DIVERSITY, DISTRIBUTION AND ABUNDANCE OF AVIFAUNA IN RESPECT TO HABITAT TYPES: A CASE STUDY OF KILAKALA AND BIGWA, MOROGORO, TANZANIA

GLORIA BIDEBERI

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

2013

ABSTRACT

The purpose of this dissertation was to find out the diversity, distribution and abundance of avifauna in respect to habitat types within Kilakala and Bigwa wards in Morogoro. The study was conducted between November and December 2011, by dividing the area into five habitat types which are settlement, farmland, shrubland, woodland and forest. Bird's abundance and diversity were compared between habitat types also related to habitat features. Point count method was used to collect data on bird diversity, abundance and distribution. Nested plots were used to collect data on habitat features. The Kruskal Wallis test was applied to test the difference in bird abundance between habitat types whereas Shannon-Wiener diversity index (H') was used to determine species diversity. On other hand, Sørensen's similarity index was used to find out similarities between habitats while the Spearman correlation coefficient was used to determine the relationship between bird abundance and habitat features within habitat types. A total of 3747 birds from 40 families and 159 species including six endemic species and two threatened species were recorded. The study found no significance differences in bird's abundance neither between habitat types nor between sampling periods. During November, diversity indices ranged from 3.224 to 3.865 with highest being shrubland and lowest being farmland while in December diversity ranged from 2.84 to 3.419 with highest being forest and lowest being settlement. Sørensen's similarity index ranged from 0.475 to 0.071, with the habitats in proximity showing higher similarity than the distant habitats. Spearman correlation analysis suggested that bird abundance is associated with habitat features. The findings from this study provide evidence that settlement areas can serve as a refuge for birds. Therefore, conservation efforts should as well be directed towards making communities view human occupied areas as a habitat for birds, and not as a lost habitat.

DECLARATION

I, Gloria N. Bideberi 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.

Gloria N. Bideberi
(Msc.Candidate)

Date

The above declaration is confirmed

Dr. Hassan Shombe.
(Supervisor)

Date

COPYRIGHT

ACKNOWLEDGEMENTS

It is a great pleasure to thank everyone who helped me write my dissertation successfully. Firstly I humbly thank Almighty God for granting me life, strength and the entire blessings. I would like to express my sincere gratitude to my supervisor Dr Shombe N. Hassan for his intellectual stimulation, professional guidance, encouragement, supervision and remarkable interest which made this study successful.

Special thanks go to my sponsor, the Belgium Technical Cooperation (BTC) without them I am sure it would have not been possible. I greatly thank the Wildlife Division for granting me study leave in the process of staff development in this domain, especially Mr. Erasmus Tarimo, the Director of Wildlife Division. My gratitude goes to the Chief Conservator of Uluguru Nature Reserve Mr. Sostenance Rwamugira for allowing me to conduct studies in part of the reserve as my study site. Without forgetting the administration of Morogoro Municipal for allowing me to do the research in the area. I further extend my gratitude to Mr. Nasibu Mkama, my research assistant. Mr. M. Nzunda and S. Kiswaga were very helpful to me. Moreover, my gratitude goes to Mr. Wisthoni Mziwanda (Manyota), his local knowledge in birds will never be forgotten. Besides, I thank you my parents for their encouragement and support throughout my studies, may God bless them abundantly.

DEDICATION

This work is dedicated to:

My parents Mr. N.H. Bideberi and Ma Severina Wamara, your support and emphasis on the importance of education to our family has made me successful today, I will always be grateful to you.

My young sisters and brothers Gladness, Paschal, Cuthbert and Catherine, I love you all.

TABLE OF CONTENTS

ABSTRACT ..... **ii**

DECLARATION ..... **iii**

COPYRIGHT ..... **iv**

ACKNOWLEDGEMENTS ..... **v**

DEDICATION ..... **vi**

TABLE OF CONTENTS ..... **vii**

LIST OF TABLES ..... **x**

LIST OF FIGURES ..... **xi**

LIST OF APPENDICES ..... **xii**

LIST OF ABBREVIATIONS AND SYMBOLS ..... **xiii**

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

1.3.3 Hypotheses 4

CHAPTER TWO **5**

2.0 LITERATURE REVIEW **5**

2.1 Bird Species Diversity and Distribution 5

2.2. Factors Affecting Bird Species Diversity, Abundance and Distribution 5

2.2.1 Habitat type 5

2.2.2 Habitat features 6

2.1.3 Anthropogenic activities 6

2.2.4 Altitude.....7

2.2.5 Climate 8

CHAPTER THREE 9

3.0 MATERIAL AND METHODS.....9

3.1 Description of the study area.....9

3.2 Research Methods 11

3.2.1 Study design 11

3.3 Data Collection.....12

3.3.1 Bird abundance, diversity and distribution 12

3.3.2 Correlation of habitat features with bird species abundance.....12

3.4 Data Analysis 12

3.4.1 Bird abundance, diversity and distribution 13

3.4.2 Correlation of habitat features with bird abundance 14

3.4.3 Bird checklist.....14

CHAPTER FOUR.....15

4.1 RESULTS.....15

4.1.1 Bird abundance, diversity and distribution 15

4.1.1.1 Abundance.....15

4.1.1.2 Diversity.....18

4.1.1.3 Distribution.....22

4.1.2 Correlation of habitat features with bird abundance 22

4.1.3 Bird checklist.....24

CHAPTER FIVE.....25

5.0 DISCUSSION 25

5.1 Bird Abundance, Diversity and Distribution.....25

5.1.1 Abundance.....25

5.1.2 Diversity.....26

5.1.3 Distribution.....28

5.2 Correlation of Habitat Features with Bird Species Abundance.....29

CHAPTER SIX.....32

6.0 CONCLUSIONS AND RECOMMENDATIONS.....32

6.1 Conclusions.....32

6.2 Recommendation.....33

REFERENCES.....34

APPENDICES.....44

LIST OF TABLES

Table 1: Abundance and density of birds within five habitat types in November 2011 15

Table 2: Abundance and density of birds within five habitat types in December 2011.....17

Table 3: Bonferroni Multiple comparison for mean abundance of birds between habitat types in 2011 18

Table 4: Structural properties of bird species for five habitats studied in November 2011. 19

Table 5: Structural properties of bird species for five habitats studied in December 2011 19

Table 6: Sørensen similarity Index of bird species for the different habitats in November 2011 20

Table 7: Sørensen similarity index of bird species for the different habitats in December 2011 21

Table 8: Sørensen similarity Index of birds for the different habitat when the two sampling periods were pooled together.....21

Table 9: Spearman correlation coefficient (r) between bird abundance in different habitat types and habitat feature in November 2011.....23

Table 10: Spearman correlation coefficient (r) between bird abundance in different habitats and habitat feature in December 2011. 24

LIST OF FIGURES

Figure 1: Map of Morogoro Municipality showing the study area 10

Figure 2: Mean bird abundance for different habitats in November 2011.....16

Figure 3: Mean bird abundance for different habitats in December 2011 17

Figure 4: Distribution of endemic bird species among the five habitats.....22

LIST OF APPENDICES

Appendix 1: Bird species recorded from Kilakala and Bigwa during survey.....44

Appendix 2: Birds Data collection form 52

Appendix 3: Vegetation cover data collection form 53

LIST OF ABBREVIATIONS AND SYMBOLS

a.s.l	-	Above Sea Level
D	-	Dominance
BTC-		Belgium Technical Cooperation
DSM	-	Dar es alaam
MD	-	Mean Difference
MNRT	-	Ministry of Natural Resources and Tourism
PAST	-	Palanteological Statistics
S	-	Sørensen Similarity Index
SE	-	Standard Error
SPSS	-	Computer based Statistical Package for Social Science
TAWIRI-		Tanzania Wildlife Research Institute
TTC	-	Teachers Training College
TFCG	-	Tanzania Forest Conservation Group
WWF	-	World Wildlife Fund

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Tropical mountains are acknowledged for harbouring high diversity of avifauna with many coexisting species within habitat types (Jankowski *et al.,* 2009). Forest is the most significant habitat for birds by supporting around 75% of all bird species while only 45% of all bird species have adapted to humans modified habitats (BirdLife international, 2008). Human activities such as farming, settlement, charcoal making, pole cutting and firewood collection have contributed in removal of forests (degradation) which has extensively damaged the natural habitat of birds, affecting their variety and variability (Storch *et al.,* 2003). Uluguru mountains as part of the Eastern Arc Mountains is known as an important Bird Area because of having high diversity of avifauna in Africa including endemic species such as Uluguru bush-shrike (*Malaconotus alius*) and threatened species such as love ridge sunbird (*Nectarinia loveridgei*) (Burgess *et al.,* 2002). The mountains are facing land use changes at the expense of their forest resources.

Birds are habitat specific and some can occupy more than one habitat type, however because of land uses changes, most of the birds have been displaced from their original habitats (Burgess *et al.,* 2002). The Studies on bird diversity by Burgess *et al.* (2002); Doggart *et al.* (2005); Frontier-Tanzania **(**2005); Yanda and Munishi (2007) in the Uluguru area were confined into the forest emphasising the general negative effects of forest conversion to human dominated habitats. Nevertheless, human dominated and agricultural habitats vary a lot and therefore the effect on birds can be very different (Tworek, 2002). Responses of birds to habitat changes differ depending on their strategies,

some lifestyles benefit from habitat change, while for others it is a principal threat (Tworek, 2002).

Birds are very visible and integral part of the ecosystem occupies many trophic levels in a food chain ranging from consumers to predators. Their occurrences have been helpful as environmental health indicator, plant pollinators and seed dispersal as well as pest controller (Hadley *et al.*, 2012; Ramchandra, 2013). Furthermore they do add enjoyment to our lives because of their distinctive colours, showy display also distinctive songs and calls.

The Study on diversity, distribution and abundance of birds with respect to different habitat types is important since will provide an understanding on the avifauna diversity, distribution and abundance within natural and human occupied habitats.

