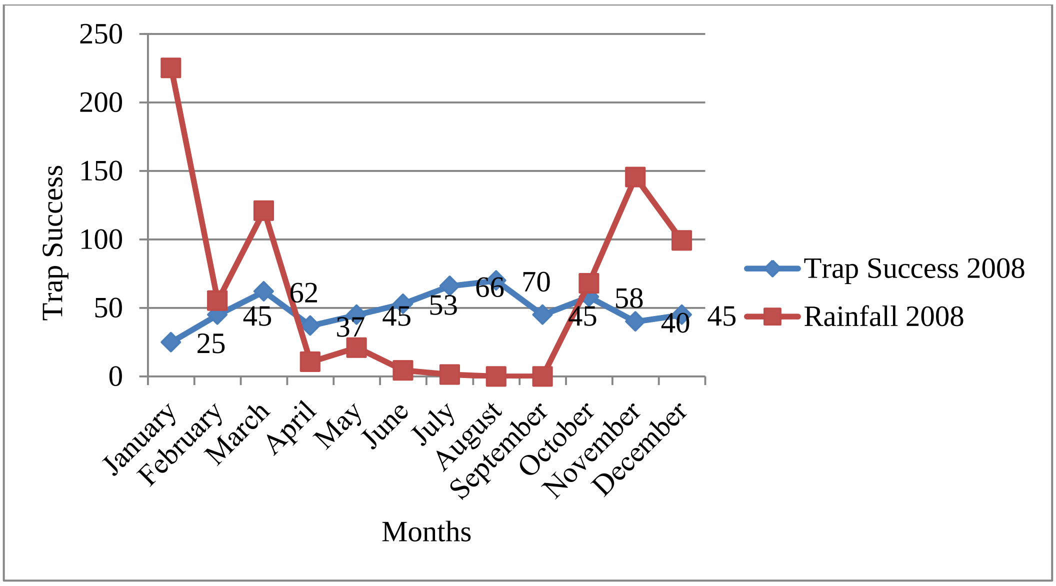

Figure 209. Graph illustrating the monthly trap success compared with average rainfall in 2008.

Seasonal trap success was recorded in 2008 and 2009, and compared with average seasonal rainfall (Fig. 210)

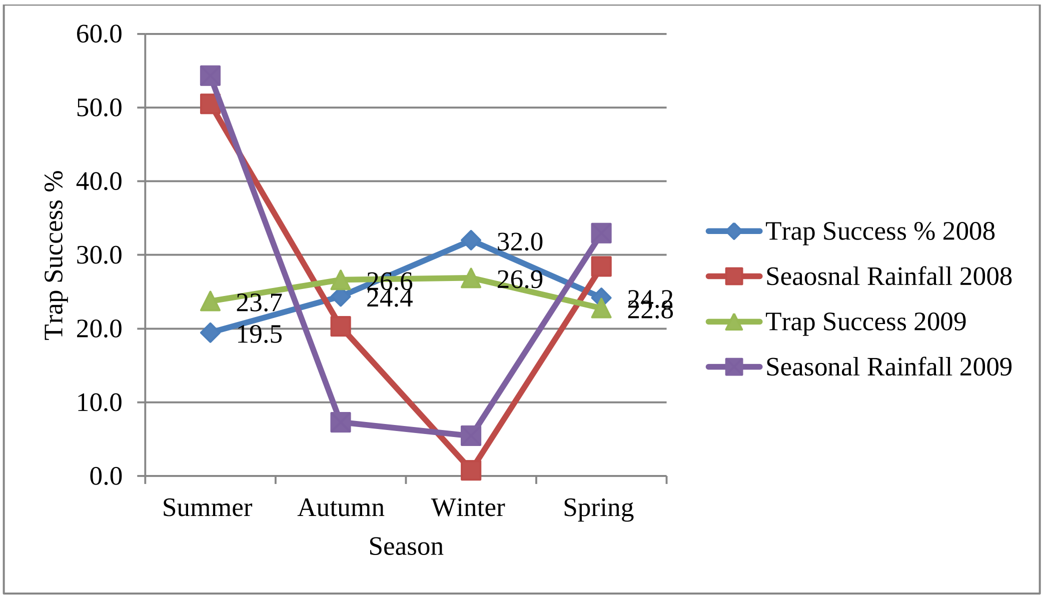

Figure 210. Graph illustrating seasonal small mammal trap success percentage compared with rainfall recorded in 2008 and 2009.

Results in 2008 indicate that the lowest trap success was recorded in summer (19.5%), when recorded rainfall was highest at 379.6 mm; followed by spring (24.2%) with a recorded rainfall of 213.6 mm, autumn (24.4%) with 152.6mm, and winter with the highest trap success (32%) in 2008 and average rainfall 5.8mm recorded. There is an strong positive correlation ($r^2$ = 0.941; *df* = 1,2; *n* = 4; *P* = 0.030) between average seasonal rainfall and trap success recorded for 2008. Results in 2009 indicates that the lowest trap success was recorded in spring (22.8%), when rainfall was 302 mm, followed by summer (23.7%) with the highest rainfall of 497.8 mm was recorded, autumn (26.6%) with rainfall of 66.8 mm recorded, and winter with a marginally highest trap success (26.9%), with the lowest rainfall of 50mm. There is an insignificant relationship ($r^2$ = 0.703; *df* = 1,2; *n* = 4; *P* = 0.162) between average seasonal rainfall and trap success recorded for 2009. The combined trap success recorded during the study suggests that small mammals are least abundant in summer, when the combined traps success was lowest (21.8%), when average rainfall between 2008 and 2009 was highest at 438.7mm, followed by spring (23.4%), with 257.8 mm recorded, autumn (25.6%) with 109.7 mm recorded, and the highest trap success recorded for the study being in winter (29.2%), when average rainfall was lowest at 5.5mm. There is an insignificant relationship ($r^2$ = 0.994; *df* = 2,1; *n* = 4; $P < 0.079$) between average rainfall and trap success recorded in 2008 (*P* = 0.087) and 2009 (*P* = 0.210), although a higher trap success was recorded in months with a lower rainfall.

## 11.6. The effects of climate on the number of new individuals recorded on Telperion in 2008 and 2009

### 11.6.1. The influence of average maximum temperature on the number of new individuals recorded on Telperion

Animals captured for the first time were compared to maximum temperature during 2008 and 2009. In 2008 these new records were compared with average monthly maximum temperature. The highest number recorded in 2008 was in March (n = 39), when the average maximum temperature was 23.6° C, while the lowest number recorded were in September (n = 14), when average maximum temperature was 24.8 ºC (Fig. 211). There is an insignificant relationship ($r^2$ = 0.073; *df* = 1,10; *n* = 12; *P* = 0.396) between average monthly maximum temperatures and the number of new indivdiuals animals recorded in 2008.

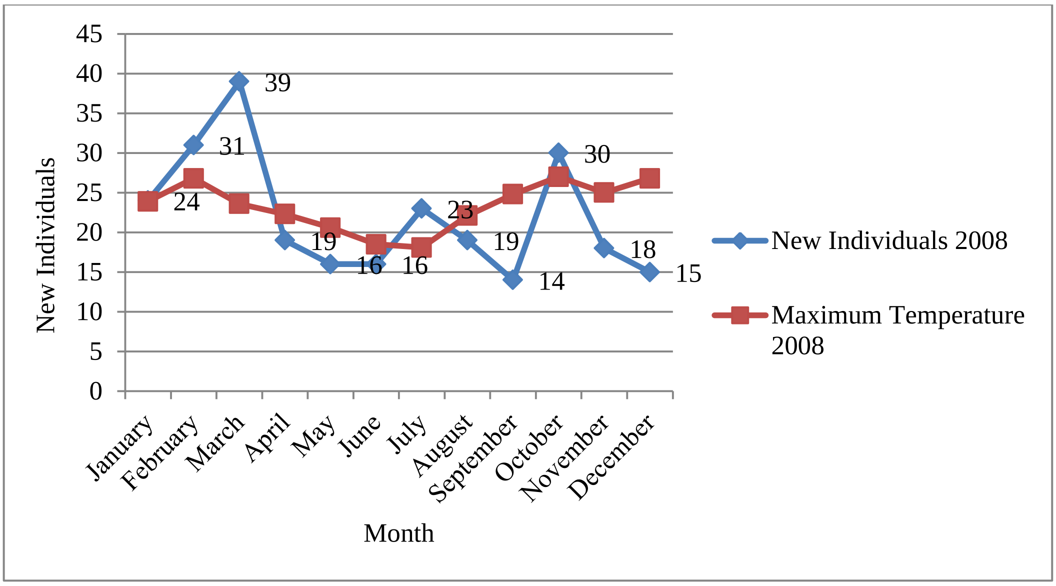

Figure 211. Graph illustrating the number of new individuals compared with average maximum temperature in 2008.

Seasonal data for newly recorded individuals was recorded in 2008 and 2009, and compared with average seasonal maximum temperature (Fig. 212)

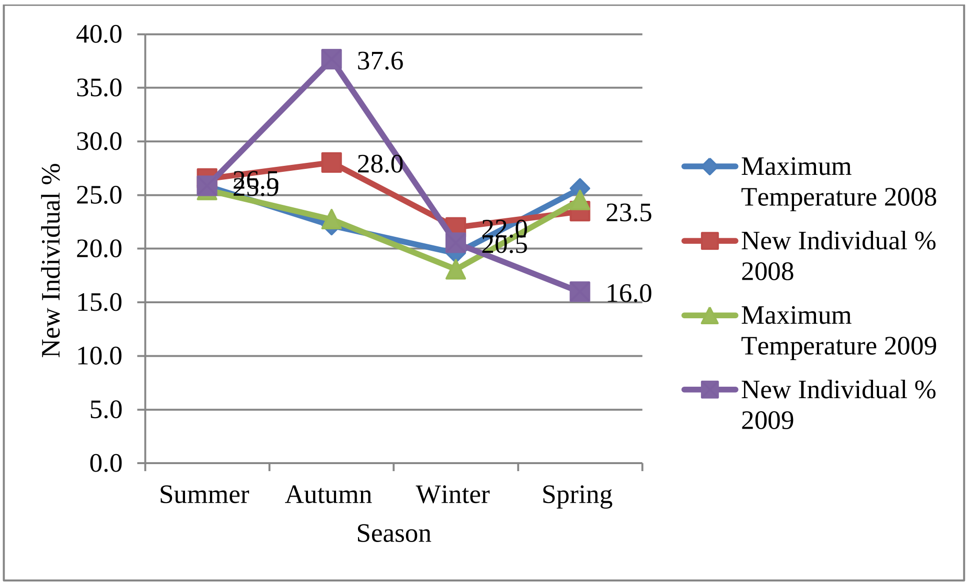

Figure 212. Graph illustrating the percentage of new individuals recorded compared with average maximum temperature in 2008 and 2009.

Data in 2008 indicates that the lowest number of new individuals were recorded in winter (22%), when the average maximum temperature were 19.6º C; closely followed by spring (23.5%) with an average maximum temperature of 25.6º C, then summer (26.5%) with a temperature of 25.8º C, and finally autumn (28%) with the highest record in 2008 with an average maximum temperature of 22.2º C. There is an insignificant relationship ($r^2$ = 0.110; *df* = 1,2; *n* = 4; *P* = 0.669) between average seasonal maximum temperature and number of new individuals recorded in 2008. The data recorded in 2009 indicates that the lowest number of new individuals were recorded in spring (16%), when the average maximum temperature was 24.5º C, followed by winter (20.5%), where the average maximum temperature was lowest at 18.1º C, then summer (25.9%) with a temperature of 25.5º C, and then autumn with the highest percentage of new animals being recorded (37.6%), when the average maximum temperature was 22.7º C. There is an insignificant relationship ($r^2$ = 0.006; *df* = 1,2; *n* = 4; *P* = 0.925) between average seasonal maximum temperature and the number of new individuals captured in 2009. The combined data recorded during the study suggests that the lowest percentage of new individuals were recorded in spring, when the combined number of new individuals was at its lowest (19.7%), and the average maximum temperature was 25.1º C, followed by winter (21.3%), with an average temperature of 18.8º C, followed by summer (26.2%) with a temperature of 25.7º C, and the highest percentage of new individuals recorded for the study were in autumn, when the maximum average temperature was 22.5º C. Although marginally more new individuals are recorded when the maximum temperature is moderate, there appears to be an insignificant relationship ($r^2$ = 0.978; *df* = 2,1; *n* = 4; $P <$ 0.150) between average maximum temperature and the combined number of new individuals recorded in 2008 (*P* = 0.117) and 2009 (*P* = 0.101) .

### 11.6.2. The influence of average minimum temperature on the number of new individuals recorded on Telperion

Animals captured for the first time were compared to minimum temperature during 2008 and 2009. In 2008 these new records were compared with average monthly minimum temperature. The highest number recorded in 2008 was in March (n = 39), when the average minimum temperature was 13º C, while the lowest number recorded was in September (n = 14), when average minimum temperature was 8.4º C (Fig. 213). There is an insignificant relationship ($r^2$ = 0.148; *df* = 1,10; *n* = 12; *P* = 0.218) between average monthly minimum temperature and the number of new individuals recorded in 2008.

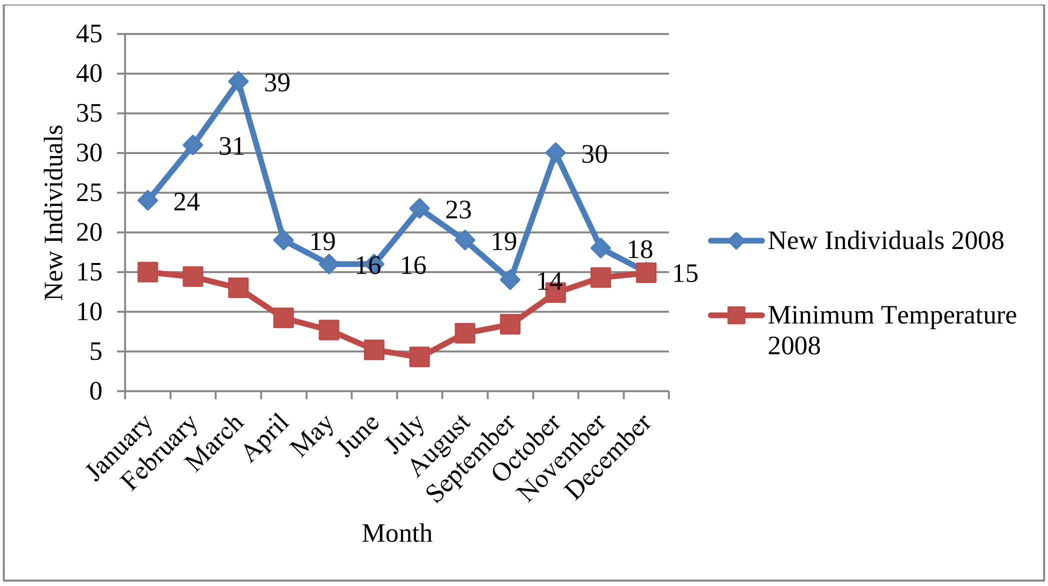

Figure 213. Graph illustrating the number of new individuals compared with average minimum temperature in 2008.

Seasonal data for new individuals was recorded in 2008 and 2009, and compared with average seasonal minimum temperature (Fig. 214)

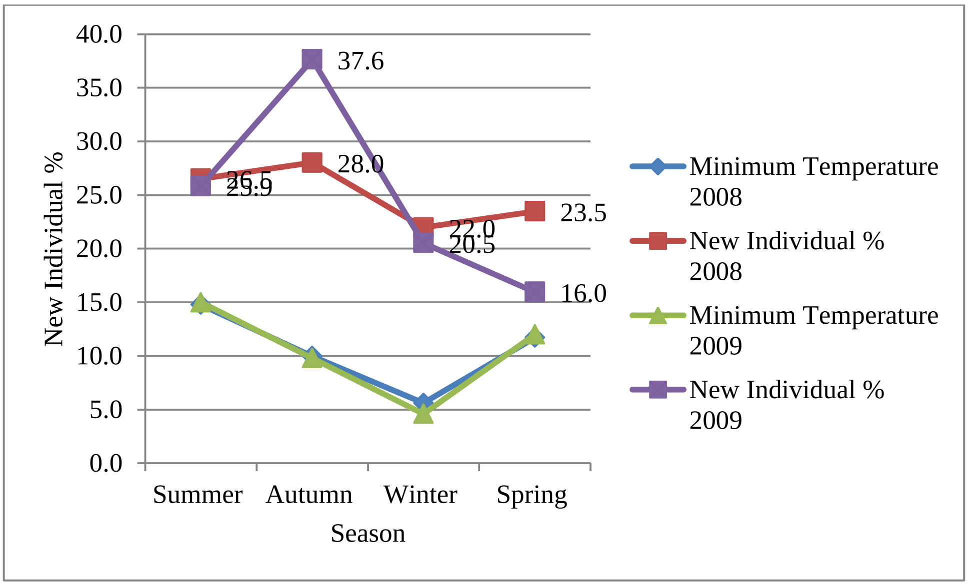

Figure 214. Graph illustrating the percentage of new individuals recorded compared with average minimum temperature in 2008 and 2009.

Data in 2008 indicates that the lowest number of new individuals were recorded in winter (22%), when the average minimum temperature were 5.6º C; closely followed by spring (23.5%) with an average minimum temperature of 11.7º C, then summer (26.5%) with a the highest minimum temperature of 14.8º C, and finally autumn (28%) with the highest record in 2008 with an average minimum temperature of 10º C. There is insignificant relationship ($r^2 = 0.317$; $df = 1,2$; $n = 4$; $P = 0.437$) between average seasonal minimum temperature and the number of new individuals recorded in 2008.The data recorded in 2009 indicates that the lowest number of new individuals were recorded in spring (16%), when the average minimum temperature was 12º C, followed by winter (20.5%), where the average minimum temperature was lowest at 4.6º C, summer (25.9%) with a temperature of 15º C, and then autumn with the highest percentage of new individuals being recorded (37.6%), when the average minimum temperature was 9.8º C. There is an insignificant relationship ($r^2 = 0.004$; $df = 1,2$; $n = 4$; $P = 0.936$) between average seasonal minimum temperature and the number of new individuals recorded in 2009. The combined data recorded during the study suggests that the lowest percentage of new individuals were recorded in spring, when the combined number of new individuals was at its lowest (19.7%), and the average minimum temperature was 11.9º C, followed by winter (21.3%), with an average temperature of 5.1º C, followed by summer (26.2%) with a temperature of 14.9º C, and the highest percentage of new individuals recorded for the study were in autumn, when the minimum average temperature was 9.9º C. Although marginally more new individuals are recorded in autumn when the minimum temperature is moderate, there is an insignificant relationship ($r^2 = 0.324$; $df = 1,2$; $n = 4$; $P < 0.822$) between average seasonal minimum temperature and the number of new individuals recorded in 2008 ($P = 0.912$) and 2009 ($P = 0.935$).

### 11.6.3. The influence of rainfall on the number of new individuals recorded on Telperion

Animals captured for the first time were compared with rainfall recorded during 2008 and 2009. The highest number recorded in 2008 was in March (n = 39), when 121 mm of rainfall was received, while the lowest number recorded was in September (n = 14), when 0 mm of rainfall was recorded (Fig. 215). There is an insignificant relationship ($r^2 = 0.115$; $df = 1,10$; $n = 12$; $P = 0.281$) between average monthly rainfall and the number of new individuals recorded in 2008.

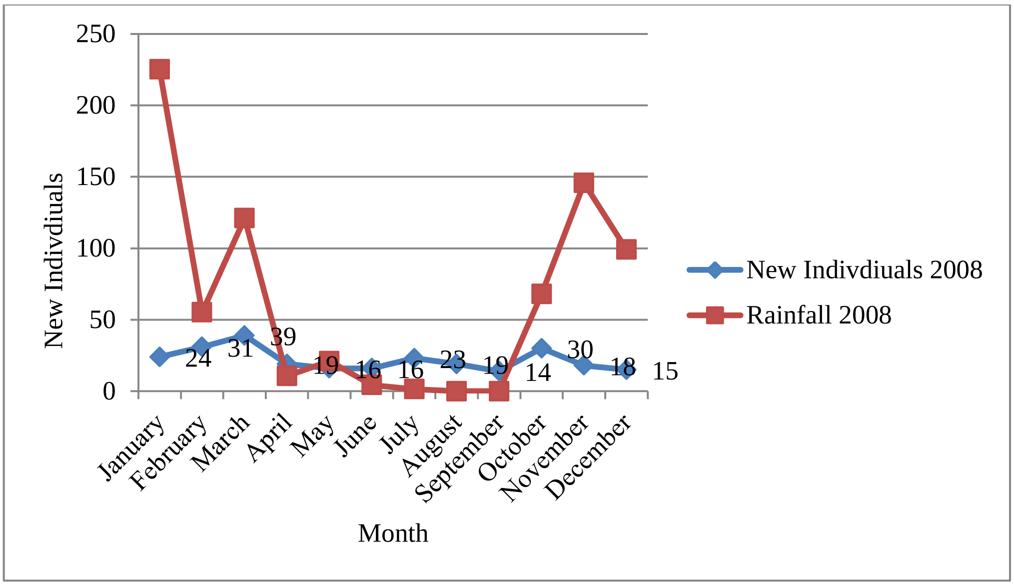

Figure 215. Graph illustrating the number of new individuals compared with rainfall in 2008.

Seasonal data for new individuals was recorded in 2008 and 2009, and compared with rainfall on Telperion (Fig. 216).

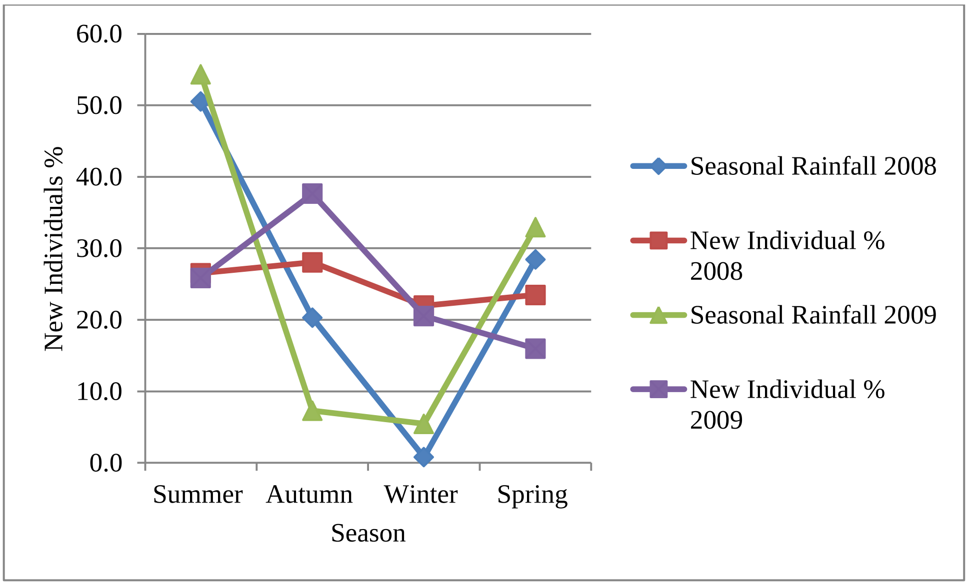

Figure 216. Graph illustrating the percentage of new individuals compared with rainfall percentage recorded in 2008 and 2009.

Data in 2008 indicates that the lowest number of new individuals were recorded in winter (22%), when 5.8 mm of rain was recorded; closely followed by spring (23.5%) with 213.6 mm, then summer (26.5%) with a the highest rainfall of 379.6 mm recorded, and finally autumn with the highest number of new animals (28%) in 2008 and with 152.6 mm of rain recorded. There is an insignficant relationship ($r^2 = 0.294$; $df = 1,2$; $n = 4$; $P = 0.458$) between average seasonal rainfall and the number of new indivdiuals captured in 2008. The data recorded in 2009 indicates that the lowest number of new individuals were recorded in spring (16%), with 302 mm of rain recorded, followed by winter (20.5%), with 50 mm, the lowest amount of rain recorded, then summer (25.9%) with the highest recorded rainfall of 497.8, and finally autumn with the highest percentage of new individuals recorded (37.6%), and with 66.8 mm of rain recoded. There was also an insignificant relationship ($r^2 = 0.079$; $df = 1,2$; $n = 4$; $P = 0.719$) between average seasonal rainfall and the number of new indivdiuals captured in 2009. The combined data recorded during the study suggests that the lowest percentage of new individuals were recorded in spring, when the combined number of new individuals was at its lowest (19.7%), and the average rainfall recorded was 257.8 mm, followed by winter (21.3%), with 5.5 mm, the lowest average rainfall recorded, followed by summer (26.2%) with 438.7 mm, the highest average rainfall recorded, and the highest percentage of new individuals recorded during the study were in autumn, with an average rainfall of 109.7 mm. Although marginally more new individuals are recorded in autumn after the summer rains, there appears to be no immediate relationship between rainfall and the number of new individuals recorded. There is an insignificant relationship ($r^2 = 0.926$; $df = 2,1$; $n = 4$; $P < 0.157$) between average seasonal rainfall and the number of new indivdiuals captured in 2008 ($P = 0.102$) and 2009 ($P = 0.120$).

## 11.7. The effects of climate on species richness recorded on Telperion in 2008 and 2009

### 11.7.1. The influence of average maximum temperature on species richness recorded on Telperion

Species richness was compared to maximum temperature during 2008 and 2009 on Telperion. The highest species richness recorded in 2008 was in August (n = 11), when the average maximum temperature was 22.1º C, while the lowest species richness recorded was in January, April and June (n = 5), when average maximum temperature was 23.9º C, 22.3º C and 18.5º C respectively (Fig. 217). In total sixteen of the eighteen species recorded during the study were recorded in 2008. There is an insignificant relationship ($r^2 = 0.144$; $df = 1,10$; $n = 12$; $P = 0.225$) between average monthly maximum temperature and species richness recorded in 2008.

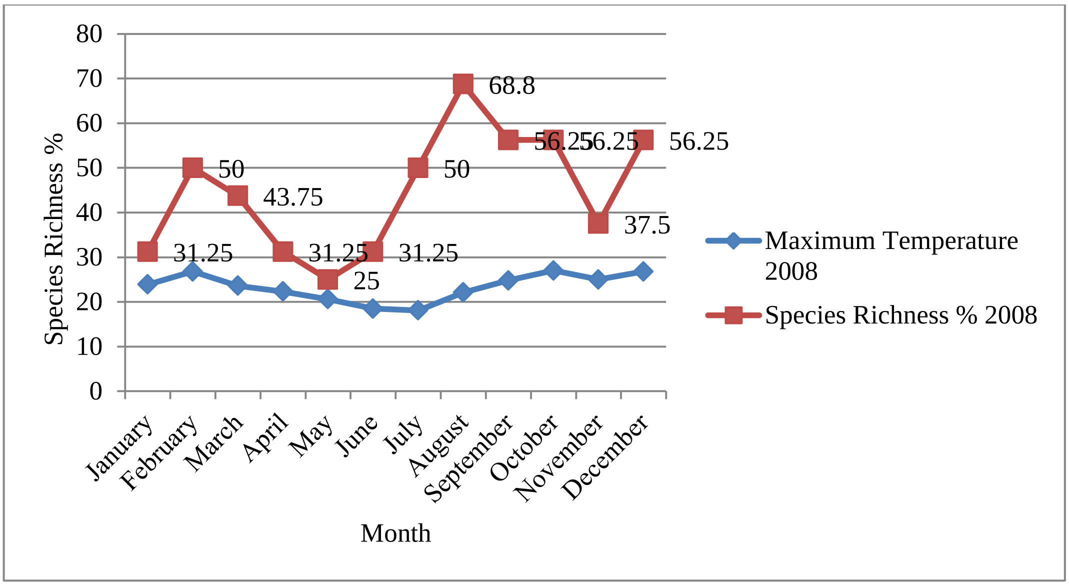

Figure 217. Graph illustrating species richness percentage compared with average maximum temperature in 2008.

Seasonal data for species richness was recorded in 2008 and 2009, and compared with average seasonal maximum temperature (Fig. 218).

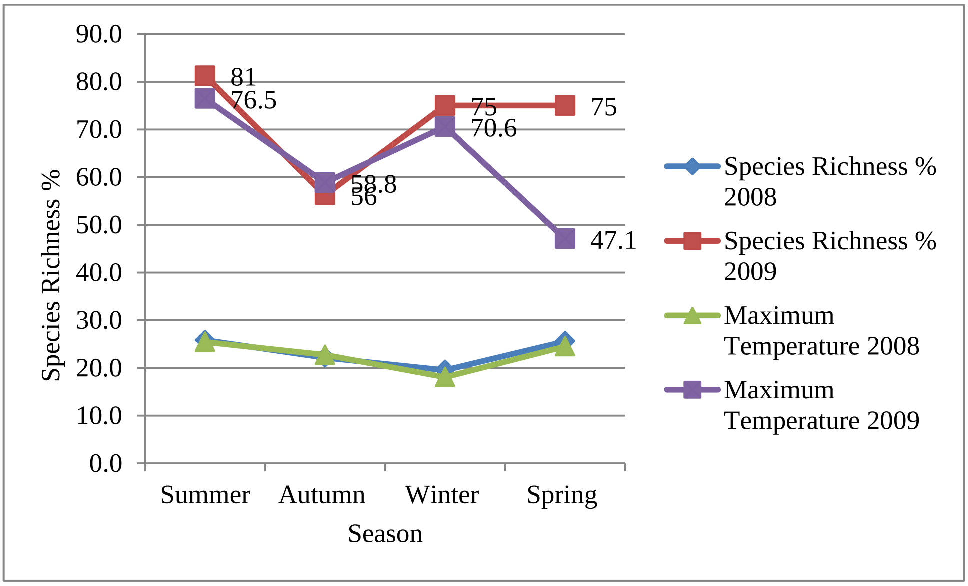

Figure 218. Graph illustrating the percentage of species richness recorded compared with average maximum temperature in 2008 and 2009.

Data in 2008 indicates that the lowest species richness were recorded in autumn, with 56% of species recorded, when the average maximum temperature were 22.2º C; followed by winter and spring, with 75% of species, with an average maximum temperature of 19.6º C and 25.6º C respectively, and summer, with 81%, the highest recorded species richness percentage in 2008, with an average maximum temperature of 25.8º C. There was an insignificant relationship ($r^2 = 0.144$; $df = 1,2$; $n = 4$; $P = 0.620$) between average seasonal maximum temperature and species richness recorded in 2008. Results in 2009 indicate that the lowest species richness percentage were recorded in spring (47.1%), when the average maximum temperature was 24.5º C, followed by autumn (58.8%1), where the average maximum temperature was 22.7º C, then winter (70.6%) with the lowest maximum temperature of 18.1º C, and then summer with the highest species richness percentage recorded (76.5%), when the average maximum temperature was 25.5º C. There was also an insignificant relationship ($r^2 = 0.001$; $df = 1,2$; $n = 4$; $P = 0.971$) between average seasonal maximum temperature and species richness recorded in 2009. The combined data recorded during the study suggests that the lowest species richness percentages were recorded in spring and autumn, when the combined percentage was at its lowest (55.6%), and the average maximum temperature were 25.1º C and 22.5º C respectively, followed by winter (66.7 %), with an average temperature of 18.8º C, and the highest species richness recorded for the study were in summer, when the maximum average temperature was 25.7º C. The summer months appear to harbour the highest species diversity, possibly due to the fact that animals are reproductively active and therefore more readily recorded, and maximum temperature doesn't appear to impact species richness, possibly due to the fact that the majority of the species recorded are nocturnal in habits. There was however an insignficant relationship ($r^2 = 0.926$; $df = 2,1$; $n = 4$; $P < 0.157$) between average seasonal maximum temperature and species richness recorded in 2008 ($P = 0.335$) and 2009 ($P = 0.360$).

### 11.7.2. The influence of average minimum temperature on species richness recorded on Telperion

Species richness was compared to minimum temperature during 2008 and 2009 on Telperion. The highest species richness recorded in 2008 was in August (n = 11), when the average minimum temperature was 7.3º C, while the lowest species richness recorded was in January, April and June (n = 5), when average minimum temperature was 15º C, 9.2º C and 5.2º C respectively (Fig. 219). There is an insignificant relationship ($r^2 = 0.001$; $df = 1,10$; $n = 12$; $P = 0.945$) between average monthly minimum temperature and species richness recorded in 2008.

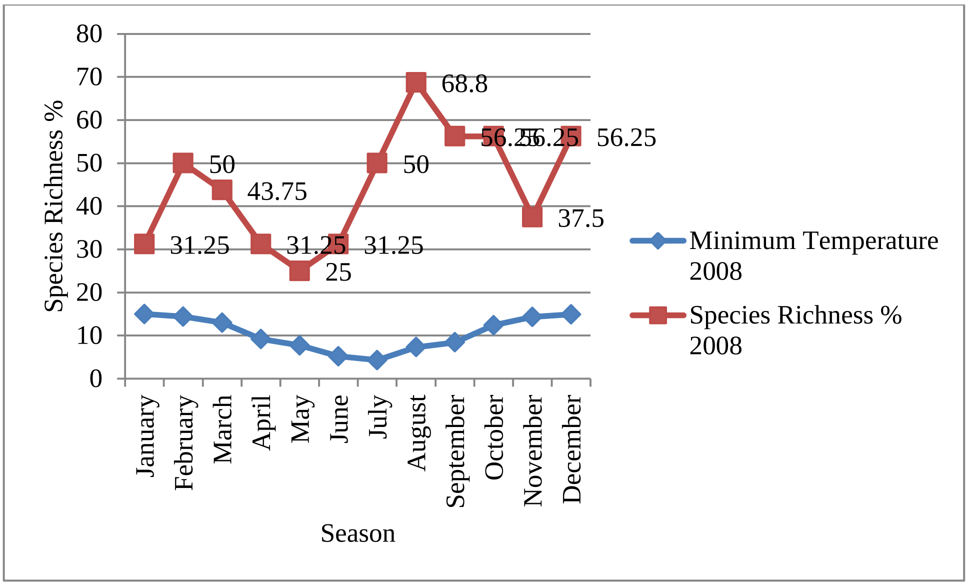

Figure 219. Graph illustrating species richness percentage compared with average minimum temperature in 2008.

Seasonal data for species richness was recorded in 2008 and 2009, and compared with average seasonal minimum temperature (Fig. 220).

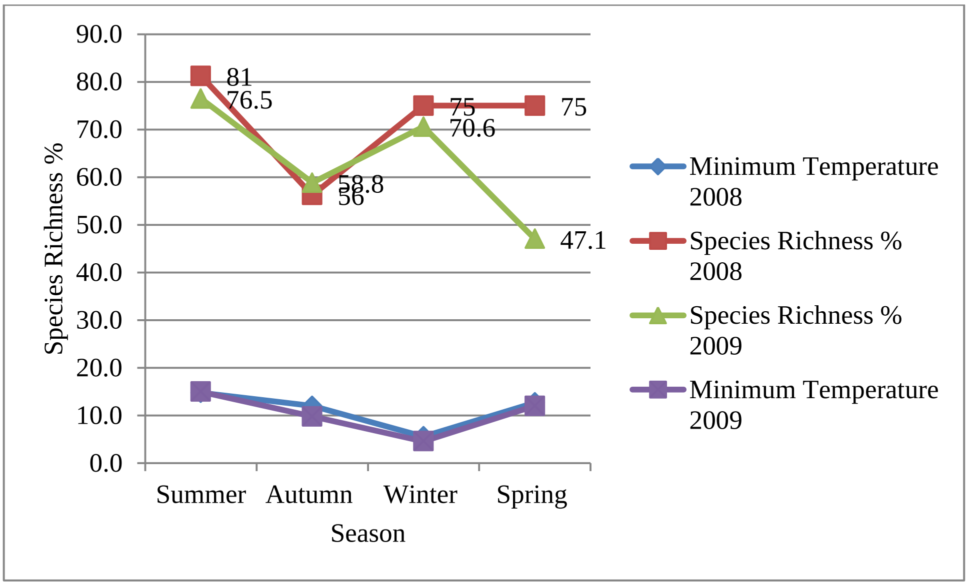

Figure 220 Graph illustrating the percentage of species richness recorded compared with average maximum temperature in 2008 and 2009.

Data in 2008 indicates that the lowest species richness were recorded in autumn, with 56% of species recorded, when the average minimum temperature was 10º C; followed by winter and spring, with 75% of species, with an average minimum temperature of 5.6º C and

11.7º C respectively, and summer, with 81%, the highest recorded species richness percentage in 2008, with an average minimum temperature of 14.8º C. recorded species richness percentage in 2008, with an average maximum temperature of 25.8º C. There was an insignificant relationship ($r^2 = 0.088$; $df = 1,2$; $n = 4$; $P = 0.704$) between average seasonal minimum temperature and species richness recorded in 2008. The data recorded for 2009 indicates that the lowest species richness percentage were recorded in spring (47.1%), when the average minimum temperature was 12º C, followed by autumn (58.8%), where the average minimum temperature was 9.8º C, then winter (70.6%) with the lowest minimum temperature of 4.6º C, and then summer with the highest species richness percentage recorded (76.5%), when the average minimum temperature was 15º C. There was an insignificant relationship ($r^2 = 0.001$; $df = 1,2$; $n = 4$; $P = 0.971$) between average seasonal minimum temperature and species richness recorded in 2009. The combined data recorded during the study suggests that the lowest species richness percentages were recorded in spring and autumn, when the combined percentage was at its lowest (55.6%), and the average minimum temperature were 11.9º C and 9.9º C respectively, followed by winter (66.7 %), with an average minimum temperature of 5.1º C, and the highest species richness recorded for the study were in summer, when the minimum average temperature was 14.9º C. Minimum temperature doesn’t appear to impact species richness, even though a higher species richness percentage occurs when average minimum temperatures are higher. There is an insignificant relationship ($r^2 = 0.223$; $df = 2,1$; $n = 4$; $P < 0.882$) between average seasonal minimum temperature and species richness recorded in 2008 ($P = 0.739$) and 2009 ($P = 0.748$).

### 11.7.3. The influence of rainfall on species richness recorded on Telperion

Species richness was compared to rainfall during 2008 and 2009 on Telperion. The highest species richness in 2008 was in August (n = 11), when 0 mm of rainfall was recorded, while the lowest species richness recorded was in January, April and June (n = 5), with 225.2 mm, 10.6 mm and 4.4 mm respectively (Fig. 221). There is an insignificant relationship ($r^2 = 0.060$; $df = 1,10$; $n = 12$; $P = 0.442$) between the average monthly rainfall and species richness recorded in 2008.

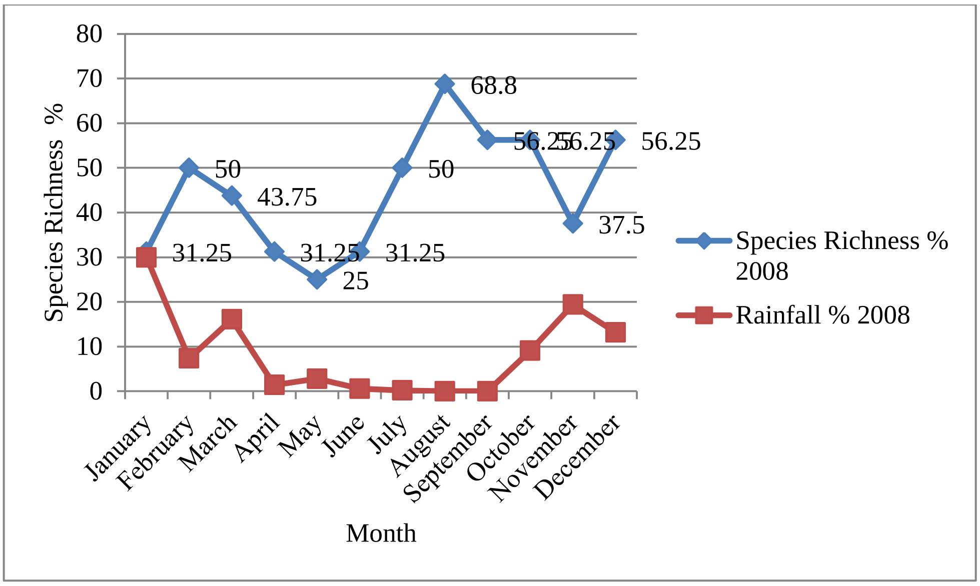

Figure 221. Graph illustrating species richness percentage compared with rainfall in 2008.

Seasonal data for species richness was recorded in 2008 and 2009, and compared with seasonal rainfall percentage (Fig. 222).

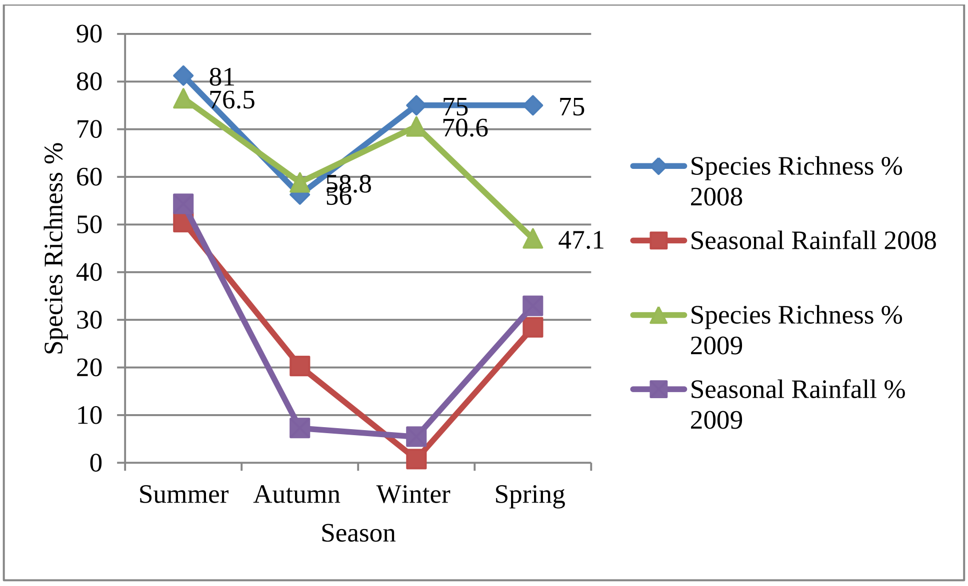

Figure 222. Graph illustrating the percentage of species richness recorded compared with rainfall percentage in 2008 and 2009.

Data in 2008 indicate that the lowest species richness were recorded in autumn, with 56% of species, when 152.6 mm of rain was recorded; followed by winter and spring, with 75% of species recorded, with 5.8 mm and 213.6 mm of rain recorded respectively, and summer, with 81% of species richness, the highest recorded percentage in 2008, with 379.6

mm of rain recorded. There is an insignificant relationship ($r^2$ = 0.137; *df* = 1,2; *n* = 4; *P* = 0.630) between average seasonal rainfall and species richness recorded in 2008. The data recorded in 2009 indicates that the lowest species richness percentage were in spring (47.1%), with 302 mm of rain being recorded, followed by autumn (58.8%), with 66.8 mm of rain recorded, then winter (70.6%) with 50 mm recorded, the lowest rainfall reading, and summer with the highest species richness percentage (76.5%), and 497.8 mm, the highest rainfall recorded. There is an insignificant relationship ($r^2$ = 0. 045; *df* = 1,2; *n* = 4; *P* = 0.787) between average seasonal rainfall and species richness recorded in 2009. The combined data recorded during the study suggests that the lowest species richness percentages were recorded in spring and autumn, when the combined percentage was at its lowest (55.6%), with 257.8 mm and 109.7 mm of rain recorded respectively, followed by winter (66.7 %), with only 5.5 mm recorded, and the highest species richness recorded for the study were in summer, with the highest average rainfall, with 438.7 mm recorded. A higher species richness percentage appears to occur in the summer months when rainfall is higher, which could be related to breeding activity and animals in search of mates. There is an insignificant relationship ($r^2$ = 0.972; *df* = 2,1; *n* = 4; *P* < 0.168) between average seasonal rainfall and species richness recorded in 2008 (*P* = 0.147) and 2009 (*P* = 0.115).

## 11.8. Discussion**:**

The objectives of this chapter are to record the effects of climate on small mammal communities in the Bankenveld grasslands. Eighteen species of small mammal were recorded during this study. Small mammals (= adults < 2kg) comprise quite a large percentage (> 60%) of all terrestrial mammal species in southern Africa (Skinner & Chimimba 2005). Marginally a larger number of animals were recorded when the maximum temperature is low, there appears to be no relationship between average maximum temperature and trap success, however there appears to be a relationship between average minimum temperature and trap success, with a higher trap success being recorded when morning and evening temperatures are low. Results indicate a higher trap success in months with a lower rainfall.

Small mammal community structure and species richness have been related to biotic and abiotic variables such as habitat structure and complexity (Rosenzweig & Winakur 1969; Brown 1973; French *et al.* 1976; Bond *et al.* 1980; Dueser & Brown 1980; Rowe-Rowe & Meester 1982a; Thompson 1982; Parmenter & MacMahon 1983; Kotler 1984; Abramsky

1988; Kerley 1992; Els & Kerley 1996), area (Abramsky *et al*. 1985; Fitzgibbon 1997), productivity (Abramsky 1978, 1988; Rosenweig 1992); predation (Kotler 1984; Norrdahl & Korpimäki 1995; Abramsky *et al.* 1998; trampling and grazing (Keesing 1998; Milchunas *et al*. 1998); surrounding landscape and the distance between similar habitats (Fitzgibbon 1997), and the maturity of the habitat and succession of the vegetation (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Rowe-Rowe 1995; Fitzgibbon 1997; Ferreira & van Aarde 1999). Temperature and rain fall is expected to influence trap success, the number of new individuals, and species richness recorded. Small mammals have specific responses to fluctuations in temperature and rainfall. Species respond by local movements, adaptation, or in cases of severe drought, and associated lack of food, death. Populations increase during periods where food and nesting materials are abundant, which may result in exponential population growth within a short period of time. When climatic conditions change, in time resources are often insufficient to maintain these large populations, and populations' crash. Other species, preferring drier, more open habitats may increase due to conditions being more suitable to their requirements. This change in species dominance is coupled with a decrease in competition with similar sized species, utilizing similar ecological niches. Local movements can sometimes follow an animal's preferred food and habitat requirement. Climate affects individuals, populations, species distributions and ecosystem composition and function both directly and indirectly, through climate changing the ecosystem, even temporarily.

There appears to be a strong connection between disturbance in an ecosystem and the presence or absence of small mammal indicator species (Noss 1990; Armstrong & Van Hensbergen 1996; Avenant 1996; Leirs *et al.* 1996; Barreto *et al.* 1998). Makundi *et al.* (2007) found that reproduction and population fluctuations in *Mastomys natalensis* were linked to the duration and amount of rainfall in Tanzania. They also found that the distribution of these species indicates a broad habitat tolerance and makes it a generalist in the colonization of disturbed habitats. Makundi *et al.* (2007) found population densities were highest at the end of the rain season to the middle of the dry season, but rapid decline in population density occurred towards the end of the dry season in September. The *Mastomys* spp. recorded during this study were located in spring, although in low numbers.

Rowe-Rowe & Lowry (1982) for instance, found fewer small mammals in dense cover, compared to the same habitats frequently burned in a fire managed plan. Vegetation biomass and seed production in grasses decreases in winter with reduced rainfall. It has been suggested that regenerating vegetation and availability of weed seeds create an attractive food resource for certain species of rodents (De Graaf 1981). Petersen (2006) found small mammal abundance and diversity to be linked and correlated with grass biomass. Biomass appears to be linked rainfall at the study site.

The results of this study support Avenant (2000a,b) that mid-autumn and mid-winter for certain species prove to be the best time to conduct small mammal sampling, although spring produced reasonable numbers of certain species. The summer months are less favourable, and produce significantly less animals and variety of species during this time of the year. How small mammals choose an area is a result of cover availability, differences in micro-climate, substrate, predation risk and food availability (Chesson 1986). Temporal differences on the other hand involve variations that act on a daily basis, such as resource renewal and availability, lunar, an increase in predation, and annual, rainfall, and temperature (Chesson 1986). Species within a community may be able to inhabit the same habitat as they respond differently to environmental fluctuations (Moro & Morris 2000; Stilmant *et al.* 2008). Thus, Bankenveld small mammal communities may be composed of species that vary from having narrow habitat requirements, referred to as specialists, to those with very broad habitat requirements, or generalists (Ben-Natan *et al.* 2004; Manor & Saltz 2008). Generalists however, may have a variety of accessible and profitable options; they often have clear resource preferences and will rank these depending on availability, whereas specialists tend to be more efficient at using specific resources (Stilmant *et al.* 2008), although this may have costs in terms of habitat, time or energy constraints (Townsend *et al.* 2000). It therefore found that specialists and generalists are often able to co-exist as generalists can exploit resources not used by specialist, and it is therefore expected that specialists should be able to out-compete less well-adapted species (Manor & Saltz 2008).

