ASSESSING THE EFFECTS OF BUSH ENCROACHMENT ON SPECIES ABUNDANCE, COMPOSITION AND DIVERSITY OF SMALL MAMMALS AT THE NEUDAMM AGRICULTURAL FARM, KHOMAS REGION, NAMIBIA.

A thesis submitted in partial fulfillment of the requirement for the degree of Master of Science in Biodiversity Management and Research at the University of Namibia and Humboldt-Universität zu Berlin

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ABSTRACT

Bush encroachment is the conversion of open savannas to tree-dominated shrub lands. Bush encroachment results in habitat degradation and the loss of resource productivity. In this study, small mammals were used to investigate the effects of bush encroachment on biodiversity. The main aim of this study was to assess the effects of bush encroachment on the species abundance, diversity and composition of small mammals. The study was conducted in selected bush encroached and non-bush encroached sites at the Neudamm Agricultural Farm in the Khomas Region, during the "Hot-dry" season, "Hot-wet" season (April 2010) and "Cold-dry" season (July 2010). Various habitat factors, namely: woody density, woody cover and grass cover, all of which influence the diversity, distribution and abundance of small mammals were measured in the bush encroached and non-bush encroached sites. An area was considered to be bush encroached when the woody density of the encroaching species was >1,000 bushes per 1ha. Non-bush encroached sites were areas with a woody density of < 1,000 bushes per 1ha. The results revealed a significant difference in the woody density ($t_{49}=5.77$; $n= 50$, $p < 0.001$), woody cover ($H_7=15.27$, $n = 8$, $p < 0.002$) and grass cover ($H_7=57.30$; $n= 8$; $p < 0.001$) between the bush encroached and non-bush encroached sites.

The data on the abundance of small mammals were collected using Sherman-live traps (23 x 8 x 9cm) which were set out over an area of 100 m x 100 m for both the bush encroached and non-bush encroached sites. This comprised a trapping grid. In each grid traps were placed in ten rows and ten columns and were spaced at 10 m intervals. A total of seven small mammal species were captured during the study. Five of these small mammals species (*Rhabdomys pumilio*, *Micaelamys namaquensis, Elephantulus intufi, Gerbilliscus leucogaster* and

Thallomys paedulcus) captured were identified to species level. The other two small mammal species (*Crocidura spp.* and *Mastomys spp.)* captured were identified to genus level. A total of 241 individuals of small mammal species comprising five species were recorded in the bush encroached sites. A total of 249 individuals of small mammal species comprising five species were also recorded in the non-bush encroached sites. The study revealed that there was no significant difference in the abundance ($\chi^2_{17} = 18.00$; $n = 18$; p=0.39), population density ($H_8=1.19$; $n = 9$; p=0.76) and diversity ($H_8=1.98$; $n= 9$; p= 0.576) of small mammals between the bush encroached and non-bush encroached sites. The Hierarchical cluster analysis (HCA) revealed that there was no difference in the composition of small mammals between the bush encroached and non-bush encroached sites. The study showed that bush encroachment did not have a significant effect on small mammal populations.

Key words: Bush encroachment, bush encroached sites, non-bush encroached sites,
small mammals, Neudamm Agricultural Farm, Namibia.

DEDICATION

This thesis is dedicated to my parents Bartholomeus Godwin Karuaera and Aline Venepiko Karuaera, for their unconditional love, encouragement, support and constructive guidance during my childhood up to now. I sincerely appreciate everything they have done in my life.

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DECLARATION

This is a thesis prepared in partial fulfillment of the requirements for the degree of Master of Science in Biodiversity Management and Research at the University of Namibia (UNAM) in Windhoek, Namibia. This thesis is the original work of the author and it has not been submitted for a degree elsewhere. The views and opinions stated therein are those of the author and not necessarily those of the institution.

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CHAPTER 1

INTRODUCTION

1.1. General Introduction

The conversion of savannas to tree-dominated thickets with little grass cover, results in a state known as "bush encroachment". *Bush encroachment is the invasion and/or thickening of aggressive undesired woody species resulting in an imbalance of the grass: bush ratio, decrease in biodiversity, and a decrease in carrying capacity"* (Kruger, 2002; de Klerk, 2004). The main species causing bush encroachment in Namibia are *Acacia mellifera* subsp. *detinens* (Black thorn), *Dichrostachys cineria* (sickle bush), *Terminalia sericea* (Silver terminalia), *Terminalia prunioides* (Purple pod terminalia), *Acacia erubescens* (Blue thorn), *Acacia reficiens* (False umbrella thorn) and *Colophospermum mopane* (mopane) (Directorate Environmental Affairs, 2003; de Klerk, 2004).

Two important models have been developed and suggested to explain the causes of bush encroachment; the State-and-Transition Model and Walter‟s Two-layer Model (de Klerk, 2004). The State-and-Transition model states that savanna ecosystems are event-driven and bush encroachment is a reversible event, depending on favourable management and environmental conditions. The model suggests that bush encroachment is driven by environmental factors such as fire suppression, inter-annual rainfall variability and exclusion of browsers (de Klerk, 2004). The state-and- transition model involves identifying the vegetation states, determining which of the states are linked and describing the transitions involved in the conversion of an open savanna site to a bush encroached state (Joubert *et al.,* 2008). The Walter‟s Two- Layer Model states that if the grass layer is over-utilized it loses its competitive edge against the trees and bushes. According to the model, water is assumed to be the major limiting factor for both grassy and woody plants (Walter, 1971). Under this assumption, the removal of grasses, e.g. by heavy grazing, allows more water to percolate into the sub-soil, where it becomes available for woody plant growth (Wiegand *et al.,* 2005). As a result, the woody plant density increases and grass levels are kept at a minimal level and bush encroachment occurs (Walter, 1971). It has also been hypothesized that increases in global CO_2 levels has led to a proliferation of woody plants in Southern Africa (Wiegand *et al.,* 2005).

Bush encroachment has severe impacts on biodiversity (Meik *et al.,* 2002). In general bush encroachment decreases the diversity of habitats, and this in turn decreases biodiversity as a whole (Meik *et al.,* 2002). Bush encroachment results in habitat degradation (de Klerk, 2004). Changes of habitat structure and complexity have been reported to be associated with changes in small mammal community structure and species richness (Hoffman & Zeller, 2005). Little is known about the impacts of bush encroachment on small mammal diversity and abundance. An ecological disturbance of the habitat is often associated with decreases in small mammal diversity (Hoffman & Zeller, 2005). Therefore it follows that diversity of small mammals may be used as a true indicator of disturbances caused by bush encroachment in the ecosystems.

1.2. Justification for the study

Bush encroachment is a serious environmental and economic problem in Namibia (Meik *et al.,* 2002). It results in loss of resource productivity, loss of agricultural productivity and land degradation. The National Programme to Combat Desertification (NAPCOD) was one of the first programmes in Namibia, which focused on investigating the effects of bush encroachment on biodiversity (de Klerk, 2004). NAPCOD represented one cross-sectoral component of the strategy to operationalise the Green Plan, which gave rise to the programme. The Green Plan is a comprehensive management plan that aims to achieve environmental and economic sustainability. The Green Plan recognises that poverty, population growth and desertification are intimately linked. Bush encroachment is a symptom of the land degradation (de Klerk, 2004). The Country Pilot Partnership (CPP) was launched in 2008. It succeeded NAPCOD in combating bush encroachment in Namibia. One of the major focal areas of CPP research is to investigate the effects of bush encroachment on rural livelihoods and on biodiversity.

Bush encroachment has adverse effects on livestock farming; it results in the decline of livestock production, due to the loss of grass production on grazing lands (Woiters, 1994). Bush encroachment has also reduced the carrying capacity of Namibia‟s rangelands, which has resulted in the concomitant loss of income of more than N$700 million per annum in meat production in Namibia (de Klerk, 2004). Bush encroachment continues to cause substantial losses in communal farms, resulting in lower food security and nutrition.

Outcomes and contributions of the study

- The study will provide an insight assessment of the effects of bush encroachment on the species diversity and abundance of small mammals in the Khomas region. The results obtained from this study will serve as a baseline for further studies of the effects of bush encroachment on small mammal biodiversity in the Khomas region and other regions in Namibia.

- The research results will be used as reference material for the Integrated Sustainable Land Management Programme. The research results will be incorporated in biodiversity conservation initiatives and strategies in Namibia.
- The research results will also contribute to literature on the effects of bush encroachment on land and biodiversity. There is little literature available focusing on the effects of bush encroachment on small mammal biodiversity.

1.3. Problem statement

Many commercial farms in the Khomas Region are heavily affected by bush encroachment. The major encroaching species is *Acacia mellifera*. These disruptions in the region have been caused by incorrect grazing practices. Bush encroachment is a form of land degradation. The unpalatable encroaching species, suppress palatable grasses and herbs resulting in a reduced carrying capacity (Ward, 2005). Many previous studies on bush encroachment focus on the effects of the process on the vegetation composition of biodiversity and agricultural productivity (Woiters, 1994; de Klerk, 2004). Little is understood on how the bush encroachment problem affects small mammal communities. Small mammals are an important component of biodiversity and have vital ecological functions in the ecosystems. Small mammal species can serve as environmental indicators to assess the health of habitats. Changes in habitat structure and diversity are often associated with changes in small mammal community structures. Various habitat factors (woody density, woody cover and grass cover) which affect the abundance, diversity and composition of small mammals were measured in the bush encroached and non bush encroached sites. Small mammals were used as bio-indicator species to determine the effects of the bush encroachment problem on biodiversity.

The study, therefore, aimed to assess the effects of bush encroachment on species abundance, diversity and composition of small mammals in the Khomas Region.

1.4. Objectives

1.4.1. General objective

The overall objective of the study was to assess the effects of bush encroachment on the species abundance, diversity and composition of small mammals in the Khomas region in Namibia.

1.4.2. Specific objectives

a) To determine and compare species abundance of small mammals in a bush encroached and a non-bush encroached site at the Neudamm Agricultural Farm in the Khomas Region.

b) To determine and compare species diversity of small mammals in a bush encroached and a non-bush encroached site at the Neudamm Agricultural Farm in the Khomas Region.

c) To determine and compare species composition of small mammals in a bush encroached and a non-bush encroached site at the Neudamm Agricultural Farm in the Khomas Region.

1.5. Research questions

The following questions were proposed for the study:

a) Is there a difference in species abundance of small mammals between a bush encroached and a non-bush encroached site at the Neudamm Agricultural Farm in the Khomas Region?

b) Is there a difference in species diversity of small mammals between a bush encroached and a non-bush encroached site at the Neudamm Agricultural Farm in the Khomas Region?

c) Is there a difference in species composition of small mammals between a bush encroached and a non-bush encroached site at the Neudamm Agricultural Farm in the Khomas Region?

1.6. Research hypotheses

a) It was hypothesized that the species abundance of small mammals would be higher in the non-bush encroached sites at the Neudamm Agricultural Farm, due to the higher grass cover. Grass is an important source of food supply for small mammals. The higher grass cover in the non-bush encroached sites would support a higher abundance of small mammals.

b) It was hypothesized that species diversity of small mammals would be higher in the non-bush encroached sites at the Neudamm Agricultural Farm, due to the more heterogeneous vegetation structure and composition. A heterogeneous vegetation structure provides more niche opportunities for different small mammal species to exploit.

c) It was hypothesized that species composition of small mammals would be different in the bush encroached and non-bush encroached sites at the Neudamm Agricultural Farm, due to the differences in the vegetation cover, structure and heterogeneity at the two sites. The composition of small mammals would be determined by the type of vegetation cover, structure and heterogeneity available in the different seasons in both sites.

CHAPTER 2

LITERATURE REVIEW

2.1. Causes of bush encroachment

The processes and events that cause bush encroachment are numerous and inter-linked (Woiters, 1994). These disruptions include: incorrect grazing practices, lack or misuse of fire, absence of browsing animals, lack of mechanical damage by large wild animals such as elephants and elevated concentration of CO_2 levels in the atmosphere. However, humans appear to be the major catalysts to the problem. According to Barnes *et al.,* (1989), the disruptions of biological control mechanisms have resulted in the current problem of bush encroachment. Rangelands are also encroached because of the poor understanding of the vegetation dynamics (Joubert *et al.,* 2008). Inappropriate fire management, poor understanding of savanna ecosystem models and poor understanding of the phenology and physiology of the encroaching species, have accelerated the bush encroachment problem (Joubert *et al.,* 2008).

The encroaching woody species may be trees or shrubs, collectively referred to as bush (Hudak & Wessman, 2001). The encroachment of new invasive bush species has drastically reduced habitat productivity (Adler, 1985). Invasive species have the ability to out-compete indigenous species and grass in the area, resulting in habitats dominated by encroaching species. Human interference has prevented regular occurrence of fires that regulates savanna vegetation, maintaining balance between the grasses and woody plants (Marsh, undated). Furthermore, the replacement of wildlife with livestock (grazers) has diminished the growth rates of grasses and thus enhanced bush encroachment (Marsh, undated). According to Marsh (undated), over-stocking aggravates bush encroachment through over-grazing that reduces grass cover.

2.2. Extent of bush encroachment in Namibia

Bush encroachment is widespread in Namibia affecting communal and commercial farming communities (Woiters, 1994). There seems to be variation in the recent estimates of bush encroachment in the different regions in Namibia (Kruger, 2002). However there is a common understanding about the regions affected by encroachment. More than 10 million hectares (12%) of Namibia"s land is encroached (Woiters, 1994). Zimmermann and Joubert (2002) estimated that about 26 million hectares of land in Namibia is affected by bush encroachment. There appears to be a relationship between high rates of bush encroachment and areas receiving minimal average rainfalls of below 600 mm per year (Woiters, 1994; Erkkila & Siiskoneni, 1992). Savanna ecosystems with low carrying capacities are also more vulnerable to bush encroachment (Woiters, 1994). As a result of heavy grazing, the encroaching species in savanna ecosystems out-compete the grass species for the available moisture in the soil, resulting in bush encroachment. According to Joubert *et al.,* (2008), *Acacia mellifera* appears to be the major species encroaching the Khomas Region. The Southern Regions in Namibia are encroached by *Rhigozum trichotomum*. The dominant species encroaching in the Eastern parts of Namibia are *A. mellifera* and *Terminalia sericea*. The central northern parts of Namibia are encroached by *A. reficiens* and *A. mellifera;* the far northern parts of the country are encroached by *Colophospermum mopane* and *Dichrostachys cinerea* (Figure 2.1). The different encroaching species occur in the different parts of the country, as a result of differences in abilities of their root systems to extract and intercept water from the different soil types in Namibia (de Klerk, 2004).

1. *Colophospermum mopane*
2. *Acacia reficiens*
3. *A. mellifera*
4. *Colophospermum mopane*
5. *A. mellifera*
6. *A. mellifera*
7. *Dichrostachys cinerea*
8. *A. mellifera*
9. *Terminalia sericea*
10. *Rhigozum trichotomun*

Figure 2.1: Occurrence of dominant encroaching species in commercial farming areas in Namibia (de Klerk, 2004).

2.3. Impacts of bush encroachment

2.3.1. Impact on agriculture

Bush encroachment has serious economic implications in the agricultural sector in Namibia. It results in the decline of livestock production due to the loss of grass production on the grazing lands (de Klerk, 2004). It also results in lower productivity of individual animals

(Kruger, 2002). Most encroaching woody species are inedible to domestic livestock (Wiegand *et al.,* 2005). Bush encroachment has reduced the number of cattle on commercial farms by 47% over the last 30 years (de Klerk, 2004). According to Els (1995), bush encroachment remains the single most important factor that limits red meat production in commercial farms in Namibia. At the national level, bush encroachment has resulted in the loss of up to N$ 700 million in lost meat production each year (de Klerk, 2004).

2.3.2. Impact on botanical diversity

Bush thickening is seen as a major threat to the botanical diversity in Namibia (de Klerk, 2004). Namibia is considered to be floristically diverse (Directorate Environmental Affairs, 2003). Species richness and endemism are not high in bush encroached vegetation (de Klerk, 2004). Bush encroaching species usually have the ability to displace other plant species, resulting in a decline in plant diversity. Bush encroaching species have extensive and well-developed tap roots and lateral root systems that reach deep into the soil to obtain water and nutrients (Walker *et al.,* 1981). The grass roots usually occur in the topsoil layer and are unable to penetrate deep further into the soil (de Klerk, 2004). The grass-tree competition is vastly influenced by the amount of water retained in the upper soil layer and that which moves to the lower soil where tree roots predominate. In the case when the grass layer is over-utilized, it loses its competitive edge against the woody species and bush encroachment results (de Klerk, 2004). As a result, fewer non-woody species are found to occur in the bush encroached vegetations (de Klerk, 2004).

2.3.3. Impact on mammalian diversity

Joubert (2003) in his review on the habitat preference of mammals in the north-central part of Namibia, the area usually associated with bush thickening, noted the following: nineteen mammalian species were often associated with dense bush cover either as a habitat preference and/or for dietary preference. Ungulate species such as the kudu, duiker, dik-dik, giraffe, black rhino and elephant favoured dense bush areas. However, if the density of woody plants was extremely high, it limited the mobility of these browsers and resulted in the inaccessibility of available browse. Sixteen other mammalian species preferred sparse woodland as habitat (Joubert, 2003).

According to de Klerk (2004), ungulate species on Namibian farmlands show a habitat preference for more open areas with only 1.4% of ungulate recordings being made in thick bush. This suggests that bush thickening may have severe consequences for several ungulate species, and possibly for rare carnivores such as cheetahs on the Namibian farmlands. The increase in woody plant cover, therefore, can have major implications for conservation and management of savanna rangelands. (Tews & Jeltsch, 2004). The encroaching species affect the home ranges of all species requiring open savannas. Encroaching species also hinder the movement of species and thus affect their hunting and foraging success.

2.4. Bush encroachment and climate change

The bush encroachment problem is also inter-linked with climate change. Previous studies indicate that increased atmospheric carbon dioxide concentrations have an effect on the different floristic components of savanna ecosystems (Smith, 1999). Increases in atmospheric carbon dioxide improves water-efficiency and increase carbon up-take in

Acacias. Elevated CO_2 reduces the transpiration rate of grasses, causing deeper infiltration of water to the sub-soil and, therefore, favouring woody plants (Bond & Midgley, 2000). Carbon dioxide concentrations also influence the photosynthetic rates of plants and light- and nutrient-use efficiency (Drake *et al.,* 1997). According to Medlyn *et al.,* (1999), photosynthesis is enhanced more in woody shrubs (+45%) than grasses (+38%) or trees (+25 %) in response to CO_2 enrichment. Climate change is also known to prolong the severity of droughts. Such scenarios favours encroaching species as they can still extract moisture far below the soil as a result of their developed tap root and lateral root systems (de Klerk, 2004). The grass roots on the other hand usually obtain moisture in the topsoil layer, and therefore suffer severely during extended periods of droughts when moisture is scarce. During periods of droughts encroaching woody species have an advantage over grasses, and out-competes the grasses for available moisture. In the context of global climate change, increase in woody plant cover has been primarily linked with elevated CO_2 (Eamus & Palmer, 2007). Evidence suggests that elevated CO_2 affect individual plant species and community composition in ecosystems, favouring the survival, vegetative growth, seed production and seedling of encroaching species (Dirkx *et al.,* 2008).

2.5. Description of small mammals

Small mammals are a dominant group of mammals. They comprise nearly about 42% species of all mammal species known to occur on earth (Aplin *et al.,* 2003). Small mammals occupy a wide range of natural habitats around the world. Most small mammals are found in almost all parts of the world except Antarctica. Most small mammals are herbivorous and they create a broad basic layer of primary consumers in the food pyramids (Southern, 1979). Small mammals are prolific breeders and represent a large number of species biomass within their natural habitats (Aplin *et al.,* 2003).

According to Delany (1974), the term „small mammal" has a specific meaning and certainly does not embrace all kinds of small mammals. It is generally accepted to include the free-living small rodents and insectivores (Delany, 1974). The lower size limit set is based on the mass of the Etruscan shrew (*Crocidura etruscus*), the smallest known mammal, and weighing as little as 2 g. The upper limit is more difficult to define as there is a gradation in size to the very large species (Delany, 1974). According to Fleming (1979), the upper limit of the weight of small mammals is generally 5kg. Examples of small mammal species at the upper limit include many shrews, moles, most rats, mice, gerbils and some of the smaller squirrels among the rodents (Delany, 1974). For this study, only the shrews, rats, gerbils and mice were considered as the small mammals of interest.

2.6. Medical importance of small mammals

Small mammals may act as reservoirs of some of the most serious diseases affecting livestock and humans (Aplin, 2003). There are more than 35 diseases known to be spread by small mammals (http://www.cdc.gov/rodents/diseases/index.htm). Septicaemia plague ranks as one of the most important small mammal-borne diseases (http://www.cdc.gov/rodents/diseases/index.htm). It is essentially a disease of rodents; this bacterial disease is transmitted to humans by a flea, which previously has fed on infected small mammals. Rickettsia is another common disease of small mammals. It is transmitted to humans by the faeces of an infected rat flea and occasionally by inhalation of dust containing infected particles of flea faeces. Small mammal diseases are also transmitted to humans and livestock, through contaminated food, contaminated water and bite wounds (http://www.cdc.gov/rodents/diseases/index.htm). Other important diseases of small mammals include the Lassa fever, leptospirosis, tick-borne encephalitis, rat-bite fever and tularemia (Buckle & Smith, 1994; http://www.cdc.gov/rodents/diseases/index.htm).

2.7. Agricultural importance of small mammals

Small mammals have a detrimental effect on the agricultural sector. Small mammals are one of the major constraints to agricultural production (Aplin *et al.,* 2003). Many small mammals are omnivorous, and feed mainly on plant materials, which may include seeds, leaves, roots and young plants; and on animal tissue, insects and other invertebrates (Buckle & Smith, 1994). Many small mammal species have capacities to multiply rapidly, become pests and usually reduce crop yield and production on the fields (Buckle & Smith, 1994). Predation by small mammals is known to be the major threat to agricultural crops and plants (Aplin, 2003). According to Wenny (2000), rodents have diverse impact on the fate of seeds; they can limit the establishment of seeds through predation. Alternatively, they can enhance germination, by decreasing the density-dependent seed mortality by thinning, also mediated via predation (Forget *et al.,* 2002). The establishment of burrowing sites of small mammals on crop fields have negative impacts on the development of seedlings and growing plants.

2.8. Ecological importance of small mammals

While large mammals can be seen as regulators of savanna ecosystem processes (Bergstorm, 2004), smaller mammals may have equally important key functions as consumers of plant biomass (Keesing, 1998), as predators on and distributors of seeds (Bergstorm, 2004) and as a source of food for other vertebrate species (Linzey and Kesner, 1997) as well as for changing abiotic factors through burrowing and their impact on nutrient re-cycling (Bergstorm, 2004). Small mammals also constitute the primary link between primary producers and secondary consumers (Avenant & Cavallani, 2007). According to Keesing (1998), small mammals play another important role in their ecosystems when they interact with ungulates. Small mammals consume vegetation and therefore are potential competitors with herbivores (Keesing, 1998). Previous studies (Keesing, 1998; Rudinow Saetnan, 2000; Bergstorm, 2004) suggest that small mammals may compete for the same food resources as ungulates. Keesing (1998) indicates that the density of small mammals increases two-fold in the absence of ungulates and reduces the plant biomass by 40%. Small mammals can therefore impose a large impact on their environments, and are an important subject of research (Bergstorm, 2004).

2.9. Small mammals as bio-indicator species

Small mammals are also used as environmental indicators in disturbed habitats (Linzey & Kesner, 1997), as changes in the environment, caused by over-grazing, fire, and drought lead to changes in the habitats for small mammals which in turn quickly affects their abundance, survival and breeding success (Dooley & Bowers, 1996). In previous studies, rodent community structure and species richness have been related to habitat structure and complexity, area, productivity, predation, trampling, grazing and the maturity of the habitat/ succession of the vegetation (Avenant & Cavallani, 2007).

In general, a change in small mammal habitats is associated with changes in small mammal diversity and community structure (Hoffmann & Zeller, 2005). The ecological disturbance of these habitats is also associated with the presence or absence of indicator species and the decrease in small mammal species richness (Avenant & Cavallani, 2007). A healthy, diverse community of small mammals can thus serve as an indicator of good ecological conditions within the environment. There are some small mammals that are able to successfully tolerate and exploit the disturbance that occurs in their physical and biological environment, while others are unable to tolerate or adapt to changes in their environment (Nyako-Lartey & Baxter, 1995). *Gerbilliscus leucogaster* is regarded to be sensitive to overgrazing, while *Gerbillurus vallinus* and *Mastomys* spp. are the first species to dominate after disturbances occur such as drought, fire, over-grazing and cultivation (Hoffmann & Zeller, 2005).

CHAPTER 3

MATERIALS AND METHODS

3.1. Features of the study area

3.1.1. Location

The Neudamm Agricultural Farm is situated between 22°30.105'' S and 017°20.824'' E in the Khomas Region, central Namibia, approximately 30km north east of Windhoek (Figure 3.1). The Neudamm Agricultural Farm is situated within the semi-arid highland savanna; an area known to be affected by bush encroachment (Joubert *et al.,* 2008).The Khomas Region borders the Otjozondjupa, Omaheke, Erongo and Hardap Regions. The Neudamm Agricultural farm forms part of the Neudamm Agricultural Campus (Faculty of Agriculture and Natural Resources), which is part of the University of Namibia. The farm has six divisions; training, large stock, small stock, dairy, agriculture and general.

