SPECIES ABUNDANCE AND DIVERSITY OF RODENTS AND SHREWS IN DIFFERENT HABITATS AND SEASONS IN THE NORTHERN SECTOR OF SELOUS GAME RESERVE, TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ECOSYSTEM SCIENCE AND MANAGEMENT OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2015

ABSTRACT

Species abundance and diversity of rodents and shrews were investigated in three different habitats and seasons in the Northern sector of Selous Game Reserve from September 2014 to May 2015. A total of 163 individuals from eight genera (5 of rodents and 3 of shrews) were captured in 1 323 trap nights using three different live traps. The abundance and diversity varied significantly between habitats ($p<0.00001$ and $p=0.00007$) and within seasons-habitat interactions ($p<0.00001$ and $p=0.01941$) respectively. Riverine habitat had the highest species abundance and diversity in dry and transition period, while wooded grassland showed the least abundance and diversity. Seasonality had no major influence on species abundance and diversity. *Acomys* sp. and *Paraxerus flavovittis* showed no major fluctuations in abundance compared to other species. *Acomys* sp. breeding patterns were not influenced by seasonal (rainfall) variation. Riverine forest and woodland had higher community similarity of 55% while riverine forest and wooded grassland had 22% dissimilarity. Therefore, this study concludes that, species abundance and diversity is highly influenced by habitat type and seasonal variations especially associated with or without rainfall. It is recommended that, a more intensive study in Selous Game Reserve to cover an extensive area and habitats to get a greater representation on the abundance and diversity of rodents and shrews found in the area.

DECLARATION

I, Saanya, Aenea do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institute.

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17/11/2015
.....
Date

The declaration above is confirmed by;

.....
Prof. Rhodes Makundi

(Supervisor)

17/11/15
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Date

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ACKNOWLEDGEMENTS

I am grateful to my supervisor, Prof. Rhodes Makundi, of Sokoine University of Agriculture Pest Management Center (SPMC), for giving me this opportunity and showing endless patience throughout the entire process of this study.

Thanks to the Ministry of Natural Resources and Tourism (MNRT) for granting a permission to conduct my study in SGR.

I would like to thank, Christopher Sabuni, for his advice, material support necessary for data collection and assistance in the development of the project and during filed work. It is from this support I managed to collect the information.

Sincere appreciation goes to Prof. Apia Massawe for her endless support especially in literature and statistical analysis part. It is from her proficiency that I managed to draw scientific conclusions in this work.

Thanks also to technicians at SPMC for their support on making traps and repairing them wherever necessary throughout the data collection period. Also, I value their advice, specimen handling and processing for further identification.

I am also indebted to Martin Mtakumwa and Matambwe staff and everyone at the Selous Game Reserve for assisting throughout data collection period. And all others who are not acknowledged in person in this work their contributions are highly valued.

DEDICATION

I dedicate this dissertation to my beloved father, the late Commissioner Eliphas Saanya Sawoka who has been behind all academic achievements I have made so far.

TABLE OF CONTENTS

ABSTRACT ii

DECLARATION iii

COPYRIGHT iv

ACKNOWLEDGEMENTS v

DEDICATION vi

TABLE OF CONTENTS vii

LIST OF TABLES xi

LIST OF FIGURES xii

LIST OF PLATES xiv

LIST OF APPENDICES xv

LIST OF ABBREVIATIONS AND SYMBOLS xvi

CHAPTER ONE 1

1.0 INTRODUCTION 1

1.1 Background Information 1

1.2 Problem Statement and Justification 2

1.3 Objectives 3

1.3.1 General objective 3

1.3.2 Specific objectives 3

1.4 Hypotheses 3

CHAPTER TWO 5

2.0 LITERATURE REVIEW 5

2.1 Descriptions of Rodents and Shrews 5

2.2 Abundance and Diversity of Rodents and Shrews 6

2.3 Feeding Habits of Rodents and Shrews 6

2.4 Habitat and Distribution of Rodents and Shrews 6

2.5 Effects of Seasonality on Abundance and Diversity of Rodents and Shrews 7

2.5.1 Effect of rainfall on abundance and diversity 7

2.5.2 Effects of temperature and humidity on abundance and diversity 7

2.6 Population Characteristics of Rodents and Shrews 8

2.7 Importance of Rodents and Shrews in the Ecosystems 9

CHAPTER THREE 10

3.0 MATERIALS AND METHODS 10

3.1 Study Area Description 10

3.1.1 Location and climate 10

3.1.2 Flora and fauna 10

3.2 Data Collection 10

3.2.1 Trapping procedure 10

3.2.2 Animal trapping 13

3.2.2.1 Sherman trapping method 13

3.2.2.2 Wire cages trapping method 14

3.2.2.3 Pitfall trapping method 14

3.2.3 Trap inspection and handling of captured animals 14

3.3 Data Analysis 15

3.3.1 Trap success, species richness, abundance, diversity and evenness 15

3.3.2 Species similarities between habitats, seasons and statistical tests 16

CHAPTER FOUR 18

4.0 RESULTS 18

4.1 Species Composition, Trap Success, Distribution and Abundance 18

4.1.1 Species composition in different habitats and seasons 18

4.1.2 Trap success for the three studied habitats and seasons 20

4.1.3 Species distribution 21

4.1.3 Rodents and shrews species abundance 22

4.1.3.1 Species abundance in different habitats 22

4.1.3.2 Seasonal species abundance in different habitats 23

4.1.4 Rodents and shrews species richness, diversity and evenness 25

4.1.4.1 Species richness of rodents and shrews 25

4.1.4.2 Species diversity in different habitats 27

4.1.4.3 Seasonal species diversity 28

4.2 Population Characteristics 29

4.2.1 Age structure of *Acomys* sp. in different habitats 30

4.2.2 Seasonal sex ratio and reproductive condition of *Acomys* sp 31

4.2.3 Age structure of *Petrodromus tetradactylus* in different habitats 33

4.2.4 Sex ratio and reproductive condition of *P. tetradactylus* 34

4.3 Community Similarity between Habitats and Seasons 35

CHAPTER FIVE 38

5.0 DISCUSSION 38

5.1 Species Composition, Distribution and Abundance 38

5.2 Rodents and Shrews Species Richness, Diversity and Evenness 40

5.3 Population Characteristics of Rodents and Shrews 42

5.3.1 Age structure and sex ratio of *Acomys* sp 42

5.3.2 Breeding and reproduction characteristics of *Acomys* sp. 42

5.3.3 Age structure and sex ratio of *Petrodromus tetradactylus* 43

5.3.4 Breeding and reproduction characteristics of *Petrodromus tetradactylus* 44

5.3.5 Community Similarity between Habitats and Seasonal Variations 44

5.4 Other Species Captured in this Study 44

5.4.1 Order Primates; Family Galagidae 44

5.4.2 Order Canivora; Family Herpestidae and Viverridae 45

CHAPTER SIX 46

6.0 CONCLUSIONS AND RECOMMENDATION 46

6.1 Conclusions 46

6.2 Recommendation 46

REFERENCES 47

APPENDICES 56

LIST OF TABLES

Table 1: Trap success in different habitats 21

Table 2: Rodents and shrews species distribution in different habitats..... 22

Table 3: Seasonal sex ratio of *Acomys* sp..... 31

Table 4: Seasonal sex ratio of *P. tetradactylus*..... 34

LIST OF FIGURES

Figure 1: Species composition of rodents and shrews in riverine forest 19

Figure 2: Species compositon of rodents and shrews in woodland..... 19

Figure 3: Species composition of rodents and shrews in wooded grassland..... 19

Figure 4: Prorpotional abundance of species of rodents and shrews 22

Figure 5: Proportional abundance (± SE) of species of rodents and shrews in different habitats 23

Figure 6: Rodents and shrews species abundance in different habitats in relation to monthly rainfall distribution in different habitats..... 24

Figure 7: Monthly relative abundance of selected species of rodents in relation to monthly rainfall distribution 24

Figure 8: Monthly relative abundance of selected species of shrews in relation to monthly rainfall distribution 25

Figure 9: Species richness (±SE) of rodents and shrews in the different habitats..... 26

Figure 10: Seasonal species richness (± SE) trend in the different habitats..... 27

Figure 11: Species diversity of rodents and shrews (± SE) in the different habitats 27

Figure 12: Seasonal species diversity (± SE) trend in different habitats..... 28

Figure 13: Rodents and shrews species diveristy trend in different habitats in relation to rainfall distribution 29

Figure 14: Overall age composition (± SE) of *Acomys* sp..... 30

Figure 15: Sesonal age composition trend of *Acomys* sp 30

Figure 16: Monthly reproductive condition (± SE) of male *Acomys* sp. (Scrotal=Sexually active, Abdominal=Sexually inactive) 32

Figure 17: Monthly reproductive condition (SE) of females *Acomys* sp. Perforated=Sexually active, Closed=Sexually inactive)..... 32

Figure 18: *Acomys* sp reproductive condition in relation to monthly rainfall patterns 33

Figure 19: Overall age composition (± SE) of captured *P. tetradactylus* 33

Figure 20: Seasonal age composition trend of *P. tetradactylus* 34

Figure 21: Monthly reproductive condition (±SE) of male *P. tetradactylus* 35

Figure 22: Monthly reproductive condition (±SE) of female *P. tetradactylus* 35

Figure 23: Jaccard's similarity indices between habitats (RF=Riverine forest, WL= Woodland and WG=Wooded grassland) 36

Figure 24: Seasonal similarity trend between habitats (RF=Riverine forest, WL=Woodland and WG=Wooded grassland) 37

LIST OF PLATES

Plate 1: (a) Riverine forest-dry season (b) Riverine forest-wet season 12

Plate 2: (a) Woodland-dry season (b) Woodland-wet season 12

Plate 3: (a) Wooded grassland-dry season (b) Wooded grassland-wet season 12

LIST OF APPENDICES

Appendix 1: Study area map 56

Appendix 2: Standard rain gauge 57

Appendix 3: Types of traps used in the capture mark release (CMR) 57

LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of Variance
CMR	Capture-Mark-Release
df	Degrees of Freedom
H'	Shannon Wiener Diversity Index
HSD	Honest Significance Difference
MNRT	Ministry of Natural Resources and Tourism
°C	Degree Centigrade
p	Significance Level
PA	Protected Area
SE	Standard Error
SGR	Selous Game Reserve
SPMC	Sokoine University of Agriculture Pest Management Centre
URT	United Republic of Tanzania
UTM	Universal Transverse Mercator
χ^2	Chi-square Test

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Despite their low status among conservationists as compared to mega-fauna, rodents and shrews play a fundamental role in ecosystem health (Marrocoli, 2011). They have been described as among the most important small mammals contributing to ecosystem diversity (Mulungu *et al.*, 2008; Makundi *et al.*, 2009). Furthermore, rodents and shrews like other small mammals are key species to nutrients cycling, habitat modification, and main indicator species for changes in ecological environment (Zhou and Ma, 2002). Consequently, they have an important position in maintaining the food chain, food web and the structure and function of an ecological system (Liu *et al.*, 2008; Yihune and Bekele, 2012). In addition, rodents and shrews are among the major determinants of ecosystem health because they particularly influence the vegetation and soils of an area (Sieg, 1987). Rodents interact extensively with the environment and their activities have complex effect on other organisms in different ecosystems (Makundi *et al.*, 2009). They are agents of seed dispersal (Van den Bergh and Kappelle, 1998) and can influence the rate of decomposition of plant materials through reduction of litter size and adding green herbage and excrete (Sieg, 1987). Furthermore, soil structure is influenced by burrowing activities and addition of feces and urine influences the chemical composition of soils (Sieg, 1987). Therefore, knowledge on rodents and shrews diversity and abundance in different habitats and how they respond to seasonal variations helps in understanding changes in the environment due to their sensitivity to habitat changes. Shenko *et al.* (2012) suggested that, population fluctuations within small mammal communities may affect energy and nutrient transfer through the food web, ultimately affecting the overall energy

and population dynamics of the ecosystem. For that reason, it is important to understand the status of abundance and diversity of rodents and shrews in different habitats and how seasonal variation influences them in Selous Game Reserve (SGR).