Suitable cover and availability of good quality food may be more important on a smaller scale, than across the species entire home range. Jorgensen (2004) attempted to simplify the matter for small mammal ecologists by defining the microhabitat as those environmental factors affecting individual behaviour while macrohabitat is the spatial area in which individuals perform their biological functions. Thus, in the present study, microhabitat refers to the specific area in which a species was recorded in terms of vegetation type and structure, while macrohabitat refers to an area traversed by the individual animal recorded. Suitable cover and sufficient food, especially in terms of invertebrates, is largely affected by climate. Temperature did not appear to have an impact on species richness recorded during the study. There was however a greater number of species recorded during the summer months when rainfall was high. This could be related to an increased activity associated with mate selection, territoriality and reproduction.

Changes in small mammal densities are dependent on a variety of factors, method used, season, climate and temperature. Three main cues, or a combination, are expected to influence reproduction in small mammals, namely abiotic factors (such as food availability), internal factors (endogenous rhythms) and social cues between individuals (Neal 1986; Ims 1990). Abiotic factors, such as rain are not likely to affect breeding directly as there is usually a lag time of two or three months between rainfall and the evidence of breeding (Bronner 1986), but rather affects breeding indirectly through food availability (Neal 1982). Rainfall therefore may still contribute to the timing of the reproductive seasonality and could explain inter-year variation in population numbers and demography (Willan & Meester 1989; Monadjem & Perrin 2003). Temperature could influence breeding success, especially during exceptionally cold and wet periods. Timing of breeding in small mammal populations is often constrained, not only by the environment but also phylogenetically in terms of age of reproduction. Population size fluctuations and species richness are due to differences in recruitment (movements into the population through birth and immigration) and emigration (movements out of the population through dispersal and death (Bronner 1986).

Home range overlap is influenced by several biological factors, such as population density, sex, age, body size and ecological factors, such as season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Priotto *et al.* 2002; Ribble *et al.* 2002; Schradin & Pillay 2006; Cooper & Randall 2007). Temperature and rainfall are expected to influence home range size and population estimates of small mammals.

Indigenous rodent populations are limited by fluctuating resources availability which includes food and shelter (Monadjem & Perrin 1998). Combined with the influence of predation, rodent communities need a specialized set of conditions if they are to persist in viable numbers. According to Bronner *et al.* (1988), Brooks (1982), Davis & Meester (1981) rodent population densities in perennial grasslands of the South African highveld are highly seasonal, with reproduction largely occurring between November and March, reaching peaks in population numbers during March and April. During winter (May-September) vegetation becomes less dense due to frost, and rodent populations decrease substantially (Davis 1973; Smithers 1983). Climate appeared to influence trap success, with a higher trap success when the when temperatures are low. Cooler conditions appear to be more suitable for foraging and increased activity is expected. Anecdotal evidence suggests that *Elephantulus myurus* is more active during the winter months, when rainfall is minimal. This could be related to increased activity and energy required to forage for invertebrates. Generally, the study site experiences severe cold and dry winters, and invertebrate life is dramatically decreased over this period. *Rhabdomys pumilio* and *Otomys irroratus*, both diurnal species, were only recorded in autumn and winter months when temperatures were low.

The historical influence in certain areas on the property resulted in some differences in vegetation diversity, density and height. These changes in habitat resulted in changes in plant communities, which consist of a combination of abiotic factors such as soil, rockiness and climate and biotic factors such as plant and animal composition with each element influencing the other. Temperature and rainfall did not appear to impact the number of new individuals recorded at the study site. Low numbers of new individuals were recorded in spring, with higher numbers recorded in autumn, which is evidence of reproduction in summer, and the resulting new individuals entering the system at the end of the breeding season.

# CHAPTER 12

# DIVERSITY OF SMALL MAMMAL ASSEMBLAGES IN THE BANKENVELD GRASSLAND

## 12.1. Abstract:

The aim of this chapter is to record the diversity of small mammals using the Shannon diversity index in seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. The diversity index is a quantitative measure that reflects the number of species occurring within a community. It differs from species richness in that unlike richness it provides insights into community composition and takes into account the relative abundance of species that are present in the community. The Rocky Highveld Grassland community had the high diversity score (H = 1.89), and was considered the most diverse community with ten species recorded on the study area. The Moist Degraded Grassland community had the second highest diversity score (H = 1.87) with eight species recorded. The Burkea Eragrostis Clumps community had the third highest diversity score (H = 1.46) with 6 species recorded. Nine species were recorded in the Degraded Grassland community with fourth highest diversity score (H = 1.38). Nine species were recorded in the Sheltered Woodland community with the fifth highest diversity score (H = 1.24) calculated. The community with the second lowest diversity score (H = 1.11) was the Northern Slope Woodland with eight species recorded. Three species were recorded in the Rocky Open Shrub community with the lowest diversity score (H = 0.65). The untransformed Rocky Highveld Grassland community is the most important from a diversity perspective in the Bankenveld grasslands.

**Keywords:** Shannon diversity index, small mammals, community, diversity score, Telperion, Ezemvelo Nature Reserve, South Africa.

## 12.2. Introduction

The purpose of this chapter is to record the diversity of small mammals using the Shannon-diversity index in seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. These properties are situated to the extreme north of the grassland biome in South Africa, recognized by Acocks (1988), and by Bankenveld and Bredenkamp and Van Rooyen (1998) as Rocky Highveld Grassland. South Africa's grassland biome has been identified as critically endangered based on total habitat loss, degree of fragmentation and taking into account future threats (Reyers *et al.* 2001). It is in need of conservation attention as little protection is given to this biome, despite its multiple sources and severity of threats to this biologically important resource (Neke & Du Plessis 2004).

The Shannon-diversity indices are essential to describe and compare small mammal fauna. The diversity index is a quantitative measure that reflects the number of species occurring within a community. It differs from species richness in that unlike richness it provides insights into community composition and takes into account the relative abundance of species that are present in the community. Biodiversity of small mammals is used as an effective indicator of disturbance in natural ecosystems. In general, changes in small mammal habitats are associated with changes in diversity and ecological disturbance of these habitats is associated with a decrease in small mammal species richness. There appears to be a strong connection between disturbance in an ecosystem and the presence or absence of small mammal indicator species (Noss 1990; Armstrong & Van Hensbergen 1996; Avenant 1996; Leirs *et al.* 1996; Barreto et al. 1998). According to Avenant (2000a,b), small mammal diversity relates to habitat structure, rainfall, state of vegetation succession, effects of overgrazing, predation and trampling.

The diversity index recorded for the overgrazed and over utilized areas is often high, while the diversity scores for the vegetation communities underutilized by game are low. Small mammal diversity therefore may be linked directly with the quality of grass seed. Petersen (2006) found small mammal diversity to be linked and correlated with grass biomass. Plant succession, condition of habitat, grass palatability, ecological status, geographic location and vegetation structure are recorded to have an impact on small mammal diversity and community composition (Els & Kerley 1996; Fitzgibbon 1997; Monadjem 1997; Abramsky *et al.* 1998; Ferreira & Van Aarde 1999; Monadjem 1999; Avenant 2000a). It is generally accepted that when there are changes in habitats through ecological disturbances, a decrease in the species richness of small mammals can be expected (Monadjem & Perrin 2003). Low level grazing and burning can help maintain small mammal biodiversity, if conducted under appropriate rainfall levels (Yarnell *et al.* 2007).

A very high grazing pressure, combined with fire, especially under drought conditions, is expected to negatively impact on small mammal biodiversity in savanna habitats (Kern 1981). Overgrazing is also expected to have negative impacts on the diversity of small mammals (Nyako-Lartey & Baxter 1995; Joubert & Ryan 1999) through the reduction in food quality (Keesing 1998) and cover (Kerley 1992). However, moderate levels of grazing may enhance small mammal diversity (Schmidt *et al.* 2005) by facilitating the creation of more ecological niches through heterogeneous habitat structuring (Kerley 1992). Grazing acts as a disturbance and, in moderation, opens up grasslands that can result in an increase in small mammal diversity (Ferreira & Van Aarde 2000; Fuller & Perrin 2001). The presence or absence of fire is expected to also play a major role in whether a vegetation community has a high or low diversity score.

## 12.3. Methodology

In year one (2008), ten transects each comprising 30 live-traps Sherman each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month. The starting-point was placing transects in the seven vegetation communities. Two transects were placed in the dominant communities to obtain a greater sample size. 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. The 10 m spacing was adopted at the study site due to availability of traps. In year two (2009), three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per site. The diversity within these vegetation communities on Telperion was assessed using the Shannon diversity index. The Shannon Diversity Index is a commonly used diversity index that takes into account both abundance and evenness of species present in the community. A high value of H would be a representative of a diverse and equally distributed community and lower values represent less diverse community. A value of 0 would represent a community with just one species. High values of H are representative of a more diverse vegetation community and evenly distributed species. So the H value provides an indication of not only the number of species but how abundance of these species is distributed among all the species within the community.

The Shannon Diversity Index was used during the study and is explained by the formula:

$$H = -\sum_{i=1}^{s} (Pi * \ln Pi)$$

where,

$Pi$ = fraction of the entire population made-up of species i (proportion of a species i relative to total number of species present, not encountered)
$S$ = numbers of species encountered.

Chi-square ($\chi^2$) test was used to analyze diversity indexes using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 12.4. Results

There is an insignificant difference in Shannon Diversity Index scores recorded for small mammals in the different vegetation communities assessed during the study ($\chi^2 = 0.898$; $df = 6$; $n = 7$; $P = 0.990$). The Rocky Highveld Grassland (H = 1.89) had the highest recorded diversity at the study site, followed by Moist Degraded Grassland (H = 1.87), Burkea Eragrostis Clumps (H = 1.46), Degraded Grassland (H = 1.38), Sheltered Woodland (H = 1.24), Northern Slope Woodland (H = 1.11) and the lowest diversity in the Rocky Open Shrub (H = 0.65) community (Table 30).

Table 30: Comparative figures indicating the diversity of small mammals in the seven broad vegetation communities on Telperion.

| Community | Shannon Diversity Index |
|---|---|
| Rocky Highveld Grassland | H = 1.89 |
| Moist Degraded Grassland | H = 1.87 |
| Burkea Eragrostis Clumps | H = 1.46 |
| Degraded Grassland | H = 1.38 |
| Sheltered Woodland | H = 1.24 |
| Northern Slope Woodland | H = 1.11 |
| Rocky Open Shrub | H = 0.65 |

### 12.5. The diversity of small mammal communities recorded using the Shannon diversity index in the vegetation communities on Telperion

#### 12.5.1. The diversity of small mammal communities recorded using the Shannon diversity index in the Rocky Highveld Grassland community (Table 31).

Ten species were recorded in the Rocky Highveld Grassland during 2008 and 2009 and the community had a high diversity score (H = 1.89), which was recorded as the most diverse community on the property. Statistically there is an insignificant difference in the Shannon Diversity Index score for small mammals in the Rocky Highveld Grassland when compared with the average diversity score ($\chi^2 = 0.109$; $df = 1$; $n = 2$; $P = 0.741$).

Table 31: Comparative figures indicating the diversity of small mammals in the Rocky Highveld Grassland.

| Species | Number | P1 | In P1 | -(P1 x In P1) |
|---|---|---|---|---|
| *Micaelamys namaquensis* | 34 | 0.37 | -0.99 | 0.37 |
| *Aethomys chrysophilus* | 1 | 0.01 | -4.61 | 0.05 |
| *Dendromus melanotis* | 18 | 0.2 | -1.61 | 0.32 |
| *Dendromus mystacalis* | 6 | 0.07 | -2.66 | 0.19 |
| *Mus minutoides* | 5 | 0.05 | -3 | 0.15 |
| *Gerbilliscus leucogaster* | 10 | 0.11 | -2.21 | 0.24 |
| *Lemniscomys rosalia* | 6 | 0.07 | -2.66 | 0.19 |
| *Steatomys pratensis* | 3 | 0.03 | -3.51 | 0.11 |
| *Mastomys spp.* | 1 | 0.01 | -4.61 | 0.05 |
| *Elephantulus myurus* | 8 | 0.09 | -2.41 | 0.22 |
| Total | 92 | | | H = 1.89 |

12.5.2. The diversity of small mammal communities recorded using the Shannon diversity index in the Moist Degraded Grassland community (Table 32)

Eight species were recorded in the Moist Degraded Grassland during 2008 and 2009 and the community had the second highest diversity score (H = 1.87). It is an interesting result, as this habitat has been historically disturbed, and is considered degraded. Statistically there is an insignificant difference in the Shannon Diversity Index score for small mammals in the Moist Degraded Grassland when compared with the average diversity score ($\chi^2$ = 0.103; *df* = 1; *n* = 2; *P* = 0.748). The numbers of insectivores recorded influenced the score and certain species of rodents were only collected in this vegetation community.

Table 32: Comparative fiugures indicating the diversity of small mammals in the Moist Degraded Grassland.

| Species | Number | P1 | In P1 | -(P1 x In P1) |
|---|---|---|---|---|
| *Dendromus melanotis* | 1 | 0.03 | -3.51 | 0.11 |
| *Dendromus mystacalis* | 4 | 0.10 | -2.3 | 0.23 |
| *Mus minutoides* | 3 | 0.08 | -2.53 | 0.2 |
| *Rhabdomys pumilio* | 13 | 0.33 | -1.11 | 0.37 |
| *Otomys irroratus* | 6 | 0.15 | -1.9 | 0.29 |
| *Mastomys spp.* | 2 | 0.05 | -3 | 0.15 |
| *Crocidura mariquensis* | 6 | 0.15 | -1.9 | 0.29 |
| *Suncus infinitesimus* | 4 | 0.1 | -2.3 | 0.23 |
| Total | 39 | | | H = 1.87 |

12.5.3. The diversity of small mammal communities recorded using the Shannon diversity index in the Burkea Eragrostis Clumps community (Table 33)

Six species were recorded in the Burkea Eragrostis Clumps during 2008 and 2009 and the community had the third highest diversity score (H = 1.46). It is an interesting result, as the habitat had a low abundance of small mammals, although the only site where *G. brantsii* was recorded. Statistically, however, there is an insignificant difference in the Shannon Diversity Index score for small mammals recorded in the Burkea Eragrostis Clumps community when compared with the average diversity score ($\chi^2 = 0.009$; $df = 1$; $n = 2$; $P = 0.923$).

Table 33: Comparative figures indicating the diversity of small mammals in the Burkea Eragrostis Clumps community.

| Species | Number | P1 | In P1 | -(P1 x In P1) |
|---|---|---|---|---|
| *Dendromus melanotis* | 9 | 0.26 | -1.35 | 0.35 |
| *Mus minutoides* | 9 | 0.26 | -3.35 | 0.35 |
| *Gerbilliscus brantsii* | 12 | 0.35 | -1.05 | 0.37 |
| *Lemniscomys rosalia* | 1 | 0.03 | -3.51 | 0.11 |
| *Steatomys pratensis* | 1 | 0.03 | -3.51 | 0.11 |
| *Mastomys spp.* | 2 | 0.06 | -2.81 | 0.17 |
| Total | 34 | | | H = 1.46 |

13.5.4. The diversity of small mammal communities recorded using the Shannon diversity index in the Degraded Grassland community (Table 34)

Nine species were recorded in the Degraded Grassland during 2008 and 2009 and the community had the fourth highest diversity score (H = 1.38). It is an interesting result, as the habitat is presently disturbed, and although it is relatively high in species richness, this community is ranked fourth. There is an insignificant difference in the Shannon Diversity Index score for small mammals recorded for the Degraded Grassland community when compared with the average diversity score ($\chi^2 = 0.002$; $df = 1$; $n = 2$; $P = 0.961$).

Table 34: Comparative figures indicating the diversity of small mammals in the Degraded Grassland community.

| Species | Number | P1 | In P1 | -(P1 x In P1) |
|---|---|---|---|---|
| *Dendromus melanotis* | 48 | 0.63 | -0.46 | 0.29 |
| *Dendromus mystacalis* | 2 | 0.03 | -3.51 | 0.11 |
| *Mus minutoides* | 8 | 0.11 | -2.21 | 0.24 |
| *Gerbilliscus leucogaster* | 2 | 0.03 | -3.51 | 0.11 |
| *Lemniscomys rosalia* | 6 | 0.08 | -2.53 | 0.21 |
| *Steatomys pratensis* | 5 | 0.07 | -2.66 | 0.19 |
| *Mastomys spp.* | 3 | 0.04 | -3.22 | 0.13 |
| *Crocidura cyanea* | 1 | 0.01 | -4.61 | 0.05 |
| *Suncus infinitesimus* | 1 | 0.01 | -4.61 | 0.05 |
| Total | 76 | | | H = 1.38 |

12.5.5. The diversity of small mammal communities recorded using the Shannon diversity index in the Sheltered Woodland community (Table 35)

Nine species were recorded in the Sheltered Woodland during 2008 and 2009 and the community had the fifth highest diversity score (H = 1.24). Statistically there is an insignificant difference in the Shannon Diversity Index score for small mammals recorded for the Sheltered Woodland community when compared with the average diversity score ($\chi^2$ = 0.002; *df* = 1; *n* = 2; *P* = 0.968). The site consists largely of rocky bolders, although the saddles between outcrops increase the diversity of the site when compared with other areas with a rocky substrate.

Table 35: Comparative figures indicating the diversity of small mammals in Sheltered Woodland community.

| Species | Number | P1 | In P1 | -(P1 x In P1) |
|---|---|---|---|---|
| *Micaelamys namaquensis* | 46 | 0.63 | -0.46 | 0.29 |
| *Dendromus melanotis* | 4 | 0.05 | -3 | 0.15 |
| *Mus minutoides* | 5 | 0.07 | -2.66 | 0.19 |
| *Acomys spinosissimus* | 2 | 0.03 | -3.51 | 0.11 |
| *Elephantulus myurus* | 12 | 0.16 | -1.83 | 0.29 |
| *Crocidura mariquensis* | 2 | 0.03 | -3.51 | 0.11 |
| *Crocidura cyanea* | 1 | 0.01 | -4.61 | 0.05 |
| *Suncus infinitesimus* | 1 | 0.01 | -4.61 | 0.05 |
| Total | 73 | | | H = 1.24 |

### 12.5.6. The diversity of small mammal communities recorded using the Shannon diversity index in the Northern Slope Woodland community (Table 36)

Eight species were recorded in the Northern Slope Woodland during 2008 and 2009 and the community had the sixth highest diversity score (H = 1.11). Statistically there is an insignificant difference in the Shannon Diversity Index score for small mammals recorded for the Northern Slope Woodland community when compared with the average diversity score ($\chi^2 = 0.015$; $df = 1$; $n = 2$; $P = 0.902$). The site consists largely of rocky areas with sparse grass cover, which is expected to influence the score as an array of species was seldom encountered.

Table 36: Comparative figures indicating the diversity of small mammals in the Northern Slope Woodland community.

| Species | Number | P1 | In P1 | -(P1 x In P1) |
|---|---|---|---|---|
| *Micaelamys namaquensis* | 82 | 0.66 | -0.42 | 0.27 |
| *Aethomys chrysophilus* | 1 | 0.01 | -4.61 | 0.05 |
| *Dendromus melanotis* | 1 | 0.01 | -4.61 | 0.05 |
| *Mus minutoides* | 1 | 0.01 | -4.61 | 0.05 |
| *Acomys spinosissimus* | 9 | 0.07 | -2.66 | 0.19 |
| *Graphiurus murinus* | 5 | 0.04 | -3.22 | 0.13 |
| *Elephantulus myurus* | 24 | 0.19 | -1.66 | 0.32 |
| *Crocidura cyanea* | 1 | 0.01 | -4.61 | 0.05 |
| Total | 124 | | | H = 1.11 |

12.5.7. The diversity of small mammal communities recorded using the Shannon diversity index in the Rocky Open Shrub community (Table 37)

Three species were recorded in the Rocky Open Shrub community during 2008 and 2009 and the community had the lowest diversity score (H = 0.65). There is an insignificant difference in the Shannon Diversity Index score for small mammals recorded for the Rocky Open Shrub community when compared with the average diversity score ($\chi^2 = 0.219$; $df = 1$; $n = 2$; $P = 0.641$). The site consists largely of rocky areas, which is expected to influence the score as an array of species was seldom encountered, as the site was dominated by *M. namaquensis* and *E. myurus*.

Table 37: Comparative figures indicating the diversity of small mammals in the Rocky Open Shrub community.

| Species | Number | P1 | In P1 | -(P1 x In P1) |
|---|---|---|---|---|
| *Micaelamys namaquensis* | 94 | 0.76 | -0.27 | 0.21 |
| *Aethomys chrysophilus* | 4 | 0.03 | -3.51 | 0.11 |
| *Elephantulus myurus* | 26 | 0.21 | -1.56 | 0.33 |
| Total | 124 | | H = 0.65 | |

## 12.6. Discussion

The objective of this chapter was to assess the diversity of small mammals in vegetation and habitat types in the Bankenveld grasslands of Gauteng and Mpumalanga Province, South Africa. Biodiversity of small mammals is used as an effective indicator of disturbance in natural ecosystems. The relationships between small mammals and the environment in which they live is often complex in nature (Avenant 2000a; Birney *et al.* 1976). It is expected that changes in the ecological state of habitat through ecological disturbances would result in a decrease is the species richness of small mammals. The Rocky Highveld Grassland community was the most diverse in terms of plant species and small mammal diversity during this study. This community had a variety of habitats, including open, sandy areas, and areas with red sandstone rocks. The variety of habitat and due to the pristine nature of this community, the highest score diversity was recorded for this community during the study. Interestingly, the Degraded Grassland community had the second highest diversity index score, possibly due to the cover provided by *Seriphium plumosum* in the winter months, aggravated by heavy grazing by antelope species in the surrounding, higher productive areas. Three species of insectivores were recorded in the degraded areas, which also influenced the communities score.

There appears to be a strong connection between disturbance in an ecosystem and the presence or absence of small mammal indicator species (Noss 1990; Armstrong & Van Hensbergen 1996; Avenant 1996; Leirs *et al.* 1996; Barreto *et al.* 1998. The Shannon-diversity indices are essential to describe and compare small mammal fauna. The aim of the chapter was to report on the diversity of small mammals present in the different vegetation communities on Telperion and Ezemvelo Nature Reserve. This information is of vital importance for conservation and for the understanding of small mammal biodiversity in terrestrial ecosystems (Rowe-Rowe 1995; Avenant 2000a, b; Petchey 2000). According to Avenant & Cavallini (2007), variety is the number of species found, while diversity, calculated using the Shannon index (Magurran 1988), is a measure of both the number of species and equality of representation of the individuals of all species. Rowe-Rowe & Meester (1982b) described the term "trap night" as one trap set for a 24-hour period. The three measures of abundance used in this study were trap success, species richness (or variety), and the diversity index (Nel 1975). Both the number of the species as well as the equality of the representation of the individuals of all species can be measured by the Shannon diversity index (H).

Generally, there were differences in small mammal diversity between different plant communities and habitat type. The conserving of biodiversity is one of the major goals justifying the presence of nature reserves and conservation areas. The ability of natural fire to rehabilitate flora in African savanna ecosystems has been well-documented (Swanepoel 1981; Manry & Knight 1986). We can therefore expect that the fauna which evolved in these habitats would also be well adapted (Rowe-Rowe & Meester 1982b). Rowe-Rowe & Lowry (1982) for instance, found fewer small mammals in dense cover, compared to the same habitats frequently burned in a fire managed plan. According to Rowe-Rowe (1995), the season, size, pattern, and intensity of burning influences recolonization of small mammals in fire climax grasslands and must be incorporated when burning programs are planned. The Rocky Highveld Grassland is reliant on fire, and under natural conditions, burns regularly. This community had the highest diversity score for the study, in comparison with communities largely protected by fire, Rocky Open Shrub, Sheltered Woodland, and Northern Slope Woodland, which had the lowest diversity scores. Fire therefore could play a major role in whether a community has a high or low diversity score.

According to Avenant (2000a,b), small mammal diversity relates to habitat structure, rainfall, state of vegetation succession, effects of overgrazing, predation and trampling. Such relationships appear complex in nature, impacting on basic habits of small mammals (Birney *et. al.* 1976). The large differences in mammal diversity observed between the habitats on Telperion and Ezemvelo Nature Reserve are therefore expected. According to Avenant & Kuyler (2002), this agrees with the numerous studies that have demonstrated the casual relationship between disturbance, lack of disturbance, and diversity and abundance of small mammals (Wootton 1998; Trojan 2000, Hastwell & Huston 2001), and between the decrease in diversity and declines in ecosystem functioning, structure, and resilience (Grime 1998: Cardinale *et al.* 2000; Chaplin *et. al.* 2000; Johnson 2000; Loreau 2000; McCann 2000; Petchey 2000; Purvis & Hector 2000; Wilsey & Potvin 2000; Fonseca & Ganade 2001; Knops *et al.* 2001; Scheffer *et al.* 2001). As stated by Avenant (2000a,b), the lack of domination by *Mastomys*, and a high diversity value are all small mammal community characteristics that indicate ecosystem integrity. Interestingly, communities with high trap success, such as Rocky Highveld Grassland, Sheltered Woodland, and Northern Slope Woodland, had the lowest diversity scores. Rocky Highveld Grassland, with the highest trap success, had the lowest diversity score for the study.

Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Co-existence in a grassland habitat may also be promoted by mechanisms that reduce interspecific competition (Kinahan & Pillay 2008) and thus improve overall fitness. Differential habitat use and the use of resources within these different systems, especially in space and time, may facilitate co-existence between species at the study site, or specific habitat (M’Closkey 1976; Brown 1989; Yunger *et al.* 2002; Zhang 2003; Bonesi & Macdonald 2004; Harris *et al.* 2006). Spatial differences in small mammal communities are based on macro- and micro-habitat selection. How small mammals choose an area is a result of cover availability, differences in micro-climate, substrate, predation risk and food availability (Chesson 1986). Temporal differences on the other hand involve variations that act on a daily basis, such as resource renewal and availability, lunar, an increase in predation, and annual, rainfall, and temperature (Chesson 1986).

Species within a community may be able to inhabit the same habitat as they respond differently to environmental fluctuations (Moro & Morris 2000; Stilmant *et al.* 2008). Thus, Bankenveld small mammal communities may be composed of species having narrow habitat requirements, referred to as specialists, to species with very broad requirements, or generalists (Ben-Natan *et al.* 2004; Manor & Saltz 2008). Generalists however, may have a variety of accessible and profitable options; they often have clear resource preferences and will rank these depending on availability, whereas specialists tend to be more efficient at using specific resources (Stilmant *et al.* 2008), although this may have costs in terms of habitat, time or energy constraints (Townsend *et al.* 2000). It is therefore found that specialists and generalists are often able to co-exist as generalists can exploit resources not used by specialist, and it is therefore expected that specialists should be able to out-compete less well-adapted species (Manor & Saltz 2008). Transformed areas, in the process of succession, often have pioneer, sub-climax and climax species, resulting in them being species rich. These areas therefore become marginal for more sensitive species, and suitable for generalists. As a result, areas such as Degraded Grassland and Moist Degraded Grassland had high diversity scores.

According to Lancaster (2009), various mechanisms are proposed to promote co-existence between species. Dietary partitioning relies on differences or modifications of the diet resulting in species utilizing different aspects of the food resource (Kinahan & Pillay 2008). Diet selection depends not only on the variety of resources available to a diversity of species in a habitat, including energy content, palatability, abundance and accessibility, but also on the species of consumers present in the habitat, their numbers, morphology and physiological characteristics that may influence their foraging behaviour and success (Chesson 1986). The concept of habitat selection is controversial due to the difference of scale. This is because habitat selection and preferences may occur at different scales, and what an individual selects within a home range may be very different to what it associates with in a smaller area. Suitable cover and availability of good quality food may be more important on a smaller scale, than across the species entire home range. Jorgensen (2004) attempted to simplify the matter for small mammal ecologists by defining the microhabitat as those environmental factors affecting individual behaviour while macrohabitat is the spatial area in which individuals perform their biological functions. Thus, in the present study, microhabitat refers to the specific area in which a species was recorded in terms of vegetation type and structure, while macrohabitat refers to an area traversed by the individual animal recorded.

Competitive release is well-understood in grassland environments, and occurs when in the absence of one species, another species increases its home range, density or range of food eaten (Chesson 1986). Intraspecific competition between small mammal species should occur at a higher density than interspecific competition since resource use is essentially the same within a species (Perri & Randall 1999; Perrin *et al.* 2001; Zhang 2003; Dammhahn & Kappeler 2008). Mutually exclusive home ranges provide evidence of avoidance rather than aggression as a behavioural mechanism promoting community structure and coexistence. However, the presence of a variety of species is just one factor influencing home range overlap. Other biological factors include population density, abundance, sex and age structure, and body size, while ecological factors may include season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Ribble *et al.* 2002; Priotto *et al.* 2002;

Schradin & Pillay 2006; Pasch & Koprowski 2006; Copper & Randall 2007). Vegetation Communities with high numbers of dominant species had the lowest diversity scores, could this be relate to high numbers *of Micaelamys namaquensis* and *Elephantulus myurus* outcompeting other species, or it is the combination of different microhabitats, appealing to a greater variety of species?

Large animals alter vegetation structure and assist in developing microtopography through herbivory and soils and nutrient movement (Naiman & Rogers 1997). This in turn effects the distribution of certain small mammal species relying on a specific vegetation structure. The organisms which cause physical state changes in abiotic or biotic materials are referred to as ecosystem engineers if they directly or indirectly modulate the availability of resources to other species (Jones *et al.* 1994). Large areas of the property are overgrazed due to the high stocking rate of ungulates. The diversity index recorded for the overgrazed and over utilized areas high, while the diversity scores for the vegetation communities underutilized by game are low. Small mammal diversity therefore may be linked directly with the quality of grass seed. Petersen (2006) found small mammal diversity to be linked and correlated with grass biomass. Biomass appears to be linked to the foraging activity and concentration of mega-herbivores and anthropogenic management of the area (in the Telperion case study, previously disturbed areas and overgrazed areas). Small mammal populations, whilst fluctuating through time are a constant influence within landscapes that contain suitable habitats. Stable ecosystems support a wide range of wildlife fauna in all niches. This study has shown, that diversity is not necessarily directly related to whether a vegetation community is pristine or previously transformed.

# CHAPTER 13

# AGE STRUCTURE RECORDED FOR SMALL MAMMAL SPECIES ON TELPERION

## 13.1. Abstract

This chapter aims to determine the age structure of small mammal fauna recorded in seven vegetation communities of Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Recording age structure is important in that it provides an indication of the health and status of a population. A population comprising of only adult animals provides an indication of possible imbalances in the ecosystem. If species within a population do not increase through young survival to adulthood or through immigration, the population decreases and ultimately become locally extinct. In certain cases young are heavily predated on due to imbalances in the ecosystem, or due to insufficient food supplies, or through excessive competition with adults or other competitors. Imbalances in age structures may be a result of stress, resulting in animals not breeding due to the unfavorable environmental conditions. The opposite is also true, with excessive numbers of young and sub-adults in a population, it can be assumed that a population explosion has occurred, possibly due to too few predators, too few competitors and therefore too many young survive, also resulting in an ecological imbalance. During this study, adult individuals were recorded for *Acomys spinosissimus, Dendromus melanotis, Dendromus mystacalis, Graphiurius murinus, Mastomys* spp., *Steatomys pratensis, Crocidura cyanea, Crocidura mariquensis*, while adult and sub-adult individuals were recorded for *Aethomys chrysophilus, Gerbilliscus brantsii, Gerbilliscus leucogaster, Lemniscomys rosalia, Mus minutoides, Otomys irroratus, and Elephantulus myurus.* Adult, sub-adult and juvenile individuals were recorded for *Micaelamys namaquensis* during this study. Juvenile and sub-adult animals are however often more difficult to trap due to being less active and adventurous. Understanding age structure of a population provides important insights into the mechanics and health of small mammal assemblages.

**Keywords:** Age structure, population, small mammals, habitat, sub-adults, adults, juveniles, sub-adults, Telperion, Ezemvelo Nature Reserve, South Africa.

## 13.2. Introduction

This chapter investigates the age structure of small mammals in fire-climax grassland of the Bankenveld. The assessment of age structure is important in determining changes in the population, community structure and dynamics. Disproportional age structures can result in changes in reproduction and ultimately the breeding performance of the population and provides an early warning sign that there could be irregularities in the population. Age structure is important in assessing the population health, as low numbers in a population could be as a result of an imbalance, or purely an indication of the biology of the species. The young of certain species are not expected to be recorded due to their nature and behavior. Age structure and reproduction within small mammal populations is expected to be impacted directly and indirectly by habitat structure, trampling and over and underutilization of vegetation, fragmentation and quantity of biomass. Individuals within different age groups representing different species are expected to coexist.

Understanding age structure within a population provides insights into the health of a population and directly relates to growth rate. The relative influence of density dependence in the dynamics of rodent populations is a matter of considerable debate (Krebs 2002; Berryman 2004). Nevertheless, population growth rates are often related negatively to density, in that population abundance is likely to decline when high and increase when low (Turchin 1999). Populations of short-lived organisms, such as rodents, appear more sensitive to changes in fecundity than adult survival (Oli & Dobson 2003; Gaillard *et al.* 2005). In the spring and summer months, large numbers of young animals are expected when compared with the number of adult and sub-adult animals. As primary and secondary consumers, small mammals have an important direct and indirect influence on ecosystem functioning, often constituting the first link in the food chain of many predators (Sibly *et al.* 2005). Home range overlap is influenced by several biological factors, such as population age structure, as well as season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Priotto *et al.* 2002; Ribble *et al.* 2002; Schradin & Pillay 2006; Cooper & Randall 2007). Recording age structure is important in that it provides an indication of the health and status of a population. A population comprising of only adult animals is an indication of possible imbalances in the ecosystem. If species within a population do not increase through young survival to adulthood or through immigration, the population decreases and ultimately become locally extinct. Juvenile and sub-adult animals are however often more difficult to trap due to being less active and adventurous.

A stable population has a balanced representation of juveniles, sub-adults and adult animals within a population. Disproportional age structures can result in changes in reproduction and ultimately the breeding performance of the population and provides an early warning sign that there could be irregularities in the population. Age structure is also expected to be influenced by variation in food distribution and abundance and the variety of acceptable food resources.

## 13.3. Methodology

The age structure of individual specimens was recorded during the duration of the study. In year one (2008), ten transects each comprising 30 live-traps Sherman each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month. The starting-point was placing transects in the seven vegetation communities. Two transects were placed in the dominant communities to obtain a greater sample size. 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. In year two (2009), three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per site.

Analysis of variance (ANOVA) was used to assess the difference between age structures of small mammal records in vegetation communities. Chi-square ($\chi^2$) test were used to analyze age structure and season, and t-tests ($t$) to analyze variance between age structures. All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 13.4. Results

Differences in age structure occurred seasonally and noticeably between species, with only adults of certain species being recorded. The combined age structure for all species recorded at the study site over the study period (Fig 223):

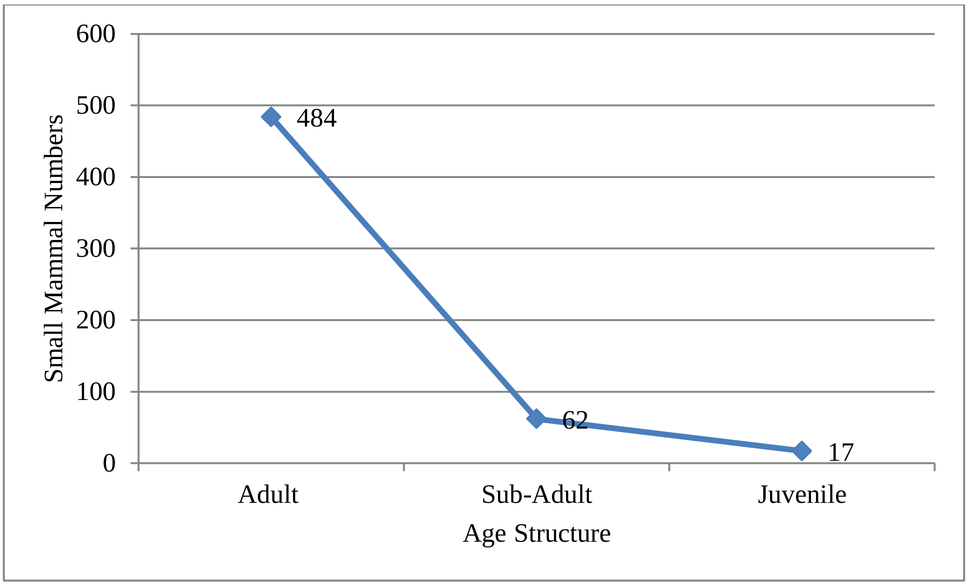

Figure 223. Graph illustrating the age structure of small mammals recorded on Telperion during 2008 and 2009.

The age structure between different species and individuals was recorded at the study site over the study period. The following data were recorded during the study period:

Table 38: A comparative table depicting the age structure of small mammals recorded during the study (Table 38).

| | Adult | Sub-Adult | Juvenile | Total |
|---|---|---|---|---|
| *Micaelamys namaquensis* | 208 | 33 | 15 | 256 |
| *Aethomys chrysophilus* | 5 | 1 | 0 | 6 |
| *Dendromus melanotis* | 81 | 0 | 0 | 81 |
| *Dendromus mystacalis* | 12 | 0 | 0 | 12 |
| *Mus minutoides* | 30 | 1 | 0 | 31 |
| *Gerbilliscus brantsii* | 6 | 6 | 0 | 12 |
| *Gerbilliscus leucogaster* | 8 | 4 | 0 | 12 |
| *Lemniscomys rosalia* | 9 | 4 | 0 | 13 |
| *Rhabdomys pumilio* | 4 | 7 | 2 | 13 |
| *Steatomys pratensis* | 9 | 0 | 0 | 9 |
| *Acomys spinosissimus* | 11 | 0 | 0 | 11 |
| *Otomys irroratus* | 3 | 3 | 0 | 6 |
| *Mastomys* spp. | 10 | 0 | 0 | 10 |
| *Graphiurus murinus* | 5 | 0 | 0 | 5 |
| *Elephantulus myurus* | 67 | 3 | 0 | 70 |
| *Crocidura mariquensis* | 8 | 0 | 0 | 8 |
| *Crocidura cyanea* | 3 | 0 | 0 | 3 |

|  |  |  |  |  |
|---|---|---|---|---|
| *Suncus infinitesimus* | 5 | 0 | 0 | 5 |
|  | 484 | 62 | 17 | 563 |

## 13.5. Age structure of the recorded population of small mammals on Telperion

### 13.5.1. Age structure of the population sample of *Acomys spinosissimus* recorded on Telperion

Age structure data recorded for *Acomys spinosissimus* indicate a frequency of adult (*n* = 11), sub-adult (*n* = 0) and juvenile (*n* = 0), represented largely by adult animals due to the low numbers of specimens recorded and the ecology of the species. Statisitcially a significant ($t_{(6)} = 3.220$; $n = 11$; $P = 0.018$) difference between the number of adult animals to sub-adults and juveniles was recorded (Fig 224).

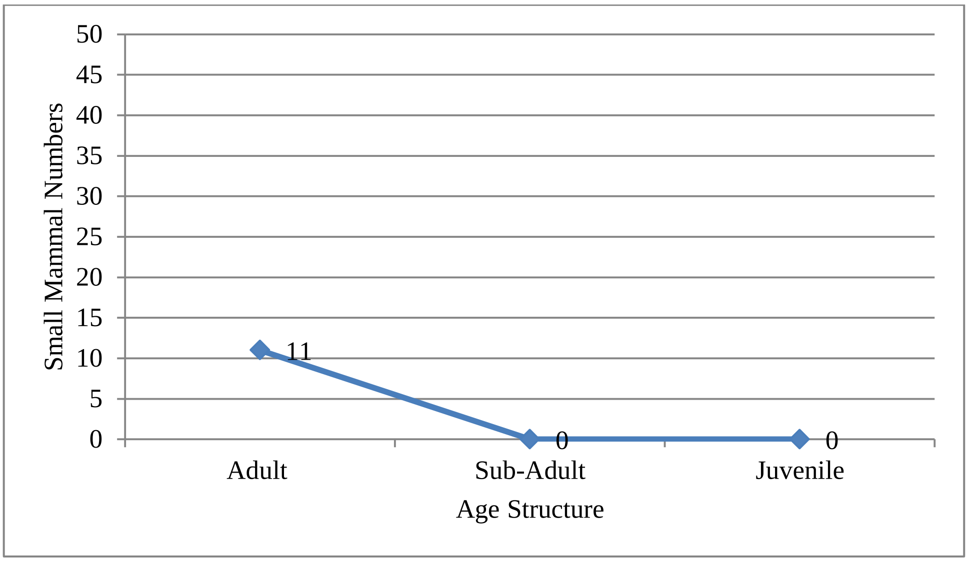

Figure 224. Graph illustrating the age structure of *Acomys spinosissimus* recorded on Telperion.

The following age structure percentage was recorded for *A. spinossimus* during the study period: Adult (100%), Sub-Adult (0%), Juvenile (0%). Only adult individuals were recorded during this study, possibly due to the sample size and densities recorded for this species, but also due to the nature of the terrain in which the animal inhabits. The habitat requirement for this species is limited to the specific rocky outcrops on the property and occurs in low densities. Statistically there is significant difference between age structure and season $\chi^2 = 16.125$; $df = 3$; $n = 4$; $P = 0.001$, with adult animals recorded on all seasons.

Age structure data for *A. spinossimus* was recorded from the Northern Slope Woodland and Sheltered Woodland, represented by 100% adult animals. Adult *A. spinossimus* accounted for 7.3% of animals recorded in the Northern Slope Woodland community and 2.7% in the Sheltered Woodland community.

### 13.5.2. Age structure of the population sample of *Aethomys chrysophilus* recorded on Telperion

Age structure data recorded for *Aethomys chrysophilus* indicate a frequency of adult ($n = 5$), sub-adult ($n = 1$) and juvenile ($n = 0$), which differed largely due to the low numbers of specimens recorded and the ecology of the species. Statistically there was an insignificant difference between adults and sub-adults ($t_{(6)} = 1.021$; $n = 6$; $P = 0.346$), and between adults and juveniles ($t_{(6)} = 0.235$; $n = 5$; $P = 0.235$) (Fig. 225).

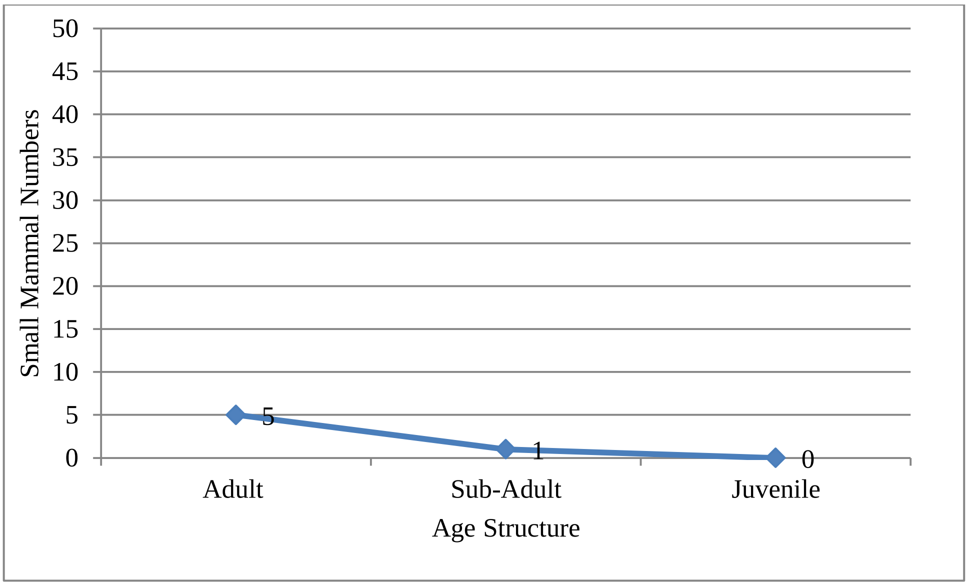

Figure 225. Graph illustrating the age structure of *Aethomys chrysophilus* recorded on Telperion.

The following age structure percentage was recorded for *A. chrysophilus* during the study period: Adult (83%), Sub-Adult (17%), Juvenile (0%). The majority of animals recorded were adult individuals, possibly due to the sample size and densities recorded for this species. The habitat requirement for this species is limited to the grass saddles between rocks on the property which limited the number of animals was recorded. Adult animals were recorded during spring, summer and autumn, with a sub-adult animal recorded in summer. Statistically there is an insignificant difference between age structure and season $\chi^2 = 5.233$; $df = 3$; $n = 4$; $P = 0.155$. Adult animals represented 100% of recorded individuals recorded from the Northern Slope Woodland and Rocky Highveld Grassland communities, with 75% representation by adults and 25% sub-adults in the Rocky Open Shrub community. Adult *A. chrysophilus* accounted for 0.8% animals recorded in the Northern Slope Woodland community, 1.1% in the Sheltered Woodland community, and 2.4% in the Rocky Open Shrubs, while 0.8% sub-adults were recorded in the Rocky Open Shrub community.

### 13.5.3. Age structure of the population sample of *Dendromus melanotis* recorded on Telperion

Age structure data recorded for *Dendromus melanotis* indicate a frequency of adult ($n = 81$), sub-adult ($n = 0$) and juvenile ($n = 0$), which differed largely due to ecology and behaviour of the species. Statisitcially a significant ($t_{(6)} = 2.666$; $n = 81$; $P = 0.037$) difference between the number of adult animals to sub-adults and juveniles was recorded. Smaller animals may also be missed due to their low mass (Fig. 226).

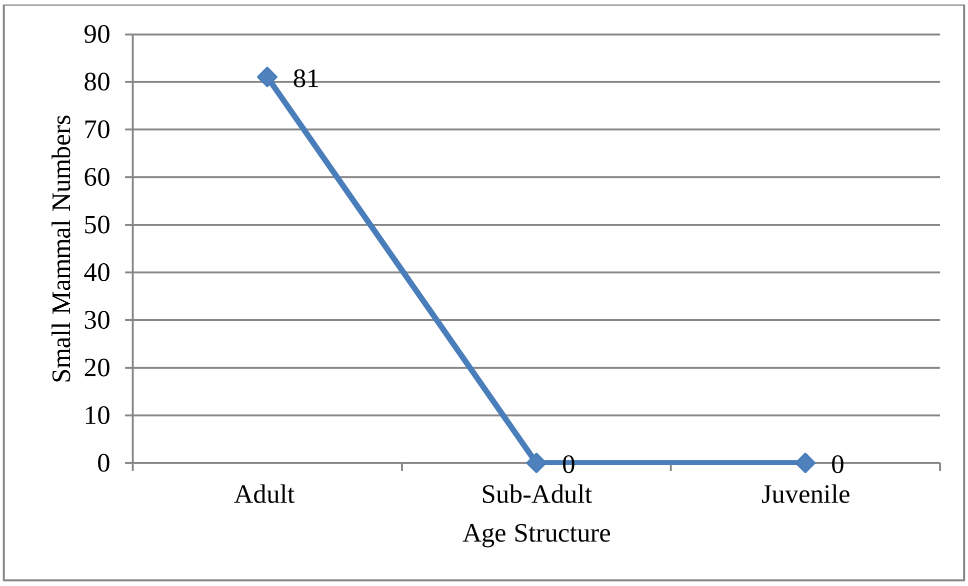

Figure 226. Graph illustrating the age structure of *Dendromus melanotis* recorded on Telperion.

The following age structure percentage was recorded for *D. melanotis* during the study period: Adult (100%), Sub-Adult (0%), Juvenile (0%). Only adult individuals were recorded during this study, possibly due the low mass of young and sub-adult animals, but possibly due to young being less active. This species appears to have a broad habitat requirement, however requiring suitable cover. Statistically there is a significant difference between age structure and season $\chi^2 = 108.808$; $df = 3$; $n = 4$; $P = 0.000$. Adult animals were recorded during spring, summer, autumn and winter, although the highest densities were recorded in autumn. Age structure for *D. melanotis* was recorded from the Northern Slope Woodland, Rocky Highveld Grassland, Degraded Grassland, Moist Degraded Grassland, Sheltered Woodland, and Burkea Eragrostis Clumps, represented by 100% adult animals. Adult *D. melanotis* accounted for 0.8% of the total animals recorded in the Northern Slope Woodland, 19.6% in the Rocky Highveld Grassland community, 61.5 % in Degraded Grassland, 5.5% in Sheltered Woodland, and 26.5% in the Burkea Eragrostis Clumps.

### 13.5.4. Age structure of the population sample of *Dendromus mystacalis* recorded on Telperion

Age structure data recorded for *Dendromus mystacalis* indicate a frequency of adult ($n = 12$), sub-adult ($n = 0$) and juvenile ($n = 0$), which differed largely due to ecology and behaviour of the species. Statisitcially an insignificant ($t_{(6)} = 1.414$; $n = 12$; $P = 0.207$) difference between the number of adult animals, sub-adults and juveniles was recorded. Similar to *D. melanotis*, smaller animals may not be captured due to their low mass (Fig. 227).