1.2 Problem Statement and Justification

Deforestation for clearance of new farms and settlements are the major causes of habitat loss occurring throughout the Uluguru mountains (Frontier-Tanzania**,** 2005; Yanda and Munishi, 2007). An estimation of 500 km^2 of the natural closed forest cover had been reduced to 300 km^2 in 1955 and 230 km^2 by 2001 and the greatest loss occurred at 600m – 1600m a. s. l outside Uluguru Nature Reserves (Burgess *et al.*, 2002). Despite efforts by different actors to improve the management of the mountains, problems of natural resource degradation and biodiversity loss in the landscape persists. Different Studies found different birds diversity in Uluguru Mountains. While Doggart *et al.* (2005) found about 140 species from 40 families, Frontier-Tanzania in 2005 found 95 species from 34 families of birds respectively within the protected land. Furthermore, some bird species in Uluguru Mountains Forest Reserve such as Tanzanian Mountain Weaver (*Ploceus nicolli*)

and Banded Green Sunbird (*Anthreptes rubritorques*) have been listed as endangered and threatened respectively. Recent studies by Doggart *et al.* (2005) and Tøttrup *et al.* (2004) failed to locate them inside the reserve while the species were previously reported in the area. This suggests that there might be displacement of bird species due to land use changes, and also that some might have adapted to human modified habitats. However, most of such avifauna studies on the Uluguru Mountains were confined to natural habitats (forest patches). As a result, comprehensive information on bird abundance, diversity and distribution that covers the entire landscape from settlement areas, farmlands to the natural forests is inadequate. The fact that birds are indicators of environmental changes emphasizes the need to study their abundance, diversity and distribution every five years to monitor these changes (MNRT, 2009). Therefore, information on the avifauna of the Uluguru landscape will help to fill in the gaps and update the scanty information available, and this will help reaching sound decision on matters pertaining to conservation of biological diversity of the area as a constituent of the Eastern Arc Mountain ranges.

1.3 Objectives

1.3.1 General objective

To determine and compare the diversity, distribution and abundance of avifauna in different habitat types within Kilakala and Bigwa wards.

1.3.2 Specific objectives

1. To determine and compare the bird species diversity, distribution and abundance
2. To relate habitat features with bird abundance.
3. To prepare a checklist of birds of the study area

1.3.3 Hypotheses

The null hypothesis states that:-

Ho: There is no significant difference in bird abundance between different habitats.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Bird Species Diversity and Distribution

Bird species diversity and distributions along the landscape is not uniform (Bibby *et al.*, 1992). Their patterns are strongly related to environmental factors (climatic condition, topography and habitats) and human interventions which determine bird species diversity and abundance (Rodríguez-Estrella, 2007; Jankowiski, 2009).

2.2. Factors Affecting Bird Species Diversity, Abundance and Distribution

2.2.1 Habitat type

Birds select habitats that fit their requirements for successful reproduction and survival though some generalist species may utilize several habitats (Rodríguez-Estrella, 2007). Differences in requirement among bird species have caused specificity on habitat requirement (Buckley and Freckleton, 2010). For example Mountain plover (*Charadrius mountainus*) feeds primarily on insects (grasshoppers, crickets, beetles, flies, ants); uses ground for nesting and prefer short grass while Mongolian sand plover (*Charadrius atrifrons*) feeds on invertebrates (molluscs, worms, crustaceans especially crabs and insects), uses tree for nesting and prefer shore of the lakes. Therefore habitats, either terrestrial or aquatic restrict bird species distribution and diversity (MacLean, 1970). In most habitats, plant communities determine the physical structure of the environment, and therefore, have a considerable influence on the distributions, abundance and diversity of birds and interactions of other animal species. For example, for bird species diversity in forests, Tewes *et al.* (2004) evidenced that the physical structure of a plant community, i.e. how the foliage is distributed vertically, may be more important than the actual composition of plant species. Ranganathan *et al.* (2007) found that farmland also has been

an important habitat for farmland bird showing that some bird species are habitat specific though some are generalist. Currently, due to land uses changes it is difficult to find forest habitat covering large areas. For example near towns, most of the land has been converted to settlement and farmlands. The study of bird species diversity, distribution and abundance become important not only for knowledge but also for conservation purposes as birds has been used as ecological indicators (Rittiboon and Karntanut, 2011).

2.2.2 Habitat features

Habitat features such as floristic complexity, cover and density of vegetation are the important factor in bird habitat selection. When these features are correlated they show positive correlation, since they provide food, nesting material and cover for predator (Marone, 1991; Whittingham and Evans, 2004). Heterogeneity of the habitat features can play a big role in the determination of specie abundance and occurrence within a habitat type (Pennington and Blair, 2011). Removal or reduction of vegetation reduces the total area of contiguous habitat available to birds and increases the isolation of the habitat which results in fragmentation. The fragmented habitat provide way to various predators that can successfully exploit by eating bird eggs, young and even adults which impact bird populations (Schlossberg and King, 2008).

2.1.3 Anthropogenic activities

Habitat destruction, fragmentation and loss have been observed due to increase of human population (Manhães and Ribeiro, 2005**).** Forests have been converted to urban settlement, agricultural field and pasture land, sometimes to open land. These human activities have an impact on bird species abundance, distribution and diversity due to isolation and fragmentation (Westphal *et al.,* 2006). Decline in abundance and loss of species due to

human interference have been observed in the tropics (Cordeiro, 2005). This concurs with the studies of Doggart *et al.* (2005) and Frontier- Tanzania (2005) on Uluguru Mountains. The results indicate that diversity and distribution of birds are affected by human activities in the Uluguru forest reserve. It has been found that areas with human activities are a threat to biodiversity contrary to Andren (1994) who found that the disturbance can become an important term of species richness or abundance if only the percentage of habitat decreasing below 20–30% is the continuous chain of thin habitat. This had been witnessed by Marzluff, (2005) when the study found that local scale bird diversity is enhanced by moderate settlement. The research done in Morogoro region by Frontier-Tanzania (2005) and Doggart *et al.* (2005) had given attention to the protected area (Uluguru Nature Reserve) without considering other habitat types outside the protected area system such as farmlands, settlement area and open shrubland which occur at the foot of the mountain. Basing on the idea that birds are widely distributed, these habitats may become important for avifauna survival.

2.2.4 Altitude

Altitude affects bird species distribution and diversity in the Montane settings (Hobson *et al.,* 2003). Elevation creates microclimate which in turn determines temperature, soil characteristics and vegetation type of the given environment (Waterhouse *et al.,* 2002). This is affecting the distribution and diversity of bird species directly or indirectly by limiting availability of the requirement and energy into the ecosystem. Ecological studies show that lower altitude has more bird species than higher altitude while some species are restricted to certain zones and others occurring throughout the altitudes (Jankowski *et al.,* 2009).

2.2.5 Climate

The impact of weather on the population biology of birds has been a major field of study by ornithologists over the past half century (George *et al.*, 1992). Weather not only affects the metabolic rate of birds (e.g. Cold weather requiring increased energy expenditure for body maintenance), but also exerts other indirect and direct effects on bird behaviour. For example, it can influence foraging conditions and the ability to carry out other essential behaviours, such as courtship. Weather also impacts on breeding success through, for example, chilling or starvation of young (Humphrey, 2004). Extreme weather events, such as prolonged frozen spells and droughts, can have catastrophic effects on bird populations, including long-term effects on whole cohorts (Humphrey, 2004).

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 Description of the study area

The study area is found at the foot of the Uluguru Mountain in the north- western part of Morogoro Municipality which lies between 5^{o} - 7^{o} 40' S and 37^{o}-38^{o} 33' E (Fig.1). The mean annual rainfall ranges between 750 mm and 1050 mm. The area experiences bimodal rainfall pattern characterized by two rainfall peaks in a year with a definite dry season separating the short and long rains. The short rain season is from October to December while the long rainy season starts from March and ends in May (Msanya *et al.*, 2003). Average temperatures for the coolest and warmest months are 24^{o}C and 26.5^{o}C respectively. The vegetation is composed of sub-montane shrubs and woodland but not characterized by any dominant species. The site represents part of the Eastern Arc Mountains, which is of global importance because of being among biodiversity hot spot areas.