1.2 Problem Statement and Justification

Selous Game Reserve (SGR) is the largest protected area (PA) in Africa (MNRT, 2012). It is believed to harbor the largest concentration of wildlife and a globally important vegetation type which provides an exceptionally high variety of habitats (McGinley, 2008; UNEP-WCMC, 2011). Rodents and shrews like other small mammals are mostly overlooked in planning and conservation of many PAs (Van Deventer and Nel, 2006). Various studies on SGR fauna have been conducted inside and adjacent areas. For example, Venance (2009) studied the distribution of rodents and shrews in the Mikumi National Park. In that study results did not show any significant differences in abundance between habitats. However, the riverine and montane forest habitats showed the least diversity. URT (2010) studied the small mammals in the Selous-Niassa wildlife corridor in the southern Tanzania. The study focused on small mammals but did not include rodents and shrews and a study using Sherman's traps was suggested. Denys *et al.* (2011) found a new species of *Gammomys* which was named *Grammomys selousi*, which justifies the need for more studies in the world heritage site and adjacent areas. Smith (2012) conducted a study on lions in the Northern sector of SGR and they estimated the area to harbor more than 4 300 lions. The study insisted on the importance of regular surveys of wildlife abundance for effective conservation of the natural ecosystem. From the studies it shows that there is scanty information on abundance and diversity of rodents and shrews in different habitats and how seasonal (rainfall) variations influence their abundance and diversity in SGR Northern sector as to most tropical countries (Marrocoli, 2007). The lack

of comprehensive studies could partly be attributed to lack of interest because rodents and shrews do not feature strongly as tourist attraction (Venance, 2009) or because mega fauna are easy to study.

This study therefore aimed at assessing the abundance and diversity of rodents and shrews in three habitats; riverine forest, woodland and wooded grassland in dry, transition and wet seasons in the Northern sector of SGR. The results are expected to generate knowledge on species which exist in the reserve and their conservation status.

1.3 Objectives

1.3.1 General objective

To assess the species abundance and diversity of rodents and shrews in different habitats and seasons in the Northern Sector of Selous Game Reserve

1.3.2 Specific objectives

i. To establish the abundance of rodents and shrews in different habitats and between seasons in the Northern Sector of SGR
ii. To determine the diversity of rodents and shrews in different habitats and between seasons in the Northern Sector of SGR
iii. To establish breeding patterns, age structure and sex ratio of rodents and shrews in the Northern sector of SGR

1.4 Hypotheses

i. Ho: There is no difference in abundance of rodents and shrews in different habitats in the Northern sector of SGR

ii. Ho: There is no difference in diversity of rodents and shrews in different habitats in the Northern Sector of SGR

iii. Ho: There is no difference in abundance and diversity of rodents and shrews between seasons in the Northern Sector of SGR

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Descriptions of Rodents and Shrews

Rodents are in the order Rodentia and they share some common features i. e. a single pair of incisors in each jaw that grow continually throughout life (Smith, 2005). Common rodents include member of families: Bathyergidae (Mole rats), Muridae (mice, pouched rats etc), Sciuridae (squirrels), etc (Happold, 2013). Rodents are both nocturnal and diurnal. They can weigh to about 65kg (Capybara-*Hydrochoerus hydrochaeris*). In Africa, 395 species of rodents occur (Happold, 2013) of which 111 species occur in Tanzania (Senzota *et al.*, 2012). However, these figures are merely a snapshot in time due to advancement in molecular genetics which could change the number of known species (Hoffmann *et al.*, 2010). True shrews are in the order Soricomorpha and are the smallest mammals (smallest- Etruscan shrew- *Suncus etruscus* with 3.5 cm). About 150 of shrew species occur in Africa and 23 in Tanzania (Senzota *et al.*, 2012). Most shrews are nocturnal and some are active day and night (Schmidt, 2013).

On the other hand, elephant shrews (sengi) are restricted to Africa and are distributed in all habitats but lacking in western Africa and large part of Sahara area (Myers, 2010; Rathbun, 2014). Sengi are in the new Super-cohort Afrotheria which includes hyraxes, elephants, sea cows, tenrec, golden moles and aardvarks (Rovero *et al.*, 2008). There are 19 known species of sengi belonging to the order Macroscelidea and family Macroscelididae with two subfamilies, the Rhynchocyoninae with one genera and Macroscelidinae with three genera (Jennings and Rathbun, 2001; Rovero *et al.*, 2008). The giant sengis include the genus *Rhynchocyon* with four species, and the soft-furred sengi include three genera i. e. *Petrodromus* with only one extant member in this genus,

Macroscelides comprising three species, and *Elephantulus* containing 11 species (Myers, 2010). According to IUCN, most of the 19 sengis are considered of least concern. However, all four species of giant sengis, are at risk (Nowak, 1999).

2.2 Abundance and Diversity of Rodents and Shrews

Abundance and diversity of rodents and shrews may be influenced by a number of habitat factors such as vegetation type and density (Mbugua, 2002), rainfall patterns (Massawe *et al.*, 2007; Makundi *et al.*, 2009) and soil types (especially texture) (Massawe *et al.*, 2008). However, Witecha (2011) suggests that, natural climatic patterns, such as El Niño Southern Oscillations, can create extreme and typical precipitation events that can have negative effects on small mammals, such as mortality from flooding. In addition, rodents show the greatest diversity in morphology, physiology, behavior and life history strategy (Cramer and Willig, 2002).

2.3 Feeding Habits of Rodents and Shrews

Rodents show considerable diversity in their diet (Alemayehu and Bekele, 2013). Most of them are omnivorous, consuming large quantities of green vegetation, fruits, seeds, and animal prey (Hope and Parmenter, 2007). On the other hand, shrews' main diet is insects including beetles, butterflies, etc and others feed on vegetable matter, seeds and roots (Schmidt, 2013).

2.4 Habitat and Distribution of Rodents and Shrews

Rodents are found in vast numbers on all continents except the Antarctica (Happold, 2013). Habitat preferences of rodents and shrews are determined primarily by the type of cover and food available to them (Venance, 2009). That means areas with mosaic vegetation types are expected to have more species of rodents and shrews as various vegetation provides different types of food and shelter. On the other hand shrews can exploit a variety of habitats from dense vegetation to littered areas (Happold and Happold,

2013). Furthermore, soils play an important role in determining the distribution of rodents and shrews (Massawe *et al.,* 2008). Different types of soils provide for or hinder the activities of burrowing and nesting. Soil texture is particularly the important component which plays a significant role in determining other soil components. Soil texture affects drainage, fertility, productivity, moisture-holding capacity, rates of water infiltration, and soil consistency (Massawe *et al.,* 2008).

Massawe *et al.* (2008) suggested that *Mastomys natalensis* prefers loam-textured soils with a high percentage of sand, which are probably better than clay soils for burrowing and nesting, particularly in the rainy season. In addition, rodents show less preference for clay soils probably due to poor aeration in these soils and the water logging especially in the wet season which hinders burrowing.

2.5 Effects of Seasonality on Abundance and Diversity of Rodents and Shrews

2.5.1 Effect of rainfall on abundance and diversity

Population dynamics of rodents follow seasonality in relation to variations in rainfall and reach peaks towards the end of the rainy season when resources are plenty (Alemayehu and Bekele, 2013). Furthermore, breeding decreases during the dry months, however species like *Avicanthis niloticus* breeding is continuous in Uganda as rainfall is continuous, but when rains are seasonal rodents also adjust to seasonal breeding (Mrosso, 2004). However, Neal (1981) cited by Mrosso (2004) cautioned that, breeding and rainfall are extremely variable in different areas and are species specific. For example, breeding in *Acomys* sp does not follow seasonal patterns of rainfall. In addition, Kingdon (1974) reported that green forage in the wild might provide a biochemical trigger to seasonal breeding. Also nutrition status in terms of quantity and quality of food do increase during the wet season.

2.5.2 Effects of temperature and humidity on abundance and diversity

Temperature and humidity play a significant role in determining rodents' activity. Alemayehu and Bekele (2013) demonstrated that, temperature showed predominantly

positive effects on diversity of small rodents; a cross-correlation function values between rodents and temperature were negatively correlated with rodent abundance. Furthermore, their results suggest that recent climate warming increased the diversity of small rodents by providing more benefits to population growth of rare or less abundant species than that of more abundant species (Alemayehu and Bekele, 2013). On the other hand, when temperatures are high in the mid and end of dry season it highly prevents breeding of rodents and shrews, but it depends on species and area.

2.6 Population Characteristics of Rodents and Shrews

Population characteristics include the age structure, sex ratio and other reproduction and breeding patterns of a species in a given habitat. Population characteristics play an important role in determining the trend of that population under study. For example, reproduction is a major factor in determining the recruitment rate in a population (Leirs, 1995). In addition, age determination also plays an important role in understanding the structure of the population under study. More young in the population means high reproduction rate.

On the other hand sex ratio (especially of adult males and female) is important since reproduction performance depends on females as one male can fertilize a number of females at a time (Leirs, 1995). However, habitat and seasonal variations might change age structure, sex ratio and reproduction performance in a given population. Leirs (1995) suggested that changes in the environment can influence physiology and behavior of animals. Among the environmental changers include rainfall which affects diet quality and quantity which in turn influences reproduction physiology directly when the food is ingested and absorbed.

2.7 Importance of Rodents and Shrews in the Ecosystems

The specific roles of rodents and shrews as other small mammals in ecosystem processes are poorly known due to their secretive nature (Marrocoli, 2007). However, they are the biological indicators of changes in an area (Olson and Brewer, 2003). Mohammadi (2010) suggested that small mammals increase vegetation decomposition rates and more efficient in mineralizing organic matter. Careful evaluation of the role of small mammals and their relationships with their environment is necessary to fully appreciate the impact of control programs on the ecosystem (Sieg, 1987).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area Description

3.1.1 Location and climate

The study was conducted in the Northern sector of SGR (Appendix 1) from September 2014 to May 2015. June to September was the dry season, October to February was the short rain season and March to May was the long rain season. Selous Game Reserve is located in central south-eastern Tanzania between 7°20' to 10°30'S and 36°00' to 38°40'E (MNRT, 2012). It covers an area of about 50 000 sq. km. The SGR falls within the bimodal rainfall belt of Southern Tanzania and annual rainfall ranges from 750mm in the east to 1 300mm in the west, falling mainly between mid-November and mid-May (Jihnson, 2003). The average annual temperature ranges from 13°C to 41°C (Jihnson, 2003).

3.1.2 Flora and fauna

Selous Game Reserve constitutes a globally important example of vegetation types (UNEP-WCMC, 2011). The Northern sector contains four main habitats: Riverine forests; along main and seasonal rivers: Thickets; riverine thickets: Woodlands; mainly Brachystegia and Terminalia Woodlands (Miombo) (McGinley, 2008; UNEP-WCMC, 2011). Others include scattered trees grasslands; open wooded grassland (McGinley, 2008; UNEP-WCMC, 2011). Selous Game Reserve contains globally significant populations of wildlife (UNEP-WCMC, 2011). In addition, there are 350 species of birds, including the endemic Udzungwa forest partridge (Briggs, 2008).

3.2 Data Collection

3.2.1 Trapping procedure

A capture-mark-release (CMR) technique was used in this study. Three types of live traps were used: medium sized Sherman's traps, wire cages and pitfall traps, in addition

opportunistic visual recording was used. The technique (CMR) and the three traps were chosen among others as they are the standard procedures for studying population trends for small mammals. The traps were placed in three habitats namely; riverine forest, woodland and wooded grassland.

Riverine forest (RF) located at GPS readings 37M 0363783 and UTM 9167294 was dominated by *Steculia apendiculatas, Kigelia Africana, Markhamia zanzibarica and Adansonia digitata* with *Combretum* sp. thicket (Plate 1a). The habitat was characterized by high percent of leaf litter in dry season and soils were dominated by sand in most parts. During the transition period with little rainfall the area had turned green although the undergrowth was not intense. In the wet season the area turned completely green with undergrowth that to a large extent impaired visibility and accessibility (Plate 1b). Common wild animals identified during the study include reptiles (monitor lizard, African python, green mamba etc.) and mammals (African elephants, leopards, yellow baboons etc).

Woodland (WL) located at GPS readings 37M 0363740 and UTM 9167863 was dominated by *Afzelia quanzensis, Sclerocarya birrea, Markhamia zanzibarica* and scattered islands of bushes (Plate 2a). Soils were mostly black cotton.