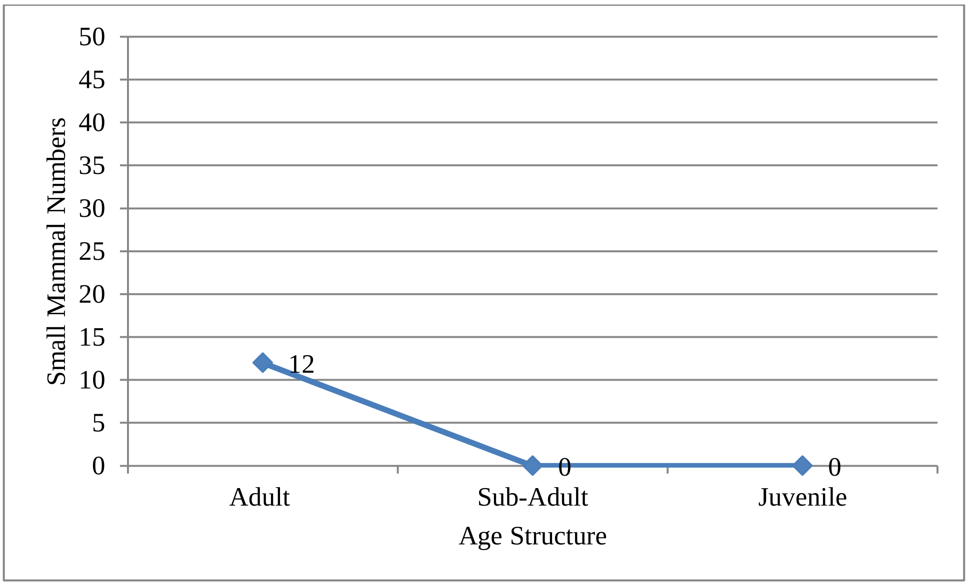

Figure 227. Graph illustrating the age structure of *Dendromus mystacalis* recorded on Telperion.

The following age structure percentage was recorded for *D. mystacalis* during the study period: Adult (100%), Sub-Adult (0%), Juvenile (0%). Only adult individuals were recorded during this study, possibly due the low mass of young and sub-adult animals, but possibly due to young being less active. This species appears to have a more specialized habitat requirement than sister species *D. melanotis*, however also requiring suitable cover. Adult animals were recorded in autumn and winter, although the highest densities were recorded in autumn. Statistically there is a significant difference between age structure and season $\chi^2 = 16.000$; $df = 3$; $n = 4$; $P = 0.001$. Age structure for *D. mystacalis* was recorded from the Rocky Highveld Grassland, Degraded Grassland, and Moist Degraded Grassland, represented by 100% adult animals. Adult *D. mystacalis* accounted for 6.5% of the total animals recorded in the Rocky Highveld Grassland, 2.6% in the Degraded Grassland and 10.5% in the Moist Degraded Grassland.

### 13.5.5. Age structure of the population sample of *Gerbilliscus brantsii* recorded on Telperion

Age structure data recorded for *Gerbilliscus brantsii* indicate a frequency of adult ($n = 6$), sub-adult ($n = 6$) and juvenile ($n = 0$), with equal numbers of adults and sub-adults being recorded (Fig. 228). Statistically there was an insignificant difference between adults and sub-adults ($t_{(6)} = -0.293$; $n = 12$; $P = 0.780$), and a significant difference between adults and juveniles ($t_{(6)} = 4.899$; $n = 5$; $P = 0.003$).

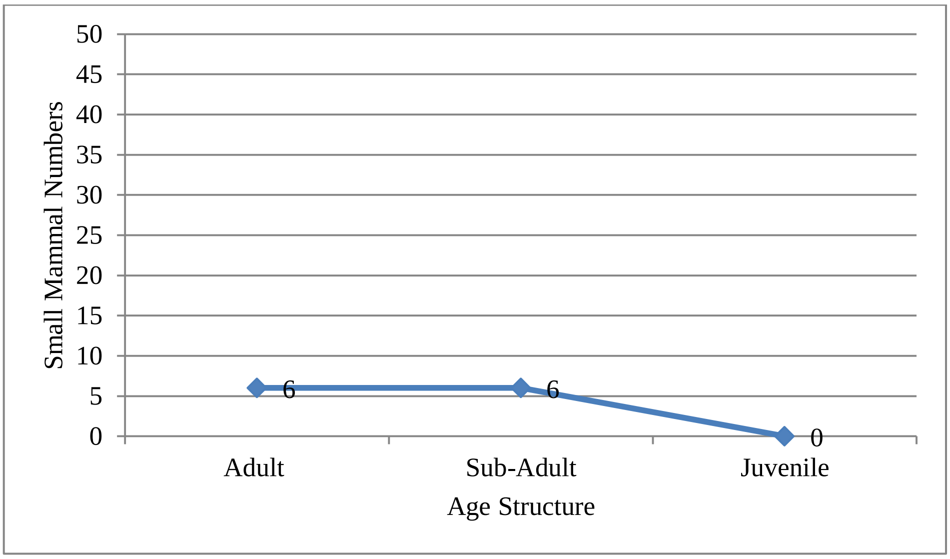

Figure 228. Graph illustrating the age structure of *Gerbilliscus brantsii* recorded on Telperion.

The following age structure percentage was recorded for *G. brantsii* during the study period: Adult (50%), Sub-Adult (50%), Juvenile (0%). Only adult and sub-adult individuals were recorded during this study, possibly due young animals remaining in the nest. This is a colonial species which appears to live in family groups, with similar requirement than sister species *G. leucogaster*, however preferring lower lying areas. Adult animals were recorded in spring, summer and winter, while sub-adult being recorded in spring and summer. Statistically there is an insignificant difference between age structure and season $\chi^2 = 2.333$; $df = 3$; $n = 4$; $P = 0.506$. Age structure was only recorded for *G. brantsii* from Burkea Eragrostis Clumps. Adult and sub-adult *G. brantsii* accounted for 35.3% of the total animals recorded in Burkea Eragrostis Clumps, 17.6% respectively.

### 13.5.6. Age structure of the population sample of *Gerbilliscus leucogaster* recorded on Telperion

Age structure data recorded for *Gerbilliscus leucogaster* indicate a frequency of adult ($n = 8$), sub-adult ($n = 4$) and juvenile ($n = 0$), with a higher numbers of adults to sub-adults being recorded (Fig. 229). There was an insignificant difference between adults and sub-adults ($t_{(6)} = 1.414$; $n = 12$; $P = 0.207$), and a significant difference between adults and juveniles ($t_{(6)} = 4.899$; $n = 8$; $P = 0.003$).

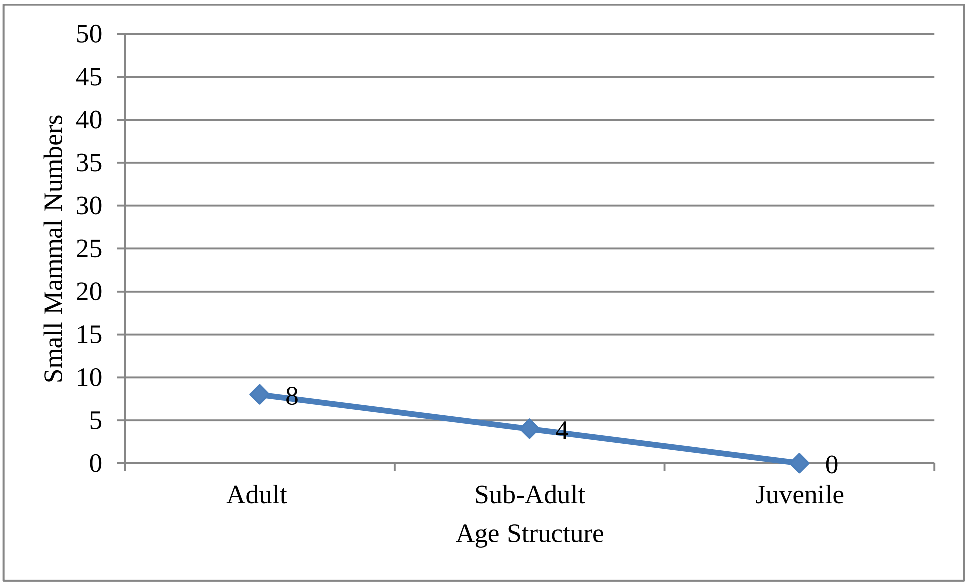

Figure 229. Graph illustrating the age structure of *Gerbilliscus leucogaster* recorded on Telperion.

The following age structure percentage was recorded for *G. leucogaster* during the study period: Adult (67%), Sub-Adult (33%), Juvenile (0%). Only adult and sub-adult individuals were recorded during this study, similarly due to young animals possibly remaining in the nest chamber. This is a colonial species which lives in family groups, with similar requirement than sister species *G. brantsii*, however preferring higher lying areas. Statistically there is a significant difference between age structure and season $\chi^2 = 7.644$; $df = 3$; $n = 4$; $P = 0.054$. Adult animals were recorded in spring, summer, autumn and winter, while sub-adult were recorded in autumn and winter. Age structure for *G. leucogaster* predominantly was recorded from Rocky Highveld Grassland, but also in Degraded Grassland. Adult *G. leucogaster* accounted for 6.5%, sub-adult 4.3% of the animals recorded in Rocky Highveld Grassland, with adults accounting for 2.6% of animals recorded in Degraded Grassland.

### 13.5.7. Age structure of the population sample of *Graphiurus murinus* recorded on Telperion

Age structure data recorded for *Graphiurus murinus* indicate a frequency of adult ($n = 5$), sub-adult ($n = 0$) and juvenile ($n = 0$), with only adult animals represented, largely due to the low numbers of individuals recorded and due the ecology of the species (Fig 230). Statistically there was an insignificant difference between adults, sub-adults and juveniles ($t_{(6)} = 1.667$; $n = 5$; $P = 0.147$).

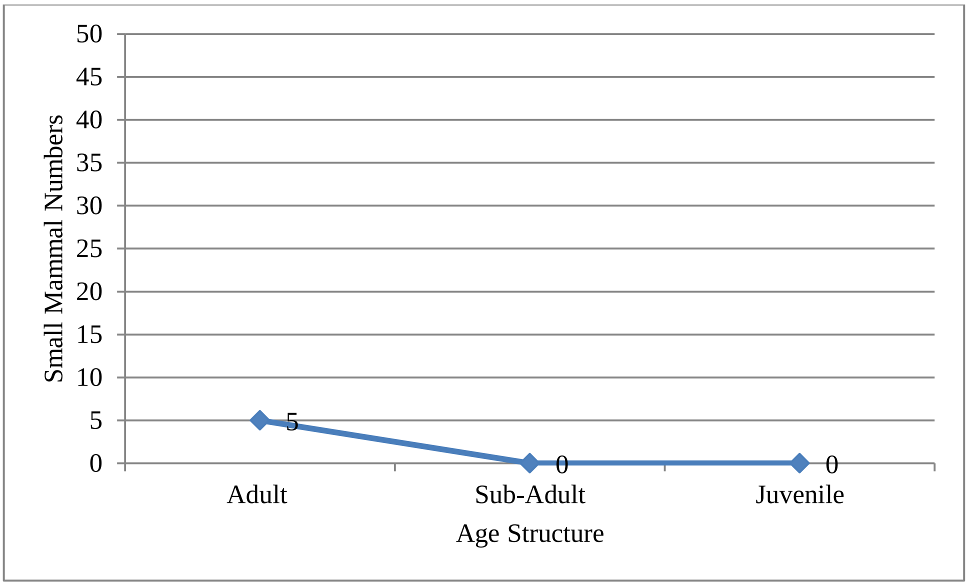

Figure 230. Graph illustrating the age structure of *Graphiurus murinus* recorded on Telperion

The following age structure percentage was recorded for *G. murinus* during the study period: Adult (100%), Sub-Adult (0%), Juvenile (0%). Only adult individuals were recorded during this study, possibly due to the sample size and densities recorded for this species. The habitat requirement for this species is limited to the specific rocky outcrops on the property which limited the number of animals was recorded. Statistically there is an insignificant difference between age structure and season $\chi^2 = 7.267$; $df = 3$; $n = 4$; $P = 0.064$. Adult animals were recorded during autumn and summer. Age structure for *G. murinus* was recorded from the Northern Slope Woodland represented by 100% adult animals. Adult *G. murinus* accounted for 4% of the animals recorded in the Northern Slope Woodland community.

### 13.5.8. Age structure of the population sample of *Lemniscomys rosalia* recorded on Telperion

Age structure data recorded for *Lemniscomys rosalia* indicate a frequency of adult ($n = 9$), sub-adult ($n = 4$) and juvenile ($n = 0$), with a higher numbers of adults to sub-adults being recorded (Fig. 231). Statistically there was an insignificant difference between adults and sub-adults ($t_{(6)} = 0.757$; $n = 13$; $P = 0.478$), and an insignificant difference between adults and juveniles ($t_{(6)} = 1.711$; $n = 9$; $P = 0.138$).

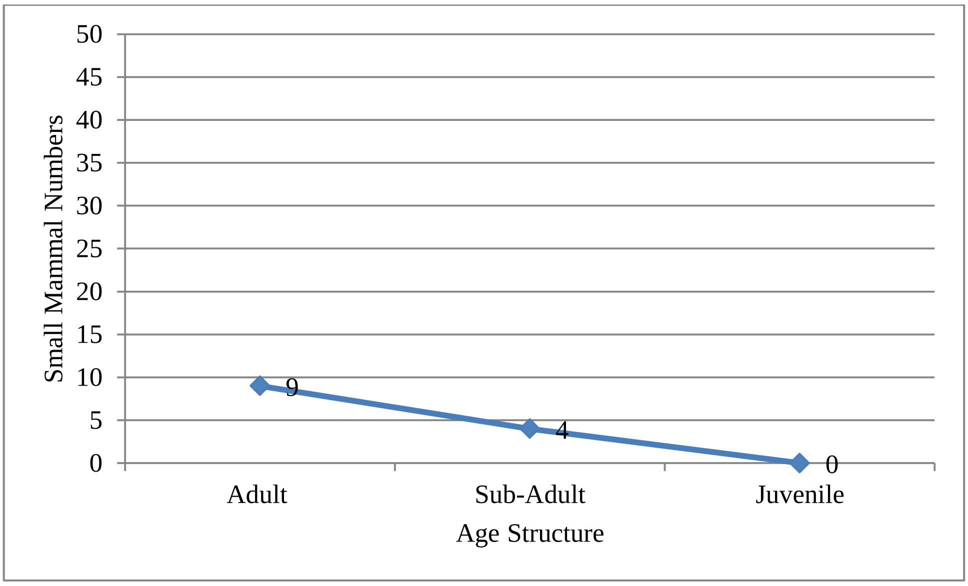

Figure 231. Graph illustrating the age structure of *Lemniscomys rosalia* recorded on Telperion

The following age structure percentage was recorded for *L. rosalia* during the study period: Adult (69%), Sub-Adult (31%), Juvenile (0%). Only adult and sub-adult individuals were recorded during this study, possibly due to young animals being less active than adults. This species appears to have a broad habitat requirement, however requiring suitable cover. Statistically there is an insignificant difference between age structure and season $\chi^2 = 7.109$; $df = 3$; $n = 4$; $P = 0.069$. Adult animals were recorded predominantly in summer, however also in spring and winter, while sub-adult were recorded in summer. Age structure for *L. rosalia* predominantly was recorded from Rocky Highveld Grassland and Degraded Grassland, but also in Burkea Eragrostis Clumps. Adult *L. rosalia* accounted for 4.3%, sub-adult 2.2% of the animals recorded in Rocky Highveld Grassland, with adult accounting for 5.1%, sub-adult 2.6% of animals recorded in Degraded Grassland, while adults accounted for 2.9% of animals recorded in Burkea Eragrostis Clumps.

### 13.5.9. Age structure of the population sample of *Mastomys* spp. recorded on Telperion

Age structure data recorded for *Mastomys* spp. indicate a frequency of adult ($n = 10$), sub-adult ($n = 0$) and juvenile ($n = 0$), which differed largely due the low abundance recorded for the species (Fig 232). Statistically there was an insignificant difference between adults, sub-adults and juveniles ($t_{(6)} = 1.321$; $n = 10$; $P = 0.235$) recorded during the study.

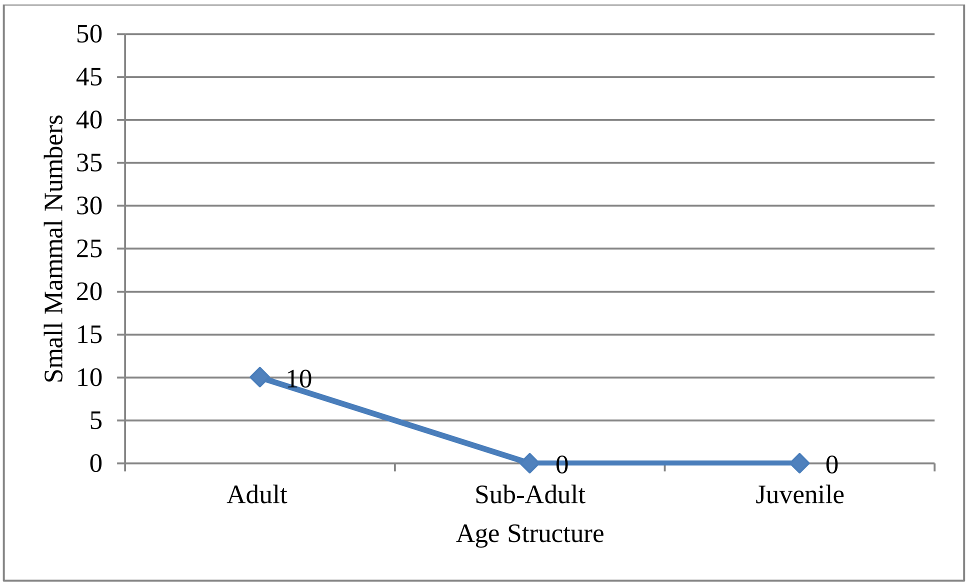

Figure 232. Graph illustrating the age structure of *Mastomys* spp. recorded on Telperion

The following age structure percentage was recorded for *Mastomys* spp. during the study period: Adult (100%), Sub-Adult (0%), Juvenile (0%). Only adult individuals were recorded during this study, as abundance of this species tends to fluctuate and low numbers were recorded during the study. This is a generalist, usually well represented in disturbed or previously disturbed areas. Statistically there is a significant difference between age structure and season $\chi^2 = 14.482$; $df = 3$; $n = 4$; $P = 0.002$. Adult animals were recorded during spring and summer, with highest densities recorded in spring. Adult *Mastomys* spp. was recorded from Rocky Highveld Grassland, Degraded Grassland, Burkea Eragrostis Clumps and Moist Degraded Grassland. Adult *Mastomys* spp. accounted for 1.1% of the total animals recorded in the Rocky Highveld Grassland, 6.4% in the Degraded Grassland community, 5.9 % in Burkea Eragrostis Clumps, and 5.3% in the Moist Degraded Grassland.

### 13.5.10. Age structure of the population sample of *Micaelamys namaquensis* recorded on Telperion

Age structure data recorded for *Micaelamys namaquensis* indicate a frequency of adult ($n = 208$), sub-adult ($n = 33$) and juvenile ($n = 15$), with a higher numbers of adults to sub-adults being recorded (Fig. 233). Statistically there is a significant difference between adults and sub-adults ($t_{(6)} = 3.029$; $n = 241$; $P = 0.023$), and a significant difference between adults and juveniles ($t_{(6)} = 3.424$; $n = 223$; $P = 0.014$).

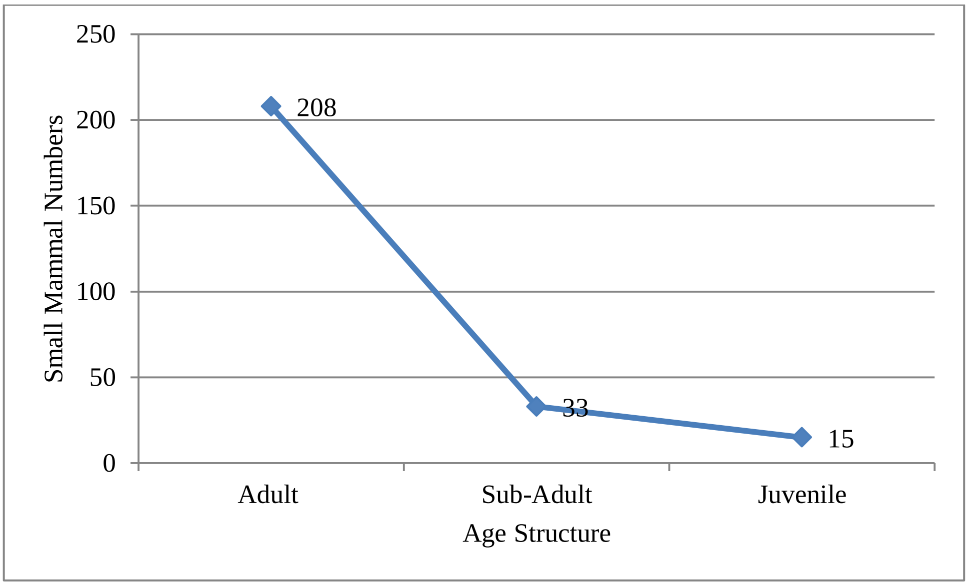

Figure 233. Graph illustrating the age structure of *Micaelamys namaquensis* recorded on Telperion.

The following age structure percentage was recorded for *M. namaquensis* during the study period: Adult (81%), Sub-Adult (13%), and Juveniles (6%). Adult, sub-adult and juvenile individuals were recorded during this study. This species is largely rock dwelling occurring in areas with a rocky substrate. Statistically there is a highly significant difference between age structure and season $\chi^2 = 184.399$; $df = 3$; $n = 4$; $P = 0.000$. Adult animals were recorded in spring, summer, autumn and winter, while juveniles and sub-adult were recorded in spring, summer and autumn. Age structure for *M. namaquensis* recorded from Northern Slope Woodland, Rocky Highveld Grassland, Sheltered Woodland and Rocky Open Shrub. Adult *M. namaquensis* accounted for 54.8%, sub-adult 8.9%, and juveniles 2.4% of the animals recorded in Northern Slope Woodland, with adult accounting for 30.4%, sub-adult 4.3%, and juveniles 2.2% of the animals recorded in Rocky Highveld Grassland, with adult accounted for 49.3%, sub-adult 8.2%, and juveniles 5.5% of the animals recorded in Sheltered Woodland, with adult accounting for 61.3%, sub-adult 9.7%, and juveniles 4.8% of the animals recorded in the Rock Open Shrub community.

### 13.5.11. Age structure of the population sample of *Mus minutoides* recorded on Telperion

Age structure data recorded for *Mus minutoides* indicate a frequency of adult ($n = 30$), sub-adult ($n = 1$) and juvenile ($n = 0$), differences in the age structure possibly due to ecology and behaviour of the species. The trapability of smaller, juvenile animals is also questionable as a result of their low mass (Fig. 234). Statistically there is a significant difference between the number of adults and sub-adults ($t_{(6)} = 3.713$; $n = 31$; $P = 0.010$), and number of adults and juveniles ($t_{(6)} = 3.873$; $n = 30$; $P = 0.008$) recorded during the study.

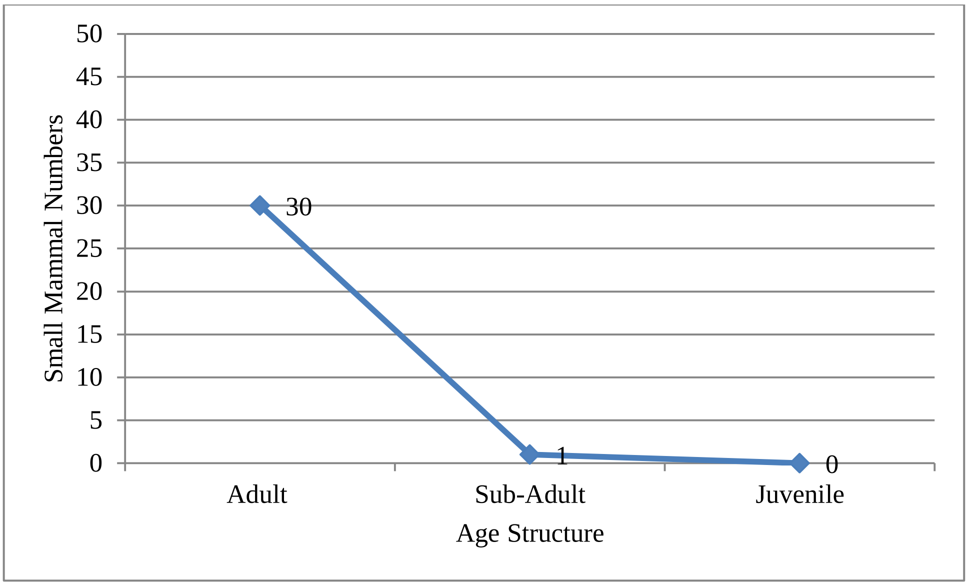

Figure 234. Graph illustrating the age structure of *Mus minutoides* recorded on Telperion.

The following age structure percentage was recorded for *M. minutoides* during the study period: Adult (97%), Sub-Adult (3%), Juvenile (0%). The majority of animals recorded were adult individuals, although a sub-adult was recorded during this study. This species appears to have a broad habitat requirement. Statistically there is a highly significant difference between age structure and season $\chi^2 = 38.551$; $df = 3$; $n = 4$; $P = 0.000$. Adult animals were recorded during spring, summer, autumn and winter, while a sub-adult was recorded in summer. The greatest numbers of adults were recorded in the summer months. Age structure for *M. minutoides* was recorded from the Northern Slope Woodland, Rocky Highveld Grassland, Degraded Grassland, Moist Degraded Grassland, Sheltered Woodland, and Burkea Eragrostis Clumps, represented by 100% adult animals. Adult *M. minutoides* accounted for 0.8% of the total animals recorded in the Northern Slope Woodland, 5.4% in the Rocky Highveld Grassland community, 10.3 % in Degraded Grassland, 5.5% in Sheltered Woodland, 26.5% in Burkea Eragrostis Clumps, and 7.9% in the Moist Degraded Grassland community. Sub-adult *M. minutoides* accounted for 1.4% of animals recorded in the Sheltered Woodland community.

### 13.5.12. Age structure of the population sample of *Otomys irroratus* recorded on Telperion

Age structure data recorded for *Otomys irroratus* indicate a frequency of adult ($n$ = 3), sub-adult ($n$ = 3) and juvenile ($n$ = 0), with similar numbers of adult and sub-adult animals recorded. No juveniles were recorded possibly due to their habits (Fig. 235). Statistically there is an insignificant difference between the number of adult and sub-adult animals ($t_{(6)} = 0.000$; $n = 6$; $P = 1.000$), and the number of adult to juvenile animals ($t_{(6)} = 1.567$; $n = 3$; $P = 0.168$) recorded during the study.

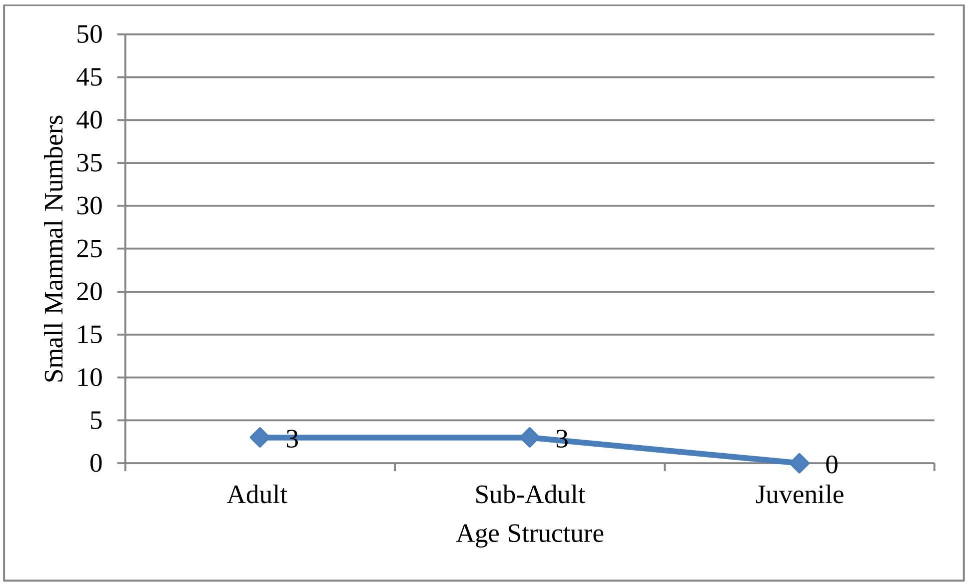

Figure 235. Graph illustrating the age structure of *Otomys irroratus* recorded on Telperion.

The following age structure percentage was recorded for *O. irroratus* during the study period: Adult (50%), Sub-Adult (50%), Juvenile (0%). Only adult and sub-adult individuals were recorded during this study, possibly due to young being less active and therefore less readily caught. This species favours vleis and marshy areas, with sufficient grass cover. Statistically there is an insignificant difference between age structure and season $\chi^2 = 0.644$; $df = 3$; $n = 4$; $P = 0.886$. Adult and sub-adult animals were recorded during autumn and winter. Age structure for *O. irroratus* was recorded from the Moist Degraded Grassland community where adult and sub-adult *O. irroratus* accounted for 7.9% respectively of animals recorded in this vegetation community.

### 13.5.13. Age structure of the population sample of *Rhabdomys pumilio* recorded on Telperion

Age structure data recorded for *Rhabdomys pumilio* indicate a frequency of adult (n = 4), sub-adult (n = 7) and juvenile (n = 2), with higher numbers of sub-adults to adults recorded, while only two juveniles were recorded (Fig. 236). Statistically there is an insignificant difference between the number of adult and sub-adult animals ($t_{(6)} = -0.407$; $n = 11$; $P = 0.698$), and the number of adult to juvenile animals ($t_{(6)} = 0.775$; $n = 6$; $P = 0.468$) recorded during the study.

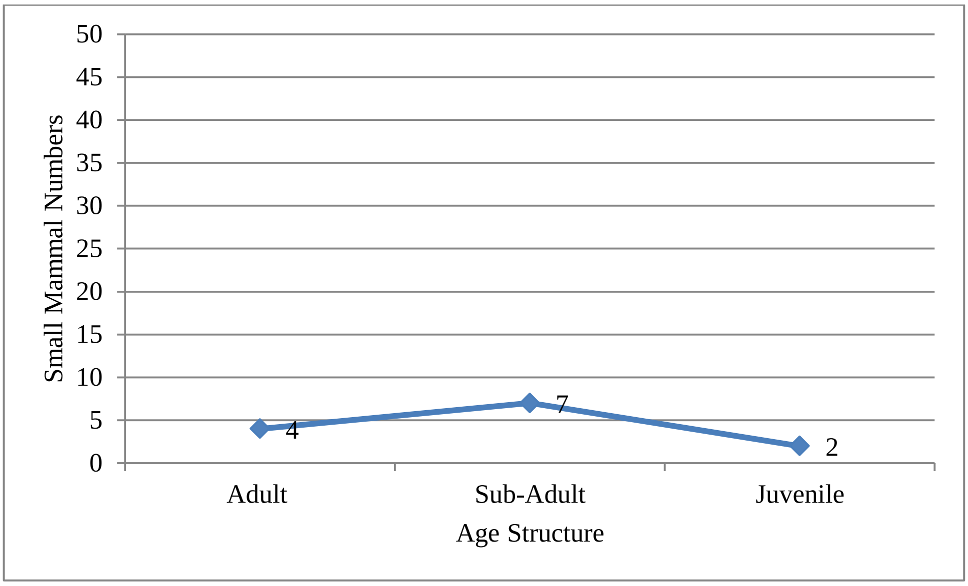

Figure 236. Graph illustrating the age structure of *Rhabdomys pumilio* recorded on Telperion

The following age structure percentage was recorded for *R. pumilio* during the study period: Adult (31%), Sub-Adult (54%), Juveniles (15%). Adult, sub-adult and juvenile individuals were recorded during this study. This species is a generalist, regularly encountered in historically degraded grasslands, with sufficient grass cover. Statistically there is an insignificant difference between age structure and season $\chi^2 = 1.512$; $df = 3$; $n = 4$; $P = 0.679$. Adult and juvenile animals were recorded during autumn and winter, while sub-adults were recorded in winter. No indivdiuals were recorded in the spring or summer months. Age structure for *R. pumilio* was recorded from the Moist Degraded Grassland community where adults accounted for 10.5%, sub-adults 18.4%, and 5.4% juvenile of animals recorded in this vegetation community.

### 13.5.14. Age structure of the population sample of *Steatomys pratensis* recorded on Telperion

Age structure data recorded for *Steatomys pratensis* indicate a frequency of adult ($n = 9$), sub-adult ($n = 0$) and juvenile ($n = 0$), which differed largely due to the low numbers of specimens recorded and possibly the ecology of the species (Fig. 237). Statistically there is an insignificant difference between the number of adult, sub-adult and juvenile animals ($t_{(6)}$ = 1.711; $n$ = 9; $P$ = 0.138 recorded during the study.

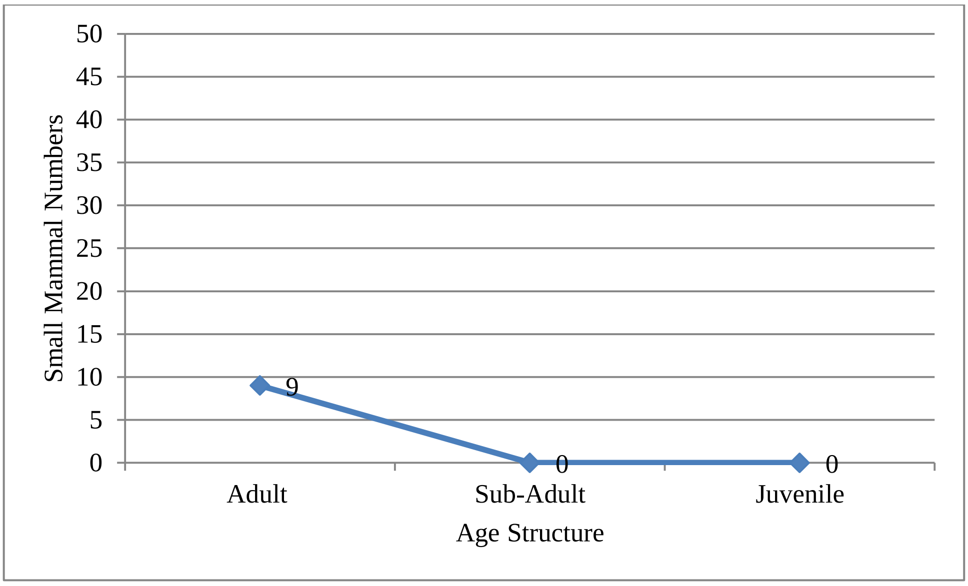

Figure 237. Graph illustrating the age structure of *Steatomys pratensis* recorded on Telperion.

The following age structure percentage was recorded for *S. pratensis* during the study period: Adult (100%), Sub-Adult (0%), Juvenile (0%). Only adult animals were recorded, possibly due to the sample size and densities recorded for this species. The habitat requirement for this species is areas with sparse grass, therefore favouring arid, open grassland habitats. Statistically there is an insignificant difference between age structure and season $\chi^2$ = 0.000; $df$ = 3; $n$ = 4; $P$ = 1.000. Adult animals were recorded during summer months from predominantly the Rocky Highveld Grassland, although also recorded from the Degraded Grassland community. Adult *S. pratensis* accounted for 3.3% of animals recorded in the Rocky Highveld Grassland community and 6.4% in the Degraded Grassland community.

### 13.5.15. Age structure of the population sample of *Crocidura cyanea* recorded on Telperion

Age structure data recorded for *Crocidura cyanea* indicate a frequency of adult ($n$ = 3), sub-adult ($n$ = 0) and juvenile ($n$ = 0), differences in the age structure possibly due to ecology and behaviour of the species. The trapability of smaller, juvenile animals is also questionable as a result of their low mass (Fig. 238). Statistically there is an insignificant difference between the number of adult, sub-adult and juvenile animals ($t_{(6)} = 1.567$; $n = 3$; $P = 0.168$ recorded during the study.

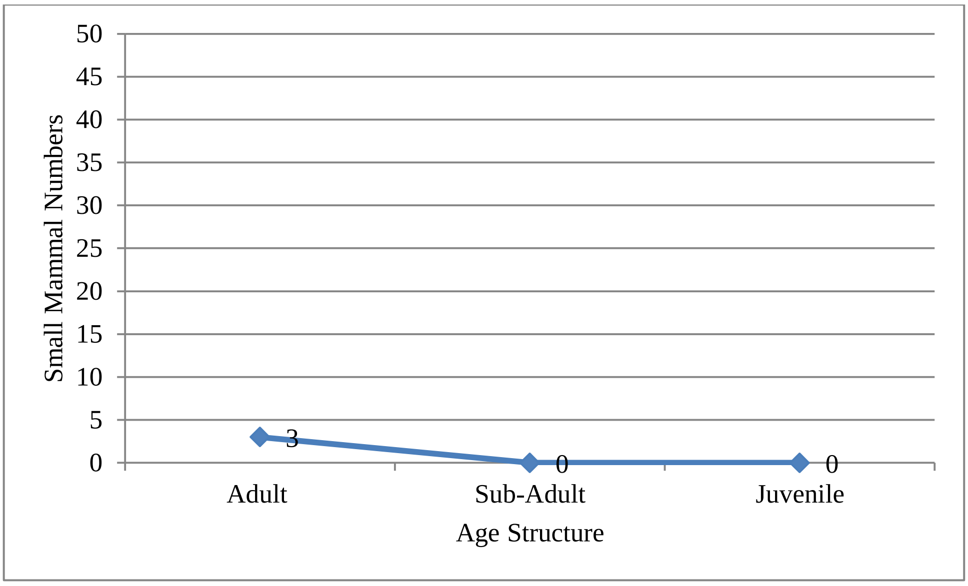

Figure 238. Graph illustrating the age structure of *Crocidura cyanea* recorded on Telperion.

The following age structure percentage was recorded for *C. cyanea* during the study period: Adult (100%), Sub-Adult (0%), Juvenile (0%). Only adult animals were recorded during this study. Statistically there is an insignificant difference between age structure and season $\chi^2 = 4.900$; $df = 3$; $n = 4$; $P = 0.179$. This species appears to have a broad habitat requirement with adult animals being recorded in summer and winter. Age structure for *C. cyanea* was recorded from the Northern Slope Woodland, Moist Degraded Grassland and Sheltered Woodland. Adult *C. cyanea* accounted for 0.8% of the total animals recorded in the Northern Slope Woodland, 1.3 % in Degraded Grassland, and 1.4% in the Sheltered Woodland community.

### 13.5.16. Age structure of the population sample of *Crocidura mariquensis* recorded on Telperion

Age structure data recorded for *Crocidura mariquensis* indicate a frequency of adult ($n = 8$), sub-adult ($n = 0$) and juvenile ($n = 0$), with no sub-adults or juveniles recorded possibly due to their habits (Fig. 239). Statistically there is an insignificant difference between the number of adult, sub-adult and juvenile animals ($t_{(6)} = 1.852$; $n = 8$; $P = 0.114$ recorded during the study.

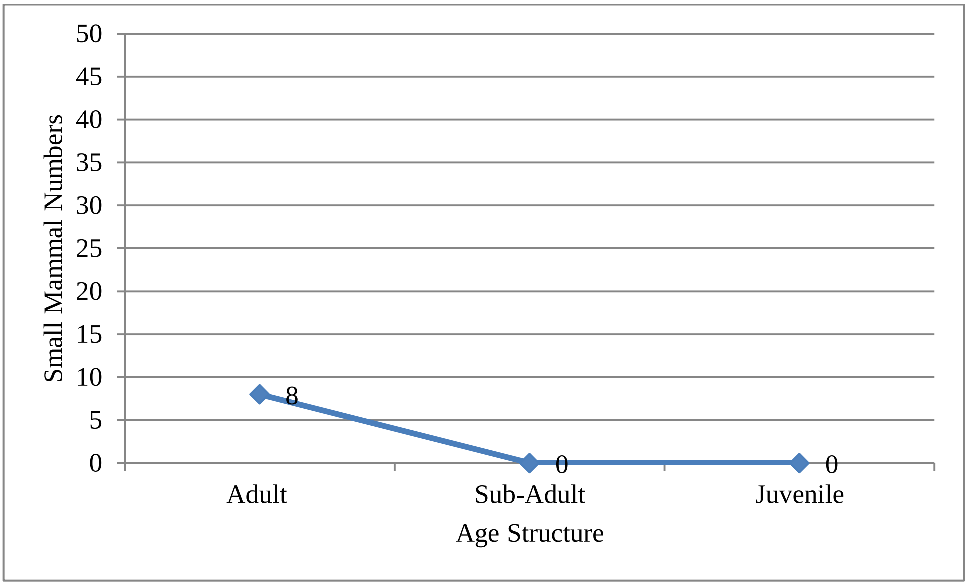

Figure 239. Graph illustrating the age structure of *Crocidura mariquensis* recorded on Telperion.

The following age structure percentage was recorded for *C. mariquensis* during the study period: Adult (100%), Sub-Adult (50%), Juvenile (0%). Only adult individuals were recorded during this study, possibly due to young being less active and therefore less readily caught. This species favours vleis and marshy areas, with sufficient grass cover. Statistically there is an insignificant difference between age structure and season $\chi^2 = 12.125$; $df = 3$; $n = 4$; $P = 0.007$. Adult animals were recorded during spring and summer, but predominantly in winter. Age structure for *C. mariquensis* was recorded from the Moist Degraded Grassland and Sheltered Woodland community where adult individuals accounted for 15.8% of animals recorded in the Moist Degraded Grassland and 2.7% in the Sheltered Woodland.

### 13.5.17. Age structure of the population sample of *Elephantulus myurus* recorded on Telperion

Age structure data recorded for *Elephantulus myurus* indicate a frequency of adult ($n = 67$), sub-adult ($n = 3$) and juvenile ($n = 0$), with a higher numbers of adults to sub-adults being recorded (Fig. 240). Statistically there is a significant difference between the number of adults and sub-adults ($t_{(6)} = 3.376$; $n = 70$; $P = 0.015$), and number of adults and juveniles ($t_{(6)} = 3.553$; $n = 67$; $P = 0.012$) recorded during the study.

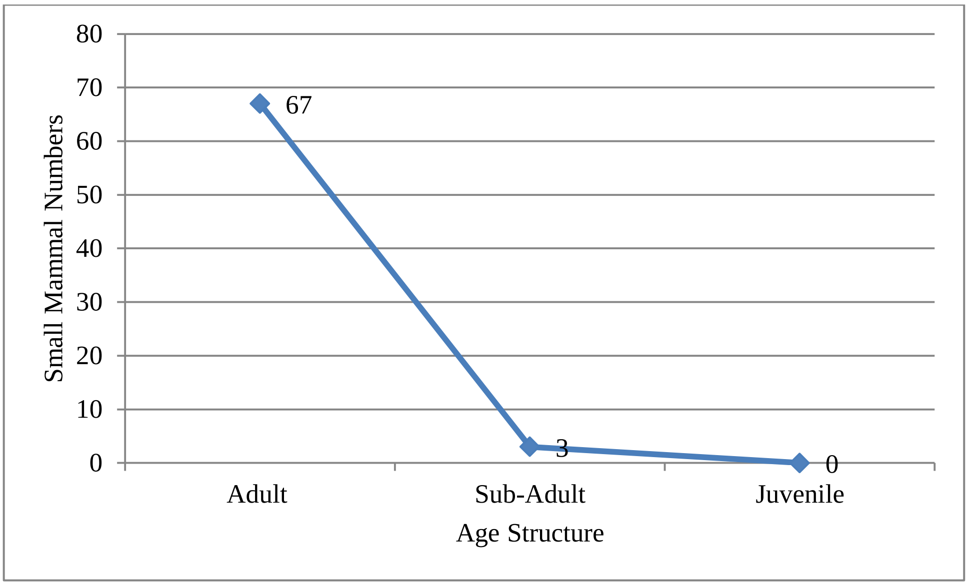

Figure 240. Graph illustrating the age structure of *Elephantulus myurus* recorded on Telperion.

The following age structure percentage was recorded for *E. myurus* during the study period: Adult (96%), Sub-Adult (4%), and Juveniles (0%). Adult and sub-adult individuals were recorded during this study. This species is a rock dwelling confined to areas with a rocky substrate. Statistically there is a highly significant difference between age structure and season $\chi^2 = 82.385$; $df = 3$; $n = 4$; $P = 0.000$. Adult animals were recorded in spring, summer, autumn and winter, while sub-adult were recorded in summer and autumn. No juveniles were recorded during the study period. Age structure for *E. myurus* recorded from Northern Slope Woodland, Rocky Highveld Grassland, Sheltered Woodland and Rocky Open Shrub. Adult *E. myurus* accounted for 17.7% and sub-adult 1.6% of animals recorded in Northern Slope Woodland, with adult individuals accounting for 8.7% of animals recorded in Rocky Highveld Grassland, and adult individuals accounted for 16.4% of animals recorded in Sheltered Woodland, with adult individuals accounting for 20.2% and sub-adults 0.8% of the animals recorded in the Rock Open Shrub community.

### 13.5.18. Age structure of the population sample of *Suncus infinitesimus* recorded on Telperion

Age structure data recorded for *Suncus infinitesimus* indicate a frequency of adult ($n$ = 5), sub-adult ($n$ = 0) and juvenile ($n$ = 0), differences in the age structure possibly due to ecology and behaviour of the species. The trapability of smaller, juvenile animals is also questionable as a result of their low mass (Fig. 241). Statistically there is an insignificant difference between the number of adult, sub-adult and juvenile animals ($t_{(6)} = 1.667$; $n = 5$; $P = 0.147$ recorded during the study.

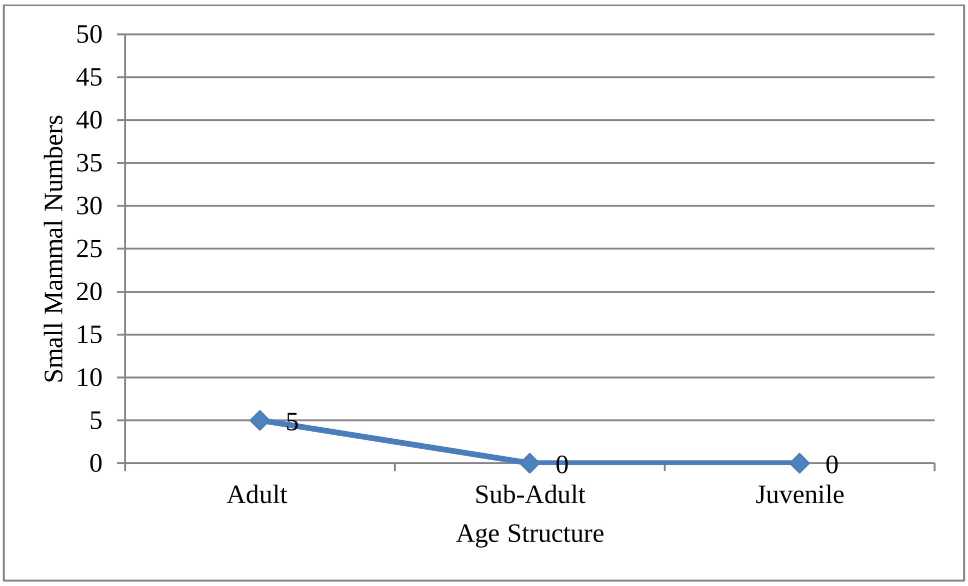

Figure 241. Graph illustrating the age structure of *Suncus infinitesimus* recorded on Telperion.

The following age structure percentage was recorded for *S. infinitesimus* during the study period: Adult (100%), Sub-Adult (0%), Juvenile (0%). Only adult animals were recorded during this study. Statistically there is an insignificant difference between age structure and season $\chi^2 = 7.267$; $df = 3$; $n = 4$; $P = 0.064$. This species appears to have a broad habitat requirement with adult animals being recorded in summer and winter. Age structure for *S. infinitesimus* was recorded from the Degraded Grassland, Sheltered Woodland and Moist Degraded Grassland. Adult *S. infinitesimus* accounted for 1.3% of the total animals recorded in the Degraded Grassland, 1.4% in Sheltered Woodland, and 7.9% in the Moist Degraded Grassland community.

## 13.6. Discussion:

This aim of this chapter was to determine the age structure for small mammals in seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. Eighteen species of small mammal were recorded during this study. Small mammals (= adults < 2kg) comprise quite a large percentage (> 60%) of all terrestrial mammal species in southern Africa (Skinner & Chimimba 2005).

A stable population has a balanced representation of juveniles, sub-adults and adult animals within a population. Disproportional age structures can result in changes in reproduction and ultimately the breeding performance of the population and provides an early warning sign that there could be irregularities in the population. Age structure is important in assessing the population health, as few young in a population could be as a result of an imbalance, or purely an indication of the biology of the species. Juvenile individuals were recorded for *Micaelamys namaquensis* and *Rhabdomys pumilio*. The young of certain species are often not recorded due to the nature and behavior of these species. Sub-adult animals are more readily recorded than juveniles, due to changes in their habits, becoming more adventurous and independent in nature. The trapability of smaller animals also come into question, smaller, lighter animals may not trigger the trap, resulting in them moving in and out unrecorded. Greater numbers of sub-adult *Rhabdomys pumilio* were recorded than adults, an indication that the population is in a growth phase. Interestingly, *R. pumilio* were only recorded in the autumn and winter in year two. *Elephantulus myurus* were interesting, as relatively high numbers of adult animals were recorded, in proportion, few sub-adults and no juveniles were recorded. This provides insight into the reclusive and secluded nature of the juveniles of this species.