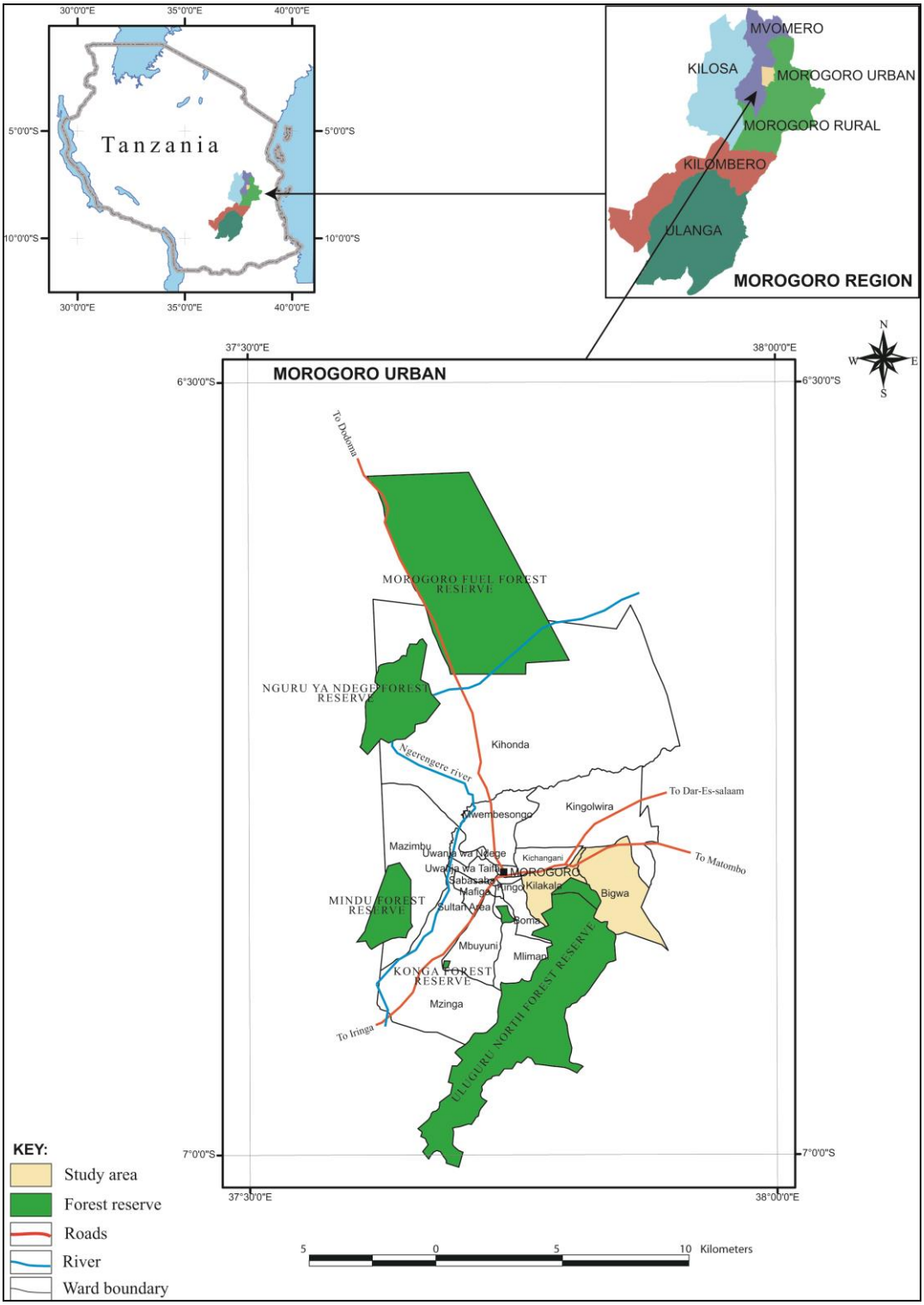

Figure 1: Map of Morogoro Municipality showing the study area

3.2 Research Methods

3.2.1 Study design

The study was conducted in Kilakala and Bigwa wards starting from Kigurunyembe Teachers Training College (TTC) (Kilakala ward) post (500m a.s.l) toward eastern side to Bigwa and southern direction up to inside Uluguru Nature Reserve (1 200m a.s.l). Data were collected during both dry season (November) and wet season (December) 2011. The area was stratified into settlements, farmland and natural habitat (Woodland, Forest, Shrubland). Areas covered with natural vegetation were stratified into different vegetation type and hence habitat types based on physiognomic features following Pratt and Gwynne (1977). Therefore, a forest area was defined as an area with a high density of trees more than 50% and close canopy characterized by over stores layers (shrub layer, herb layer and above layer); and a woodland as an area of low density trees with open canopy of 20%. Shrubland were defined as vegetation characterized by height of two meters but not exceeding eight meters. Then, the position of each habitat were Geo-referenced using a hand held GPS (Sport Trak, Magellan) in UTM coordinates.

Systematic sampling method was applied to select 10 permanent counting points of 30 m radius with a distance of 200m apart (Jankowski *et al.,* 2009), however, the first sampling point in each habitat was established randomly. The point count method is most suitable for such uneven terrain (steepness), and dense undergrowth in which detection of birds using other techniques may be difficult.

In each habitat type, nested plots of 1m x 1m, 5m x 5m and 10m x10 m were laid during each sampling occasion (dry and wet seasons) to obtain information on habitat features (i.e. vegetation cover, density and height) using the line intercept method (Fiala *et al.,* 2006). At the left side corner of the 10 m x 10 m plots (facing south), a 5m x 5m plot was

established, and at the left side corner of the 5m x 5m plot (facing south again), a 1m x 1m plot was established.

3.3 Data Collection

3.3.1 Bird abundance, diversity and distribution

In each habitat, birds were counted within 10 sampling points. The same points were used both in dry and wet seasons. Upon reaching a point, 2-5 minutes were provided for the birds to settle in case of any disturbances (Bryan *et al.,* 1984). Ten minutes were used to count and record all birds observed or heard within 30m radius (Terborgh *et al.* (1990) and Robinson *et al.*, (2000)). Unidentified calls were recorded using a digital voice recorder (model W2180) for further identification. The study was conducted in the morning from 0630 h–1030 h as this is the period when most birds are active. Date, bird species, number, habitat type and altitude were recorded. Birds were identified to the species level and their taxonomic groups were properly categorized based on field guides (Stevenson and Fanshawe, 2002). This study was limited to diurnal birds only due to lack of special equipment to detect nocturnal birds.

3.3.2 Correlation of habitat features with bird species abundance.

Plant species, cover and density were recorded from the nested plots. While grass and forbs were recorded from 1m x 1m plots, shrubs were recorded from 5m x 5m plots and trees from 10 m x10m plots. The line-intercept method was used to measure density and cover of grass and forb species in the 1m x 1m plots.

3.4 Data Analysis

One sample Kolmnogorous- Smirnov test was applied to test if data were normally distributed. Since they failed to comply therefore non-parametric tests were employed.

A 0.05 level of significance were used to determine level of significance.

3.4.1 Bird abundance, diversity and distribution

Difference in bird abundance between habitat types was tested using Kruskal Wallis test whereby habitats were treated as an independent variable and abundance as a dependent variable. Species diversity was determined using Shannon-Weiner diversity Index in the Palaeontological Statistics (PAST) program. Shannon-Weiner diversity Index takes into account the number of species richness as well as evenness.

$$H' = -\sum_{i=1}^{S}(p_i \ln p_i) \quad \text{.....(1)}$$

Where;

p_i The relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community $\frac{n_i}{N}$.

The value of the index ranges from 1.5 (low species richness and evenness) to 5.0 (high species evenness and richness).

The index of dominance was also measured in order to find the probability of taking randomly two individuals belonging to different species. Dominance measures the extent of common species in the habitat and it ranges from 0 to 1. Moreover, Sørensen similarity index (S) was used to measure species similarity of different habitat types. It is designed to equal to **1** in case of complete similarity between two habitats and **0** if species of two habitat types are dissimilar (Krebs, 1999 in Azeria, 2007; Magurran, 1988).

Sørensen similarity index (S) was computed as:

$$S = 2C / (A + B) \quad \text{.....(2)}$$

Where: A and B are number of species in habitat A and B, C is the number of species common to both habitats A and B

3.4.2 Correlation of habitat features with bird abundance

Simple correlation test (Spearman Correlation Coefficient test) was used in Statistical Package for Social Science (SPSS) to correlate habitat features and bird abundance. The correlation coefficient is always between -1 and +1. The closer the correlation is to +/-1, the closer to a perfect relationship while zero means no correlation. Positive correlation means the increase of habitat variable trigger the increase of bird abundance within the habitat type whereas negative correlation means the increase of habitat variable cause decrease in bird abundance.

3.4.3 Bird checklist

A checklist of bird species was compiled in Microsoft office excel showing Families, species and habitat type in which the birds occur.

CHAPTER FOUR

4.1 RESULTS

4.1.1 Bird abundance, diversity and distribution

4.1.1.1 Abundance

Results show no significant difference in abundance between habitat types in November (Kruskal-Wallis test: $\alpha = 0.05$, $H = 6.81$, $df = 4$ and $p = 0.15$), in December ($H = 8.57$, $df = 4$ and $p = 0.08$) and when the two sampling periods were combined ($H = 1.31$, $df = 4$ and $p = 0.86$). However in November, mean bird abundance per specie count was higher in settlement and least in forest (Fig. 2). In contrast, density, as for the number of birds counted was highest in shrubland and also least in the forest (Table 1).

Table 1: Abundance and density of birds within five habitat types in November 2011

Habitat	Number of birds counted	Density (N of birds/m^2)	Std. Error
Settlement	437	0.015	1.556
Farmland	329	0.012	1.473
Shrubland	457	0.016	0.756
Woodland	317	0.011	0.528
Forest	252	0.008	0.385

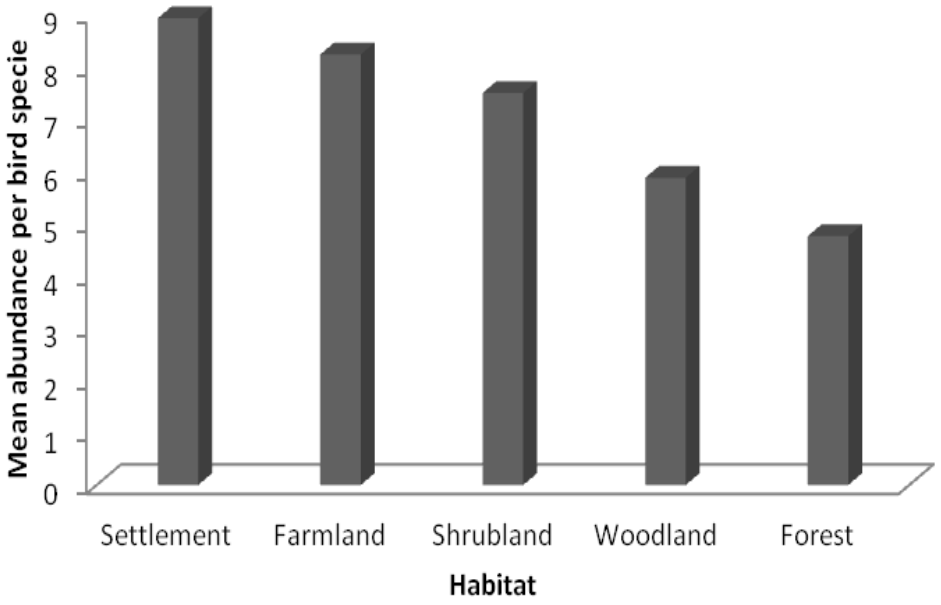

Figure 2: Mean bird abundance for different habitats in November 2011

Increase in number of birds was observed in December compared to November. The increase was detected in settlement by 54.5%, farmland by 7.3% and forest by 4.3%, but a decrease in shrubland by 21.8% and woodland by 8.8% (Tables 1 and 2). This trend was also true for mean abundance, being highest in the habitat with rampant human activities than the least utilized (Fig. 3). The increase in bird abundance resulted to increase in number of individuals per m^2 with the highest and the lowest density occurring in the settlement and forest, respectively (Table 2).