Plate 1: (a) Riverine forest-dry season (b) Riverine forest-wet season

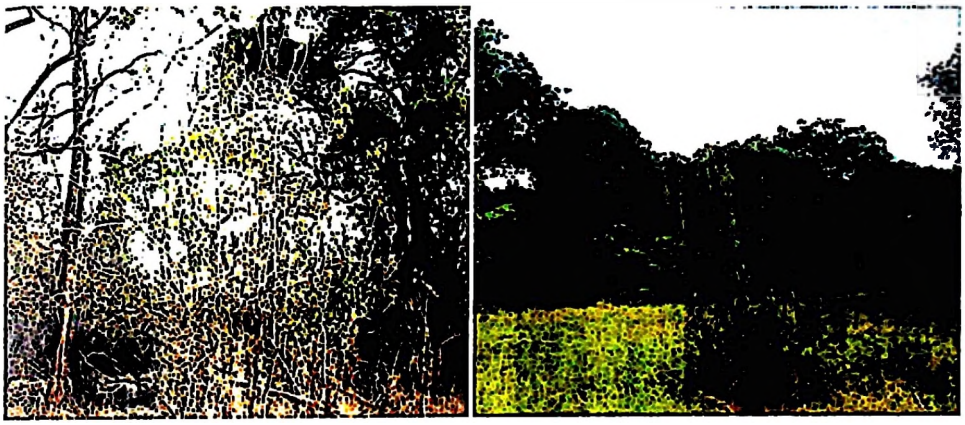


Plate 2: (a) Woodland-dry season (b) Woodland-wet season

Plate 3: (a) Wooded grassland-dry season (b) Wooded grassland-wet season

During the dry season the flora of the area was completely dry and there was little undergrowth, and grasses were almost dry with some areas with bare ground. During the wet season tall grasses emerged, and the most dominant were *Hyparenia* sp. (Plate 2b). Most common wild animals identified included African elephants, African cape buffalos, Zebras, Impalas etc.

Wooded grassland (WG) located at GPS readings 37M 0362628 and UTM 9166689 was dominated by scattered *Salvadora persica, Sclerocarya birrea and Afzelia quanzensis* and the dominant grass were *Hyparenia rufa.* In this habitat, fire is regular especially in early dry season (late wet season), therefore most areas were bare (Plate 3a). In addition, large herbivores like zebra, hartebeests, buffalos and wildebeests spend most of their time as compared to other two habitats. Due to that, the area suffers regular disturbances. However, in the wet season the area was completely covered by *Hyparenia* grasses (Plate 3b). Soils were dominated by black cotton soils. On the other hand rainfall data were collected in all nine months of study. A standard rain gauge was used in data collection (Appendix 2).

3.2.2 Animal trapping

3.2.2.1 Sherman trapping method

In each habitat a grid of 70m x 70m was established each with seven (7) parallel lines at a distance of 10m apart. Each line had seven (7) trapping stations. A total of 147 medium-sized (LFA, 7.5 x 9 x 23cm) Sherman's traps (H.B. Sherman traps Tallahassee, Florida) (Appendix 3a) for rodents and shrews were used (Hoffmann *et al.*, 2010). The grids were established at least 7.5m from the habitat edge to minimize edge effect (Falout and Nelson, 1997). The Sherman traps were baited with a mixture of peanut butter and maize

flour. In addition Sherman traps were covered with some vegetative materials to reduce heat from sunlight (Frontier Tanzania, 2008).

3.2.2.2 Wire cages trapping method

A total of 15 (five in each habitat) wire cages of 60 x 15 x 170cm were used (Appendix 3b). These were aimed for arboreal species like squirrels and larger ground dwelling species like elephant shrews (Order-Macroscelidae) which were not possible to trap by Sherman's and pitfall traps. Slices of ripe bananas were used as bait (Frontier Tanzania, 2008). Traps were placed on tree branches between two and three meters from the ground depending on the tree type for arboreal species and others were placed on the ground in areas preferred by these species.

3.2.2.3 Pitfall trapping method

Pitfall traps were employed for capturing small rodents and shrews which could not be trapped using Sherman's traps especially those weighing less than 10g (Hoffmann *et al.*, 2010). A transect line was established in each habitat. In each transect there were 10 pitfall traps spaced at five meters interval (Appendix 3c). Pitfalls were made of 10 liter buckets with 250mm high x 220mm rim. Buckets were buried in soil such that the rim was level with ground. A 50m long plastic sheet drift fence which was one meter high was used to connect pitfalls through the center bisecting the rim of each pitfall. The fence was used to increase trappability (Frontier Tanzania, 2008).

3.2.3 Trap inspection and handling of captured animals

All traps were investigated twice daily, before 10hrs and evening before 18hrs for three consecutive nights (Frontier Tanzania, 2008). Identification of captured species was done

following the keys proposed by Kingdon (1997) to genus level. Voucher specimens were collected and preserved for further identification at Sokoine University of Agriculture Pest Management Center (SPMC). For each individual measurement on weight (in grams), body, tail and tarsus lengths (in millimeters) were recorded. Sex and reproductive conditions were observed as for rodent males were considered sexually active when testes were scrotal and sexually in active when testes were abdominal. Sexually active females were considered when vagina was perforated or pregnant and sexually inactive when the vagina was closed. Age classification based on body weight. The animals were marked by clipping the toe and released at the trap station of capture.

3.3 Data Analysis

3.3.1 Trap success, species richness, abundance, diversity and evenness

Trap success in various trapping sites was determined as the numbers of catches of the respective species per trap-nights, i. e. the proportion of catches relative to the number of traps set over a given period (one trap set for a 24h period=one trap night).

$$\text{Formula; } TS = (N/T) \times 100 \quad \text{..... (i)}$$

Where; TS is percentage trap success, N is number of species and T trap nights.

Species abundance was calculated as the ratio between the number of species found in each habitat and the total number of species recorded in the whole study (Venance, 2009). Simple species richness was calculated as the count of different species captured in each habitat and season.

Species diversity was determined using Shannon-Wiener diversity Index (Van Deventer and Nel, 2006) in different habitats, months and seasons in SGR. Shannon – Wiener diversity index (H') is presented as;

$$H' = -\sum_{i=1}^{s} (Pi)(\log_2 Pi) \quad \text{..... (ii)}$$

Where; H′ is information content of a sample, species diversity index, *s* is number of species, *P*i is the proportion of individuals of the i^{th} species or the abundance of the i^{th} species expressed as the proportion of the total individuals and $\log_2$ is log base.

Shannon Wiener measures the amount of uncertainty in predicting from which species an individual will belong if chosen randomly from a given sample. It also measures the effective number of species (Van Deventer and Nel, 2006).

Species evenness: this measures how evenly species are distributed in the community which also reflect distribution of resources/niches to those species. It is expressed as follows;

$$J' = H'/H'max \quad \text{..... (iii)}$$

Where: J is species evenness; H' is diversity index and H'max is *ln* of total number of species in the sample (citation).

3.3.2 Species similarities between habitats, seasons and statistical tests

Species similarity was determined using formula following Jaccard (1901) expressed as;

$$Sij = a/(a+b+c) \quad \text{..... (iv)}$$

Where; *a* is number of species present in i and j. b is number of species found in habitat i only and c is number of species found in habitat j only. The lower the index i. e. <50% the less similar are the communities under study.

Sex ratio i. e. the proportion of males relative to total number of individuals caught (Liers, 1995) was determined for the most abundant species of rodents and shrews by the following formula:

$$n/N \quad \text{..... (v)}$$

Where; n= number of males captured in respective month

N= total individuals captured for a given specie in respective month

Chi-square (χ^2) test was used to test for sex ratio differences in different seasons for the most abundant species.

Two-way analysis of variance was used to compare and test for significant differences between different habitats, seasons and an interaction effect of season-habitat for species trap success, abundance, richness and diversity, for the captured species. Tukey's HSD post-hoc test was used to identify the pairs which were significantly different as ANOVA simply shows a general difference to exist among the compared means. Statistical package STATISTICA was used to perform the above comparison.

CHAPTER FOUR

4.0 RESULTS

4.1 Species Composition, Trap Success, Distribution and Abundance

A total of 163 individuals from eight genera (5 of rodents and 3 of shrews- Macroscelidae and Soricidae) belonging to four families i.e. Muridae comprising (50.9%), Siuridae (23.3%), Macroscelididae (17.2%) and Soricidae (8.6%) were captured in 1 323 trap nights. Family Muridae dominated the group of rodents (68.6%) with four of six rodents species captured while Macroscelididae was the dominant family among the shrews (66.7%) with two of three types of shrews captured.

4.1.1 Species composition in different habitats and seasons

Acomys sp. (18%) and *Petrodromus tetradactylus* (31%) comprised the highest percentage of rodents and shrews, respectively, of the total capture in the riverine forest, while no *Mastomys natalensis* was captured in this habitat (Fig. 1). *Mastomys natalensis* (23%) and *Crocidura* sp. (18%) comprised the highest percentage of captured rodents and shrews, respectively, in woodland habitat (Fig. 2). *Mastomys natalensis* was the most dominant species captured with 50% of all species in wooded grassland while no shrew species were captured in this habitat (Fig. 3).

Species composition varied with season. During the dry season more species were captured in the riverine forest while in woodland and wooded grassland only few species including *Paraxerus flavovittis,* and *Acomys* sp were captured. During the transition period more species comprised the capture in woodland while in wooded grassland species composition remained constant (Table 2). In the wet season the riverine forest had fewer species composition especially in March and April as compared to dry and transition periods.

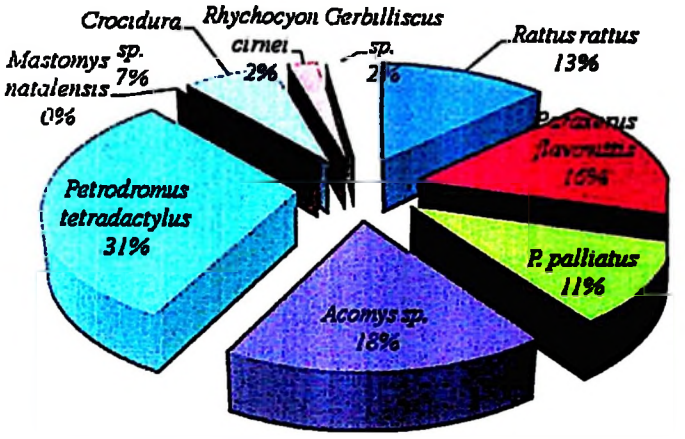


Figure 1: Species composition of rodents and shrews in riverine forest

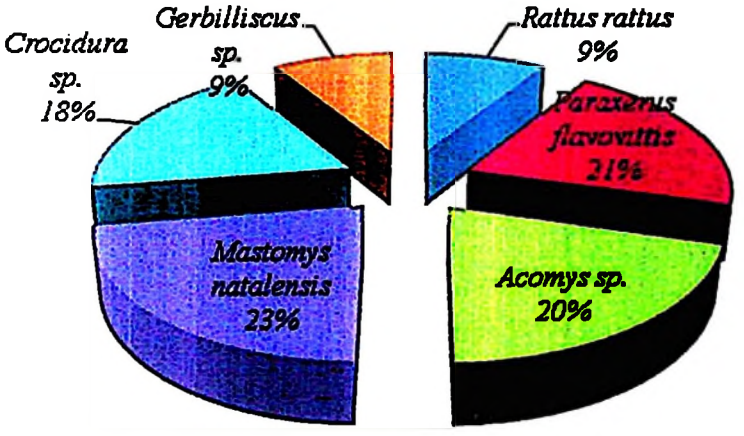


Figure 2: Species compositon of rodents and shrews in woodland

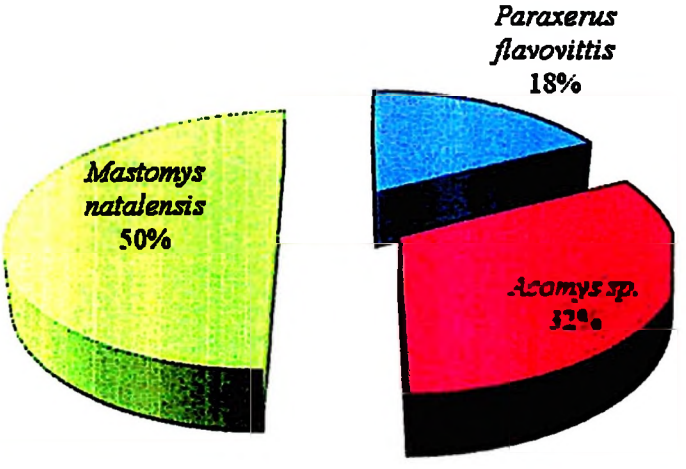


Figure 3: Species composition of rodents and shrews in wooded grassland

Three species of small mammals which were not the target for this study were captured using wire cages in the riverine forest. The species were *Galago* sp. (bush-baby) (Order: Primate) and *Helogale parvula* (dwarf mongoose) and *Genetta genetta* (Order: Carnivora).

4.1.2 Trap success for the three studied habitats and seasons

The traps used in this study differed significantly in trapping success ($F(2, 54)=50.915$, $p=0.000000$). Riverine forest had the highest trap success followed by woodland and wooded grassland which had the least for all three types of traps used and it was significantly different ($F(2, 54)=17.643$, $p=0.00000$) (Table 1). The trap success was significantly different in different habitats ($F(2, 54)=17.643$, $p=0.00000$). Also a post hoc test using Tukey HSD test show the difference to exist in all mean pairs ($df=54$, $p<0.05$).