There has been some evidence which suggests that unburnt seeds on the ground attract rodents (Makundi *et al.* 1999). Managers of nature reserves and conservation areas readily burn areas of moribund grass to stimulate growth of early grasses. This new growth presumably provides better nutrition for rodents and the requirements of breeding, growth and survival of young, provided sufficient shelter remains. Telperion and Ezemvelo Nature Reserve do not have burning programs, and only accidental fires occur. The absence of regular fire could hamper reproduction, and indirectly influence the age structure of the population. Massawe *et al.* (2006) found an increase in rodent population in areas after seed emergence, although this trend was more evident in areas which has been slashed and burned through farming practices. Rainfall, timing, duration and amount, has a strong influence on the reproduction and the age structure of small mammal populations as it indirectly affects availability of resources. The majority of juveniles and sub-adult animals were recorded in the spring and summer at the study site, except for *R. pumlio*, with recorded in autumn and winter.

This chapter is important as it investigates the age structure of small mammal populations in the fire-climax grassland of the Bankenveld. Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Co-existence in a grassland habitat may also be promoted by mechanisms that reduce interspecific competition (Kinahan & Pillay 2008) and thus improve overall fitness. Differential habitat use and the use of resources within these different systems, especially in space and time, may facilitate co-existence between species on a reserve, or specific habitat (M'Closkey 1976; Brown 1989; Yunger *et al.* 2002; Zhang 2003; Bonesi & Macdonald 2004; Harris *et al.* 2006). Spatial differences in small mammal communities are based on macro- and micro-habitat selection.

Both abiotic and biotic factors have been proposed as regulators of breeding in different species and density in small mammal communities (Perrin & Boyer 2000). These could result in a skewed age structure within a population. The seasonal reproductive change sometime recorded within these small mammal communities is often associated with changes in the diet (Perrin & Boyer 2000). Mechanisms that reduce interspecific competition and improve overall fitness promote coexistence in communities (Kinahan & Pillay 2008). The competition theory assumes that at competitive equilibrium in densities are maintained (Ferreira & Van Aarde 1999), and may thus act to structure communities (Hughes *et al.* 1994; Manor & Saltz 2008). Species may coexist successfully in an environment should they respond differently to environmental conditions and fluctuations (Moro & Morris 2000; Stilmant *et al.* 2008). Individuals within different age groups representing different species may also coexist. As natural environments are dynamic, the processes promoting similarities and differences in population variables may change over space and time (Brown & Zeng 1989; Chesson 2003). Three main cues, or a combination, are expected to influence reproduction in small mammals, namely abiotic factors (such as food availability), internal factors (endogenous rhythms) and social cues between individuals (Neal 1986; Ims 1990). Abiotic factors, such as rain are not likely to affect breeding directly as there is usually a lag time of two or three months between rainfall and the evidence of breeding (Bronner 1986), but rather affects breeding indirectly through food availability (Neal 1982). Rainfall therefore may still contribute to the timing of the reproductive seasonality and could explain inter-year variation in population numbers and demography (Willan & Meester 1989; Monadjem & Perrin 2003). Temperature could influence breeding success and age structure in a population, especially during exceptionally cold and wet periods. Timing of breeding in small mammal populations is often constrained, not only by the environment but also phylogenetically in terms of age of reproduction. Population size fluctuations and species richness are due to differences in recruitment (movements into the population through birth and immigration) and emigration (movements out of the population through dispersal and death (Bronner 1986).

Home range overlap is influenced by several biological factors, such as population age structure, as well as season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Priotto *et al.* 2002; Ribble *et al.* 2002; Schradin & Pillay 2006; Cooper & Randall 2007). Studies of spatial organisation may also contribute to understanding patterns of coexistence between similar species (Ferreira & Van Aarde 1999; Priotto *et al.* 2002; Ribble *et al.* 2002). The age structure of the small mammal population at the study site is expected to be influenced by variation in food distribution and abundance and the variety of acceptable food resources. Low numbers of juvenile and sub-adult animals were recorded, with only juvenile *Micaelamys namaquensis* and *Rhabdomys pumilio* been recorded. The low trapability of sub-adults and juveniles could solely be attributed to their small size and much lower levels of activity for some species

# CHAPTER 14

# BREEDING PATTERNS OF SMALL MAMMAL SPECIES RECORDED ON TELPERION

## 14.1. Abstract

The aim of this chapter is to record breeding patterns in small mammal fauna in seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. The reproductive status of a population provides an indication of the health of the population. When signs of reproduction are noted, it can be assumed a population is stable or increasing. Species in a population with no signs of reproducing are often a symptom of an imbalance in the ecosystem. No signs of reproductive activity were recorded in certain species during the study which is possibly related to the small sample size recorded. Skewed sex ratio and age structures could influence reproduction in a population. Harsh environmental conditions, minimal food supply and decreased cover availability may also impact reproduction. Low numbers of *Acomys spinosissimus* were recorded, with 8.3% of individuals showing signs of reproduction in spring. High numbers of *Dendromus melanotis* were recorded, with 8.7% showing signs of reproduction in the spring and summer months. Both *Gerbilliscus brantsii* and *Gerbilliscus leucogaster* were recorded, with the former showing signs of reproduction in spring and summer, and the later in the summer and autumn months. *Mastomys* spp. showed signs of reproduction in spring and summer months, and although *Micaelamys namaquensis* were recorded in high numbers during the study, 12.6% of individuals showing signs of reproduction in spring, with lower numbers in summer, and a few scattered records for the winter months. *Mus minutoides* individuals showed signs of reproduction exclusively in the summer months, with *Steatomys pratensis* with the majority of breeding in late spring and summer. Insectivores, *Crocidura cyanea* and *Elephantulus myurus* showed signs of reproduction exclusively in summer months during the study. The majority of breeding activity in small mammals in the Bankenved grasslands appears to occur in the spring and summer months.

**Keywords:** Reproduction, small mammals, breeding, spring, summer, sex ratio, age structure, Telperion, Ezemvelo Nature Reserve, South Africa.

## 14.2. Introduction

This chapter deals with recording signs of reproduction for small mammals in seven vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and Telperion in Mpumalanga Province, South Africa. The study site is situated to the extreme north of the grassland biome in South Africa, recognized by Acocks (1988) as Bankenveld, and by Bredenkamp & Van Rooyen (1998) as Rocky Highveld Grassland. Populations of short-lived organisms, such as rodents, appear more sensitive to changes in fecundity than adult survival (Oli & Dobson 2003; Gaillard *et al.* 2005). Rodents may reach large densities, particularly in agro-ecosystems (Leirs & Verheyen 1995; Julliard *et al.* 1999; Vibe-Petersen. *et al.* 2006; Sluydts *et al.* 2007). Makundi *et al.* (2007) found that reproduction and population fluctuations in *Mastomys natalensis* were linked to the duration and amount of rainfall in Tanzania.

Polygynous species tend to have a high degree of intraspecific overlap, especially between females and thus also tend to have higher densities (Ribble & Stanley 1998; Priotto *et al.* 2002). Promiscuous species within a community also tend to have high densities with a high degree of overlap between sexes, since males are unable to monopolise widespread females (Ostfeld 1990; Ribble & Stanley 1998; Jackson 1999). Life history characteristics such as fecundity, longevity and dispersal that allow species to minimise or avoid competition however promote coexistence between species (Brown & Zeng 1989; Dammhahn & Kappeler 2008), since these traits may be an adaptive response to the environment (Neal 1986). Both abiotic and biotic factors have been proposed as regulators of reproduction in different species and density in small mammal communities (Perrin & Boyer 2000).

The seasonal reproductive change sometime recorded within these small mammal communities is often associated with changes in the diet (Perrin & Boyer 2000). Three main cues, or a combination, are expected to influence reproduction in small mammals, namely abiotic factors (such as food availability), internal factors (endogenous rhythms) and social cues between individuals (Neal 1986; Ims 1990). Abiotic factors, such as rain are not likely to affect breeding directly as there is usually a lag time of two or three months between rainfall and the evidence of breeding (Bronner 1986), but rather affects breeding indirectly through food availability (Neal 1982). Rainfall therefore may still contribute to the timing of the reproductive seasonality and could explain inter-year variation in population numbers and demography (Willan & Meester 1989; Monadjem & Perrin 2003). A dynamic reproductive strategy will enable a species to vary its life history strategy depending on environmental variability (Perrin & Swanepoel 1987; Willan & Meester 1989), and also to minimise or avoid competition by varying particular characteristics, thus promoting coexistence between species within a community (Dammhahn & Kappeler 2008). According to Bronner *et al.* (1988), Brooks (1982), Davis & Meester (1981) rodent population densities in perennial grasslands of the South African highveld are highly seasonal, with reproduction largely occurring between November and March, reaching peaks in population numbers during March and April. During winter (May-September) vegetation becomes less dense due to frost, and rodent populations decrease substantially (Davis 1973; Smithers 1983).

The reproductive status of a population provides an indication of the health of the population. When signs of reproduction are noted, it can be assumed a population is stable or increasing. Scrotal males will provide an indication that the animal is reproductively active and in search of females. A perforated vagina is an indication that a female animal is reproductively active. Pregnant females as well as lactating females will also be recorded during the study. Skewed sex ratio and age structures could influence reproduction in a population. Harsh environmental conditions, minimal food supply and decreased cover availability may also impact reproduction. The majority of breeding activity of small mammals in the Bankenved grasslands is expected to occur in the spring and summer months. This study is important as it investigates these signs of reproduction in this fire-climax grassland.

## 14.3. Methodology

In year one (2008), ten transects each comprising 30 live-traps Sherman each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month. The starting-point was placing transects in the seven vegetation communities. Two transects were placed in the dominant communities to obtain a greater sample size. 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily in year one. In year two, three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per site. Signs of reproduction and reproductive activity were recorded during this study. These included females showing signs of lactating, being pregnant, having perforate vaginas, and scrotal or non-scrotal in males.

Chi-square ($\chi^2$) test were used to analyze reproductive status and season, and t-tests (*t*) to analyze variance between reproductive and non-reproductive animals. All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 14.4. Results

Eighteen species of small mammals were recorded between 2008 and 2009, of which 10 species showed signs of lactating, being pregnant, having perforate vaginas, or scrotal males. Results indicate 9.1% of animals recorded during this study showed signs of reproduction. The following rodent species were showed signs of reproduction: *Acomys spinosissimus, Dendromus melanotis, Gerbilliscus brantsii, Gerbilliscus leucogaster, Mastomys* spp., *Micaelamys namaquensis, Mus minutoides* and *Steatomys pratensis. Crocidura cyanea* and *Elephantulus myurus* are insectivores which displayed sign of reproduction (Fig. 242).

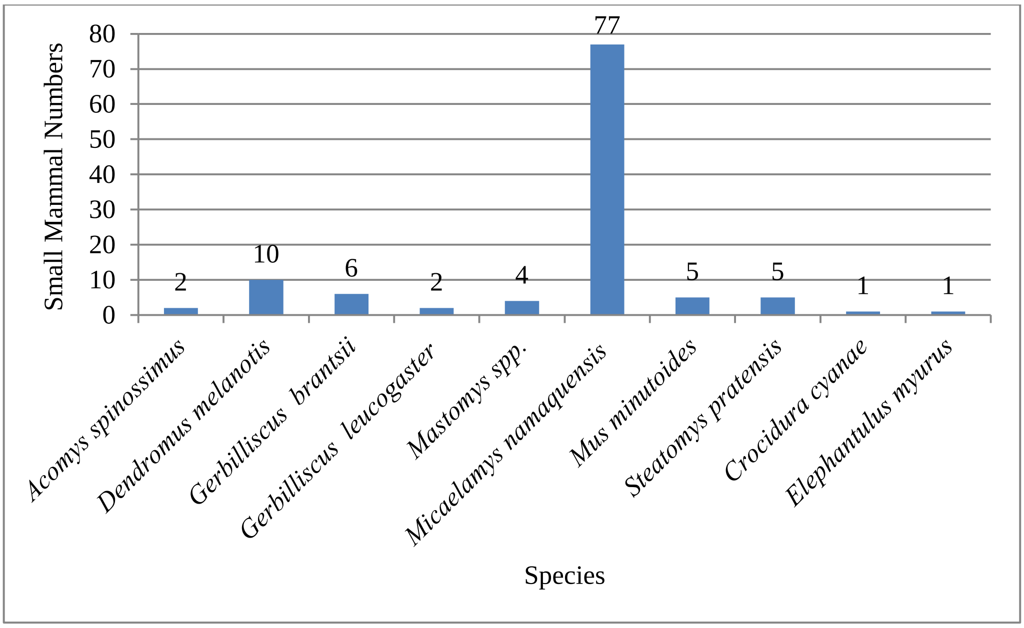

Figure 242. Graph illustrating the species of small mammals indicating signs of reproduction recorded on Telperion during 2008 and 2009.

## 14.5. Signs of reproduction recorded in different species of small mammals on Telperion

### 14.5.1. Signs of reproduction recorded in *Acomys spinosissimus* on Telperion

Signs of reproduction were recorded for *Acomys spinosissimus* in the Northern Slope Woodland community in spring (Fig. 243).

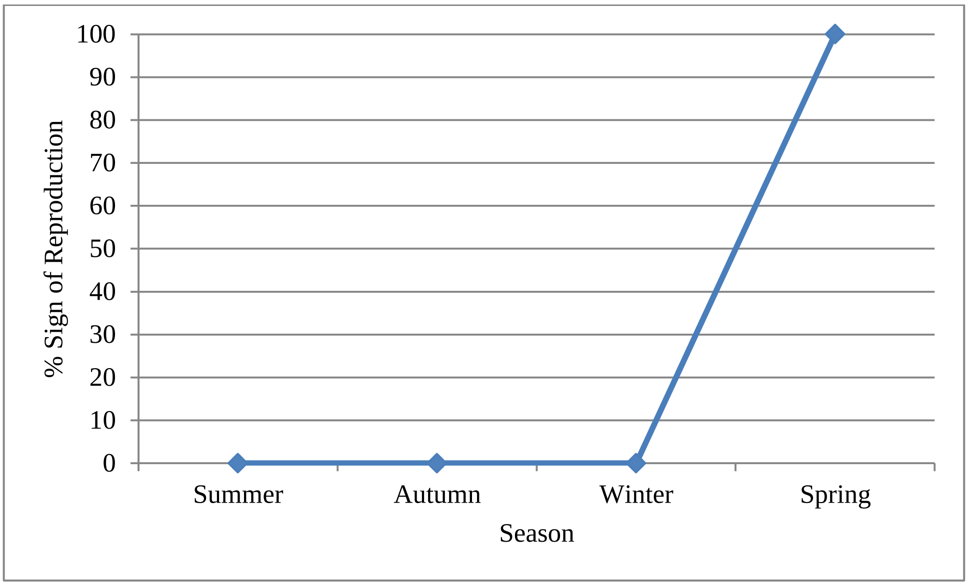

Figure 243. Graph illustrating seasonal reproduction in *Acomys spinosissimus* recorded on Telperion in 2008 and 2009.

There is a significant ($t_{(6)} = 5.000$; $n = 24$; $P = 0.002$) difference between the number of individuals recorded showing signs of reproduction to non-breeding individuals during the study. Data were recorded from a scrotal male on 23rd October 2008 and a lactating female was recorded on 10th October 2009. This species was recorded in relatively low numbers during the study; however 8.3% of individuals recorded showed signs of reproduction. Statistically there is an insignificant difference between reproductive status and season $\chi^2 = 9.143$; $df = 3$; $n = 4$; $P = 0.027$. Results from this study indicate that 100% of breeding activity in *A. spinossimus* occurs in spring in the Bankenveld grasslands, although the samples size is small. No signs of breeding activity were recorded in the summer, autumn and winter months. Smithers (1971) collected gravid females in December, January, March and April in Botswana. In the former Transvaal, pregnant females were recorded in October, and from January to April (Rautenbach 1982).

### 14.5.2. Signs of reproduction recorded in *Dendromus melanotis* on Telperion

Signs of reproduction were recorded for *Dendromus melanotis* in the Rocky Highveld Grassland, Degraded Grassland, Moist Degraded Grassland and Burkea Eragrostis Clumps community in spring and summer (Fig. 244).

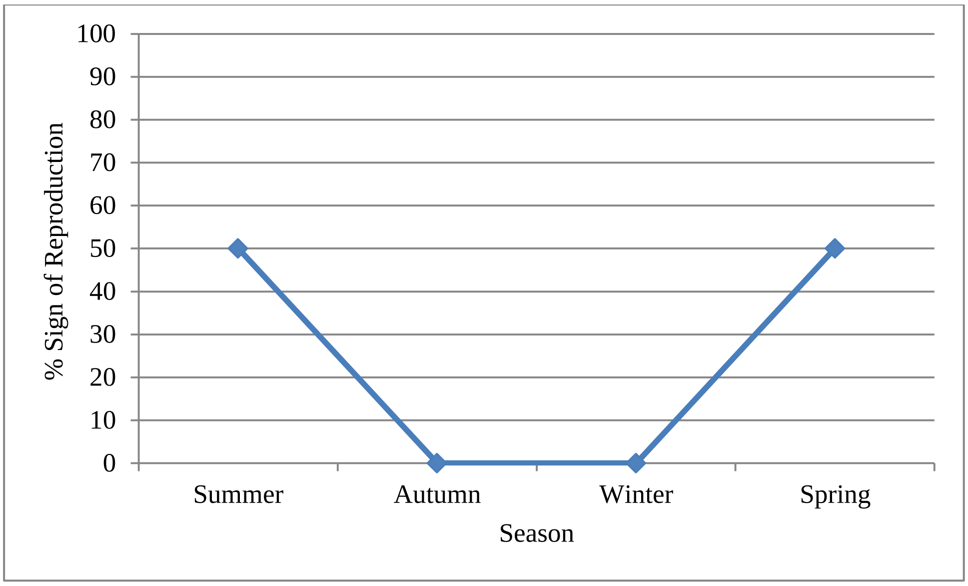

Figure 244. Graph illustrating seasonal reproduction in *Dendromus melanotis* recorded on Telperion in 2008 and 2009

There is a significant ($t_{(6)} = -2.378$; $n = 116$; $P = 0.055$) difference between the number of individuals showing signs of reproduction to non-breeding individuals recorded during the study period. Statistically there is also a significant difference between reproductive status and season $\chi^2 = 45.381$; $df = 3$; $n = 4$; $P = 0.000$. Data were recorded from four scrotal males on 24th and 25th September 2008, 29th January 2009 and 25th February 2009. Four female animals were recorded showing signs of reproduction, three pregnant females, on 23rd October 2008, 5th December 2008 and 30th January 2009, and one lactating female was recorded 23rd February 2009. This species was recorded in reasonable numbers during the study; however only 8.7% of individuals recorded showed signs of reproduction. Results for this study indicate that 50% of breeding activity occurs in spring, and 50% in summer in the Bankenveld grasslands. No signs of breeding activity were recorded in the autumn and winter months. Smithers (1971) recorded a gravid female in December. In the KwaZulu Natal Drakensberg, Rowe-Rowe & Meester (1982b) found a lactating female in January, perforate females in May and November, and scrotal males in April, October and November.

### 14.5.3. Signs of reproduction recorded in *Gerbilliscus brantsii* on Telperion

Signs of reproduction were recorded for *Gerbilliscus brantsii* in the Burkea Eragrostis Clumps community in spring and summer (Fig. 245).

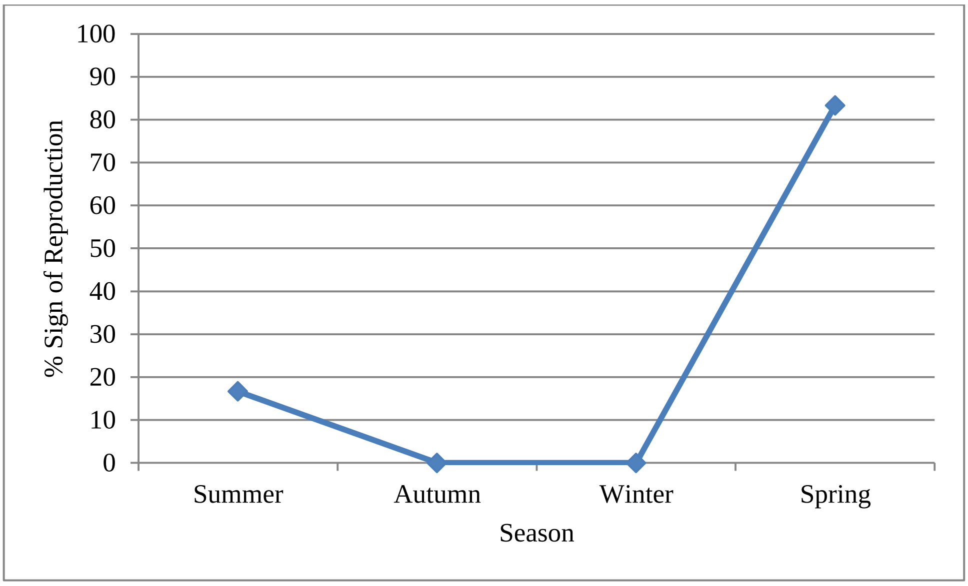

Figure 245. Graph illustrating seasonal reproduction in *Gerbilliscus brantsii* recorded on Telperion in 2008 and 2009.

There is an insignificant ($t_{(6)} = 0.823$; $n = 21$; $P = 0.442$) difference between the number of individuals showing signs of reproduction to non-breeding individuals recorded during the study period. Data were recorded from four scrotal males, one record on 23rd October 2008, and three on 28th November 2008. Two female animals were showing signs of lactating, one on 23rd October 2008, and another on 5th December 2008. This species was recorded in low numbers during the study; however only 28.6% of individuals recorded showed signs of reproduction. Results for this study indicate that 83% of breeding activity occurs in spring, and 17% in summer in the Bankenveld grasslands, however statistically there is an insignificant difference between reproductive status and season $\chi^2 = 5.810$; $df = 3$; $n = 4$; $P = 0.121$. No signs of breeding activity were recorded in the autumn and winter months. Measroch (1954) recorded that in the Free State this species bred throughout the year, except in the dry months, and a similar situation exists in Botswana (Smithers 1971) and the Kgalagadi Transfrontier Park (Nel *et al.* 1984).

### 14.5.4. Signs of reproduction recorded in *Gerbilliscus leucogaster* on Telperion

Signs of reproduction were recorded for *Gerbilliscus leucogaster* in the Rocky Highveld Grassland community in summer and autumn (Fig. 246).

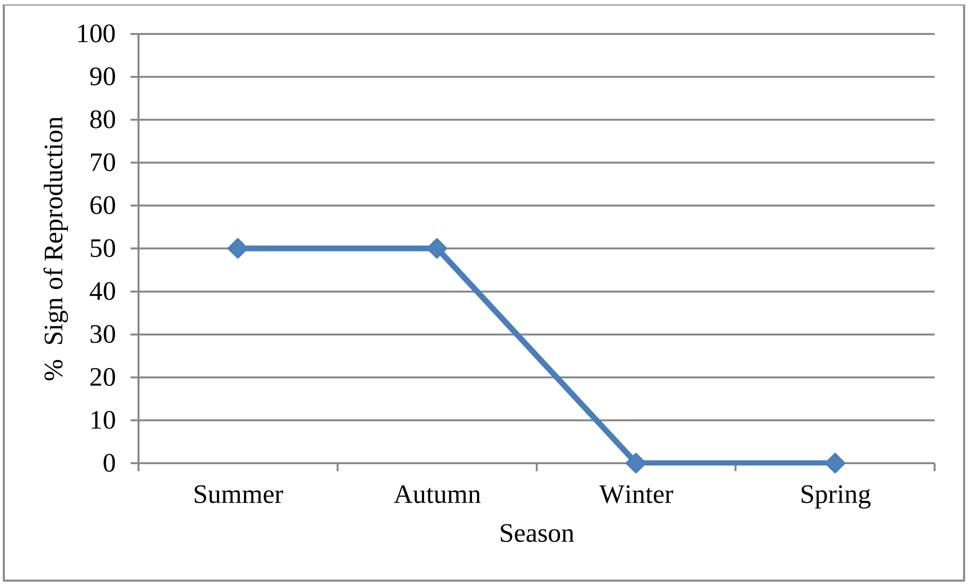

Figure 246. Graph illustrating seasonal reproduction in *Gerbilliscus leucogaster* recorded on Telperion in 2008 and 2009.

There is a significantly ($t_{(6)}$ = 3.273; $n$ = 24; $P$ = 0.017) higher numbers of non-breeding individuals compared with animals showing signs of reproduction recorded during the study period. Data were recorded from a single scrotal male on 27th February 2009 and a lactating female was recorded on 15th March 2008. This species was recorded in relatively low numbers during the study; however 8.3% of individuals recorded showed signs of reproduction. Results for this study indicate that 50% of breeding activity in *G. leucogaster* occurs in summer, and 50% in autumn in the Bankenveld grasslands, although the samples size is small. Statistically there is a significant difference between reproductive status and season $\chi^2 = 8.622$; $df = 3$; $n = 4$; $P = 0.035$. No signs of breeding activity were recorded in the winter and spring months. Smithers (1983) recorded gravid females in every month of the year, except for September, with a peak late in the warm, wet summer months. Perrin & Swanepoel (1987) also reported a distinct summer breeding season, with a bimodal peak in early and late summer closely related to rainfall.

### 14.5.5. Signs of reproduction recorded in *Mastomys* spp. on Telperion

Signs of reproduction were recorded for *Mastomys* spp. in the Degraded Grassland community in spring and summer (Fig. 247).

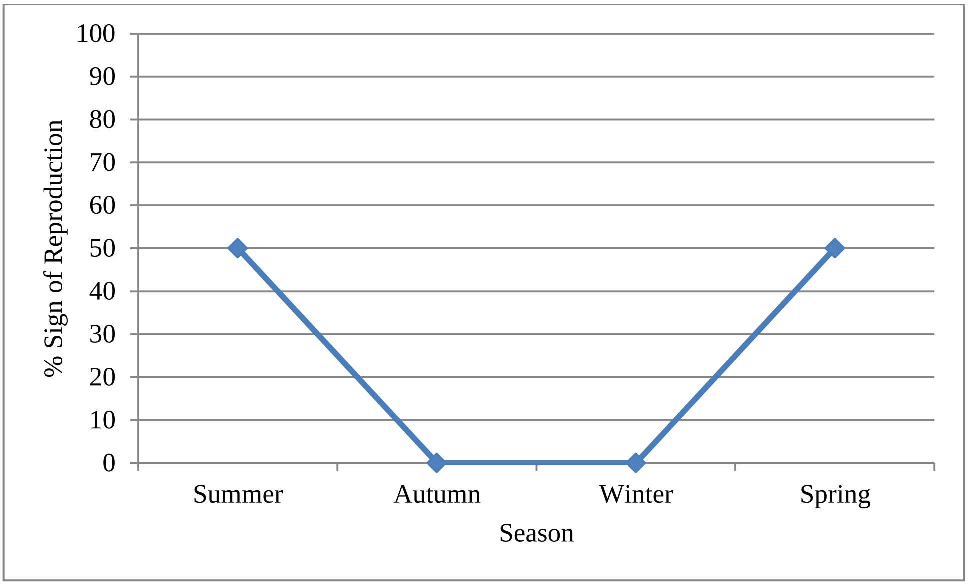

Figure 247. Graph illustrating seasonal reproduction in *Mastomys* spp. recorded on Telperion in 2008 and 2009.

There is an insignificant ($t_{(6)} = 0.791$; $n = 15$; $P = 0.459$) difference between the numbers of non-breeding individuals compared with those showing signs of reproduction recorded during the study period. Data were recorded from four scrotal males on 24th October 2008, 29th November 2008, 05th December 2008 and 29th January 2009. This species was recorded in relatively low numbers during the study; however 30.8% of individuals recorded showed signs of reproduction. Results for this study indicate that 50% of breeding activity occurs in spring, and 50% in summer in Bankenveld grasslands, although the samples size is small. No signs of breeding activity were recorded in the autumn and winter months. Statistically there is an insignificant difference between reproductive status and season $\chi^2 = 2.227$; $df = 3$; $n = 4$; $P = 0.527$. According to Smithers (1971) *M. natalensis* breeds all year round in Zimbabwe with a falling off in May and June. From studies on the highveld both Coetzee (1965) and De Wit (1972) both indicate the breeding season as the end of the rain season and start of the dry season, with a winter quiescence.

### 14.5.6. Signs of reproduction recorded in *Micaelamys namaquensis* on Telperion

Signs of reproduction were recorded for *Micaelamys namaquensis* in the Northern Slope Woodland, Rocky Highveld Grassland, Sheltered Woodland and Rocky Open Shrub community in spring, summer and winter (Fig. 248).

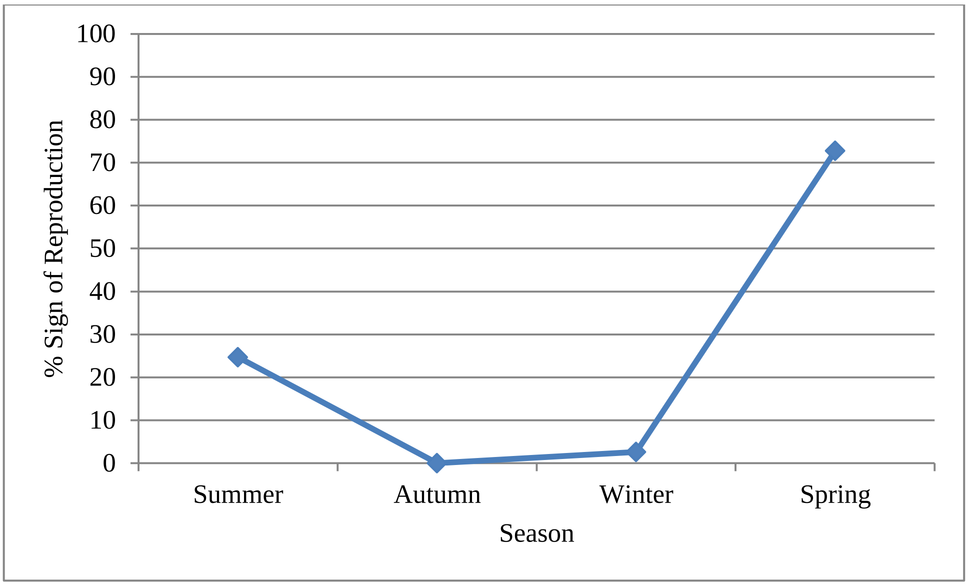

Figure 248. Graph illustrating seasonal reproduction in *Micaelamys namaquensis* recorded on Telperion in 2008 and 2009.

There is a significant ($t_{(6)}$ = 8.235; $n$ = 748; $P$ = 0.000) difference in the numbers of non-breeding individuals compared with those showing signs of reproduction recorded during the study period. Statistically there is a highly significant difference between reproductive status in the different seasons $\chi^2$ = 244.201; $df$ = 3; $n$ = 4; $P$ = 0.000. Data were recorded from 38 scrotal males, six individuals in the summer months, 31 in spring and one in winter. Data were recorded for 32 females, 20 females with perforate vaginas in spring, with twelve female individuals showing signs of lactating, four in spring and eight in summer months. One individual was recorded with two newly born individual's nipple clinging to the female in the trap. This species was recorded in high numbers during the study; however only 12.6% of individuals recorded showed signs of reproduction. Results for this study indicate that 73% of breeding activity occurs in spring, and 25% in summer, and 3% in the winter months in the Bankenveld grasslands. No signs of breeding activity were recorded in the autumn month. Results indicate that 66.7% of lactating females were recorded in summer, with 33.3% in spring, and 81.6% of males with descended testes were recorded in spring. Smithers (1971) recorded breeding gravid females from September to May, peaking in March; however no signs of breeding during the colder months, from June to August, were recorded. Results from this study indicated that the majority of mating's took place during spring, which in turn resulted in a large number of pregnant females in summer.

### 14.5.7. Signs of reproduction recorded in *Mus minutoides* on Telperion

Signs of reproduction were recorded for *Mus minutoides* in the Rocky Highveld Grassland, Sheltered Woodland and Burkea Eragrostis Clumps community in summer (Fig. 249).

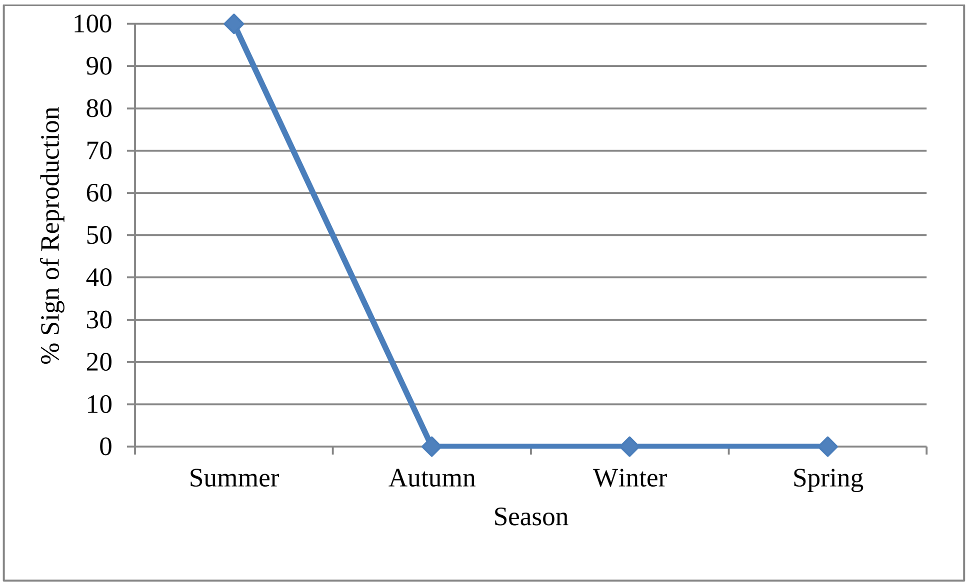

Figure 249. Graph illustrating seasonal reproduction in *Mus minutoides* recorded on Telperion in 2008 and 2009

There is a significant ($t_{(6)}$ = 2.598; $n$ = 41; $P$ = 0.041) difference in the numbers of non-breeding individuals compared with those showing signs of reproduction recorded during the study period. Data were recorded from five female animals, of which three of these individuals were lactating, recorded on 29th January 2009, 30th January 2009, and 23rd February 2009. Two individuals were pregnant, recorded on 30th January 2009, and 24th February 2009. This species was recorded in reasonable numbers during the study; although only 12.2% of individuals recorded showed signs of reproduction. Statistically there is a highly significant difference between reproductive status in the different seasons $\chi^2 = 12.773$; $df = 3$; $n = 4$; $P = 0.005$. Results for this study indicate that 100% of breeding activity in *M. minutoides* occurs in summer in the Bankenveld grasslands, although the samples size is relatively small. No signs of breeding activity were recorded in the autumn, winter and spring months. According to Skinner & Chimimba (2005), there is little information available on reproduction in the wild. Litters have been recorded in December and January, and a gravid female was recorded in February in Zimbabwe (Smithers & Wilson 1979).

### 14.5.8. Signs of reproduction recorded in *Steatomys pratensis* on Telperion

Signs of reproduction were recorded for *Steatomys pratensis* in the Rocky Highveld Grassland and the Degraded Grassland community in late spring and summer (Fig. 250).

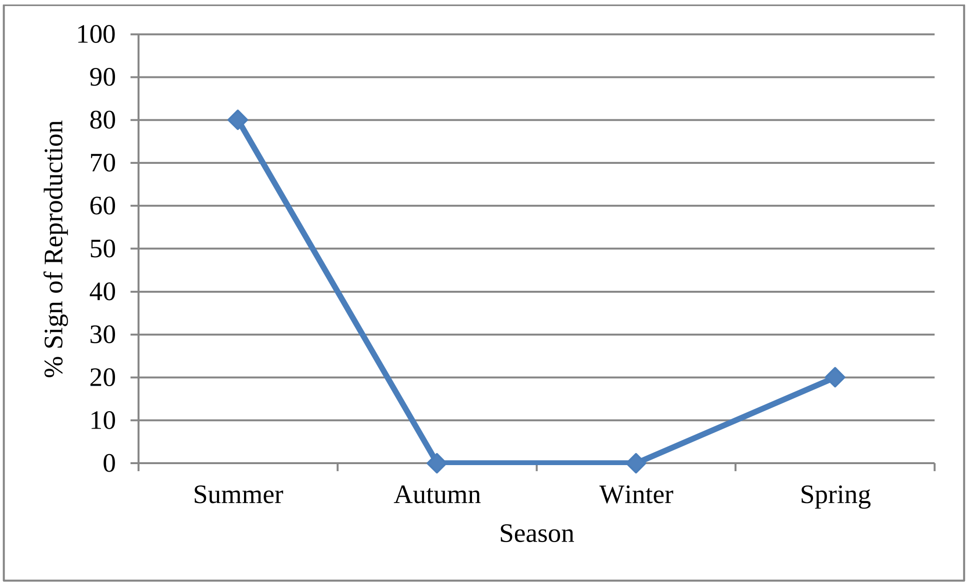

Figure 250. Graph illustrating seasonal reproduction in *Steatomys pratensis* recorded on Telperion in 2008 and 2009.

Statistically there is an insignificant ($t_{(6)} = 0.617$; $n = 14$; $P = 0.560$) difference in the numbers of non-breeding individuals compared with those showing signs of reproduction recorded during the study period. Data were recorded from two scrotal males on 25th September 2008 and 05th December 2008, and three lactating females 23rd February 2009, 26th February 2009 and 27th February 2009. This species was recorded in relatively low numbers during the study; although 35.7% of individuals recorded showed signs of reproduction. Results for this study indicate that 80% of breeding activity in *S. pratensis* occurs in summer, and 20% in late spring in the Bankenveld grasslands, and statistically there is a significant difference between the reproductive status recorded for the different seasons $\chi^2 = 8.600$; $df = 3$; $n = 4$; $P = 0.035$. No signs of breeding activity were recorded in the autumn and winter months. In the wild the young are born during the warm, wet summer months from October to April (Smithers 1971; Kern 1977; Smithers & Wilson 1979; Rautenbach 1982).

### 14.5.9. Signs of reproduction recorded in *Crocidura cyanea* on Telperion

Signs of reproduction were recorded for *Crocidura cyanea* in the Sheltered Woodland community in spring (Fig. 251).

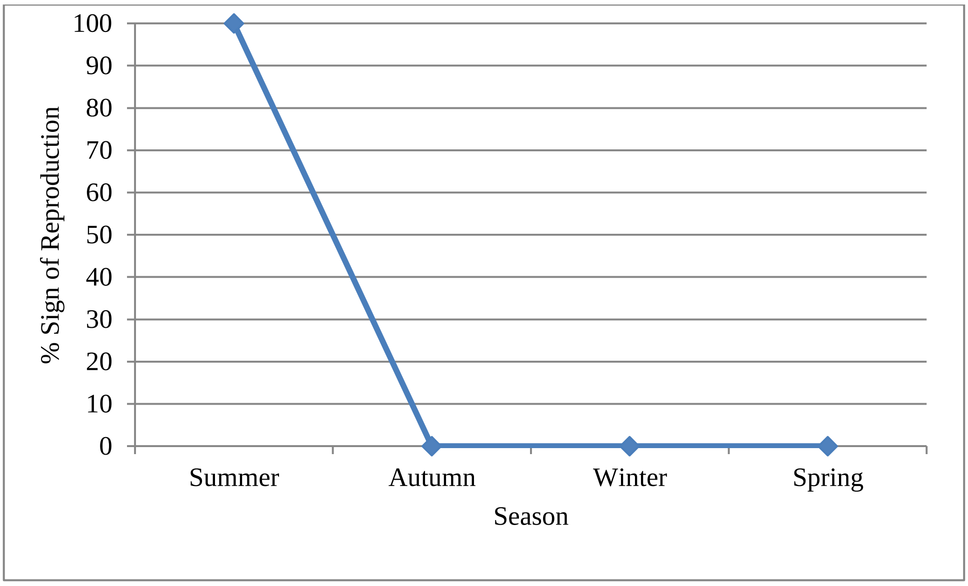

Figure 251. Graph illustrating seasonal reproduction in *Crocidura cyanea* recorded on Telperion in 2008 and 2009.

There is an insignificant ($t_{(6)} = 0.655$; $n = 3$; $P = 0.537$) difference in the numbers of non-breeding individuals recorded compared with individuals showing signs of reproduction during the study period. Data were recorded from a single lactating female animal on 24th February 2009. This species was recorded in low numbers during the study; therefore 33.3% of individuals recorded showed signs of reproduction. Statistically there is an insignificant difference between reproductive status and season $\chi^2 = 0.500$; $df = 3$; $n = 4$; $P = 0.919$. Preliminary results for this study indicate that 100% of breeding activity in *C. cyanea* occurs in summer in the Bankenveld grasslands, although the samples size is small. No signs of breeding activity were recorded in the autumn, winter and spring months. In Namibia, Hoesch & Leymann (1956) took three gravid females in November, December and January. In western Zimbabwe, Smithers & Wilson (1979) recorded a gravid female in March, and Rautenbach (1982) recorded a gravid female in December in the former Transvaal.

### 14.5.10. Signs of reproduction recorded in *Elephantulus myurus* on Telperion

Signs of reproduction were recorded for *Elephantulus myurus* in the Rocky Open Shrub community in spring (Fig. 252).

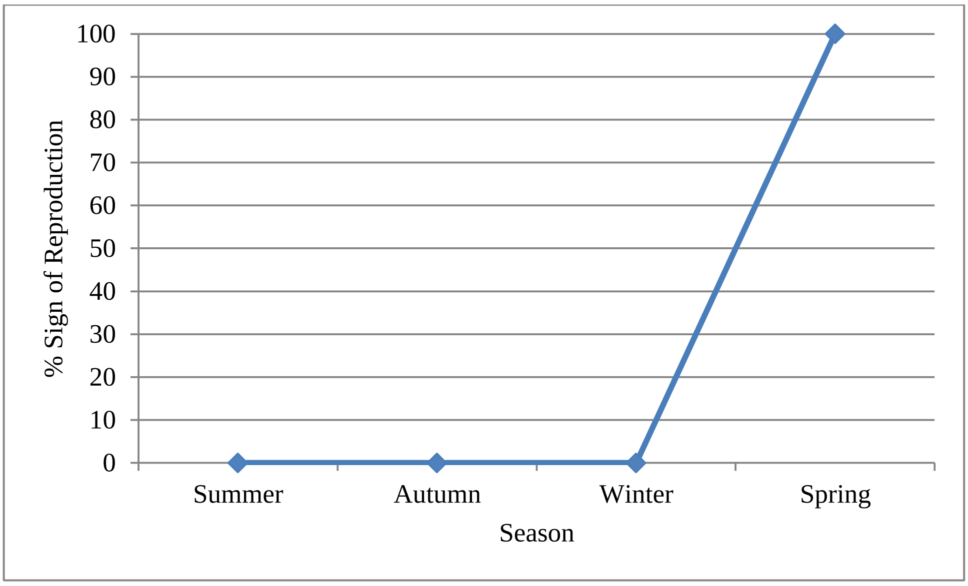

Figure 252. Graph illustrating seasonal reproduction in *Elephantulus myurus* recorded on Telperion in 2008 and 2009.

There is a significant ($t_{(6)}$ = 3.057; $n$ = 218; $P$ = 0.022) difference in the numbers of non-breeding individuals when compared with individuals showing signs of reproduction. Data were recorded from a single pregnant female animal on 26th October 2009. Statistically there is an insignificant difference between reproductive status and season $\chi^2 = 3.000$; $df = 3$; $n = 4$; $P = 0.392$. This species was recorded in high numbers during the study; however 0.5% of individuals were recorded showing signs of reproduction. This is exceptionally low, and indicative perhaps of breeding animals being less trappable, or due to breeding individuals being more difficult to identify by external means. Results for this study indicate that 100% of breeding activity in *Elephantulus myurus* occurs in spring in the Bankenveld grasslands, although the samples size of reproductive animals is small. No signs of breeding activity were recorded in the summer, autumn and winter months. Information available from eastern Botswana (Smithers 1971), the former Transvaal (Van der Horst 1946; Rautenbach 1982) and KwaZulu Natal (Taylor 1998) indicates that young are born during the warm, wet summer months between September and March.

No signs of reproduction were recorded for *Aethomys chrysophilus*, *Dendromus mystacalis*, *Graphiurus murinus*, *Lemniscomys rosalia*, *Otomys irroratus*, *Crocidura mariquensis* and *Suncus infinitesimus*. No signs of reproduction were recorded in adult

*Rhabdomys pumilio*, although juveniles were recorded on 15th May 2009 and 09th July 2009 in the Moist Degraded Grassland Community.

## 14.6. Discussion

The aim of this chapter being to record signs of reproduction in the small mammal fauna in the Bankenveld grasslands of Telperion, Mpumalanga Province, and Ezemvelo Nature Reserve, South Africa.  Eighteen species of small mammal were recorded during this study. Small mammals (= adults < 2kg) comprise quite a large percentage (> 60%) of all terrestrial mammal species in southern Africa (Skinner & Chimimba 2005).

Spring and summer are the important seasons for reproduction in small mammals in the Bankenveld grassland. This area experiences cold, dry, harsh winters, and no signs of reproduction were recorded in this season. Juvenile and sub-adult *Rhabdomys pumilio* were recorded in autumn, with sub-adult in winter. Small mammals appear to breed when conditions are favourable, when sufficient cover is available, and when food is plentiful. In January 2008, a female *Micaelamys namaquensis* was found in a Sherman trap with three newly born individual's nipple clinging in the Rocky Open Shrub community. This individual is suspected to have given birth in the trap. The visible grassy nest of *M. namaquensis* amongst the rock crevices appears more visible in the summer months. Surprisingly few reproductively active *Elephantulus myurus* were recorded taking into account the numbers of animals at the study site. Signs of lactating in the small species were recorded summer and spring for *Dendromus melanotis*, and in summer for *Mus minutoides*. These signs include visible suckling around each nipple, including visible milk beneath the skin.

Makundi *et al*. (2007) found that reproduction and population fluctuations in *Mastomys natalensis* were linked to the duration and amount of rainfall in Tanzania. Rainfall, timing, duration and amount, has a strong influence on the population dynamics and reproduction in small mammals as it indirectly affects availability of resources.

This study is important as it investigates when signs of reproduction in small mammal populations in the fire-climax grassland of the Bankenveld. Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Co-existence in a grassland habitat may also be promoted by mechanisms that reduce interspecific competition (Kinahan & Pillay 2008) and thus improve overall fitness.

Polygynous species tend to have a high degree of intraspecific overlap, especially between females and thus also tend to have higher densities (Ribble & Stanley 1998; Priotto *et al.* 2002). Promiscuous species within a community also tend to have high densities with a high degree of overlap between sexes, since males are unable to monopolise widespread females (Ostfeld 1990; Ribble & Stanley 1998; Jackson 1999). Life history characteristics such as fecundity, longevity and dispersal that allow species to minimise or avoid competition however promote coexistence between species (Brown & Zeng 1989; Dammhahn & Kappeler 2008), since these traits may be an adaptive response to the environment (Neal 1986).

Both abiotic and biotic factors have been proposed as regulators of reproduction in different species and density in small mammal communities (Perrin & Boyer 2000). The seasonal reproductive change sometime recorded within these small mammal communities is often associated with changes in the diet (Perrin & Boyer 2000). Mechanisms that reduce interspecific competition and improve overall fitness promote coexistence in communities (Kinahan & Pillay 2008). The competition theory assumes that at competitive equilibrium in densities are maintained (Ferreira & Van Aarde 1999), and may thus act to structure communities (Hughes *et al.* 1994; Manor & Saltz 2008).

Changes in small mammal densities are dependent on a variety of factors, method used, season, climate and temperature. Three main cues, or a combination, are expected to influence reproduction in small mammals, namely abiotic factors (such as food availability), internal factors (endogenous rhythms) and social cues between individuals (Neal 1986; Ims 1990). Abiotic factors, such as rain are not likely to affect breeding directly as there is usually a lag time of two or three months between rainfall and the evidence of breeding (Bronner 1986), but rather affects breeding indirectly through food availability (Neal 1982). Rainfall therefore may still contribute to the timing of the reproductive seasonality and could explain inter-year variation in population numbers and demography (Willan & Meester 1989; Monadjem & Perrin 2003). Temperature could influence breeding success, especially during exceptionally cold and wet periods. Timing of breeding in small mammal populations is often constrained, not only by the environment but also phylogenetically in terms of age of reproduction. Population size fluctuations and species richness are due to differences in recruitment (movements into the population through birth and immigration) and emigration (movements out of the population through dispersal and death (Bronner 1986). The fluctuations which occurred in small mammal diversity and abundance in the present study appears to correlate with the breeding season in certain species, and appeared cover driven in other species, such as *D. melanotis*.