The farm covers an area of about 10, 187 hectares of land. The farm is divided into nine blocks and 210 camps. Two hundred (200) hectares of land are used for experimental growing of vegetables and maize. The whole border fences of the farm are jackal- proof. The large stock consists of Afrikander Cattle, dairy cows and horses. Different breeds of sheep and goats make up the small stock. Many wild species are also found on the farm, such as kudus, oryx, hartebeests, warthogs, waterbucks and baboons. The water supply is provided by nine boreholes some reaching down to depths of 120 meters. The farm also receives water from the Otjihase mine, during emergencies. Nampower supplies the farm with electricity.

Figure 3:1. The location of the study sites at the Neudamm Agricultural Farm in the Khomas Region in Namibia.

3.1.2. Climate

In summer, the days are warm and the nights are cool in the Khomas Region. The winter is usually experienced in May, June, July and August. The winters are generally cold with an average minimum temperature of 3° C (Joubert *et al.,* 2008). In summer the average maximum temperatures are about 29° C. Frost occurs between 10 and 20 nights/year (Mendelsohn *et al.,* 2002). The average annual temperature in the Khomas Region is 19.47 ° C. The mean annual rainfall on the farm is about 300 millimetres. Precipitation in the Khomas Region is highly variable and seasonal, 80% of the annual rainfall occurs between January and March (Joubert *et al.,* 2008). The Khomas region is about 1350-2400m above sea level (Joubert *et al.,* 2008).

3.1.3. Physical features, geology and soils

The Khomas Region is mountainous and characterized by three major mountain ranges namely the Eros Mountains to the north-east of Windhoek, the Auas Mountains to the south-east of Windhoek and the Khomas Hochland Mountain range to the west of Windhoek (Consulting Service Africa, 2005). The area around Windhoek is part of the South-West African plateaux (Bridges, 1990). The landscape at the western part of the Khomas Region contains plains with scattered inselbergs. To the east, the Neudamm highlands form a counter-part of the Khomas highlands (King, 1963). The mountains found around the north-western corner of the Neudamm farm peaks at around 2000 m (Bertram & Bramen, 1999). Further towards the east, the highlands sub-merge gradually into the Kalahari sands in the intramontane plain of the Seeis (King, 1967).

Soils (lithic leptosols) in the area are generally shallow; often with a cover of quartzitic pebbles that improves soil moisture (Joubert, 1997). The soils are also skeletic on the slopes, where they can turn into blockfields and bare bedrock (Ganssen, 1963). The soils are rich in material derived from physical weathering (Scholz, 1973). The soils contain very little organic matter because of low litter supply and rapid mineralization (Bertram & Bramen, 1999). This results in soils with low water-holding capacities. Duricrusts like calcrete, silcrete and ferricrete are common compounds in the soils (Bertram & Bramen, 1999).

3.1.4. Vegetation

The Neudamm Agricultural Farm is situated within the semi-arid highland savanna, an area known to be affected by bush encroachment (Joubert *et al.,* 2008). The vegetation in the region is characterized by woody species such as *Acacia hereroensis*, *A. hebeclada, A. reficiens, Euclea undulata, Dombeya rotundifolia, Tarchonanthus camphoratus, Rhus marlothii, Albizia anthelmintica* and *Ozoroa crassinervia* (Joubert *et al.,* 2008). *Acacia mellifera* is the dominant woody species in the Khomas Region. The common grasses in the area are *Brachiaria nigropedata, Anthephora pubescens, Heteropogon contortus, Cymbopogon spp., Digitaria eriantha* and *Eragrostis nindensis*. *Eragrostis nindensis* is considered a sub- climax grass and is the most abundant grass species in the area (Joubert *et al.,* 2008).

3.2. Methods

3.2.1. Identification of the sites

The Neudamm Agricultural Farm was accessible for the whole duration of this study. A preliminary survey was conducted on the Neudamm Farm, to select the bush encroached and non-bush encroached sites. Various sites in different camps on the farm were visited; before the appropriate sites were selected. The areas that were considered bush encroached, were dominated by encroaching species (predominately *A. mellifera*). An area was considered to be bush encroached when the woody density of the encroaching species was > 1,000 bushes per 1 ha **(**de Klerk, 2004). Non-bush encroached (open savannas) sites were areas with a woody density of <1,000 bushes per 1ha (de Klerk, 2004). Two sites were selected for the study, bush encroached and non-bush encroached sites on the farm.

3.2.2. Experimental design

The selected sites were located in the A20 and B11 camps of the farm. Two 1ha grids were established in the bush encroached (22°30.105‟S, 017°20.824 E; and 22°30.143‟ S, 017°20.469 E) and non-bushed encroached (22°30.471‟ S, 017°20.216‟ E; and 22°30.773‟ S, 017°20.730 E) sites. The grids (named Grid 1, Grid 2, Grid 3 and Grid 4) were demarcated with metal droppers. Grid 1 and Grid 3 were situated in the bush encroached sites; Grid 2 and Grid 4 were situated in the non-bush encroached sites.

All the grids were spaced at least 1 km apart from each other. According to Eiseb, S. (personal communication, December 2009) this was done to avoid catching small mammals from adjacent grids, during the study. Each sampling grid consisted of 100 small mammal Sherman-live traps (23 x 8 x 9 cm) (Forestry Suppliers Inc., Jackson MS, USA) (Leirs, 1995;

Nyako-Lartey & Baxter, 1995). The metal droppers were labelled from letter A to J, and each letter numbered from 1 to 10. The traps were placed in 10 rows and 10 columns and were spaced at 10m intervals forming an area of 1hectare (100 m x 100 m) (Hoffmann & Zeller, 2005) (Figure 3.2).

3.2.3. Measurement and estimation of woody and grass cover

The woody cover for each grid was determined using the line intercept method (Barbour *et al.,* 1987). Four 100 m lines in each grid were stretched out using a measuring tape. The lines were spaced at intervals of 20 m within the grid. The beginning and end of each woody plant intercepting the tape was measured and recorded. For taller plants which intercepted the tape, the intercepting part was projected onto the tape and the distance recorded. Using the nested plot design (Barbour *et al.,* 1987), the percentage cover for grasses was visually estimated in eight selected 1 m^2 plots (6 plots were situated at the edges of the1ha grid and two plots at the centre of the grid) in each grid; in both the bush encroached and non-bush encroached sites.

3.2.4. Measurement and estimation of woody density

Each 1 ha grid was partitioned into 25 plots; measuring 20 m x 20 m. All individual woody plants were counted and recorded in each plot. The density of woody plants per plot were calculated and expressed per hectare. The mean density of woody plants was determined in the bush encroached and non-bush encroached grids.

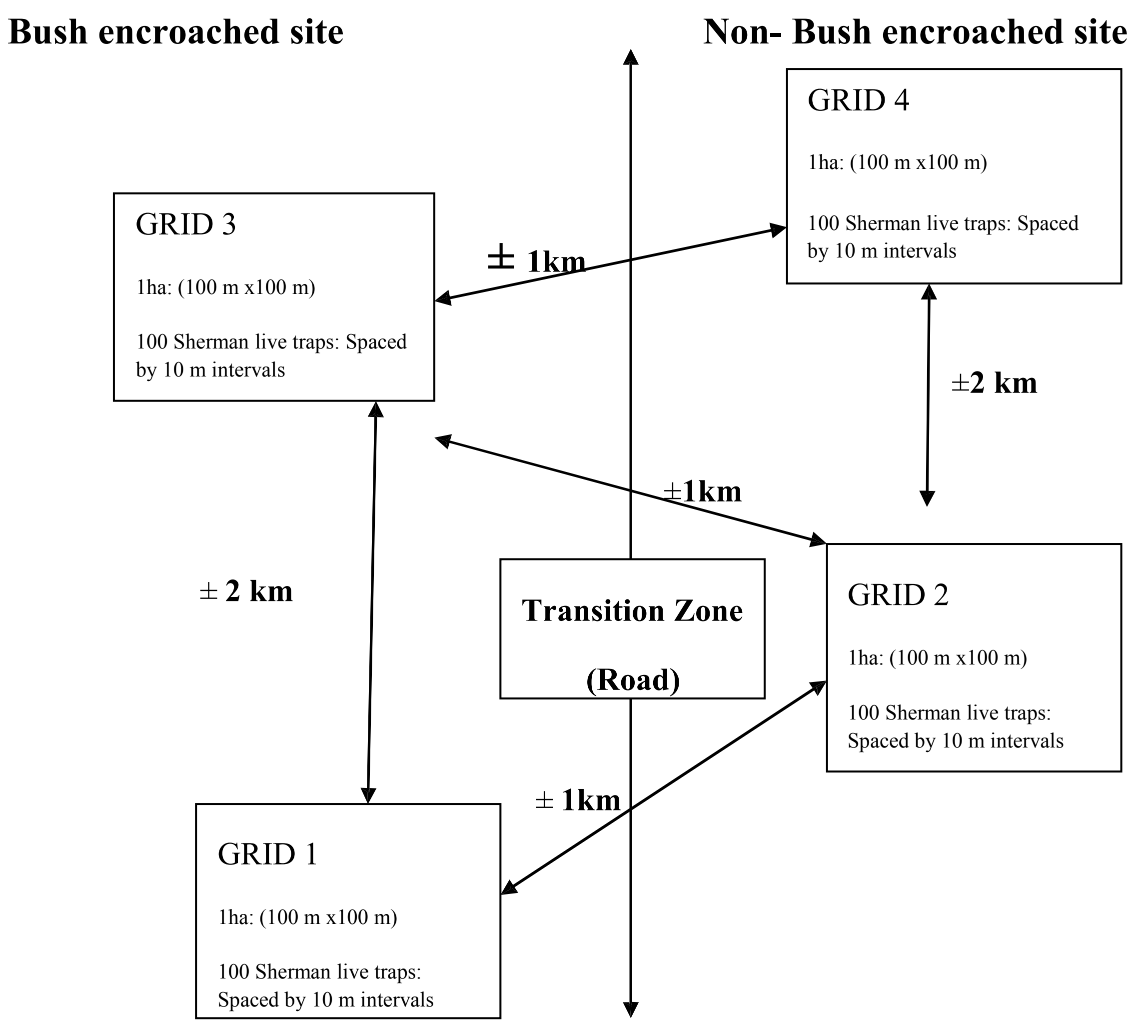

Figure 3.2: The experimental design in the bush encroached (Grid 1 and Grid 3) and non-bush encroached sites (Grid 2 and Grid 4) at the Neudamm Agricultural Farm.

3.5.5. Field trapping of small mammals

The Capture-Mark-Recapture technique was used to capture small mammals to generate data that was used to estimate the population abundance of small mammals in the bush encroached and non-bush encroached sites. The Petersen method was used (Kreb, 1999). This method is based on a single episode of marking animals, and a second single episode of recapturing individuals (Krebs, 1999). The aim is to mark a number of individuals over a short period, release them, and then to recapture individuals to check for marks (Krebs, 1999). All the individuals (marked and non -marked) must have an equal chance of being captured in the preceding samples (Krebs, 1999). The goal was to calculate the proportion of marked animals in the recapture sample which were equal to the proportion of all marked animals in the whole population. The following formulae was used:

$N = M(C+1)/(R+1)$

Where N is the number of animals in the population at the time of marking, M is the total number of individuals marked in the first sample, C is the total number of individuals captured in the second sample and R is the number of individuals in second sample that are marked. The assumption of the Petersen method:

i) All animals have the same chance of getting caught in the first sample.

ii) Marking individuals does not affect their catchability.

iii) Animals do not lose marks during trapping sessions.

iv) All marks are reported upon discovery in each sample.

Nocturnal small mammals were targeted for this study. This was done, in order to obtain a higher sample size of small mammals during the study. According to Stuart & Stuart (2007) many small mammals exhibit temperature preferences and prefer to forage for prey and carry out their activities during the night, when the temperatures are cooler. Trapping of small mammals was conducted in December 2009 („Hot –dry" season), in April 2010 ("hot-wet" season) and July 2010 ("cold- dry" season) (http://www.climatetemp.info/namibia/windhoek). The small mammals were collected over three consecutive trapping nights. A total of three trapping sessions in three trapping seasons were carried out on the farm. Trapping session refers to three consecutive nights of trapping per season. A total of 3600 trap nights were carried out on the farm. Traps were set a day before the start of the trapping session. Each trap was baited with a mixture of oats and peanut butter. The traps were checked in the morning between 07:00 and 11:00 and reset between 16:00- 18:00 for three consecutive nights.

3.5.6. Measurements of small mammals

The research permit was obtained at the Ministry of Environment and Tourism. The research permit number was 1444/2010. Small mammals were only allowed to be captured and collected in non-conservation areas. Small mammals were maintained under the guidelines of the American Society of Mammalogists (www.mammalogy.org/committees/index.asp). The traps were closed during the day to prevent the capturing of diurnal small mammals and non target taxa. The non target species captured during trapping, were released at the point of capture. The small mammals captured during the trapping sessions were only used for the purpose of this study.

The captured small mammals were placed in separate plastic bags and were weighed to the nearest gram using a 100 g Pesola spring balance (Forestry Suppliers Inc., Jackson MS, USA) The standard body measurements (the tail, ear, left hind foot (with claws) and head body length) (Stuart & Stuart, 2007), were recorded, after the animals were immobilized in the transparent plastic bags. The head body length was the total length of the species minus the tail length (Stuart & Stuart, 2007). The standard body measurements taken were used to identify the small mammals to the genus and species level. Each trapped small mammal was sexed, and assigned to the relative age classes (juveniles, sub adults and adults). Relative age class was assigned to individual small mammal species by comparing all the small mammal species captured in the sample areas. The category for adult referred to the large and potentially breeding members of the population. The category for sub-adult individual referred to a young and medium sized non- breeding small mammal. The juvenile individual small mammal was generally much smaller in size than the sub-adult. The reproductive status of the small mammals was also determined. The male small mammals were examined to determine whether they were breeding (descended testes) or non - breeding (abdominal testes). The female small mammals were also examined and their reproductive status was determined, breeding (opened vagina, pregnant or lactating) or non breeding (closed vagina). The overall appearance of the small mammals was also taken into consideration, to identify the animals to species level using de Graaf (1981) and Stuart & Stuart (2007). The Capture-Mark-Recapture technique was used to capture small mammals and to generate data used to estimate the population density of small mammals in the bush encroached and non-bush encroached sites. The simple toe-clipping technique (Gannon *et al.,* 2007) was used in marking the small mammals.

3.5.7. Data analysis

The Shannon-Wienner index of diversity (Shannon & Weaver, 1949) was used to compare the small mammal diversity in the bush encroached and non-bush encroached sites based on the following formula.

$$H' = -\sum_{i=1}^{s} (p_i)(\ln p_i)$$

Where p*i* is the proportion of individuals found in the ith species, *ln* is the natural logarithm and s is the total number of species (Krebs, 1999). The index is one of several diversity indices used to measure diversity in categorical data. This Shannon-Wienner index takes into account species richness as well as evenness, thus giving a good measure of species diversity (Krebs, 1999).

The Hierarchical Cluster Analysis (HCA) was used to determine and compare species composition of small mammals in the bush encroached and non-bush encroached sites. The Hierarchical Cluster Analysis (HCA) is a multivariate test that groups observations by similarity and dissimilarity (Gauch, 1982). Using the Bray-Curtis similarity analysis, the group average linkage method was performed on the small mammals‟ data in the three seasons. The cluster analysis was also used to generate dendrograms that showed similarities and dissimilarities, among the small mammal species that were captured in the bush encroached and non-bush encroached sites in all the seasons.

The data that were collected on vegetation structure and small mammals were analyzed in Statistical Package for the Social Sciences for Windows (SPSS). A Kolmogorov-Smirnov (K-S) test was used to determine whether the data on vegetation structure (woody density, woody cover and grass cover) and small mammals‟ (number of females and males in breeding condition; population density and species diversity) data followed a normal distribution or not.

The Kolmogorov-Smirnov (Ashcroft & Pereira, 2003) normality test conducted on the data revealed that the woody density data was normally distributed ($D= 0.071$; $p<0.200$). The test also revealed that the data pertaining to the woody cover ($D=0.253$; $p<0.0001$), grass cover ($D=0.368$; $p<0.00001$) data was normally distributed.

The data pertaining to the abundance of small mammals ($D=0.293$; $p<0.025$), the males in breeding condition ($D=0.189$; $p<0.00001$), the females in breeding condition ($D=0.196,$

$p<0.00001$), the diversity (*D=0.385*, $p<0.00001$) and population density (*D=0.253,* $p<0.00001$) of small mammals were not normally distributed.

The independent t-test was used to determine whether there were any significant differences in the mean woody density between the bush encroached and non-bush encroached sites on the farm. The independent t-test is sometimes referred to as an unpaired (Ashcroft & Pereira, 2003). The test is used to determine whether the means of two independent samples are different to conclude they are drawn from separate populations (Ashcroft & Pereira, 2003). The independent t-test was useful for testing for significant difference for the woody density obtained in the bush encroached and non-bush encroached sites. The test hypothesized (null hypothesis) that the means of wood density would not be different between the bush encroached and non-bush encroached sites.

The Kruskal Wallis test was used to determine whether there were any significant differences in the number of males and females, estimated population density and species diversity of small mammals among the three seasons between the bush encroached and non-bush encroached sites on the farm. The test was also used to determine whether there were any significant differences in the mean woody cover among the three seasons between the bush encroached and non-bush encroached sites. The Kruskal Wallis test was also used to determine whether there was any significant difference in the grass cover amongst the different seasons between both sites. The Kruskal Wallis test is a non-parametric test that compares three or more unpaired groups. It is the alternative test to the one-way ANOVA (Ashcroft & Pereira, 2003). The Kruskal-Wallis tested the null hypothesis that there were no significant differences between the median values of the woody cover, grass cover, mean abundance and diversity of small mammals data, between the bush encroached and non-bush encroached sites. (Ashcroft & Pereira, 2003).

The Mann-Whitney U-test is a powerful nonparametric statistical test equivalent to the *t*-test (Runyon *et al.,* 1996). The test uses most of the quantitative information inherent in the data (Runyon *et al.,* 1996).The Mann-Whitney U-test is used to determine whether the medians of two independent samples are different enough to conclude that they were drawn from different populations (Ashcroft & Pereira, 2003). The test was used to determine whether there was any significant difference in the woody, grass cover, females and males in breeding condition between the bush encroached and non-bush encroached sites.

The Chi-square test was used to test for significant differences in the proportions of small mammals captured between the bush encroached and non- bush encroached sites. The chi-square test was also used to test significant differences in the number of individual males and females captured in the bush encroached and non-bush encroached sites. Chi-square test is a non-parametric test and therefore makes no requirement concerning normally distributed data (Runyon *et al.,* 1996). The Chi-square test may only be used to test the data, if the sample size is large enough and the samples tested are independence of one another (Runyon *et al.,* 1996).

The Spearman‟s correlation coefficient (r) test was used to determine whether there was any significant relationship between the vegetation cover and abundance of small mammals in the bush encroached and non-bush encroached sites. It was also used to determine any significant relationship between the vegetation cover and population density of small mammals between the bush encroached and non bush encroached sites in the different seasons. The Spearman‟s correlation coefficient is also known as the Pearson‟s correlation coefficient (Runyon *et al.,* 1996). It is used to measure the strength of the linear relationship or association between two independent variables (Ashcroft & Pereira, 2003).

CHAPTER 4

RESULTS

4.1. Vegetation structure

4.1.1. Woody density

The common woody species in the area were *Acacia mellifera*, *A. erioloba, A. reficiens, A. hebeclada*, A. *hereroensis*, *A. karroo*, *Euclea undulate, Prosopis glandulosa* and *Cataphractes alexandri*. The mean density of woody plants in the bush encroached and non-bush encroached sites were 1441.50/ha and 573.50/ha, respectively (Figure 4.1). The independent sample t-test (t_{49}=8.258; *n= 50*; p<0.001) revealed that there was significant difference in the mean density of woody plants between the bush encroached (BE) and non-bush encroached (NBE) sites. The bush encroached sites had a higher woody density than the non- bush encroached sites.

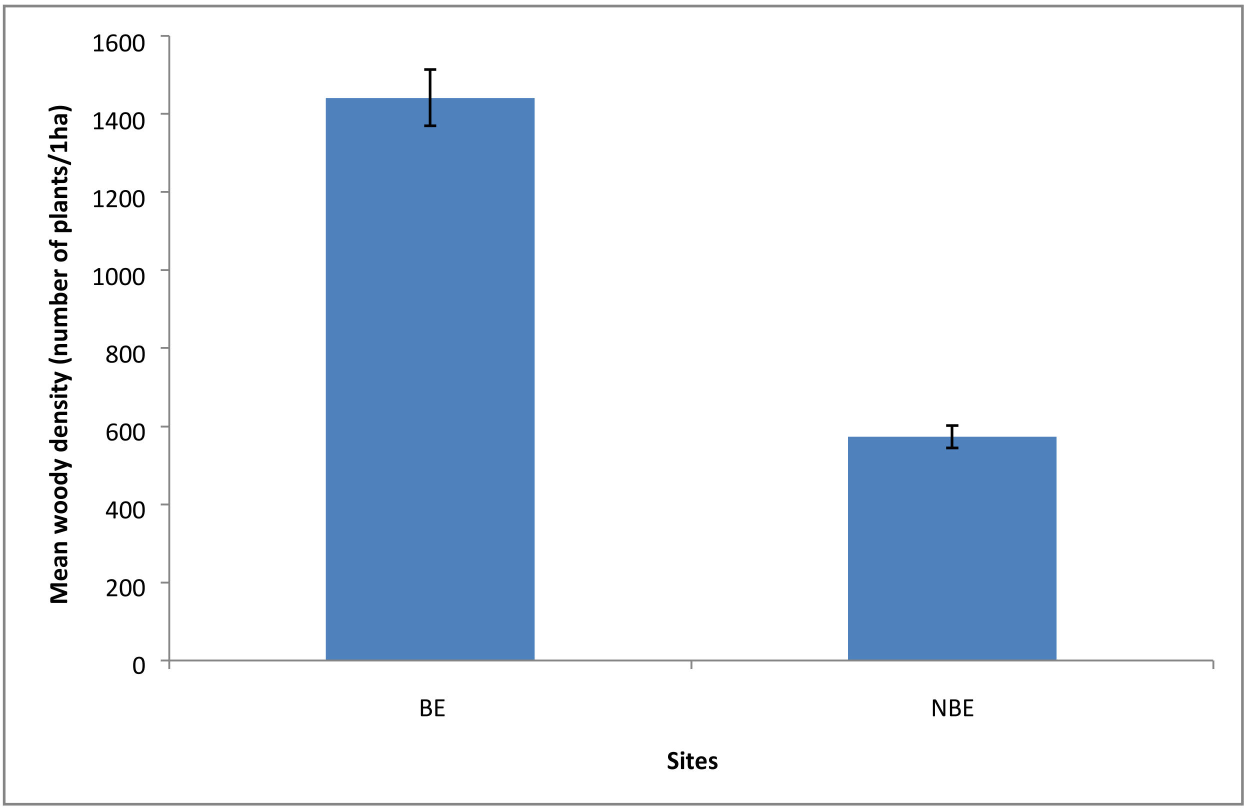

Figure 4.1: The mean density of woody plants (number of plants per ha) in the bush encroached (BE) and non-bush encroached (NBE) sites at the Neudamm Agricultural Farm during the "hot- dry" season (December 2009). Bars indicate standard errors of the mean.

4.1.2. Woody cover

The mean woody cover in the bush encroached sites was 35% during the "hot-dry" season (December 2009). The mean woody cover increased to 39% during the "hot-wet" season (April 2010) and declined to 36% in the cold and dry season (July 2010) (Figure 4.2). The Kruskal Wallis test revealed that there was a significant difference (H_8=0.02; n = 8; p< 0.001) in the mean woody cover in the bush encroached sites among the three seasons.

In the non-bush encroached sites, the mean woody cover increased from 13% during the hot and dry season (December 2009) and doubled to 26% during the "hot-wet" season (April 2010). The mean woody cover then declined to 14 % during the "cold-dry" season (July 2010). The Kruskal Wallis test revealed that there was a significant difference (H_8=0.86;

n=8; p< 0.001) in the mean woody cover in the non- bush encroached sites among the three seasons.

The Mann- Whitney U test revealed a significant difference in the woody cover between the bush encroached and non-bush encroached sites during the "hot-dry" season (December 2009) (U_7=11.00; *n=8*; p=0.027), "hot -wet" season (April 2010) (U_7=8.00; *n=8*; p<0.0001) and during the "cold–dry" season (July 2010) (U_7=7.00; *n=8*; p<0.009). The tests showed that the bush encroached sites had a higher woody cover than the non-bush encroached sites.

