RODENT COMMUNITY COMPOSITION, DISTRIBUTION AND BREEDING PATTERN IN TARANGIRE NATIONAL PARK, TANZANIA

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

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ABSTRACT

This study investigated the community composition, distribution and breeding pattern of rodent in three habitats (grassland, woodland and shrubland) found in Tarangire National Park. Rodent population was sampled using Sherman live traps following capture-mark-recapture technique from March-August 2020. A total of 6 species of rodents were captured in 2646 trap nights (covering wet and dry seasons). Overall, *Mastomys natalensis* was by far the most abundant rodent species with trap success of 4.8% and the least was *Mus* spp with trap success of 0.03%. Shrubland had the highest trap success with 88 individuals, followed by woodland with 70 individuals and grassland with 44 individuals. Shrubland indicated the highest diversity (H´= 0.989), followed by woodland (H´= 0.8859) and grassland (H´= 0.2338), with statistical difference in all habitats when compared pairwise ($p < 0.05$). More adults were captured compared to sub-adults and juvenile. In addition, sex ratio was skewed more to females than males although the difference was not significant ($p > 0.05$). Breeding was high in wet season than dry season ($p = 0.0237$). Species were aggregate and randomly distributed, uneven distribution of food was probably the main factor for most of rodents to be randomly and aggregate distributed. This shed light on the management on which habitat needs more concentration in conservation in order to increase number of rodent species as they play important role in ecology. More studies are needed to cover the gap of different methods, more trapping sites and long duration of study period from three years and above.

DECLARATION

I, **RUTH ZAKAYO KAMUNGO**, 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 has neither been submitted nor is being concurrently submitted in any other institution

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The above declaration is confirmed by

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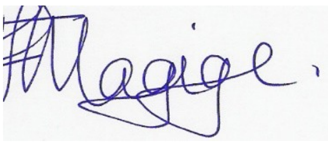
DR. SAYUNI MARIKI   **Date**

(Supervisor)



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DEDICATION

This dissertation is dedicated to my beloved parents, Mr. and Mrs. Kamungo who laid the foundation of my education and for their affectionate love.

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ACE	African Centre of Excellence
PAST	Paleontological Statistics
SUA	Sokoine University of Agriculture
TNP	Tarangire National Park

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Mammals are the biologically successful group because they thrive very well in most of the environments, with the possible exception of insects (Hickman *et al.,* 1988). Worldwide, small mammals form a major proportional of fauna (Jacob *et al*., 2003; Workneh *et al.*, 2005). Small mammals are animal which weighs less than 500 g and are terrestrial and arboreal in nature (Anke *et al.*, 2010) with the highest diversity comprising more than 2065 species worldwide (Kassa and Bekele, 2008). In East Africa there are different species of small mammals which include rodents, insectivores, shrew, moles, rats, squirrels, hyraxes and bats, and they represent a heterogeneous group of the mammalian orders (Keesing, 2000).

Rodents is a conspicuous group of small mammals that have been described as ubiquitous and occur in abundance nearly everywhere (Krebs, 1999). They are well adapted to a wide range of environment (Nowak, 1999). Their distribution and abundance refers to how species are organized in a certain habitat within ecosystem (Steem, 1996). Rodents can benefit the ecosystem as they are source of food for other animals (Davies, 2002), seed dispersers (Fischer and Turkey, 2016), and also help in bio-control by consuming weed seeds (Daedlow *et al.,* 2014).

On the other hand, absence of sufficient food and ground cover largely determine the number of individual rodents in a certain area (Rubio *et al.,* 2014). The loss of ground cover and food supply for small mammals decrease rodent diversity but increase predation risk (Hoffmann and Zeller, 2005). Also, habitat structure and predation risk affects species composition in various habitat type (Massawe *et al.,* 2007).

Rodents show habitat preference and this mainly depend upon the vegetation type (Fitzherbert *et al.,* 2006). There are rodents that can only survive in narrow altitudinal range where as others are altitude generalists (Bateman *et al.,* 2010; Rubio *et al.*, 2014). Their distribution and abundance are influenced by environmental factors such as the nature and density of vegetation, climatic conditions, disease and predation (Johnson and Horns, 2008).

Population dynamics of rodents have shown to be influenced by rainfall patterns. For instance, breeding of *Mastomys natalenis* increase towards the end of wet season and decrease during dry season (Feliciano *et al*., 2002; Tilaye, 2005; Massawe *et al*., 2006). Despite being the most wide spread and diverse group of mammals on earth, the distribution of rodents in Tarangire National Park remains poorly understood.

In Tanzania, studies on rodents have been mainly concentrated on pest rodent species (Odhiambo *et al.,* 2008; Mulungu, 2017), whereby there are few attempts on distribution and diversity in various parts of Tanzania (Magige and Senzota, 2006; Timbuka and Kabigumila, 2006; Mulungu *et al*, 2008; Stanley and Kihaule, 2016)). Although ecological studies on rodent have been carried out in different parts of Tanzania, community composition, distribution and breeding pattern of rodents in many areas are poorly known. Therefore, this study was conducted in Tarangire National Park to determine community composition, distribution and breeding pattern of rodents.

1.2 Problem Statement and Justification

Tarangire National Park is the 6th largest parks found in Tanzania (Foley, 2002). The park is rich in biodiversity and provides several habitats for different kind of species (Mwalyosi, 1992; Foley, 2002). Due to its richness in biodiversity, different studies focusing on large mammals have been done (e.g. Emmanuel *et al*., 2004; David, 2007; Christian *et al*., 2014; Heather and James, 2017; Christian *et al*., 2019). One study, however, has focused on surveying small mammals in the Park (Stanley *et al*., 2007). The study did not document the entire biodiversity of small mammals in the park and did not focus on age structure, sex ratio, breeding pattern and distribution among others. Apart from research done by Stanley *et al.* (2007), there is no follow up study on small mammals.