The studying of population dynamics and fluctuation in small mammal populations may be as important in understand the coexistence between species as patterns of resource use (Brown & Zeng 1989). A dynamic reproductive strategy will enable a species to vary its life history strategy depending on environmental variability (Perrin & Swanepoel 1987; Willan & Meester 1989), and also to minimise or avoid competition by varying particular characteristics, thus promoting coexistence between species within a community (Dammhahn & Kappeler 2008).

Both *M. namaquensis* and *E. myurus* has distinct breeding seasons during this study, confirming results of previous studies (De Graaff 1981; Skinner & Chimimba 2005) with *E. myurus* breeding restricted to the rainy season and *M. namaquensis* starting breeding towards the end of the early rainy season and continuing into the late rainy season. During this study, the seasons with regular signs of reproduction were spring and summer. According to Bronner *et al.* (1988), Brooks (1982), Davis & Meester (1981) rodent population densities in perennial grasslands of the South African highveld are highly seasonal, with reproduction largely occurring between November and March, reaching peaks in population numbers during March and April. During winter (May-September) vegetation becomes less dense due to frost, and rodent populations decrease substantially (Davis 1973; Smithers 1983).

The success rate in young reaching maturity is unknown, and is expected that a large number of breeding attempts fail. Scrotal males are an indication that the animal is reproductively active and in search of females. Sexual maturity occurs at a young age in most rodent species, specifically noted in *Gerbilliscus leucogaster* during the study. A perforated vagina is an indication that a female animal is reproductively active. Pregnant females as well as lactating females were recorded during the study. Reproductively active individuals behave differently, and may occupy different sized territories and show a greater degree of aggression. The project has identified seasons with high reproductive activity, taking lifecycles and ecological requirements of various species into account.

# CHAPTER 15

# SEASONAL CHANGES IN SMALL MAMMAL BODY CONDITION

## 15.1. Abstract

This chapter aims to determine seasonal changes in the body condition (weight indexed against body length) of small mammal species in seven different vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and on Telperion in Mpumalanga Province, South Africa. Small mammal condition is affected by the changing seasons and associated dry and wet conditions which result. In the winter months less food and cover is available resulting in a greater amount of energy required to search for limited quantities of seed or invertebrate life. Reproduction is closely associated with body condition, which is intern closely associated with season. In the summer and autumn months, individuals are expected to be in peak body condition. Body condition effects basic behaviour and individuals in a poor body condition are less active, heavily infested with parasites and likely to be predated upon. Large differences in body condition between seasons was recorded for the study, with major differences between summer and autumn, and summer and spring, autumn and, and winter and spring. Results indicate that eight species, *Dendromus melanotis*, *Aethomys chrysophilus*, *Gerbilliscus leucogaster*, *Mastomys* spp., *Mus minutoides*, *Crocidura cyanea*, *Crocidura mariquensis* and *Suncus infinitesimus*, had the best body condition in the summer months, while four species, *Acomys spinosissimus*, *Gerbilliscus brantsii*, *Micaelamys namaquensis* and *Elephantulus myurus* in spring, four species, *Dendromus mystacalis*, *Lemniscomys rosalia*, *Otomys irroratus* and *Rhabdomys pumilio* in the winter months, and two species, *Graphiurus murinus* and *Steatomys pratensis*, in autumn. Two species, *Gerbilliscus brantsii* and *Graphiurus murinus* were in the worst condition in summer, two species, *Steatomys pratensis* and *Crocidura mariquensis* in the poorest condition in spring. Five species, *Acomys spinosissimus*, *Gerbilliscus leucogaster*, *Crocidura cyanea*, *Elephantulus myurus* and *Suncus infinitesimus* were in poorest condition in winter, and eight species, *Aethomys chrysophilus*, *Dendromus melanotis*, *Dendromus mystacalis*, *Micaelamys namaquensis*, *Lemniscomys rosalia*, *Mus minutoides*, *Otomys irroratus* and *Rhabdomys pumilio* were in poor condition in autumn. As would be expected, the majority of species in the Bankenveld grasslands are in good condition in summer and poor condition in autumn, due to energy expenditure associated with reproduction.

**Keywords:** Body condition, reproduction, small mammals, seasons, behavior, Telperion, Ezemvelo Nature Reserve, South Africa.

## 15.2. Introduction

Small mammal condition is affected by the changing seasons and associated dry and wet conditions which result. In the winter months it is expected that less food and cover will be available resulting in a greater amount of energy required to search for limited quantities of seed or invertebrate life. The purpose of this chapter is to determine seasonal changes in the body condition of small mammal species in seven different vegetation communities on Ezemvelo Nature Reserve in Gauteng Province, and on Telperion in Mpumalanga Province, South Africa. These properties are situated to the extreme north of the grassland biome in South Africa, recognized by Acocks (1988) as Bankenveld, and by Bredenkamp & Van Rooyen (1998) as Rocky Highveld Grassland. South Africa's grassland biome has been identified as critically endangered based on total habitat loss, degree of fragmentation and taking into account future threats (Reyers *et al.* 2001).

The question arises whether body condition is impacted by habitat structure and complexity, area, rainfall, productivity, predation, trampling, grazing, maturity of habitat and succession of vegetation. Competition between species is expected to directly or indirectly influence body condition negatively. Mutually exclusive home ranges provide evidence of avoidance rather than aggression as a behavioural mechanism promoting community structure and coexistence. Reproduction is closely associated with body condition, which is intern closely associated with season. In the summer and autumn months, individuals are expected to be in peak body condition. Food supply is an important factor that influences small mammal biomass (Doonan & Slade 1995). Many small mammal communities are directly influenced by vegetation structure (Linzey & Kesner 1997; Ferreira & Van Aarde 1999; Fuller & Perrin 2001) and consequently will be indirectly influenced by rainfall, fire and grazing; they can therefore be utilized to explore the interactions between these factors on ecosystem processes and biodiversity maintenance (Yarnell *et al* 2007).

The relationships expected to affect body condition are complex, reflecting the physiological, nutritional, social and anti-predatory requirements of specific small mammals (Birney *et al.* 1976). It is however expected that the stresses associated with combating predation may influence body condition. Diet selection in Bankenveld grassland small mammal species depends not only on the variety of resources available, but also the species of consumers present, their numbers and morphological and physiological characteristics. Habitat selection may facilitate species coexistence in a habitat (Rosenzweig 1981) because of food distribution (Jorgensen 2004). Habitats are often related to foraging efficiencies (Bonesi & Macdonald 2004), often resulting in a specialist dominating over a generalist. Both abiotic and biotic factors are proposed to impact body condition in small mammal communities. The seasonal reproductive change recorded within these small mammal communities is often associated with changes in the diet (Perrin & Boyer 2000). Body condition effects basic behaviour and individuals in a poor body condition are less active, heavily infested with parasites and more likely to be predated upon.

Large differences in body condition between seasons are expected for the study, with major differences between summer and autumn, summer and spring, autumn and sping, and winter and spring. It is expected that the majority of species in these grasslands will be in good condition in summer and poor condition in winter, due to less available food, and energy expenditure associated with reproduction during summer. Limited food resources impact species differently, however, generally it is expected that winter and spring are times of the greatest hardship. Animals are required to survive with limited food available during these periods. Other factors may come into play during the summer months, such as increased mating and disputes between males, which may result in large amounts of energy been utilized. Similarly, the effects of pregnancy and lactation may influence the body condition in female individuals. Recording seasons when body condition of populations is good or poor provides insights into understanding the population dynamics and growth of small mammal assemblages in these grasslands. Temperature appears to influence body condition of certain species of small mammal, especially during exceptionally cold and wet periods.

## 15.3. Methodology

Body condition is assessed by determining the ratio between body weight and body length in adult animals. This data assesses the seasonal changes in body weight as an indicator of health. Seasonal calculations of the ratio provide an indication of the body condition for each species of small mammals recorded during this study. In year one (2008), ten transects each comprising 30 live-traps Sherman each were placed in the seven identified vegetation communities in the study area. Markers were placed along each transect line and around each trap to ensure the same site was surveyed each month. The starting-point was placing transects in the seven vegetation communities. Two transects were placed in the dominant communities to obtain a greater sample size. 30 Sherman live-traps were placed at 10 m intervals and checked and re-baited daily. In year two (2009), three sites were discontinued, namely NSW1, DG3 and RHG2. Traps at the remaining seven sites were doubled to 60 traps per site.

Analysis of variance (ANOVA) was used to test for significant differences between body condition and season (Fowler *et al.* 1998). Tukey's test was undertaken when the result from ANOVA indicated a significant difference between the variables. Tukey's test provides an indication of where significant differences occur. All statistical analyses were performed using the computer programme Statistica for Windows (Statsoft Inc., 2008).

## 15.4. Results

### 15.4.1. Assessment of seasonal body condition of *Acomys spinosissimus* on Telperion

A sample of individual animals ($n$ = 11) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed seasonally. ANOVA revealed an insignificant difference between the body condition of *Acomys spinosissimus* recorded during the study and season ($F_{2.6}$ = 2.277; $n$ = 11; $P$ = 0.106), with a significant difference between Summer and Spring (Tukey's: $P$ = 0.02). The following measurements and ratios were recorded, in the summer months 5 individuals were measured reporting an average ratio of 16.6 g/ 15 mm, in autumn 2 individuals were measured with an average ratio of 18.5 g/ 14.8 mm, in winter 1 individual was measured with average ratio of 16 g/ 15.2 mm, and in spring 3 individuals were measured with an average ratio of 23.7 g/ 17 mm recorded (Table 39).

Table 39: Assessment of seasonal body condition of *Acomys spinosissimus* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 19 | 14.5 | 19 | 14 | 16 | 15.2 | 25 | 17.2 |
| 18 | 16.5 | 18 | 15.6 | | | 26 | 17.2 |
| 17 | 15.5 | | | | | 20 | 16.6 |
| 13 | 13.8 | | | | | | |
| 16 | 14.9 | | | | | | |
| | | | | | | | |
| 83 | 75.2 | 37 | 29.6 | 16 | 15.2 | 71 | 51 |
| 16.6 | 15.0 | 18.5 | 14.8 | 16 | 15.2 | 23.7 | 17 |

Results indicate that *A. spinossimus* on Telperion have the best body condition in spring when their body weight – length ratio is 23.7 g/17 mm, followed by autumn 18.5 g/14.8 mm, then summer 16.6 g/15 mm and are in poorest condition in winter 16 g/ 15.2 mm, although a small sample size was recorded in winter (Fig. 253).

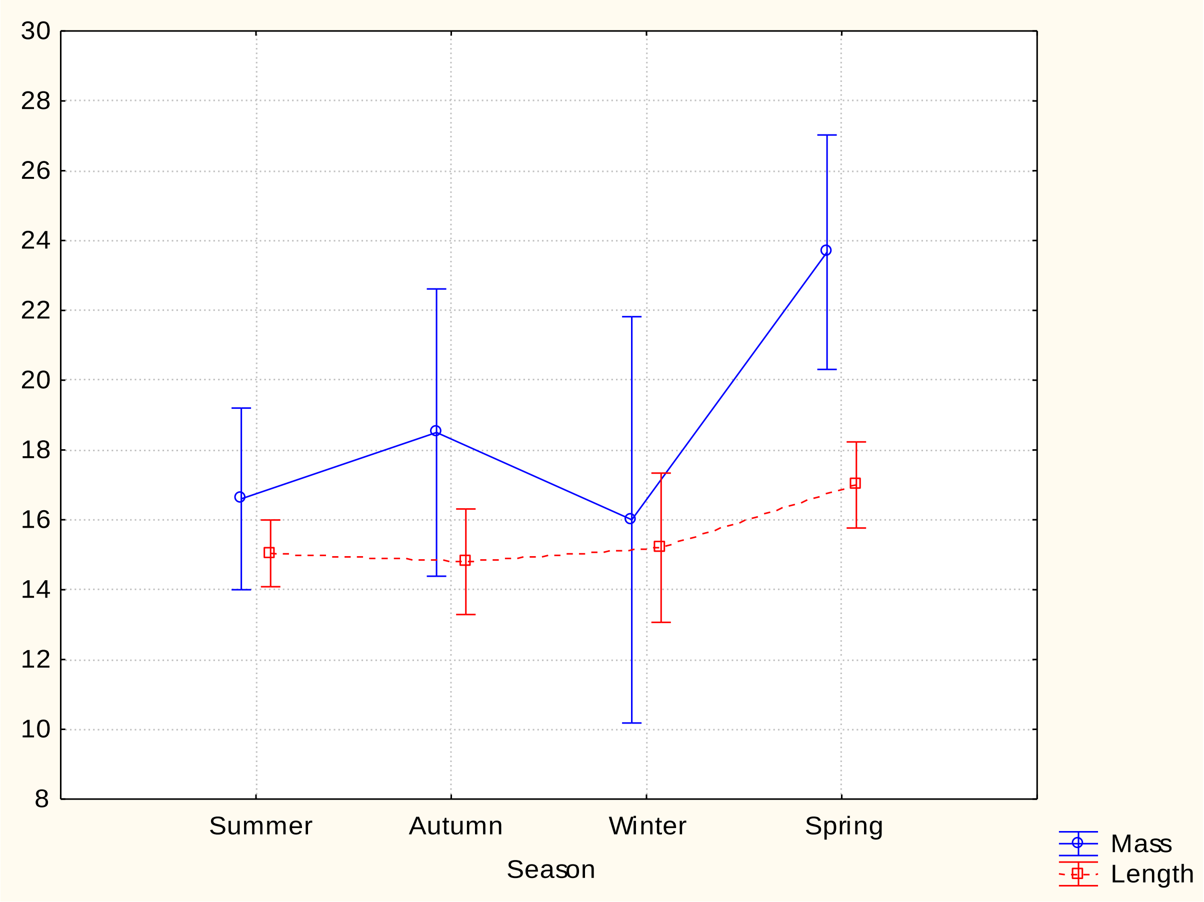

Figure 253. Graph illustrating seasonal ratio between body mass and length in adult *Acomys spinosissimus* on Telperion.

*A. spinossimus* are estimated to be 26.6% heavier than the average recorded weight (18.7 g) in spring, 1.1% lower in autumn, 11.2% lower in summer and 14.4% under the average recorded weight in winter. The good body condition in spring could be a result of seed producing plants reacting to spring rains quicker in the rocky areas with shallow soils, than in other areas. Body weight remains relatively constant through summer into winter, although a marginal increase occurs at the end of summer into autumn.

15.4.2. Assessment of seasonal body condition of *Aethomys chrysophilus* on Telperion

A sample of individual animals (*n* = 5) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in summer and autumn, as no new individuals were recorded in winter and spring. ANOVA revealed an insignificant difference between the body condition of *Aethomys chrysophilus* recorded during the study and season ($F_{2.2}$ = 0.929; *n* = 5; *P* = 0.518). The following measurements and ratios were recorded, in the summer months 4 individuals were measured reporting an average ratio of 61 g/27.1 mm (Table 40).

Table 40: Assessment of seasonal body condition of *Aethomys chrysophilus* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 56 | 31 | 45 | 26 | | | | |
| 74 | 27.2 | | | | | | |
| 52 | 27.8 | | | | | | |
| 62 | 22.5 | | | | | | |
| 244 | 108.5 | 45 | 26 | | | | |
| 61 | 27.1 | 45 | 26 | | | | |

Preliminary results indicate that *Aethomys chrysophilus* on Telperion has the best body condition in summer when their body weight – length ratio is 61 g/27.1 mm and their condition appears to decrease towards autumn 45 g/26 mm, although the sample size calculated was low (Fig. 254).

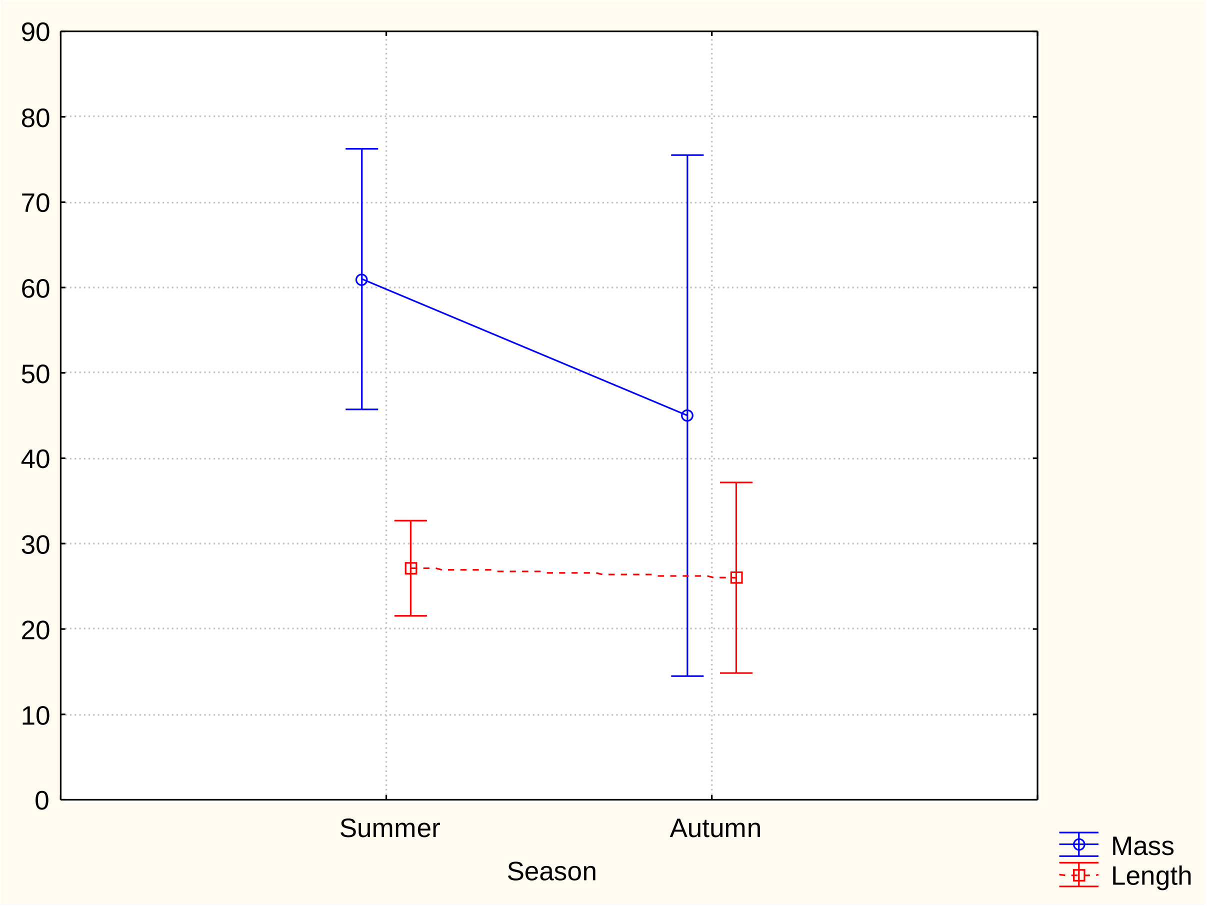

Figure 254. Graph illustrating seasonal ratio between body mass and length in adult *Aethomys chrysophilus* on Telperion.

*A. chrysophilus* are estimated to be 15.1% heavier than the average recorded weight (53 g) in summer and 15.1% lower in autumn. The good body condition in summer could be a result of the number of seed producing plants. There is an indication that body condition decreases towards winter, although the sample size recorded during this study is small.

### 15.4.3. Assessment of seasonal body condition of *Dendromus melanotis* on Telperion

A sample of individual animals ($n$ = 78) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed seasonally. ANOVA revealed a highly significant differences between body condition of *Dendromus melanotis* recorded during the study and season ($F_{2.6}$ = 5.178; $n$ = 78; $P$ = 0.00), with significant differences between Summer and Autumn (Tukey's: $P$ = 0.00) and Summer and Winter (Tukey's: $P$ = 0.00); and Summer and Spring (Tukey's: $P$ = 0.01).The following measurements and ratios were recorded, in the summer months 7 individuals were measured reporting an average ratio of 11.1 g/ 14.1 mm, in autumn 40 individuals were measured with an average ratio of 7.9 g/ 13.4 mm, in winter 26 individuals were measured with average ratio of 8.3 g/ 13.7 mm, and in spring 5 individuals were measured with an average ratio of 8.7 g/ 14.1 mm recorded (Table 41).

Table 41: Assessment of seasonal body condition of *Dendromus melanotis* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 11 | 14.9 | 8 | 12.5 | 8 | 12.9 | 8 | 14.1 |
| 13 | 15.1 | 10 | 12.5 | 8 | 13.1 | 8 | 13.8 |
| 7 | 12.1 | 7 | 13.1 | 7 | 13.6 | 9 | 14.5 |
| 12 | 13.5 | 8 | 13.1 | 8 | 13.3 | 8.5 | 13.6 |
| 15 | 15.1 | 4.5 | 14.1 | 6 | 14.8 | 10 | 14.4 |
| 10 | 13.9 | 4.5 | 15.7 | 8 | 13.2 | | |
| 10 | 13.8 | 8 | 13.9 | 9 | 14.1 | | |
| | | 11 | 15.1 | 8 | 12.2 | | |
| | | 8 | 13.3 | 8 | 13.3 | | |
| | | 9.5 | 13.9 | 9 | 14 | | |
| | | 9 | 13.5 | 8 | 14.1 | | |
| | | 8 | 13.6 | 8 | 13.4 | | |
| | | 8 | 14.9 | 9.5 | 13.6 | | |
| | | 8 | 15.6 | 8 | 13.4 | | |
| | | 8 | 13.5 | 7 | 13 | | |
| | | 6.5 | 13.1 | 10 | 14.5 | | |
| | | 7.5 | 13.5 | 8 | 13.7 | | |
| | | 8 | 13.2 | 8 | 14.6 | | |
| | | 7.5 | 13.3 | 8 | 13.1 | | |
| | | 7.5 | 13.2 | 8 | 13.9 | | |
| | | 5 | 12.9 | 11 | 13.7 | | |
| | | 6 | 13.7 | 10 | 14.8 | | |
| | | 8.5 | 13.3 | 8 | 13.7 | | |
| | | 8.5 | 13.7 | 8 | 13.5 | | |
| | | 7 | 14.1 | 8 | 14.1 | | |
| | | 7.5 | 14.4 | 9 | 13.6 | | |
| | | 7.5 | 13.5 | | | | |
| | | 8 | 13.9 | | | | |
| | | 7 | 13.2 | | | | |
| | | 10 | 13.3 | | | | |
| | | 7 | 14.2 | | | | |
| | | 9.5 | 14.7 | | | | |
| | | 9 | 14.5 | | | | |
| | | 8 | 13.7 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 8 | 13.9 | | | | |
| | | 10 | 14.5 | | | | |
| | | 8 | 13.1 | | | | |
| | | 9 | 13.5 | | | | |
| | | 8.5 | 13.5 | | | | |
| | | 8 | 13.5 | | | | |
| 78 | 98.4 | 316.5 | 536.5 | 215.5 | 355.2 | 43.5 | 70.4 |
| 11.1 | 14.1 | 7.9 | 13.4 | 8.3 | 13.7 | 8.7 | 14.1 |

Results indicate that *D. melanotis* on Telperion have the best body condition in summer when their body weight – length ratio is 11.1 g/14.1 mm, followed by spring 8.7 g/14.1 mm, then winter 8.3 g/13.7 mm and are in poorest condition in autumn 7.9 g/ 13.4 mm, although appear to improve body condition into the winter months (Fig. 255).

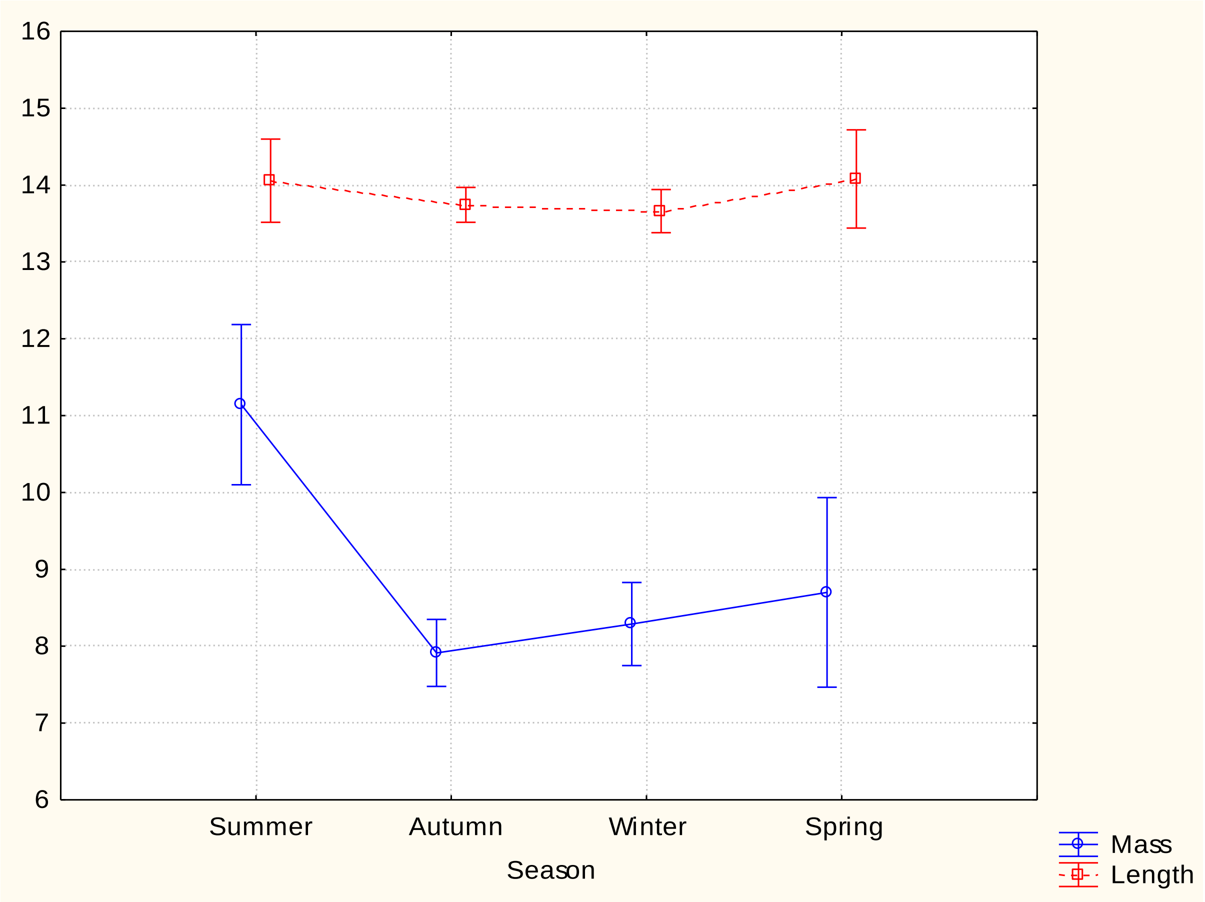

Figure 255. Graph illustrating seasonal ratio between body mass and length in adult *Dendromus melanotis* on Telperion.

*Dendromus melanotis* are estimated to be 28.3% heavier than the average recorded weight (9 g) in summer, 3.3% lower in spring, 7.9% lower in winter and 12.9% under the average recorded weight in autumn. This could result in the higher trap success recorded for this species during the autumn months. Higher numbers of individuals through reproduction during the summer months and the resultant completion for food may have result in this loss of body condition from summer into autumn. The body condition of recorded individuals appears to gradually improve through winter and spring.

### 15.4.4. Assessment of seasonal body condition of *Dendromus mystacalis* on Telperion

A sample of individual animals ($n$ = 12) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in autumn and winter, as no new individuals were recorded in summer and spring. ANOVA revealed an insignificant difference between the body condition of *Dendromus mystacalis* recorded during the study and season ($F_{2.2} = 1.298$; $n = 12$; $P = 0.320$). The following measurements and ratios were recorded, in the autumn months 9 individuals were measured reporting an average ratio of 8 g/14.8 mm and winter 3 individuals were measured with an average ratio of 9.3 g/ 16.1 mm (Table 42).

Table 42: Assessment of seasonal body condition of *Dendromus mystacalis* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| | | 9 | 12.9 | 10 | 15.7 | | |
| | | 4 | 13.2 | 8 | 16.4 | | |
| | | 11 | 16.3 | 10 | 16.2 | | |
| | | 7 | 15.4 | | | | |
| | | 7 | 14.1 | | | | |
| | | 7 | 14.4 | | | | |
| | | 9 | 15.8 | | | | |
| | | 7 | 14.4 | | | | |
| | | 11 | 16.5 | | | | |
| | | 72 | 133 | 28.0 | 48.3 | | |
| | | 8 | 14.8 | 9.3 | 16.1 | | |

Results indicate that *Dendromus mystacalis* on Telperion has the best body condition in winter when their body weight – length ratio is 9.3 g/16.1 mm and their condition appears to improve compared with autumn 8 g/14.8 mm, although the sample size calculated was low (Fig. 256).

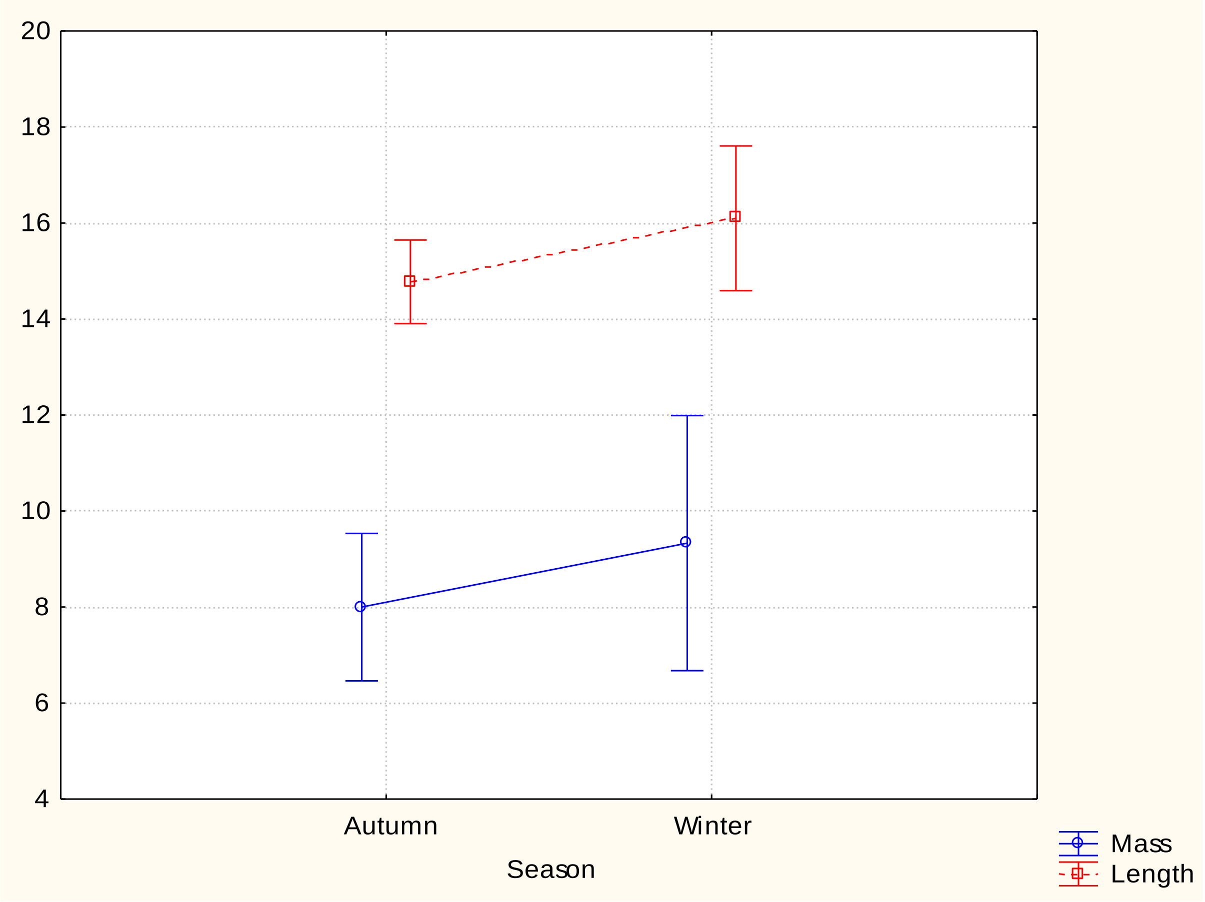

Figure 256. Graph illustrating seasonal ratio between body mass and length in adult *Dendromus mystacalis* on Telperion.

*Dendromus mystacalis* are estimated to be 7.5% heavier than the average recorded weight (8.7 g) in winter and 7.5% lower in autumn. The better body condition in winter could be as result of lower densities, and less competition for food, although the sample size recorded during the study is small.

### 15.4.5. Assessment of seasonal body condition of *Gerbilliscus brantsii* on Telperion

A sample of individual animals ($n$ = 6) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in summer, winter and spring, as no new adult individuals were recorded in autumn. ANOVA revealed an insignificant difference between the body condition of *Gerbilliscus brantsii* recorded during the study and season ($F_{2.4}$ = 1.055; $n$ = 6; $P$ = 0.480), The following measurements and ratios were recorded, in the summer months 3 individuals were measured reporting an average ratio of 69 g/27.9 mm, in winter 1 individuals with an average ratio of 76 g/ 29.4 mm, and 2 individuals in spring with 80.5 g/ 28.8 mm (Table 43).

Table 43: Assessment of seasonal body condition of *Gerbilliscus brantsii* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 69 | 27 | | | 76 | 29.4 | 67 | 25.6 |
| 73 | 28.8 | | | | | 94 | 31.9 |
| 65 | 27.8 | | | | | | |
| 207 | 83.6 | | | 76 | 29.4 | 161 | 57.5 |
| 69 | 27.9 | | | 76 | 29.4 | 80.5 | 28.8 |

Results indicate that *G. brantsii* on Telperion has the best body condition in spring when their body weight – length ratio is 80.5 g/28.8 mm, while their worst body condition appears to be in summer; however this could be due to the increased activity around courting, mating and reproduction. This species condition appears to improve in winter with a ratio of 76 g/29.4 mm, although the sample size calculated was low (Fig. 257).

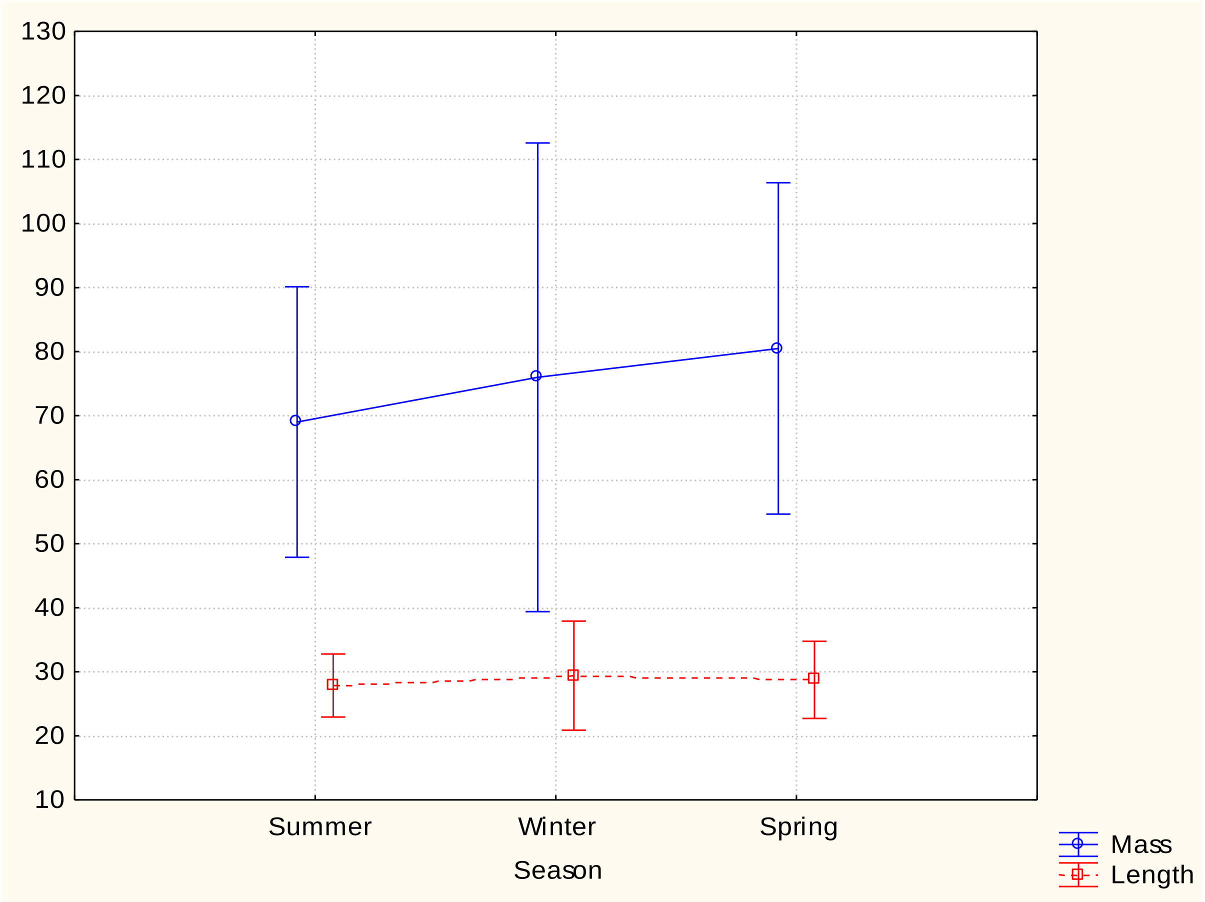

Figure 257. Graph illustrating seasonal ratio between body mass and length in adult *Gerbilliscus brantsii* on Telperion.

*Gerbilliscus brantsii* are estimated to be 7.1% heavier than the average recorded weight (75.2 g) in spring, 1.1% heavier in winter, while 8.2% lower in summer. The better body condition in winter could be as result of lower densities, and less competition for food, although the sample size recorded during the study is small.

### 15.4.6. Assessment of seasonal body condition of *Gerbilliscus leucogaster* on Telperion

A sample of individual animals ($n$ = 8) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed seasonally. ANOVA revealed a significant difference between body condition of *Gerbilliscus leucogaster* recorded during the study and season ($F_{2.6}$ = 4.257; $n$ = 8; $P$ = 0.051). The following measurements and ratios were recorded, in the summer months 3 individuals were measured reporting an average ratio of 69.3 g/ 26.3 mm, in autumn 2 individuals were measured with an average ratio of 68.5 g/ 27.2 mm, in winter 1 individual was measured with average ratio of 54 g/ 27.6 mm, and in spring 2 individuals were measured with an average ratio of 69.5 g/ 28.3 mm recorded (Table 44).

Table 44: Assessment of seasonal body condition of *Gerbilliscus leucogaster* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 74 | 27 | 67 | 27.1 | 54 | 27.6 | 74 | 29.6 |
| 55 | 23.9 | 70 | 27.2 | | | 65 | 27 |
| 79 | 28.1 | | | | | | |
| | | | | | | | |
| 208 | 79 | 137 | 54.3 | 54 | 27.6 | 139 | 56.6 |
| 69.3 | 26.3 | 68.5 | 27.2 | 54 | 27.6 | 69.5 | 28.3 |

Results indicate that *G. leucogaster* on Telperion have a marginally better body condition in spring when their body weight – length ratio is 69.5 g/28.3 mm, followed by summer 69.3 g/26.3 mm, then autumn 68.5 g/27.2 mm and are in poorest condition in winter 54 g/ 27.6 mm, although a small sample size was recorded in winter (Fig. 258).

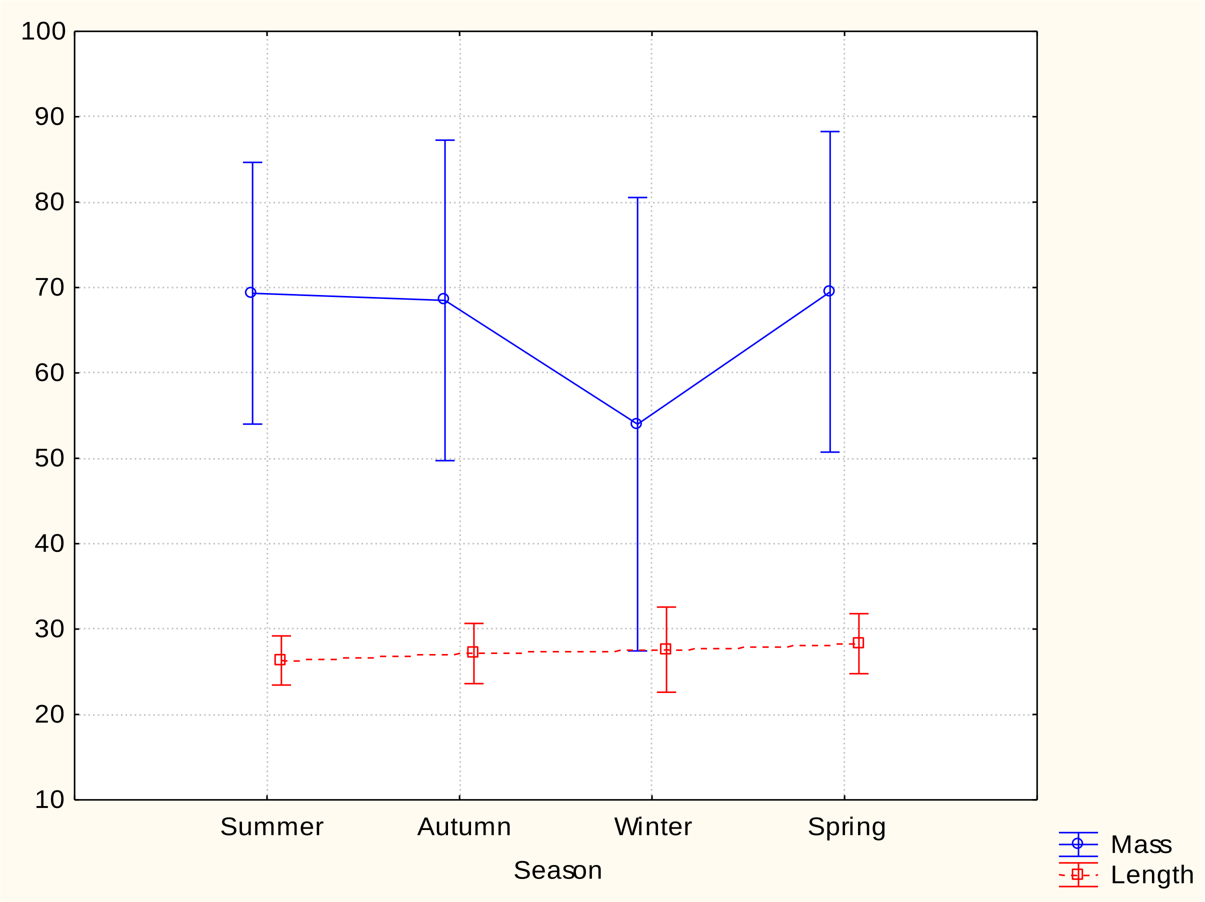

Figure 258. Graph illustrating seasonal ratio between body mass and length in adult *Gerbilliscus leucogaster* on Telperion.

*Gerbilliscus leucogaster* are estimated to be 6.4% heavier than the average recorded weight (65.3 g) in spring, 6.1% heavier in summer, and 4.9% heavier in autumn, and 1.1% under the average recorded weight in winter. The good body condition in spring and summer could be a result of seed producing plants being more abundant. Body weight remains relatively constant through autumn, but falls considerable in the winter months.

### 15.4.7. Assessment of seasonal body condition of *Graphiurus murinus* on Telperion

A sample of individual animals ($n$ = 5) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in summer and autumn, as no new individuals were recorded in winter and spring. ANOVA revealed an insignificant difference between body condition of *Graphiurus murinus* recorded during the study and season ($F_{2.2}$ = 12.981; $n$ = 5; $P$ = 0.072). The following measurements and ratios were recorded, in the summer months 3 individuals were measured reporting an average body ratio of 36.3 g/19.4 mm and 2 individuals in autumn with a ratio of 52.5 g/ 20 mm (Table 45).

Table 45: Assessment of seasonal body condition of *Graphiurus murinus* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 39 | 19.2 | 57 | 19.7 | | | | |
| 33 | 20.4 | 48 | 20.3 | | | | |
| 37 | 18.6 | | | | | | |
| | | | | | | | |
| 109 | 58.2 | 105 | 40 | | | | |
| 36.3 | 19.4 | 52.5 | 20 | | | | |

Preliminary results indicate that *Graphiurus murinus* on Telperion has the best body condition in autumn when their body weight – length ratio is 52.5 g/20 mm and their condition appears to decrease in summer at 36.3 g/19.4 mm, although the sample size calculated was low (Fig. 259).

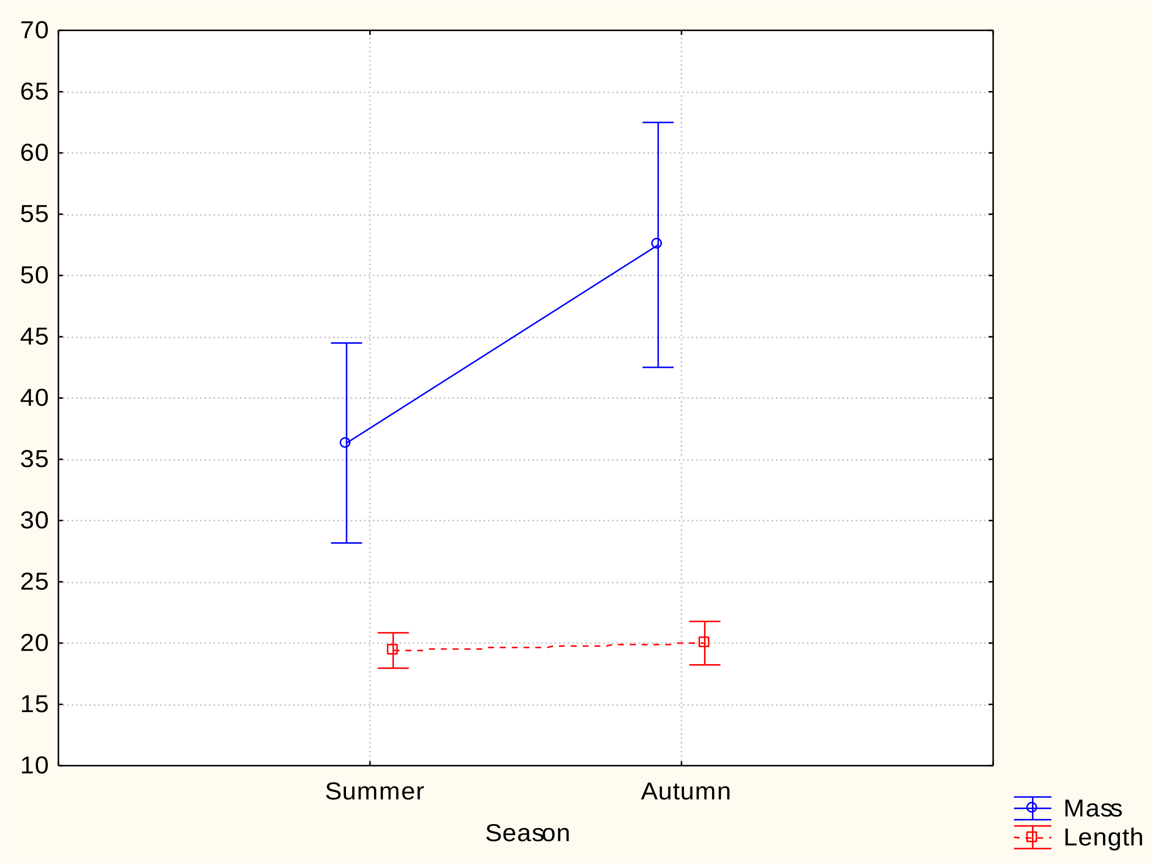

Figure 259. Graph illustrating seasonal ratio between body mass and length in adult *Graphiurus murinus* on Telperion.

*Graphiurus murinus* are estimated to be 18.2% heavier than the average recorded weight (44.4 g) in autumn and 18.2% lower in autumn. The good body condition in autumn could be a result of a weight increase post summer and the associated availability of suitable food. There is an indication that body condition is decreased in summer, although the sample size recorded during this study is small, this could be related to increased activity associated with reproduction.

### 15.4.8. Assessment of seasonal body condition of *Lemniscomys rosalia* on Telperion

A sample of individual animals (*n* = 25) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed seasonally. ANOVA revealed an insignificant difference between body condition of *Lemniscomys rosalia* recorded during the study and season ($F_{2.6}$ = 1.082; *n* = 25; *P* = 0.320).The following measurements and ratios were recorded, in the summer months 6 individuals were measured reporting an average ratio of 48.8 g/ 24.3 mm, in autumn 7 individuals were measured with an average ratio of 44.9 g/ 25 mm, in winter 5 individual were measured with an average ratio of 53.2 g/ 25.6 mm, and in spring 7 individuals were measured with an average ratio of 51.8 g/ 25.2 mm recorded (Table 46).