Moreover, the interaction of habitat and traps showed a significant difference in trap success ($F(4, 54)=10.813$, $p<0.0001$). A post hoc test using Tukey HSD test suggests significant differences exist for interaction of pairs of habitat and traps with exception of interactions between habitat and pitfall and some of wire cages and habitat ($p>0.05$).

On the other hand, slight decrease in trap success was observed in different seasons. However, the observed differences were not significant including seasons and traps and interaction of trap, season and habitats ($p>0.05$) (Table 1). High trap success in riverine especially for Sherman's and wires cages might have been attributed to high species richness and abundance of rodents and shrews captured as compared to woodland and wooded grassland habitats (Table 1).

Table 1: Trap success in different habitats

s/n	Site	Trap type	Individual captured	Trap nights	Trap success (%)
1	Riverine	Shermans'	60	1 323	4.53
		Wire cages	24	135	1.77
		Pitfalls	1	270	0.37
2	Woodland	Shermans'	33	1 323	2.49
		Wire cages	9	135	6.66
		Pitfalls	2	270	0.74
3	Wooded grassland	Shermans'	28	1 323	2.11
		Wire cages	6	135	4.44
		Pitfalls	0	270	0

4.1.3 Species distribution

Acomys sp. and *Paraxerus flavovittis* occurred in all three habitats studied. *Paraxerus paliatus paliatus*, *P. tetradactylus* and *Rhychocyon cirnei* appeared to be strictly confined to riverine forest while *M. natalensis* was only captured in woodland and wooded grassland (Table 2). *Crocidura* sp., *Rattus rattus* and *Gerbilliscus* sp. occurred in riverine forest and woodland only (Table 2).

Only arboreal species, *Paraxerus* sp. were captured during mid-wet season (April) in riverine and most of the species which were common during dry and transition periods were not captured. In woodland number of species increased in transition period than it was in dry and wet seasons while in wooded grassland species remained constant in all three studied periods (Table 2).

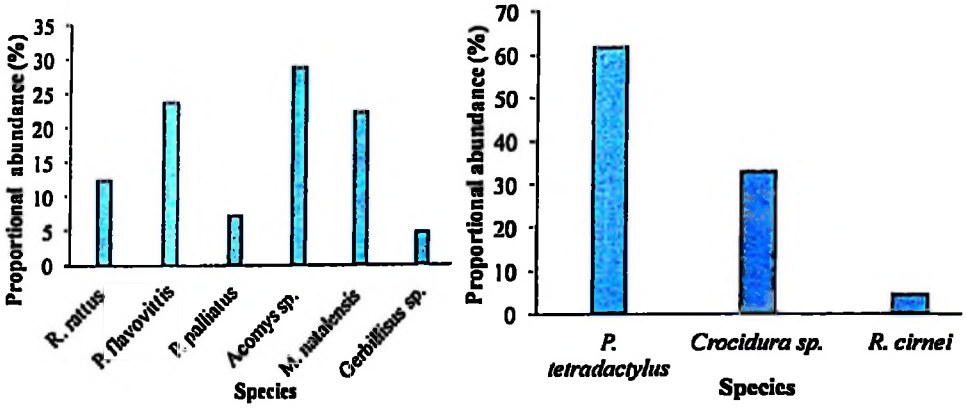
Table 2: Rodents and shrews species distribution in different habitats

s/n	Scientific Name	Riverine Forest	Woodland	Wooded Grassland
1	*Rattus rattus*	x	x	-
2	*Paraxerus flavovittis*	x	x	x
3	*Paraxerus palliatus*	x	-	-
4	*Acomys* sp.	x	x	x
5	*Petrodromus tetradactylus*	x	-	-
6	*Mastomys natalensis*	-	x	x
7	*Crocidura sp.*	x	x	-
8	*Rhynchocyon cirnei*	x	-	-
9	*Gerbilliscus* sp.	x	x	-

4.1.3 Rodents and shrews species abundance

4.1.3.1 Species abundance in different habitats

Nine species of rodents and shrews were captured in this study (Fig. 4). *Acomys* sp. comprised the highest proportional abundance (28.9%) among the captured rodents in the three studied habitats (Fig. 4a). *Pertrodromus tetradactaylus* recorded the highest proportional abundance (61.9%) of all the shrews captured during the study (Fig. 4b). On the other hand, *Gerbilliscus* sp. and *R. cirnei* were the least abundant (4.9% and 4.7%) species captured for rodents and shrews, respectively (Fig. 4a, b).



(a) Rodents **(b) Shrews**

Figure 4: Prorpotional abundance of species of rodents and shrews

Riverine forest comprised the highest species abundance (52.15%) followed by woodland, while wooded grassland had the least abundance (20.85%) (Fig. 5). The difference in abundance between habitats was statistically different ($F(2, 18)=66.412$, $p=0.00000$). In addition, a post-hoc comparison between means using Tukey HSD test show all the pairs to differ significantly ($df=18$, $p<0.05$).

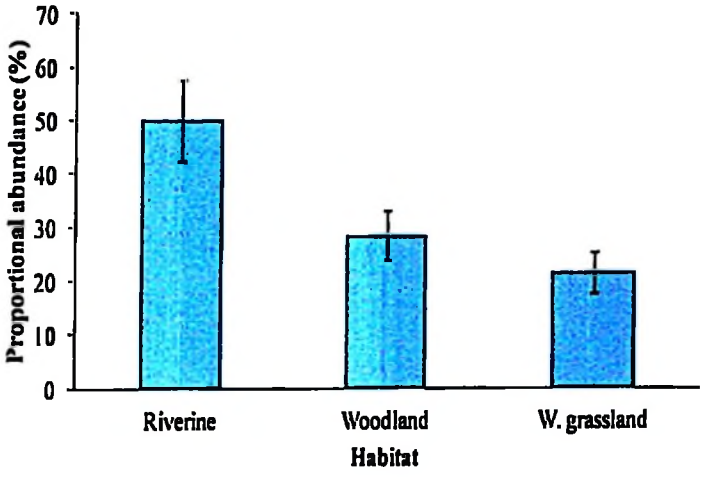


Figure 5: Proportional abundance (± SE) of species of rodents and shrews in different habitats

4.1.3.2 Seasonal species abundance in different habitats

Seasonality showed a notable influence on species abundance in all studied habitats (Fig. 6 a, b and c). In general, some species were favored by change in weather from dry towards transition to wet season and vice versa (Fig. 7 and 8). For example, there was a notable drop in abundance (relative abundance in brackets for different seasons; dry (D), transition (T) and wet (W) of *R. rattus* (D-15.3%, T-10.6 and W-0%) (Fig. 7). Also *P. tetradactylus* (D-27.6%, T-14.8% and W-1.9%), *Crocidura* sp (D-7.6%, T-0% and W-17.3%) (Fig. 8).

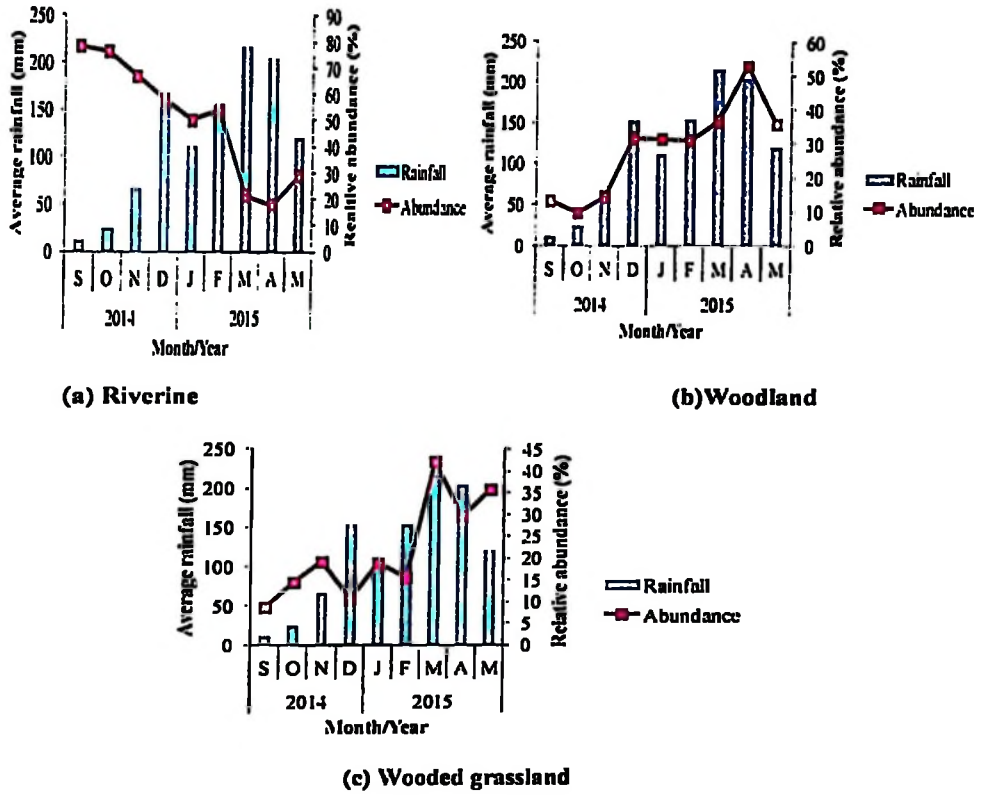


Figure 6: Rodents and shrews species abundance in different habitats in relation to monthly rainfall distribution in the different habitats

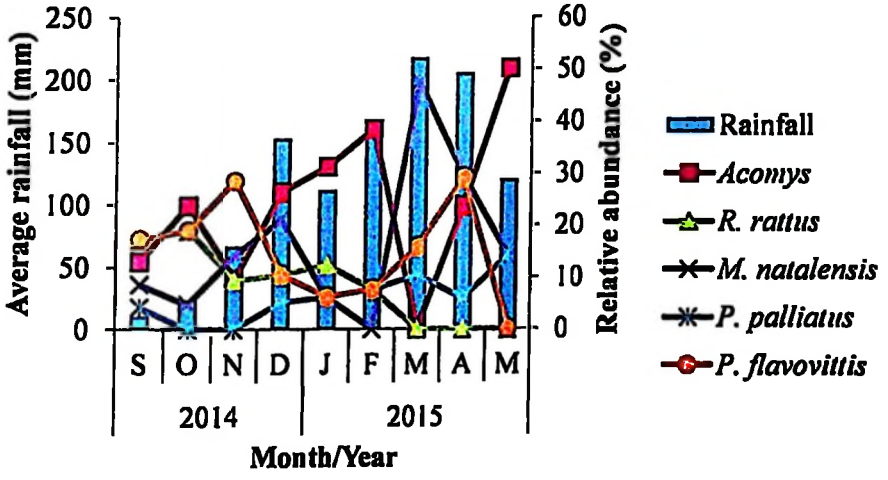


Figure 7: Monthly relative abundance of selected species of rodents in relation to monthly rainfall distribution

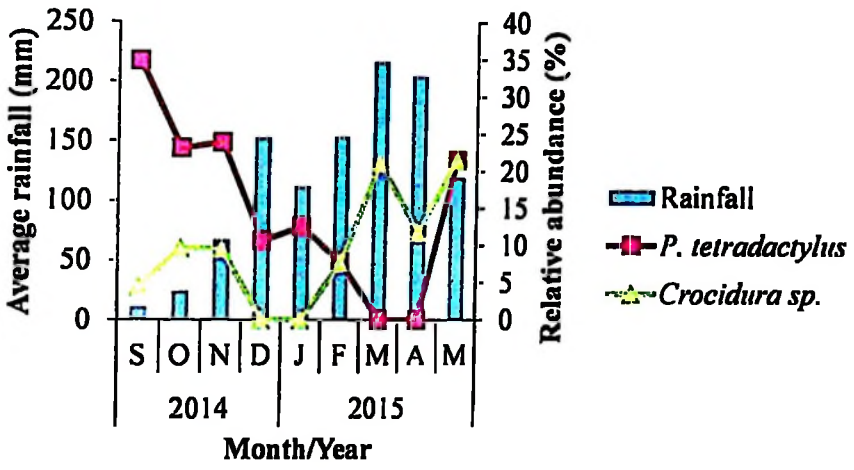


Figure 8: Monthly relative abundance of selected species of shrews in relation to monthly rainfall distribution

Equally, other species increased as wet season was approached. For example, *M. natalensis* (D-9.2%. T-10.6% and W-31.3%) and *P. palliatus* (D-1.5%, T-6.3% and W-9.8%) (Fig. 7). Besides, some species maintained their relative abundance with slight fluctuations. For example, *Acomys* sp (D-13.8%, T-31.9% and 21.5) and *P. flavovittis* (D-21.5%, T-12.7% and 17.6%) (Fig. 7). However, in general the species abundance did not differ significantly with changing season.