Elsewhere in Tanzania, different studies have been done on small mammals (Stanley *et al*., 1998; Stanley and Hutterer, 2007; Massawe *et al.*, 2007; Stanley *et al.*, 2011; Stanley and Kihaule, 2016; Mulungu, 2017). Also there are several studies that have specifically focused on rodents (e.g. Timbuka and Kabigumila, 2006; Mulungu *et al*., 2008; Venance, 2009; Mulungu *et al*., 2014).

Therefore this research aimed to shed light on composition, distribution and breeding pattern of rodents in Tarangire National Park. The results of this study will help in biodiversity conservation and management in Tarangire ecosystem as small mammals (including rodents) are indicators of habitat condition. In additional it will update the species lists of rodents existing in the park and if there is any species of IUCN concern which will increase *in-situ* conservation.

1.3 Objectives

1.3.1 General Objective

To determine the community composition, distribution and breeding pattern of rodents in Tarangire National Park.

1.3.2 Specific Objectives

i. To determine composition of rodents in different habitats in Tarangire National Park

ii. To assess age, sex and breeding pattern of rodent in Tarangire National Park

iii. To examine distribution of rodent species in Tarangire National Park.

1.3.3 Research Questions

i. What is the composition of rodents found in different habitats in Tarangire National Park?

ii. What is the age, sex ratio, and breeding pattern of rodents found in different habitats in Tarangire National Park?

iii. How rodents are distributed in different habitats found in Tarangire National Park?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Abundance and Diversity of Rodents

Rodentia is the largest order of mammals comprising 44% of mammals worldwide (Wolf and Sherman, 2007). They are found in different environments from aquatic environments, underground, in trees and on the ground (Wolf and Sherman, 2007). Rodents being in order Rodentia they can be identified through their teeth (Legendre, 2003; Churakov *et al*., 2010).

There are more than 2000 species of rodent which differ in size, habitat, diet and behavior (Kay and Hoekstra, 2008). Rodent are either diurnal or nocturnal (Bergstrom, 2013), where some are herbivorous, omnivores, insectivorous and others are opportunistic generalist (Leirs and Verheyen, 1995; Bergstrom, 2013). Due to their formation they eat variety of food from seed to scorpion (Kay and Hoekstra, 2008).

Globally, there is about 5416 species of mammals and more than 2,277 species are rodents (Wilson and Reeder, 2005) which represents almost half of all living mammalian species. In Africa, more than 1150 species of mammals are currently listed (Venance, 2010). In East Africa, rodent account for 28% of the total mammalian population (Venance, 2010). In Tanzania, there more than 101 species of rodent (IUCN, 2019). As for Tarangire only 15 species of rodents were recorded (Stanley *et al*., 2007).

2.2 Age, Sex Ratio and Breeding Patterns of Rodents

Rodents may be active all year or in seasons (wet and dry) thus breeding time, length of gestation, and litter size vary widely (Leirs and Verheyen, 1995; Mulungu *et al*., 2016).

They are different in productive breeders with a litter size ranging from 1 to 28 offspring in a single litter (Leirs and Verheyen, 1995; Kay and Hoekstra, 2008; Happold *et al*., 2013; Kingdon, 2015). This makes population size to remain stable or fluctuate, and some species, may migrate when populations is disturbed or become excessively large (Massawe *et al*., 2006). Their sex ratio are in favor of females, as males can be active throughout the season and one male can impregnate many females in one season (Mulungu *et al.*, 2013). Sex ratio can be determined as the ratio of the number of individuals of one sex (females) to that of the other sex (males) in the population. Typically fluctuated around in a ratio of 1:1 (expected ratio) as the most common evolutionary stable strategy (ESS), led by frequency-dependent natural selection due to competition for mates among individuals of the same sex (Jennions and Fromhage, 2017).

Small size, short breeding cycles, and wide range of food have made rodent to become of the most mammalian group to be found almost all over the world (Kingdon, 1974; Spradling *et al.*, 2001). Rodents show many adaptation to the environment which enable them to live and survive in different ecological niches. Availability of food and shelter, habitat heterogeneity, seasonal variation and predation influence distribution and abundance of rodents (Massawe *et al.*, 2006; Datiko and Bekele, 2014). Age structure of rodents can be determined through weight, morphological measurements like body length, ear length and tail length (Leirs and Verheyen, 1995).

2.3 Distribution of Rodents

The distribution, abundance and diversity of organisms are influenced by the interaction of abiotic and biotic factors (Brown, 1984). Soil type is one of the factors that affect rodents as it affects vegetation type (Silva *et al.*, 2005; Massawe *et al.*, 2008) which affects predation risk; thus affecting abundance of rodents in a given habitat (Grant *et al.*, 1982).

In the habitat species can either be random, aggregate and uniform distributed. Variation of species distribution in the habitat can be related to vegetation cover found in the habitats and availability of food (Happold, 1990; Timbuka and Kabigumila, 2006). Most of small mammals are not specific to any particular habitat due to their ability of utilizing almost all habitats in the continents (Amori and Luiselli, 2011; Kok *et al*., 2012). As their selection of habitat is determined primarily by the type of vegetation cover available (Iyawe, 1988).

The knowledge of distribution and diversity of mammals are not complete, especially for small mammals including rodents as many taxa are still being discovered (Kingdon 1997; Wilson and Reeder 2005). In that case, it has caused distribution of species and their abundance to receiving serious attention in Tanzania, as distribution and abundance of rodent refers to how the species are organized on a small or geographical scale (Odhiambo *et al.,* 2008; Mulungu *et al.,* 2008). Direct monitoring of small mammals, including rodents, is suggested to be a quick and cheap method of understand health status in ecosystem. Knowledge of their abundance and diversity can facilitate the management of nature areas (Avenant, 2000).

Diversity of small mammals correlates positively with vegetation as rainfall promotes growth of vegetation, which provides food for small mammals that consequently increase their rate of reproduction (Meserve *et al.,* 2010). Like other small mammals, rodent abundance and diversity in a habitat can be an important indicator of habitat quality, also alteration in the environment is likely to twist the condition in the ecosystem (Hoffmann and Zeller, 2005) and can either favor or reduce rodent species diversity (Othiambo *et al.*, 2008).