Table 46: Assessment of seasonal body condition of *Lemniscomys rosalia* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 63 | 26.8 | 32 | 26.7 | 62 | 26.7 | 47.5 | 25.7 |
| 58 | 25 | 47 | 25 | 49 | 25 | 56 | 25.9 |
| 40 | 21.5 | 49 | 23 | 56 | 27 | 55 | 26 |
| 56 | 26.6 | 47 | 22 | 46 | 25 | 55 | 26 |
| 40 | 23.6 | 47 | 23.6 | 53 | 24.5 | 50 | 23.5 |
| 36 | 22.2 | 44 | 26.7 | | | 50 | 24 |
| | | 48 | 28 | | | 49 | 23.5 |
| 293 | 145.7 | 314 | 175 | 266 | 128.2 | 362.5 | 174.6 |
| 48.8 | 24.3 | 44.9 | 25 | 53.2 | 25.6 | 51.8 | 25.2 |

Results indicate that *L. rosalia* on Telperion have a better body condition in winter when their recorded body weight – length ratio is 53.2 g/25.6 mm, followed by the spring months with 51.8 g/25.2 mm, followed by summer with 48.8 g/24.3 mm and are in poorest condition in autumn 44.9 g/ 25 mm (Fig. 260).

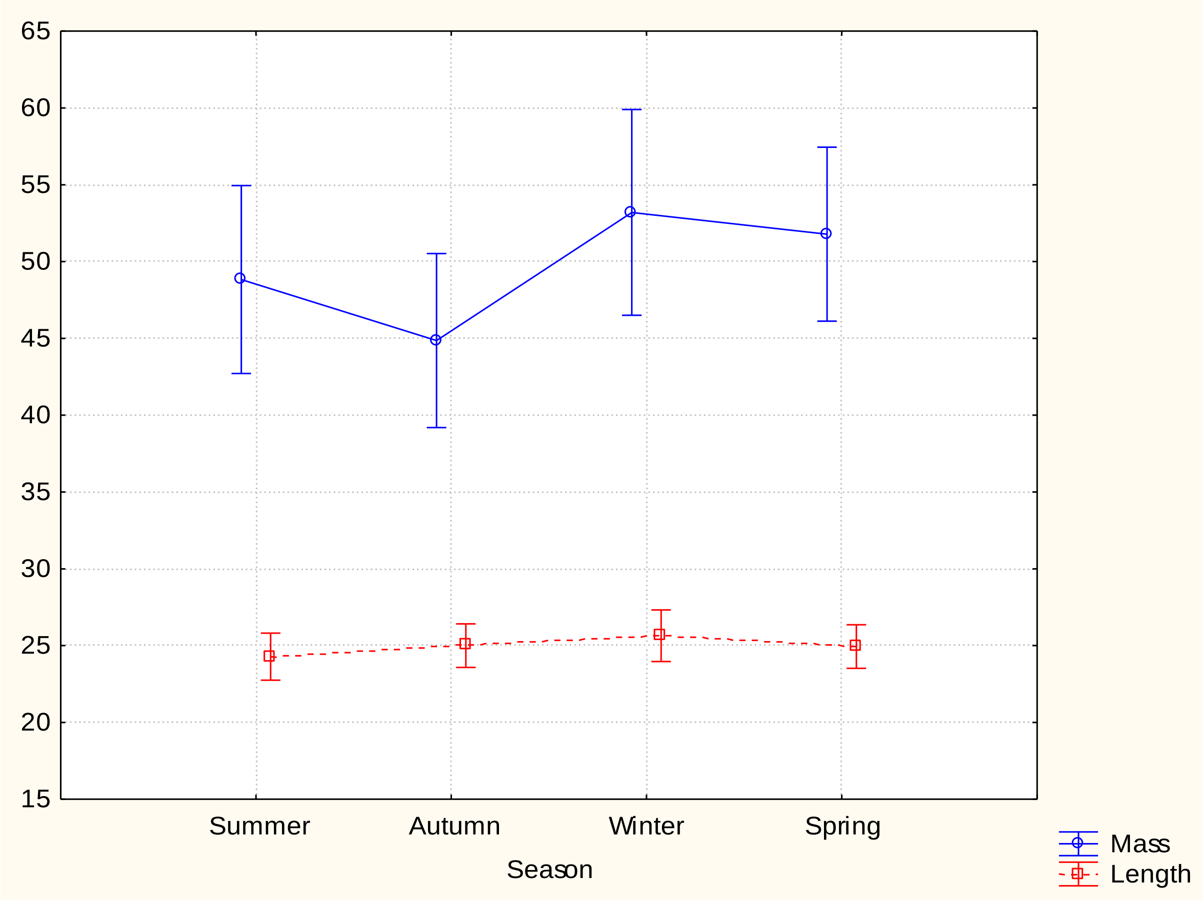

Figure 260. Graph illustrating seasonal ratio between body mass and length in adult *Lemniscomys rosalia* on Telperion.

*Lemniscomys rosalia* are estimated to be 7.1% heavier than the average recorded weight (49.7 g) in winter, 4.2% heavier in spring, and 1.7% and 9.7% under the average recorded weight in summer and autumn respectively. The good body condition in winter and spring could be a competition related. The decrease in body condition in autumn could be the delayed impact of the stress related to reproduction.

15.4.9. Assessment of seasonal body condition of *Mastomys* spp. on Telperion

A sample of individual animals (*n* = 10) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in spring and summer, as no individuals were recorded in autumn and winter. ANOVA revealed a significant difference between body condition of *Mastomys* spp. recorded during the study and season ($F_{2.2}$ =

15.552; $n$ = 10; $P$ = 0.003). The following measurements and ratios were recorded; in the summer months 2 individuals were measured reporting an average ratio of 43.5 g/22.3 mm, with a lower average body ratio is spring with 34 g/ 18.3 mm (Table 47).

Table 47: Assessment of seasonal body condition of *Mastomys* spp. on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 44 | 22.4 | | | | | 45 | 20 |
| 43 | 22.2 | | | | | 30 | 19 |
| | | | | | | 38 | 19.4 |
| | | | | | | 47 | 19.5 |
| | | | | | | 25 | 16.9 |
| | | | | | | 24 | 16.5 |
| | | | | | | 36 | 18.2 |
| | | | | | | 27 | 16.9 |
| 87 | 44.6 | | | | | 272 | 146.4 |
| 43.5 | 22.3 | | | | | 34 | 18.3 |

Preliminary results indicate that *Mastomys* spp. on Telperion has the best body condition in summer when their body weight – length ratio is 43.5 g/22.3 mm and a lower mean condition in spring with 34 g/18 mm, although the sample size calculated in spring had a number of underweight individuals which skewed the mean (Fig. 261).

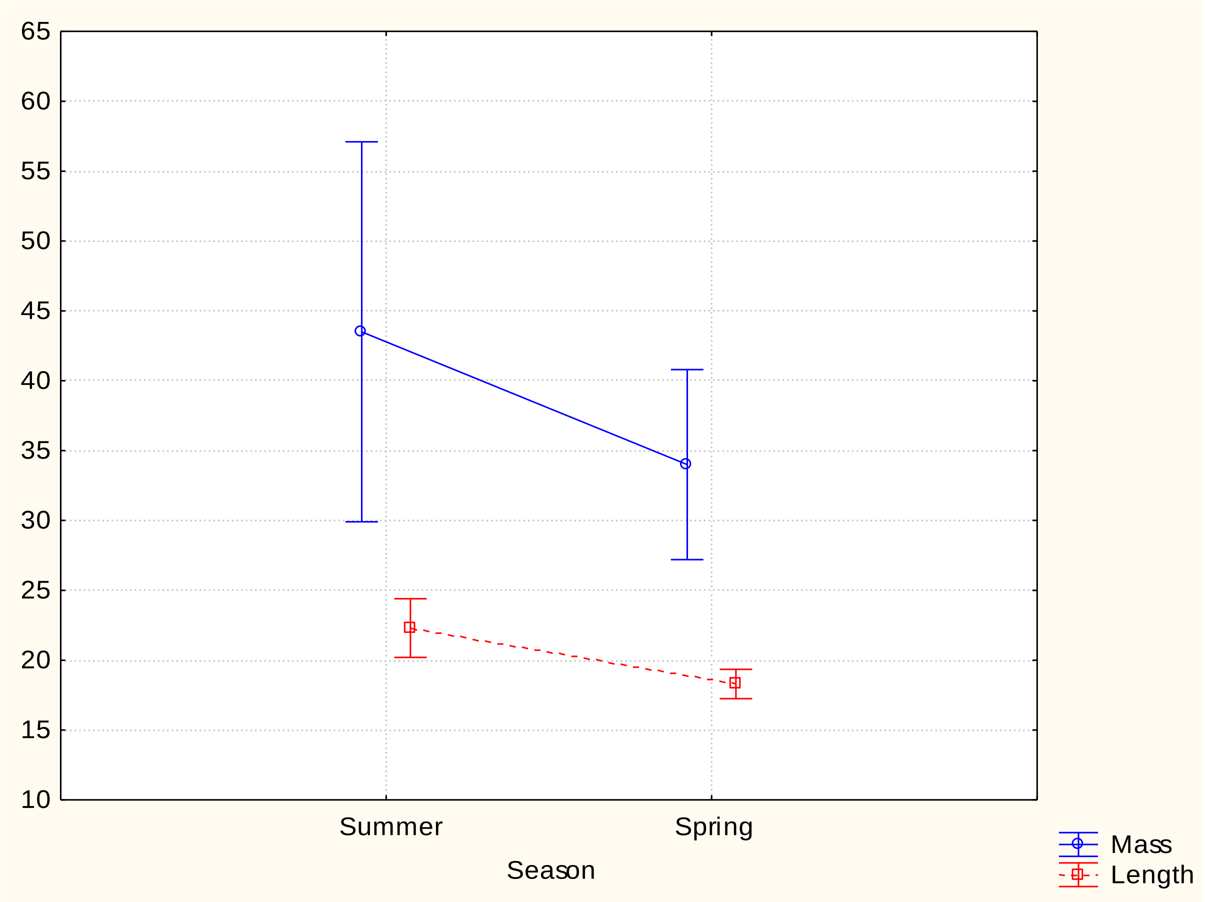

Figure 261. Graph illustrating seasonal ratio between body mass and length in adult *Mastomys* spp. on Telperion.

*Mastomys* spp. are estimated to be 12.3% heavier than the average recorded weight (38.8 g) in summer and 12.3% lower in spring. The good body condition in summer could be a result of the number of seed producing plants, although a number of individuals with a higher body mass – length ratio were recorded in spring, although the average was reduced by the number of underweight individuals also captured.

### 15.4.10. Assessment of seasonal body condition of *Micaelamys namaquensis* on Telperion

A sample of individual animals ($n$ = 240) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed seasonally. ANOVA revealed a highly significant differences between body condition of *Micaelamys namaquensis* recorded during the study and season ($F_{2.6}$ = 10.473; $n$ = 240; $P$ = 0.000), with significant differences between Summer and Spring (Tukey's: $P$ = 0.00) and Autumn and Spring (Tukey's: $P$ = 0.00); and Winter and Spring (Tukey's: $P$ = 0.04). The following measurements and ratios were recorded, in the summer months 66 individuals were measured reporting an average ratio of 41.6 g/ 23.5 mm, in autumn 55 individuals were measured with an average ratio of 40.4 g/ 24.4 mm, in winter 24 individuals were measured with average ratio of 44.1 g/ 25.9 mm, and in spring 95 individuals were measured with an average ratio of 50.2 g/ 25.9 mm recorded (Table 48).

Table 48: Assessment of seasonal body condition of *Micaelamys namaquensis* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 43 | 25.7 | 27 | 21.1 | 43 | 25.1 | 47 | 25.3 |
| 41 | 26.1 | 48 | 25.4 | 52 | 24.8 | 59 | 26.2 |
| 27 | 19 | 36 | 23.5 | 51 | 26.8 | 43 | 25.4 |
| 47 | 24.5 | 32 | 23.2 | 45 | 26.4 | 50 | 26.2 |
| 34 | 20.6 | 37 | 24.1 | 48 | 28.2 | 55 | 26 |
| 36 | 25.7 | 30 | 21.5 | 47 | 26.8 | 48 | 21.6 |
| 38 | 26 | 28 | 22.7 | 41 | 25.6 | 51 | 26.8 |
| 35 | 2.57 | 43 | 25.1 | 47 | 25.4 | 54 | 28.1 |
| 28 | 19.1 | 37 | 24.2 | 49 | 26.9 | 50 | 26.2 |
| 37 | 26.1 | 57 | 25.2 | 50 | 25.4 | 57 | 27.5 |
| 27 | 19 | 46 | 25.7 | 46 | 26.7 | 57 | 26.9 |
| 53 | 25.5 | 22 | 24.8 | 47 | 25.2 | 49 | 26.2 |
| 31 | 19.5 | 36 | 22.6 | 43 | 25.2 | 55 | 25.2 |
| 48 | 22.3 | 30 | 21.6 | 36 | 25.4 | 46 | 25.5 |
| 34 | 25.8 | 32 | 21.6 | 47 | 25.7 | 52 | 27.4 |
| 35 | 25.5 | 48 | 25.8 | 42 | 26.3 | 52 | 26.6 |
| 36 | 22.5 | 31 | 21.7 | 52 | 27.2 | 55 | 26.6 |
| 35 | 22.4 | 45 | 25.3 | 39 | 26.8 | 51 | 26.5 |
| 41 | 22.8 | 47 | 24.8 | 37 | 23.6 | 26 | 19.6 |
| 55 | 26.6 | 40 | 26.9 | 40 | 25.6 | 41 | 26.6 |
| 50 | 24.8 | 53 | 28.1 | 37 | 23.9 | 46 | 27.1 |
| 33 | 21.5 | 36 | 21.9 | 39 | 26.3 | 54 | 27.9 |
| 58 | 24.7 | 51 | 27.6 | 41.5 | 25.2 | 52 | 26.6 |
| 45 | 24.5 | 45 | 25.2 | 39.5 | 27.8 | 46 | 26.2 |
| 55 | 27 | 29 | 22.7 | | | 66 | 27.6 |
| 26 | 21 | 35 | 25.7 | | | 56 | 28.1 |
| 52 | 22.6 | 41 | 25.8 | | | 61 | 26.4 |
| 57 | 22.5 | 53 | 24.2 | | | 28 | 20.5 |
| 30 | 23.1 | 39 | 28.2 | | | 53 | 21 |
| 28 | 21.4 | 46 | 26.2 | | | 53 | 25.7 |
| 54 | 26.2 | 50 | 26.2 | | | 37 | 20.5 |
| 32 | 22.1 | 45 | 25.2 | | | 31 | 22.5 |
| 32 | 21 | 57 | 26.5 | | | 26 | 22.5 |
| 56 | 28.4 | 47 | 24.8 | | | 35 | 25.8 |
| 22 | 19 | 46 | 27.6 | | | 48 | 26 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 52 | 26.4 | 31 | 20.4 | | | 62 | 26.9 |
| 46 | 24.2 | 51 | 26.9 | | | 48 | 25.3 |
| 26 | 20.5 | 54 | 26.7 | | | 60 | 27.3 |
| 21 | 21.5 | 43 | 23.4 | | | 64 | 28.5 |
| 26 | 16 | 25 | 20.6 | | | 50 | 24.7 |
| 48 | 25.4 | 39 | 23.9 | | | 59 | 28.6 |
| 44 | 24.6 | 32 | 22.1 | | | 40 | 23.7 |
| 72 | 28.2 | 27 | 21.2 | | | 37 | 23.1 |
| 27 | 18.5 | 34.7 | 24.8 | | | 48 | 25.4 |
| 42 | 24.7 | 51 | 26.6 | | | 30 | 22.4 |
| 61 | 25.4 | 31 | 23.5 | | | 35 | 25.3 |
| 23 | 20.9 | 31 | 21.1 | | | 27 | 22.1 |
| 29 | 21.3 | 46 | 24.9 | | | 53 | 26.2 |
| 24 | 18.2 | 39 | 23.3 | | | 35 | 23.8 |
| 60 | 28.3 | 29 | 23.5 | | | 67 | 28.4 |
| 31 | 24.2 | 39 | 23.4 | | | 47 | 26 |
| 53 | 25.5 | 36 | 21.9 | | | 32 | 22.3 |
| 49 | 25.7 | 59.5 | 27.6 | | | 55 | 28.6 |
| 46 | 26.9 | 37 | 24.7 | | | 54 | 27.5 |
| 28 | 20.2 | 60 | 27.2 | | | 47 | 25.9 |
| 45 | 24.5 | | | | | 45 | 24.3 |
| 61 | 27.5 | | | | | 47.5 | 25.5 |
| 52 | 26.2 | | | | | 53 | 25.2 |
| 76 | 28.4 | | | | | 56 | 27.7 |
| 46 | 25.5 | | | | | 54 | 25.7 |
| 43 | 26.1 | | | | | 47 | 23 |
| 52 | 27.3 | | | | | 28 | 21 |
| 44 | 26.1 | | | | | 48 | 27.2 |
| 29 | 21.8 | | | | | 42 | 25.5 |
| 43 | 26.2 | | | | | 53 | 25.9 |
| 53 | 27.9 | | | | | 43 | 25 |
| | | | | | | 51 | 24.9 |
| 2743 | 1551.2 | 2220.2 | 1340.4 | 1059 | 622.3 | 42 | 25.3 |
| 41.6 | 23.5 | 40.4 | 24.4 | 44.1 | 25.9 | 55 | 25.2 |
| | | | | | | 51 | 25.1 |
| | | | | | | 52 | 28.2 |
| | | | | | | 60 | 28.2 |
| | | | | | | 55 | 26.2 |
| | | | | | | 54 | 27.5 |
| | | | | | | 64 | 27.6 |
| | | | | | | 56 | 27.9 |
| | | | | | | 54 | 26.5 |
| | | | | | | 53 | 25.2 |
| | | | | | | 48 | 27.6 |
| | | | | | | 50 | 25.8 |
| | | | | | | 49 | 28.5 |
| | | | | | | 65 | 26.6 |
| | | | | | | 62 | 27.6 |

|  |  |
|---|---|
| 52 | 27.2 |
| 58 | 28.7 |
| 63 | 27.9 |
| 57 | 26.5 |
| 56 | 29.5 |
| 73 | 29.5 |
| 65 | 27.5 |
| 61 | 27.4 |
| 60 | 28.4 |
| 51 | 25.9 |
| 50 | 26.7 |
| 42 | 26.2 |
|  |  |
| 4765.5 | 2464.1 |
| 50.2 | 25.9 |

Results indicate that *M. namaquensis* on Telperion have the best body condition in spring when their body weight – length ratio is 50.2 g/25.9 mm, followed by winter 44.1 g/25.9 mm, then summer 41.6 g/23.5 mm and are in poorest condition in autumn 40.4 g/ 24.4 mm, although appear to increase body condition into the winter months (Fig. 262).

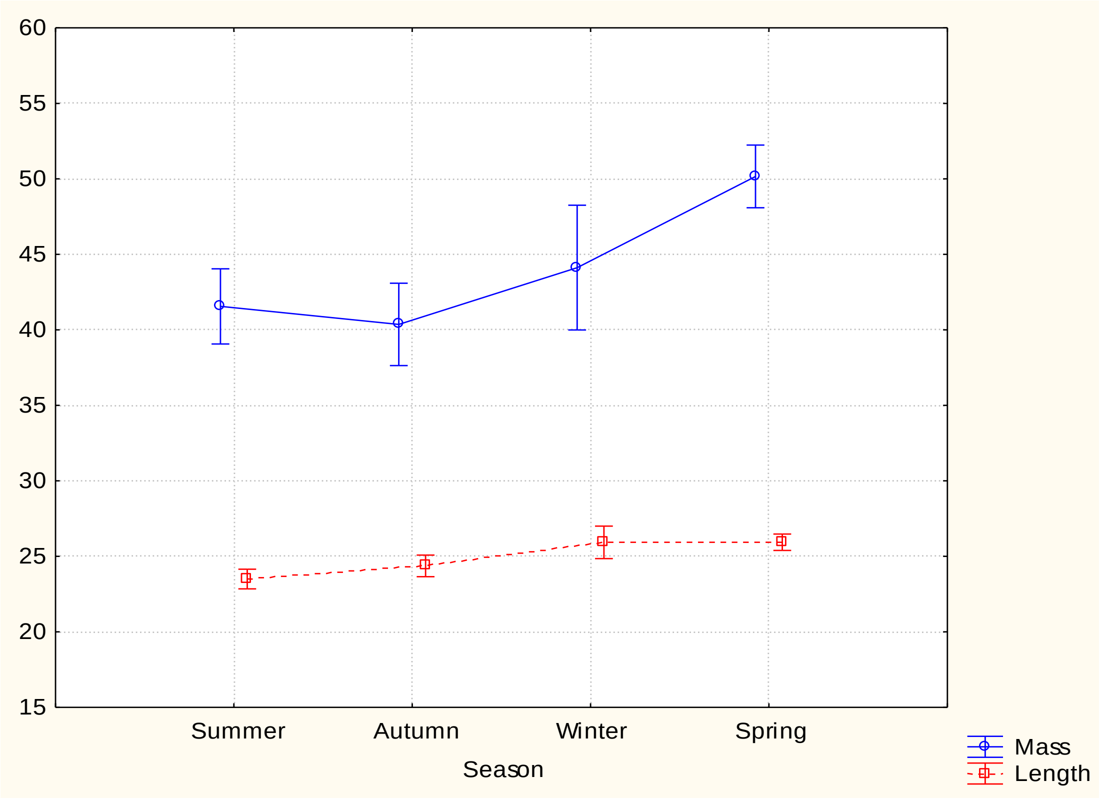

Figure 262. Graph illustrating seasonal ratio between body mass and length in adult *Micaelamys namaquensis* on Telperion.

*Micaelamys namaquensis* are estimated to be 13.7% heavier than the average recorded weight (44.1 g) in spring, 0.2% above average in winter, and 5.7% lower in summer and 8.4% under the average recorded weight in autumn. Higher numbers of individuals and the resultant completion for food may have result in this loss of body condition from summer into autumn. Weak individuals may perish with the onset of winter, resulting in their body condition of those individuals surviving stabilizing through winter and ultimately improving into spring.

### 15.4.11. Assessment of seasonal body condition of *Mus minutoides* on Telperion

A sample of individual animals ($n$ = 25) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed seasonally. ANOVA revealed a highly significant differences between body condition of *Mus minutoides* recorded during the study and season ($F_{2.6} = 2.822$; $n = 25$; $P = 0.022$), with significant differences between Summer and Autumn (Tukey's: $P = 0.01$) and Summer and Winter (Tukey's: $P = 0.04$).

The following measurements and ratios were recorded, in the summer months 8 individuals were measured reporting an average ratio of 8.8 g/ 10.3 mm, in autumn 7 individuals were measured with an average ratio of 5.4 g/ 10.0 mm, in winter 6 individuals were measured with average ratio of 5.8 g/ 9.8 mm, and in spring 4 individuals were measured with an average ratio of 6.3 g/ 10.5 mm recorded (Table 49).

Table 49: Assessment of seasonal body condition of *Mus minutoides* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 8 | 10.2 | 4.5 | 9.6 | 6 | 9.5 | 9 | 10.7 |
| 6 | 10.5 | 5 | 9.7 | 5 | 9.2 | 6 | 10.7 |
| 8 | 10.4 | 6 | 9.8 | 6 | 9.2 | 5 | 10.9 |
| 11 | 10.6 | 5 | 10.1 | 7 | 10.8 | 5 | 9.6 |
| 12 | 10.7 | 5 | 10.2 | 5 | 9.5 | | |
| 13 | 10.4 | 5 | 9.4 | 5.5 | 10.3 | | |
| 7 | 10.6 | 7 | 11 | | | | |
| 5 | 9.1 | | | | | | |
| 70 | 82.5 | 37.5 | 69.8 | 34.5 | 58.5 | 25 | 41.9 |
| 8.8 | 10.3 | 5.4 | 10.0 | 5.8 | 9.8 | 6.3 | 10.5 |

Results indicate that *M. minutoides* on Telperion have the best body condition in summer when their body weight – length ratio is 8.8 g/10.3 mm, followed by spring 6.3 g/10.5 mm, then winter 5.8 g/9.8mm and are in poorest condition in autumn 5.4 g/ 10.0 mm, although appear to maintain body condition into the winter months (Fig. 263).

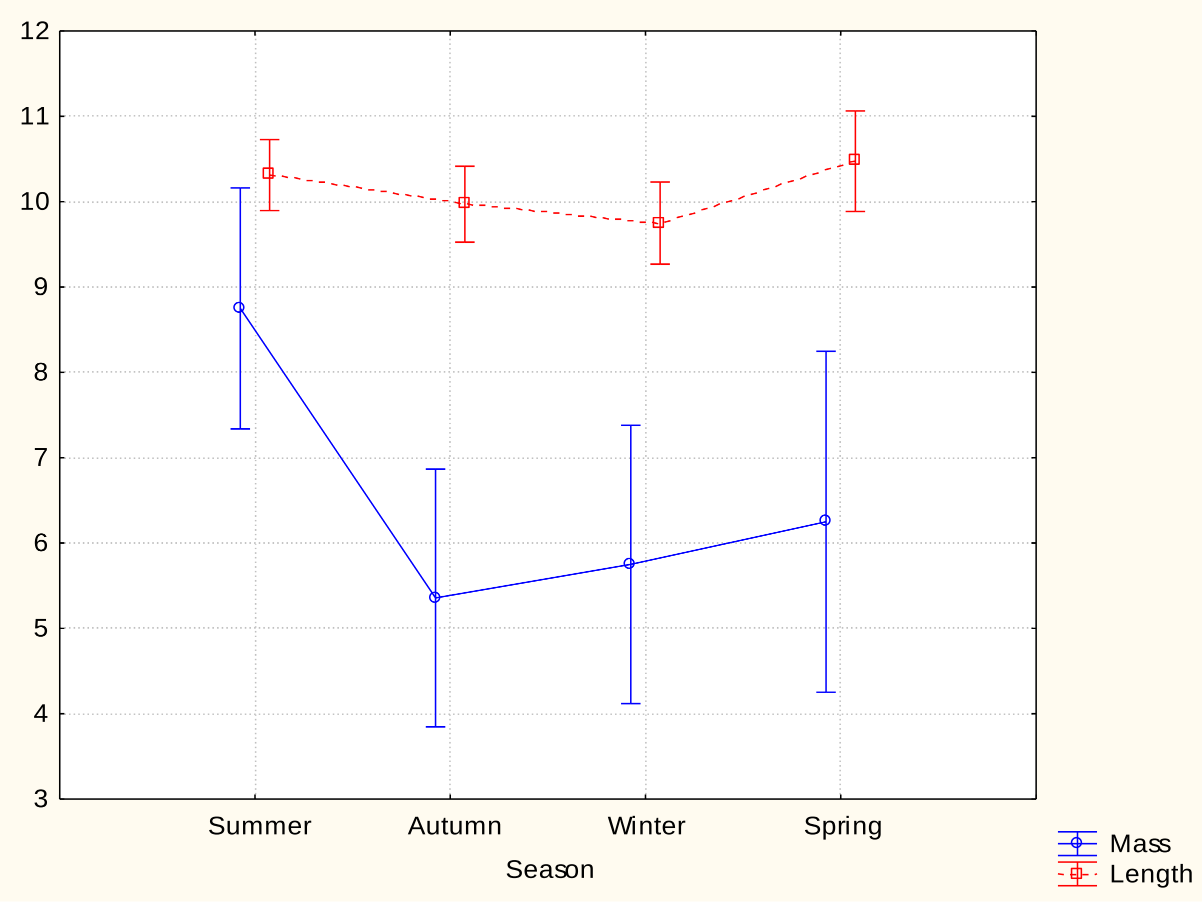

Figure 263. Graph illustrating seasonal ratio between body mass and length in adult *Mus minutoides* on Telperion.

*Mus minutodies* are estimated to be 34.1% heavier than the average recorded weight (6.5 g) in summer, 4.2% lower in spring, 11.9% lower in winter and 17.9% under the average recorded weight in autumn. This could result in the higher trap success recorded for this species during the autumn months. Higher numbers of individuals and the resultant completion for food may have result in this loss of body condition from summer into autumn. Weak individuals may perish with the onset of winter, resulting in their body condition of those individuals surviving stabilizing through winter and ultimately improving into spring.

### 15.4.12. Assessment of seasonal body condition of *Otomys irroratus* on Telperion

A sample of individual animals (*n* = 4) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in autumn and winter, as no individuals were recorded in summer and spring. ANOVA revealed an insignificant differences between body condition of *Otomys irroratus* recorded during the study and season ($F_{2.2}$ = 0.243; *n* = 4; *P* = 0.000). The following measurements and ratios were recorded, in the autumn months 1 individual was measured reporting an average body ratio of 79 g/23.7 mm and 3 individuals in winter with a ratio of 101.7 g/ 26.8 mm (Table 50).

Table 50: Assessment of seasonal body condition of *Otomys irroratus* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| | | 79 | 23.7 | 114 | 27.7 | | |
| | | | | 77 | 23.7 | | |
| | | | | 114 | 28.9 | | |
| | | 79 | 23.7 | 305 | 80.3 | | |
| | | 79 | 23.7 | 101.7 | 26.8 | | |

Preliminary results indicate that *Otomys irroratus* on Telperion has the best body condition in winter when their body weight – length ratio is 101.7 g/26.8 mm, while body condition appears to lower in autumn at 79 g/23.7 mm, although the sample size calculated is low (Fig. 264).

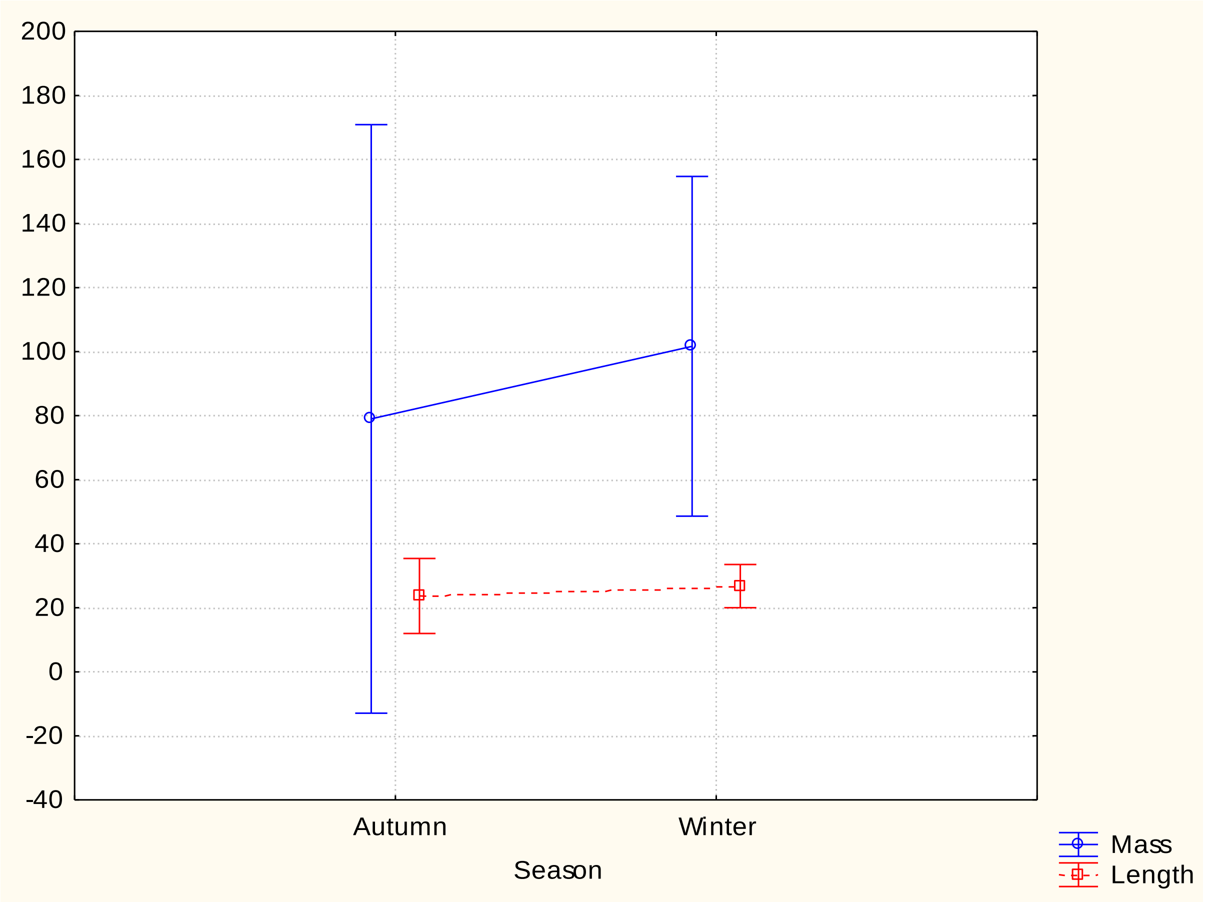

Figure 264. Graph illustrating seasonal ratio between body mass and length in adult *Otomys irroratus* on Telperion.

*Otomys irroratus* are estimated to be 12.6% heavier than the average recorded weight (90.4 g) in winter and 12.6% under the average in autumn. The sample size recorded during this study is small and results may be skewed as a result.

### 15.4.13. Assessment of seasonal body condition of *Rhabdomys pumilio* on Telperion

A sample of individual animals ($n$ = 7) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in autumn and winter, as no individuals were recorded in summer and spring. ANOVA revealed an insignificant difference between body condition of *Rhabdomys pumilio* recorded during the study and season ($F_{2.2}$ = 0.139; $n$ = 7; $P$ = 0.875). The following measurements and ratios were recorded, in the autumn months 2 individual was measured reporting an average body ratio of 32.3 g/19.3 mm and 5 individuals in winter with a ratio of 35.5 g/ 19.6 mm (Table 51).

Table 51: Assessment of seasonal body condition of *Rhabdomys pumilio* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| | | 35 | 19.2 | 36.5 | 20 | | |
| | | 29.5 | 19.4 | 48 | 21 | | |
| | | | | 31 | 18.5 | | |
| | | | | 31 | 19 | | |
| | | | | 31 | 19.5 | | |
| | | 64.5 | 38.6 | 177.5 | 98 | | |
| | | 32.3 | 19.3 | 35.5 | 19.6 | | |

Preliminary results indicate that *Rhabdomys pumilio* on Telperion has the best body condition in winter when their body weight – length ratio is 35.5 g/19.6 mm, while body condition appears to lower in autumn at 32.3 g/19.3 mm, although the sample size calculated is small (Fig. 265).

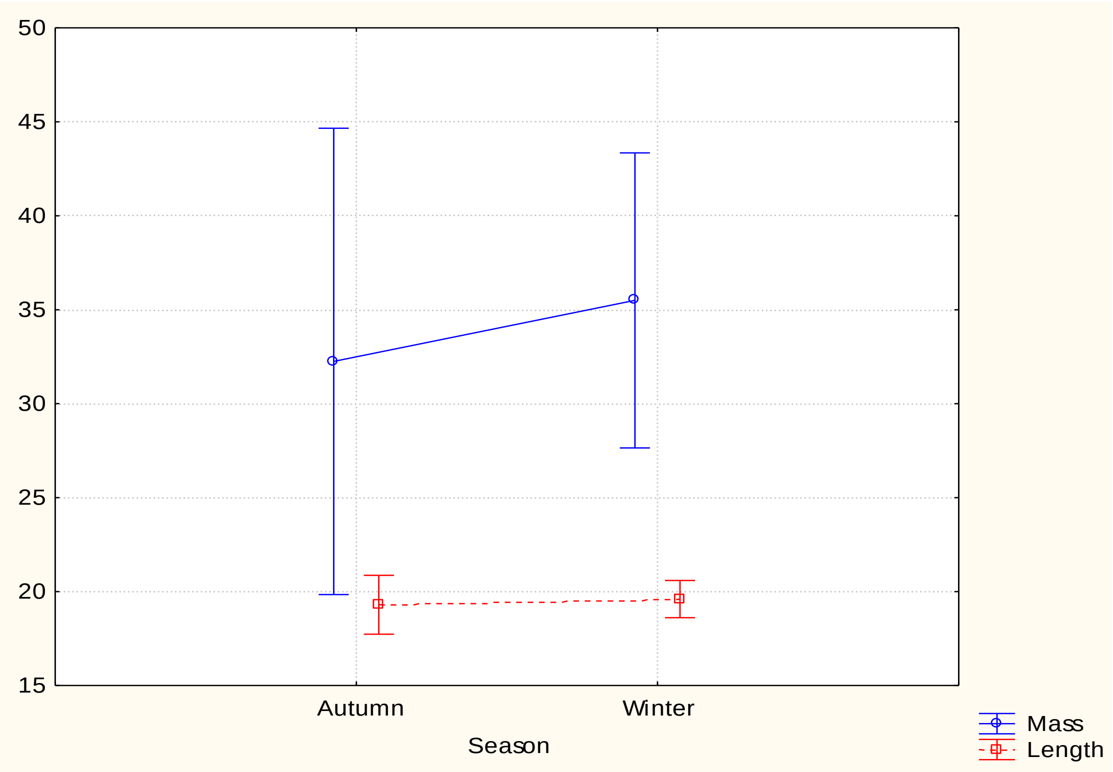

Figure 265. Graph illustrating seasonal ratio between body mass and length in adult *Rhabdomys pumilio* on Telperion.

*Rhabdomys pumilio* are estimated to be 4.8% heavier than the average recorded weight (33.9 g) in winter and 4.8% under the average in autumn. The sample size recorded during this study is small and results may be skewed as a result.

### 15.4.14. Assessment of seasonal body condition of *Steatomys pratensis* on Telperion

A sample of individual animals ($n$ = 10) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in summer, autumn and spring, as no new individuals were recorded in winter. ANOVA revealed an insignificant difference between body condition of *Steatomys pratensis* recorded during the study and season ($F_{2.4}$ = 2.933; $n$ = 10; $P$ = 0.067. The following measurements and ratios were recorded, in the summer months 7 individuals were measured reporting an average ratio of 33.3 g/14.8 mm, with 2 individuals in autumn at 40 g/ 14.9 mm and in spring 1 individual with a ratio of 19 g/ 12.6 mm (Table 52).

Table 52: Assessment of seasonal body condition of *Steatomys pratensis* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 29 | 13 | 47 | 13.8 | | | 19 | 12.6 |
| 31 | 15 | 33 | 16 | | | | |
| 32 | 15 | | | | | | |
| 39 | 15.3 | | | | | | |
| 35 | 14.1 | | | | | | |
| 34 | 14 | | | | | | |
| 33 | 13.5 | | | | | | |
| 233 | 99.9 | 80 | 29.8 | | | 19 | 12.6 |
| 33.3 | 14.3 | 40 | 14.9 | | | 19 | 12.6 |

Results indicate that *Steatomys pratensis* on Telperion has the best body condition in autumn when the body weight – length ratio is 40 g/14.9 mm, followed by summer, while in spring the condition appears worst at 19 g/12.6 mm, although the sample size calculated was low (Fig. 266).

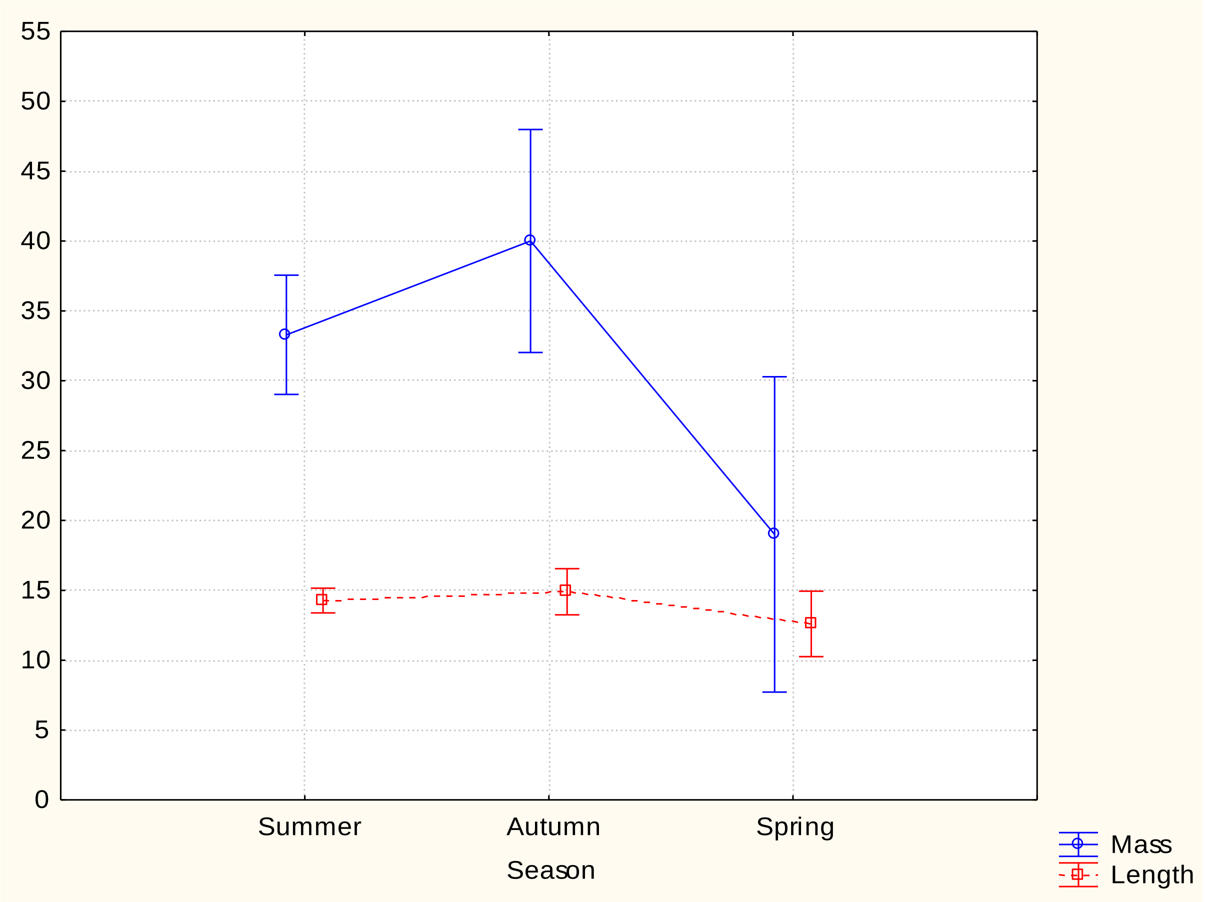

Figure 266. Graph illustrating seasonal ratio between body mass and length in adult *Steatomys pratensis* on Telperion.

*Steatomys pratensis* are estimated to be 8.8% heavier in autumn than the average recorded weight (36.8 g), with 9.5% and 48.3% lower than the average in summer and spring respectively. The body condition of the individual in spring could represent difficulties with food availability during winter months, and subsequent loss of body weight, although the body length ratio is indicative of a generally smaller animal.

### 15.4.15. Assessment of seasonal body condition of *Crocidura cyanea* on Telperion

A sample of individual animals ($n$ = 3) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in summer and winter, as no new individuals were recorded in autumn and spring. ANOVA revealed an insignificant differences between body condition of *Crocidura cyanea* recorded during the study and season ($F_{1.1}$= 40.333; $n$ = 3; $P$ = 0.099). The following measurements and ratios for were recorded, in the summer months 2 individuals were measured reporting an average ratio of

9.5 g/11.8 mm and winter 1 individual was measured with an average ratio of 4 g/ 7.7 mm (Table 53).

Table 53: Assessment of seasonal body condition of *Crocidura cyanea* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 10 | 11.7 | | | 4 | 7.7 | | |
| 9 | 11.8 | | | | | | |
| 19 | 23.5 | | | 4 | 7.7 | | |
| 9.5 | 11.8 | | | 4 | 7.7 | | |

Results indicate that *Crocidura cyanea* on Telperion has the improved body condition in summer when their body weight – length ratio is 9.5 g/11.8 mm and their condition appears decrease in winter 4 g/7.7 mm, although the sample size calculated was low and the body ratio of the individual recorded in winter indicates a smaller animal (Fig. 267).

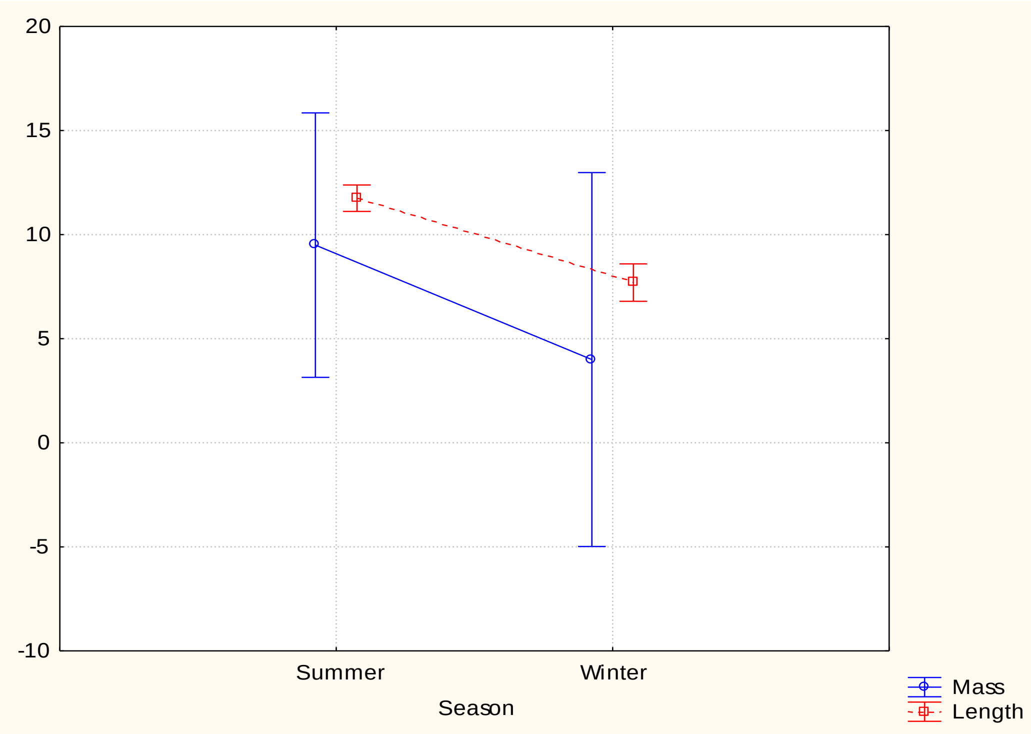

Figure 267. Graph illustrating seasonal ratio between body mass and length in adult *Crocidura cyanea* on Telperion

*Crocidura cyanea* are estimated to be 40.7% heavier than the average recorded weight (6.8 g) in summer and 40.7% under the average weight in winter. The sample size of this species recorded during this study is small and this result may be skewed.

### 15.4.16. Assessment of seasonal body condition of *Crocidura mariquensis* on Telperion

A sample of individual animals ($n$ = 11) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in summer, winter and spring, as no new individuals were recorded in autumn. ANOVA revealed a significant differences between body condition of *Crocidura mariquensis* recorded during the study and season ($F_{2.4}$ = 5.592; $n$ = 11; $P$ = 0.007), with significant differences between Summer and Winter (Tukey's: $P$ = 0.03). The following measurements and ratios were recorded, in the summer months 3 individuals were measured reporting an average ratio of 10 g/10.9 mm, with 7 individuals in winter at 7.5 g/ 12.2 mm and in spring 1 individual with a ratio of 7 g/ 11.6 mm (Table 54).

Table 54: Assessment of seasonal body condition of *Crocidura mariquensis* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 9 | 8 | | | 8 | 11.7 | 7 | 11.6 |
| 11 | 12.8 | | | 7 | 10.3 | | |
| 10 | 12 | | | 9 | 14.1 | | |
| | | | | 9 | 14.1 | | |
| | | | | 7 | 13.2 | | |
| | | | | 6.5 | 11.2 | | |
| | | | | 6 | 11 | | |
| 30 | 32.8 | | | 52.5 | 85.6 | 7 | 11.6 |
| 10 | 10.9 | | | 7.5 | 12.2 | 7 | 11.6 |

Results indicate that *Crocidura mariquensis* on Telperion has the best body condition in summer when the body weight – length ratio is 10 g/10.9 mm, followed by winter, while in spring the body condition appears lowest at 7 g/11.6 mm, although the sample size calculated was low (Fig. 268).