Conversely, the interaction between season and habitat had a significant effect on species abundance ($F(4, 18)=52.367$, $p=0.00000$). Also, post-hoc comparison using the Tukey HSD test suggest all pairs of means to differ significantly ($df=18$, $p<0.05$).

4.1.4 Rodents and shrews species richness, diversity and evenness

4.1.4.1 Species richness of rodents and shrews

Riverine forest comprised the highest species richness (8) while wooded grassland had the least (3) (Fig. 9). There was a statistically significant difference in species richness between the habitats studied ($F(2, 18)=51.1$, $p=0.00000$). Post-hoc comparison using

Tukey HSD test indicated mean scores for species richness in different pairs of habitats to differ significantly (df=18, p<0.05).

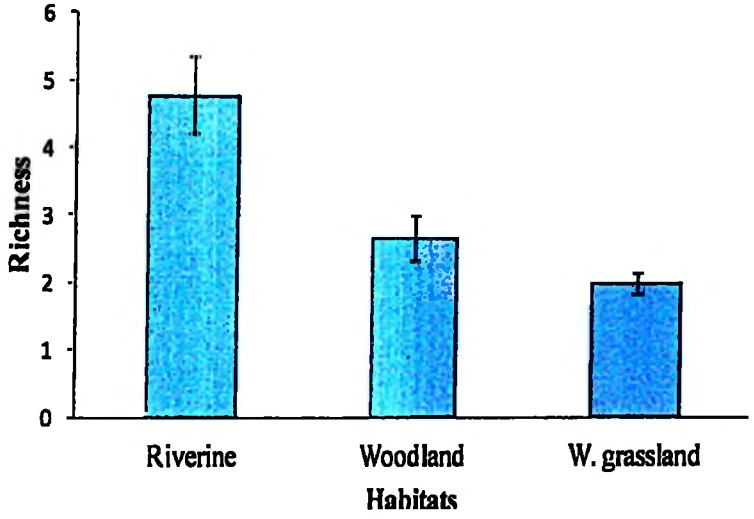


Figure 9: Species richness (±SE) of rodents and shrews in the different habitats

The dry season had the highest species richness followed by transition period. The wet season had the least species richness. The difference was statistically significant (F(2, 18)=6.4, p=0.00795). A post-hoc comparison using Tukey HSD test showed significant difference for all mean pairs (df=18, p<0.05).

The species richness trend show a decrease in the wet season in riverine forest, while in the woodland it increased in transition period and started decreasing towards the wet season. Wooded grassland showed a different response to seasonality as compared to the other two habitats where species richness decreased towards transition period and started rising towards the wet season (Fig. 10).

The interaction of season and habitats was significantly different in species richness (F(4, 18)=14.95, p=0.00002). Consequently, a post-hoc test using Tukey HSD suggest a significant difference between dry season in riverine forest versus woodland and wooded grassland in dry, transition and wet seasons (df=18, p<0.05).

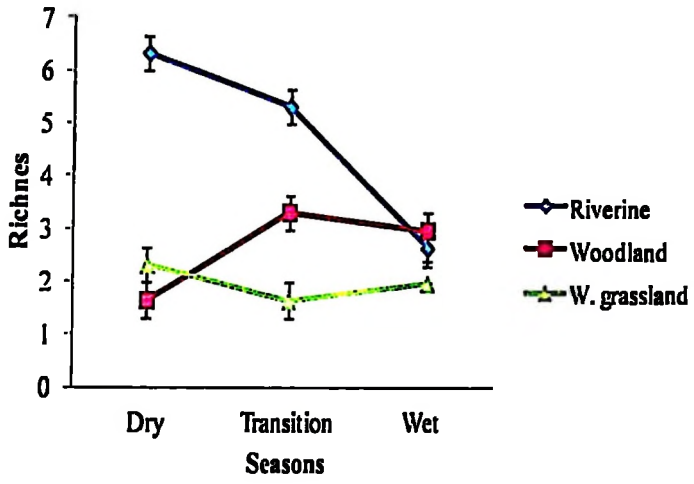


Figure 10: Seasonal species richness (± SE) trend in the different habitats

4.1.4.2 Species diversity in different habitats

Overall results show riverine forest to harbor the highest species diversity whereas wooded grassland had the least species diversity. The difference was found to be significantly different ($F(2, 18)=16.909$, $p=0.00007$) (Fig. 11). In addition, post hoc test using Tukey HSD showed all pairs of means for species diversity in all habitats to differ significantly ($df=18$, $p<0.05$).

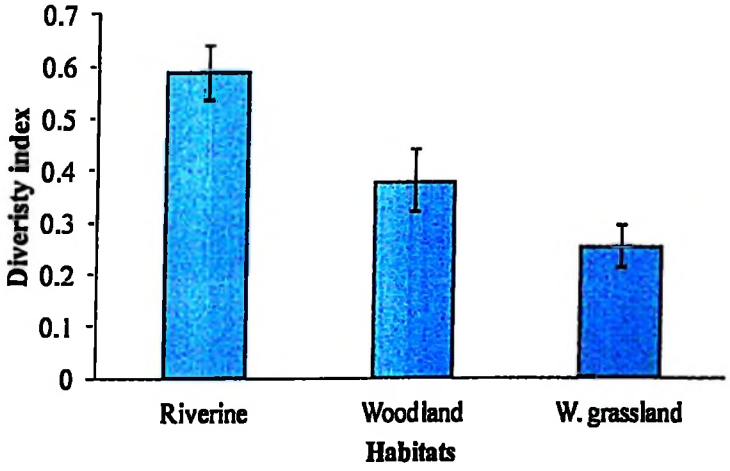


Figure 11: Species diversity of rodents and shrews (± SE) in the different habitats

4.1.4.3 Seasonal species diversity

The dry season had the highest species diversity while the wet season had the least. However, the difference between seasons was not statistically significant. Interaction between season and habitat show significant differences in species diversity ($F(4, 18)=3.8680$, $p=0.01941$). Also, a post-hoc test using Tukey HSD suggests all pairs of means and interaction between season and habitat to differ significantly ($df=18$, $p<0.05$) with exception of two pairs of means i. e. transition and wet season in wooded grassland versus dry season in woodland.

The riverine species diversity decreased towards the wet season while in the woodland the species diversity increased (Fig. 12 and 13a and b). Wooded grassland showed different responses to seasons whereby in dry and wet seasons the diversity was almost the same and it was low during transition period (Fig. 12 and 13c). This suggests that rainfall exhibited a different effect on species diversity in different habitats.

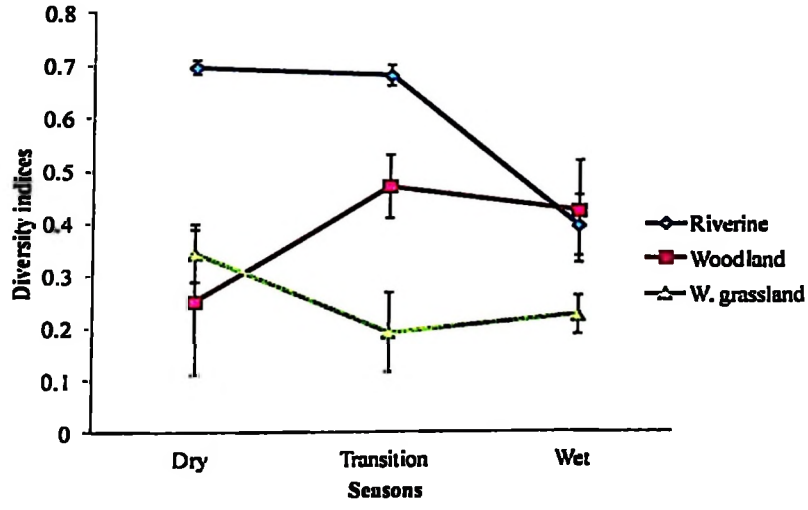


Figure 12: Seasonal species diversity (± SE) trend in different habitats

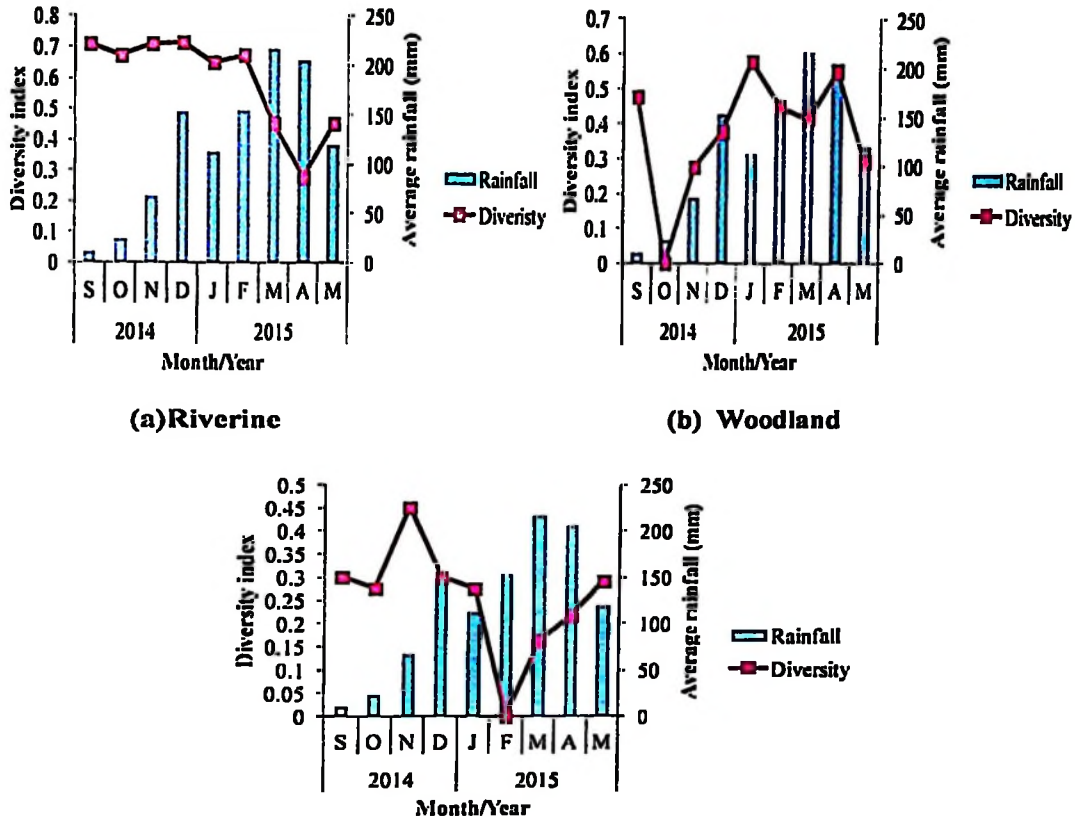


Figure 13: Rodents and shrews species diveristy monthly trend in different habitats in relation to rainfall distribution

Riverine forest exhibited higher species evenness (J'=0.179) as compared to woodland (J'= 0.142) and wooded grassland (J'=0 .095).

4.2 Population Characteristics

Population characteristics involve components such as age structure and sex ratio in a given population. Age structure and sex ratio were determined for one most abundant species of rodents and one of shrews. Age structure was determined as the proportion of each group in the population. Sex ratio refers to proportion of males in the whole population (Leirs, 1995). The species were *Acomys* sp. and *P. tetradactylus*. It involves determination of age composition and sex ratio in different habitats, seasons and breeding

patterns of these species. Also, effects of seasonality (rainfall) on breeding patterns of these species were examined.

4.2.1 Age structure of *Acomys* sp. in different habitats

Adults *Acomys* sp. comprised the highest number of captured individuals while juvenile were the least (Fig. 14).

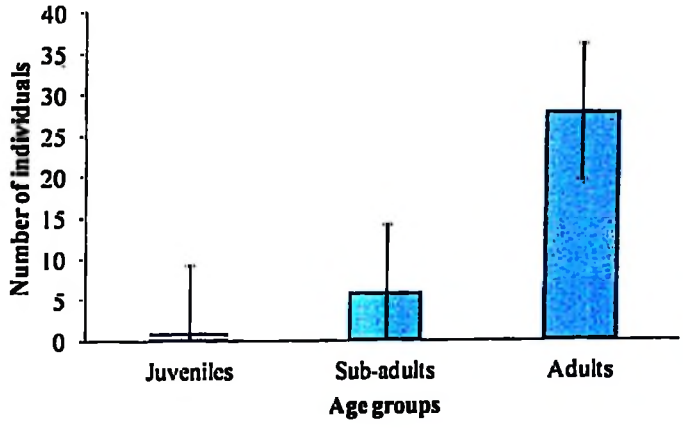


Figure 14: Overall age composition (± SE) of *Acomys* sp.