Table 2: Abundance and density of birds within five habitat types in December 2011

Habitat	Number of birds counted (n)	Density (n birds/m^2)	Std. Error
Settlement	675	0.024	5.138
Farmland	353	0.012	2.420
Shrubland	357	0.013	4.220
Woodland	289	0.010	1.209
Forest	263	0.009	1.357

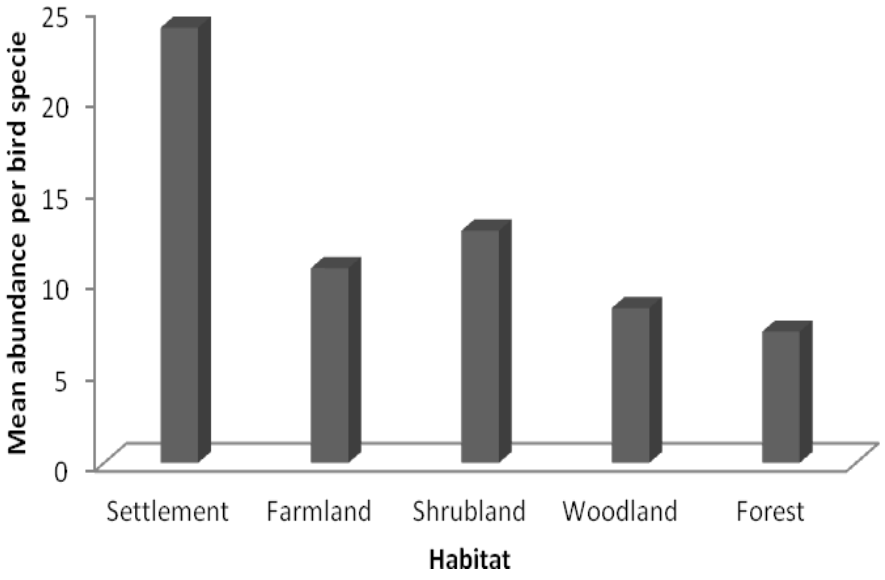

Figure 3: Mean bird abundance for different habitats in December 2011

Comparison of mean bird abundance between habitat types within sampling periods

When the mean abundance per species count was statistically compared within sampling periods, results were significant only for December, and when November and December were combined (Table 3). During December, the high difference was observed in settlement and forest (settlement greater than forest by 67.9%) followed by settlement and woodland (settlement greater than woodland by 61.9%), and least between settlement and farmland (settlement greater than farmland by 52.6%). When sampling periods were

combined, settlement was slightly higher than forest by 55.1%, and woodland by 52.6 %. The higher differences of mean seem to increase with the distance from one habitat to the next.

Table 3: Bonferroni Multiple comparison for mean abundance of birds between habitat types in 2011

Dependent Variable	Habitat (I)	Habitat (J)	Mean difference (I-J)	SE	P value
Mean abundance of birds in December 2011	Settlement	Farmland	12.56	4.22	0.034
		Woodland	14.78	4.20	0.006
		Forest	16.07	4.07	0.001
Mean abundance of birds in Dec and Nov 2011 Combined	Settlement	Woodland	11.18	3.56	0.019
		Forest	11.83	3.62	0.012

The mean abundance per specie count is significant at 0.05

4.1.1.2 Diversity

In November, results show higher species dominance in farmland and settlement, but low in the other three habitats (Table 4). Contrary, Shannon-Weinner diversity index was higher in habitats with less human disturbance such as shrubland, woodland and forest compared to the habitats with higher human disturbance that is, farmland and settlement (Table 4). The same trend was observed for evenness whereby there is high evenness in the forest, woodland and shrubland than on settlement and farmland (Table 4).

Table 4: **Structural properties of bird species for five habitats studied in November 2011.**

Diversity measure	Settlement	Farmland	Shrubland	Woodland	Forest
Dominance (D)	0.049	0.056	0.027	0.026	0.025
Shannon (H′)	3.423	3.224	3.865	3.816	3.778
Evenness (e^H/S)	0.601	0.628	0.795	0.841	0.858

In December, results showed slight changes in dominance from that of November, with the highest being in shrubland and the lowest being forest (Table 5). Surprisingly, there is comparatively decrease in bird species diversity in all habitat types compared to November (Table 4 and 5) with significant difference ($t= 2.132$, $df=4$ and $P= 0.01$ at $\alpha= 0.05$) between the sampling period. Despite of the decrease, still forest and woodland fetches relatively higher diversity (Table 5), with the decrease of 9.5% and 15.5% respectively. The least diversity was observed in shrubland with the decrease of 30.2 % compared to November (Table 5).

Evenness showed the same trend as that of November, where by high evenness were observed in the forest and woodland compared to the rest of habitats (Table 5). Like other diversity measures, which had shown a decrease in December, evenness also did decreased in forest, woodland, shrubland, farmland and settlement by 3.8%, 12.0%, 35.6%, 6.1% and 8.2% respectively.

Table 5: Structural properties of bird species for five habitats studied in December 2011

Diversity measure	Settlement	Farmland	Shrubland	Woodland	Forest
Dominance (D)	0.078	0.079	0.138	0.049	0.038
Shannon (H′)	2.84	2.97	2.697	3.225	3.419
Evenness (e^H/S)	0.552	0.59	0.512	0.74	0.825

Similarity of bird species between habitat types within sampling periods

In November, Sørensen similarity index (S) of bird species showed higher bird species similarity for habitat types located closer than distant ones. For example, settlement and farmland had higher similar species compared to settlement and forest which had least (Table 6). Likewise farmland and shrub-land compared to farmland and forest (Table 6). The trend showed that the closer the habitat types the higher the similarity and vice versa.

Table 6: Sørensen similarity Index of bird species for the different habitats in November 2011

Habitat	Distance between habitats (Km)	Similarity Index
Settlement and farmland	0	0.396
Settlement and Shrubland	2	0.321
Settlement and Woodland	4	0.324
Settlement and Forest	4	0.118
Farmland and shrubland	0	0.376
Farmland and woodland	4	0.276
Farmland and Forest	2	0.198
Shrubland and woodland	2	0.313
Shrubland and forest	0	0.214
Woodland and forest	2	0.275

In December, settlement and shrubland showed higher similarity followed by settlement and farmland while least being settlement and forest (Table 7). Nevertheless, slight increment of similarity was observed from that of November (Table 6 and 7). When the two sampling periods were pooled, the index was higher in the Settlement and farmland while least in shrubland and forest (Table 8). Overall, those habitats which were highly utilized by human being had higher species similarity compared to less utilized habitats.

Table 7: Sørensen similarity index of bird species for the different habitats in December 2011

Habitat	Distance between habitats (Km)	Similarity Index
Settlement and farmland	0	0.438
Settlement and Shrubland	2	0.475
Settlement and Woodland	4	0.338
Settlement and Forest	4	0.118
Farmland and shrubland	0	0.361
Farmland and woodland	4	0.328
Farmland and Forest	2	0.071
Shrubland and woodland	2	0.323
Shrubland and forest	0	0.123
Woodland and forest	2	0.281

Table 8: Sørensen similarity Index of birds for the different habitat when the two sampling periods were pooled together

Habitat	Distance between habitats (Km)	Similarity Index
Settlement and farmland	0	0.485
Settlement and Shrubland	2	0.373
Settlement and Woodland	4	0.318
Settlement and Forest	4	0.151
Farmland and shrubland	0	0.432
Farmland and woodland	4	0.240
Farmland and Forest	2	0.202
Shrubland and woodland	2	0.328
Shrubland and forest	0	0.110
Woodland and forest	2	0.280

4.1.1.3 Distribution

The study recorded 3747 birds from 40 families and 159 species, distributed within different habitats (settlement, farmland, shrubland, woodland and forest) (Appendix 1). Of the 159 species observed, six were endemic to Uluguru Mountain and two were endemic-threatened (Appendix 1and Fig. 4). The study found that some species had occurred in all habitat types while others were restricted in one, two, three or four habitat types (Appendix 1).

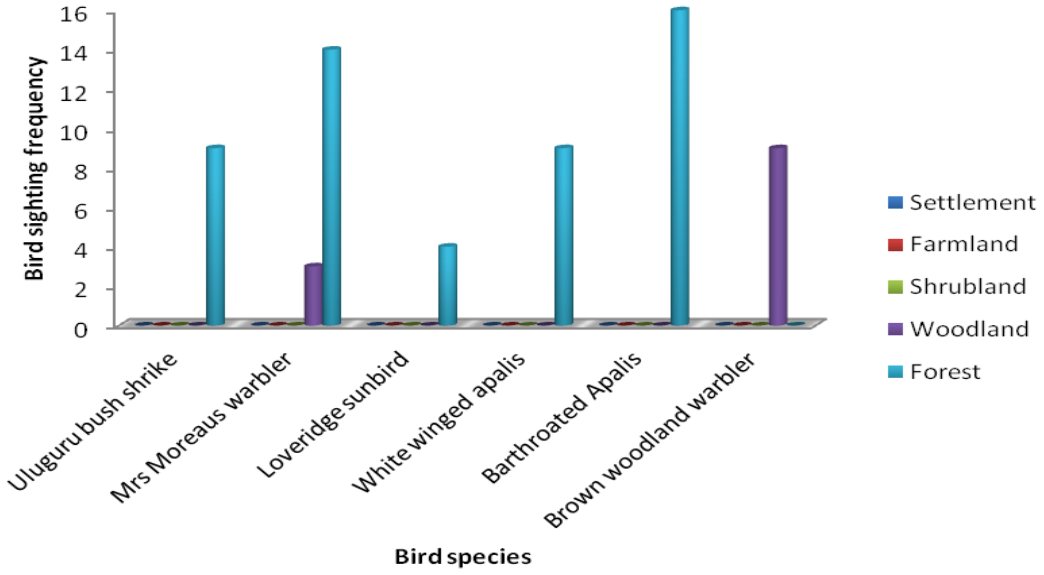

Figure 4: Distribution of endemic bird species among the five habitats

4.1.2 Correlation of habitat features with bird abundance

Bird abundance was found to correlate with habitat features (Table 9 and 10). Strong negative correlation was observed between bird abundance and shrub percentage cover in the settlement during November (Table 9). Likewise strong positive correlation was observed between bird abundance and tree percentage cover as well as tree density in the settlement during the same month. Interestingly, bird abundance in the settlement and shrubland had significant results with all habitat features (Table 9).

In December, none of the habitat features showed strong correlation with the bird abundance in all habitats (Table 10), despite that few habitat features showed significant correlation with bird abundance (Table 10). For example tree percentage cover and tree density had positive correlation with bird abundance in the settlement contrary to shrub density which had negative correlation in the same habitat (Table 10). Grass cover percentage had positive correlation with bird abundance in farmland while correlating negatively with bird abundance in the forest (Table 10). The study found that association tends to increase toward highly disturbed areas such as settlement, farmland and shrubland and decrease toward less disturbed areas like forest and woodland (Table 9 and 10).

Table 9: Spearman correlation coefficient (r) between bird abundance in different habitat types and habitat feature in November 2011

Habitat features	Settlement	Farmland	Shrubland	Woodland	Forest
Grass cover (%)	0.159*	0.393**	0.439**	-0.192*	-0.281**
Shrub cover (%)	-0.797**	-0.421**	-0.233**	0.054	0.365**
Tree cover (%)	0.768**	0.062	-0.212**	0.15	-0.119
Grass density (bundle)	-0.159*	-0.393**	-0.439**	0.192*	0.281**
Shrub density	-0.159*	-0.393**	-0.439**	0.192*	0.281**
Tree density	0.768**	0.062	-0.212**	0.15	-0.119

** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level.

Table 10: Spearman correlation coefficient (r) between bird abundance in different habitats and habitat feature in December 2011.