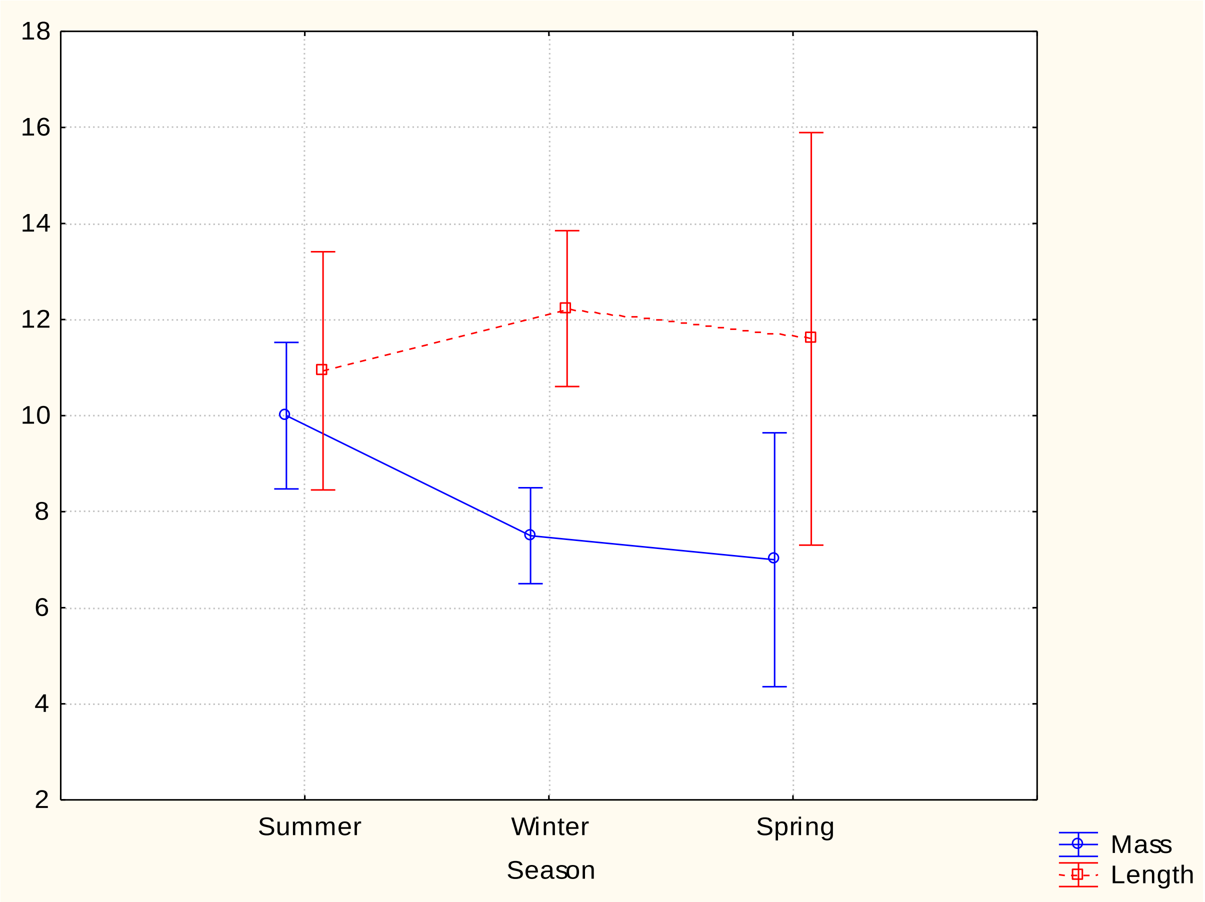

Figure 268. Graph illustrating seasonal ratio between body mass and length in adult *Crocidura mariquensis* on Telperion.

*Crocidura mariquensis* are estimated to be 22.4% heavier in summer than the average recorded weight (8.2 g), with 8.2% and 14.3% lower than the average in winter and spring respectively. The body condition of this species appears to decrease into winter and further into spring. This decrease in body condition could be related to the number of invertebrates available, their emergences which are largely temperature and rainfall related.

### 15.4.17. Assessment of seasonal body condition of *Elephantulus myurus* on Telperion

A sample of individual animals ($n$ = 78) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed seasonally. ANOVA revealed highly significant differences between body condition of *Elephantulus myurus* recorded during the study and season ($F_{2.6}$ = 5.420; $n$ = 78; $P$ = 0.000), with significant differences between Autumn and Spring (Tukey's: $P$ = 0.00) and Winter and Spring (Tukey's: $P$ = 0.00).The following measurements and ratios were recorded, in the summer months 17 individuals were measured reporting an average ratio of 65.2 g/ 25.5 mm, in autumn 26 individuals were measured with an average ratio of 60.5 g/ 26.3 mm, in winter 20 individuals were measured with average ratio of 59.9 g/ 26.8 mm, and in spring 15 individuals were measured with an average ratio of 73.6 g/ 27.5 mm recorded (Table 55).

Table 55: Assessment of seasonal body condition of *Elephantulus myurus* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 100 | 27.5 | 56 | 26.7 | 51 | 25.4 | 58 | 28.6 |
| 91 | 27.5 | 50 | 24 | 62 | 26.4 | 71 | 27.5 |
| 67 | 22.5 | 61 | 26.5 | 51 | 25.7 | 58 | 28.2 |
| 59 | 26.2 | 64 | 26.7 | 53 | 26.9 | 56 | 25.7 |
| 89 | 27.2 | 64 | 25.8 | 58 | 26.2 | 99 | 27.5 |
| 74 | 23.5 | 56 | 24.8 | 62 | 26.9 | 107 | 27 |
| 69 | 27.7 | 62 | 25.2 | 59 | 26.5 | 71 | 27.5 |
| 64 | 26.5 | 58 | 26.2 | 64 | 26.3 | 71.5 | 28 |
| 75 | 27 | 55 | 25.1 | 63 | 26.5 | 70 | 26 |
| 67 | 28.2 | 57 | 26.7 | 62 | 28.2 | 67 | 28.2 |
| 42 | 23.8 | 64 | 29 | 53 | 25.9 | 99 | 27.5 |
| 40 | 21.1 | 67 | 28 | 69 | 30 | 69 | 27 |
| 47 | 22.2 | 47 | 24.2 | 60 | 27.2 | 72 | 28 |
| 67 | 27 | 46 | 25.4 | 66 | 27.2 | 67 | 28.1 |
| 62 | 26.8 | 53 | 25.9 | 66 | 27.2 | 69 | 27 |
| 57 | 26.5 | 66 | 27 | 60 | 27.1 | | |
| 38 | 23.1 | 59 | 27.3 | 65 | 26.9 | | |
| | | 67 | 26.8 | 58 | 27.2 | | |
| | | 69 | 25.8 | 56 | 25.5 | | |
| | | 62 | 27.2 | 59 | 27.4 | | |
| | | 68 | 27.1 | | | | |
| | | 60 | 25.5 | | | | |
| | | 62 | 26.7 | | | | |
| | | 65.5 | 28.6 | | | | |
| | | 70 | 26.1 | | | | |
| | | 64 | 26.2 | | | | |
| 1108 | 434.3 | 1572.5 | 684.5 | 1197 | 536.6 | 1104.5 | 411.8 |
| 65.2 | 25.5 | 60.5 | 26.3 | 59.9 | 26.8 | 73.6 | 27.5 |

Results indicate that *Elephantulus myurus* on Telperion have the best body condition in spring when their body weight – length ratio is 73.6 g/27.5 mm, followed by summer 65.2 g/25.5 mm, then autumn 60.5 g/26.3 mm and are in poorest condition in winter 59.9 g/ 26.8 mm, although marginally poorer (Fig. 269).

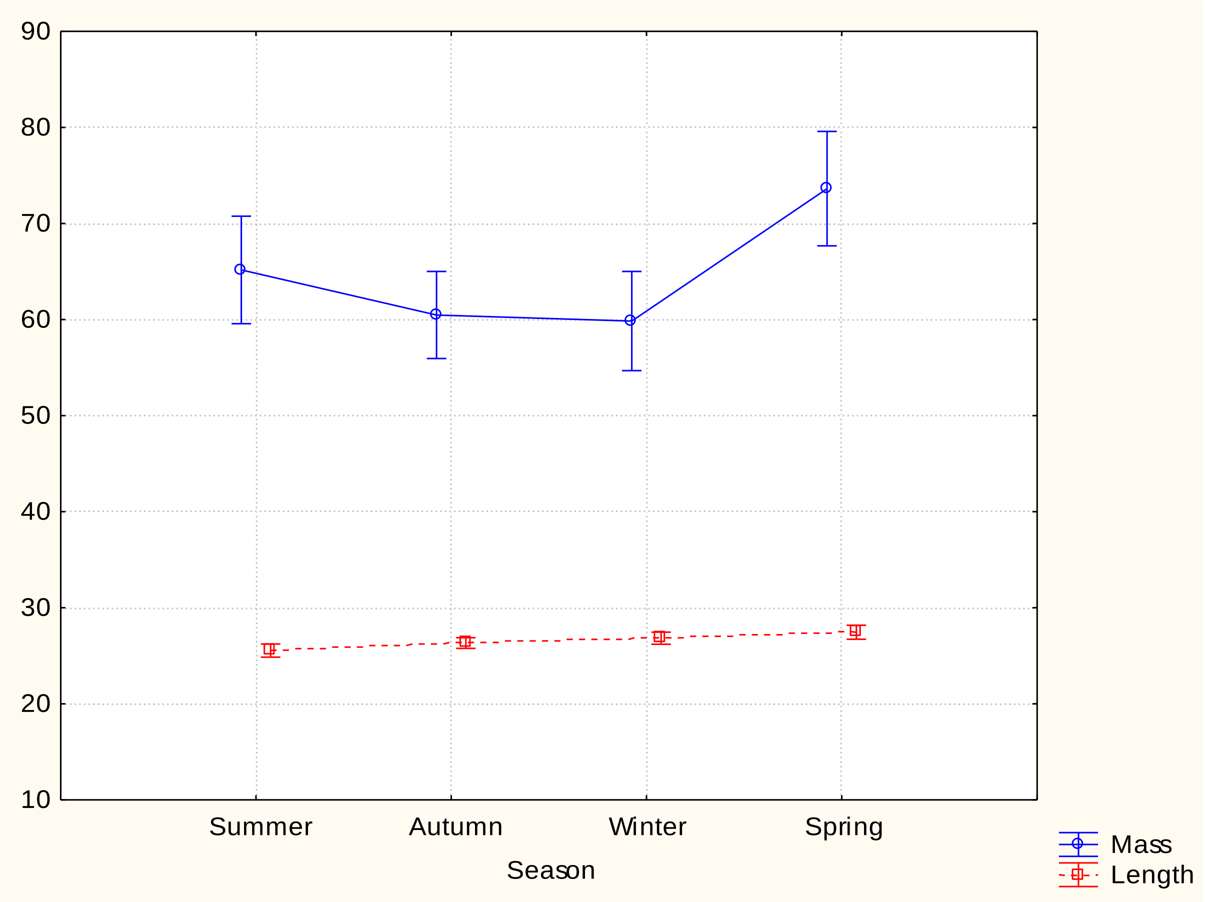

Figure 269. Graph illustrating seasonal ratio between body mass and length in adult *Elephantulus myurus* on Telperion.

*Elephantulus myurus* are estimated to be 13.7% heavier than the average recorded weight (64.8 g) in spring, 0.6% above average in summer, and 6.6% and 7.6% under the average weight in autumn and winter respectively. The results are not surprising for an insectivore, as a greater abundance of invertebrates are expected in the warmer months. Spring rains result in the emergence of a wide diversity of invertebrate species which would result in the increase in average body weight recorded.

### 15.4.18. Assessment of seasonal body condition of *Suncus infinitesimus* on Telperion

A sample of individual animals ($n$ = 5) were measured during the study and the ratio between body mass (g) and body length (mm) were assessed in summer and winter, as no new individuals were recorded in autumn and spring. ANOVA revealed an insignificant differences between body condition of *Suncus infinitesimus* recorded during the study and season ($F_{2.2} = 5$; $n = 1614$; $P = 0.589$). The following measurements and ratios were recorded, in the summer months 2 individuals were measured reporting an average ratio of 4 g/8.3 mm and winter 3 individuals were measured with an average ratio of 3 g/ 8.2 mm (Table 56).

Table 56: Assessment of seasonal body condition of *Suncus infinitesimus* on Telperion.

| Summer | | Autumn | | Winter | | Spring | |
|---|---|---|---|---|---|---|---|
| Mass | Length | Mass | Length | Mass | Length | Mass | Length |
| 4 | 7.9 | | | 3 | 7.9 | | |
| 4 | 8.6 | | | 4 | 8.6 | | |
| | | | | 2 | 8.2 | | |
| 8 | 16.5 | | | 9 | 24.7 | | |
| 4 | 8.3 | | | 3 | 8.2 | | |

Results indicate that *Suncus infinitesimus* on Telperion has the improved body condition in summer when their body weight – length ratio is 4 g/8.3 mm and their condition appears decrease in winter 3 g/8.2 mm, although the sample size calculated was small (Fig. 270).

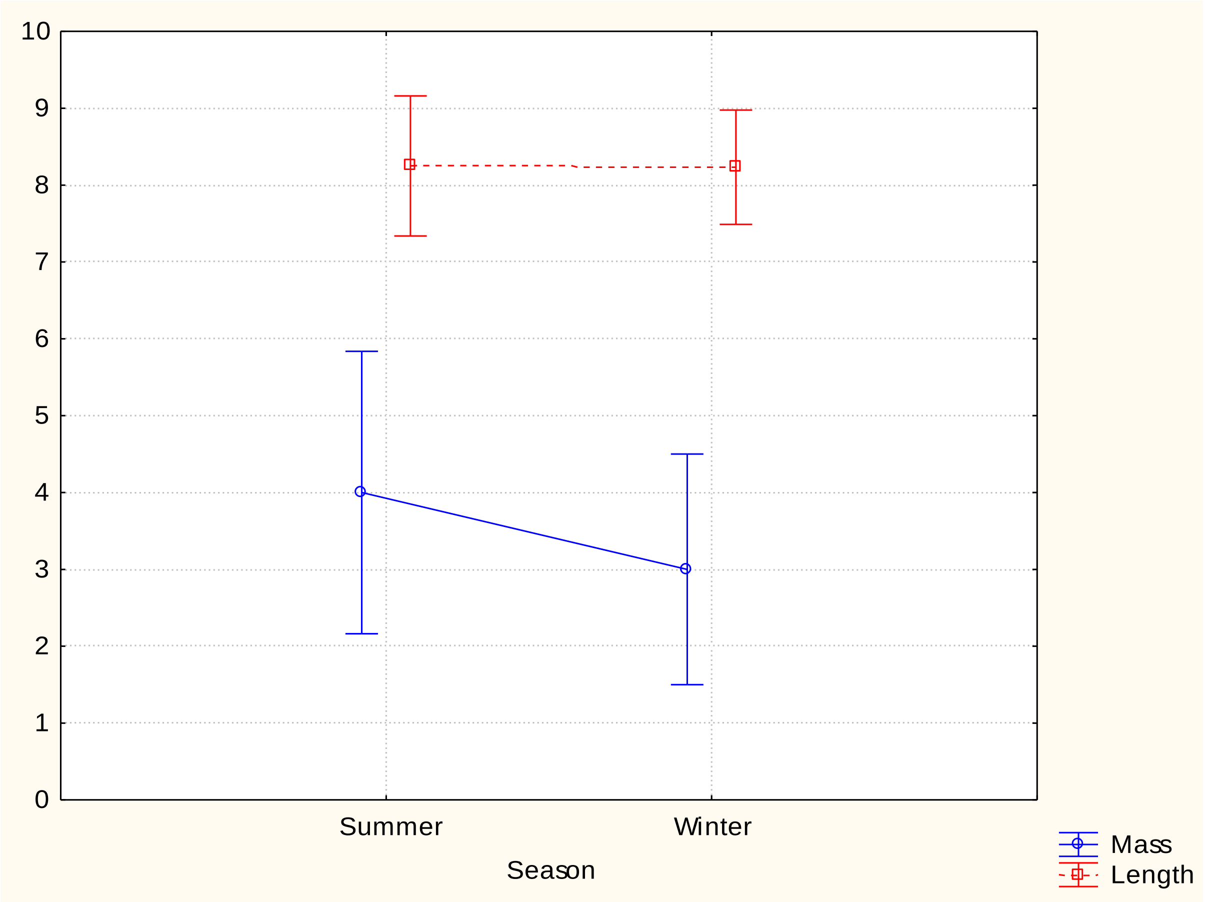

Figure 270. Graph illustrating seasonal ratio between body mass and length in adult *Suncus infinitesimus* on Telperion.

*Suncus infinitesimus* are estimated to be 14.3% heavier than the average recorded weight (3.5 g) in summer and 14.3% under the average weight in winter. The sample size of this species recorded during this study is small, although the decrease in body condition is expected between summer and winter.

## 15.5. Discussion:

The primary aim of this chapter was to determine the seasonal body condition of the small mammal fauna in the Bankenveld grasslands of Mpumalanga Province, South Africa. Large differences in body condition were found between seasons, although similarities were also recorded. Limited food resources impact species differently, however, generally it is expected that winter and spring are times of the greatest hardship. Animals are required to survive with limited food available during these periods. Other factors may come into play during the summer months, such as increased mating and disputes between males, which may result in large amounts of energy been utilized. Similarly, the effects of pregnancy and lactation may influence the body condition in female individuals. Recording seasonal changes in the body mass provides an insight into the population dynamics in these grasslands. These limiting factors often result in a drastic decrease in body mass, which may result in death, and a decrease in the population. Reproduction and growth in the population occurs when food is plentiful and readily available. Eighteen species of small mammal were recorded during this study. Small mammals (= adults < 2kg) comprise quite a large percentage (> 60%) of all terrestrial mammal species in southern Africa (Skinner & Chimimba 2005).

There appears to be a strong connection between disturbance in an ecosystem and the presence or absence of small mammal indicator species (Noss 1990; Armstrong & Van Hensbergen 1996; Avenant 1996; Leirs *et al.* 1996; Barreto *et al.* 1998. This information is of vital importance for conservation and for the understanding of small mammal biodiversity in terrestrial ecosystems (Rowe-Rowe 1995; Avenant 2000a, b; Petchey 2000). Generally, there were differences in small mammal body condition between seasons and habitat type. Makundi *et al*. (2007) found that reproduction and population fluctuations in *Mastomys natalensis* were linked to the duration and amount of rainfall in Tanzania. Makundi *et al.* (2007) found population densities were highest at the end of the rain season to the middle of the dry season, but rapid decline in population density occurred towards the end of the dry season in September.

It has been suggested that regenerating vegetation and availability of weed seeds create an attractive food resource for certain species of rodents (De Graaf 1981). It can be assumed that body condition of certain small mammals improves during this period. The impact of herbivores on shelter and the availability of seed bearing plants are without question. The stocking rates of game farms and nature reserves directly and indirectly affect small mammal populations. In certain overgrazed areas, grass plants are not permitted to mature, therefore do not produce inflorescences, and ultimately do not produce food for certain species of rodents. Massawe *et al.* (2006) found an increase in rodent population in areas after seed emergence, although this trend was more evident in areas which has been slashed and burned through farming practices. Rainfall, timing, duration and amount, has a strong influence on the population dynamics of rodents as it indirectly affects availability of resources.

According to Avenant (2000a,b), small mammal diversity relates to habitat structure, rainfall, state of vegetation succession, effects of overgrazing, predation and trampling. Such relationships appear complex in nature, impacting on basic habits of small mammals (Birney *et. al.* 1976). This study is important as it investigates the seasonal body condition of small mammal populations in the fire-climax grassland of the Bankenveld. Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Co-existence in a grassland habitat may also be promoted by mechanisms that reduce interspecific competition (Kinahan & Pillay 2008) and thus improve overall fitness.

Eight species of small mammal had the best body condition in the summer months, these included, *Aethomys chrysophilus, Dendromus melanotis, Crocidura cyanea, Crocidura mariquensis Gerbilliscus leucogaster, Mastomys* spp., *Mus minutoides*, and *Suncus infinitesimus*. The study site is in a summer rainfall area, and vegetation condition is at its best, with maximum grass seed at this time. Invertebrate availability is also most abundant and visible during these months. Interestingly, *Gerbilliscus brantsii* and *Graphiurus murinus* had the worst body condition recorded in summer. This could be a result of competition experienced during mating and reproduction.

Four species, *Acomys spinosissimus, Gerbilliscus brantsii, Micaelamys namaquensis* and *Elephantulus myurus* has the best body condition in spring. Early rains initiate vegetation growth, and it is in these months that invertebrate activity starts, after almost zero activity at the study site in winter. *Steatomys pratensis* and *Crocidura mariquensis* had the worst recorded body condition in spring, which could be a result of the hardship experienced during the winter months.

Four species, *Dendromus mystacalis, Lemniscomys rosalia, Otomys irroratus* and *Rhabdomys pumilio* had the best body condition recorded in the winter months. This result is skewed, as *O. irroratus* and *R. pumilio* were only recorded in autumn and winter during this study. It would be interesting to have compared body condition with spring and summer for these species. Both species were recorded in the Moist Degraded Grassland, and perhaps the prolonged moisture in the community provided extended food supplies into winter. It also appeared that *R. pumilio* was absent at the site prior to autumn. Five species, *Acomys spinosissimus, Gerbilliscus leucogaster, Crocidura cyanea, Elephantulus myurus* and *Suncus infinitesimus* has the lowest body condition in winter. This is expected due to the decrease in seed production of grasses, and the absence of invertebrates at this time of the year. Extreme cold is experienced at the study site during these months, and dry conditions further contribute to these extreme conditions.

Two species, *Graphiurus murinus* and *Steatomys pratensis* has the best body condition in autumn. These two species were recorded in low numbers, and the result is possibly compromised by the small sample size. Eight species, *Aethomys chrysophilus, Dendromus melanotis*, *Dendromus mystacalis*, *Micaelamys namaquensis, Lemniscomys rosalia*, *Mus minutoides*, *Otomys irroratus* and *Rhabdomys pumilio* had the lowest recorded body condition in autumn. This result could be related to the energy loss experienced with the increases activity with territoriality, mating, pregnancy and lactating during the summer months.

Species within a community may be able to inhabit the same habitat as they respond differently to environmental fluctuations (Moro & Morris 2000; Stilmant *et al.* 2008). Thus, Bankenveld small mammal species may from varying body condition indexes as a result of having different habitat requirements, specialists differing to those with very broad habitat requirements, or generalists (Ben-Natan *et al.* 2004; Manor & Saltz 2008). Generalists however, may have a variety of accessible and profitable options; they often have clear resource preferences and will rank these depending on availability, whereas specialists tend to be more efficient at using specific resources (Stilmant *et al.* 2008), although this may have costs in terms of habitat, time or energy constraints (Townsend *et al.* 2000). It therefore found that specialists and generalists are often able to co-exist as generalists can exploit resources not used by specialist, and it is therefore expected that specialists should be able to out-compete less well-adapted species (Manor & Saltz 2008).

Dietary partitioning relies on differences or modifications of the diet resulting in species utilizing different aspects of the food resource (Kinahan & Pillay 2008). Diet selection depends not only on the variety of resources available to a diversity of species in a habitat, including energy content, palatability, abundance and accessibility, but also on the species of consumers present in the habitat, their numbers, morphology and physiological characteristics that may influence their foraging behaviour and success (Chesson 1986). The concept of habitat selection is controversial due to the difference of scale. This is because habitat selection and preferences may occur at different scales, and what an individual selects within a home range may be very different to what it associates with in a smaller area. Suitable cover and availability of good quality food may be more important on a smaller scale, than across the species entire home range. Jorgensen (2004) attempted to simplify the matter for small mammal ecologists by defining the microhabitat as those environmental factors affecting individual behaviour while macrohabitat is the spatial area in which individuals perform their biological functions. Thus, in the present study, microhabitat refers to the specific area in which a species was recorded in terms of vegetation type and structure, while macrohabitat refers to an area traversed by the individual animal recorded.

Certain small mammal species are more susceptible to predation, possibly due to size, locomotion, colour, physiological constraints, morphological, or behaviourally, that species often modifies its activity patters to become less conspicuous, such as foraging at night, or under thick cover rather than in the open (Shargal *et al.* 2000; Cramer & Willig 2002; Sundell *et al.* 2008). The stresses associated with combating predation may influence body condition. Demonstrating that different species of small mammals may use different parts of a resource, such as seeds as opposed to culms of grass, does not indicate the absence of competition between species, and thus competitive interactions, similarly, competition cannot be inferred in a variety of species occurring in the same resource (Conley 1976; Holbrook 1979; Schoener 1983).

Competitive release is well-understood in grassland environments, and occurs when in the absence of one species, another species increases its home range, density or range of food eaten (Chesson 1986). Intraspecific competition between small mammal species should occur at a higher density than interspecific competition since resource use is essentially the same within a species (Perri & Randall 1999; Perrin *et al.* 2001; Zhang 2003; Dammhahn & Kappeler 2008). Competition between species can directly or indirectly influence body condition negatively.  Mutually exclusive home ranges provide evidence of avoidance rather than aggression as a behavioural mechanism promoting community structure and coexistence.  However, the presence of a variety of species is just one factor influencing home range overlap. Other biological factors include population density, abundance, sex and age structure, and body size, while ecological factors may include season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Ribble *et al.* 2002; Priotto *et al.* 2002; Schradin & Pillay 2006; Pasch & Koprowski 2006; Copper & Randall 2007). All these biological factors influence body condition in small mammals. Home range also gives an indication of the social structure of small mammal species (Schradin & Pillay 2006; Cooper & Randall 2007). Polygynous species tend to have a high degree of intraspecific overlap, especially between females and thus also tend to have higher densities (Ribble & Stanley 1998; Priotto *et al.* 2002). Promiscuous species within a community also tend to have high densities with a high degree of overlap between sexes, since males are unable to monopolise widespread females (Ostfeld 1990; Ribble & Stanley 1998; Jackson 1999). Males defending territories and mates tend to have a decreased body condition at the end of the breeding season due to this increased activity.

Lancaster (2009) confirmed *M. namaquensis* as a dietary generalist while *E. myurus* is a dietary specialist. Dietary specialists possibly have more difficulty in maintaining body condition as the search for specialised food items may require a greater amount of energy. There are several explanations for seasonal variation in diet and although rain is not always implicated, rainfall may influence diet composition and quality (Perrin & Swanepoel 1987). Specialisation could result in species exploiting a specific part of the environment differently to other coexisting species (Ben-Natan *et al.* 2004), thereby facilitating the coexistence of generalists and specialists (Manor & Saltz 2008). Where there is an overlap in a variety of species, and the specialist is dominant, the generalists can exploit resources within the community not used or underused by the specialist (Perrin & Boyer 2000). The number of mechanisms such as dietary, habitat and clump size selection and aggressive interference promote the coexistence of rodents in ecosystems (Kalcounis-Ruppell & Millar 2002; Brown 1989).

Diet selection of Bankenveld grassland small mammal species depends not only on the variety of resources available, but also the species of consumers present, their numbers and morphological and physiological characteristics. Habitat selection may facilitate species coexistence in a habitat (Rosenzweig 1981) because of food distribution (Jorgensen 2004). Additionally, the presence of other consumer species may change the value of the habitat (Kerley *et al.* 1990) by making certain resources unavailable. These changes may be in space, although distinct preferences, (Kotler & Brown 1988), time, through trade-offs or variation in resource availability (Brown 1989, M'Closkey 1976) or through interspecific interactions (Douglass 1976). The presence of different species of small mammals within a community is often associated with grass cover, plant litter and vegetation density, and substrate with certain species in known to influence the assemblage recorded. Habitats are often related to foraging efficiencies (Bonesi & Macdonald 2004), often resulting in a specialist dominating over a generalist. Although, a generalist has a wider scope in its feeding and habitat selection, being more flexible should it be required to change its optimal choice selection. Life history characteristics such as fecundity, longevity and dispersal that allow species to minimise or avoid competition however promote coexistence between species (Brown & Zeng 1989; Dammhahn & Kappeler 2008), since these traits may be an adaptive response to the environment (Neal 1986).

Both abiotic and biotic factors are proposed to impact body condition in small mammal communities. The seasonal reproductive change sometime recorded within these small mammal communities is often associated with changes in the diet (Perrin & Boyer

2000). Mechanisms that reduce interspecific competition and improve overall fitness promote coexistence in communities (Kinahan & Pillay 2008). Three main cues, or a combination, are expected to influence reproduction in small mammals, namely abiotic factors (such as food availability), internal factors (endogenous rhythms) and social cues between individuals (Neal 1986; Ims 1990), which impact body condition. Temperature appears to influence body condition of certain species of small mammal, especially during exceptionally cold and wet periods. Recording seasons when body condition is good or poor provides important insights into understanding the health and growth of small mammal population. It is accepted that stable ecosystems support a wide range of wildlife fauna in all niches.

# CHAPTER 16

# GENERAL DISCUSSION

The objective of this study as to conduct an investigation into the small mammal fauna in the Bankenveld grasslands of of Telperion in Mpumalanga Province, and Ezemvelo Nature Reserve in Gauteng, South Africa. This includes an assessment of small mammal diversity, species richness (variety), and abundance ratio in specific vegetation and habitat types. Large differences in mammal composition, abundance and diversity were found between habitats, although similarities were also recorded. In areas which were previously under agriculture, surprisingly high species richness was recorded at certain times of the year, although generalist species such as *Mastomys* sp. and *Rhabdomys pumilio* were recorded. The number of microhabitats and primary productivity is also high at the point of climax, and able to sustain a number of individuals from different species. Avenant & Watson (2002) found small mammal communities correlated with the abundance of pioneer plants species and their ecological value of the veld, indicating that a similar curve could be expected. Generalist species, those with a wide habitat tolerance, are generally found to dominate small mammal numbers on the lower part of the succession curve, with the opposite is expected to occur for specialist species, which increase in number towards the end of the curve. Avenant (2005) felt that together, these finding support the idea that direct monitoring of small mammals could be used as a relatively effective and efficient method of indicating ecological disturbance, habitat health and integrity, and therefore a useful tool for reserve managers and ecologists.

Biodiversity of small mammals is used as an effective indicator of disturbance in natural ecosystems. High numbers of *Mastomys* spp. in all habitats indicates a level of disturbance at the study site; hence low numbers indicate a balanced system. It is expected that changes in the ecological state of habitat through ecological disturbances would result in a decrease is the species richness of small mammals (Avenant 2000a; Birney *et al.* 1976). Small mammal community structure and species richness have been related to biotic and abiotic variables such as habitat structure and complexity (Rosenzweig & Winakur 1969; Brown 1973; French *et al.* 1976; Bond *et al.* 1980; Dueser & Brown 1980; Rowe-Rowe & Meester 1982a; Thompson 1982; Parmenter & MacMahon 1983; Kotler 1984; Abramsky 1988; Kerley 1992; Els & Kerley 1996), area (Abramsky *et al*. 1985; Fitzgibbon 1997), productivity (Abramsky 1978, 1988; Rosenweig 1992); predation (Kotler 1984; Norrdahl &

Korpimäki 1995; Abramsky *et al.* 1998; trampling and grazing (Keesing 1998; Milchunas *et al*. 1998); surrounding landscape and the distance between similar habitats (Fitzgibbon 1997), and the maturity of the habitat and succession of the vegetation (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Rowe-Rowe 1995; Fitzgibbon 1997; Ferreira & van Aarde 1999). It is expected that changes in the ecological state of habitat through ecological disturbances would result in a decrease is the species richness of small mammals.

There appears to be a strong connection between disturbance in an ecosystem and the presence or absence of small mammal indicator species (Noss 1990; Armstrong & Van Hensbergen 1996; Avenant 1996; Leirs *et al.* 1996; Barreto *et al.* 1998. The Shannon-diversity indices are essential to describe and compare small mammal fauna. The objective of this study was to report on the seasonal abundance (trap success), species richness (variety), evenness of the component species and diversity of small mammals present in specific habitats and plant communities on Telperion and Ezemvelo Nature Reserve. This information is of vital importance for conservation and for the understanding of small mammal biodiversity in terrestrial ecosystems (Rowe-Rowe 1995; Avenant 2000a, b; Petchey 2000). Trap success (or percentage success) is the number of small mammals captured per 100 trap nights. According to Avenant & Cavallini (2007), variety is the number of species found, while diversity, calculated using the Shannon index (Magurran 1988), is a measure of both the number of species and equality of representation of the individuals of all species. Rowe-Rowe & Meester (1982b) described the term “trap night” as one trap set for a 24-hour period. The three measures of abundance used in this study were trap success, species richness (or variety), and the diversity index (Nel 1975). Both the number of the species as well as the equality of the representation of the individuals of all species can be measured by the Shannon diversity index (H).

Generally, there were differences in small mammal diversity and trap success between different plant communities and habitat type. Owls and other predators are expected to have an influence on the number of small mammals recorded. Avanent (2005) found that the nocturnal species, *Mastomys coucha* and *Gerbilliscus leucogaster* contributed by far to the volume of prey ingested by barn owls (*Tylo alba*), although during spring and summer, the crepuscular species *Rhabdomys pumilio* and the diurnal species *Otomys irroratus* become more important as prey. The multimammate mouse *Mastomys* spp., as well as species richness and diversity, has been used as an indicator of disturbance (Avenant 2000a, b; Avery 1991, 1992).

Makundi *et al.* (2007) found that reproduction and population fluctuations in *Mastomys natalensis* were linked to the duration and amount of rainfall in Tanzania. They also found that the distribution of these species indicates a broad habitat tolerance and that disturbed habitats were colonized. The fact that few *Mastomys* spp. records were collected on Telperion and Ezemvelo Nature Reserve is indicative of the stable, in some cases, climax condition of the vegetation. In areas which showed signs of previous agricultural practices, sufficient time had progresses to allow these areas to recover. Ferreira & Van Aarde (1996) suggested that *Mastomys* spp. would be the first to colonize areas rehabilitated from mining operations, and it has been described as an opportunistic species, characteristically conforming to an r-selected strategist when conditions are favourable (Leirs *et al.* 1997). Makundi *et al.* (2007) found population densities were highest at the end of the rain season to the middle of the dry season, but rapid decline in population density occurred towards the end of the dry season in September. The *Mastomys* spp. recorded during this study were located in spring, although in low numbers.

The conserving of biodiversity is one of the major goals justifying the presence of nature reserves and conservation areas. The ability of natural fire to rehabilitate flora in African savanna ecosystems has been well-documented (Swanepoel 1981; Manry & Knight 1986). We can therefore expect that the fauna which evolved in these habitats would also be well adapted (Rowe-Rowe & Meester 1982b). Rowe-Rowe & Lowry (1982) for instance, found fewer small mammals in dense cover, compared to the same habitats frequently burned in a fire managed plan. According to Rowe-Rowe (1995), the season, size, pattern, and intensity of burning influences recolonization of small mammals in fire climax grasslands and must be incorporated when burning programs are planned. Fire is often excluded from nature reserves due to its perceived danger to wildlife, infrastructure and human life, fire is however important in maintaining natural balances in an ecosystem, especially evident in fire climax grasslands and the species which inhabit them. Beck & Vogl (1972) suggested that some of the mortality associated with fire on small mammals might be caused by predation. Burned areas are left open and therefore, the lack of cover improves accessibility to avian and mammalian predators (Motobu 1978). MacFadyen (2007) found that *Mastomys* spp. numbers in the Kruger National Park persisted months after such a burn without a drastic decrease in abundance. There has been some evidence which suggests that unburnt seeds on the ground attract rodents (Makundi *et al.* 1999). Managers of nature reserves and conservation areas readily burn areas of moribund grass to stimulate growth of early grasses. This new growth presumably provides better nutrition for rodents and the requirements of breeding, growth and survival of young, provided sufficient shelter remains.

It has been suggested that regenerating vegetation and availability of weed seeds create an attractive food resource for certain species of rodents (De Graaf 1981). According to Avenant (2000), the ecological role of predators in the maintenance of a balanced prey population and high prey diversity, ultimately affects the whole ecosystem, including the predator population (Kotler 1984; Norrdahl & Korpimäki 1995; Avenant & Nel 1997; McPeek 1998: Barreto *et al.* 1998; Ceballos *et al.* 1999). Humans can partially fulfil this role for the larger game species, but not for the rodents and insectivores. The questions raised through this study being do game farming practices influence the population densities and species richness of rodent species in a "natural system". The impact of herbivores on shelter and the availability of seed bearing plants are without question. The stocking rates of game farms and nature reserves directly and indirectly affect small mammal populations. In certain overgrazed areas, grass plants are not permitted to mature, therefore do not produce inflorescences, and ultimately do not produce food for certain species of rodents. Massawe *et al.* (2006) found an increase in rodent population in areas after seed emergence, although this trend was more evident in areas which has been slashed and burned through farming practices. Rainfall, timing, duration and amount, has a strong influence on the population dynamics of rodents as it indirectly affects availability of resources.

According to Avenant (2000a,b), small mammal diversity relates to habitat structure, rainfall, state of vegetation succession, effects of overgrazing, predation and trampling. Such relationships appear complex in nature, impacting on basic habits of small mammals (Birney *et. al.* 1976). The large differences in mammal community structure, trap success and diversity observed between the habitats on Telperion and Ezemvelo Nature Reserve are therefore expected. According to Avenant & Kuyler (2002), this agrees with the numerous studies that have demonstrated the casual relationship between disturbance, lack of disturbance, and diversity and abundance of small mammals (Wootton 1998; Trojan 2000, Hastwell & Huston 2001), and between the decrease in diversity and declines in ecosystem functioning, structure, and resilience (Grime 1998: Cardinale *et al.* 2000; Chaplin *et. al.* 2000; Johnson 2000; Loreau 2000; McCann 2000; Petchey 2000; Purvis & Hector 2000; Wilsey & Potvin 2000; Fonseca & Ganade 2001; Knops *et al.* 2001; Scheffer *et al.* 2001).

As stated by Avenant (2000a,b), the lack of domination by *Mastomys*, species richness and diversity are all small mammal community characteristics that indicate ecosystem integrity. The results of this study support Avenant (2000a,b) that mid-autumn and mid-winter for certain species prove to be the best time to conduct small mammal sampling, although spring produced reasonable numbers of certain species. The summer months are less favourable, and produce significantly less animals and variety of species during this time of the year.

This study is important as it investigates the community structure of small mammal populations in the fire-climax grassland of the Bankenveld. Species inhabiting similar habitats can be facilitated by variability in the environment and the ability of individual species to specialise and exploit this variability (Perrin & Kotler, 2005). Co-existence in a grassland habitat may also be promoted by mechanisms that reduce interspecific competition (Kinahan & Pillay 2008) and thus improve overall fitness. Differential habitat use and the use of resources within these different systems, especially in space and time, may facilitate co-existence between species on a reserve, or specific habitat (M'Closkey 1976; Brown 1989; Yunger *et al.* 2002; Zhang 2003; Bonesi & Macdonald 2004; Harris *et al.* 2006). Spatial differences in small mammal communities are based on macro- and micro-habitat selection. How small mammals choose an area is a result of cover availability, differences in micro-climate, substrate, predation risk and food availability (Chesson 1986). Temporal differences on the other hand involve variations that act on a daily basis, such as resource renewal and availability, lunar, an increase in predation, and annual, rainfall, and temperature (Chesson 1986). Therefore, for community structure of small mammals, there needs to be an axis of environmental heterogeneity and a trade-off between interacting species, resulting in each species having a place on that axis where it is the superior competitor (Kotler & Brown 1988; Brown 1989; Abramsky *et al.* 1990; Perrin & Kotler 2005).

Species within a community may be able to inhabit the same habitat as they respond differently to environmental fluctuations (Moro & Morris 2000; Stilmant *et al.* 2008). Thus, Bankenveld small mammal communities may be composed of species that vary from having narrow habitat requirements, referred to as specialists, to those with very broad habitat requirements, or generalists (Ben-Natan *et al.* 2004; Manor & Saltz 2008). Generalists however, may have a variety of accessible and profitable options; they often have clear resource preferences and will rank these depending on availability, where as specialists tend to be more efficient at using specific resources (Stilmant *et al.* 2008), although this may have costs in terms of habitat, time or energy constraints (Townsend *et al.* 2000). It therefore found that specialists and generalists are often able to co-exist as generalists can exploit resources not used by specialist, and it is therefore expected that specialists should be able to out-compete less well-adapted species (Manor & Saltz 2008).

According to Lancaster (2009), various mechanisms are proposed to promote co-existence between species. Dietary partitioning relies on differences or modifications of the diet resulting in species utilizing different aspects of the food resource (Kinahan & Pillay 2008). Diet selection depends not only on the variety of resources available to a diversity of species in a habitat, including energy content, palatability, abundance and accessibility, but also on the species of consumers present in the habitat, their numbers, morphology and physiological characteristics that may influence their foraging behaviour and success (Chesson 1986). The concept of habitat selection is controversial due to the difference of scale. This is because habitat selection and preferences may occur at different scales, and what an individual selects within a home range may be very different to what it associates with in a smaller area. Suitable cover and availability of good quality food may be more important on a smaller scale, than across the species entire home range. Jorgensen (2004) attempted to simplify the matter for small mammal ecologists by defining the microhabitat as those environmental factors affecting individual behaviour while macrohabitat is the spatial area in which individuals perform their biological functions. Thus, in the present study, microhabitat refers to the specific area in which a species was recorded in terms of vegetation type and structure, while macrohabitat refers to an area traversed by the individual animal recorded.

A small mammal species is more susceptible to predation, possibly due to size, locomotion, colour, physiological constraints, morphological, or behaviourally, that species often modifies its activity patters to become less conspicuous, such as foraging at night, or under thick cover rather than in the open (Shargal *et al.* 2000; Cramer & Willig 2002; Sundell *et al.* 2008), These activities may alter a species microhabitat selection. Temporal influences become important when similar species prefer to exist in the same habitat, although different food selection, activity times and behaviour could in essence promote their individual success. The competition theory assumes that at competitive equilibrium in densities are maintained (Ferreira & Van Aarde 1999), and may thus act to structure communities (Hughes *et al.* 1994; Manor & Saltz 2008). Competitive co-existence may be emphasized when there is spatial or temporal variation in resource abundance or non-equilibrium between resource and consumer dynamics (Chesson 1986). Demonstrating that different species of small mammals may use different parts of a resource, such as seeds as opposed to culms of grass, does not indicate the absence of competition between species, and thus competitive interactions, similarly, competition cannot be inferred in a variety of species occuring in the same resource (Conley 1976; Holbrook 1979; Schoener 1983).

Competitive release is well-understood in grassland environments, and occurs when in the absence of one species, another species increases its home range, density or range of food eaten (Chesson 1986). Intraspecific competition between small mammal species should occur at a higher density than interspecific competition since resource use is essentially the same within a species (Perri & Randall 1999; Perrin *et al.* 2001; Zhang 2003; Dammhahn & Kappeler 2008). Mutually exclusive home ranges provide evidence of avoidance rather than aggression as a behavioural mechanism promoting community structure and coexistence. However, the presence of a variety of species is just one factor influencing home range overlap. Other biological factors include population density, abundance, sex and age structure, and body size, while ecological factors may include season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Ribble *et al.* 2002; Priotto *et al.* 2002; Schradin & Pillay 2006; Pasch & Koprowski 2006; Copper & Randall 2007). Home range also gives an indication of the social structure of small mammal species (Schradin & Pillay 2006; Cooper & Randall 2007). Polygynous species tend to have a high degree of intraspecific overlap, especially between females and thus also tend to have higher densities (Ribble & Stanley 1998; Priotto *et al.* 2002). Promiscuous species within a community also tend to have high densities with a high degree of overlap between sexes, since males are unable to monopolise widespread females (Ostfeld 1990; Ribble & Stanley 1998; Jackson 1999).

Lancaster (2009) confirmed *M. namaquensis* is a dietary generalist while *E. myurus* is a dietary specialist. The proportion of arthropods in faeces of *E. myurus* was significantly higher than in the faeces of *M. namaquensis* which contained a greater number of leaves and seeds. In this study, these two species dominated the rocky areas at the study site however were absent from areas without suitable rock. According to Lancaster (2009), *M. namaquensis* was recorded to have a higher proportion of vegetative matter and seeds in their faces when compared with *M. myurus*, with over 60% of faeces of *E. myurus* consisted of arthropods. There are several explanations for seasonal variation in diet and although rain is not always implicated, rainfall may influence diet composition and quality (Perrin & Swanepoel 1987). Specialisation could result in species exploiting a specific part of the environment differently to other coexisting species (Ben-Natan *et al.* 2004), thereby facilitating the coexistence of generalists and specialists (Manor & Saltz 2008). Where there is an overlap in a variety of species, and the specialist is dominant, the generalists can exploit resources within the community not used or underused by the specialist (Perrin & Boyer 2000). The number of mechanisms such as dietary, habitat and clump size selection and aggressive interference promote the coexistence of rodents in ecosystems (Kalcounis-Ruppell & Millar 2002; Brown 1989).

Diet selection of Bankenveld grassland small mammal species depends not only on the variety of resources available, but also the species of consumers present, their numbers and morphological and physiological characteristics. Habitat selection may facilitate species coexistence in a habitat (Rosenzweig 1981) because of food distribution (Jorgensen 2004). Additionally, the presence of other consumer species may change the value of the habitat (Kerley *et al.* 1990) by making certain resources unavailable. These changes may be in space, although distinct preferences occur, (Kotler & Brown 1988), time, through trade-offs or variation in resource availability (Brown 1989, M'Closkey 1976) or through interspecific interactions (Douglass 1976). The presence of different species of small mammals within a community is often associated with grass cover, plant litter and vegetation density, and substrate with certain species in known to influence the assemblage recorded. Habitats are often related to foraging efficiencies (Bonesi & Macdonald 2004), often resulting in a specialist dominating over a generalist. Although, a generalist has a wider scope in its feeding and habitat selection, being more flexible should it be required to change its optimal choice selection. Life history characteristics such as fecundity, longevity and dispersal that allow species to minimise or avoid competition however promote coexistence between species (Brown & Zeng 1989; Dammhahn & Kappeler 2008), since these traits may be an adaptive response to the environment (Neal 1986).

Both abiotic and biotic factors have been proposed as regulators of breeding in different species and density in small mammal communities (Perrin & Boyer 2000). The seasonal reproductive change sometime recorded within these small mammal communities is often associated with changes in the diet (Perrin & Boyer 2000). Mechanisms that reduce interspecific competition and improve overall fitness promote coexistence in communities (Kinahan & Pillay 2008). The competition theory assumes that at competitive equilibrium in densities are maintained (Ferreira & Van Aarde 1999), and may thus act to structure communities (Hughes *et al.* 1994; Manor & Saltz 2008). Species may coexist successfully in an environment should they respond differently to environmental conditions and fluctuations (Moro & Morris 2000; Stilmant *et al.* 2008). As natural environments are dynamic, the processes promoting similarities and differences in population variables may change over space and time (Brown & Zeng 1989; Chesson 2003). This is evident when examining patterns of density and abundance in small mammal communities. Changes in small mammal densities are dependent on a variety of factors, method used, season, climate and temperature.

Three main cues, or a combination, are expected to influence reproduction in small mammals, namely abiotic factors (such as food availability), internal factors (endogenous rhythms) and social cues between individuals (Neal 1986; Ims 1990). Abiotic factors, such as rain are not likely to affect breeding directly as there is usually a lag time of two or three months between rainfall and the evidence of breeding (Bronner 1986), but rather affects breeding indirectly through food availability (Neal 1982). Rainfall therefore may still contribute to the timing of the reproductive seasonality and could explain inter-year variation in population numbers and demography (Willan & Meester 1989; Monadjem & Perrin 2003). Temperature could influence breeding success, especially during exceptionally cold and wet periods. Timing of breeding in small mammal populations is often constrained, not only by the environment but also phylogenetically in terms of age of reproduction. Population size fluctuations and species richness are due to differences in recruitment (movements into the population through birth and immigration) and emigration (movements out of the population through dispersal and death (Bronner 1986). Many small mammal species in southern Africa have a sex ratio that approximates 1:1 (Bronner 1986; Perrin & Swanepoel 1987; Ostfeld & Manson 1996; Monadjem 1999; Yarnell & Scott 2006). The fluctuations which occurred in small mammal diversity and abundance in the present study appears to correlate with the breeding season in certain species, and appeared cover driven in other species, such as *D. melanotis*.

The spatial organisation of a species varies spatio-temporally, and reflects the social organisation of that species (Salvioni & Lidicker 1995; Cooper & Randall 2007). Home range overlap is influenced by several biological factors, such as population density, sex, age, body size and ecological factors, such as season and food availability and distribution (Burt 1943; Wolff 1985; Ostfeld 1990; Priotto *et al.* 2002; Ribble *et al.* 2002; Schradin & Pillay 2006; Cooper & Randall 2007). Studies of spatial organisation may also contribute to understanding patterns of coexistence between similar species (Ferreira & Van Aarde 1999; Priotto *et al.* 2002; Ribble *et al.* 2002). Since ecological and resource portioning may be the underlying mechanisms of coexistence (Rosenzweig 1981; Kalcounis-Ruppell & Millar 2002; Bonesi & Macdonald 2004; Jorgensen 2004), it would be expected that ecologically-similar species would occupy adjacent, non-overlapping home ranges (Bleich & Price 1995; Christopher & Barrett 2006), but that these may vary depending on resource availability (Orland & Kelt 2007). Space use by small mammals in the Bankenveld may be influenced by variation in food distribution and abundance and the variety of acceptable food resources. This in unpredictable environments, or under high population density, home range size may be larger as distance travelled to find resources in order to meet energy requirements increases (Pasch & Koprowski 2006).