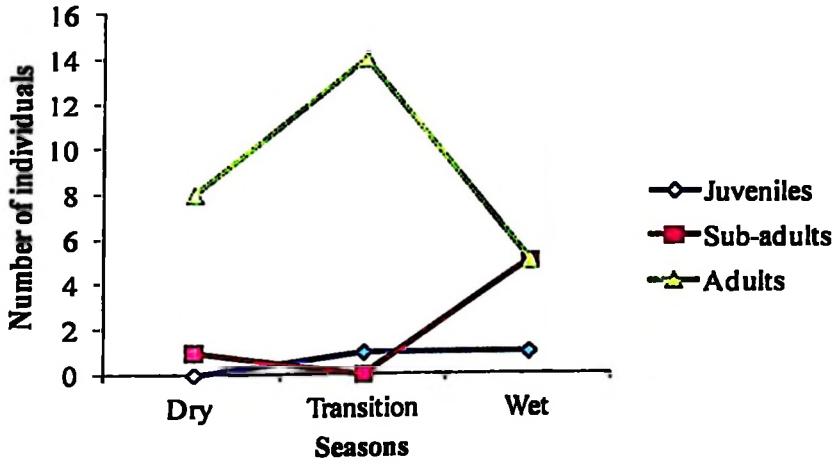


Figure 15: Sesonal age composition trend of *Acomys* sp.

Fig.15: shows the seasonal trends of different age groups of *Acomys* sp.

Adult *Acomys* sp. increased towards transition period and showed sharp decrease towards wet season. Sub-adults showed different responses to seasonality as they had a slight decrease towards transition but they increased towards wet season. Juveniles' number remained low in all seasons with slight increase towards wet season.

4.2.2 Seasonal sex ratio and reproductive condition of *Acomys* sp.

Table 3 shows overall and seasonal sex ratio of *Acomys* sp. The overall results shows sex ratio to be male biased and it was statistically significant (χ^2= 0.03, df=1, p<0.05). Sex ratio was male biased and was significantly different irrespective of seasons (p<0.05) (Table 3).

Table 3: Seasonal sex ratio of *Acomys* sp.

Season	Count	Males	Females	O	E	χ^2	s/n.s
Dry	9	5	4	0.55	0.5	0.005	s
Transition	15	11	4	0.73	0.5	0.05	s
Wet	11	8	3	0.72	0.5	0.05	s
Overall	35	24	11	0.71	0.5	0.03	s

Sexually active male *Acomys* sp. were recorded in six of nine studied months. Most sexually active males were recorded in April and none was recorded in November, March and May (Fig. 16).

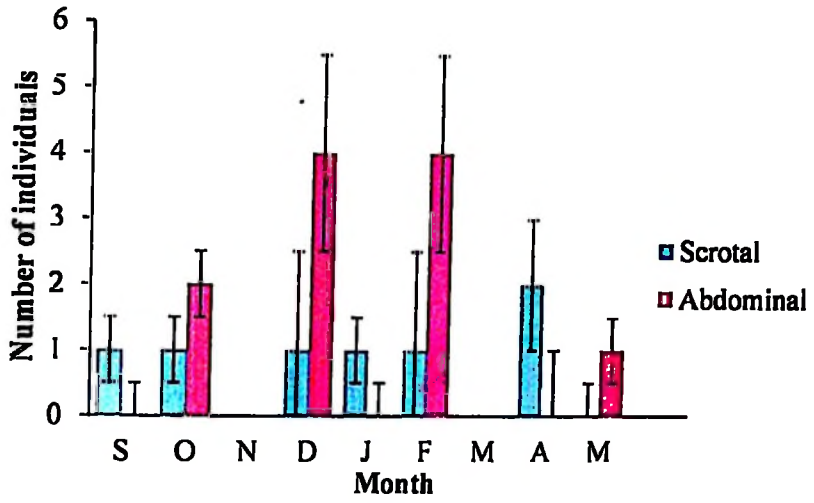


Figure 16: Monthly reproductive condition (± SE) of male *Acomys* sp.

(Scrotal=Sexually active, Abdominal=Sexually inactive)

Sexually active females were captured in four of the nine studied months. January had the highest recorded sexually active females while there were no sexually active females in December, February, March and April (Fig. 17). In addition, seasonality (rainfall) had no influence on reproduction activities of *Acomys* sp. in SGR (Fig. 18).

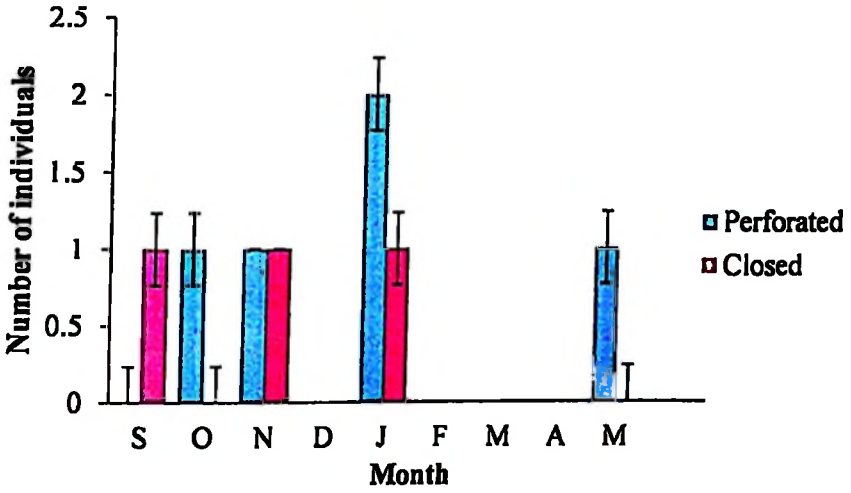


Figure 17: Monthly reproductive condition (± SE) of females *Acomys* sp.

Perforated=Sexually active, Closed=Sexually inactive).

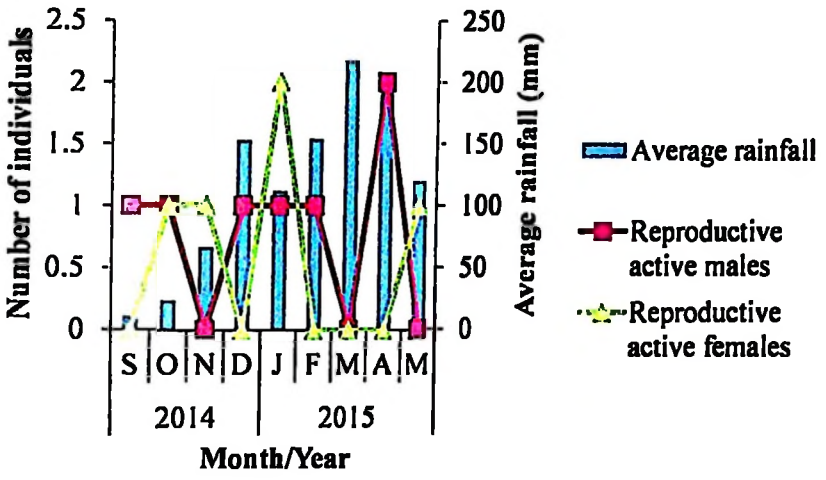


Figure 18: *Acomys* sp. reproductive condition in relation to monthly rainfall patterns

4.2.3 Age structure of *Petrodromus tetradactylus* in different habitats

Petrodromus tetradactylus was strictly found in riverine forest. Adults were the most dominant, while juveniles were the least found in this habitat (Fig. 19).

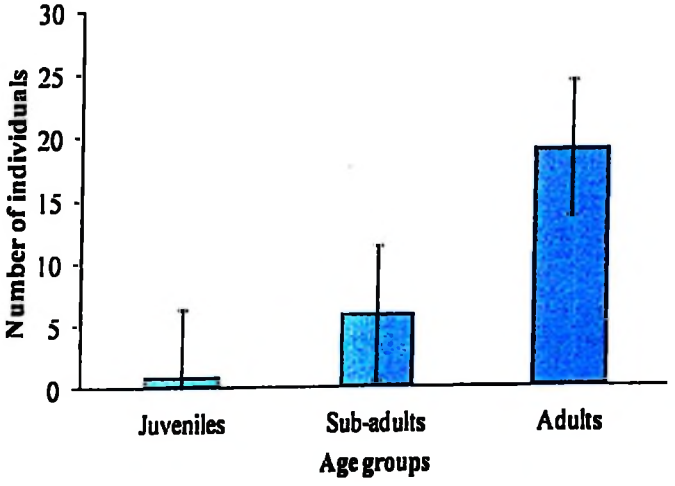


Figure 19: Overall age composition (± SE) of captured *P. tetradactylus*

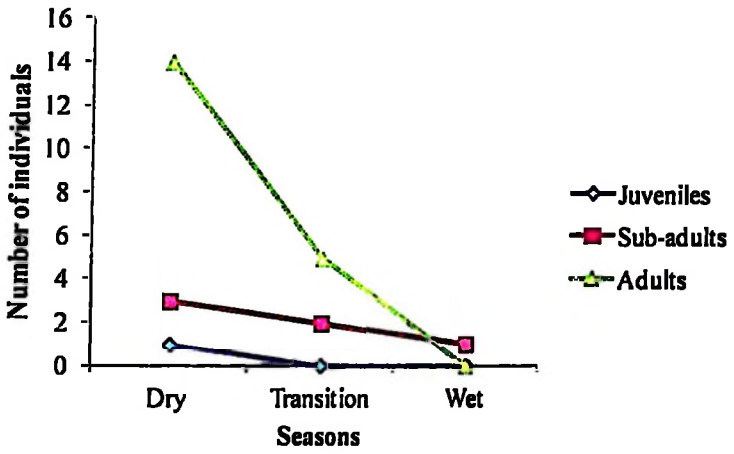


Figure 20: Seasonal age composition trend of *P. tetradactylus*

Fig. 20: shows different age groups and seasonal trends of *P. tetraductylus*. Seasonality had influences on all age groups with numbers decreasing towards wet season.

4.2.4 Sex ratio and reproductive condition of *P. tetradactylus*

Table 4 shows overall and seasonal sex ratio of *P. tetraductylus*. The overall sex ratio was significantly different (χ^2= 0.045, *df*=1, p<0.05).

Table 4: Seasonal sex ratio of captured *P. tetradactylus*

Season	Count	Males	Females	O	E	χ^2	s/n.s
Dry	18	11	7	0.61	0.5	0.0242	s
Transition	7	6	1	0.86	0.5	0.2592	n.s
Wet	1	0	1	0	0.5	1	n.s
Overall	**26**	**17**	**9**	**0.65**	**0.5**	**0.045**	**s**

Males were most dominant in the dry and transition period. However, only the dry season showed the ratio between males and females to be significantly different

(χ^2=0.0242, df=1, p<0.05). The results also show no sexually active males of *P. tetradactylus*were captured during the study period (Fig. 21). Conversely, only September of the studied months had two pregnant females (Fig. 22).