2.4 Importance of Rodents in the Ecosystem

Rodents have ecological, social, education and research value (Amori and Luiselli, 2011). They are predators of invertebrates and a link between primary producers and secondary consumers (Avenant and Cavallini, 2007). Moreover, they are an important source of food to humans, large array of predators and birds (Tadesse *et al.*, 2008). . For example rodents have been shown to contribute significantly to the survival of one of the most endangered canids in the world (Amori and Luiselli, 2011).

CHEPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Geographical Location

Tarangire National Park is located in northern Tanzania between 3°35’ and 4°35’S, and 35°45E’ and 36°.39’E with elevation ranging from 1000 to 1600 meters above the sea level. It covers 2642km^2 of the Tarangire ecosystem. The entire ecosystem is in the southern Maasai steppe and it includes mto wa mbu Game Controlled Area (north), and Lolkisala and Simanjiro plains Game Controlled Area (east), Mkungunero Game Controlled Area (south), and Kwakuchinja Open Area (west).

The park is in a semi-arid area, averaging about 650 mm in annual rainfall, rain in this area is unpredictable but it tends to rain in this area from November to the end of April (Foley, 2002). The average temperature of this area range from 27°C to 16°C in January, February, June and July (Gawynne, 1977; Pittiglio *et al.*, 2012). Tarangire National Park is the refuge for most of the migratory animals in the Tarangire ecosystem. During dry season Tarangire River becomes source of water for the entire ecosystem.

Tarangire National Park is dominated by acacia and commiphora genera (Foley, 2002). Habitats found in this park include riparian woodland, riverine grassland, woodland, *Acacia tortilis*, shrubland and grassland with scattered baobab trees (Foley, 2002). The park provides habitats for large diversity of fauna including elephant, zebra, wildebeest, lion, cheetah, leopard, lesser and greater kudu, oryx, hartebeest, buffalo, bird species and rodents among others (Foley, 2002).

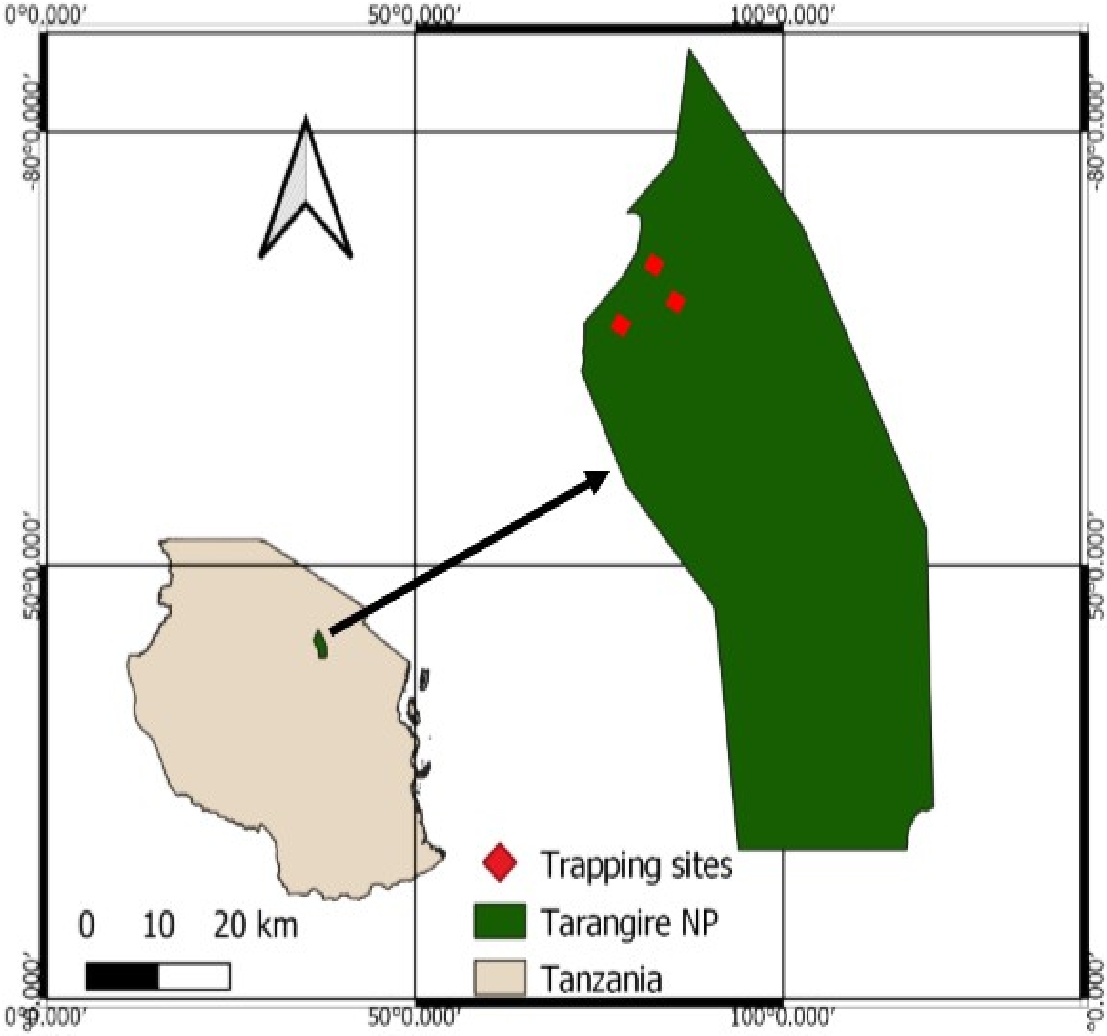

Figure 1: Map Showing Trapping Sites in Tarangire National Park

3.2 Study/Sampling Design

Field study was carried out for 6 months, from March to August 2020 so as to cover wet and dry seasons. Study area was selected purposively by considering habitat types and distance from one habitat to another. Distance from one habitat to another was more than 500m. This distance was adopted as most literature have suggested the same distance. Though the help of park ecologist and secondary information, three different habitats found in the park were selected; which are grassland, woodland and shrubland. Areas which were general open with flat area of grass were considered as (grassland), areas were trees was the dominant plant form, and their canopy overlap and interlink with few grass were considered as (woodland) and bush areas dominated by shrubs, with grasses and herbs were considered as (shrubland). In each habitat, a permanent grid of 70 × 70m was established with total of 147 trapping station, making 49 trapping stations per grid. The Capture-Mark –Recapture method was used (Borremans *et al*., 2014).