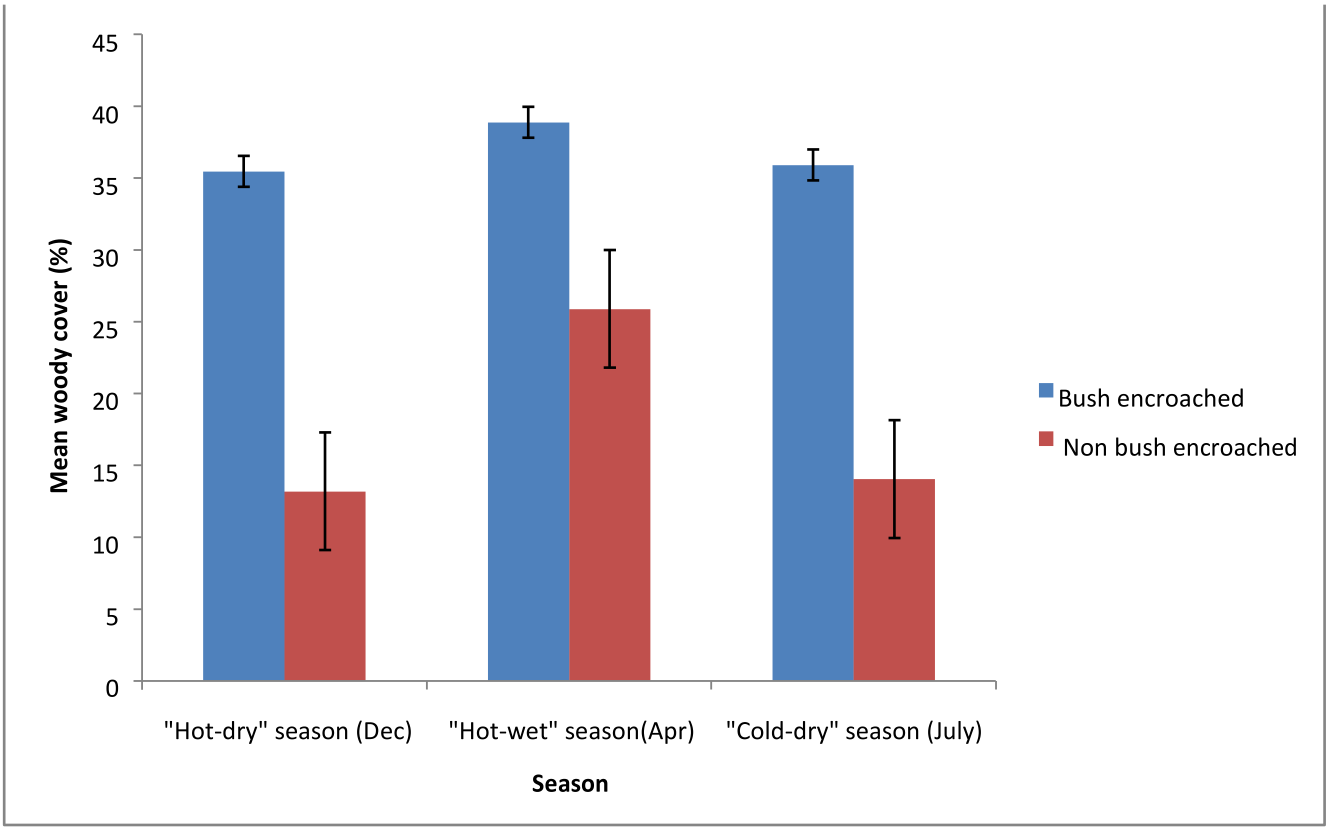

Figure 4.2: The mean percentage cover (%) of woody plants in the bush encroached (BE) and non-bush encroached (NBE) sites at the Neudamm Agricultural Farm in the "hot-dry" season (December 2009), "hot-wet" season (April 2010) and "cold-dry" season (July 2010). Bars indicate standard errors of the means.

4.1.3. Grass cover

The common grasses in the bush encroached and non-bush encroached sites were *Stipagrostis uniplumis, Cenchrus ciliaris, Cynodon dactylon, Enneapogon cenchroides, Aristida adecen, Eragrostis nindensis, Brachiaria nigropedata, Anthephora pubescens, Heteropogon contours, Cymbopogon spp.,* and *Digitaria eriantha*. The mean grass cover in the bush encroached sites was 7.5% in the "hot-dry" season (December 2009). The mean grass cover increased to 10 % in the "hot–wet" season (April 2010) and to 12% during the "cold-dry" season (July 2010). The Kruskal Wallis test revealed no significant difference (H_7=0.69; $n=7$; p=0.708) in the mean grass cover in the bush encroached sites among the three seasons.

The mean grass cover in the non-bush encroached sites was 44% in the "hot-dry" season (December 2009). The mean grass cover increased to 46% in the "hot–wet" season (April 2010) and to 49% during the "cold-dry" season (July 2010). The Kruskal Wallis test revealed a significant difference (H_7=0.28; $n=8$; p<0.0001) in the mean grass cover in the non-bush encroached sites among the three seasons.

The Mann Whitney U Test revealed a significant difference in the grass cover between the bush encroached and non-bush encroached sites during the "hot-dry" season (December 2009) (U_7=23.00; $n=8$; p<0.0001), "hot-wet" season (April 2010) (U_7=20.00; $n=8$, p<0.0001) and during the "cold-dry" season (July 2010) (U_7=25.00; $n=8$; p<0.0001). The tests showed that the non-bush encroached sites had a higher grass cover than the bush encroached sites (Figure 4.3).

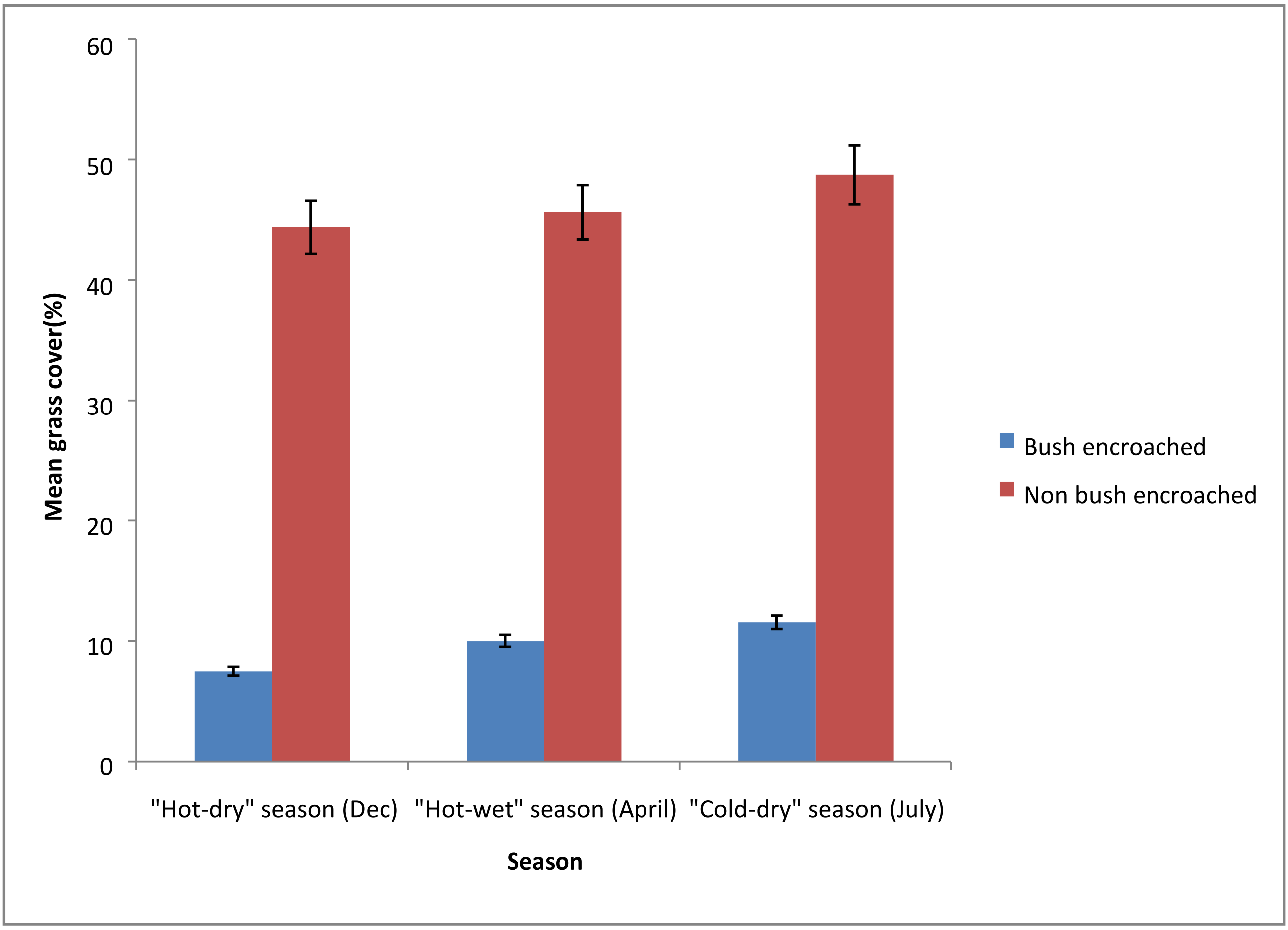

Figure 4.3: The mean grass cover (%) in the bush encroached and non-bush encroached sites at the Neudamm Agricultural Farm in "hot-dry" season (December 2009)," hot-wet" season (April 2010) and "cold-dry" season (July 2010). Bars indicate standard errors of the means.

4.2. Small mammals trapped

4.2.1. Abundance of small mammals

A total of 111 individual small mammals belonging to 5 species were captured in the bush encroached sites during the "hot-dry" season (December 2009). *Rhabdomys pumilio* dominated the catches (*n = 63*), followed by *M. namaquensis* (*n= 22)*. The least captured small mammals were *Mastomys spp.* (*n= 7*) and *E. intufi* (*n= 5*) (Table 4.1.). A total of 77 individual small mammals belonging to 5 species were captured in the non-bush encroached sites during the "hot-dry" season (December 2009). *R. pumilio* dominated the catches (*n=*

46), followed by *M. namaquensis* (*n= 11*). The least captured small mammal species was *Mastomys spp.* (*n= 2*) (Table 4.1.).

During the "hot-wet" season (April 2010), a total of 103 individual small mammals belonging to 6 species were captured in the bush encroached sites. *Rhabdomys pumilio* dominated the catches (*n= 71*), followed by *G. leucogaster* (*n= 25*). The least captured small mammals were *Mastomys spp.* (*n= 1*) (Table 4.1.). A total of 122 individual small mammals belonging to 6 species were also captured in the non-bush encroached sites during the "hot-wet" season (April 2010). *Rhabdomys pumilio* dominated the catches (*n= 85*), followed by *M. namaquensis* (*n= 16*). The least captured small mammal species were *G. leucogaster* (*n= 3*) followed by *Mastomys spp.* (*n= 2*) (Table 4.1.).

During the "cold-dry" season (July 2010), a total of 27 individual small mammals belonging to 6 species were captured in the bush encroached sites. *Rhabdomys pumilio* and *M. namaquensis* (*n= 8*) dominated the catches (*n= 8*). The least captured small mammals were *Mastomys spp.* (*n= 2*) and *T. paedulcus* (*n= 2*) (Table 4.1.). A total of 50 individual small mammals belonging to 6 species were captured in the non-bush encroached sites during the "cold-dry" season (July 2010). *Rhabdomys pumilio* dominated the catches (*n= 32*), followed by *M. namaquensis* (*n= 8*). The least captured small mammal species were *Mastomys spp.* (*n= 1*) and *Crocidura spp.* (*n= 1*) (Table 4.1.).

Table 4.1. Total number of small mammal species (species richness) captured over the 3600 trap nights in the bush encroached and non-bush encroached grids at the Neudamm Agricultural Farm during the "hot –dry" season (December 2009), "hot-wet" season (April 2010) and "cold-dry" season (July 2010) trapping sessions.

Species	**Order**	**Family**	**Abundance of small mammals (total number)**					
			"Hot-dry" season		**"Hot-wet" season**		**"Cold-dry" season**	
			BE	**NBE**	**BE**	**NBE**	**BE**	**NBE**
Rhabdomys pumilio	Rodentia	Muridae	63	46	71	85	8	32
Micaelamys namaquensis	Rodentia	Muridae	22	9	6	16	8	8
Elephantulus intufi	Macroscelidea	Macroscelididea	5	9	0	12	4	2
Gerbilliscus leucogaster	Rodentia	Muridae	14	11	25	3	3	6
Mastomys spp.	Rodentia	Muridae	7	2	1	2	2	1
Crocidura spp.	Eulipotyphla	Soricidea	0	0	0	4	0	1
Thallomys paedulcus	Rodentia	Muridae	0	0	0	0	2	0
Sum of captures			**111**	**77**	**103**	**122**	**27**	**50**
Species richness			**5**	**5**	**6**	**6**	**6**	**6**

R. pumilio dominated the male and female small mammals captured in the bush encroached and non- bush encroached sites among the three seasons (Table 4.2). In the bush encroached sites, a total of 29 and 36 individual *R. pumilio* males were captured respectively during the "hot-dry" season (December 2009) and "hot-wet" season (April 2010). During the "cold-dry" season (July 2010) only two individual *R. pumilio* males were captured in the bush encroached sites. A total of 34 and 35 individual *R. pumilio* females were captured respectively during the "hot-dry" season (December 2009) and "hot-wet" season (April 2010) in the bush encroached sites. During the "cold-dry" season (July 2010), only eight individual *R. pumilio* females were captured in the bush encroached sites.

In the non-bush encroached sites, a total of 29 and 35 individual *R. pumilio* males were captured respectively during the “hot-dry” season (December 2009) and “hot-wet” season (April 2010). During the “cold-dry” season (July 2010) only one individual *R. pumilio* male was captured in the bush encroached sites. A total of 15, 35 and 31 individual *R. pumilio* females were captured respectively during the “hot-dry” season (December 2009), “hot-wet” season (April 2010) and in the “cold-dry” season (July 2010) in the non-bush encroached sites. *Crocidura spp.* and *T. paedulcus* had the least number of male and female small mammal species captured in the bush encroached and non bush encroached sites during the three seasons (Table 4.2.). Statistical analysis revealed that there was no significant difference ($\chi 2_{11}$ = 9.333; n= *12*; p=0.407) in the number of individual males of small mammals captured between the bush encroached and non-bush encroached sites. There was also no significant difference ($\chi 2_{11}$ = 10.00; n= *12*; p=0.530) in the number of individual females of small mammals captured between the bush encroached and non-bush encroached sites.

Table 4.2. Total number of individual males and females of different species of small mammal species captured over the 3600 trap nights in the bush encroached (BE) and non-bush encroached (NBE) sites at the Neudamm Agricultural Farm during the "hot-dry" season (December 2009), "hot-wet" season (April 2010) and "cold–dry" season (July 2010) trapping sessions.

	Total number											
	"Hot-dry" season				**"Hot-wet" season**				**"Cold-dry" season**			
	BE		**NBE**		**BE**		**NBE**		**BE**		**NBE**	
Species	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Rhabdomys pumilio	29	34	29	15	36	35	35	48	2	6	1	31
Micaelamys namaquensis	17	4	5	4	3	3	10	6	0	8	0	8
Elephantulus intufi	1	4	2	7	11	10	7	5	3	1	1	1
Gerbilliscus leucogaster	7	7	6	5	1	0	1	2	1	2	3	3
Mastomys spp.	5	2	2	0	1	0	1	1	0	2	0	1
Crocidura spp.	0	0	0	0	0	0	1	3	0	0	1	0
Thallomys paedulcus	0	0	0	0	0	0	0	0	0	2	0	0

4.2.2. Breeding condition of small mammals

The mean number of female small mammals in breeding condition that were captured in the bush encroached (BE) sites, ranged from 11 individuals during the “hot-dry” season (December 2009) to 3 individuals in the “cold-dry” season (July 2010) (Figure 4.4a.). The mean number of female small mammals in breeding condition were highest during the hot and dry season (December 2009) (*n= 11*). In the non-bush encroached (NBE) sites, the mean number of female small mammals in breeding condition that were captured ranged from 6 individuals in the “hot-dry” season (December 2009) to 1 individual during the “cold-dry” season (July 2010) (Figure 4.4a.). The highest mean number of females in breeding condition were captured during the “hot-wet” season (April 2010) (*n= 10*). There was significant difference (H_8=8.00; *n= 9*; p<0.02) in the mean number of females in breeding condition in the bush encroached (BE) and non-bush encroached sites (NBE) among the three seasons. The Mann Whitney U test revealed that the mean number of females in breeding condition were significantly (U_7=25.00; *n=8*; p<0.0001) lower in the bush encroached and non-bush encroached sites during the “cold-dry” season (July 2010) (Figure 4.4a).

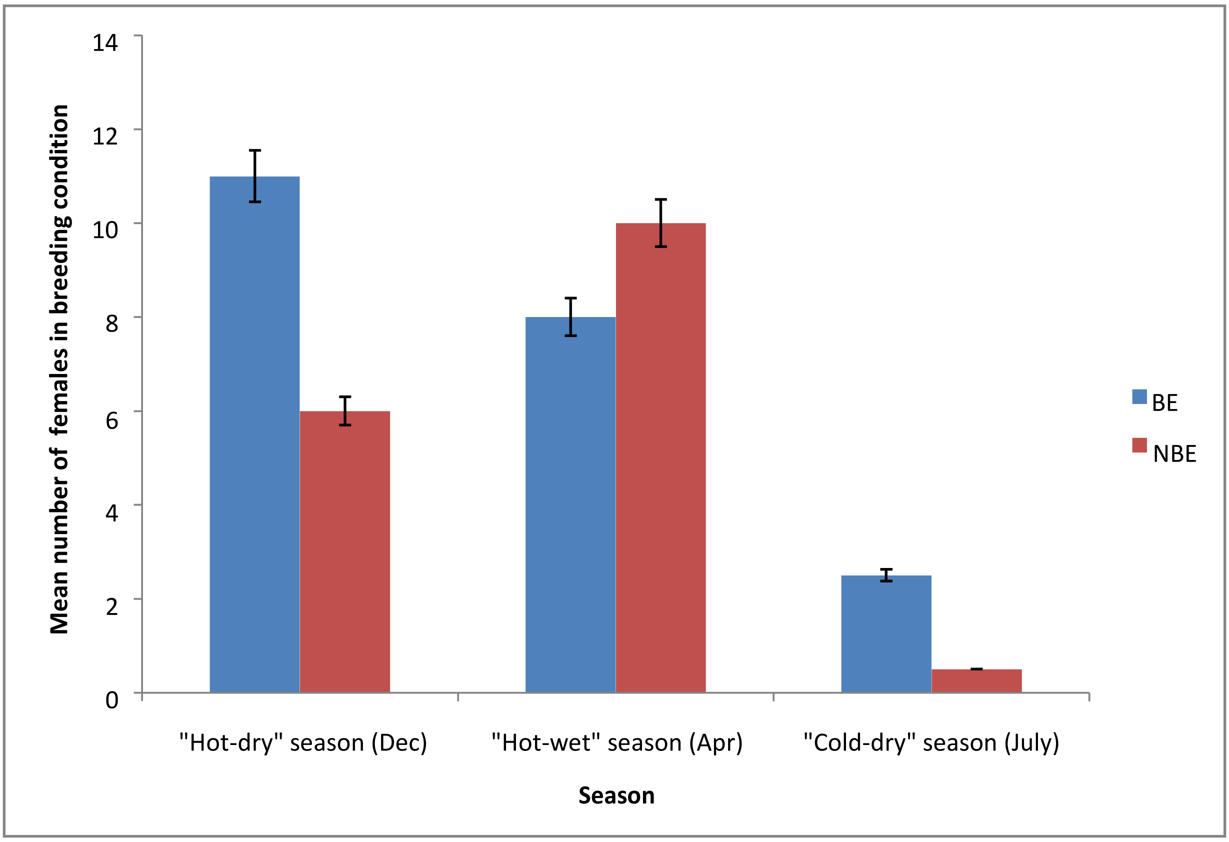

Figure 4.4a: The mean number of female small mammals in breeding condition in the bush encroached (BE) and non-bush encroached (NBE) sites at the Neudamm Agricultural Farm in the "hot-dry" season (December 2009), "hot-wet" season (April 2010) and in the "cold- dry" season (July 2010). Bars indicate standard errors of the means.

The mean number of male small mammals in breeding condition that were captured in the bush encroached (BE) sites, ranged from 24 individuals during the "hot-dry" season (December 2009) to 3 individuals in the "cold-dry" season (July 2010) (Figure 4.4b.). The highest mean number of males in breeding condition were captured during December 2009 ($n = 24$). In the non-bush encroached (NBE) sites, the mean number of male small mammals in breeding condition that were captured ranged from 20 individuals in December 2009 to 3 individuals in July 2010 (Figure 4.4b.). The highest mean number of males in breeding condition were captured during December 2009 ($n = 20$).

There was a significant difference (H_8=16.00; n= 9; p<0.0001) in the mean number of males in breeding condition in the bush encroached (BE) and non-bush encroached sites (NBE) among the three seasons. The Mann -Whitney U test revealed that the mean number of males in breeding condition were significantly (U_7=26.00; n=8; p<0.0001) lower in the bush encroached and non-bush encroached sites during the "cold-dry" season (July 2010) (Figure 4.4b).

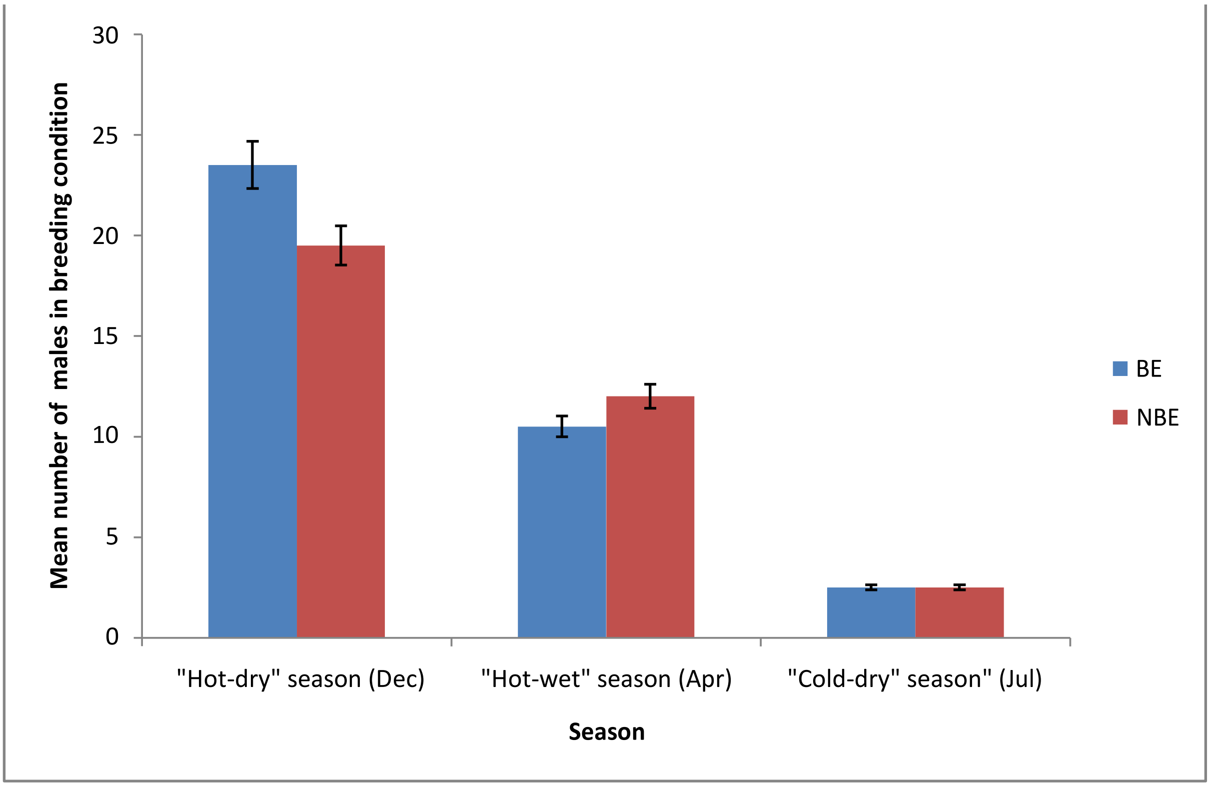

Figure 4.4b: The mean number of male small mammals in breeding condition in the bush encroached (BE) and non-bush encroached (NBE) sites at the Neudamm Agricultural Farm in the "hot-dry" season (December 2009), "hot-wet" season (April 2010) and in the "cold- dry" season (July 2010). Bars indicate standard errors of the means.

A total proportion of 85% adult small mammals were recorded in the bush encroached (BE) sites during "hot-dry" season (December 2009). The proportion of the captures declined to

46% during the “hot-wet” season (April 2010) and to 37% during the “cold-dry” season (July 2010) (Figure 4.5). The total proportion of sub adults recorded in the bush encroached sites was 14% during the “hot-dry” season (December 2009). The proportion of sub adults recorded increased drastically to about 41% during the “hot-wet” season (April 2010). The proportion of sub adults recorded declined in the “cold-dry” season (July 2010). The highest proportion of juvenile small mammals was recorded during the “hot-wet” season (April 2010) (Figure 4.5).

In the non bush encroached sites (NBE), a total proportion of 83% adult small mammals were recorded during the “hot-dry” season (December 2009). The proportion of adults declined to 42% during the “hot-wet” season and increased to 54% during the “cold-dry” season (July 2010). The proportion of sub adult small mammals recorded increased drastically from 16% during the “hot-dry” season to 45% during the “hot-wet” season. The proportion of sub adults captured in the “cold-dry” season (July 2010) also declined (Figure 4.5). The highest proportion of juvenile small mammals was also recorded during the “hot-wet” season (April 2010) in the non bush encroached sites. The proportion of juvenile small mammals recorded during the “cold-dry” season (July 2010) declined (Figure 4.5). There was no significant difference ($\chi2_{17}$=18.00; *n= 18*; p=0.389) in the proportions of small mammals captured between the bush encroached and non-bush encroached sites among the three seasons.