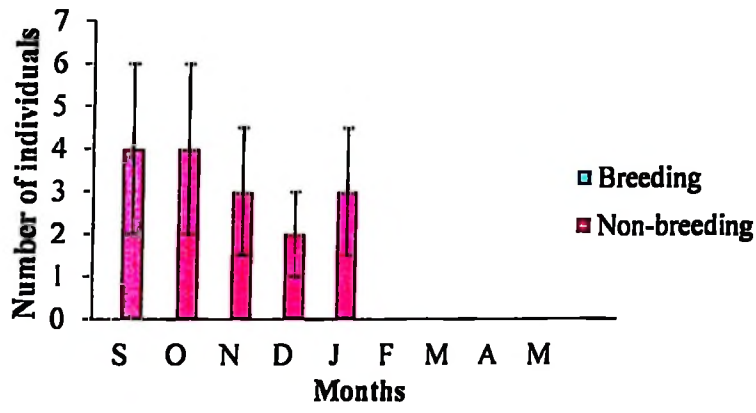


Figure 21: Monthly reproductive condition (±SE) of male *P. tetradactylus*

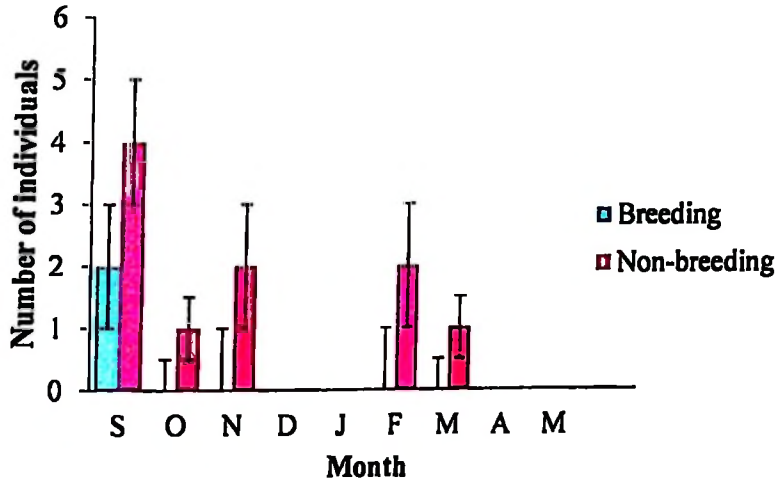


Figure 22: Monthly reproductive condition (±SE) of female *P. tetradactylus*

4.3 Community Similarity between Habitats and Seasons

Jaccard's similarity coefficient showed variation especially with increased floristic diversity. Riverine forest and woodland habitats showed more community similarity as compared to riverine forest and wooded grassland which showed dissimilarity (Fig. 23).

Dry and transition period showed higher community similarity (88.9%) and transition and wet season showed the least similarity (50%).

However, comparing the habitats per season, the general similarity coefficient indices showed some variation. In transition and wet seasons, riverine and woodland communities were more similar (50% each) as compared to dry season when the habitats were dissimilar (22%).

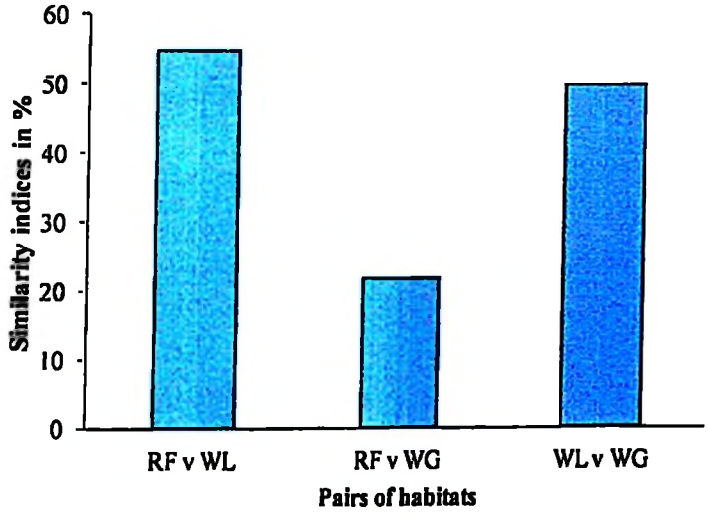


Figure 23: Jaccard's similarity indices between habitats (RF=Riverine forest, WL=Woodland and WG=Wooded grassland)

In addition, the relation between riverine forest and wooded grassland communities was below 50% in all seasons suggesting dissimilarity. Furthermore, woodland and wooded grassland showed higher similarity in dry and wet seasons (66% and 75%, respectively) and dissimilarity was observed in transition period (Fig. 24).

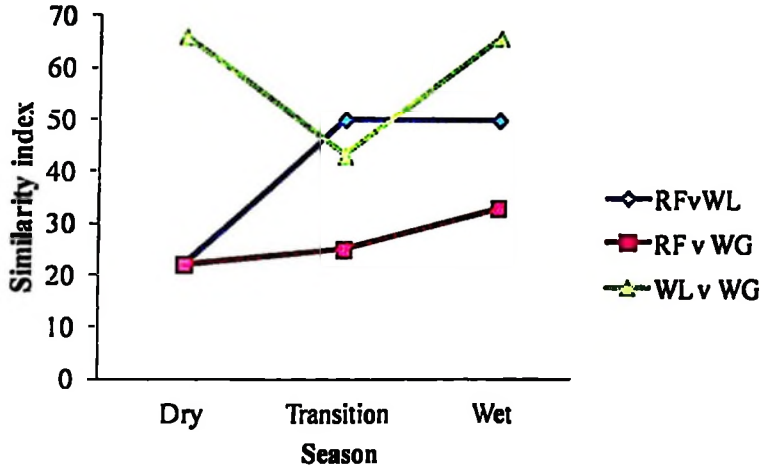


Figure 24: Seasonal similarity trend between habitas (RF=Riverine forest, WL=Woodland and WG=Wooded grassland)

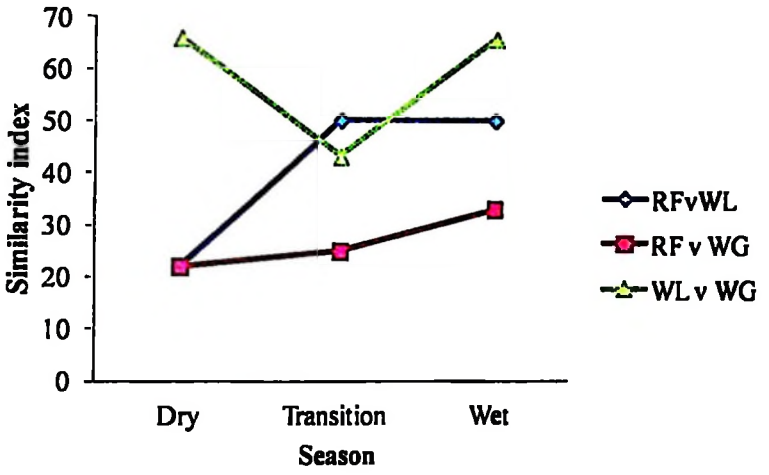


Figure 24: Seasonal similarity trend between habitats (RF=Riverine forest, WL=Woodland and WG=Wooded grassland)

CHAPTER FIVE

5.0 DISCUSSION

5.1 Species Composition, Distribution and Abundance

Riverine forest comprised higher species composition compared to other habitats. Among the potential contributing factors could be food and shelter availability which were presumably more favorable than in the woodland and wooded grassland.

Acomys sp., *P. flavoittis* and *Crocidura* sp. were the most widely distributed species of rodents and shrews in most habitats and seasons. These results are similar to those reported by Mbugua (2002). According to Kingdon (1997) *Acomys* species are widely distributed in dry tropical Africa and is a successful group in the family Muridae. They are common species that inhabit dry rocky areas and avoid moist forests in most of their range (Kingdon, 1997). Also, Venance (2009) found *Crocidura* species to occupy all the sampled habitats in Mikumi National Park.

The results from this study agree with various authors (Makundi *et al.*, 2005; Mukinzi *et al.*, 2005; Mulungu *et al.*, 2008; Elmouttie, 2009; Yihune and Bekele, 2012; Garshong *et al.*, 2013) who suggested that vegetation diversity, spatial and temporal heterogeneity and complexity in a given habitat influence species abundance and distribution. This is by influencing food and shelter which are the key determinants for a species to select a given habitat.

Furthermore, Mohammadi (2010) suggested that small mammals' distribution and abundance are affected by both macro and micro-habitat. Among important factors include; temperature, nesting, competition, predation risk, mate searching and others. The

author added that, small mammals species will avoid open areas like open wooded grassland similar to those in this study due to exposure to predators hence the abundance is likely to be low. Also, fire as a natural ecological phenomena, highly influence vegetation structure and composition which in-turn influence small mammals' distribution and abundance (Witecha, 2011), a case of wooded grassland. Equally, Makundi *et al.* (2005) suggested that, species in stable habitats tend to maintain stable population densities as compared to those in less predictable and unstable habitats.

Observations by Venance (2009) in Mikumi NP showed low species abundance in riverine as compared to woodland and wooded grassland. The author also gave some reasons including recurrent flooding that cause high mortality to rodents and shrews. The disparity that exists between this study and that of Venance (2009) can be attributed to type of river (seasonal or permanent). Others includes shape of the landscape in that riverine (gorge, gentle slope, rocky etc), stage of the river (young, middle or flood plain of a river) and season of the year. All these characteristics could exhibit different influence on abundance and diversity of rodents and shrews in a given locality/site.

In addition, although floristic diversity has been mentioned by several authors (Makundi *et al.*, 2005; Mukinzi *et al.*, 2005; Mulungu *et al.*, 2008) to have impact on relative abundance and distribution, this phenomenon remains species and habitat specific. For example, the results from this study suggest a variation in distribution and abundance with both increasing during the dry and/or wet seasons.

As suggested by Takele *et al.* (2011) distribution patterns and relative abundance of rodents depends on seasonal (with effect mainly brought by rainfall or no rainfall) availability of cover and food. This might not be a general phenomenon in all areas and to all species. For instance, although abundance went down in general in riverine for this

study, *Paraxerus* species continued to maintain their abundance. That means the effect of wet season was specifically affecting availability of some species like *P. tetraductylus*, *R. rattus*, and *R. cirnei* while favoring others in the same habitat.

The results for this study are in line with those of Makundi *et al.* (2005) who found that population of *Gerbilliscus leucogaster* did not show major fluctuations with seasonal changes although other species in the same habitat had remarkably high fluctuations. Also, Windberg (1998) in Texas added that, species coexisting in the same habitat but with differing life history may demonstrate different patterns of fluctuations in the matching environment. This was also experienced in woodland where *M. natalensis* and *Crocidura* sp. increased in number as wet season approached, although *Crocidura* sp. was not available in the riverine in wet season as in dry and transition seasons. As suggested by Krebs (1999) cited by Makundi *et al.* (2005) that environmental factors can shape the population of the same species differently depending on locality.

5.2 Rodents and Shrews Species Richness, Diversity and Evenness

Habitat characteristics are the key factors that determine the richness of small mammals of a particular species (Mbugua, 2002). Riverine forest showed higher species richness and diversity of rodents and shrews while wooded grassland had the least. This can be associated with some vegetation factors. For example, Mbugua (2002) pointed out that some plants like *Combretum* sp. positively correlate with high number of rodents, although it is not directly linked to food. *Combretum* sp. is a common thicket in the riverine forest for this study.

Generally the dry season had the highest species diversity while the wet season had the least. Despite species richness and diversity being high in the dry season most of the

species were captured in one habitat only i. e. *P. palliatus, R. cirnei, P. tetradactylus, Gerbilliscus* sp. and *Crocidura* sp. On the contrary, in the wet season the riverine habitat favored only two arboreal species i. e. *P. flavovittis* and *P. palliatus*. Ground dwellers and burrowers decreased dramatically probably due to nature of soils (wet) and increased undergrowth as well as recurrent flooding. Venance (2009) suggested that flooding might cause species to die or locally migrate to upper side of the river were flooding is not frequent.

On the other hand, some species might have developed a foraging strategy that enable them to store food in burrows and use it during harsh conditions (i. e. like rainfall in wet season) thus limiting their movement or they were swept by frequent flooding in wet season. Another possible reason for decreased species richness and diversity in riverine forest might be attributed to reduced home range by most species due to increased resource availability in a smaller area in the wet season (Borremans, 2013).

Riverine forest exhibited higher species evenness whereas wooded grassland had the least. This is attributed to high species richness in riverine forest followed by woodland while in the wooded grassland *M. natalensis* contributed to low species evenness as it was dominant in transition and wet seasons.

Nevertheless, seasonal variations were evident in all habitats for evenness. Evenness increased with increasing dry season in riverine forest. Evenness decreased as species richness and diversity decreased. In addition, it increased in both woodland and wooded grassland habitats as richness and diversity increased in transition and wet season for woodland and in dry and wet seasons for wooded grassland. This means seasonality has different influence on species evenness in different habitats.

5.3 Population Characteristics of Rodents and Shrews

Two most abundant species (one of rodents and one of shrews) were examined on their population characteristics with the aim of establishing age, sex, and breeding patterns. The species were *Acomys* sp. and *P. tetraductylus.*

5.3.1 Age structure and sex ratio of *Acomys* sp.

Acomys sp. was among the most widely distributed specie in all studied habitats and was the most abundant rodent species captured in this study. Of all captured *Acomys* sp. age was skewed towards adults with exception of April when the age was almost level. These results are in line with those of Bantihun and Bekele (2015). The reasons for high trappability for adults might be associated with their movement and rank in social level. However seasonality especially the influence of rainfall increases the number of young and sub-adults thus the age groups become almost leveled in wet season. These results also mirror those of Bantihun and Bekele (2015).