3.3 Trapping Procedure and Data Collection

After site survey, the permanent trapping grids were set at Sangaiwe area in the park. The area was selected because it is the area where the three categories of habitats can be found adjacent to each other. One grid with 49 traps was set in each habitat, whereby a total of 147 Sherman live traps were set in three habitats following Mulungu *et al* (2012). Grids were formed by arranging seven parallel lines with 10m apart; also trapping stations were set 10m between one station to another. Each line consisted of 7 trapping stations, making a total of 49 trapping stations per grid (Figure 2).

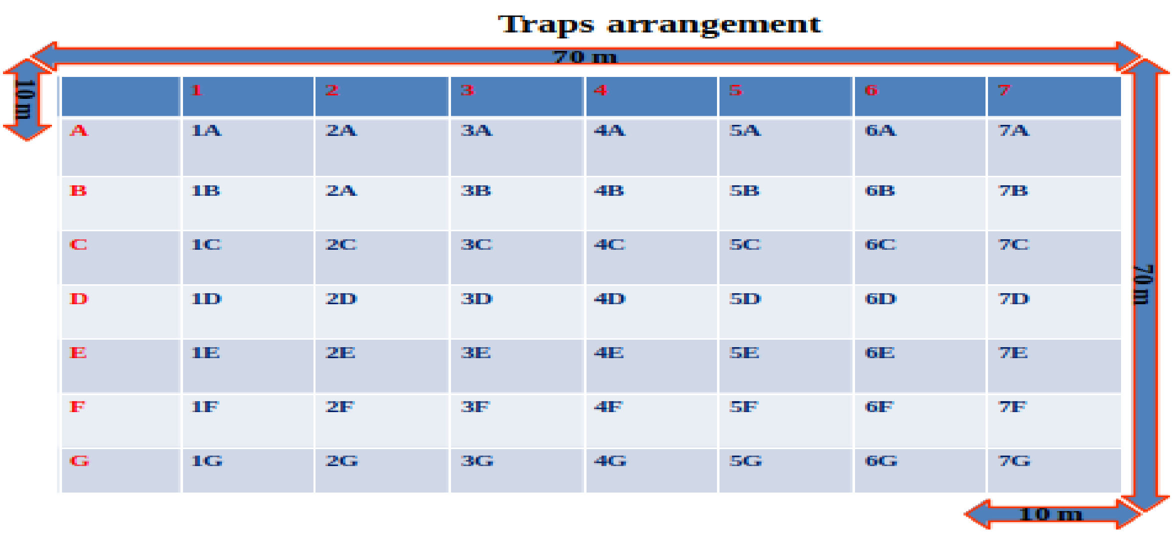

Figure 2: Sketch of Sherman Live Traps Layout in a Grid

Traps were set in the evening of the first day and were baited with a mixture of peanut butter and maize flour. The bait was replaced with new one after every trap check which was conducted every morning and late evening for three consecutive nights per month. This is because most rodents are active at night and few are active at day time (Senzota, 1982; Mulungu *et al*., 2008; Magige, 2016).

Rodent species captured in Sherman live traps were identified to species level (Happold *et al*., 2013; Kingdon, 2015) and age was determined basing on weight (Leirs and Verheyen, 1995). Their taxonomic groups were properly identified based on field guide books (Happold *et al*., 2013; Kingdon, 2015). All the new captured animals were marked by toe clipping using specific number coding. This helped to identify them as recaptures during subsequent trap check and released at the site of capture. Data recorded includes trap location, weight (in grams), code number which each captured species was given, species name, sex and reproductive conditions and habitat type.

3.4 Data Analysis

Trap success was calculated using the following formula (Stanley, 1996):

$$TS\ (\%) = \frac{Tc}{Tn} \times 100$$

Where:

Tc = Total catch (The total number of animals caught)

Tn = Trap night (Number of traps sets multiplied by the number of night deployed, minus number of misfired and non-targeted species).

Species composition is the contribution of each species in a given area in relation to other species in the same area. Species composition is calculated in terms of percentage (%)

where by each species in relative to others was calculated through dividing the number of captured individuals of each species by the total number of captured animals in each habitat and multiplied by 100. The percentage (%) of each species was computed using the formula;

$$\%\ Composition\ spp\ A = \left(\frac{Number\ of\ spp\ A}{Total\ number\ of\ individuals}\right) \times 100$$

The number of individuals captured in each species, habitat and month were recorded and estimation of abundance in the area was done. The minimum number alive (MNA) (also called the minimum number known alive, MNKA) index was used to estimate the true abundance in the area. MNA in Capture-Mark-Recapture is defined as the number of individuals caught in that time in a capture session on each habitat and those that were caught both previously and subsequently (Krebs, 1966). The method is used in a small number of trapping occasions and individuals to reduce bias on detection of the true abundance of live capture and recaptures for rodents (Pocock *et al.*, 2004). It is a widely used index of abundance in mark-recapture method also it is unbiased as it uses information from prior and subsequent capturing sessions of rodents.

The Shannon Weiner Diversity Index (Shannon and Weiner, 1948) was used to calculate diversity indices of rodents in the three habitats and it was calculated as follows:

H’=∑ (Pi) × in(pi).

Whereby;

H’- Diversity index

Pi- is the proportion of total sample belonging to the *i*th species

The Shannon Weiner Diversity Index was used as it assumes that individuals are randomly sampled from an independent large population, and all samples are presented (Shannon and Weiner, 1948).