The correlation coefficient test revealed that the abundance of small mammals was not significantly correlated with the vegetation cover in the bush encroached (r_8=0.973; *n= 9*; P=0.749) and non-bush encroached sites (r_8=0.899; *n= 9*; P=0.069) among the three seasons. The test also revealed that the population density of small mammals was not significantly correlated to the vegetation cover in the bush encroached (r_8=0.782; *n= 9*; P=0.064) and non-bush encroached sites (r_8=0.973; *n= 9*; P=0.059) among the three seasons.

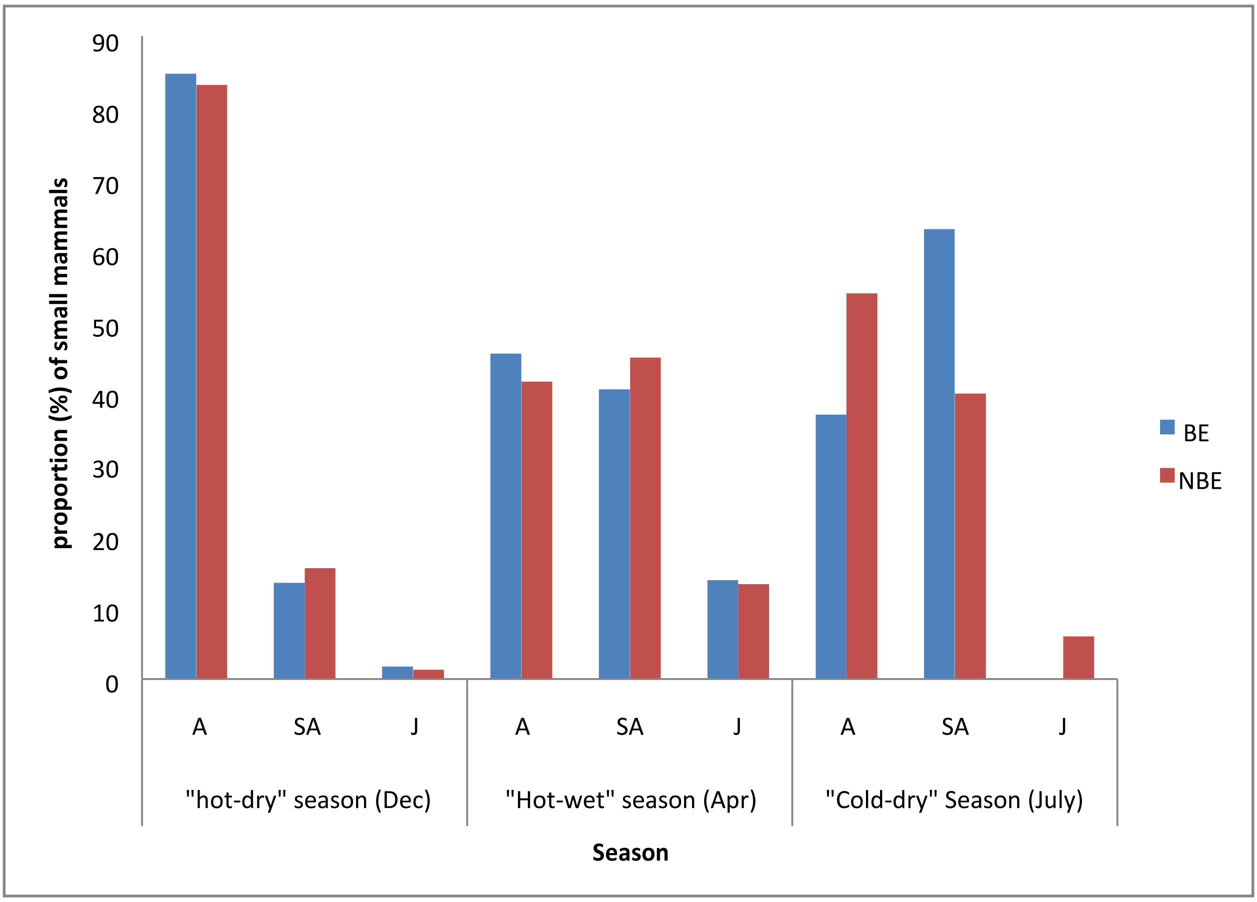

Figure 4.5. The proportion (%) of Adults (A), Sub-adults (SA) and Juveniles (J) of the small mammal species captured over the 3600 trap nights in the bush encroached (BE) and non-bush encroached (NBE) sites at the Neudamm Agricultural Farm during the "hot-dry" season (December 2009), "hot-wet" season (April 2010), and in the "cold-dry" season (July 2010) trapping sessions.

4.2.3. Estimated population density of small mammals

A total of 6 species of small mammals were caught in the bush encroached sites (Figure 4.6a). During the "hot-dry" season (December 2009), *M. namaquensis* and *R. pumilio* shared a similar mean estimated population density of 3.5 individuals/ha. The mean population density of *Rhabdomys pumilio* increased in the "hot-wet" season (April 2010) to an estimated 16.5 individuals/ha in the bush encroached sites. The mean estimated population density of *E. intufi* and *M. namaquensis* in the bush encroached sites during the "hot-wet" season (April

2010) was 3.5 and 2 individuals/ha respectively. The population density of all the small mammal species declined in cold and dry season (July 2010) (Figure 4.6a).

A total of 6 small mammal species were caught in the non-bush encroached sites (Figure 4.6b). During the “hot-dry” season (December 2009), *R. pumilio* shared the highest estimated mean population density of 4 individuals/ha. The population density of *R. pumilio* increased to a mean estimated 13.5 individuals/ha during the “hot- wet” season (April 2010). The mean population density of *E. intufi* was 11 individuals/ha during the” hot-wet” season (April 2010). The population density of all the small mammal species declined during the “cold-dry” season (July 2010) (Figure 4.6b).

a)

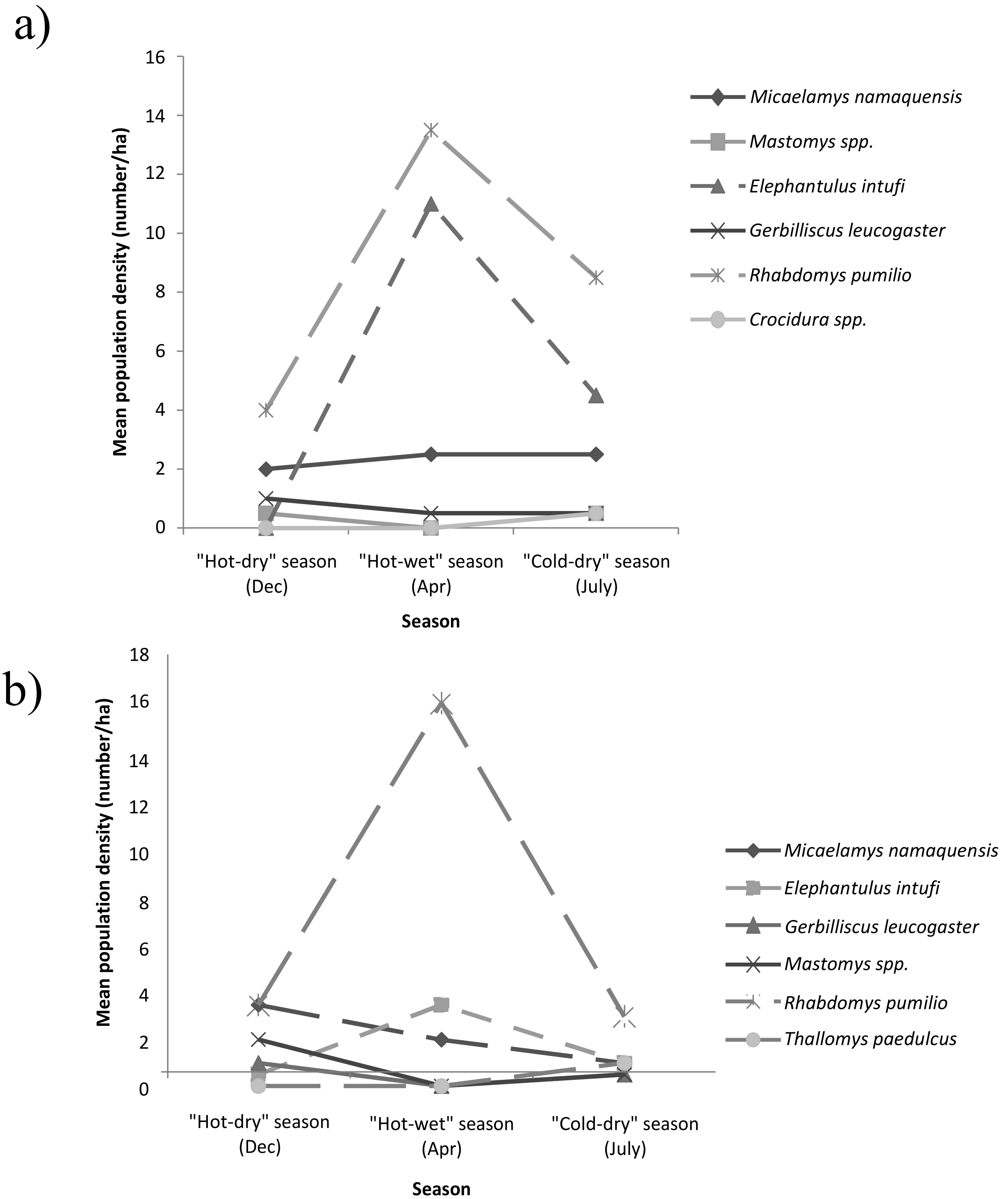

Figure 4.6. Seasonal variation in the estimated population density (number/ha) of species of small mammals estimated using the Petersen method of Capture-Mark-Recapture in the bush encroached site s (a) and non- bush encroached sites (b) at the Neudamm Agricultural Farm in the “hot-dry” season (December 2009), “ hot- wet” season (April 2010) and “cold –dry” season (July 2010).

There was no significant difference (H_8=1.19; *n*= *9*; p=0.756) in the mean population density of all small mammals in bush encroached and non-bush encroached sites among the three seasons. The Mann Whitney U Test further revealed no significant difference in the mean population density of small mammals between the bush encroached and non-bush encroached sites during the "hot-dry" season (December 2009) (U_8=4.500; *n*= *9*; p=0.304), "hot-wet" season (April 2010) (U_8=1.500; *n*= *9*; p=0.590) and during the "cold-dry" season (July 2010) (U_8=0.500; *n*= *9*; p=0.029) (Figure 4.8).

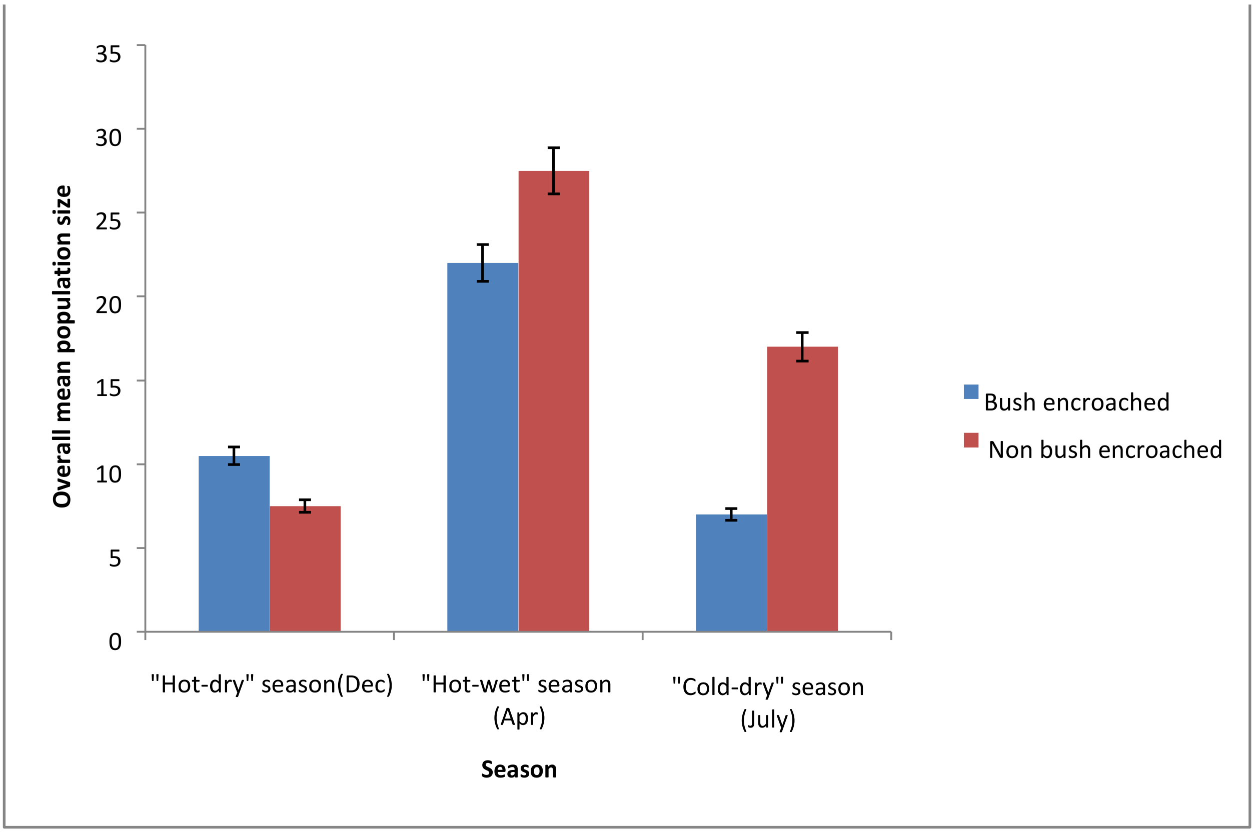

Figure 4.7. The overall mean population density (number/ha) of species of small mammals estimated using the Petersen method of Capture Mark-Recapture in the bush encroached and non-bush encroached sites at the Neudamm Agricultural Farm in the "hot-dry" season (December 2009), "hot–wet" season (April 2010) and in the "cold-dry" season (July 2010).

4.2.4. Diversity of small mammals

The mean species diversity in the bush encroached sites in the "hot-dry" season (December 2009) was 1.07, in the "hot-wet" season (April 2010) it was 0.84 and in "cold-dry" season (July 2010), 1.38 (Figure 4.9). The mean species diversity in the non-bush encroached sites in the "hot-dry" season (December 2009) , "hot-wet" season (April 2010) and "cold-dry" season (July 2010) was 1.02, 0.64 and 1.10 respectively (Figure 4.9). There was no significant difference (H_8=1.98, *n*= *9*, p=0.576) in the mean species diversity in the bush encroached and non-bush encroached sites among the three seasons.

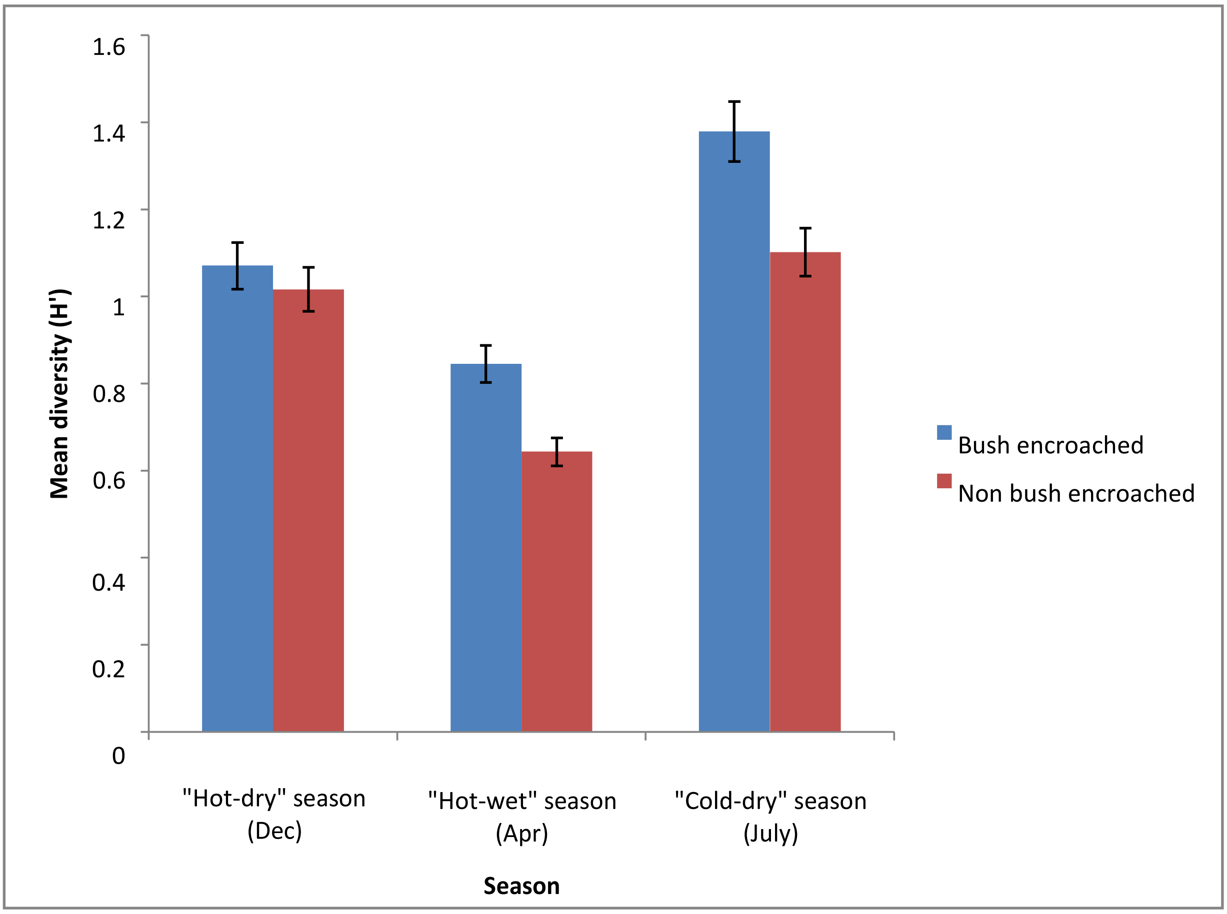

Figure 4.8. The mean species diversity (Shannon-Wiener index, H´) of small mammals in the bush encroached and non-bush encroached sites at the Neudamm Agricultural Farm in the "hot-dry" season (December 2009), "hot-wet" season (April 2010) and in the "cold-dry" season (July 2010). Bars indicate standard errors of the means.

4.2.5. Species composition of small mammals

The Hierarchical Cluster Analysis compared the species composition of the small mammals between the bush encroached and non-bush encroached sites: bush encroached site 1 (BE1), non-bush encroached site 2 (NBE 2), bush encroached site 2 (BE 2) and non-bush encroached site 2 (NBE 2) among the three seasons. During the "hot-dry" season (December 2009), the HCA revealed that the bush encroached site 1 (BE 1) and non-bush encroached site 1 (NBE 1) shared a 78.6% similarity in species composition (Figure 4.9). The bush encroached site 2 (BE 2) and non-bush encroached site 2 (NBE 2) shared an 86.5% similarity in species composition.

During the "hot-wet" season (April 2010), the HCA revealed that the bush encroached site 1 (BE 1) and non-bush encroached site 2 (NBE 2) shared a 96.5% similarity in species composition. The bush encroached site 1 (BE 1) and non bush encroached site 2 (NBE 2) cluster shared an 85.9% similarity in species composition with bush encroached site 2 (BE 2). The cluster containing BE 1, NBE 2 and BE 2 shared a 61.6% similarity in species composition with NBE 1 (Figure 4.10).

During the "cold-dry" season (July 2010), the HCA revealed that the bush encroached site 1 (BE 1) and non-bush encroached site 2 (NBE 2) shared a 77.8% similarity in species composition. The bush encroached site 1 (BE 1) and non bush encroached site 2 (NBE 2) cluster shared a 69.1% similarity in species composition with bush encroached site 2 (BE 2). The cluster containing BE 1, NBE 2 and BE 2 shared a 57.7% similarity in species composition with NBE 1. The HCA analyses revealed that there was no significant difference in the species composition of small mammals between the bush encroached and non- bush encroached sites among the three seasons (Figure 4.9).

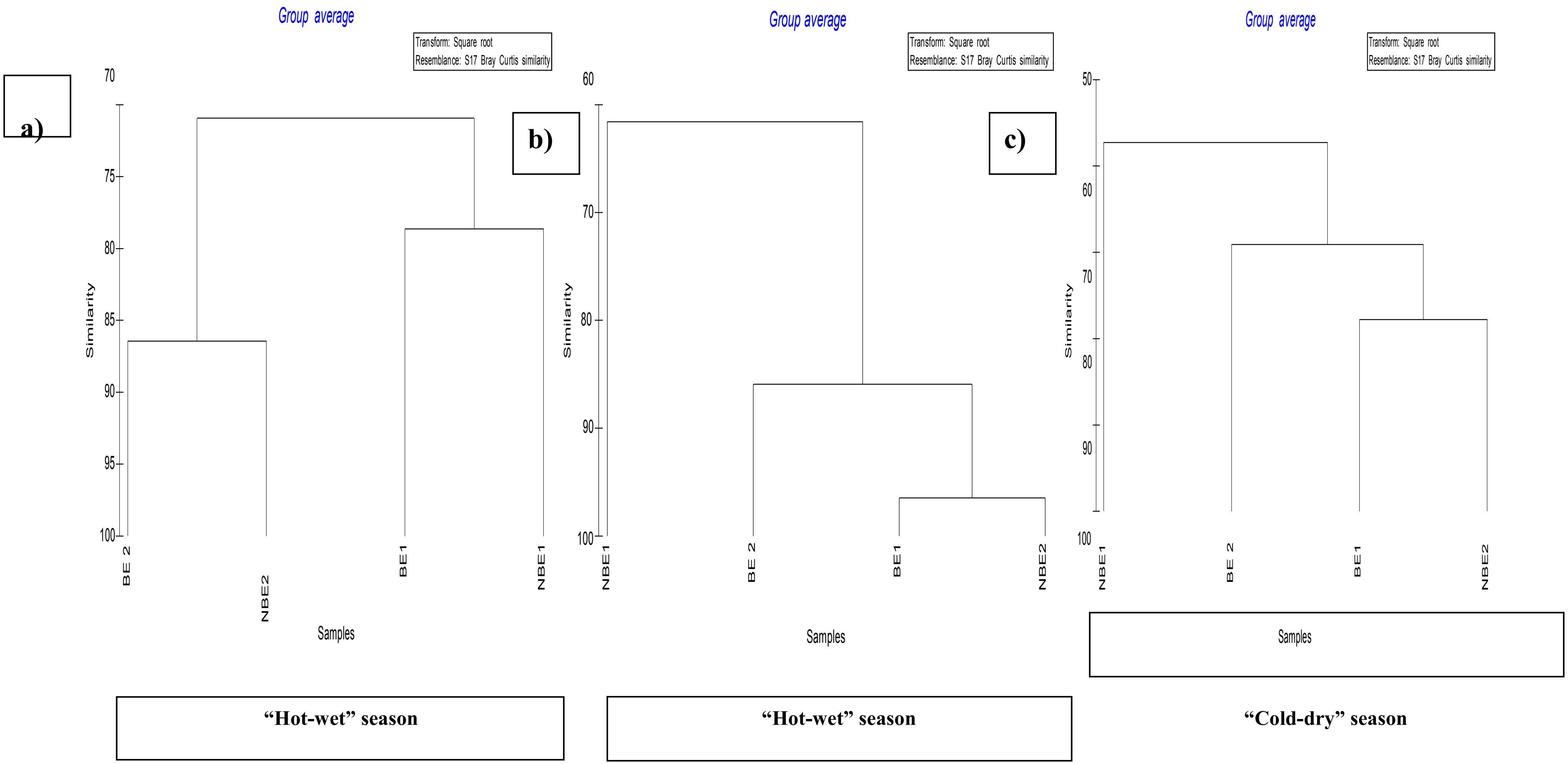

Figure 4.9: The Hierarchical Cluster Analysis (HCA) dendrograms indicating the composition of small mammals between the bush encroached sites (BE1 and BE2) and non-bush encroached sites (NBE1 and NBE2) at the Neudamm Agricultural Farm in the "Hot-dry" season (December
2009)(a) , "Hot-wet" season (April 2010) (b) and in the "Cold-dry" season" (July 2010) (c).

CHAPTER 5

DISCUSSION

5.1. Small mammals trapped

5.1.1. Abundance and population density of small mammals

The results of this study revealed that there was no significant difference in the abundance (Figure 4.5) and population density of small mammals (Figure 4.7) between the bush encroached and non-bush encroached sites. There was no supporting evidence for the hypothesis that suggested that the abundance of small mammals would be higher in the non-bush encroached sites. The study revealed that changes in the vegetation cover in the different seasons did not have a significant effect on the abundance and population density of small mammals between the bush encroached and non-bush encroached in the different seasons (Figure 4.7). Both sites had sufficient vegetation cover and thus supported the same abundance and population density of small mammals during the study. According to Bowland & Perin (1989) the total vegetation cover available determines the abundance and population density of small mammals in their habitats (Bowland & Perin, 1989). Small mammal community structure is often correlated with the functional and general characteristics of the vegetation structure (Muck & Zeller, 2006). Diverse vegetation structures are a source of higher food availability and quality, which in turn structure the small mammal community diversity and abundance (Ylonen *et al.,* 2003). The spatial distance of 1kilometer between the grids, did not have a significant impact on the abundance and population density of small mammals between the bush encroached and non-bush encroached sites among the three seasons. This resulted in the similar pattern of abundance and population density of small mammals observed between the bush encroached and non bush encroached sites. Both sites were in close proximity to each other and were therefore exposed to similar environmental variables and conditions (rainfall, temperature and sunlight) during the study. The bush encroached and non-bush encroached sites were situated within the semi-arid highland savanna. Hence, the type of plant species and diversity were similar in both sites. Both sites therefore provided the small mammals with similar niche opportunities to exploit. Niche availability is a function of habitat complexity (Rosenzweig & Winakur, 1969). According to Rosenzweig & Winakur, (1969) complex habitats supplies more niche opportunities, which can be exploited by a higher number of small mammal species (Rosenzweig & Winakur, 1969). The small mammal populations in both sites were probably also regulated by density dependent factors, such as intra-specific, inter-specific competition and predation within the communities. According to Odhiambo *et al.,* (2005) the population dynamics of small mammals is known to be influenced by density dependent factors that occur simultaneously within their environments.