Habitat features	Settlement	Farmland	Shrubland	Woodland	Forest
Grass cover (%)	0.094	0.320**	0.089	-0.102	-0.181*
Shrub cover (%)	-0.535**	-0.340**	-0.163*	0.014	0.230**
Tree cover (%)	0.530**	0.047	0.094	0.097	-0.071
Grass density (bundle)	-0.094	-0.320**	-0.089	0.102	0.181*
Shrub density	-0.094	-0.320**	-0.089	0.102	0.181*
Tree density	0.530**	0.047	0.094	0.097	-0.071

** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level.

4.1.3 Bird checklist

A checklist of birds was compiled in Microsoft office excel showing Families and habitat types in which the birds occur (Appendix 1).

CHAPTER FIVE

5.0 DISCUSSION

5.1 Bird Abundance, Diversity and Distribution

5.1.1 Abundance

There was no substantial difference in bird abundance neither between habitat types nor between sampling periods though there was minimal variation in mean abundance per species count and density. The distance between the habitats observed during field visit could be the reason for lack of differences observed. However, the trend demonstrated higher bird abundance and densities in areas with highly induced human activities and decreased towards woodland and in forest areas. The result of this study concurs with the findings of Clergeau *et al.* (1998); Chace and Walsh (2006) and Sandstrom *et al.* (2005) concluded that human-disturbed areas provides heterogeneous habitats which attract human tolerant bird species. Higher abundance per species count and density in settlement could have had been contributed by few species that can coexist with humans such as Bronze Mannikinn (*Spermestes cucullatus*), Common Bulbul (*Pycnonotus barbatus*) and House Sparrow (*Passer domesticus*). Others included Grey- headed Sparrow (*Passer griseus*), Indian House Crow (*Corvus splendens*), and Southern Codorn - blue (*Uraeginthus angolensis*). Other studies elsewhere in human settlements (Pennington and Brail, 2011; Shochat *et al.,* 2010) also found similar result and concluded that higher abundance in the settlement were triggered by habitat heterogeneity such as buildings, trees and gardens created by man.

It was observed that during November, shrubland had higher density of birds. This could be associated with greater openness in the habitat which supports shrubs that provides food and cover for different bird species (Askin *et al.,* 2012; Shochast *et al.,* 2010). Forest

habitat had a few individuals recorded; the least number could be due to forest degradation through tree logging, cutting of building poles, collection of fuel-wood and charcoal making which affect forest birds (Frontier - Tanzania, 2005; Doggart *et al.,* 2005; Poulin *et al.,* 1992). Decreased cover for escape from enemies and shelter, food supply and breeding sites increases competition within and between species hence the decrease in number can be reflected.

Bird abundance and density was observed to change during December with an increase in three habitat types i.e. settlement, farmland and forest. This can be associated with the increase in rainfall during December by 67.5%, from 37mm in November to 191mm in December (Tanzania Metolological Agency- Morogoro, 2011). According to the study done by George *et al.* (1992) also Sagarin and Gaines,(2002) precipitation had an impact on bird habitats by generating food and cover availability which improve their ability to reproduce and survive hence increasing their abundance. Despite the increase, the decrease in abundance observed in woodland and shrubs could be triggered by the temporal and spatial movements of bird species following specific species requirement such as nesting sites and breeding site for their survive (Rodriguez- Estrella, 2007).

5.1.2 Diversity

In November, bird species diversity was found to increase towards less human-activity areas with higher vegetation cover. The lower bird species diversity observed in the settlement and farmland could be caused by continuing clearing of natural vegetation for human settlement as it was observed during field visits. The findings comply with many other studies (Clergeau *et al.,* 1998; Chace and Walsh, 2006; Sandstrom *et al.,* 2005) that higher vegetation cover support higher diversity of birds. The highest diversity observed in

shrubland, woodland and forest was more likely because of well sufficient vegetation cover than in the settlement and farmland which has been affected by land use changes (Fahring *et al.,* 2010). The highest species diversity indicates a complex community in which a high degree of species interaction is possible contrary to higher dominance observed in settlement and farmland, which implies that few species predominate the habitats. Though farmland showed less diversity, higher dominance was due to persistence of native and generalist species like a large number of cattle egret (*Bubulcus ibis*) (Chance and Walsh, 2006; Pennigton and Blair, 2011). On the other hand, the higher evenness in the forest is supported by continuation of vegetation which reduces the impact of predation to adult birds, young and eggs. The case is different to highly interfered habitat like settlement and farmland (Campbell and John, 2012).

A significant decrease in diversity was observed in all habitat types during December. This signifies that bird diversity is impacted by weather condition (precipitation and temperature) (Waterhouse *et al.,* 2002). According to Parmesan (2005), weather condition determines bird diversity by spatial temporal shift of the species from one habitat to the other seeking for favourable conditions. The highest diversity shown by forest is due to availability of food, water, breeding sites, breeding material and cover from predators (Hobson *et al.,* 2003; Waterhouse *et al.,* 2002). Interestingly, in December higher dominance in shrubland were contributed by little swift (*Apus affinis)* that were feeding on insects influenced by higher rainfall (Busch *et al.,* 2011; Soini, 2006).

In general, forest habitat had higher diversity when the sampling periods were pooled together. The result is in agreement with many studies which conclude that forest is the main habitat which harbours large bird species diversity (Campbell and John, 2012;

Askins *et al.,* 2012; Azeria *et al.,* 2007; Burgess *et al.,* 2002; Buckley and Bhatia, 1998). Therefore, the forest bird species may disappear if degradation will continue to modify the habitat.

5.1.3 Distribution

The studied habitat types recorded 159 bird species which calls attention for conservation. According to Storch *et al.* (2003) also Buckley and Freckleton (2010) the distribution patterns of bird species normally follow the spatial structure of the environment and habitat requirement of the bird species. This corresponds with results of this study whereby habitat specificity and generalization were observed. For example African Sedge Warbler (*Acrocephalus schoenobaenus*) and Red-chested Cuckoo (*Cuculus solitaries*) were recorded in all habitat type. On the contrary, Bronze Mannikin (*Spermestes cucullatus*), Common Bulbul (*Pycnonotus barbatus*), House Sparrow (*Passer domesticus*), Grey Headed Sparrow (*Passer griseus*), Indian House Crow (*Corvus splendens*), and Southern Codorn-blue (*Uraeginthus angolensis*) were recorded in settlement. Although human settlement areas have mixtures of built habitats and green patches, bird species have managed to exist and thrive in this complex habitat (Sandstrom *et al.,* 2005). This is explained by the availability of ecological requirements for the species offered by a mixture of an environment with settlement and garden patches (Sandstrom *et al.,* 2005). The study also recorded six endemic species in the forest which were previously recorded by Frontier- Tanzania (2005) in the biodiversity survey done in Uluguru Nature Reserve. The list includes Uluguru Bush-shrike (*Malaconotus alius*), Mrs Moreaus Warbler (*Sceptomycter winifredae*), Loveridge sunbird (*Cinnyris loveridgei*), White-winged Apalis (*Apalis chariessa*), Bar-throated Apalis(*Apalis thoracica*) and Brown Woodland Warbler (*Phylloscopus umbrovirens*). Among the mentioned Ulugulu bushshrike (*Malaconotus*

alius) is endanged while White inged apalis (*Apalis chariessa*) is vulnerable and love ridge sunbird (*Nectarinia loveridgei*) is threatened .Despite the species comprising about 3.8% of the all species observed, forest reserve remain as their only refuge for these endemic species. Most of the birds recorded in all habitat types are widely distributed in Tanzania (Mahinya, 2005). The higher species distribution similarities between habitats which are spatially closer were expected since these habitat shares some bird species especially the generalist species (Fricke, 2006). The similarity observed between forest and woodland was also observed by Doggart *et al.* (2007) when the comparison was done between forest and woodland on Nguru Mountain- Tanzania. The least similarity observed in distant habitats was caused by a considerable number of species that were not seen in other habitats due to considerable separation. This highlights that while species may be similar between habitats still, there is a difference in requirement hence it is important to conserve a mosaic of natural habitats.

5.2 Correlation of Habitat Features with Bird Species Abundance

Bird abundance found to be influenced by the habitat features of the studied area as it was also reported by Pearman (2002) and Naido (2004). During November, Bird abundance had strong positive correlation with tree cover and tree density in the settlement. Shochat *et al.* (2010) argued that trees contribute to the complexity of the habitat that enables bird's survival. The negative association shown by bird abundance toward tree cover and tree density in the shrubland was due to seasonal occurrence of insects that birds feed on, causing them to concentrate in a small area with sufficient shrub density as it was also observed by Askin *et al.* (2012). The study concluded that the openness of the habitat favours less availability of food, cover, nesting material and site compared to other habitats. Grass percentage cover showed a positive correlation with bird abundance in

settlement, farmland and shrubland, indicating that high amounts of grassland support relatively high numbers of some grassland bird species in the habitats. The finding concurs with Murray *et al.* (2008) who found that number of grassland birds tend to increase with grass cover. The negative association observed between bird abundance and tree percentage cover as well as tree density in the forest was expected because bird abundance tends to decrease with tree canopy closure in the well developed forest (McWethy *et al.*, 2009). However, the strong negative association between bird abundance and shrub percentage cover in the settlement was due to the decrease in shrub, which would provide refuge for human tolerant bird species. On the other hand, the positive correlation observed between bird abundance and shrub percentage cover in the forest, and between bird abundance and shrub density in the forest and woodland support the argument by Chapman and Reich (2007) that bird abundance increase with shrubs cover and density in the forest and woodland. This is associated with increased ground cover and understory layer in which both birds and their nests are concealed. This underscores the fact that any human activity that causes changes in habitat structure tends to impact on micro-ecological pattern thus affecting species abundance, diversity and distribution (Gaston, 2004).