In order to determine if there was a significant difference in diversity between habitats t-test was used. Statistical test was performed in Paleontological Statistics (PAST) program PAST 9.1.3. Age structure was determined for one species, *M. natalensis* as it is the only species studied in terms of age by categorizing juveniles, sub adults or adults using body weight in gram (Leirs and Verheyen, 1995). Individuals weighing > 24 g were grouped as adults, 21 g to 24 g were grouped as sub adults, while those weighing ≤ 20 g were grouped as juveniles.

The presence of active adult rodents was used as an indicator of breeding and the presence of juveniles in a population was used as proof of recent reproduction and was determined in each habitat and each month (Mulungu *et al.,* 2013) indication of breeding most of the time depend on the breeding condition of the animals e.g. for males the scrotum and testes if they are everted is an obvious marker, pregnancy, perforation and non-perforation for females etc.

Sex ratio was determined as the ratio of the number of individuals of one sex (females) to that of the other sex (males) in the population. Typically fluctuated around in a ratio of 1:1 (expected ratio) as the most common evolutionary stable strategy (ESS), led by frequency-dependent natural selection due to competition for mates among individuals of the same sex (Jennions and Fromhage, 2017). Sex ratio variation was determined in both habitats and in different seasons. In this study, the sex ratio was the proportion of females in the whole population and is in favor of females, as males can be active throughout the time and one male can impregnate many females in one breeding season (Campbell, 2007; Mulungu *et al*., 2013).

Where by female population is given

$$r = \frac{f}{m+f}$$

Where, r = sex Ratio, m = Number of Males, f = Number of Females

Kruskal-Wallis chi-squared test was used in this study to test if there is a significance association of sex ratio between habitats and seasons.

Using number of rodents captured per trapping station during each trapping session as sub-quadrat, distribution pattern were calculated using Morisita's Index of Dispersion. A value of $I_d<1$ indicates uniform distribution, $I_d=1$ indicates random distribution and $I_d>1$ indicates an aggregate distribution. This index calculate distribution coefficient of I_d (Morisita, 1962) using the following equation:

$$\mathbf{I_d = n}\left[\frac{\sum x 2 - \sum x}{\left(\sum x\right) 2 - \sum x}\right]$$

Where as

I_d =Morisita index of dispersion

n = sample size of species

∑x = sum of the quadrant counts.

All values obtains from I_d were tested using Chi-squared.

All analysis were performed with program PAST and R Version 3.5.1.

CHAPTER FOUR

4.0 RESULTS

4.1 Abundance of Rodents in Three Habitats in Tarangire National Park

Over the entire time of study in all habitats, six rodent species were collected, all belonging to family Muridae, order Rodentia. Species were *Mastomys natalensis, Lemniscomys rosalia, Arvicanthis* spp, *Aethomys chrysophilus*, *Acomys wilsoni* and *Mus* spp. A total of 202 minimal number alive were captured in three habitats. There was a statistically significant difference in rodent's abundance across all habitat types (F = 3.682, df = 2, p =0.0096). Whereby, shrubland was observed to have high trap success compared to woodland and grassland (Table 1). Also, there was significant difference in abundance between species across the habitats (F = 21.62, df = 5, p = 0.0001). In all habitats *M. natalensis* had the highest abundance with trap success of 4.7% (Table 1).

Table 1: Abundance of Rodents Trapped in Three Habitats

Species	**Grassland MNA**	**Woodland MNA**	**Shrubland MNA**	**Overall Trap success**
M.natalensis	4.6% (41)	6% (52)	4% (34)	4.8% (127)
L. rosalia	0	0	5.2% (46)	1.7% (46)
Arvicanthis spp	0.3% (3)	0.9% (8)	0.6% (5)	0.6% (16)
A.chrysophilus	0	0.5% (4)	0	0.1% (4)
A. wilsoni	0	0.6% (5)	0.3% (3)	0.3% (8)
Mus spp	0	0.1% (1)	0	0.03% (1)
Total	**44**	**70**	**88**	**7.43**

4.2 Rodent Species Richness and Composition in Tarangire National Park

The species caught were *M. natalensis* (n = 127), *L. rosalia* (n = 46), *Arvicanthis spp* (n = 16), *A. chrysophilus* (n = 4), *A. wilsoni* (n = 8) and Muss spp (n = 1). Specie richness was high in shrubland unlike in woodland and grassland. (Table 2). Species composition and individual species capture rates varied expressively. *M. natalensis* was captured in all habitats, however most individuals of this species were captured in grassland and woodland with 93 individuals, comprising 81.6%, while in Shrubland *L. rosalia* was the dominant species with 46 individuals, comprising 52.3% (Table 2).

Table 2: Rodent Species Composition per Species in Three Habitats

Habitats	Grassland		Woodland		Shrubland	
Genus	**Abundance**	**Percentage**	**Abundance**	**Percentage**	**Abundance**	**Percentage**
M.natalensis	41	93.18	52	74.3	34	38.6
L. rosalia	0	0	0	0	46	52.3
Arvicanthis spp	3	6.82	8	11.42	5	5.7
A.chrysophilus	0	0	4	5.71	0	0
A. wilsoni	0	0	5	7.14	3	3.4
Mus spp	0	0	1	1.43	0	0
Total	44	100	70	100	88	100

4.3 Diversity of Rodents in Tarangire National Park

There was variation in diversity between habitats throughout the trapping period. High diversity was observed in shrubland (H'= 0.989), followed by woodland (H'= 0.8859) and the least diverse habitat was grassland (H'= 0.2338). Statistical significant difference was observed between shrubland and grassland ($t = 4.620$, $df = 111.95$, $p = 0.001$), and between woodland and grassland ($t = 3.479$, $df = 117.58$, $p = 0.001$), while there was no significant difference shown between woodland and shrubland as ($p > 0.05$).

4.4 Age Structure

Among the trapped individuals of *M.natalensis*, were adults, sub-adults and juveniles. A total of (56) adults (44.1%) were captured compared to 47 sub-adult (37%) and 24 juveniles (18.89 %). The difference in abundance among age was statistically different ($F = 3.967$, $df = 2$, $p = 0.003$). Furthermore, in all habitats there was no statistical significant difference in the trap success in all age group ($F = 6.1752$, $df = 2$, $p = 0.2372$).