On the other hand, sex was male biased except for September and January when more females were captured. Bantihun and Bekele (2015) suggested that males are active than females hence high chance of being trapped. Consequently, male conduct more movements than female thus a biased sex ratio in most rodents' population studies.

5.3.2 Breeding and reproduction characteristics of *Acomys* sp.

The findings from this study show that both *Acomys* sp. males and females were sexually active in most months as compared to other species. According to Makundi *et al.* (2005) in Africa, most Muridae species will breed when resources are favorable and plenty. Furthermore, rainfall has been linked to rodent's reproduction activities and outbreaks (Leirs, 1995). The reasons put forward include influence of rain on flora by stimulating growth thus increasing food and shelter availability which in-turn provides optimal conditions for reproduction of rodents (Tekele *et al.*, 2011; Borremans, 2013). The authors

also suggested that, areas with two seasons (dry and wet) tend to favour high breeding during wet season. However, breeding and rainfall relationship remains extremely variable (Mrosso, 2004).

Acomys sp. does not follow rainfall patterns and it may be reproductively active throughout the year (Neal, 1982, cited by Mrosso, 2004). Females can conceive throughout the year and may produce up to six litters in a year. To manage such an expensive activity such as breeding throughout the year, the species might be a generalist feeder as pointed out by Elmouttie (2009). This is by adapting utilization of a variety of food regardless of preference as opposed to specialist species which rely on specific type of diet before investing in expensive activity like breeding. In some species the breeding behavior involves nursing the young by all females (Kingdon, 1997) in the group which reduce the burden from one female. Hence, the activity becomes easy and the chance of breeding throughout the year is increased.

5.3.3 Age structure and sex ratio of *Petrodromus tetradactylus*

Four toed elephant shrew (*Petrodromus tetradactylus*) was captured in riverine forest only. It is the only species in the genus *Petrodromus* and the second most widespread species following short-snouted elephant shrew (*Elephantulus brachyrhynchus*) (FitzGibbon *et al.*, 2008). The species is mentioned as of least concern in the threatened list of IUCN (Nowak, 1999). Subsequently, FitzGibbon *et al.* (2008) suggested the species to prefer dense forests, thickets, woodland and riparian areas. The species is monogamous in nature and the sexes stay separate during non-breading season (Kingdon, 1997).

Age structure for the captured *P. tetradactylus* suggests being adult biased throughout the study period. In addition, sex ratio was males biased except for February 2015 where only two individuals, one male and female were captured.

5.3.4 Breeding and reproduction characteristics of *Petrodromus tetradactylus*

In this study only two females of *P. tetradactylus* were identified as pregnant in September and no other species showed any trait of being sexually active during the study period. These results are inconsistence with other studies were no distinct seasonal reproductive conditions have been observed in this species. However, Olbricht (2009) noted that breeding for this species is throughout the year showing increased reproduction with increased feeding grounds. In addition, the adoption of an omnivorous diet has diversified their energy source which is a factor for year round breeding ability.

5.3.5 Community Similarity between Habitats and Seasonal Variations

Jaccard's similarity coefficient suggested having a slight similarity between riverine forest and woodland habitats as compared to other pairs compared. The possible reasons may include relatedness in terms of vegetation composition thus increasing habitat diversity which attracts more animals.

On the other hand, there was a variation in community similarity with seasonal changes. This might be attributed to effect of seasonal changes particularly influence of rainfall on specific species in different habitat.

5.4 Other Species Captured in this Study

Three species which were not the target for this study were captured. All of the species were captured using wire cages in the riverine forest.

5.4.1 Order Primates; Family Galagidae

One *Galago* sp. was captured in this study. *Galogo* or bushbabies are in the family Galagidae and they involve a number of living species. They inhabit dense vegetation in miombo, coastal and montane areas (Kingdom, 1997).

5.4.2 Order Canivora; Family Herpestidae and Viverridae

Dwarf mongoose, *Helogale parvula* is a small social carnivore which forms small packs of up to eight individuals. They inhabit savannah, thickets and woodland and avoid forests and highlands (Kingdon, 1997). In addition, common genet, *Genetta genetta* was captured. The animal inhabits most of habitats where it is associated with rivers and it is a generalist feeder but mainly small vertebrates.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATION

6.1 Conclusions

This study has confirmed the influence of floristic diversity on abundance, distribution and diversity of rodents and shrews in different habitats. It has also showed how seasonal variations affect abundance and distribution of some species. Subsequently, some species in habitats like riverine forest were highly affected by wet season than in woodland and wooded grassland habitats which were somewhat constant in terms of species abundance. Consequently, the study has shown that *Acomys* sp. breeding patterns are not season specific as it was not affected by rainfall distribution during the study. *Petrodromus tetradactylus*, although widely studied with some studies showing that it breeds year round, this study failed to confirm these conclusions as only few females were identified as pregnant during September.

Therefore, this study concludes that floristic diversity is among the key factors in determining the abundance and diversity of rodents and shrews in any given habitat presumably because species choose habitats with variety of food and shelter which is necessary for their survival.

Also, the effect of season is not a generalized phenomenon for all species. Finally, breeding depends highly on the ability of the animal to adopt a variety of diet as substitute during nutritional constraints periods like for *Acomys* sp.

6.2 Recommendation

Prolonged and extensive study is needed to cover more habitats in SGR so as to have a clear picture of abundance and diversity of rodents and shrews.

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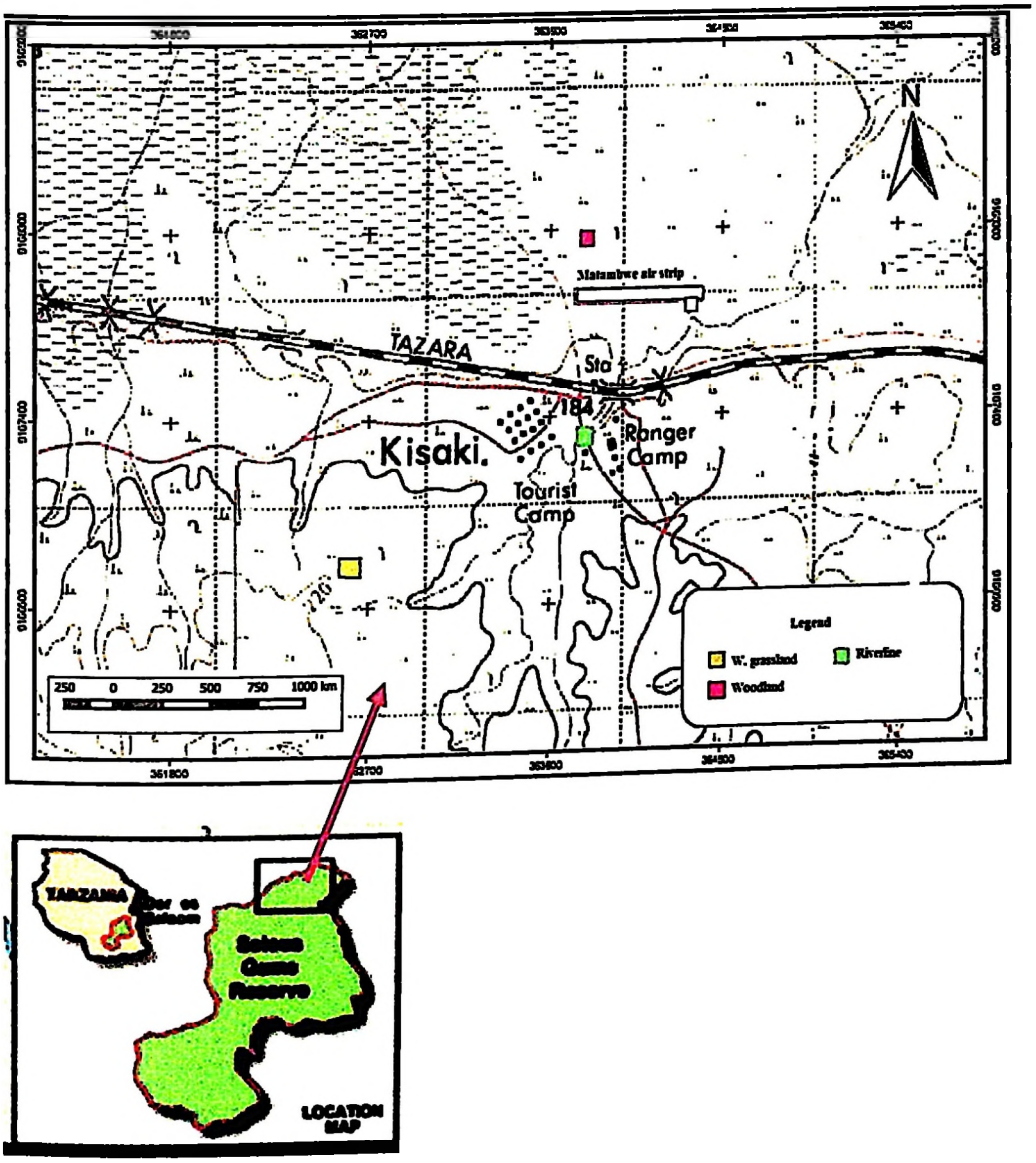
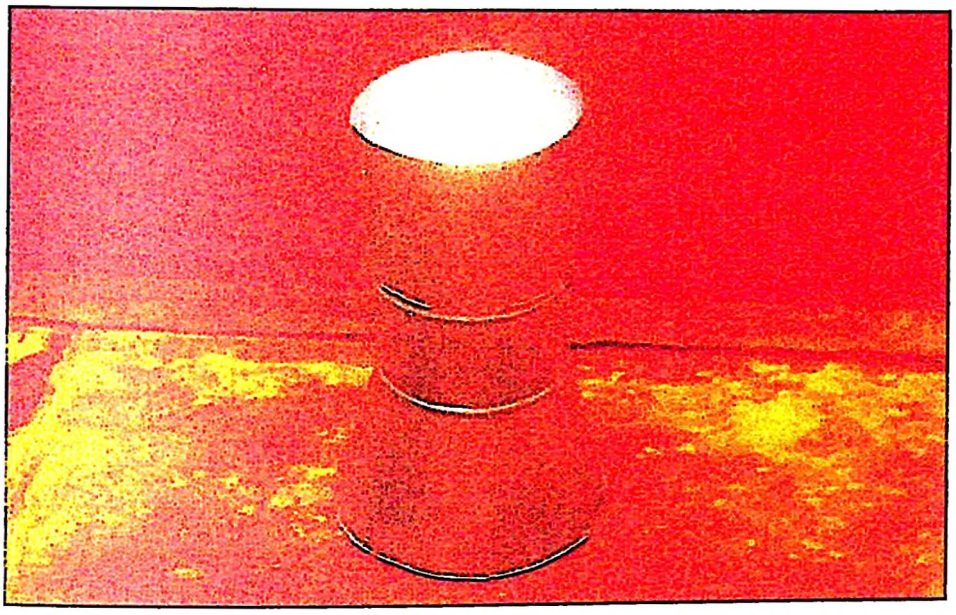
APPENDICES

Appendix 1: Study area map



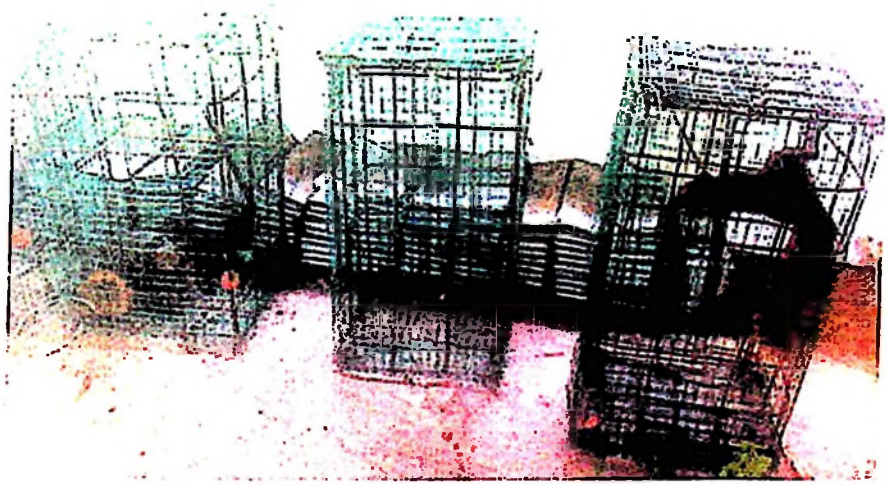
Appendix 2: Standard rain gauge



Appendix 3: Types of traps used in the capture mark release (CMR)

a. Sherman's traps

b. Wire cages traps



c. Pitfall traps alignment