During December, none of the habitat types showed strong association between bird abundance and habitat features probably because there were dramatic increases in bird abundance. Increased rainfall during December could have caused positive changes in vegetation cover, recruitment, productivity and food supply leading to a positive change in abundance. Similar observation was made by George *et al.* (1992). The negative correlation observed between bird abundance and percentage cover of shrubs and the density of shrubs in the settlement, farmland and shrubland might have had been caused

by the presence of a large number of insectivorous birds like Little Swift (*Apus affinis*). Little Swift (*Apus affinis*) usually are specialized and become more sensitive to prey abundance (Sekercioglu *et al.*, 2002).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

i. Bird species diversity was higher in the areas with less human activities i.e forest, woodland and shrubland than in the settlement and farmland. The higher diversity suggests higher ecological stability compared to human disturbed habitats where few species occur.

ii. The study also provides evidence that though human induced disturbance may cause low diversity, yet settlement and farmland are important part of the ecosystem that harbour large numbers of birds compared to forest, woodland and shrubland.

iii. Differences in resource availability between habitats such as breeding sites, nesting materials, cover, food and water restrict some species to certain habitat type while allowing others to be widely distributed.

iv. The studied forest remains the refuge for migratory species like Buff- spotted Fluff- tail (*Sarothrura elegans*) and endemic species such as Uluguru Bush-shrike (*Malaconotus alius*) and Loveridge′s Sunbird (*Cinnyris loveridgei*) that are conserved to maintain integrity of the Uluguru Mountains.

v. The study also concluded that any activities that change the habitat structure impact avifauna abundance, diversity and distribution.

6.2 Recommendations

i. In order to improve bird diversity in human occupied environment gardening and tree planting should be encouraged. This will enhance bird species diversity such that human settlement and farmland will no longer be viewed as a lost habitat for wildlife, but rather a habitat that with proper management, has the potential to support diverse bird communities.

ii. Since communities lack awareness that birds are important part of ecosystem as environmental health indicator, pollinators and pest controller, the department of Natural Resource, Land and Environment in the municipality has to provide conservation education to the communities so that the contribution of birds in the ecosystem can be realized. This is the mandate given by Wildlife policy of Tanzania.

iii. The presence of Environmental Committee in villages offers an opportunity to improve conservation of birds and their habitats. The committee should limit forest conversion and fragmentation by adopting bylaws that prevent land degradation.

iv. Cooperation among different stakeholders i.e. ecologists, land surveyors, municipal council, social scientists, environmentalists, communities and bird watcher groups is required to ensure birds are conserved. A conservation group such as WCST (Wildlife Conservation Society of Tanzania) should initiate the cooperation.

v. It was observed during field visit that the communities do not know the biological resource and value that made Uluguru area popular. This suggests that that research findings are not communicated back to the society. As result, societies have no knowledge on the importance of the area for this and coming generations.

REFERENCES

Andren, H. (1994). Effect of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: A review. *Oikos* 71: 355- 366.

Askins, R.A; Folsom-Okeefon,C. M and Hardly, M.C. (2012). Effect of vegetation, corridor width and Regional land use on Early Successional Birds on Powerline corridor. *Plos one* 7 (2): 1-10.

Azeria, E.T; Sanmartı´n, I; Stefan A; Carlson, A and Burgess, A. (2007). Biogeographic patterns of the East African coastal forest vertebrate fauna. *Biodiversity Conservation* 16 (4): 883-912.

Bibby, C. J; Burgess, N. D and Hills, D. A. (1992). *Birds census technique*. Academic press. London. San. Diego. New York. Tokyo. Toronto.86-96 pp

BirdLife International (2008). Birds occur in all major habitat types, with forest being particularly important. Presented as part of the BirdLife State of the world's birds website. [http://www.birdlife.org/datazone/sowb/casestudy/172] site visited on 01/09/2011.

Bryan , I. S; Joseph S. I, and Richard M. D. (1984). Relationship of breeding bird density and diversity to habitat variables in forested wetlands. *Wilson Bull* 96 (l): 48-59.

Buckley, H.L and. Freckleton R. P. (2010). Understanding the role of species dynamics inabundance–occupancy relationships. *Journal of Ecology* 98: 645–658.

Buckley, P and Bhatia, Z. (1998). The Uluguru slopes planning project: Promoting community involvement in biodiversity conservation. *Journal of the East African Natural History Society* 87: 339 - 348.

Burgess, N.D; Doggart. N and Lovett, J. (2002). The Uluguru Mountains of EasternTanzania: the effect of forest loss on biodiversity. *Oryx* 36: 140-152.

Busch, D. S; Robinson, W.D; Robinson, T.R and Wingfield, J.C. (2011). Influence of proximity to a geographical range limit on the physiology of a tropical bird. *Journal of Animal Ecology* 80:640–649.

Campbell, M and John, M. (2012). Habitat Fragmentation and Birds **[**faculty.ncwc.edu/mbrooks/pif/.../fragmentation%20fact%20sheet. Htm] site visited on 24/4/2012.

Chace, J.F., and Walsh, J.J. (2006). Urban effects on native avifauna: A review. *Landscape Urban Plan* 74:46–69.

Chapman, K. A and Reich, P.B. (2007). Land use and habitat gradients determine bird community diversity and abundance in suburban, rural and reserve landscapes of Minnesota, USA. *Biologycal conservation* 135: 527-541.

Clergeau, P; savard, G; Mennechez, G and Falardeau, G. (1998). Bird abundance and diversity along an Urban-Rural gradient: A comparative study between two cities on different continent. *The condor* 100 (3): 413-425.

Cordeiro, N.J. (2005). Does forest fragmentation impact mixed species foraging bird flocks in Tanzania forest. In TAWIRI. *Proceedings of the 5th Annual Scientific Conference;* December 1- 3, 2002, Arusha – Tanzania, 157-165 pp.

Doggart, N; Lovett, J; Mhoro, B; Kiure, J and Burgess, N. (2005). Biodiversity surveys in the Forest Reserves of the Uluguru Mountains. Technical paper for The Wildlife Conservation Society of Tanzania and Tanzanian Forest Conservation Group. DSM, Tanzania. 8 – 18 pp.

Doggart, N; Kiure, J. and Bracebridge, C. (2007). Birds of the South Nguru Mountains. In: Doggart, N. and D. Loserian (eds.).South Nguru Mountains: A Description of the biophysical landscape. TFCG Technical Paper No 11. DSM Tanzania pp 1–71.

Fahrig, L; Baudry, J; Brotons,L; Burel, F. G; Crist, T. O; Fuller, R. J; Sirami, C; Siriwardena, G.M and Martin, J.L. (2010). Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. *Ecology Letters* 14:101–112.

Fiala, A. C.S; Garman, S. L and Gray, A.N. (2006). Comparison of five canopy cover estimation techniques in the western Oregon Cascades. *Forest Ecology and Management* 232:188–197.

Fricke, K. A. (2006). Documenting relationships between small mammals, ground-nesting passerine birds, and grazing systems on private rangelands in the Nebraska sandhills. University Honor Thesis. University of Nebraska-Lincoln, 6-9 pp.

Frontier-Tanzania. (2005). Uluguru Component Biodiversity Survey 2005 (Volume III): Uluguru North Forest Reserve. Bracebridge, Fanning, Howell, Rubio, St. John (eds). Society for Environmental Exploration and the University of Dar es Salaam; CARE-Tanzania, Conservation and Management of the Eastern Arc Mountain Forests (CMEAMF): Uluguru Component, Forestry and Beekeeping Divison of the Ministry of Natural Resources and Tourism, Dar es salaam,Tanzania.1-78 pp.

Gaston, K.J. (2004). Macroecology and people. *Basic and applied ecology* 5:303-307.

George, T. L; Fowler, A. C; Knight, R. L. and McEwen, L. C. (1992). Impacts of a severe drought on grassland birds in western North Dakota. *Ecological Applications* 2:275–284.

Hadley, S.J.K; Hadley, A.S and Betts, M. (2012). Acoustic classification of multiple simultaneous bird species: A multi- Instance multi- label approach. *Journal of Acoustical Society of America* 131 (6): 4640- 4650.

Hobson, K. A; Wassenaar. L. I; Mil , B; Lovette, I; Dingle , C and Smith, T.B. (2003). Stable isotopes as indicators of altitudinal distributions and movements in an Ecuadorean hummingbird community. *Oecologia* 136:302–308.

Humphrey, Q.P.C. (2004). The impact of climatic change on birds. *Ibis* 146 (1): 48-56.

Jankowski, J. E; Ciecka A. L; Meyer, N. Y and Rabenold, K.N. (2009). Beta diversity along environmental gradient: implications of habitat specialization in tropical montane land scapes. *Journal of Animal ecology* 78:315-327.

MacLean, G.L. (1970). An analysis of the avifauna of the southern Kalahari Gemsbok National Park. *Zoological Africana* 5:249–273.

Magurran, A. E. (1988). *Ecological diversity and its measurement*. Princeton University. Press, Princeton, New Jersey.179 pp.

Mahinya , S.G. (2005). Assessment of ecological integrity of land use systems using birds as bio- indicators in the Malagarasi- Muyowosi Ramser site, western- Tanzania. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 35 pp.

Manhães, M.A and Ribeiro, A.L. (2005). Spatial Distribution and Diversity of Bird Community in an Urban Area of Southeast Brazil. *International journal* 48 (2): 285-294.

Marone, L. (1991). Habitat features affecting bird spatial distribution in the monte desert Argentina. *Ecological Austral* 1:77-86.

Marzluff, J.M. (2005). Island biogeography for an urbanizing world: How extinction and colonization may determine biological diversity in human-dominated landscapes. *Urban Ecosystem* 8:157–177.

McWethy, D.B; Hansen, A. J and Verschuyl, J.P. (2009). Bird response to disturbance varies with forest productivity in the northwestern United States. *Landscape Ecology* 9: 9437-9446.

Ministry of Natural Resource and Tourism. (2009). Management plan for Uluguru nature reserve, Prepared by Conservator, Uluguru Nature Reserve.78 pp.

Msanya ,E.M; Kaaya, A.K; Araki,S;Otsuka, H and Nyadzi,G. (2003). Pedological characteristics, general fertility and classification of some benchmark soils of Morogoro district, Tanzania. *African Journal of Science and Technology (AJST) Science and Engineering Series* 4 (2): 101-112.

Murray, L. D; Ribic, C. A. and Thogmartin, W. E. (2008). Relationship of obligate grassland birds to landscape structure in Wisconsin. *Journal of Wildlife Management* 72: 463–467.

Naidoo, R. (2004). Species richness and community composition of songbirds in a tropical forest - agricultural landscape. *Animal Conservation* 7: 93-105.

Parmesan, C. (2005). Biotic response: Range and abundance changes. In: *Climate Change and Biodiversity*: (Edited by Lovejoy, T.E. and Hannah, L.). Yale University Press, New Haven & London. pp 41.