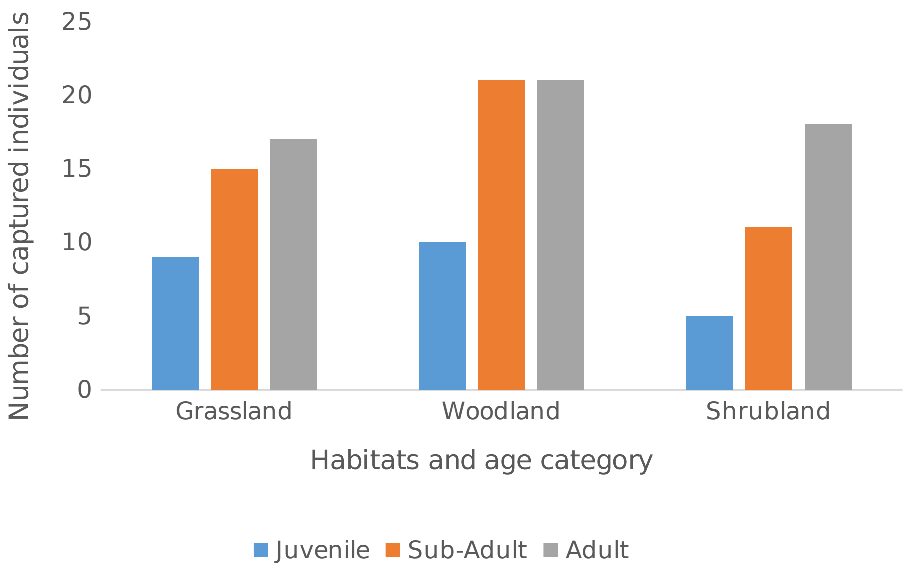

Figure 3: Proportion of *M. natalensis* Age Class in Three Habitats

4.5 Sex Ratio of Rodent across Habitats and Season

There were no significant difference between the numbers of females and males of rodents captured between the three habitats χ^2 =3.1392, df=2, p=0.2081). Also, there was no statistical significant difference between seasons (χ^2= 0.01782, df=1, p= 0.8938). However, females' number was relative high (0.80) in dry season compared to wet season (0.73) (Fig 4).

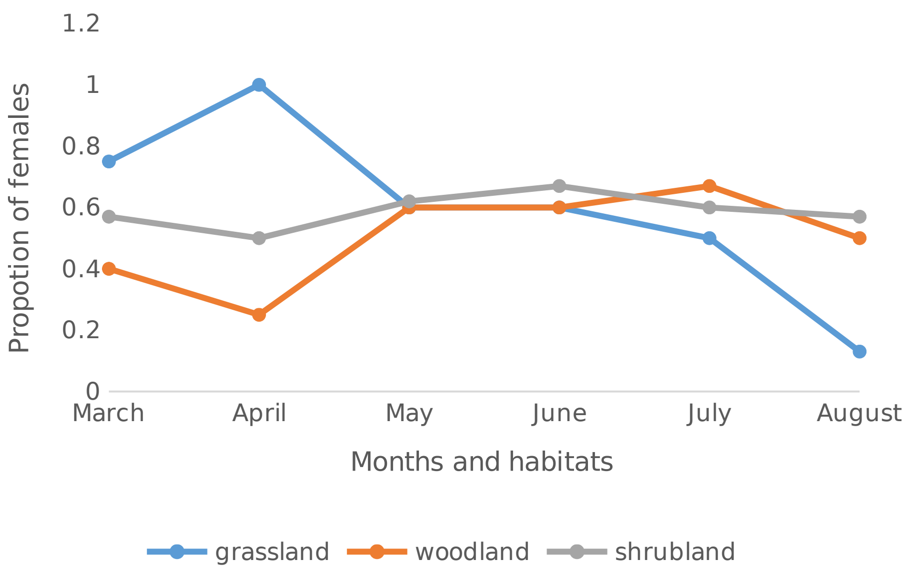

Figure 4: Rodent Sex Ratio in Different Months and Habitats

4.6 Breeding Pattern

The number of active breeding females (i.e. perforated (vagina), pregnant or lactating) was observed to be significantly different between seasons (χ^2 =1.625, df = 1, p=0.0237), with higher number of breeding individuals being observed in wet season (Figure 5). Also between habitats numbers of sexual active rodents was observed to be statistically significant (χ^2= 3.2192, df = 2, p = 0.0343), with higher number of active individuals being observed in shrubland followed by woodland then grassland.