5.1.2. Small mammals in breeding condition

The present study revealed that there was no significant difference in the mean number of females and males in breeding condition (Figure 4.4a and Figure 4.4b respectively) between the bush encroached and non-bush encroached sites. Rainfall is considered to be a major density independent factor that influences the breeding activity in small mammals (Leirs *et al.,* 1989). The bush encroached and non-bush encroached sites received similar amount of rainfall during the study, because they were in close proximity to each other. This resulted in no significant difference in the number of male and female small mammals in breeding condition between the two sites. Previous studies show that small mammal breeding activity is initiated by rainfall (Odhiambo *et al.,* 2005; Makundi, 2006). Small mammals become reproductively active at the onset of the rainy season (Odhiambo *et al.,* 2005; Makundi, 2006). Rainfall affects primary productivity in the ecosystem, which in turn favours reproduction in small mammals (Jacksic *et al.,* 1997).Numerous studies have also shown that small mammals time their reproductive activity and produce young during the time of the year ("hot-wet" season) when food availability is high (Bergallo, 1994; Alder & Beauty, 1997; Field, 1976). A study by Liers *et al.,* (1994) also revealed that the reproductive activity of small mammals is highly correlated to the amounts of rainfall received. According to Makundi *et al.,* (2006), small mammals tend to have specific well-defined periods of reproduction. The maximum period of their reproductive activity is usually reached with high rainfall. Rainfall is therefore considered to be the major density-independent factor that influences small mammal populations (Leir et *al.,* 1994). Changes experienced in the small mammal population densities have been shown to depend strongly on the onset and duration of rainfall (Delany, 1986).

5.1.3. Diversity of small mammals

The results revealed that there was no significant difference in the mean diversity of small mammals (Figure 4.9) between the bush encroached and non-bush encroached sites. There was no supporting evidence for the hypothesis that proposed that the species diversity of small mammals would be higher in the non-bush encroached sites.

The type of plant species that occurred in the bush encroached and non-bush encroached sites were not different, both sites were situated within the semi-arid highland savanna vegetation. As a result both sites provided the small mammals with similar niche opportunities to exploit. Numerous studies have shown that small mammal diversity is a function of plant architecture

(Bond *et al.,* 1980; Els & Kerley, 1996). Sites that have similar plant communities have similar small mammal diversities (Bergström, 2004) as was observed in the bush encroached and non-bush encroached sites during this study.

Small mammal species are known to be sensitive to the quality of their habitats (McArthur & McArthur, 1961; Pianka, 1967; Ajayi, 1974). Habitat characteristics regulate small mammal diversity and population size (Mugatha, 2002). The quantity of vegetation cover is considered vital for a higher diversity of small mammals (Hoffman & Zeller, 2005). Dense vegetation cover provides heterogeneous microhabitats for small mammals to exploit. However, small mammals" diversity and abundance only tends to increase with higher woody cover up to a certain level above which the diversity and abundance decrease again (Abramsky & Rosenzweig, 1984). This is the point when bush encroachment keeps the grass cover low and thus limit and reduce essential food supply and shelter for the small mammals (Bergström, 2004).

5.1.4. Species composition of small mammals

During this study, five rodent species and two shrews species were recorded. Two species; mainly *T. paedulcus* and *Crocidura spp* were site restricted. *T. paedulcus* was only captured in the bush encroached sites. *Crocidura spp* was also only captured in the non-bush encroached sites. *T. paedulcus,* commonly known as the Acacia rat prefers habitats dominated by Acacias (Stuart & Stuart, 2007). The species predominantly inhabits areas dominated by a high density of Acacia woody species. It occurs rarely in open grassland savannas (Stuart & Stuart, 2007). The species can serve as a good biological and environmental indicator to identify areas that are encroached by Acacia species. *Crocidura spp* is generally associated with moist habitats with a high ground vegetation cover (Stuart & Stuart, 2007). The species is very sensitive to dry and lowly covered vegetation areas (Stuart

& Stuart, 2007). The occurrence of this species in a habitat, serves as a good environmental indicator, that the habitat is moist and has a high ground vegetation cover. *Rhabdomys pumilio*, *E. intufi* and *G. leucogaster* were captured in both the bush encroached and non-bush encroached sites. However the abundance of these three species was higher in the non-bush encroached sites (Table 4.1). The abundance of *M. namaquensis* and *Mastomys spp* was higher in the bush encroached sites.

Rhabdomys pumilio numerically dominated the small mammal catches in both the bush encroached and non-bush encroached sites (Table 4.1). It is known to exploit the widest range of habitat types (Stuart & Stuart, 2007) and in the present study *R. pumilio* recorded the highest abundance and density in both the bush encroached and non-bush encroached sites. *R. pumilio* is highly flexible to both disturbed and undisturbed habitats. The species has a wide range of tolerance to microhabitat variations (Stuart & Stuart, 2007), and can therefore serve as a good bio-indicator species to assess the environmental stability in both disturbed and undisturbed habitats. *M. namaquensis* is also known to have a wide range of habitat tolerance (Jooster & Palmer, 1982). This species is known to inhabit areas with a low vegetation cover. The species can serve as an effective biological indicator species in areas with a low vegetation cover (Jooster & Palmer, 1982). *M. namaquensis* was the second most dominant small mammal species that was captured during the study. *Elephantulus intufi* inhabits various habitats, but it usually has more preference for areas with sandy soils (Stuart & Stuart, 2007). *E. intufi* is an insectivore and its diet is usually composed of ants and terminates (Stuart & Stuart, 2007). The species is generally found to occur in open grasslands. The occurrence of this species in a habitat can give an indication of the abundance of insects in the area (Stuart & Stuart, 2007). The species occurred in both the bush encroached and non-bush encroached sites. However its abundance was higher in the non-bush encroached sites. *Mastomys spp* is highly adaptable (Meester *et al.,* 1979) a characteristic that also allows the species to inhabit a wide range of habitat types. This species is described as an opportunistic and coloniser species and becomes dominant once disturbances have occurred (Leir *et al.,* 1995; Avenant & Kuyler, 2002). It also serves as a good environmental bio-indicator, because it is one of the first species to invade habitats that have suffered from disturbances. *Mastomys spp* is known to inhabit various harsh habitats, even if the ground vegetation cover is low (Wandrag *et al.,* 2002). *Gerbilliscus leucogaster* is known to be very sensitive to an overgrazing disturbance (Hofmann & Zeller, 2005). The species can be used as a biological and environmental indicator to determine the health status of ecosystems (Linzey & Kesner, 1997). Ground vegetation cover remains very essential for the occurrence of *G. leucogaster* in a habitat (Hoffmann & Zeller, 2005). *G. leucogaster* was also caught in the bush encroached sites. This finding could indicate that although the bush encroached sites are disturbed; the species could still tolerate and adapt to survive in the sites. The species was predominately captured during the "hot-dry" season (December 2009) in the bush encroached sites. This finding suggests that the bush encroached sites can still accommodate a wide range of small mammal communities.

The Hierarchical Cluster Analysis (HCA) revealed that the composition of the small mammals was not different between the bush encroached and non-bush encroached sites among the three seasons (Figure 4.9). The results of the present study did not support the research hypothesis that the composition of small mammals would be significantly different between the bush encroached and non encroached sites. Habitat factors such as plant composition, temperature and soil types were not different between the bush encroached and non-bush encroached sites, because the sites were in close proximity to each other. This resulted in the similar composition of small mammals between the bush encroached and non-bush encroached sites. Mugatha (2002) showed that habitat factors have a pervasive effect on the behaviour and spatial organization of small mammals. Small mammal species composition is linked to habitat characteristics and vegetation structure (Rowe-Rowe & Meeter, 1982; Iyawe, 1988). Mugatha (2002) showed that small mammals react to habitat factors in a similar way. Habitat preference of small mammals is also determined primarily by the type of vegetation cover available during the different seasons (Rowe-Rowe & Meeter, 1982; Iyawe, 1988).

A study by Eccard *et al.,* (2000) reports that small mammal species such as *Gerbilliscus leucogaster, Crocidura spp* and *Thallomys paedulcus* have specific habitat requirements, and these species compositions are instantly affected by structural changes in the vegetation cover and structure. Other small mammal species such as *R. Pumilio* and *Mastomys spp* have diverse habitat requirements (Stuart & Start, 2007), these species inhabited both the bush encroached and non-bush encroached sites during the present study. Small mammals are known to be able to adapt to disturbances in their environments, resulting in an alteration in their composition and structure (Haveron, 2008). Many species of small mammals develop an ability to tolerate and survive in unfavourable habitats, despite them not being fully suited for such habitats (Haveron, 2008). For example certain species (*E. intufi*, and *G. Leucogaster)* adapted to non-bush encroached sites, can become more abundant in the bush encroached sites. Such adaptations of small mammals to habitat change, enhances their survival rates in disturbed habitats (Grant *et al.,* 1982; Milton *et al.*, 1994).

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The main purpose of this study was to determine the effects of bush encroachment on the species abundance, diversity and composition of small mammals between the bush encroached and non-bush encroached sites. Small mammal species were trapped in the two sites (bush encroached and non-bush encroached sites), which differed significantly in the woody density, woody cover and grass cover. It was evident from the results of this study, that there was no significant difference in the diversity and abundance of small mammals between the bush encroached and non-bush encroached sites. The results further revealed that the composition of small mammals was not different between the bush encroached and non-bush encroached sites. Hence, bush encroachment did not have any effect on the abundance, population density, diversity and composition of small mammals. This suggests that bush encroached sites are suitable areas that can be inhabited by small mammal species. However there might be a „threshold" of woody plant density in bush encroached sites, that was not met during this study that would have probably affected the small mammal population dynamics differently. The study revealed that the differences in the vegetation structure between the bush encroached and non-bush encroached sites did not have a significant effect on the small mammal population dynamics.

6.2. Recommendations

- It is recommended that other long term studies should be conducted, to assess the effects of bush encroachment. The present study only served as a baseline study, thus further investigations are required to assess the effects of bush encroachment on small mammal biodiversity.
- It is recommended that in a future study, more regions should be included that are encroached by different invader species, which are also encroached by different plant densities. This will help determine the effects of different encroaching species on the small mammal communities in the different regions. Results from the other regions will also be compared with the results obtained in this study.
- It is recommended that other additional variables should be included in future studies, such as the comparison of soil substrates between the bush encroached and non-bush encroached sites. This information would give us a further in-depth understanding of the effects of bush encroachment on small mammals.
- It is recommended that in future studies, researchers should incorporate and link the effects of anthropogenic activities (land use practices and farming systems) on small mammal biodiversity and bush encroachment.
- It is recommended that in future studies, *Gerbilliscus leucogaster, Thallomys paedulcus* and *Crocidura spp* should be used as ideal biological and environmental bio-indicators for bush encroachment studies. During the present study, *Gerbilliscus leucogaster* was found to be very sensitive to bush encroached sites. *Thallomys paedulcus* and *Crocidura spp* were site specific. *Thallomys paedulcus* was only found to occur in bush encroached sites. *Crocidura spp* was only found to occur in bush encroached sites.

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APPENDICES

Appendix 1: The GPS coordinate points of selected metal droppers in the bush encroached and non-bush encroached sites at the Neudamm Agricultural Farm.

Grid 1 (Bush encroached site)	Grid 2 (Non-bush encroached site)	Grid 3 (Bush encroached site)	Grid 4 (Non-bush encroached site)
A1: 22°30.105‟ S, 017°20.824‟E	A1: 22°30.143‟S, 017°20.469‟E	A1: 22°30.471‟S, 017°20.216‟E	A1: 22°30.773‟S, 017°20.730‟E
B1 : 22°30.103‟ S, 017°20.830‟E	B1: 22°30.138‟S, 017°20.469‟E	B1: 22°30.469‟S, 017°20.221‟E	B1: 22°30.770‟S, 017°20.735‟E
E1 : 22°30.097‟ S, 017°20.843‟E	E1: 22°30.123‟S, 017°20.468‟E	E1: 22°30.463‟S, 017°20.237‟E	E1: 22°30.761‟S, 017°20.751‟E
F1 : 22°30.095‟ S, 017°20.849‟E	F1: 22°30.117‟S, 017°20.467‟E	F1: 22°30.462‟S, 017°20.243‟E	F1: 22°30.758‟S, 017°20.755‟E
G1 : 22°30.093‟ S, 017°20.853‟E	G1: 22°30.112‟S, 017°20.467‟E	G1: 22°30.461‟S, 017°20.249‟E	G1: 22°30.755‟S, 017°20.760‟E
H1 : 22°30.097‟ S, 017°20.857‟E	H1: 22°30.106‟S, 017°20.467‟E	H1: 22°30.459‟S, 017°20.255‟E	H1: 22°30.753‟S, 017°20.765‟E
I1 : 22°30.090‟ S, 017°20.862‟E	I1: 22°30.100‟S, 017°20.468‟E	I1 : 22°30.458‟S, 017°20.260‟E	I1: 22°30.765‟S, 017°20.750‟E
J1 : 22°30.088‟S, 017°20.867‟E	J1: 22°30.095‟S, 017°20.468‟E	J1: 22°30.457‟S, 017°20.266‟E	J1: 22°30.747‟S, 017°20.775‟E
A10: 22°30.152‟S, 017°20.833‟E	A10: 22°30.126‟S, 017°20.518‟E	A10: 22°30.510‟S, 017°20.233‟E	A10: 22°30.728‟S, 017°20.703‟E
J10: 22°30.129‟S, 017°20.884‟E	J10: 22°30.081‟S, 017°20.516‟E	J10: 22°30.500‟S, 017°20.274‟E	J10: 22°30.706‟S, 017°20.749‟E

Appendix 2. The total number of small mammal species captured in the bush encroached and non-bush encroached grids at the Neudamm Agricultural Farm during the hot and dry season (December 2009), hot and wet season (April 2010) and in the cold and dry season (July 2010).

New capture	Recapture	Toe code	Trap station	Label no.	Date	Grid no.	*Species*	Sex	Age	Testis (A/S)	Vagina (close/open)	Nipple (Small/Lactating)	Pregnant	Body weight	Head body	Hind foot	Tail	Ear
Y		15	A1	BE1D	10-Dec-09	1	*Mastomys spp.*	M	SA	A				32	72	21	67	10
Y		16	A10	BE2D	10-Dec-09	1	*Micaelamys namaquensis*	M	A	S				51	92	25	93	13
Y		17	B7	BE3D	10-Dec-09	1	*Micaelamys namaquensis*	M	A	S				47	81	21	76	11
Y		18	B6	BE4D	10-Dec-09	1	*Rhabdomys pumilio*	M	A	S				53	92	21	98	11
Y		110	C6	BE5D	10-Dec-09	1	*Mastomys spp.*	M	SA	A				35	84	19	75	16
Y		120	B5	BE6D	10-Dec-09	1	*Rhabdomys pumilio*	M	A	S				51	85	20	100	18
Y		130	C1	BE7D	10-Dec-09	1	*Rhabdomys pumilio*	F	A		O	S		60	87	87	101	11
Y		140	B2	BE8D	10-Dec-09	1	*Rhabdomys pumilio*	F	A		C	S		55	96	21	115	7
Y		150	D3	BE9D	10-Dec	1	*Rhabdomys pumilio*	F	A		O	S		67	99	22	116	13

					-09													
Y		160	E2	BE10D	10-Dec-09	1	*Mastomys spp.*	M	A	S				37	91	19	81	17
Y		170	D4	BE11D	10-Dec-09	1	*Rhabdomys pumilio*	F	A		O	S		44	83	21	110	17
Y		180	E5	BE12D	10-Dec-09	1	*Rhabdomys pumilio*	M	A	S				54	99	21	111	12
Y		190	F1	BE13D	10-Dec-09	1	*Mastomys spp.*	F	SA		C	S		33	89	20	76	12
Y		1100	G1	BE14D	10-Dec-09	1	*Micaelamys namaquensis*	M	A	S				39	89	21	91	17
Y		25	H3	BE15D	10-Dec-09	1	*Micaelamys namaquensis*	M	A	S				46	90	21	89	17
Y		26	I3	BE16D	10-Dec-09	1	*Rhabdomys pumilio*	M	A	S				53	100	23	112	13
Y		27		BE17D	10-Dec-09	1	*Rhabdomys pumilio*	F	A		O	S		57	94	22	121	14
Y		dead		dead	10-Dec-09	1	*Gerbilliscus leucogaster*	M	A	S				44	102	30	110	15
Y		28	A1	BE18D	11-Dec-09	1	*Rhabdomys pumilio*	F	A		C	S		59	105	20	116	10
Y		210	A2	BE19D	11-Dec-09	1	*Rhabdomys pumilio*	F	A		O	S		58	83	20	86	11
Y		220	A4	BE20D	11-Dec	1	*Rhabdomys pumilio*	F	A		C	S		60	92	24	91	8

					-09													
Y		230	A5	BE21D	11-Dec-09	1	*Rhabdomys pumilio*	M	A	S				60	100	21	95	11
	Y	120	A6		11-Dec-09	1	*Rhabdomys pumilio*											
Y		240	A9	BE22D	11-Dec-09	1	*Rhabdomys pumilio*	M	A	S				61	95	24	91	10
Y		250	A10	BE23D	11-Dec-09	1	*Micaelamys namaquensis*	M	A	S				40	84	20	80	10
Y		260	B1	BE24D	11-Dec-09	1	*Rhabdomys pumilio*	M	A	S				52	79	21	102	10
Y		270	C1	BE25D	11-Dec-09	1	*Rhabdomys pumilio*	M	A	S				50	83	21	92	11
Y		280	D3	BE26D	11-Dec-09	1	*Gerbilliscus leucogaster*	M	J	A				84	115	24	105	16
Y		290	E1	BE27D	11-Dec-09	1	*Rhabdomys pumilio*	M	A	S				57	89	23	125	11
Y		2100	E3	BE28D	11-Dec-09	1	*Gerbilliscus leucogaster*	M	J	A				20	45	10	42	7
	Y	190	D4		11-Dec-09	1	*Mastomys spp.*											
Y		35	E5	BE29D	11-Dec-09	1	*Rhabdomys pumilio*	F	A		C	S		50	82	25	105	10
Y		36	G6	BE30D	11-Dec-09	1	*Rhabdomys pumilio*	M	A	S				63	100	23	93	10

Y		37	F5	BE31D	11-Dec-09	1	*Rhabdomys pumilio*	F	A		C	S		60	86	22	115	11
Y		38	G2	BE32D	11-Dec-09	1	*Mastomys spp.*	M	A	S				53	87	21	95	11
	Y	1100	F2		11-Dec-09	1	*Micaelamys namaquensis*											
Y		310	H1	BE33D	11-Dec-09	1	*Gerbilliscus leucogaster*	F	A		C	S	P	76	99	29	140	11
Y		320	H2	BE34D	11-Dec-09	1	*Rhabdomys pumilio*	M	A	S				61	45	19	105	18
Y		Dead	H3	Dead	11-Dec-09	1	*Rhabdomys pumilio*	F	A		O	S		50	93	21	85	15
Y		Dead	I2	Dead	11-Dec-09	1	*Rhabdomys pumilio*	F	A		C	S		50	89	21	100	12
	Y	15	I3		11-Dec-09	1	*Mastomys spp.*											
	Y	26	J2	Dead	11-Dec-09	1	*Rhabdomys pumilio*											
Y		330	H4	BE35D	11-Dec-09	1	*Rhabdomys pumilio*	M	A	S				46	100	20	81	11
Y		Dead	H8		11-Dec-09	1	*Micaelamys namaquensis*	M	A	S				45	103	20	70	15
Y		340	I7	BE36D	11-Dec-09	1	*Rhabdomys pumilio*	F	A		O			49	83	20	90	8
Y		Dea	J5	Dead	11-	1	*Rhabdomys*	M	A	S				52	100	20	80	12

		d			Dec-09		*pumilio*											
Y		350	A2	BE37D	12-Dec-09	1	*Micaelamys namaquensis*	F	A		C	S		75	100	30	135	20
Y		360	A3	BE38D	12-Dec-09	1	*Rhabdomys pumilio*	F	A		O	S		63	104	20	102	9
Y		370	A4	BE39D	12-Dec-09	1	*Rhabdomys pumilio*	F	A		O	S		61	91	21	102	9
Y		380	A5	BE40D	12-Dec-09	1	*Micaelamys namaquensis*	M	A	A				40	84	30	114	9
Y		390	A9	BE41D	12-Dec-09	1	*Mastomys spp.*	M	A	A				55	93	20	90	11
	Y	16	A10		12-Dec-09	1	*Micaelamys namaquensis*											
	Y	15	B2		12-Dec-09	1	*Mastomys spp.*											
	Y	130	C1		12-Dec-09	1	*Rhabdomys pumilio*											
Y		3100	D4	BE42D	12-Dec-09	1	*Micaelamys namaquensis*	F	A		C	S		61	84	11	23	20
	Y	1100	E3		12-Dec-09	1	*Micaelamys namaquensis*											
	Y	290	F2		12-Dec-09	1	*Rhabdomys pumilio*											
	Y	38	G2		12-Dec	1	*Mastomys spp.*											

					-09													
	Y	310	G3		12-Dec-09	1	*Gerbilliscus leucogaster*											
Y		45	H4	BE43D	12-Dec-09	1	*Micaelamys namaquensis*	M	A	S				50	110	21	87	21
Y		46	H1	BE44D	12-Dec-09	1	*Rhabdomys pumilio*	M	A	S				62	90	20	93	10
Y		47	I2	BE45D	12-Dec-09	1	*Mastomys spp.*	F	A		C			40	82	18	80	10
Y		48	I2	BE46D	12-Dec-09	1	*Rhabdomys pumilio*	F	A		C	S	P	63	90	20	90	10
	Y	37	I4		12-Dec-09	1	*Rhabdomys pumilio*											
Y		410	I6	BE47D	12-Dec-09	1	*Micaelamys namaquensis*	M	A	S				46	100	20	90	12
Y		420	I9	BE48D	12-Dec-09	1	*Rhabdomys pumilio*	F	A		C	S		50	100	20	95	10
Y		430	J8	BE49D	12-Dec-09	1	*Micaelamys namaquensis*	F	SA		C	S		34	80	20	70	15
Y		440	J5	BE50D	12-Dec-09	1	*Rhabdomys pumilio*	F	SA		C	S		49	80	20	95	10
Y		450	J3	BE51D	12-Dec	1	*Rhabdomys pumilio*	F	A		C	S	P	65	89	21	90	15

					-09													
	Y	37	J2	Dead	12-Dec-09	1	*Rhabdomys pumilio*											
Y		15	B10	NBE1D	15-Dec-09	2	*Rhabdomys pumilio*	M	A	S				57	105	24	103	10
Y		16	C5	NBE2D	15-Dec-09	2	*Rhabdomys pumilio*	F	A		C	S	P	55	100	21	99	10
Y		17	E2	NBE3D	15-Dec-09	2	*Gerbilliscus leucogaster*	M	A	S				80	110	32	105	12
Y		18	E3	NBE4D	15-Dec-09	2	*Rhabdomys pumilio*	F	A		C	S	P	59	102	22	89	9
Y		110	F4	NBE5D	15-Dec-09	2	*Rhabdomys pumilio*	M	A	S				44	95	18	92	10
Y		120	G5	NBE6D	15-Dec-09	2	*Gerbilliscus leucogaster*	M	A	S				80	111	23	140	20
Y		130	G8	NBE7D	15-Dec-09	2	*Mastomys spp.*	M	A	S				50	95	12	84	12
Y		140	H10	NBE8D	15-Dec-09	2	*Rhabdomys pumilio*	M	A	S				49	84	20	105	10
Y		150	H9	NBE9D	15-Dec-09	2	*Rhabdomys pumilio*	M	A	S				56	98	24	105	10
Y		160	H2	NBE10D	15-Dec-09	2	*Mastomys spp.*	M	SA	A				35	65	20	80	10
Y		170	I2	NBE11D	15-Dec-09	2	*Gerbilliscus leucogaster*	M	A	S				63	121	30	122	11