Pearman, P. B. (2002). The scale of community structure: habitat variation and avian guilds in tropical forest understory. *Ecological Monographs* 72: 19–39.

Pennington, D.N and Blair, R.B. (2011). Habitat selection of breeding riparian birds in an urban environment: Untangling the relative importance of biophysical element and spatial scale. *Diversity and Distribution* 17:506 – 518.

Poulin, B; Lefebvre, G and McNeil, R. (1992). Tropical Avian Phenology in relation to Abundance and Exploitation of food Resources. *Ecology* 6:2295-2309.

Pratt, D.J and Gwynne, M.D. (1977). Rangeland management and ecology in East Africa. Hodder and Stoughton, London Sydney Auckland Toronto. 44-50 pp.

Ramchandra, A.M. (2013). Diversity and richness of bird species in newly formed habitats of Chandoli National Park in Western Ghats, Maharashtra State, India. *Biodiversity Journal* 4 (1): 235-242.

Ranganathan, J; Chang, K. A and Daily, G.C. (2007). Satellite detection of bird communities in tropical countryside. *Ecological Applications* 17 (5): 499–1510.

Rittiboon, K and Karntanut, W. (2011). Distribution of resident birds in a protected tropical habitat in south Thailand. *Journal of Issaas* 17(2):95-103.

Robinson, W.D; Brawn, J.D and Robinson, S.K. (2000). Forest bird community structure in central Panamá: influence of spatial scale and biogeography. *Ecological Monographs* 70: 209–235.

Rodríguez-Estrella, R. (2007). Land use changes affect distributional patterns of desert birds in the Baja California peninsula, Mexico. *Diversity and Distribution* 13: 877–889.

Sagarin, R.D and Gaines, S.D. (2002). The 'abundant center' distribution: to what extent is it a biogeographical rule?. *Ecology* 5:137–147.

Sandstrom, U.G; Angelstam, P. and Mikusinski, G. (2005). Ecological diversity of birds in relation to the structure of urban green space. *Landscape Urban Plan* 77:39–53.

Schlossberg, S and King, D. I . (2008). Are shrubland birds edge specialists?. *Ecological Applications*18 (6)1325 – 1330.

Sekercioglu, C. H; Ehrlich, P .R; Daily, G. C; Aygen, D; Goehring, D and Sandi, R. F. (2002). Disappearance of insectivorous birds from tropical forest fragments. *Ecology* 99: 263–267.

Shochat, E; Lerman, S and Fernández-Juricic, E. (2010). Birds in Urban Ecosystems: Population Dynamics, Community Structure, Biodiversity, and Conservation. *Urban Ecosystem Ecology* 55:75-86.

Soini E. (2006). Bird diversity and land use on the slopes of Mt. Kilimanjaro and the adjacent plains, Tanzania. ICRAF Working Paper number 11. Nairobi, Kenya: World Agroforestry Centre.8-23 pp.

Stevenson, T and Fanshawe, J. (2002). *Field Guide to the Birds of East Africa: Kenya, Tanzania, Uganda, Rwanda and Burundi*. T and A D Poyser Ltd, London. 1- 286 pp.

Storch, D; Konvicka, M; Benes, J; Martinkova, J. and Gaston, J.K. (2003). Distribution patterns in butterflies and birds of the Czech Republic: separating effects of habitat and geographical position. *Journal of Biogeography* 30: 1195–1205.

Tanzania Metolological Agency. (2011). Monthly Weather Report. Morogoro, Tanzania. 1 pp.

Terborgh, J; Robinson, S.K; Parker III, T.A; Munn, C.A. and Pierpont, N. (1990). Structure and organization of an Amazonian forest bird community. *Ecological Monographs* 60: 213–238.

Tewes, J; Brose, U; Grimm, V; Tielborger, K; Wichmann, M.C; Schwagen, M and Jeltsch,F.(2004). Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. *Journal of Biogeograph* 31**:**79-92

Tøttrup, A.P; Larsen, J. L and Burgess, N. (2004). A first estimate of the population size of Loveridge's Sunbird (Nectarinia loveridgei), endemic to the Uluguru Mountains, Tanzania. *Birdlife Conservation International* 14: 25-32.

Tworek, S. (2002). Different bird strategies and their responses to habitat changes in an agricultural landscape. *Ecological Research* 17: 339-359.

Waterhouse, F. L; Mather, M. H and Seip .D. (2002). Distribution and abundance of birds relative to elevate on and biogeoclimatic zones in coastal old-growth forests in southern British Columbia B.C. *Journal of Ecosystems and Management* 2: 1488-4674.

Westphal, C; I. Steffan-Dewenter and T. Tscharntke. (2006). Bumblebees experience landscapes at different spatial scales: possible implications for coexistence. *Oecologia* 149:289 –300.

Whittingham, M.J and Evans, K.L. (2004). The effects of habitat structure on predation risk of birds in agricultural landscapes. *Ibis* 146(2):210–220.

Yanda, P.Z and Munishi, K.T. (2007). Hydrologic and land use/cover change analysis for the Ruvu river (Uluguru) and Sigi river (Eastern Usambara watersheds.) Report for WWF/CARE Dar es Salaam, Tanzania. 9-38 pp.

APPENDICES

Appendix 1: Bird species recorded from Kilakala and Bigwa during survey

Family	Common Name	Scientific Name	Settlement	Farmland	Shrubland	Woodland	Forest
Ardeidae	Cattle Egret	*Bubulcus ibis*	+	+	+	0	0
	Grey headed heron	*Ardea cinerea*	0	+	0	0	0
	Little Egret	*Egretta garzetta*	+	+	0	0	0
Scopidae	Hamerkope	*Scopus umbretta*	+	+	0	0	0
Accipitridae	Black Kite	*Milvus migrans*	0	+	+	0	0
	African Harrier-Hawak	*Polyboroides typus*	0	0	0	0	+
	Martial Eagle	*Polemaetus bellicosus*	+	0	0	0	0
	African crowed Eagle	*Stephanoaetus coronatus*	0	0	0	0	+
Phasianidae	Ring-necked Francolin	*Francolinus streptophorus*	0	0	+	0	0
	Crested Francolin	*Francolinus sephaena*	0	0	+	0	0
Columbidae	Mourning Dove	*Streptopelia decipiens*	+	0	0	+	+
	Red-eyed Dove	*Streptopelia semitorquata*	+	0	0	+	0
	Ring-necked Dove	*Streptopelia capicola*	+	+	0	+	0
	Blue-spotTed Dove	*Turtur afer*	0	0	0	+	+
	Emerald-spotted Wood-Dove	*Turtur chalcospilos*	0	0	+	+	0
	Collared Dove	*Streptopelia decaocto*	0	0	+	+	+
	Laughing Dove	*Streptopelia senegalensis*	0	0	0	+	0
	Namaqua Dove	*Oena capensis*	0	0	0	+	0
	African Green-pegion	*Treron calvus*	0	0	0	+	0

Appendix 1(Continue): Bird species recorded from Kilakala and Bigwa during survey

Family	Common Name	Scientific Name	Settlement	Farmland	Shrubland	Woodland	Forest
Cuculidae	Diederic Cuckoo	*Chrysococcyx caprius*	+	0	0	0	0
	Klaas′s Cuckoo	*Chrysococcyx klaas*	+	+	0	+	+
	Black Cuckoo	*Cuculus clamosus*	+	0	0	+	+
	Red -chested Cuckoo	*Cuculus solitarius*	+	+	+	+	+
	Emerald Cuckoo	*Chrysococcyx cuprius*	0	0	0	+	0
	Great- spoted Cuckoo	*Clamator glandarius*	0	0	0	+	0
Cuculidae	Lesser Cuckoo	*Cuculus poliocephalus*	0	0	0	+	+
	White- Browed Caucal	*Centropus superciliosus*	+	0	+	+	+
Apodidae	Little swift	*Apus affinis*	+	+	+	0	+
	Eurasian Swift	*Apus apus*	+	0	0	0	0
Coliidae	White-headed Mousebird	*Colius leucocephalus*	+	+	+	+	0
	Spackled Mousebird	*Colius striatus*	+	0	+	+	0
Trogonidae	Narina Trogon	*Apaloderma narina*	0	0	+	0	0
	Forktail Drongo	*Dicrurus adsimilis*	+	0	0	+	0
Musophagidae	Livingstone′s Turaco	*Tauraco livingstonii*	0	0	0	0	+
Alicadinidae	Woodland Kingfisher	*Halcyon senegalensis*	0	0	0	+	
	Grey-headed Kingfisher	*Halcyon leucocephala*	0	0	+	+	0
	Pied Kingfisher	*Ceryle rudis*	0	0	+	0	0
Meropidae	Little Bee-eater	*Merops pusillus*	+	+	+	+	0
Coraciidae	Lilac-breasted Roller	Coracias caudatus	0	+	+	+	0

Appendix 1(Continue): Bird species recorded from Kilakala and Bigwa during survey

Family	Common Name	Scientific Name	Settlement	Farmland	Shrubland	Woodland	Forest
Bucerotidae	Trumpete Hornbill	*Bycanister bucinator*	0	0	+	0	+
Capitonidae	Pied Barbert	*Tricholaema leucomelas*	+	0	0	0	0
	Moustached Green Tinkerbird	*Pogoniulus leucomystax*	0	+	0	0	+
	Yellow-Throated Tinkerbird	*Pogoniulus chrysoconus*	0	+	+	+	+
	Black-collared Barbert	*Lybius torquatus*	0	0	0	+	0
Hirundinidae	Lesser Striped Swallow	*Cecropis abyssinica*	+	+	+	+	0
Motacillidae	African Pied Wagtail	*Motacilla aguimp*	+	0	+	0	0
	Mountain Wagtail	*Motacilla clara*	0	0	0	+	+
	Yellow Wagtail	*Motacilla flava*	0	0	+	0	+
	Golden Pipit	*Tmetothylacus tenellus*	0	+	0	0	0
	Striped Pipit	*Anthus lineiventris*	0	0	+	0	0
Numididae	Creasted Guineafowl	*Cuttera pucherani*	0	0	0	0	+
Rallidae	Buff-spoted Flufftail	*Sarothrura elegans*	+	0	+	0	0
Pcynonotidae	Common Bulbul	*Pycnonotus barbatus*	+	+	+	+	0
	Cape Bulbul	*Pycnonotus capensis*	+	0	0	0	0
	Black-eyed Bulbul	*Pycnonotus barbatus*	0	0	0	+	0
	Sombe Bulbul	*Andropadus importunus*	0	0	0	+	0
	Little Greenbul	*Andropadus virens*	0	0	+	+	+
	Stripe- checked Greenbul	*Andropadus milanjensis*	0	+	0	0	0