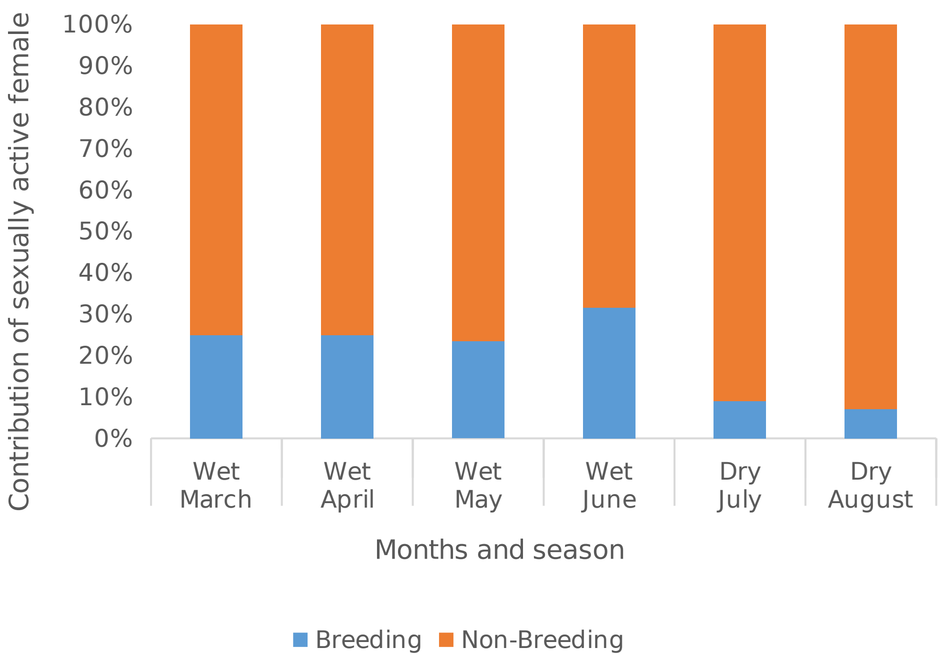

Figure 5: Rodent Breeding Pattern in Wet and Dry Season

4.7 Distribution of Species in Three Habitats

Species were aggregate (clumped) and randomly distributed in all three habitats (grassland, woodland and shrubland) (Fig 6). There was a significant difference in distribution for *M. natalensis* captured from Shrubland (χ^2=32.49, df =17, p=0.01) compared to other species (P>0.05). Also during wet and dry seasons rodent species were aggregate distributed, and there was no significant difference (p > 0.05) (Fig 7).

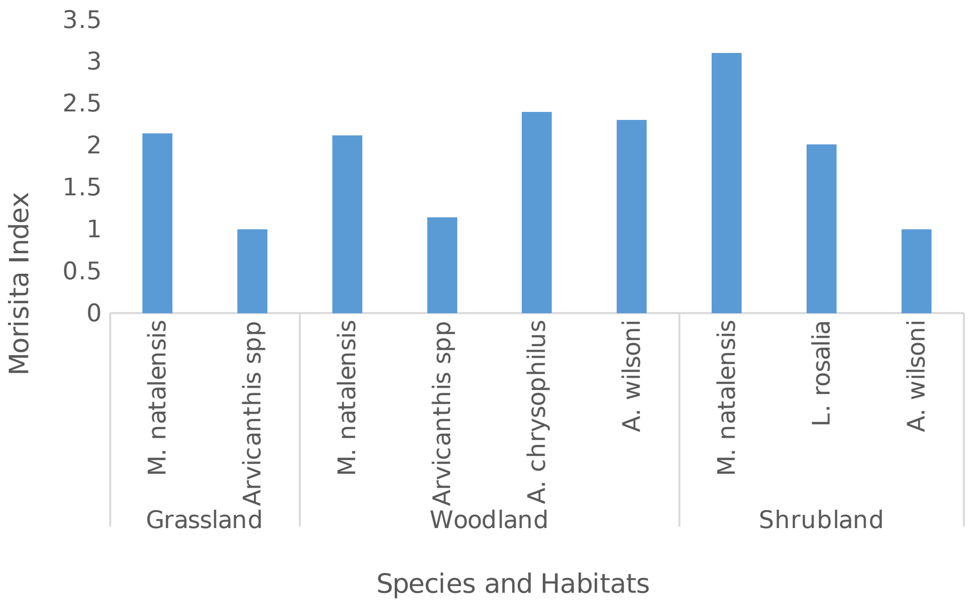

Figure 6: Distribution of Rodents in Different Habitats

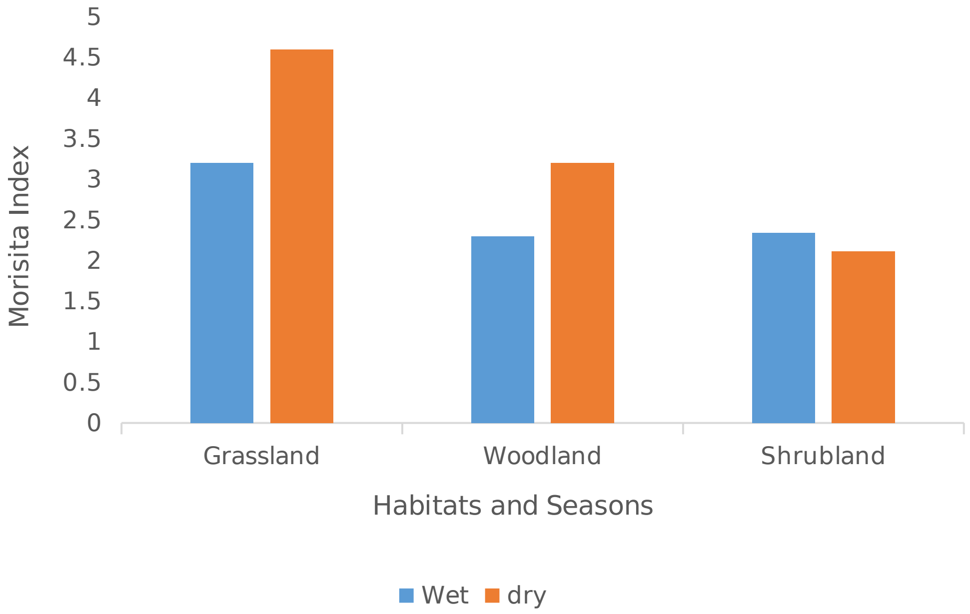

Figure 7: Seasonal Distribution of Rodents in Each Habitat

CHAPTER FIVE

5.0 DISCUSSION

In this study, six species of rodents were captured. This is because the study period was short and covered only a small part of the park; also only one method was used due to limited budget and time in which the researcher had to complete the study.

The abundance of rodents varied across all habitats in the present study. Results show that there was high number of individuals in shrubland followed by woodland. This is probably because these habitats are good in providing shelter due to their dense cover, also sufficient resources due to heterogeneous vegetation (Masswe *et al.,* 2006; Datiko and Bekele, 2014).

Grassland had least number of rodents compared to other two habitats. This may be due to the poor cover of the habitat exposing rodents to the predators (as the area was plain grassland with very few trees) and insufficient food (Demeke and Afework, 2014). The abundance was even lower in July and August because of fire which was set in the last two months of data collection. Similar case has been reported by Tadesse and Afework (2008), Demeke and Afework (2014) where disturbance like fire and poor vegetation cover reduced the abundance of rodents.