Y		180	I10	NBE12D	15-Dec-09	2	*Rhabdomys pumilio*	M	A	S				53	95	21	100	10
Y		190	J9	NBE13D	15-Dec-09	2	*Rhabdomys pumilio*	M	A	S				50	99	23	105	10
Y		1100	A5	NBE14D	16-Dec-09	2	*Gerbilliscus leucogaster*	F	A		C	S		40	73	25	114	11
Y		25	A9	NBE15D	16-Dec-09	2	*Rhabdomys pumilio*	F	A		C	S	P	55	96	21	95	11
Y		26	B10	NBE16D	16-Dec-09	2	*Rhabdomys pumilio*	F	A		C	S		41	82	75	99	10
Y		27	B7	NBE17D	16-Dec-09	2	*Gerbilliscus leucogaster*	M	SA	A				39	92	25	104	9
	Y	16	B8		16-Dec-09	2	*Rhabdomys pumilio*											
Y		28	C8	NBE18D	16-Dec-09	2	*Gerbilliscus leucogaster*	M	A	S				67	102	21	111	10
Y		210	D8	NBE19	16-Dec-09	2	*Rhabdomys pumilio*	F	A		C	S		53	91	21	88	10
Y		220	D6	NBE20	16-Dec-09	2	*Gerbilliscus leucogaster*	F	A		C	S		71	111	30	144	12
Y		230	D3	NBE21D	16-Dec-09	2	*Rhabdomys pumilio*	F	A		C	S		45	89	20	95	9
Y		240	E3	NBE22D	16-Dec-09	2	*Rhabdomys pumilio*	M	A	S				50	83	21	34	10
Y		250	E5	NBE23	16-	2	*Rhabdomys*	M	A	S				64	101	21	87	7

					Dec -09		*pumilio*											
	Y	120	G3		16-Dec -09	2	*Gerbilliscus leucogaster*											
Y		260	H7	NBE24 D	16-Dec -09	2	*Rhabdomys pumilio*	M	A	S				60	95	21	80	10
	Y	160	H2		16-Dec -09	2	*Mastomys spp.*											
Y		270	I2	NBE25 d	16-Dec -09	2	*Gerbilliscus leucogaster*	F	A		C	S		52	95	21	103	11
Y		280	I4	NBE26 D	16-Dec -09	2	*Rhabdomys pumilio*	M	A	S				60	85	21	96	11
Y		290	I10	NBE27 D	16-Dec -09	2	*Rhabdomys pumilio*	M	A	S				45	88	25	89	11
Y		210 0	J9	NBE28 D	16-Dec -09	2	*Rhabdomys pumilio*	M	A	S				59	97	25	104	11
Y		35	J8	NBE29 D	16-Dec -09	2	*Rhabdomys pumilio*	M	A	S				53	80	22	103	12
	Y	170	J3		16-Dec -09	2	*Gerbilliscus leucogaster*											
Y		36	A6	NBE30 D	17-Dec -09	2	*Rhabdomys pumilio*	M	A	S				61	84	21	94	10
	Y	27	A7		17-Dec -09	2	*Gerbilliscus leucogaster*											
Y		37	B7	NBE31 D	17-Dec	2	*Rhabdomys pumilio*	M	A	S				63	85	21	105	10

					-09													
	Y	15	C8		17-Dec-09	2	*Rhabdomys pumilio*											
Y		38	C10	NBE32D	17-Dec-09	2	*Micaelamys namaquensis*	F	SA		C	S		35	73	20	71	11
Y		310	C8	NBE33D	17-Dec-09	2	*Rhabdomys pumilio*	F	SA		C	S		45	85	20	84	10
Y		320	C7	NBE34D	17-Dec-09	2	*Rhabdomys pumilio*	M	A	S				40	105	21	81	9
	Y	18	D2		17-Dec-09	2	*Rhabdomys pumilio*											
	Y	240	E3		17-Dec-09	2	*Rhabdomys pumilio*											
Y		340	F9	NBE35D	17-Dec-09	2	*Rhabdomys pumilio*	F	A		C	S	P	50	66	22	95	9
	Y	120	G5		17-Dec-09	2	*Gerbilliscus leucogaster*											
	Y	270	I2		17-Dec-09	2	*Gerbilliscus leucogaster*											
	Y	180	I1		17-Dec-09	2	*Rhabdomys pumilio*											
Y		350	I10	NBE36D	17-Dec-09	2	*Rhabdomys pumilio*	M	A	S				54	89	21	90	11
	Y	190	J9		17-Dec	2	*Rhabdomys pumilio*											

					-09													
Y		370	J4	NBE37D	17-Dec-09	2	*Rhabdomys pumilio*	F	A		C	S	P	60	89	20	95	11
Y		15	A1	2BE1D	18-Dec-09	3	*Rhabdomys pumilio*	M	A	S				60	98	28	92	11
Y		16	A2	2BE2D	18-Dec-09	3	*Gerbilliscus leucogaster*	M	A	S				51	105	25	120	14
Y		17	A9	2BE3D	18-Dec-09	3	*Micaelamys namaquensis*	M	A	S				50	104	21	87	12
Y		18	A10	2BE4D	18-Dec-09	3	*Gerbilliscus leucogaster*	F	A		O	S		78	106	34	125	25
Y		110	C1	2BE5D	18-Dec-09	3	*Rhabdomys pumilio*	F	A		O	S		66	106	23	96	10
Y		120	C2	2BE6D	18-Dec-09	3	*Rhabdomys pumilio*	F	A		O	S		61	103	23	111	11
Y		130	C3	2BE7D	18-Dec-09	3	*Elephantulus intufi*	F	A		O	S		50	105	34	115	13
Y		140	C4	2BE8D	18-Dec-09	3	*Micaelamys namaquensis*	M	SA	S				48	102	20	74	9
Y		150	D2	2BE9D	18-Dec-09	3	*Elephantulus intufi*	F	A		O	S		59	102	35	109	15
Y		160	F8	2BEE10D	18-Dec-09	3	*Rhabdomys pumilio*	F	A		O	S		65	103	21	94	9
Y		170	F6	2BE11D	18-Dec-09	3	*Micaelamys namaquensis*	M	SA	A				40	80	15	76	12

Y		180	F7	2BE12D	18-Dec-09	3	*Micaelamys namaquensis*	M	SA	A				45	85	20	81	15
Y		190	G1	2BE13D	18-Dec-09	3	*Micaelamys namaquensis*	M	A	S				50	85	20	80	10
Y		1100	G3	2BE14D	18-Dec-09	3	*Rhabdomys pumilio*	M	A	S				85	105	20	85	10
Y		25	G7	2BE15D	18-Dec-09	3	*Gerbilliscus leucogaster*	F	A					75	89	28	132	13
Y		26	G8	2BE16D	18-Dec-09	3	*Rhabdomys pumilio*	M	A	S				41	80	21	91	11
Y		27	H6	2BE17D	18-Dec-09	3	*Gerbilliscus leucogaster*	F	A		C	S		65	111	30	126	12
Y		28	I2	2BE18D	18-Dec-09	3	*Gerbilliscus leucogaster*	M	A	S				55	90	26	120	10
Y		210	I6	2BE19D	18-Dec-09	3	*Gerbilliscus leucogaster*	F	A		O	S		50	90	20	121	13
Y		220	I8	2BE20D	18-Dec-09	3	*Micaelamys namaquensis*	M	SA	A				39	80	15	81	15
Y		Dead	J10		18-Dec-09	3	*Gerbilliscus leucogaster*	F	A			S		55	98	22	130	16
Y		Dead	J6		18-Dec-09	3	*Gerbilliscus leucogaster*	M	A	S				57	84	20	150	15
Y		Dead	J5		18-Dec-09	3	*Micaelamys namaquensis*	M	A	S				40	100	20	65	16

Y		230	A1	2BE21D	19-Dec-09	3	*Rhabdomys pumilio*	F	A		C	S	Y	64	95	23	105	10
Y		240	A2	2BE22D	19-Dec-09	3	*Micaelamys namaquensis*	M	S A	A				44	95	19	95	12
Y		250	A6	2BE23D	19-Dec-09	3	*Micaelamys namaquensis*	F	S A		C	S		35	87	18	81	10
Y		260	A7	2BE24D	19-Dec-09	3	*Elephantulus intufi*	F	A		O	S		50	98	33	111	20
Y		270	A8	2BE25D	19-Dec-09	3	*Rhabdomys pumilio*	F	A		C	S		70	95	22	105	10
Y		280	A8		19-Dec-09	3	*Rhabdomys pumilio*	M	A	S				70	108	20	64	10
	Y	17	A9		19-Dec-09	3	*Micaelamys namaquensis*											
Y		290	B10	2BE27D	19-Dec-09	3	*Rhabdomys pumilio*	F	A		O	S		61	98	25	97	10
Y		2100	B3	2BE28D	19-Dec-09	3	*Rhabdomys pumilio*	M	A	S				70	111	25	43	10
Y		35	B2	2BE29D	19-Dec-09	3	*Micaelamys namaquensis*	M	A	S				59	100	25	90	10
Y		36	C1	2BE30D	19-Dec-09	3	*Rhabdomys pumilio*	F	A		O	S		45	95	20	100	11
	Y	150	C3		19-Dec-09	3	*Elephantulus intufi*											

Y		37	C5	2BE31D	19-Dec-09	3	*Elephantulus intufi*	M	A	A				64	120	35	111	20
Y		38	E3	2BE32D	19-Dec-09	3	*Rhabdomys pumilio*	M	A	S				55	96	20	92	10
	Y	25	F6		19-Dec-09	3	*Gerbilliscus leucogaster*											
Y		310	F2	2BE33D	19-Dec-09	3	*Rhabdomys pumilio*	M	A	S				62	102	20	90	10
Y		320	F1	2BE34D	19-Dec-09	3	*Rhabdomys pumilio*	F	A		C	S		70	105	25	107	11
Y		330	G1	2BE35D	19-Dec-09	3	*Rhabdomys pumilio*	F	A		C	S		45	95	23	108	10
Y		340	G4	2BE36D	19-Dec-09	3	*Gerbilliscus leucogaster*	F	S A		C	S		34	70	30	94	11
	Y	170	G7		19-Dec-09	3	*Micaelamys namaquensis*											
Y		350	G9	2BE37D	19-Dec-09	3	*Rhabdomys pumilio*	M	A	S				66	112	25	74	10
	Y	160	H6		19-Dec-09	3	*Rhabdomys pumilio*											
Y		Dead	I5		19-Dec-09	3	*Rhabdomys pumilio*	F	A		C	S		47	100	22	97	10
Y		Dead	H4		19-Dec-09	3	*Elephantulus intufi*	F	A		O	S		72	112	31	135	31

	Y	190	I2		19-Dec-09	3	*Micaelamys namaquensis*											
Y		360	I4	2BE38D	19-Dec-09	3	*Rhabdomys pumilio*	M	A	S				50	112	21	111	11
Y		370	J2	2BE39D	19-Dec-09	3	*Rhabdomys pumilio*	M	A	S				60	119	23	93	10
Y		380	A1	2BE40D	20-Dec-09	3	*Rhabdomys pumilio*	F	SA		C	S		35	87	18	81	10
	Y	120	A2		20-Dec-09	3	*Rhabdomys pumilio*											
	Y	250	A5		20-Dec-09	3	*Micaelamys namaquensis*											
Y		390	A6	2BE41D	20-Dec-09	3	*Rhabdomys pumilio*	F	A		O	S		57	75	21	105	10
	Y	270	A10		20-Dec-09	3	*Rhabdomys pumilio*											
	Y	290	B10		20-Dec-09	3	*Rhabdomys pumilio*											
	Y	35	B3		20-Dec-09	3	*Micaelamys namaquensis*											
Y		3100	B2	2BE42D	20-Dec-09	3	*Rhabdomys pumilio*	M	A	S				49	95	20	85	10
Y		45	C1	2BE43D	20-Dec-09	3	*Rhabdomys pumilio*	M	A	S				62	111	20	100	10
	Y	210	C2		20-	3	*Rhabdomys*											

		0			Dec-09		*pumilio*											
	Y	15	C3		20-Dec-09	3	*Rhabdomys pumilio*											
Y		46	D1	2BE44D	20-Dec-09	3	*Rhabdomys pumilio*	F	A		O	S		60	100	20	85	10
Y		47	E1	2BE45D	20-Dec-09	3	*Rhabdomys pumilio*	M	A	S				69	105	22	115	10
	Y	160	F7		20-Dec-09	3	*Rhabdomys pumilio*											
	Y	1100	F3		20-Dec-09	3	*Rhabdomys pumilio*											
	Y	320	G1		20-Dec-09	3	*Rhabdomys pumilio*											
	Y	150	G2		20-Dec-09	3	*Elephantulus intufi*											
	Y	27	G6		20-Dec-09	3	*Gerbilliscus leucogaster*											
Y	Dead	48	G8	2BE46D	20-Dec-09	3	*Rhabdomys pumilio*	M	SA	A				36	85	20	90	11
	Y	26	G9	Dead	20-Dec-09	3	*Rhabdomys pumilio*											
	Y	170	H7	Dead	20-Dec-09	3	*Micaelamys namaquensis*											
Y		Dead	H6		20-Dec	3	*Rhabdomys pumilio*	F	SA		C	S		33	78	19	90	10

					-09													
Y		410	J6	2BE47D	20-Dec-09	3	*Gerbilliscus leucogaster*	M	A	S				59	90	23	125	15
Y		420	J5	2BE48D	20-Dec-09	3	*Rhabdomys pumilio*	M	A	S				49	100	23	91	10
Y		Dead			20-Dec-09	3	*Rhabdomys pumilio*	F	A		C	S		50	95	20	105	12
Y		15	A3	2NBE1D	21-Dec-09	4	*Rhabdomys pumilio*	M	A	S				53	105	20	100	10
Y		16	B7	NBE2D	21-Dec-09	4	*Rhabdomys pumilio*	M	A	S				56	104	20	105	9
Y		17	B5	2NBE3D	21-Dec-09	4	*Rhabdomys pumilio*	F	A		O	S		66	102	20	95	10
Y		18	C7	2NBE4D	21-Dec-09	4	*Rhabdomys pumilio*	M	A	S				46	90	20	95	9
Y		110	D5	2NBE5D	21-Dec-09	4	*Micaelamys namaquensis*	M	SA	A				40	90	20	86	10
Y		Dead	D2	Dead	21-Dec-09	4	*Elephantulus intufi*	F	A		O	S		65	120	35	109	20
Y		120	F8	2NBE6D	21-Dec-09	4	*Elephantulus intufi*	F	A		O	S		65	120	35	109	20
Y		130	F6	2NBE7D	21-Dec-09	4	*Micaelamys namaquensis*	M	SA	A				47	89	19	85	10
Y		140	F3	2NBE8D	21-Dec-09	4	*Rhabdomys pumilio*	M	SA	A				59	90	20	81	10

Y		150	G2	2NBE9D	21-Dec-09	4	*Micaelamys namaquensis*	M	SA	A				41	96	20	81	10
Y		160	H8	2NBE10D	21-Dec-09	4	*Gerbilliscus leucogaster*	F	A		C	S		55	100	30	112	20
Y		170	H6	2NBE11D	21-Dec-09	4	*Rhabdomys pumilio*	F	A		C	S		48	100	20	95	11
Y		180	H2	2NBE12D	21-Dec-09	4	*Elephantulus intufi*	F	SA		C	S		35	71	27	85	15
Y		190	I3	2NBE13D	21-Dec-09	4	*Gerbilliscus leucogaster*	F	A		O	S		53	92	30	120	15
Y		1100	I6	2NBE14D	21-Dec-09	4	*Rhabdomys pumilio*	M	SA	A				39	80	23	90	10
Y		25	J8	2NBE15D	21-Dec-09	4	*Rhabdomys pumilio*	M	A	S				56	91	20	95	10
Y		26	J2	2NBE15D	21-Dec-09	4	*Rhabdomys pumilio*	M	A	S				55	100	21	100	11
	Y	15	A2		22-Dec-09	4	*Rhabdomys pumilio*											
	Y	18	A5		22-Dec-09	4	*Rhabdomys pumilio*											
Y		27	A7	2NBE17D	22-Dec-09	4	*Micaelamys namaquensis*	M	A	S				36	79	19	15	11
Y		28	B10	2NBE18D	22-Dec-09	4	*Elephantulus intufi*	M	A	S				37	85	22	79	15

Y		210	B1	2NBE19D	22-Dec-09	4	*Elephantulus intufi*	F	A		O	S		59	120	35	115	20
	Y	110	C3		22-Dec-09	4	*Micaelamys namaquensis*											
Y		220	C4	2NBE20D	22-Dec-09	4	*Rhabdomys pumilio*	M	A	S				53	97	25	105	10
Y		230	C6	2NBE21D	22-Dec-09	4	*Rhabdomys pumilio*	M	A	S				50	94	20	90	9
Y		240	D2	2NBE22D	22-Dec-09	4	*Rhabdomys pumilio*	F	A		C	S		51	85	20	84	10
Y		250	C5	2NBE23D	22-Dec-09	4	*Micaelamys namaquensis*	F	S A		C	S		34	85	19	72	10
Y		260	F8	2NBE24D	22-Dec-09	4	*Gerbilliscus leucogaster*	M	A	S				85	147	30	145	19
	Y	150	G2		22-Dec-09	4	*Micaelamys namaquensis*											
Y		270	G6	2NBE25D	22-Dec-09	4	*Rhabdomys pumilio*	M	A	S				55	86	25	96	10
Y		280	G7	2NBE26D	22-Dec-09	4	*Elephantulus intufi*	F	A		O	S		46	100	33	100	15
	Y	110	H10		22-Dec-09	4	*Micaelamys namaquensis*											
	Y	140	H4		22-Dec-09	4	*Rhabdomys pumilio*											

Y		290	I6	2NBE27D	22-Dec-09	4	*Rhabdomys pumilio*	M	A	S				51	111	26	105	10
Y		2100	J8	2NBE28D	22-Dec-09	4	*Micaelamys namaquensis*	M	A	S				43	109	19	100	10
Y		35	J10	2NBE29D	22-Dec-09	4	*Rhabdomys pumilio*	F	A		C	S		51	100	22	99	10
Y		36	J9	2NBE30D	22-Dec-09	4	*Rhabdomys pumilio*	M	A	S				61	105	24	111	10
Y		37	J1	2NBE31D	22-Dec-09	4	*Micaelamys namaquensis*	F	J		C	S		29	75	20	74	15
Y		38	A2	2NBE32D	23-Dec-09	4	*Rhabdomys pumilio*	F	A		C	S		59	90	20	100	15
Y		310	A4	2NBE33D	23-Dec-09	4	*Micaelamys namaquensis*	F	SA		C	S		32	70	20	70	10
Y		320	A5	2NBE34D	23-Dec-09	4	*Rhabdomys pumilio*	F	A		O	S		50	95	20	100	10
Y		330	A6	2NBE35D	23-Dec-09	4	*Elephantulus intufi*	M	A	S				65	110	30	100	20
	Y	18	A8		23-Dec-09	4	*Rhabdomys pumilio*											
	Y	17	B6		23-Dec-09	4	*Rhabdomys pumilio*											
Y		340	C9	2NBE36D	23-Dec-09	4	*Elephantulus intufi*	F	A		O	S		60	105	30	100	15
	Y	230	D3		23-	4	*Rhabdomys*											

					Dec -09		*pumilio*											
Y		350	E5	2NBE3 7D	23-Dec -09	4	*Rhabdomys pumilio*	M	A	S				58	100	20	101	9
Y		360	F8	2NBE3 8D	23-Dec -09	4	*Rhabdomys pumilio*	F	A		C	S		82	92	22	103	10
	Y	170	F6		23-Dec -09	4	*Rhabdomys pumilio*											
	Y	140	F3		23-Dec -09	4	*Rhabdomys pumilio*											
	Y	130	H10		23-Dec -09	4	*Micaelamys namaquensis*											
	Y	160	H8		23-Dec -09	4	*Gerbilliscus leucogaster*											
	Y	150	I4		23-Dec -09	4	*Micaelamys namaquensis*											
	Y	15	I9		23-Dec -09	4	*Rhabdomys pumilio*											
Y		310 0	J1	2NBE4 2D	23-Dec -09	4	*Elephantulus intufi*	F	A		O	S		37	78	30	87	20

New capture	Recapture	Toe code	Trap station	Label no.	Date	Grid no.	*Species*	Sex	Age	Testis (A/S)	Vagina (C/O)	Pregnant	Nipples(S/L)	Body weight	Head body	Hind foot	Tail	Ear
Y		38	A1	1ABE1D	13/04/2010	1	*Micaelamys namaquensis*	F	A		O			49	82	20	95	19
Y		310	A3	1ABE2D	13/04/2010	1	*Rhabdomys pumilio*	M	A	S				42	85	20	104	10
	Y	260	A4	1ABE3D	13/04/2010	1	*Rhabdomys pumilio*	F	A			P		55	111	20	95	11
Y		320	A6	1ABE4D	13/04/2010	1	*Rhabdomys pumilio*	M	SA	S				42	90	20	102	11
Y		Dead	A7		13/04/2010	1	*Elephantulus intufi*	F	A					60	98	35	115	20
Y		330	A8	1ABE5D	13/04/2010	1	*Rhabdomys pumilio*	M	SA	A				37	86	20	90	10
Y		340	A9	1ABE6D	13/04/2010	1	*Mastomys spp.*	M	SA	A				32	73	15	68	10
Y		350	A10	1ABE7D	13/04/2010	1	*Rhabdomys pumilio*	M	A	S				65	105	22	106	10
	Y		B6		13/04/2010	1	*Rhabdomys pumilio*	M	A	S				61	90	21	97	11
Y		360	C10	1ABE8D	13/04/2010	1	*Elephantulus intufi*	M	A	S				65	111	34	95	14
Y		370	E2	1ABE9D	13/04/2010	1	*Elephantulus intufi*	F	A					63	109	35	115	20
	Y	290	F2		13/04/2010	1	*Rhabdomys pumilio*	M	A					60	95	25	112	10
Y		380	G3	1ABE10D	13/04/2010	1	*Rhabdomys pumilio*	F	SA					52	91	25	112	13
Y		390	G5	1ABE11D	13/04/2010	1	*Rhabdomys pumilio*	M	A	S				52	85	24	105	11
Y		310	G6	1ABE12D	13/04/20	1	*Elephantulus*	M	A	S				55	112	30	98	16

		0			10		*intufi*											
	Y	420	G7		13/04/2010	1	*Rhabdomys pumilio*	F	A		C			60	95	13	106	25
	Y	45	H10	1ABE13D	13/04/2010	1	*Rhabdomys pumilio*	F	SA	S				40	85	21	96	10
Y		46	H9	1ABE14D	13/04/2010	1	*Rhabdomys pumilio*	F	SA					25	68	14	77	10
Y		47	H8	1ABE15D	13/04/2010	1	*Rhabdomys pumilio*	M	J	A				26	68	20	74	10
Y		48	H8	1ABE15D	13/04/2010	1	*Rhabdomys pumilio*	M	SA	A				36	63	23	95	10
Y		410	H6	1ABE16D	13/04/2010	1	*Rhabdomys pumilio*	M	SA	S				40	81	23	96	10
Y		420	H4	1ABE17D	13/04/2010	1	*Rhabdomys pumilio*	F	SA		C			35	80	18	91	10
	Y	180	I2		13/04/2010	1	*Rhabdomys pumilio*	M	A	S				56	120	23	97	10
Y		430	I3	1ABE18D	13/04/2010	1	*Rhabdomys pumilio*	M	SA	A				37	85	20	90	12
Y		440	I5	1ABE19D	13/04/2010	1	*Rhabdomys pumilio*	F	A		O			45	92	22	100	10
Y		Dead	I7		13/04/2010	1	*Rhabdomys pumilio*	M	A	S				50	109	21	105	11
Y		450	I9	1ABE20D	13/04/2010	1	*Rhabdomys pumilio*	M	SA	A				38	77	22	100	10
Y		460	J10	1ABE21D	13/04/2010	1	*Rhabdomys pumilio*	F	A		O			50	80	12	97	10
Y		470	J9	1ABE22D	13/04/2010	1	*Elephantulus intufi*	M	A	S				65	112	31	100	20
Y		Dead	I6		13/04/2010	1	*Elephantulus intufi*	F	A		O			66	116	34	111	22
	Y	?	J5		13/04/2010	1	*Rhabdomys pumilio*	M	A	S				60	105	23	97	10
Y		480	J4	1ABE23D	13/04/2010	1	*Rhabdomys pumilio*	M	SA	A				43	96	25	105	10
	Y	35	J2	Dead	13/04/20	1	*Rhabdomys*	F	A					50	95	21	10	10

					10		*pumilio*										6	
Y		Dead	J1		13/04/2010	1	*Rhabdomys pumilio*	F	SA		C			34	75	22	95	11
	Y	320	A3	Dead	14/04/2010	1	*Rhabdomys pumilio*											
Y		490	A4	1ABE24D	14/04/2010	1	*Rhabdomys pumilio*	F										
	Y	220	A4		14/04/2010	1	*Rhabdomys pumilio*	F	A					53	75	22	100	10
	Y	46	A6		14/04/2010	1	*Rhabdomys pumilio*	F	SA									
Y		4100	A7	1ABE25D	14/04/2010	1	*Rhabdomys pumilio*	M	SA	A				45	85	25	102	10
	Y	330	A8	1ABE5D	13/04/2010	1	*Rhabdomys pumilio*	M	SA	A				37	86	20	90	10
	Y	340	A9		14/04/2010	1	*Mastomys spp.*	A										
	Y	38	B4		14/04/2010	1	*Micaelamys namaquensis*	F										
Y		510	C1	1ABE26D	14/04/2010	1	*Micaelamys namaquensis*	M	SA	A				45	98	20	90	11
Y		520	C6	1ABE27D	14/04/2010	1	*Rhabdomys pumilio*	M	SA	A				49	91	22	106	11
Y		530	C9	1ABE28D	14/04/2010	1	*Rhabdomys pumilio*	M	SA	A				35	90	24	100	11
Y		540	D10	1ABE29D	14/04/2010	1	*Elephantulus intufi*	M	J	A				16	62	10	43	5
	Y	370	D7		14/04/2010	1	*Elephantulus intufi*	F	A									
Y		550	E5	1ABE30D	14/04/2010	1	*Rhabdomys pumilio*	F	A		C			42	105	18	100	10
	Y	3100	F10		14/04/2010	1	*Elephantulus intufi*	M	A									
	Y	420	F8		14/04/2010	1	*Rhabdomys pumilio*	F	SA									
	Y	290	F2		14/04/20	1	*Rhabdomys*	M	A									