***endemic**

Appendix 1(Continue): Bird species recorded from Kilakala and Bigwa during survey

Family	Common Name	Scientific Name	Settlement	Farmland	Shrubland	Woodland	Forest
Pcynonotidae	Shelly′s Green bul	*Andropadus masukuensis*	0	0	0	0	+
	Cabanis′s Greenbul	*Phyllastrephus cabanisi*	0	+	0	0	+
	Yellow-steaked Greenbul	*Chlorocichla flaviventris*	0	+	0	+	0
	Joyful Greenbul	*Chlorocichla laetissima*	0	0	+	0	0
	Mountain Greenbul	*Andropadus nigriceps*	0	0	+	+	0
	Olive Mountain Greenbul	*Phyllastrephus placidus*	0	0	+	+	0
Turdidae	Orange Ground-Trush	*Zoothera gurneyi*	0	+	+	0	+
	Olive Thrush	*Turdus olivaceus*	0	0	0	0	+
	Thrush Nightingala	*Luscinia luscinia*	0	+	0	0	0
	Black-faced Babbler	*Turdoidaes melanops*	0	0	0	+	0
	African Hill-Babbler	*Pseudoalcippe abyssinica*	0	0	0	0	+
	White-chested Alethe	*Alethe fuelleborni*	0	0	0	0	+
Cisticolidae	Rattling Cisticola	*Cisticola chiniana*	0	+	0	0	0
	Croacking Cisticola	*Cisticola natalensis*	0	+	+	+	0
	Piping Cisticola	*Cisticola fulvicapilla*	+	+	+	0	0
	Bar-throated Apalis*	*Apalis thoracica*	0	0	0	0	+
	Uluguru Bar-throated Apalis	*Apalis thoracica uluguru*	0	0	0	0	+
	White-winged apalis*	*Apalis chariessa*	0	0	0	0	+
	Tawny-flanked Prinia	*Prinia subflava*	+	+	0	0	0

***endemic**

Appendix 1(Continue): Bird species recorded from Kilakala and Bigwa during survey

Family	Common Name	Scientific Name	Settlement	Farmland	Shrubland	Woodland	Forest
Sylviidae	African Sedge Warbler	*Acrocephalus schoenobaenus*	+	+	+	+	+
	Bleating Warbler	*Camaroptera brachyura*	+	0	0	+	0
	Willow Warbler	*Phylloscopus trochilus*	+	+	+	0	0
	White-winged Warbler	*Bradypterus carpalis*	0	0	+	0	0
	Great Red Warbler	*Acrocephalus arundinaceus*	0	0	+	0	0
	Yellow-throated woodland Warbler	*Phylloscopus ruficapilla*	0	0	0	+	+
	Cape Reed Warbler	*Acrocephalus rufescens*	0	0	0	+	+
	Mountain Yellow Warbler	*Chloropeta similis*	0	0	0	0	+
	Mrs Moreau′s warbler*	*Sceptomycter winifredae*	0	0	0	+	+
	Brown Woodland Warbler*	*Phylloscopus umbrovirens*	0	0	0	+	0
	Red-winged Warbler	*Heliolais erythropterus*	0	0	+	0	0
Muscicapidae	Collared Flycatcher	*Ficedula albicollis*	0	0	+	+	+
	Sharpe′s Akalat	*Sheppardia sharpei*	0	0	+	+	+
	Blue-mentled Creasted-flycatcher	*Trochocercus cyanomelas*	0	0	0	0	+
	White-tailed Crested-flycatcher	*Trochocercus albonotatus*	0	0	0	0	+
	White-browed scrub – Robin	*Cercotrichas leucophrys*	0	+	0	0	0
	White-browed Robin-Chat	*Cossypha heuglini*	0	+	+	0	0
	Starred Robin	*Pogonocichla stellata*	0	0	+	0	+
	Chorister Robin-Chat	*Cossypha dichroa*	0	0	0	+	0
	Red-caped Robbin-Chat	*Cossypha natalensis*	0	0	0	0	+

**** endemic and endangered, * endemic**

Appendix 1(Continue): Bird species recorded from Kilakala and Bigwa during survey

Family	Common Name	Scientific Name	Settlement	Farmland	Shrubland	Woodland	Forest
Muscicapidae	Heuglin Robin-Chat	*Cossypha heuglini*	+	+	0	+	0
	Rufous bush Chat	*Cercotrichas galactotes*	+	0	0	0	+
Monarchidae	African Paradise-flycatcher	*Terpsiphone viridis*	+	0	0	0	0
	Livingstone′s flycatcher	*Erythrocercus livingstonei*	0	0	0	+	0
Platysteiridae	Forest Batis	*Batis mixta*	0	0	0	0	+
	Cape Batis	*Batis capensis*	0	0	0	+	0
	Chin-spot Batis	*Batis molitor*	0	0	0	+	0
Nectarinidae	Black Sunbird	*Nectarinia aspasia*	+	0	+	0	0
	Malachite Surnbird	*Nectarinia famosa*	+	0	0	0	0
	Amethyst Sunbird	*Chalcomitra amethystina*	0	+	0	0	0
	Scarlet-chested sunbird	*Chalcomitra senegalensis*	0	0	+	0	0
	Blue-throated Brown Sunbird	*Cyanomitra cyanolaema*	0	0	+	0	0
	Collared Sunbird	*Hedydipna collaris*	0	0	+	0	0
	Loveridge′s Sunbird**	*Cinnyris loveridgei*	0	0	0	0	+
Oriolidae	African Golden Oriole	*Oriolus auratus*	+	0	0	0	0
	Green-headed Oriole	*Oriolus chlorocephalus*	0	0	0	0	+
Laniidae	Common Fiscal	*Lanius collaris*	0	0	+	0	0
	Red-backed Shrike	*Lanius collurio*	+	0	0	0	0

**** endemic and endangered**

Appendix 1(Continue): Bird species recorded from Kilakala and Bigwa during survey

Family	Common Name	Scientific Name	Settlement	Farmland	Shrubland	Woodland	Forest
Malaconotidae	Southern Boubou	*Laniarius ferrugineus*	+	0	+	+	0
	Black-crowened Tchagra	*Tchagra senegalus*	+	+	0	+	0
	Crimson breasted boubou	*Laniarius atrococcineus*	0	0	0	+	0
	Fueleborns black boubou	*Laniarius fuelleborni*	0	0	0	0	+
	Black-throated Bush-shrike	*Telophorus nigrifrons*	0	0	0	0	+
	Many- coloured Bush-shrike	*Telophorus multicolor*	0	0	+	0	0
	Black-backed Puffback	*Dryoscopus cubla*	0	0	0	+	0
	Grey-headed Bush-shrike	*Malaconotus blanchoti*	+	0	0	0	0
	Uluguru Bush-shrike**	*Malaconotus alius*	0	0	0	0	+
Campephagidae	Grey Cuckoo shrike	*Coracina caesia*	0	0	0	+	0
Dicruridae	Common Drongo	*Dicrurus adsimilis*	0	0	+	0	0
	Square-tailed Drongo	*Dicrurus ludwigii*	0	0	0	0	+
Corvidae	Indian House Crow	*Corvus splendens*	+	+	0	0	0
	Pied Crow	*Corvus albus*	+	+	+	0	0
	White- napen Raven	*Corvus albicollis*	0	+	+	0	0
Sturnidae	Kenrick′s Starling	*Poeoptera kenricki*	0	0	0	0	+
	Wallers Starling	*Onychognathus walleri*	0	0	0	0	+
Passeridae	House Sparrow	*Passer domesticus*	+	+	0	0	0
	Grey-headed Sparrow	*Passer griseus*	+	+	0	0	0

**** Endemic and threatened**

Appendix 1(Continue): Bird species recorded from Kilakala and Bigwa during survey

Family	Common Name	Scientific Name	Settlement	Farmland	Shrubland	Woodland	Forest
Ploceidae	Parasitic Weaver	*Anomalospiza imberbis*	+	0	+	0	0
	Red-billed Quelea	*Quelea quelea*	+	0	0	0	0
	Golden Palm Weaver	*Ploceus bojeri*	0	0	+	0	0
	Spackled Weaver	*Sporopipes frontalis*	0	+	+	0	0
	Little Weaver	*Ploceus luteolus*	0	0	+	0	0
Estrildidae	Green-winged Pytilia	*Pytilia melba*	0	+	+	0	+
	Orange-winged Pytlia	*Pytilia afra*	0	0	+	0	0
	Green-backed Twinspot	*Mandingoa nitidula*	0	+	0	0	+
	Red-faced Crimsonwing	*Cryptospiza reichenovii*	0	0	0	0	+
	Red-billed Fireficher	*Lagonosticta senegala*	+	0	+	0	0
	Southern Codorn-blue	*Uraeginthus angolensis*	+	+	+	+	0
	Bronze Manikin	*Spermestes cucullatus*	+	+	+	0	0
	Southern Red Bishop	*Euplectes orix*	+	+	0	0	0
	Black-winged Red Bishop	*Euplectes hordeaceus*	0	+	0	0	0
Fringillidae	Cape Canary	*Serinus canicollis*	+	0	0	0	0
	Forest Canary	*Serinus scotops*	+	0	0	0	0
	Yellow-crowed Canary	*Serinus canicollis*	0	0	0	0	+
	Brimstone Canary	*Serinus sulphuratus*	0	+	0	0	0
	Oriole Finch	*Linurgus olivaceus*	0	0	0	0	+
Eurylaimidae	African Broadbill	*Smithornis capensis*	0	0	0	0	+
Emberizidae	Lesser Seedcracker	*Pyrenester minor*	0	0	+	0	0
	Pin- tailed Whydah	*Vidua macroura*	0	0	+	0	0
	Steel-blue Whydah	*Vidua hypocherina*	+	0	0	0	0

Appendix 2: Birds Data collection form

Date		Examinar						Page....	
	Bird found			Habitat type					
Point No	Family	Common name	Scientific name	Settlement	farmland	shrubland	woodland	Forest	altitude

Appendix 3: Vegetation cover data collection form

Line Intercept														
Date				Examiner				Page……of…….						
	Location				Habitat type									
Line Length	Grass Sp				Shrub Sp				Trees Sp					Notes
Total														
% Cover														
% Composition														