Abundance of *M. natalensis* was higher as it was found in all habitats and was dominant in grassland and woodland with the highest trap success of 5% in all habitats. This could be due to its high reproductive potential, large litter size, ability to adapt in different environments, generalist in feeding habits and coexisting with different kind of rodent species (Hubbard, 1972; Demeke *et al*., 2007; Tadesse *et al*., 2008; Mulungu *et al*., 2013).

Abundance of *L. rosalia* with the trap success of 2.2% was less compared *to M. natalensis*, as it was only found in shrubland and it was the dominant species. This is because of it is habitat specialization where some species are habitat specialists while others are generalists (Magige and Senzota, 2006; Rubio *et al.*, 2014). Although one species of rodents can be found in different habitats other species can be found only in their preferred habitats (Bateman *et al.,* 2010; Rubio *et al.,* 2014).

The least abundant species were *Arvicanthis spp, A.chrysophilus, A.wilsoni* and *Mus spp* with trap success of less than 1%. Although these species are mostly found in these three habitats (grassland, woodland and shrubland), their low rate of being captured during this study was possibly that the specific selected habitats were not suitable for them in term of breeding and survival (Schlitter and Monadjem, 2004; Kingdon *et al*., 2013). Also, it could be due to their difference in adaptation and food preferences for the specific selected habitats (Yihune, and Bekele, 2012; Assefa and Srinivasulu, 2019).

There was variation in species diversity in shrubland and woodland compared to grassland. Shrubland and woodland was high in species diversity, and no significant difference was shown between these two habitats. This is consistent with Kotler (1984) who observed that these areas due to complex vegetation structure and micro habitats provide enough food, cover and predation is very low hence increase species diversity (see also Makundi *et al.,* 2005; Avenant and cavallini, 2007). Also, better cover and different vegetation types which increase availability of sites for breeding, provide shelter for species hence low predation risk and it provide different types of foods for species (Conde and Rocha, 2006; Jacob, 2008).

Low species diversity in grassland could probably be due to low unsuitable habitat within the areas, which attracts fewer species (Granjon, 2007) also, it could be related to habitat specificity, as habitat complexity may provide more niches that could be exploited by several species of rodents (Workneh *et al*, 2005).

In this study, sex ratio shows no significant difference between males and females, although more females were captured than males. This is might be due to that females have more frequencies of movement than males due to their mating behavior. Similar observation has been reported by Tadesse and Afework (2008), Kennis *et al*., (2008) Mulungu *et al* (2013), and Borremans *et al*., (2014).

More captures were observed in adults and sub-adults than juvenile. This may be due to their large home range, active movement, and higher social ranking as identified by Assefa and Srinivasulu (2019). This observation suggests that high capture of adults is due to their wide movement over the course of their lives, except for the time when their protecting their juvenile, is when they do not move in a wide range (Mora *et al*., 2010).

High number of sub adults was probably due to increase in vegetation at the end of wet season, (as they were most captured in dry season) which help them to hide from their predators during their movements (Macfadyen, 2012). Also, it may be due to their ability to detect predators when away from their barrows as they are mature enough (Leahy *et al*., 2016). Moreover, as their stage of maturity they must be roaming around to find their own food and mates, unlike juveniles (Mora *et al*., 2010).

Low number of juveniles during this study period may due to their limited movements, as they mostly stay inside burrows as they depend on their adults for food and protection.

Also, they might be afraid of heat outside their burrow as documented by Monadjem and Perrin (2003) that juvenile animals may quickly decrease due to harsh environment. They apparently range over smaller areas than do the adults and occasionally travel with adults far from their nesting searching for food (Monadjem and Perrin, 2003; Mulungu *et al*., 2013).

Breeding was higher in wet than dry season. Similar results have been reported by Makundi *et al.,* (2006) and Getachew and Afework (2015). More juveniles and pregnant females were capture during the wet season than during the dry season. This confirms that the reproductive periods of most rodents occurred during the wet season as rain influences germination and growth of vegetation that serve as sources of food and shelter (Manyingerew *et al*., 2006; Dawit and Afework 2008). Juvenile and pregnant individuals were observed in March to June. This might be due to rain, temperature and potential food source at the end of the wet season. As most of juvenile being observed in wet season, this is because most of the females were pregnant when food resources were plenty (Tilahun *et al*., 2012).

This study shows that rodents were not uniformly distributed in all habitats. They were aggregate and randomly distributed. It has been reported by Datito and Bakele (2014) that distribution of small mammals is influenced by the availability of food, vegetation cover which help rodents to hide form their predators and protection against heat during the day. The random and aggregate distribution can probably be due to that in many areas food cannot be available all over the area or habitat (Dickman, 1999).

This type of distribution may be due to less competition of species in term of food and habitats, as the habitats had enough food and microhabitats with shelter that promoted nesting and safety (Brown *et al*., 2001). The presence of random distribution for some of the species may be attributed to their large home range (see e.g. Leirs *et al*., 1996; Monadjem *et al*., 2011).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In this study, six rodent species were identified. Shrubland had the highest number of individuals and species diversity, followed by woodland and then grassland. More adults were captured than juveniles, also more females were captured than males, breeding was high in wet than dry season and lastly species were aggregate and random distributed. It important to notice that there different species of rodents in Tarangire that were not captured during this study, this can be due to methodology used, few sites and duration of the study. This study does establish community composition, distribution and breeding pattern of rodents in the park, which provide light which can be used as a reference to investigate ecology of small mammals.

6.2 Recommendations

More studies on small mammals need to be conducted in the park to fully document all if not most of small mammals found in the park. This will help the management to have records of small mammals found in the park and their preferred habitats for conservation purpose.. The decrease of small mammals in term of abundance and diversity can affect predator community as they are source of food for different animals and indicators of habitat condition Also, study on age category of other rodent species is needed as the present study has focused only on *M.natalensis*.

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