					10		*pumilio*											
Y		560	F1	1ABE31D	14/04/2010	1	*Rhabdomys pumilio*	M	SA	A				45	95	25	105	10
	Y	380	G2		14/04/2010	1	*Rhabdomys pumilio*											
Y		570	G3	1ABE32D	14/04/2010	1	*Elephantulus intufi*	M	A	S				65	120	30	100	20
Y		580	G4	1ABE33D	14/04/2010	1	*Rhabdomys pumilio*	M	SA	A				41	95	20	105	10
Y		590	H6	1ABE34D	14/04/2010	1	*Elephantulus intufi*	M	A	S				65	118	33	111	15
	Y	420	H3		14/04/2010	1	*Rhabdomys pumilio*	F	SA									
	Y	180	I2		14/04/2010	1	*Rhabdomys pumilio*	M	A									
Y		5100	I5	1ABE35D	14/04/2010	1	*Elephantulus intufi*	M	A	S				55	118	32	90	15
	Y	440	I6		14/04/2010	1	*Rhabdomys pumilio*	F	A									
	Y	36	I9		14/04/2010	1	*Rhabdomys pumilio*	M	A									
	Y	410	I10		14/04/2010	1	*Rhabdomys pumilio*	M	SA									
	Y	3100	J10		14/04/2010	1	*Elephantulus intufi*	M										
Y		610	J9	1ABE36D	14/04/2010	1	*Elephantulus intufi*	M	A	S				66	122	130	103	15
	Y	480	J4		14/04/2010	1	*Rhabdomys pumilio*	M	SA									
	Y	46	J1		14/04/2010	1	*Rhabdomys pumilio*	M	A									
	Y	370	A5		15/04/2010	1	*Rhabdomys pumilio*	F	A		O			49	100	20	105	10
	Y	220	A6		15/04/2010	1	*Rhabdomys pumilio*	F						46	74	21	100	10
	Y	260	A7		15/04/20	1	*Rhabdomys*	M						52	95	20	99	10

					10		*pumilio*											
Y		620	A10	1ABE37D	15/04/2010	1	*Rhabdomys pumilio*	M	SA	A				40	95	20	99	10
Y		630	B9	1ABE38D	15/04/2010	1	*Micaelamys namaquensis*	M	SA	A				25	83	15	70	10
Y		640	B6	1ABE39D	15/04/2010	1	*Rhabdomys pumilio*	F	SA		C			40	88	25	103	10
	Y	38	B5		15/04/2010	1	*Micaelamys namaquensis*	F										
	Y	330	F8		15/04/2010	1	*Rhabdomys pumilio*	M	SA									
	Y	570	D4		15/04/2010	1	*Elephantulus intufi*	M	A									
	Y	5100	D1	Dead	15/04/2010	1	*Elephantulus intufi*											
Y		650	E4	1ABE39D	15/04/2010	1	*Gerbilliscus leucogaster*	M	SA	A				15	59	15	40	10
	Y	380	F2		15/04/2010	1	*Rhabdomys pumilio*	F	SA									
Y		660	G2	1ABE40D	15/04/2010	1	*Rhabdomys pumilio*	M	SA	S				35	83	25	90	10
	Y	370	G3		15/04/2010	1	*Elephantulus intufi*	F	A									
	Y	290	G5		15/04/2010	1	*Rhabdomys pumilio*	M	A									
	Y	3100	G7		15/04/2010	1	*Elephantulus intufi*	M										
Y		670	H10	1ABE41D	15/04/2010	1	*Rhabdomys pumilio*	M	A	S				56	105	20	100	10
	Y	420	H9		15/04/2010	1	*Rhabdomys pumilio*	F	SA									
	Y	420	H2		15/04/2010	1	*Rhabdomys pumilio*											
Y		680	H1	1ABE42D	15/04/2010	1	*Rhabdomys pumilio*	M	SA	A				35	85	15	90	10
	Y	530	I3		15/04/20	1	*Rhabdomys*	M	SA									

					10		*pumilio*											
	Y	440	I5		15/04/2010	1	*Rhabdomys pumilio*											
	Y	410	I7		15/04/2010	1	*Rhabdomys pumilio*											
	Y	46	I7		15/04/2010	1	*Rhabdomys pumilio*	M										
Y		690	J10	1ABE43D	15/04/2010	1	*Rhabdomys pumilio*	M	SA	A				36	95	25	96	10
	Y	590	J9		15/04/2010	1	*Elephantulus intufi*											
	Y	36	J8		15/04/2010	1	*Rhabdomys pumilio*	M										
	Y	430	J5		15/04/2010	1	*Rhabdomys pumilio*	M	SA	A								
	X	38	A3		17/04/2010	2	*Micaelamys namaquensis*	F						38	85	20	98	10
X		380	A5	2ANBE1D	17/04/2010	2	*Rhabdomys pumilio*	M	SA	A				43	90	20	21	10
X		390	A6	2ANBE2D	17/04/2010	2	*Micaelamys namaquensis*	F	J		C			22	65	15	65	10
X		3100	A7	2ANBE3D	17/04/2010	2	*Gerbilliscus leucogaster*	F	A		C			67	105	25	143	15
X		45	B8	2ANBE4D	17/04/2010	2	*Micaelamys namaquensis*	M	SA	A				28	80	20	72	10
X		46	B7	2ANBE5D	17/04/2010	2	*Micaelamys namaquensis*	M	SA	A				25	75	15	73	10
	X	18	B3		17/04/2010	2	*Rhabdomys pumilio*	M						50	103	20	29	10
X		47	C2	2ANBE5D	17/04/2010	2	*Rhabdomys pumilio*	M	SA	A				40	87	25	100	10
X		48	C3	2ANBE5D	17/04/2010	2	*Micaelamys namaquensis*	M	SA	A				25	75	20	70	10
X		410	C5	2ANBE6D	17/04/2010	2	*Rhabdomys pumilio*	F	A		O			46	95	20	103	10
X		420	C6	2ANBE7	17/04/20	2	*Crocidura*	F	SA		O			25	75	10	40	10

				D	10		*spp.*											
X		430	C9	2ANBE8D	17/04/2010	2	*Gerbilliscus leucogaster*	M	SA	A				32	83	25	90	10
X		440	C10	2ANBE9D	17/04/2010	2	*Crocidura spp.*	F	SA		C			19	64	12	40	8
X		450	D10	2ANBE10D	17/04/2010	2	*Micaelamys namaquensis*	M	A	S				45	95	20	97	10
	X	270	D9		17/04/2010	2	*Gerbilliscus leucogaster*	F	A					73	112	30	155	15
X		460	D5	2ANBE11D	17/04/2010	2	*Rhabdomys pumilio*	M	SA	A				44	95	25	104	10
X		470	E1	2ANBE12D	17/04/2010	2	*Micaelamys namaquensis*	M	SA	A				25	75	20	73	10
	X	230	E2		17/04/2010	2	*Rhabdomys pumilio*	F	A					52	95	20	106	10
X		480	E3	2ANBE13D	17/04/2010	2	*Rhabdomys pumilio*	M	SA	A				43	90	15	116	10
X		490	E5	2ANBE14D	17/04/2010	2	*Rhabdomys pumilio*	M	SA	A				38	74	20	95	10
	X	210	E7		17/04/2010	2	*Rhabdomys pumilio*	F	A					51	105	20	100	10
X		4100	E9	2ANBE15D	17/04/2010	2	*Rhabdomys pumilio*	M	SA	A				45	85	25	95	10
X		510	F9	2ANBE16D	17/04/2010	2	*Rhabdomys pumilio*	F	SA		C			52	90	25	89	10
X		520	F7	2ANBE17D	17/04/2010	2	*Rhabdomys pumilio*	M	A	S				43	85	24	103	10
	X	28	F6	Dead	17/04/2010	2	*Micaelamys namaquensis*	M	A					57	92	21	85	12
X		530	F3	2ANBE18D	17/04/2010	2	*Crocidura spp.*	M	J					15	70	13	45	7
X		540	F2	2ANBE19D	17/04/2010	2	*Rhabdomys pumilio*	M	SA	S				30	73	20	91	10
X		550	G7	2ANBE20D	17/04/2010	2	*Rhabdomys pumilio*	M	A	S				56	105	25	102	10
X		560	H7	2ANBE21	17/04/20	2	*Rhabdomys*	F	A		O			50	105	16	10	10

				D	10		*pumilio*										7	
	X	250	H5		17/04/2010	2	*Rhabdomys pumilio*	M	A					60	95	28	90	10
X			H3	Dead	17/04/2010	2	*Rhabdomys pumilio*	M						40	80	20	100	10
X		570	I2	2ANBE22D	17/04/2010	2	*Micaelamys namaquensis*	M	SA	A				45	93	23	132	10
X		580	I4	2ANBE23D	17/04/2010	2	*Rhabdomys pumilio*	F	A		C			45	96	25	91	10
X		590	I10	2ANBE24D	17/04/2010	2	*Rhabdomys pumilio*	F	A		O			60	100	20	112	10
X			J10	Dead	17/04/2010	2	*Rhabdomys pumilio*	F	A					45	85	20	105	10
X			J10	Dead	17/04/2010	2	*Rhabdomys pumilio*	M	A					50	96	20	105	10
X			J8	Dead	17/04/2010	2	*Micaelamys namaquensis*	M	J					20	65	15	60	15
X		5100	J4	2ANBE25D	17/04/2010	2	*Rhabdomys pumilio*	M	SA	A				55	95	23	103	10
	X	380	A5		18/04/2010	2	*Rhabdomys pumilio*	M										
X		610	A7	2ANBE26D	18/04/2010	2	*Micaelamys namaquensis*	M	SA	A				25	78	20	75	10
X		620	A7	2ANBE27D	18/04/2010	2	*Micaelamys namaquensis*	M	J	A				20	57	15	65	10
X		630	B9	2ANBE28D	18/04/2010	2	*Rhabdomys pumilio*	M	SA	A				43	102	20	106	10
	X	220	B8	Dead	18/04/2010	2	*Gerbilliscus leucogaster*	F						67	105	30	149	15
X		640	B7	2ANBE29D	18/04/2010	2	*Micaelamys namaquensis*	M	SA	A				25	65	16	73	10
X		650	B1	2ANBE30D	18/04/2010	2	*Rhabdomys pumilio*	F	SA		O			36	92	20	100	10
X		660	C2	2ANBE31D	18/04/2010	2	*Rhabdomys pumilio*	F	J		C			27	78	23	95	10
	X	410	C5		18/04/20	2	*Rhabdomys*	F										

					10		*pumilio*											
X		670	D10	2ANBE32D	18/04/2010	2	*Rhabdomys pumilio*	F	SA					42	72	20	101	10
	X	18	D8	Dead	18/04/2010	2	*Rhabdomys pumilio*	M										
X		680	D7	2ANBE33D	18/04/2010	2	*Rhabdomys pumilio*	F	SA		O			34	80	20	95	10
	X	230	D2		18/04/2010	2	*Rhabdomys pumilio*	F										
X		690	E1	2ANBE34D	18/04/2010	2	*Rhabdomys pumilio*	F	J		C			21	45	15	76	7
	X	140	E2		18/04/2010	2	*Rhabdomys pumilio*	M	A						95	20	35	10
	X	490	E5		18/04/2010	2	*Rhabdomys pumilio*	M	SA									
X		6100	E7	2ANBE35D	18/04/2010	2	*Rhabdomys pumilio*	F	SA		O			27	73	20	91	10
X		710	E8	2ANBE36D	18/04/2010	2	*Rhabdomys pumilio*	F	J		C			60	75	20	75	8
	X	450	E9		18/04/2010	2	*Micaelamys namaquensis*	M	A									
X		Dead	E10	Dead	18/04/2010	2	*Rhabdomys pumilio*	F	SA					25	62	20	83	5
X		720	F10	2ANBE37D	18/04/2010	2	*Rhabdomys pumilio*	F	A		O			38	83	20	94	10
X		730	F7	2ANBE38D	18/04/2010	2	*Rhabdomys pumilio*	F	A		O			35	77	16	99	10
X		740	F4	2ANBE39D	18/04/2010	2	*Rhabdomys pumilio*	M	SA	A				33	70	20	92	10
X		Dead	F2	Dead	18/04/2010	2	*Crocidura spp.*	F	J					11	15	10	42	5
	X	46	G4		18/04/2010	2	*Micaelamys namaquensis*	M	SA									
	X	250	G5		18/04/2010	2	*Rhabdomys pumilio*	M	A					53	79	20	85	10
	X	210	G7	Dead	18/04/20	2	*Rhabdomys*	F	A									

					10		*pumilio*											
X		750	G9	2ANBE40D	18/04/2010	2	*Rhabdomys pumilio*	F	A		O			36	65	20	95	10
X		760	H10	2ANBE41D	18/04/2010	2	*Rhabdomys pumilio*	F	A		C			39	66	22	107	10
	X	560	H7		18/04/2010	2	*Rhabdomys pumilio*	F	A									
X		Dead	H5		18/04/2010	2	*Rhabdomys pumilio*	M	J					20	55	15	80	5
X		770	H1	2ANBE42D	18/04/2010	2	*Rhabdomys pumilio*	M	A	S				35	75	21	95	10
X		780	I5	2ANBE43D	18/04/2010	2	*Rhabdomys pumilio*	M	A	S				55	111	20	52	10
X		790	I8	2ANBE44D	18/04/2010	2	*Rhabdomys pumilio*	M	SA	A				32	69	20	99	10
X		7100	J3	2ANBE45D	18/04/2010	2	*Rhabdomys pumilio*	F	A		o			62	83	2		
X		Dead	A3	Dead	19/04/2010	2	*Rhabdomys pumilio*	M	SA					32	75	20	93	10
X		Dead	A4	Dead	19/04/2010	2	*Rhabdomys pumilio*	F	SA					47	78	20	105	10
X		810	A5	2ANBE46D	19/04/2010	2	*Rhabdomys pumilio*	M	A	S				47	80	16	89	10
X		820	A6	2ANBE47D	19/04/2010	2	*Rhabdomys pumilio*	F	SA					36	66	20	100	10
X		830	B9	2ANBE48D	19/04/2010	2	*Rhabdomys pumilio*	F	SA		C			37	75	22	99	10
	X	3100	B5	Dead	19/04/2010	2	*Gerbilliscus leucogaster*	F	A									
X			B1	Dead	19/04/2010	2	*Rhabdomys pumilio*	F	A					35	105	20	91	15
X			C2	Dead	19/04/2010	2	*Rhabdomys pumilio*	M	SA					30	71	21	87	10
X		840	C10	2ANBE49D	19/04/2010	2	*Rhabdomys pumilio*	F	SA		O			40	70	16	75	10
X			D10	Dead	19/04/20	2	*Rhabdomys*	M	J					20	65	20	80	10

					10		*pumilio*											
	X	460	D5	Dead	19/04/2010	2	*Rhabdomys pumilio*	M	SA									
	X	230	E2	Dead	19/04/2010	2	*Rhabdomys pumilio*	F										
	X	6100	E5	Dead	19/04/2010	2	*Rhabdomys pumilio*	F										
	X	450	E7	Dead	19/04/2010	2	*Micaelamys namaquensis*	M										
	X	640	E9	Dead	19/04/2010	2	*Micaelamys namaquensis*	M										
X		850	E10	2ANBE50D	19/04/2010	2	*Micaelamys namaquensis*	F	J		C			22	60	15	65	10
	X	530	F10	Dead	19/04/2010	2	*Crocidura spp.*	M										
X		860	F9	2ANBE51D	19/04/2010	2	*Rhabdomys pumilio*	F	A		O			30	65	21	86	10
	X	250	F5	Dead	19/04/2010	2	*Rhabdomys pumilio*	M	A									
	X	740	F4		19/04/2010	2	*Rhabdomys pumilio*	M										
	X	240	F1	Dead	19/04/2010	2	*Rhabdomys pumilio*	M						50	95	25	35	10
	X	46	G4	Dead	19/04/2010	2	*Micaelamys namaquensis*	M										
	X	520	G7	Dead	19/04/2010	2	*Rhabdomys pumilio*	M										
	X	5100	G9	Dead	19/04/2010	2	*Rhabdomys pumilio*	M										
X			G10	Dead	19/04/2010	2	*Rhabdomys pumilio*	F						22	60	20	80	10
X			H10	Dead	19/04/2010	2	*Rhabdomys pumilio*	F	SA		O			40	66	20	105	10
X			H9	Dead	19/04/2010	2	*Rhabdomys pumilio*	F	SA					32	75	20	93	10
	X	610	H7	Dead	19/04/20	2	*Rhabdomys*	F	SA									

		0			10		*pumilio*											
X			H6	Dead	19/04/2010	2	*Rhabdomys pumilio*	F						50	85	25	106	10
x			H3	Dead	19/04/2010	2	*Rhabdomys pumilio*	F						37	70	21	95	10
X		870	I6	2ANBE52D	19/04/2010	2	*Rhabdomys pumilio*	F	SA		O			37	75	20	95	10
X			I8	Dead	19/04/2010	2	*Rhabdomys pumilio*	F	A		O			50	95	20	90	10
X		880	J9	2ANBE53D	19/04/2010	2	*Rhabdomys pumilio*	F	A		O			50	80	20	105	10
	X	280	A1		22/04/2010	3	*Rhabdomys pumilio*							62	95	20	100	10
		37	A2		22/04/2010	3	*Elephantulus intufi*	M	A					60	125	35	115	20
X		830	A3	3ABE1D	22/04/2010	3	*Elephantulus intufi*	F	A		O			67	95	35	111	25
X			A4	Dead	22/04/2010	3	*Rhabdomys pumilio*	M	A	S				50	85	20	100	10
X		840	A8	3ABE2D	22/04/2010	3	*Elephantulus intufi*	M	A	S				57	120	35	110	15
X		450	A9	3ABE3D	22/04/2010	3	*Elephantulus intufi*	F	A		O			55	110	30	110	20
	X	150	B7		22/04/2010	3	*Elephantulus intufi*	M	A					62	115	30	105	15
X		460	B3	3ABE4D	22/04/2010	3	*Elephantulus intufi*	M	A	S				65	110	35	113	20
X			D10	Dead	22/04/2010	3	*Micaelamys namaquensis*	M	SA	A				19	75	20	105	10
x		470	E2	3ABE5D	22/04/2010	3	*Rhabdomys pumilio*	M	SA	A				45	90	20	85	10
X		480	F2	3ABE6D	22/04/2010	3	*Rhabdomys pumilio*	M	SA	A				29	65	20	100	10
	X	110	F1		22/04/2010	3	*Rhabdomys pumilio*	F	A					60	95	20	100	10
	X	110	G1		22/04/20	3	*Rhabdomys*	M	A					60	11	20	90	10

		0			10		*pumilio*											
X		490	G5	3ABE7D	22/04/2010	3	*Rhabdomys pumilio*	M	SA	A				40	80	20	100	10
X		4100	G8	3ABE8D	22/04/2010	3	*Rhabdomys pumilio*	F	A					52	90	20	100	10
X		510	G9	3ABE9D	22/04/2010	3	*Elephantulus intufi*	M	A	S				45	90	30	100	15
	X	290	H10		22/04/2010	3	*Rhabdomys pumilio*	F	A					54	90	20	100	10
X		520	H3	3ABE10D	22/04/2010	3	*Rhabdomys pumilio*	M	SA	A				40	90	21	100	10
X		530	H1	3ABE11D	22/04/2010	3	*Rhabdomys pumilio*	M	SA	A				30	75	20	90	10
	X	28	I3		22/04/2010	3	*Gerbilliscus leucogaster*	M	A					76	100	25	90	15
X		540	J8	3ABE12D	22/04/2010	3	*Elephantulus intufi*	F	A		O			55	100	34	105	20
	X	150	J6	Dead	22/04/2010	3	*Elephantulus intufi*	F	A					60	112	32	125	20
	X	310	J3		22/04/2010	3	*Rhabdomys pumilio*	M	A					56	85	20	100	10
X		550	A1	3ABE13D	23/04/2010	3	*Rhabdomys pumilio*	M	A					30	65	20	84	10
X			A2	Dead	23/04/2010	3	*Rhabdomys pumilio*	F			C			35	75	20	96	10
	X	390	A5		23/04/2010	3	*Rhabdomys pumilio*	F	A					56	75	20	96	10
X		560	A7	3ABE14D	23/04/2010	3	*Elephantulus intufi*	F	A		O			56	115	34	110	15
X		570	A8	3ABE15D	23/04/2010	3	*Rhabdomys pumilio*	F	A		C			50	90	20	105	10
X		Dead	A10		23/04/2010	3	*Elephantulus intufi*	F	A					55	100	35	102	20
X		130	B6		23/04/2010	3	*Elephantulus intufi*	F	A					56	85	30	111	20
X		830	B4		23/04/20	3	*Elephantulus*											

					10		*intufi*											
	X	580	C3		23/04/2010	3	*Rhabdomys pumilio*	F	J					37	80	20	95	10
X		590	C5	3ABE17D	23/04/2010	3	*Rhabdomys pumilio*	F	J		C			35	65	12	90	10
	X	540	D9		23/04/2010	3	*Elephantulus intufi*	F	A									
	X	460	D3		23/04/2010	3	*Elephantulus intufi*	M	A									
	X	15	D2		23/04/2010	3	*Rhabdomys pumilio*	M	A					54	90	23	94	10
X		Dead	D1		23/04/2010	3	*Rhabdomys pumilio*	F	SA		C			34	70	20	90	7
X		5100	E3	3ABE18D	23/04/2010	3	*Rhabdomys pumilio*	M	SA					40	65	20	105	10
X		610	F2	3ABE19D	23/04/2010	3	*Rhabdomys pumilio*	F	SA		C			40	80	20	100	10
X		620	F1	3ABE20D	23/04/2010	3	*Elephantulus intufi*	F	A		O			69	100	30	105	20
	X	490	G1		23/04/2010	3	*Rhabdomys pumilio*	M	SA									
X			G2	Dead	23/04/2010	3	*Rhabdomys pumilio*	M	J					25	60	19	84	5
X			G5	Dead	23/04/2010	3	*Rhabdomys pumilio*	F	A					43	80	20	105	10
X		630	G8	3ABE21D	23/04/2010	3	*Rhabdomys pumilio*	F	A		O			44	75	20	90	10
	X	510	G9		23/04/2010	3	*Elephantulus intufi*	M	A									
X		640	G10	3ABE322D	23/04/2010	3	*Rhabdomys pumilio*	F	J		C							
X		650	H10	£ABE23D	23/04/2010	3	*Rhabdomys pumilio*	F	A		O			58	85	21	100	10
X		660	H9	3ABE24D	23/04/2010	3	*Rhabdomys pumilio*	F	SA		C			40	74	20	100	10
X			H6	Dead	23/04/20	3	*Rhabdomys*	M	SA					32	65	20	86	10

					10		*pumilio*											
X			H1	Dead	23/04/2010	3	*Rhabdomys pumilio*	F	A		O			40	75	20	95	10
	X	310	I2		23/04/2010	3	*Rhabdomys pumilio*	M	A		S			57	85	20	100	10
x		670	I5	3ABE25D	23/04/2010	3	*Micaelamys namaquensis*	F	A		O			40	80	20	115	10
X		680	I6	3ABE26D	23/04/2010	3	*Rhabdomys pumilio*	M	A	S				56	95	20	55	10
X		690	I7	3ABE27D	23/04/2010	3	*Rhabdomys pumilio*	F	J		C			30	75	12	85	10
X		6100	J8	3ABE28D	23/04/2010	3	*Rhabdomys pumilio*	F	J		C			26	75	15	80	5
X		710	J1	3ABE29D	23/04/2010	3	*Rhabdomys pumilio*	F	A		O			40	74	21	96	10
X		720	A1	3ABE30D	24/04/2010	3	*Elephantulus intufi*	M	A	S				65	111	30	105	20
	X	120	A2		24/10/2010	3	*Rhabdomys pumilio*	F	A		O			57	89	20	107	10
	X	460	A3		24/10/2010	3	*Elephantulus intufi*	M	A									
X		730	A7	3ABE31D	24/10/2010	3	*Rhabdomys pumilio*	F	SA		O			45	85	20	105	10
	X	450	A8		24/10/2010	3	*Elephantulus intufi*	F	A									
	X	840	A9		24/10/2010	3	*Elephantulus intufi*	M	A									
	X	540	A10		24/10/2010	3	*Elephantulus intufi*	F	A									
	X	560	B6		24/10/2010	3	*Elephantulus intufi*	F	A		C							
X		740	B5	3ABE332D	24/10/2010	3	*Rhabdomys pumilio*	F	A		C			43	85	20	100	10
	X	520	B1		24/10/2010	3	*Rhabdomys pumilio*	M	SA									
	X	110	D1	Dead	24/10/20	3	*Rhabdomys*	F	A									