The studying of population dynamics and fluctuation in small mammal populations may be as important in understand the coexistence between species as patterns of resource use (Brown & Zeng 1989). A dynamic reproductive strategy will enable a species to vary its life history strategy depending on environmental variability (Perrin & Swanepoel 1987; Willan & Meester 1989), and also to minimise or avoid competition by varying particular characteristics, thus promoting coexistence between species within a community (Dammhahn & Kappeler 2008). Interactions between species may also be asymmetrical for various reasons such as the large species displacing the smaller species, especially in aggressive encountered (Perri & Randall 1999; Pinter-Wollman *et al.* 2006), or because some species are more sensitive to the degree or resource overlap (Schoener 1983), so that one species dominates over another. Differences in this resource use may act to reduce this kind of interspecific competition (Kinahan & Pillay 2008). Diet selection also depends on a variety of variables, including the type, number and seasonal variables of food resources available (Brown & Lieberman 1973; Perrin & Swamepoel 1987; Rabiu & Rose 1997), the presence of competing species (Kalcounis-Rupelll & Millar 2002), and the adaptations of the consumer (Kerley 1989; Abt & Bock 1998).

Both *M. namaquensis* and *E. myurus* have distinct breeding seasons during this study, confirming results of previous studies (De Graaff 1981; Skinner & Chimimba 2005) with *E. myurus* breeding restricted to the rainy season and *M. namaquensis* starting breeding towards the end of the early rainy season and continuing into the late rainy season. Small Mammals are important components in Bankenveld grassland habitats ecosystems, as predators, consumers, dispersers of seed, burrowers and prey for carnivores, reptiles and raptors. Total biomass and density of small mammals should be taken into account when calculating carrying capacity on a reserve. More practically, their use should be maximised when monitoring ecosystems. In the present study, the domination of indicator species, high species richness and high diversity are useful tools in highlighting the variability of the habitats found at the study site. During this study, the highest trap success, species richness and diversity were found in autumn and winter. According to Avenant (2000a), homogeneous habitats should be selected and marginal areas (at the edge of habitats) should be avoided as the edges often house more species and can be seen as refugia where individuals can profit from the best of both habitats. Care was taken to ensure the habitats selected where “pure” representations of these habitat types, as although ecologically important, these edges often house more species and can be seen as refugia where individuals can profit from the best in two environments (Rowe-Rowe & Lowry 1982; Rowe-Rowe & Meester 1982b; Hansson 1998). For this reason they play an important role in the recolonization and species persistence of small mammals.

Interpretation of trapping results of small mammals in the Bankenveld grasslands of Telperion is complicated by the fact that many rodents could potentially be trapped even if only part of their home range fell into a survey area, which could give rise to biases in population estimates based on trapping rates (Bowers *et al.* 1996). Certain vegetation communities appear more stable habitats for certain species of small mammal, for example, Northern Slope Woodland and Rocky Open Shrub for *Micaelamys namaquensis* and *Elephantulus myurus*, which are represented throughout the year, although the numbers fluctuate. Other communities such as Moist Degraded Grassland and Degraded Grassland differ seasonally in their suitability for harbor small mammals. These localities include Pretoria (Gauteng Province) and the possibility exists that this could extend to Bronkhorstspruit and Witbank, therefore there is uncertainty whether the eight individuals recorded are *M. natalensis* or *M. coucha,* although the latter is suspected. Genetic work will be required to be undertaken on the nail clippings of these individuals to confirm this. It is expected that *M. natalensis* occurs in the lower altitude, high rainfall eastern coastal region, extending to north-eastern South Africa, while *M. coucha* is recorded to occur in high altitude, moderate rainfall of central and north-eastern South Africa. Members of the genus *Mastomys* are small to medium-sized murid rodents and are widely distributed in Africa (Musser & Carleton 1993). The taxonomic problem is exacerbated by the presence of high levels of cytogenetic diversity within the genus (Green *et al.* 1980). Some of the systematic problems within the genus *Mastomys* are reviewed in a more recent systematic synthesis of the genus (Granjon *et al*. 1997) in which, for example, the authors argue about the inappropriate use of the name *hilderbrandtii* for the more commonly used *hubertii* in West Africa. In southern Africa alone, three species, namely, *M. shortridgei*, *M. natalensis* and *M. croucha* are recognized (Meester *et al.* 1986; Skinner & Chimimba 2005; Musser & Carleton 1993; Granjon *et al.* 1997). The two cytotypes have also been reported to differ in gross sperm and bacular morphology, reproductive behaviour, pheromones, and ultrasonic vocalizations (Skinner & Chimimba 2005; Musser & Carleton 1993). Although both *M. natalensis* and *M. coucha* are widely distributed in their combined geographic range in South Africa (Meester *et al.* 1986; Skinner & Chimimba 2005; Musser & Carleton 1993), their respective distributional ranges still remain uncertain. Known verified locality data showed the two cryptic species to be either sympatric or to occur in close proximity at four localities. All these differences together with the absence of hybrids in areas of sympatry strongly suggested reproductive isolation between the two chromosomal races (Gordon & Watson 1986). This led to the recognition of two cryptic species referred to as the nominate species *M. natalensis* for the $2n = 32$ cytotype and *M. coucha* for the $2n = 36$ cytotype (Meester *et al.* 1986; Skinner & Chimimba 2005; Musser & Carleton 1993). Despite the cytogenetic, electrophoretic, and a variety of other reported differences, the two cryptic species cannot easily be distinguished on qualitative external and/or cranial morphology (Gordon & Watson 1986). However, a subsequent study by Dippenaar *et al.* (1993) revealed subtle cranial morphometric differences between the two sibling species, but cautioned that such data need to be carefully evaluated before being applied due to the potential influence of geographic variation over the species' distributional ranges.

Indigenous rodent populations are limited by fluctuating resources availability which includes food and shelter (Monadjem & Perrin 1998). Combined with the influence of predation, rodent communities need a specialized set of conditions if they are to persist in viable numbers. Human-induced disturbances include management of grazing, alterations of the natural fire regime and woody vegetation removal. According to Bronner *et al.* (1988), Brooks (1982), Davis & Meester (1981) rodent population densities in perennial grasslands of the South African highveld are highly seasonal, with reproduction largely occurring between November and March, reaching peaks in population numbers during March and April. During winter (May-September) vegetation becomes less dense due to frost, and rodent populations decrease substantially (Davis 1973; Smithers 1983).

Petersen (2006) suggested that small mammal dietary habits have a significant predatory impact on increaser seeds and seedlings within landscapes that contain suitable habitat. This high energy requirement of small mammals, alongside their continuous, where fluctuating abundance in the landscape is one of the many limiting effects on highly nutritive seeds and seedlings. Grazing mammals may affect their habitat by selective feeding on a particular plant species and plant parts, and by disturbing the substrate in which these plants are rooted (Petersen 2006). Like their larger counterparts, small mammals are important contributors to the biodiversity of grassland ecosystems in sub-Saharan Africa (Linzey & Kesner 1997). Such animals are important ecosystem, components as consumers, dispersers of seed, burrowers and prey for carnivores and raptors (Avenant 2000a). Petersen (2006) found both abundance and diversity of small mammals appeared related to site habitat structure and grass biomass. Grass biomass and trapping studies showed that small mammal abundance and diversity showed a direct positive correlation to grass biomass under storey and habitat quality. Petersen (2006) demonstrated a link between grass biomass, small mammal abundance and diversity and their potential increaser seed and seedling predatory activities in certain areas of South Africa. Animals have traditionally been viewed as passive components of ecosystems, merely responding to the conditions to which they are subjected (Naiman & Rogers 1997). Herbivores are, however, responsible for biogeochemical, successional and landscape alterations that may persist for centuries (Levick 2001). Large animals alter vegetation structure and assist in developing microtopography through herbivory and soils and nutrient movement (Naiman & Rogers 1997). This in turn effects the distribution of certain small mammal species relying on a specific vegetation structure. The organisms which cause physical state changes in abiotic or biotic materials are referred to as ecosystem engineers if they directly or indirectly modulate the availability of resources to other species (Jones *et al.* 1994).

The project has identify areas of high species richness, assessing vegetation structure and taking in to consideration small mammal groups that reflect the species richness across a set of environments, thus acting as surrogates for the “wholesale” biodiversity (Gaston 1996a; McGeoch 1998). The conservation value of an area is typically judged using a measure of species richness, or some variant of it (Gaston 1996b; Angermeier & Winston 1997). Petersen (2006) describes the removal of small mammal species through habitat alteration, alongside fire, overgrazing, climate change and other factors are complicit in the increasing of densification of woody shrubs and trees in southern African savannas. This is difficult to quantify, however, should not be ruled out when discussing plant cover and density in the changes in habitat structure of the Bankenveld grasslands.

Diffendorfer *et al.* (1995) found that fragmentation increases the distance moved by three species of small mammals, whereas the proportion of animals moving decreases. It is possible that increased movement is a result of decreased resource availability. In the case of *G. murinus*, a decrease in numbers with a decline in trees, or alternatively local extinction as a result of unsuitable habitat is expected. According to Noss & Csuti (1997), local extinctions are expected to decrease species diversity within habitat remnants. It is believed that the main reason for small mammal reaction is not overwhelmingly different in areas historically cultivated due to their successional change and improvement of habitat which has been gradual, as opposed to other fragmentation experiments involving abrupt and regular removal of vegetation. Gradual fragmentation allows small mammals to adapt and interact with those in the surrounding habitat (Johnson *et al.* 2002).

The important species to monitor in future being species collected in low numbers. These species are specific to a certain habitat structure and appear to be strongly influenced by changes in vegetation density and structure.  The assessment of small mammal richness and changes in abundance in areas in a successional cycle and record the differences as a result of this species niche separation. Data were also recorded in communities at different areas according to vegetation community and historical agricultural influences on the property. The historical influence in certain areas on the property resulted in some differences in vegetation diversity, density and height. The assessment of small mammal diversity at these sites resulted in differences as a result of this altered habitat. Inventories of species associations with habitat are valuable for aiding in conservation related decisions, since decisions are often made at local scales and small mammals can provide a rich source of data on environmental change (Kremen *et al.* 1993).  These changes in habitat resulted in changes in plant communities, which consist of a combination of abiotic factors such as soil, rockiness and climate and biotic factors such as plant and animal composition with each element influencing the other. Therefore a vegetation community can be seen as an ecosystem and these should be managed effectively to ensure the future well-being of the organisms. The vegetation communities on Telperion were identified, described and ecologically interpreted.

The point survey nearest plant survey method was used in the study of herbaceous layer which proved to be efficient and a reliable method of vegetation surveying and assessment.  The data recorded was processed according to various values of each recorded plant, in order to assess the herbaceous layer. The woody component, which included trees, shrubs and dwarf shrubs was assessed at each survey site using the beld transect survey method (Du Plessis & Krynauw 2009). All plant communities could be related to specific environmental conditions and the communities are therefore floristically and ecologically distinguishable and interpretable.  The vegetation of Telperion is typical of Bankenveld veld type (Acocks 1988; Bredenkamp & Van Rooyen 1998) although some grassland communities correspond to the *Cymbopogon–Themeda* veld type (Acocks 1988). The results of this study confirm to the statement of Bredenkamp & Brown (2003) that Bankenveld can be interpreted as a mosaic of grassland and woodland communities in a topographically heterogeneous landscape with heterogeneous microclimatic conditions. Floristic elements of the grassland, savanna and forest biomes are present on the property which confirms the statement of Bredenkamp (1975), Bredenkamp & Theron (1978) and Bredenkamp & Brown (2003) that there is a large overlap in the species composition of grassland and woodland communities, especially on geologically similar substrates.

# CHAPTER 17

# CONCLUSION

This study provides evidence that small mammal populations in the grasslands of Telperion exhibit similar trends; numbers recorded peaked in autumn. This could be explained as result of numbers building through the summer months, prior to tapering off during winter. Species such as *E. myurus* were however more abundant during winter months, possibly due to being more active in search of invertebrates which are less abundant in winter. These surveys were performed monthly and seasonally in order to record reproduction, seasonal changes and changes in vegetation densities. Results indicated an extreme fluctuation in *Dendromus melanotis* populations during this study. Initially, only *D. melanotis* was expected to be recorded during the study, however, *D. mystacalis* also occur in the area. Low numbers of *Mastomys* spp. were recorded during the study. The medically and agriculturally important Natal multimammate mouse *Mastomys natalensis* (A. Smith 1834) and the multimammate mouse *Mastomys coucha* (A. Smith 1836) are sibling species and cannot easily be distinguished morphologically. Results indicated that small mammal populations differed between vegetation communities, although similarities also occurred. Differences and similarities were largely due to substrate, soil, as well as vegetation cover. The important species to discuss are the abundant and less frequently recorded species. This spectrum of highly populated to scarcely populated species may provide an indication of environmental health in the grasslands.

Data recorded from Telperion indicated a degree of species domination and inter- and intra-species competition, for example, two species such as *M. namaquensis* and *E. myurus* occupying similar niche’s. *Mastomys* and *Rhabdomys* are groups indicative of disturbance, regularly reaching plague proportions in agricultural lands. These two species however occurred in relatively low numbers on Telperion, which could be indicative of a healthy ecology and a balanced ecosystem. It is encouraging to note, as large areas of the study site were utilized historically as agricultural lands, although they have been allowed to recover ecologically, in some cases for decades. Population assemblages of small mammals generally decrease in winter after a period of relative stress i.e., limited resources due to temperature and a decrease in precipitation. In the summer months, largely due to reproduction, numbers increase with an increase in cover and food availability. This often rapid increase in reproduction and a corresponding increase in the overall population. A partial burn was recorded in the Sheltered Woodland community in 2008, and results indicate no impact on the population, it is speculated that sufficient grass seeds on the ground and other plant material could be found by rodents after the burn to temporarily sustain the population. The species dominating this area are also largely rock-dwelling species which are less reliant on grass cover, rather inhabiting crevices in rocks and boulders. The present study indicated that certain management practices have a positive influence on rodent species diversity and abundance, while others have a negative influence. These management activities may result in changes in vegetation structure, density and species composition, which may result in altered habitat being selected or rejected by certain species of small mammal, depending on their habitat requirements. As with the herbivores, small mammals are important components of a landscape. The general abundance and species richness of small mammal species is impacted by grazing and land use, which ultimately contributes to overall habitat change.

There appears to be movement of *D. melanotis* into areas considered degraded by *Seriphium plumosum* in the winter months. It is expect that this is related to the lack of grass cover in the surrounding areas. Signs of a decrease in these populations only occurred in spring. There is a possibility that these individuals dispersed into the adjacent areas on the onset of summer, although numbers decreased prior to receiving rains. As mentioned, generally small mammal populations, except for *E. myurus*, decrease in winter. It is assumed that the population decreased gradually due to a decrease in food and cover, an increase in competition and an increase in predation as a result of a lack of cover.

It is accepted that the Bankenveld is a fire climax grassland and that frequent fires are expected to occur which result in the vegetation in open areas being denude of trees, thus favouring certain rodent species preferring open areas i.e. *T. leucogaster*, *T. brantsii* and *S. pratensis*, while having a negative influence on species favouring wooded habitat i.e., *G. murinus*, which inhabit the rocky outcrops, inaccessible to fire. An increase in certain species such as *S. pratensis* can be expected after fire, while the numbers of those species preferring tall grass, such as *D. melanotis* and *D. mystacalis*, could be reduced. It is however, recognized that the species are adapted to these changes in habitat structure, and increases and decreases are expected to be temporary. It appears that the majority of small mammal species do not recognize the differences in habitat because the micro-habitats contain sufficient resources for survival, and substrate and cover appear to be the driving factors in this grassland habitat. Ultimately, we expect habitat changes to have strong effects on certain small mammal species; however these do not appear evident at this stage except for specific key species such as *Mystromys albicaudatus*, although the presence of species is known to fluctuate considerably. It is, therefore, suggested that this research be continued as a longer-term study with provide a better understanding of the presence of other species not recorded and changes in the small mammal community structure over time.

Telperion is threatened as they are situated in South Africa's agriculturally most productive area. It is further the country's major source of beef, crops, dairy and timber. Our grasslands are nationally threatened as the majority of South Africa's population lives in the grassland biome. The establishment of new coal mines on the boundaries of the reserve poses an even greater threat and result in the fragmentation of habitat, ultimately surrounding Telperion as an island of suitable habitat. Other less apparent threats exist such as soil erosion, invasion by alien species and acid rain due to the sulphur dioxide released by the coal power stations (Neke & Du Plessis 2004). Browsing disturbance and fire has altered the structure, composition and function of the area. It is recommended that certain small mammal species be used as indicators of change in landscape. Gradual changes in vegetation structure, density and composition may result in gradual changes in certain species of small mammal, which when monitored could act as an early warning signal that imbalances occur within the system.

Large herbivores are referred to as ecosystem engineers, altering vegetation structure, sometimes to the detriment or benefit of certain species of small mammals. Their grazing and trampling effects have pronounced effects on the distribution of vegetation and habitat structure. The question on Telperion is that high densities of herbivores do influence the abundance of small mammals, vegetation and insectivores through herbivory and trampling. The abundance and species richness of small mammals in these areas provides a clear indication that herbivores have an impact on the vegetation, rodent populations and thus all creatures feeding on rodents. Again, large numbers of herbivores affect cover and create a patchy effect which is assumed to increases habitat suitability for certain species. It is expected that Telperion has high species richness due to this patch effect, allowing for suitable habitat for small mammals across the successional line. Climax small mammal species inhabiting areas which are less disturbed, while generalist species prefer areas disturbed by herbivores. Those intermediate species occur in the majority of habitats, and are therefore more general in their habitat selection. This study was primarily concerned with defining and assessing small mammals in an ecosystem and providing ecological indicators for ecosystem management through evaluating and understanding small mammal assemblages in the grassland habitats of Telperion. Past management influences and seasonal changes in the ecosystem were assumed to have a profound impact on the diversity and abundance of small mammal assemblages, however, certain species appear to have a broader ecological niche than other more habitat specific species.

Of the 73 species of rodents that occur in southern Africa, 19% (14 taxa) were recorded within a two year period on Telperion. It is known that rodents form the staple diet for many birds, reptiles and mammals, thereby occupying a key position in the intricate balance of nature. Apart from forming a food source for many animals they also have the ability to modify the environment during plague conditions. Rodents play a major role in the consumption of seeds of many plant species, thereby influencing plant recruitment. Different rodent species also favour different habitat conditions. For these reasons rodents as well as insectivores are important indicators of ecosystem health and worthy of attention and further study in the Bankenveld grasslands. Data were recorded between January 2008 and October 2009 from 17 sampling trips covering 16200 traps nights, where 1369 capture successes of small mammals belonging to eighteen taxa were recorded. The small mammal trap success percentage recorded for the study from ten sampling transects was 8.6%. The distributions and movements of small mammals can be explained in terms of cover and litter preference. Despite differences in habitat successional structure and the influence of past agricultural practices, small mammal populations are intact and diverse in nature. We conclude that Telperion is diverse and varied in the number of small mammals recorded, and therefore provides an important role in the conservation of species in an ever reducing grassland community in South Africa. For all the reasons mentioned above, these areas are important for conserving biodiversity and ensuring representative Bankenveld is protected.

As large areas of the property, specifically the ridges, Wilge River and wetlands, are in a good condition and provide habitat for many plant and animal species, the future management and conservation of Telperion is important. It is recommended that the numerous alien and invasive species such as *Populus x canescens*, *Acacia mearnsii* and *Eucalyptus camaldudensis* on the property be eradicated, with follow-up measures to ensure the veld returns to its natural condition. It is also recommended that the optimal stocking rates of certain species on the property be determined to prevent possible overgrazing and further degradation of degraded areas and future degradation in the natural vegetation. Management encompassing best practice for fire climax grassland flora and fauna remains an extremely complex matter, requiring broad in-depth understanding of landscape, it ecological components and the dynamics thereof. This data suggests that managing areas to maximize species richness, especially key small mammal assemblages, should be achieved by maintaining diverse and structurally varied habitats in the correct proportions. The $H_o$ is rejected, as data from the study indicates that small mammal diversity and abundance is dependent on vegetation and time on Telperion and that small-scale studies are necessary to determine species-specific responses to disturbance and the consequences that such responses hold to small mammal biodiversity and assemblages.

# CHAPTER 18

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# LIST OF APPENDIXES

Appendix A: Species list of woody and herbaceous plants recorded at Northern Slope Woodland (NSW 1)

| Woody Plants |
|---|
| *Ancylobotrys capensis* |
| *Burkea africana* |
| *Canthium gilfillanii* |
| *Combretum molle* |
| *Cussonia paniculata* |
| *Diospyros lycioides* |
| *Diplorynchus condylocarpon* |
| *Elephantorrhiza burkei* |
| *Englerophytum magalismontanum* |
| *Gymnosporia polyacantha* |
| *Gymnosporia tenuispina* |
| *Lannea edulis* |
| *Mundulea sericea* |
| *Ochna pulchra* |
| *Ozoroa paniculosa* |
| *Parinari capensis* |
| *Protea caffra* |
| *Rhoicissus tridentata* |
| *Searsea magalismontana* |
| *Searsea zeyheri* |
| *Solanum nigrum* |
| *Strychnos pungens* |
| *Vangueria infausta* |
| *Vangueria parvifolia* |
| *Ximenia caffra* |
| *Zanthoxylum capense* |
| *Ziziphus mucronata* |

Appendix B: Species list of woody and herbaceous plants recorded at Northern Slope Woodland (NSW 3)

| Woody Plants | Forbs | Grasses and Sedges |
|---|---|---|
| *Ancylobotrys capensis* | *Acrotome inflata* | *Andropogon shirensis* |
| *Brachylaena rotundata* | *Bidens pilosa* | *Aristida transvaalensis* |
| *Burkea africana* | *Ceratotheca triloba* | *Aristida stipitata* |
| *Canthium gilfillanii* | *Cereus jamacaru* | *Brachiaria serrata* |
| *Combretum hereroense* | *Cleome rubella* | *Bulbostylis burchelli* |
| *Combretum molle* | *Commelina erecta* | *Cymbopogon plurinodis* |
| *Croton gratissimus* | *Crassula swaziensis* | *Cymbopogon excavatus* |
| *Cryptolepus oblongifolia* | *Datura ferox* | *Digitaria eriantha* |
| *Diospyros lycioides* | *Dichapetalum cymosum* | *Diheteropogon amplectens* |
| *Elephantorrhiza burkei* | *Fadogia homblei* | *Elionurus muticus* |
| *Englerophytum magalismontanum* | *Haemanthus humilis* | *Eragrostis racemosa* |
| *Euclea natalensis* | *Hibiscus engleri* | *Eragrostis rigidior* |
| *Gymnosporia tenuispina* | *Indigofera melanadenia* | *Eragrostis curvula/chloromelas* |
| *Ilex mitis* | *Oldenlandia herbacea* | *Eragrostis unidentified* |
| *Maytenus undata* | *Pearsonia sessilifolia* | *Eragrostis gummiflua* |
| *Mundulea sericea* | *Pellaea calomelanos* | *Heteropogon contortus* |
| *Ochna pulchra* | *Protasparagus laricinus* | *Loudetia simplex* |
| *Ozoroa paniculosa* | *Pygmaeothamnus zeyheri* | *Melinis repens* |
| *Parinari capensis* | *Salacia rehmannii* | *Melinis nerviglumis* |
| *Pavetta zeyheri* | *Scadoxus puniceus* | *Panicum natalense* |
| *Searsea leptodictya* | *Selaginella dregei* | *Perotis patens* |
| *Searsea magalismontana* | *Senecio oxyriifolius* | *Pogonarthria squarrosa* |
| *Strychnos pungens* | *Solanum incanum* | *Setaria sphacelata* |
| *Tapiphyllum parvifolium* | *Stylochaeton natalensis* | *Setaria lindenbergiana* |
| *Vangueria infausta* | *Tagetus minuta* | *Shizachyrium sanguinium* |
| *Vepris reflexa* | *Tetradenia riparia* | *Tracypogon spicatus* |
| *Ximenia caffra* | *Vernonia natalensis* | *Tristachya leucothrix* |
|  | *Xerophyta retinervis* |  |

Appendix C: Species list of woody and herbaceous plants recorded at Rocky Highveld Grassland (RHG 2)

| Woody Plants | Forbs | Grasses and Sedges |
|---|---|---|
| *Cryptolepus oblongifolia* | *Aloe verecunda* | *Andropogon chinensis* |
| *Parinari capensis* | *Babiana hypogea* | *Aristida transvaalensis* |
| *Pavetta zeyheri* | *Bidens pilosa* | *Aristida stipitata* |
| *Protea welwitschii* | *Boophane disticha* | *Aristida congesta* |
| *Searsea magalismontana* | *Bulbine abyssinica* | *Bewsia biflora* |
| *Strychnos pungens* | *Bulbine narcissifolia* | *Brachiaria serrata* |
| *Vangueria infausta* | *Ceratotheca triloba* | *Bulbostylis burchellii* |
|  | *Chamaecrista mimosoides* | *Cymbopogon excavatus* |
|  | *Chascanum hederaceum* | *Cynodon dactylon* |
|  | *Cleome maculata* | *Diheteropogon amplectens* |
|  | *Cleome monophyla* | *Elionurus muticus* |
|  | *Cleome rubella* | *Eragrostis curvula/ chloromelas* |
|  | *Commelina africana* | *Eragrostis nindensis* |
|  | *Commelina erecta* | *Eragrostis racemosa* |
|  | *Crassula capitella* | *Heteropogon contortus* |
|  | *Dicoma anomala* | *Loudetia flavida* |
|  | *Dicoma zeyheri* | *Loudetia simplex* |
|  | *Evolvulus alsinoides* | *Melinis nerviglumis* |
|  | *Fadogia homblei* | *Melinis repens* |
|  | *Felicia mossamedensis* | *Microchloa caffra* |
|  | *Gladiolus sp.* | *Panicum natalense* |
|  | *Gomphocarpus glaucophyllus* | *Perotis patens* |
|  | *Hypoxis hemerocalidea* | *Pogonarthria squarrosa* |
|  | *Hypoxis rigidula* | *Schizachyrium sanguineum* |
|  | *Kalanchoe paniculata* | *Setaria sphacelata* |
|  | *Kalanchoe thyrsiflora* | *Sporobolis pectinatus* |
|  | *Kyphocarpa angustifolia* | *Sporobolus staphianus* |
|  | *Ledebouria ovatifolia* | *Sporobolus festivus* |
|  | *Pearsonia sp.* | *Tristachya leucothrix* |
|  | *Pellaea calomelanos* | *Urelytrum agropyriodes* |
|  | *Vigna vexillata* |  |
|  | *Wahlenbergia caledonica* |  |
|  | *Xerophyta retinervis* |  |

Appendix D: Species list of woody and herbaceous plants recorded at Rocky Highveld Grassland (RHG 4)

| Woody Plants | Forbs | Grasses and Sedges |
|---|---|---|
| *Englerophytum magalismontanum* | *Acrotome inflate* | *Andropogon chirensis* |
| *Parinari capensis* | *Commelina sp.* | *Aristida transvaalensis* |
|  | *Conyza bonariensis* | *Aristida stipitata* |
|  | *Cotyledon orbiculata* | *Aristida congesta subsp. congesta* |
|  | *Eriosema burkei* | *Brachiaria serrata* |
|  | *Fadogia homblei* | *Bulbostylis burchellii* |
|  | *Geigeria burkei* | *Cynodon dactylon* |
|  | *Hibiscus engleri* | *Digitaria ternata* |
|  | *Hypoxis acuminata* | *Digitaria monodactyla* |
|  | *Hypoxis rigidula* | *Diheteropogon amplectens* |
|  | *Indigofera melanadenia* | *Elionurus muticus* |
|  | *Kyphocarpa angustifolia* | *Eragrostis stipitata* |
|  | *Lippia javanica* | *Eragrostis racemosa* |
|  | *Lopholaena coriifolia* | *Eragrostis sp.* |
|  | *Oldenlandia herbacea* | *Eragrostis curvula* |
|  | *Pearsonia sessilifolia* | *Eragrostis plana* |
|  | *Pellaea calomelanos* | *Heteropogon contortus* |
|  | *Phylanthus maderaspatensis* | *Loudetia simplex* |
|  | *Pollichia campestris* | *Melinis nerviglumis* |
|  | *Portulacca quadrifida* | *Melinis repens* |
|  | *Protasparagus laricinus* | *Panicum natalense* |
|  | *Raphionacme hirsuta* | *Perotis patens* |
|  | *Rhynchosia monophylla* | *Pogonarthria squarrosa* |
|  | *Richardia brasiliensis* | *Schizachyrium sanguineum* |
|  | *Searsea magalismontana* | *Setaria sphacelata* |
|  | *Solanum incanum* | *Sporobolus pectinatus* |
|  | *Tagetus minuta* | *Themeda triandra* |
|  | *Verbena bonariensis* | *Trachypogon spicatus* |
|  | *Vernonia natalensis* | *Trichneura grandiglumis* |
|  | *Xerophyta retinervis* | *Tristachya rehmannii* |
|  | *Ximenia caffra* | *Tristachya leucothrix* |

Appendix E: Species list of woody and herbaceous plants recorded at Degraded Grassland (DG 2)

| Woody Plants | Forbs | Grasses and Sedges |
|---|---|---|
| *Diospyros lycioides* | *Chamaecrista mimosoides* | *Andropogon eucomus* |
| *Heteropyxis natalensis* | *Cleome maculata* | *Aristida stipitata* |
| *Seriphium plumosum* | *Commelina erecta* | *Aristida congesta subsp. congesta* |
|  | *Conyza bonarirens* | *Aristida congesta* |
|  | *Cucumis zeyheri* | *Aristida transvaalensis* |
|  | *Gomphrena celosioides* | *Aristida stipitata* |
|  | *Helichrysum luridum* | *Bulbostylis hispidula* |
|  | *Hibiscus engleri* | *Bulbostylis burchellii* |
|  | *Hypoxis acuminata* | *Cynodon dactylon* |
|  | *Indigofera melanadenia* | *Elionurus muticus* |
|  | *Lippia javanica* | *Eragrostis racemosa* |
|  | *Oldenlandia herbacea* | *Eragrostis gummiflua* |
|  | *Pelargonium luridum* | *Eragrostis capensis* |
|  | *Pellaea calomelanos* | *Eragrostiscurvula/chloromelas* |
|  | *Pygmaeothamnus zeyheri* | *Melinis repens* |
|  | *Richardia brasiliensis* | *Melinus nerviglumis* |
|  | *Schurria pinnata* | *Perotis patens* |
|  | *Senecio oxyriifolius* | *Pogonarthria squarrosa* |
|  | *Senecio sp.* | *Shizachyrium sanguineum* |
|  | *Solanum lichtensteini* | *Themeda triandra* |
|  | *Solanum panduriforme* | *Trichoneura grandiglumis* |
|  | *Tagetus minuta* |  |
|  | *Verbena bonariensis* |  |
|  | *Vernonia natalensis* |  |

Appendix F: Species list of woody and herbaceous plants recorded at Degraded Grassland (DG 3)

| Woody Plants | Forbs | Grasses and Sedges |
|---|---|---|
| *Burkea africana* | *Ceratotheca triloba* | *Andropogon shirensis* |
| | *Cleome maculata* | *Aristida stipitata* |
| | *Commelina erecta* | *Aristida congesta subsp. congesta* |
| | *Crinum graminicola* | *Bulbostylis burchellii* |
| | *Cucumis zeyheri* | *Cynodon dactylon* |
| | *Dichapetalum cymosum* | *Cyperus obtusiflorus* |
| | *Elephantorrhisa elephantina* | *Digitaria eriantha* |
| | *Fadogia homblei* | *Digitaria diagonalis* |
| | *Gomphocarpus fruticosus* | *Eragrostis chloromelas* |
| | *Gomphrena celosioides* | *Heteropogon contortus* |
| | *Hypoxis hemerocallidea* | *Perotis patens* |
| | *Indigofera daleoides* | *Pogonarthria squarrosa* |
| | *Indigofera melanadenia* | *Schizachyrium sanguineum* |
| | *Laperosia sandersonii* | *Setaria sphacelata sphacelata* |
| | *Ledebouria ovatifolia* | *Tricholaena monachne* |
| | *Parinari capensis* | *Trichoneura grandiglumis* |
| | *Pellaea calomelanos* | |
| | *Phylanthus maderaspatensis* | |
| | *Pollichia campestris* | |
| | *Portulaca quadrifida* | |
| | *Protasparagus laricinus* | |
| | *Pygmaeothamnus zeyheri* | |
| | *Salacia rehmannii* | |
| | *Schkuhria pinnata* | |
| | *Solanum incanum* | |
| | *Tephrosia lupinifolia* | |
| | *Vernonia natalensis* | |

Appendix G: Species list of woody and herbaceous plants recorded at Sheltered Woodland (SW 1)

| Woody Plants | Forbs | Grasses and Sedges |
|---|---|---|
| *Acacia caffra* | *Bidens pilosa* | *Brachiaria serrata* |
| *Ancylobotrys capensis* | *Ceratotheca triloba* | *Bulbostylis burchellii* |
| *Burkea africana* | *Cleome monophylla* | *Cymbopogon excavatus* |
| *Combretum molle* | *Cleome rubella* | *Cyperus esculentus* |
| *Croton gratissimus* | *Commelina africana* | *Diheteropogon amplectens* |
| *Diospyros whyteana* | *Cyphostemma setosum* | *Eragrostis gummiflua* |
| *Elephantorrhiza burkei* | *Dichapetalum cymosum* | *Eragrostis curvula* |
| *Englerophytum magalismontanum* | *Elephantorrhiza elephantina* | *Eustachys paspaloides* |
| *Euclea crispa* | *Fadogia homblei* | *Heteropogon contortus* |
| *Faurea saligna* | *Hypoxis acuminata* | *Loudetia simplex* |
| *Ficus abutilifolia* | *Jamesbrittenia sp.* | *Protasparagus laricinus* |
| *Gymnosporia tenuispina* | *Ledebouria ovatifolia* | *Pteridium aquilium* |
| *Heteropyxis natalensis* | *Oldenlandia herbacea* | *Setaria lindenbergiana* |
| *Ilex mitis* | *Pavonia burchellii* | *Setaria incrassata* |
| *Lannea edulis* | *Pellaea calomelanos* | *Setaria sphacelata* |
| *Maytenus undata* | *Protasparagus laricinus* | *Shizachyrium sanguinium* |
| *Ochna pulchra* | *Pteridium aquilinum* | *Themeda triandra* |
| *Ozoroa paniculosa* | *Schkuhria pinnata* | *Trachypogon spicatus* |
| *Pappea capensis* | *Solanum lichtensteinii* | *Tristachya leucothrix* |
| *Parinari capensis* | *Tagetus minuta* | |
| *Rhoicissus tridentata* | *Tetradenia riparia* | |
| *Searsea leptodictya* | *Vernonia oligocephala* | |
| *Vangueria infausta* | | |
| *Vangueria parvifolia* | | |
| *Ximenia caffra* | | |

Appendix H: Species list of woody and herbaceous plants recorded at Burkea Eragrostis Clumps (BEC 1)

| Woody Plants | Forbs | Grasses and Sedges |
|---|---|---|
| *Burkea africana* | *Achyranthes aspera* | *Aristida adscensionis* |
| *Canthium gilfillanii* | *Acrotome hispida* | *Aristida stipitata* |
| *Euclea crispa* | *Asclepias glaucophylla* | *Aristida congesta congesta* |
| *Fadogia homblei* | *Bidens pilosa* | *Bulbostylis burchellii* |
| *Ochna pulchra* | *Ceratotheca triloba* | *Cynodon dactylon* |
| *Parinari capensis* | *Cleome rubella* | *Eleusine coracana* |
| *Pygmaeothamnus zeyheri* | *Conyza bonariensis* | *Elionurus muticus* |
| *Strychnos pungens* | *Crabbea angustifolia* | *Eragrostis rigidior* |
|  | *Crinum graminicola* | *Eragrostis chloromelas* |
|  | *Cucumis zeyheri* | *Melinis repens* |
|  | *Datura stramonium* | *Panicum maximum* |
|  | *Elephantorrhiza elephantina* | *Panicum natalense* |
|  | *Fadogia homblei* | *Perotis patens* |
|  | *Gladiolus elliotii* | *Pogonarthria squarrosa* |
|  | *Hibiscus engleri* | *Schizachyrium sanguineum* |
|  | *Indigofera melanadenia* | *Setaria sphacelata sphacelata* |
|  | *Oldenlandia herbacea* | *Themeda triandra* |
|  | *Phylanthus maderaspatensis* | *Tricholaena monachne* |
|  | *Pollichia campestris* |  |
|  | *Richardia brasiliensis* |  |
|  | *Schkuhria pinnata* |  |
|  | *Solanum incanum* |  |
|  | *Tagetus minuta* |  |
|  | *Tephrosia lupinifolia* |  |
|  | *Verbena brasiliensis* |  |
|  | *Vernonia natalensis* |  |

Appendix I: Species list of woody and herbaceous plants recorded at Moist Degraded Grassland (MDG 3)

| Woody Plants | Forbs | Grasses and Sedges |
|---|---|---|
| | *Bidens pilosa* | *Cynodon dactylon* |
| | *Capsella sp.* | *Digitaria* **spp.** |
| | *Chamaecrista mimosoides* | *Digitaria eriantha* |
| | *Gomphrena celosioides* | *Eragrostis curvula/chlorom* |
| | *Gomphrocarpus fruticosus* | *Eragrostis plana* |
| | *Conyza albida* | *Hyparrhenia hirta* |
| | *Helichrysum sp.* | *Imperata cylindrica* |
| | *Hibiscus engleri* | *Miscanthus junceus* |
| | *Oxalis sp.* | *Mischantus capensis* |
| | *Richardia brasiliensis* | *Paspalum urvillei* |
| | *Schkuhria pinnata* | *Setaria pallide-fusca* |
| | *Sida cordifolia* | *Sporobolus africanus* |
| | *Solanum panduriforme* | |
| | *Sonchus sp.* | |
| | *Tagetus minuta* | |
| | *Taraxacum officinale* | |
| | *Trifolium repens* | |
| | *Verbena bonariensis* | |
| | *Verbena brasiliensis* | |

## Appendix J: Species list of woody and herbaceous plants recorded at Rocky Open Shrub (ROS 1)

| Woody Plants | Forbs | Grasses and Sedges |
|---|---|---|
| *Ancylobotrys capensis* | *Bidens pilosa* | *Andropogon shrirensis* |
| *Brachylaena rotundata* | *Cleome rubella* | *Aristida transvaalensis* |
| *Canthium mundianum* | *Commelina erecta* | *Bewsia biflora* |
| *Combretum molle* | *Cryptolepus oblongifolia* | *Brachiaria serrata* |
| *Cussonia paniculata* | *Dicoma anomala* | *Bulbostylis burchellii* |
| *Englerophytum magalismontanum* | *Dicoma zeyheri* | *Cymbopogon excavatus* |
| *Euclea crispa* | *Fadogia homblei* | *Digitaria diagonalis* |
| *Gymnosporia tenuispina* | *Geigeria sp.* | *Digitaria monodactyla* |
| *Heteropyxis natalensis* | *Indigofera melanadenia* | *Diheteropogon amplectens* |
| *Maytenus undata* | *Indigofera sp.* | *Elionurus muticus* |
| *Mundulea sericea* | *Jamesbrittenia burkeana* | *Eragrostis gummflua* |
| *Myrothamnus flabellifolia* | *Kalanchoe sp.* | *Eragrostis nindensis* |
| *Nuxia floribunda* | *Ledebouria cooperi* | *Eragrostis racemosa* |
| *Ochna pulchra* | *Nidorella hottentotica* | *Eragrostis capensis* |
| *Ozoroa paniculosa* | *Oldenlandia herbacea* | *Eragrostis curvula* |
| *Parinari capensis* | *Oxalis obliquifolia* | *Loudetia simplex* |
| *Pavetta lanceolata* | *Pearsonia sessilifolia* | *Melinis repens* |
| *Protea caffra* | *Pellaea calomelanos* | *Melinis nerviglumis* |
| *Searsea magalismontana* | *Phyllanthus maderaspatensis* | *Microchloa caffra* |
| *Strychnos pungens* | *Protasparagus laricinus* | *Panicum natalense* |
| *Tapyphyllum parvifolium* | *Protasparagus sp.* | *Pogonarrthria squarrosa* |
| *Vangueria infausta* | *Salacia rehmannii* | *Setaria sphacelata spha* |
| *Zanthoxylum capense* | *Schkuhria pinnata* | *Shizachyrium sanguinium* |
| | *Selaginella dregei* | *Sporobolis staphianus* |
| | *Stylochaeton natalensis* | *Trachypogon spicatus* |
| | *Tagetus minuta* | *Tristachya leucothrix* |
| | *Verbena bonariensis* | |

Appendix K: The capture percentage recorded during the study period per species on Telperion.

| Survey Plots | NSW | RHG | DG | SW | BEC | MDG | ROS | Total |
|---|---|---|---|---|---|---|---|---|
| *Micaelamys namaquensis* | 17.0 | 5.8 | 0.0 | 9.2 | 0.0 | 0.0 | 24.4 | 56.4 |
| *Elephantulus myurus* | 4.9 | 2.0 | 0.0 | 2.0 | 0.0 | 0.0 | 7.2 | 16.0 |
| *Dendromus melanotis* | 0.1 | 1.6 | 5.4 | 0.3 | 0.9 | 0.1 | 0.0 | 8.4 |
| *Lemniscomys rosalia* | 0.0 | 1.5 | 1.4 | 0.0 | 0.15 | 0.0 | 0.0 | 3.1 |
| *Mus minutoides* | 0.1 | 0.4 | 0.7 | 0.7 | 0.9 | 0.2 | 0.0 | 3.0 |
| *Acomys spinosissimus* | 1.6 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 1.8 |
| *Gerbilliscus leucogaster* | 0.0 | 1.6 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 |
| *Rhabdomys pumilio* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 0.0 | 1.6 |
| *Gerbilliscus brantsii* | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 | 1.5 |
| *Dendromus mystacalis* | 0.0 | 0.7 | 0.2 | 0.0 | 0.0 | 0.4 | 0.0 | 1.3 |
| *Steatomys pratensis* | 0.0 | 0.5 | 0.4 | 0.0 | 0.1 | 0.0 | 0.0 | 1.0 |
| *Crocidura mariquensis* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.7 | 0.0 | 0.9 |
| *Mastomys* spp. | 0.00 | 0.07 | 0.44 | 0.00 | 0.15 | 0.29 | 0.00 | 0.9 |
| *Aethomys chrysophilus* | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.8 |
| *Otomys irroratus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.5 |
| *Suncus infinitesimus* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.0 | 0.4 |
| *Graphiurus murinus* | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| *Crocidura cyanea* | 0.1 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.2 |
| Total | 24.3 | 14.5 | 8.8 | 12.6 | 3.8 | 4.1 | 32.1 | 100.0 |

Appendix L: Data recorded for small mammal species richness recorded on Telperion in each vegetation community

| Vegetation Community | Species Richness |
|---|---|
| Northern Slope Woodland | 8 |
| Rocky Highveld Grassland | 10 |
| Degraded Grassland | 9 |
| Sheltered Woodland | 8 |
| Burkea Eragrostis Clumps | 6 |
| Moist Degraded Grassland | 8 |
| Rocky Open Shrub | 3 |

Appendix M: The sex ratio recorded for individual species recorded on Telperion during the study period.

| Species | Female | Male | Total |
|---|---|---|---|
| *Micaelamys namaquensis* | 107 | 146 | 253 |
| *Dendromus melanotis* | 31 | 50 | 81 |
| *Elephantulus myurus* | 36 | 34 | 70 |
| *Mus minutoides* | 17 | 13 | 30 |
| *Lemniscomys rosalia* | 5 | 8 | 13 |
| *Rhabdomys pumilio* | 4 | 9 | 13 |
| *Dendromus mystacalis* | 7 | 5 | 12 |
| *Gerbilliscus brantsii* | 6 | 6 | 12 |
| *Gerbilliscus leucogaster* | 9 | 3 | 12 |
| *Acomys spinosissimus* | 2 | 9 | 11 |
| *Steatomys pratensis* | 6 | 3 | 9 |
| *Crocidura mariquensis* | 5 | 3 | 8 |
| *Mastomys* spp. | 0 | 8 | 8 |
| *Aethomys chrysophilus* | 2 | 4 | 6 |
| *Otomys irroratus* | 0 | 6 | 6 |
| *Graphiurus murinus* | 3 | 2 | 5 |
| *Suncus infinitesimus* | 3 | 2 | 5 |
| *Crocidura cyanea* | 3 | 0 | 3 |
| Total | 246 | 311 | 557 |

Appendix N: The sex ratio of small mammals recorded in the seven vegetation communities recorded on Telperion during the study period.

| | | NSW | RHG | DG | SW | BEC | MDG | ROS | Total |
|---|---|---|---|---|---|---|---|---|---|
| *M. namaquensis* | | | | | | | | | |
| | Female | 42 | 10 | 0 | 18 | 0 | 0 | 37 | 107 |
| | Male | 41 | 24 | 0 | 27 | 0 | 0 | 54 | 146 |
| | Unknown | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 |
| *D. melanotis* | | | | | | | | | |
| | Female | 1 | 6 | 17 | 2 | 3 | 2 | 0 | 31 |
| | Male | 0 | 12 | 26 | 2 | 6 | 4 | 0 | 50 |
| *E. myurus* | | | | | | | | | |
| | Female | 11 | 4 | 0 | 6 | 0 | 0 | 15 | 36 |
| | Male | 13 | 4 | 0 | 6 | 0 | 0 | 11 | 34 |
| *M. minutoides* | | | | | | | | | |
| | Female | 1 | 2 | 5 | 3 | 4 | 2 | 0 | 17 |
| | Male | 0 | 3 | 2 | 2 | 5 | 1 | 0 | 13 |
| *L. rosalia* | | | | | | | | | |
| | Female | 0 | 1 | 3 | 0 | 1 | 0 | 0 | 5 |
| | Male | 0 | 5 | 3 | 0 | 0 | 0 | 0 | 8 |
| *R. pumilio* | | | | | | | | | |
| | Female | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 4 |
| | Male | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 9 |
| *D. mystacalis* | | | | | | | | | |
| | Female | 0 | 3 | 1 | 0 | 0 | 3 | 0 | 7 |
| | Male | 0 | 3 | 1 | 0 | 0 | 1 | 0 | 5 |
| *G. brantsii* | | | | | | | | | |
| | Female | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 6 |
| | Male | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 6 |
| *G. leucogaster* | | | | | | | | | |
| | Female | 0 | 7 | 2 | 0 | 0 | 0 | 0 | 9 |
| | Male | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *A spinossimus* | | | | | | | | | |
| | Female | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | Male | 7 | 0 | 0 | 2 | 0 | 0 | 0 | 9 |
| *S. pratensis* | | | | | | | | | |
| | Female | 0 | 2 | 3 | 0 | 1 | 0 | 0 | 6 |
| | Male | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 3 |
| *Mastomys* spp. | | | | | | | | | |
| | Female | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Male | 0 | 1 | 4 | 0 | 2 | 1 | 0 | 8 |
| *S. mariquensis* | | | | | | | | | |
| | Female | 0 | 0 | 0 | 2 | 0 | 3 | 0 | 5 |
| | Male | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 |
| *A chrysophilus* | | | | | | | | | |
| | Female | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 |
| | Male | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 4 |
| *O. irroratus* | | | | | | | | | |
| | Female | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Male | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 6 |
| *G. murinus* | | | | | | | | | |
| | Female | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| | Male | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *S. infinitesimus* | | | | | | | | | |
| | Female | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 3 |
| | Male | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| *C. cyanea* | | | | | | | | | |
| | Female | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 3 |
| | Male | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Appendix O: Seasonal species richness recorded for small mammals on Telperion

| Seasons | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|
| *Micaelamys namaquensis* | 1 | 1 | 1 | 1 |
| *Aethomys chrysophilus* | 1 | 1 | 0 | 1 |
| *Dendromus melanotis* | 1 | 1 | 1 | 1 |
| *Dendromus mystacalis* | 1 | 1 | 0 | 0 |
| *Mus minutoides* | 1 | 1 | 1 | 1 |
| *Gerbilliscus brantsii* | 1 | 0 | 1 | 1 |
| *Gerbilliscus leucogaster* | 1 | 1 | 1 | 1 |
| *Lemniscomys rosalia* | 1 | 1 | 1 | 1 |
| *Rhabdomys pumilio* | 0 | 1 | 1 | 0 |
| *Steatomys pratensis* | 1 | 1 | 1 | 1 |
| *Acomys spinossisimus* | 1 | 1 | 1 | 1 |
| *Otomys irroratus* | 0 | 1 | 1 | 0 |
| *Mastomys* spp. | 1 | 0 | 1 | 1 |
| *Graphiurus murinus* | 1 | 1 | 0 | 0 |
| *Elephantulus myurus* | 1 | 1 | 1 | 1 |
| *Crocidura mariquensis* | 1 | 0 | 1 | 1 |
| *Crocidura cyanea* | 1 | 0 | 1 | 0 |
| *Suncus infinitesimus* | 1 | 0 | 1 | 0 |
| Total | 16 | 13 | 15 | 12 |