					10		*pumilio*											
	X	1100	E3		24/10/2010	3	*Rhabdomys pumilio*	M	A					65	100	15	85	10
X		750	F3	3ABE33D	24/10/2010	3	*Rhabdomys pumilio*	F	SA		O			42	85	20	99	10
X		760	F2	3ABE34D	24/10/2010	3	*Rhabdomys pumilio*	F	SA		C			35	70	20	95	10
X		770	F1	3ABE35D	24/10/2010	3	*Rhabdomys pumilio*	M	SA	A				23	70	20	95	10
X		780	G1	3ABE36D	24/10/2010	3	*Rhabdomys pumilio*	F	A		O			55	105	20	100	10
	X	480	G2		24/10/2010	3	*Rhabdomys pumilio*	M	SA									
X		790	G8	3ABE37D	24/10/2010	3	*Rhabdomys pumilio*	F	J		C			30	70	15	85	5
	X	130	G9		24/10/2010	3	*Elephantulus intufi*	F	A									
X		7100	G10	3ABE38D	24/10/2010	3	*Rhabdomys pumilio*	F	J		C			30	65	21	82	10
X		810	H10	3ABE39D	24/10/2010	3	*Rhabdomys pumilio*	F	J		C			32	70	20	90	10
X		820	H5	3ABE40D	24/10/2010	3	*Rhabdomys pumilio*	F	J		C			27	60	16	80	10
X		Dead	H3		24/10/2010	3	*Rhabdomys pumilio*	F	J		C			20	70	20	71	10
X		850	H2	3ABE41D	24/10/2010	3	*Rhabdomys pumilio*	M	A	S				47	90	20	95	10
X		860	I2	3ABE42D	24/10/2010	3	*Rhabdomys pumilio*	F	J		C			31	75	20	100	10
	X	310	I3		24/10/2010	3	*Rhabdomys pumilio*	M	A									
	X	28	I4		24/10/2010	3	*Gerbilliscus leucogaster*	M	A									
	X	670	I5		24/10/2010	3	*Micaelamys namaquensis*	F	A									
X		870	I7	39ABE43	24/10/20	3	*Micaelamys*	F	J		C			25	65	10	40	9

				D	10		*namaquensis*											
	X	640	I9		24/10/2010	3	*Rhabdomys pumilio*	F	J									
	X	4100	I9		24/10/2010	3	*Rhabdomys pumilio*	F	A									
	X	360	J9		24/10/2010	3	*Rhabdomys pumilio*	M	A					60	111	23	70	10
X		880	J7	3ABE44D	24/10/2010	3	*Rhabdomys pumilio*	M	A	S				45	90	20	100	10
X		890	J4	3ABE45D	24/10/2010	3	*Elephantulus intufi*	F	A		O			50	111	30	104	20
	X	330	A5		26/04/2010	4	*Elephantulus intufi*	M	A					65	111	30	95	15
	X	340	B10		26/04/2010	4	*Elephantulus intufi*	F	A					61	115	30	90	20
x		45	C10	4ANBE1D	26/04/2010	4	*Elephantulus intufi*	M	A	S				64	100	30	105	16
X		46	D2	4ANBE2D	26/04/2010	4	*Rhabdomys pumilio*	M	A	S				57	85	20	100	7
X		47	E2	4ANBE3D	26/04/2010	4	*Rhabdomys pumilio*	F	SA		C			32	70	20	85	10
X		48	E9	4ANBE4D	26/04/2010	4	*Mastomys spp.*	M	SA	A				30	60	15	75	12
X		510	F1	4ANBE5D	26/04/2010	4	*Elephantulus intufi*	F	A		O			65	100	30	115	20
X		520	I2	4ANBE6D	26/04/2010	4	*Elephantulus intufi*	F	A		O			55	100	30	112	20
X		530	I3	4ANBE7D	26/04/2010	4	*Elephantulus intufi*	M	A	S				60	105	30	111	20
X		540	I4	4ANBE8D	26/04/2010	4	*Rhabdomys pumilio*	M	A	S				58	115	15	100	10
X		550	J8	4ANBE9D	26/04/2010	4	*Mastomys spp.*	F	SA		C			26	65	17	60	10
X		560	J5	4ANBE10D	26/04/2010	4	*Micaelamys namaquensis*	F	SA		C			25	60	15	70	10
X		570	J2	4ANBE11	26/04/20	4	*G.*	F	SA		C			56	90	31	11	10

				D	10		*Leucogaster*										1	
X		Dead	J1		26/04/2010	4	*Micaelamys namaquensis*	F	J		C			20	60	16	52	15
X		580	A5	4ANBE12D	27/04/2010	4	*Micaelamys namaquensis*	F	J		C			21	65	16	70	10
	X	550	A6	Dead	27/04/2010	4	*Mastomys spp.*	F										
	X	18	A7	Dead	27/04/2010	4	*Rhabdomys pumilio*	M	A					47	105	20	100	10
	X	45	B9		27/04/2010	4	*Elephantulus intufi*	M	A									
X		590	B6	4ANBE13D	27/04/2010	4	*Rhabdomys pumilio*	F	A		O			47	95	20	90	10
	X	330	C2		27/04/2010	4	*Elephantulus intufi*											
X		Dead		Dead	27/04/2010	4	*Rhabdomys pumilio*	M	A	S				41	80	20	105	10
X		5100	C10	4ANBE13D	27/04/2010	4	*Elephantulus intufi*	M	A					70	100	30	95	20
X		610	D8	4ANBE14D	27/04/2010	4	*Elephantulus intufi*	M	A	S				60	112	30	90	20
X		Dead	D5		27/04/2010	4	*Rhabdomys pumilio*	M	A	S				70	75	20	100	10
X		Dead	D3	Dead	27/04/2010	4	*Rhabdomys pumilio*							36	70	20	95	10
x		620	E1	4ANBE15D	27/04/2010	4	*Rhabdomys pumilio*							35	70	20	90	10
	X	530	E2		27/04/2010	4	*Elephantulus intufi*											
X		630	E3	4ANBE16D	27/04/2010	4	*Rhabdomys pumilio*	F	SA					45	65	20	54	10
X		640	E4	4ANBE17D	27/04/2010	4	*Rhabdomys pumilio*	F	SA		C			37	65	21	95	10
X		650	E9	4ANBE18D	27/04/2010	4	*Rhabdomys pumilio*	M	A	S				43	75	22	85	10
X		660	G10	4ANBE19	27/04/20	4	*Rhabdomys*	M	A	S				42	85	20	10	10

				D	10		*pumilio*										4	
X		670	H8	4ANBE20D	27/04/2010	4	*Rhabdomys pumilio*	M	A	S				59	100	20	70	10
X		680	H7	4ANBE21D	27/04/2010	4	*Rhabdomys pumilio*	F	A		O			51	80	25	99	10
X		690	H6	4ANBE22D	27/04/2010	4	*Rhabdomys pumilio*	F	J		C			26	75	15	82	5
	X	520	H4		27/04/2010	4	*Elephantulus intufi*	F	A									
X		6100	I2	4ANBE23D	27/04/2010	4	*Rhabdomys pumilio*	F	SA		C			40	80	16	90	10
X		Dead		Dead	27/04/2010	4	*Micaelamys namaquensis*	F	J		C			24	54	15	60	10
X		710	I4	4ANBE24D	27/04/2010	4	*Rhabdomys pumilio*	M	A	S				46	100	20	95	10
X		720	I7	4ANBE25D	27/04/2010	4	*Rhabdomys pumilio*	F	A		O			33	80	20	85	10
X		730	I10	4ANBE26D	27/04/2010	4	*Elephantulus intufi*	F	A		O			69	111	30	111	15
X		740	J10	4ANBE27D	27/04/2010	4	*Elephantulus intufi*	F	A		O			70	115	30	111	15
X		750	J8	4ANBE28D	27/04/2010	4	*Elephantulus intufi*	M	A	S				61	112	25	85	20
X		760	J5	4ANBE29D	27/04/2010	4	*Elephantulus intufi*	M	A	S				67	100	30	111	15
X		770	J1	4ANBE30D	27/04/2010	4	*Elephantulus intufi*	M	A	S				65	100	30	104	15
	X	550	A6	Dead	28/04/2010	4	*Micaelamys namaquensis*	F	J									
	X	45	A10		28/04/2010	4	*Elephantulus intufi*	M	A									
	X	340	B9		28/04/2010	4	*Elephantulus intufi*	F	A									
X		780	B6	4ANBE31D	28/04/2010	4	*Rhabdomys pumilio*	F	SA		C			35	70	20	100	10
	X	210	B2		28/04/20	4	*Elephantulus*	F	A					69	100	30	10	15

					10		*intufi*										5	
X		790	D8	4ANBE32D	28/04/2010	4	*Rhabdomys pumilio*	M	SA	A				50	95	22	100	10
X		7100	D4	4ANBE33D	28/04/2010	4	*Rhabdomys pumilio*	F	SA		C			35	75	25	90	10
X		Dead	D3		28/04/2010	4	*Rhabdomys pumilio*	F	SA		C			39	78	20	95	6
	X	640	E3		28/04/2010	4	*Rhabdomys pumilio*	F	SA									
X		810	E4	4ANBE34D	28/04/2010	4	*Rhabdomys pumilio*	F	SA					31	75	20	94	10
	X	330	E5		28/04/2010	4	*Elephantulus intufi*	M	A									
X		820	F9	4ANBE35D	28/04/2010	4	*Rhabdomys pumilio*	F	SA		C	Y		57	90	20	111	5
X		830	F3	4ANBE36D	28/04/2010	4	*Rhabdomys pumilio*	F	A		O			48	75	20	100	10
	X	770	F1		28/04/2010	4	*Elephantulus intufi*	M	A									
X		840	G1	4ANBE37D	28/04/2010	4	*Rhabdomys pumilio*	M	A	S				51	100	20	95	10
	X	530	G4		28/04/2010	4	*Elephantulus intufi*	M	A									
	X	680	G5		28/04/2010	4	*Rhabdomys pumilio*	F	A									
X		850	G7	4ANBE38D	28/04/2010	4	*Rhabdomys pumilio*	F	A		C			31	75	20	105	10
	X	610	H6		28/04/2010	4	*Elephantulus intufi*	M	A									
X		860	H4	4ANBE39D	28/04/2010	4	*Rhabdomys pumilio*	M	SA	A				42	75	20	90	10
	X	540	I2		28/04/2010	4	*Rhabdomys pumilio*	M	A									
	X	290	J8		28/04/2010	4	*Rhabdomys pumilio*	M	A					60	112	20	90	10
X		870	J5	4ANBE40	28/04/20	4	*Rhabdomys*	M	SA	A				41	75	20	82	10

				D	10		*pumilio*											
X		880	J4	4ANBE41D	28/04/2010	4	*Elephantulus intufi*	F	A		O			62	112	30	105	20
X		890	J1	4ANBE42D	28/04/2010	4	*Rhabdomys pumilio*	M	A	S				55	105	20	111	10

New capture	Recapture	Toe code	Trap station	Label no.	Date	Grid no.	*Species*	Sex	Age	Testis (A/S)	Vagina (close/open)	Nipple (S/L)	Pregnant	Body weight	Head body	Hind foot	Tail	Ear
Y		Dead	A2		15/07/2010	1	*Mastomys spp.*	F	SA		C	S		22	53	15	65	10
	Y	320	A4		15/07/2010	1	*Rhabdomys pumilio*	M	A	S				43	80	20	95	10
Y		Dead	C3		15/07/2010	1	*Elephantulus intufi*	M	A	S				49	105	30	35	20
Y		Dead	G1		15/07/2010	1	*Micaelamys namaquensis*	F	SA		C	S		30	61	20	86	15
Y		Dead	H6		15/07/2010	1	*Micaelamys namaquensis*	F	SA		C	S		25	72	20	69	15
Y		Dead	J2		15/07/2010	1	*Micaelamys namaquensis*	F	SA		C	S		30	75	20	80	15
Y		Dead	J1		15/07/2010	1	*Micaelamys namaquensis*	F	SA		C	S		26	69	20	71	11
	Y	580	F3	Dead	16/07/2010	1	*Rhabdomys pumilio*	M	A	S				44	80	20	105	10
Y		Dead	H2	Dead	16/07/2010	1	*Micaelamys namaquensis*	F	SA		C	S		30	75	20	72	15
Y		Dead	I2	Dead	16/07/2010	1	*Rhabdomys pumilio*	M	SA	A				32	70	20	80	10
Y		Dead	J1	Dead	16/07/2010	1	*Mastomys spp.*	F	SA		C	S		30	64	20	82	15
Y		6100	J2	1JBE1D	17/07/2010	1	*Rhabdomys pumilio*	F	SA		C	S		22	69	20	90	10
Y		Dead	A5		18/07/2010	2	*Gerbilliscus leucogaster*	M	A	S				73	105	30	111	20
Y		890	A8	JNBE1D	18/07/2010	2	*Mastomys spp.*	F	SA		c	S		21	70	19	75	10
Y		8100	B9	JNBE2D	18/07/2010	2	*Gerbilliscus leucogaster*	M	A	S				64	100	30	95	20

Y		Dead	B4		18/07/2010	2	*Rhabdomys pumilio*	F	SA		C	S		38	70	20	90	10
Y		Dead	B1		18/07/2010	2	*Micaelamys namaquensis*	F	A		C	S		36	86	20	105	20
Y		Dead	C2		18/07/2010	2	*Micaelamys namaquensis*	F	SA		C	S		26	70	20	45	15
Y		Dead	C7		18/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		50	75	22	103	10
Y		Dead	D7		18/07/2010	2	*Micaelamys namaquensis*	F	SA		C	S		24	60	15	66	15
Y		1060	E4	JNBE3D	18/07/2010	2	*Rhabdomys pumilio*	F	SA		C	S		32	75	20	100	10
Y		1070	H3	JNBE4D	18/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		43	90	20	105	10
Y		1080	J7	JNBE5D	18/07/2010	2	*Rhabdomys pumilio*	F	SA		C	S		33	75	15	90	10
Y		Dead	A5		19/07/2010	2	*Gerbilliscus leucogaster*	F	A		C	S		56	100	30	135	20
Y		Dead	A6		19/07/2010	2	*Rhabdomys pumilio*	F	SA		C	S		33	70	15	90	10
Y		Dead	A10		19/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		50	95	21	95	10
Y		Dead	A10		19/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		50	85	20	96	10
	Y	890	B10		19/07/2010	2	*Mastomys spp.*	F	SA		C	S						
	Y	410	B5		19/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		44	85	20	100	10
Y		Dead	E10		19/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		40	83	20	105	10
Y		Dead	G9		19/07/2010	2	*Rhabdomys pumilio*	M	A	S				60	95	20	100	10
Y		Dead	H10		19/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		49	80	20	100	10
Y		Dead	I6		19/07/2010	2	*Gerbilliscus leucogaster*	f	J		C	S		16	43	10	50	10

Y		Dead	I10		19/07/2010	2	*Rhabdomys pumilio*	F	SA		C	S		50	100	21	95	10
Y		Dead	J5		19/07/2010	2	*Rhabdomys pumilio*	F	SA		C	S		39	84	20	95	10
	Y	280	J3		19/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		51	91	21	95	10
Y		Dead	J2		19/07/2010	2	*Micaelamys namaquensis*	F	J		C	S		24	65	14	80	15
	Y	890	A8	Dead	20/07/2010	2	*Mastomys spp.*	F	SA		C	S		21	70	19	75	10
	Y	620	A9	Dead	20/07/2010	2	*Micaelamys namaquensis*	M	SA	A				22	75	19	66	15
Y		1090	B3	JNBE6D	20/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		35	75	21	86	10
Y		10100	D5	JNBE7D	20/07/2010	2	*Rhabdomys pumilio*	F	SA		C	S		32	70	20	75	10
Y		Dead	E2		20/07/2010	2	*Rhabdomys pumilio*	F	SA		C	S		31	74	21	90	14
Y		2060	F2	JNBE8D	20/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		35	72	19	90	10
Y		2070	H10	JNBE9D	20/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		34	75	20	87	10
Y		2080	H8	JNBE10D	20/07/2010	2	*Micaelamys namaquensis*	F	SA		C	S		24	75	19	74	10
Y		2090	H3	JNBE11D	20/07/2010	2	*Gerbilliscus leucogaster*	M	A	S				80	125	27	124	20
Y		20100	H2	JNBE12D	20/07/2010	2	*Rhabdomys pumilio*	F	SA		C	S		30	70	15	79	10
Y		3060	I5	JNBE13D	20/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		46	80	20	100	10
	Y	870	I6		20/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		44	70	20	95	10
Y		3070	I8	JNBE14D	20/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		40	70	15	95	10
Y		3080	J10	JNBE15D	20/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		35	80	20	90	10

Y		3090	J7	JNBE16D	20/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		35	70	21	95	10
	Y	280	J3		20/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		51	91	21	95	10
Y		30100	J2	JNBE17D	20/07/2010	2	*Rhabdomys pumilio*	F	A		C	S		43	80	20	105	10
	Y	730	A4	Dead	22/07/2010	3	*Rhabdomys pumilio*	F	A		C	S		49	85	22	105	10
	Y	450	A6	Dead	22/07/2010	3	*Elephantulus intufi*	F	A		C	S		47	98	35	106	20
Y		Dead	A7	Dead	22/07/2010	3	*Micaelamys namaquensis*	F	SA		C	S		27	55	16	71	15
Y		8100	B10	2JBE1D	22/07/2010	3	*Elephantulus intufi*	M	A	S				54	112	30	100	20
	Y	830	B7		22/07/2010	3	*Elephantulus intufi*	F	A		O	S		56	111	30	100	15
Y		1060	E2	2JBE2D	22/07/2010	3	*Elephantulus intufi*	M	A	S				56	100	31	115	20
Y		Dead	G10		22/07/2010	3	*Micaelamys namaquensis*	F	SA		C	S		25	75	20	76	15
	Y	490	H1		22/07/2010	3	*Rhabdomys pumilio*	M	A	S				40	77	15	100	10
Y			I6	Dead	22/07/2010	3	*Gerbilliscus leucogaster*	M	A	S				67	100	30	113	25
	Y	28	J3		22/07/2010	3	*Gerbilliscus leucogaster*	M	A	S				70	100	25	85	15
Y		1070	A1	2JBE3D	23/07/2010	3	*Elephantulus intufi*	F	A		C	S		56	105	30	111	20
	Y	8100	E7		23/07/2010	3	*Elephantulus intufi*	M	A	S				54	112	30	100	20
	Y	1060	H7		23/07/2010	3	*Elephantulus intufi*	M	A	S				56	100	31	115	20
Y		1070	H1	Dead	23/07/2010	3	*Rhabdomys pumilio*	F	A		C	S		44	95	25	111	10
Y		1080	I10	2JBE4D	23/07/2010	3	*Gerbilliscus leucogaster*	F	SA		C	S		43	90	23	112	15

Y		1090	J10	2JBE5D	23/07/2010	3	*Gerbilliscus leucogaster*	F	SA		C	S		47	95	20	114	10
Y		Dead	J7	Dead	23/07/2010	3	*Rhabdomys pumilio*	M	A	S				75	105	25	113	20
	Y	28	J4		23/07/2010	3	*Gerbilliscus leucogaster*	M	A	S				65	95	27	90	16
Y		Dead	J3	Dead	23/07/2010	3	*Rhabdomys pumilio*	F	SA		C	S		43	84	20	105	15
Y		Dead	A10		24/07/2010	3	*Rhabdomys pumilio*	F	SA		C	S		35	90	20	111	10
Y		10100	B10	2JBE6D	24/07/2010	3	*Micaelamys namaquensis*	F	SA		C	S		25	65	16	75	10
	Y	830	D8		24/07/2010	3	*Elephantulus intufi*	F	A		O	S		56	111	30	100	15
Y		Dead	F5		24/07/2010	3	*Thallomys paedulcus*	F	A		C	S		45	90	20	135	20
Y		2060	I2	2JBE7D	24/07/2010	3	*Rhabdomys pumilio*	F	A		C	S		40	75	20	100	10
Y		2070	J9	2JBE8D	24/07/2010	3	*Thallomys paedulcus*	F	A		C	S		75	85	20	145	16
Y		Dead	J3		24/07/2010	3	*Rhabdomys pumilio*	F	SA		C	S		31	80	22	96	12
Y		8100	A1	2JNBE1D	25/07/2010	4	*Micaelamys namaquensis*	F	SA		C	S		23	60	15	65	9
Y		1060	A4	2JNBE2D	25/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		50	100	20	95	10
	Y	330	A5		25/07/2010	4	*Elephantulus intufi*	M	A	S				54	105	30	95	20
Y		1070	A6	2JNBE3D	25/07/2010	4	*Micaelamys namaquensis*	F	SA		C	S		29	70	20	69	10
	Y	230	A9		25/07/2010	4	*Elephantulus intufi*	M	A	S				60	111	31	100	20
	Y	590	B6		25/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		50	85	20	90	10
Y		1080	C2	2JNBE4D	25/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		40	80	20	90	10

Y		1090	C10	2JNBE5D	25/07/2010	4	*Elephantulus intufi*	F	A		O	S		55	115	30	105	20
	Y	620	D2		25/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		43	75	20	100	10
	Y	210	D1		25/07/2010	4	*Elephantulus intufi*	F	A		C	S		55	115	30	124	20
	Y	6100	E2		25/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		43	75	20	104	10
	Y	860	F4		25/07/2010	4	*Elephantulus intufi*	F	A		C	S		39	80	20	95	10
	Y	730	H10		25/07/2010	4	*Elephantulus intufi*	F	A		C	S		56	100	31	100	20
	Y	120	H8		25/07/2010	4	*Elephantulus intufi*	F	A		C	S		56	115	25	105	20
	Y	610	H7		25/07/2010	4	*Elephantulus intufi*	F	A	S		S		50	105	30	105	20
	Y	530	I1		25/07/2010	4	*Elephantulus intufi*	M	A	S				55	112	30	115	20
	Y	570	I2		25/07/2010	4	*Gerbilliscus leucogaster*	F	SA		C	S		54	80	27	126	15
Y		10100	I4	2JNBE6D	25/07/2010	4	*Rhabdomys pumilio*	F	SA		C	S		39	85	21	90	10
	Y	710	I9		25/07/2010	4	*Rhabdomys pumilio*	M	A	S				49	75	15	100	10
Y		2060	I10	2JNBE7D	25/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		45	75	19	64	10
	Y	740	J10		25/07/2010	4	*Elephantulus intufi*	F	A		C	S		55	105	37	111	20
	Y	750	J8		25/07/2010	4	*Elephantulus intufi*	M	A	S				50	111	30	90	20
Y		2070	J7	2JNBE8D	25/07/2010	4	*Rhabdomys pumilio*	F	SA		C	S		40	70	20	100	10
	Y	880	J3		25/07/2010	4	*Elephantulus intufi*	F	A		C	S		51	111	30	115	20
	Y	760	J2		25/07/2010	4	*Elephantulus intufi*	M	A	S				52	105	35	100	20

	Y	8100	A1		26/07/2010	4	*Micaelamys namaquensis*	F	SA		C	S		23	60	15	65	9
	Y	210	A5		26/07/2010	4	*Elephantulus intufi*	F	A		C	S		55	115	30	124	20
Y		2080	B10	2JNBE9D	26/07/2010	4	*Gerbilliscus leucogaster*	F	SA		C	S		40	80	27	105	10
	Y	45	B9		26/07/2010	4	*Elephantulus intufi*	M	A	S				55	95	32	115	20
Y		2090	B2	2JNBE10D	26/07/2010	4	*Rhabdomys pumilio*	F	SA		C	S		30	55	26	88	10
	Y	330	D5		26/07/2010	4	*Elephantulus intufi*	M	A	S				54	105	30	95	20
	Y	570	E1		26/07/2010	4	*Gerbilliscus leucogaster*	F	SA		C	S		54	80	27	126	15
	Y	1070	E6		26/07/2010	4	*Micaelamys namaquensis*	F	SA		C	S		29	70	20	69	10
	Y	7100	F4		26/07/2010	4	*Rhabdomys pumilio*	F	SA		C	S		41	80	20	95	10
	Y	6100	G4		26/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		41	65	20	100	10
	Y	610	H10		26/07/2010	4	*Elephantulus intufi*	F	A	S		S		50	105	30	105	20
	Y	530	I1		25/07/2010	4	*Elephantulus intufi*	M	A	S				55	112	30	115	20
	y	750	J9		26/07/2010	4	*Elephantulus intufi*	M	A	S				50	111	30	90	20
	Y	720	J7		26/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		40	70	20	100	10
	Y	880	J5		26/07/2010	4	*Elephantulus intufi*	F	A		C	S		51	111	30	115	20
	Y	760	J4		26/07/2010	4	*Elephantulus intufi*	M	A	S				52	105	35	100	20
Y		20100	J2	2JNBE11D	26/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		49	85	20	100	10
Y		Dead	C7		27/07/2010	4	*Micaelamys namaquensis*	F	SA		C	S		23	75	19	76	15

Y		Dead	D3		27/07/2010	4	*Crocidura spp.*	M	J	A				13	45	10	35	6
Y		Dead	D2		27/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		46	90	20	85	10
	Y	6100	C4	Dead	27/07/2010	4	*Rhabdomys pumilio*	F	A		C	S		41	65	20	100	10
	Y	530	G1		27/07/2010	4	*Elephantulus intufi*	M	A	S				55	112	30	115	20
	Y	610	G9		27/07/2010	4	*Elephantulus intufi*	F	A	S		S		50	105	30	105	20
Y		3060	H10	2JNBE12D	27/07/2010	4	*Elephantulus intufi*	M	A	S				60	115	30	111	20
	Y	750	I9		27/07/2010	4	*Elephantulus intufi*	M	A	S				50	111	30	90	20
	Y	730	I10		27/07/2010	4	*Elephantulus intufi*	F	A		C	S		56	100	31	100	20
	Y	760	J6		27/07/2010	4	*Elephantulus intufi*	M	A	S				52	105	35	100	20
	Y	880	J2		27/07/2010	4	*Elephantulus intufi*	F	A		C	S		51	111	30	115	20