INFLUENCE OF HUMAN DISTURBANCES ON BIRD ASSEMBLAGES IN SELECTED COASTAL FORESTS OF PANGANI- SAADANI ECOSYSTEM

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

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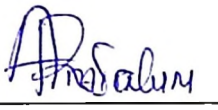
ABSTRACT

This study was carried out in four forest patches; Zaraninge, Kwamsisi, Msumbugwe and Gendagenda in Pangani – Saadani ecosystem, with the aim of assessing the influence of human disturbances on bird communities, from October 2010 to January 2011. A total of eight transects stratified into core and edge areas were used in each forest patch to identify type and quantify the level of human disturbances, determine bird species composition and abundance. To achieve that, three circular plots each 20 m radius were allocated at the beginning, middle and end of a 500 m long permanent transect. The level of human disturbances was assessed using four disturbance indicators; tree lopping, human trails, pit- sawing and snaring while bird species were identified by sight and call. One-way analysis of variance (ANOVA) was used to test for differences between forests in human disturbances and bird abundance. While Shannon Wiener diversity index (H) was calculated for each forest patch to assess species diversity and evenness, Bray-Curtis Cluster analysis was used to determine similarity in bird species between forests. A total of 564 individuals composed of 88 bird species distributed in ten Orders were recorded. The level of pit sawing and tree lopping differed significantly between forest patches ($P<0.05$) with Msumbugwe being more disturbed than the rest of the forests. On the other hand, bird abundance differed significantly between the forest patches ($P<0.05$) with the highest abundance occurring in Msumbugwe. Contrary, Species richness and diversity were greater in least disturbed forests, Zaraninge and Kwamsisi than in the highly disturbed forest. Apparently, only pit-sawing was found to correlate with bird abundance ($P<0.01$) whereas similarities in species composition were evident among forests with Zaraninge and Gendagenda exhibiting much overlap.

DECLARATION

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



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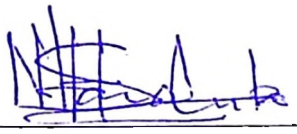

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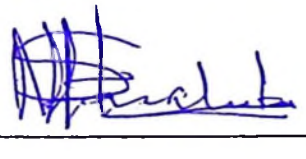

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In the end I would like to pay my tribute to my loving parents and my brothers whose prayers and affection strengthened me to go forward.

DEDICATION

This work is dedicated to my parents Mrs Halima Mbiru and Mr. Rashid Mbiru for their everlasting love, patience, tolerance and encouragement throughout the time I was undertaking my studies.

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LIST OF ABBREVIATIONS AND ACRONYMS

SANAPA	Saadan National Park
SUA	Sokoine University of Agriculture
TANAPA	Tanzania National Parks

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Coastal Forests are distinct from the lowland forests that surround mountainous areas and which form a natural continuum with the sub montane forest that occurs at higher altitudes (Sheil, 1992). The Eastern African coastal forest is a biodiversity hotspot found up to 1030 meters above sea level. They stand as patches dotted along the eastern edge of Africa from southern Somalia up to the Limpopo River in Mozambique (WWF, 2008). Generally, these coastal forests are one of the highest priority ecosystems for conservation in Africa and globally due to large number of endemic species, high biodiversity, and concentration of rare and threatened taxa, including birds and mammals (Azeria *et al.*, 2007).

The Pangani-Saadani ecosystem for example, encompasses several patches of coastal forests that are rich in avifauna resources (Azeria *et al.*, 2007). For example, the 11 bird species reported by Burgess and Muir (1994) and Azeria *et al.* (2007) as endemic to East African coastal forests are represented in the famous Kiono/Zaraninge Forest Reserve and other comparable forest reserves in the ecosystem (Burgess and Muir, 1994; Azeria *et al.*, 2007). Unfortunately these forests are increasingly subjected to unsustainable biomass extractions by humans. Ongoing human activities include logging for timber, uncontrolled wildfires, collection of fuel wood and illegal hunting, and conversion to agriculture accompanied by extensive burns (WWF, 2009).

Birds are good indicator of environmental quality, by studying birds in respect to habitat changes due to human disturbances is important for Avifauna ecology. Birds are sensitive

to changes in habitat quality (Sekercioglu, 2002), Borghesio (2008); Romper *et al.* (2007); Wittern and Berggren, 2007 revealed that changes in habitat structure as a result of human disturbances affect bird activities and therefore have the potential to affect their composition and abundance. Existing studies in the East African coastal forests have concentrated primarily on biogeography (Hawthorne, 1984; Burgess *et al.*, 1992) and biodiversity inventories of flora and fauna (Burgess and Mlingwa, 1993; Burgess, 1998; Mligo *et al.*, 2009). Therefore there is currently no ecological study that has attempted to fathom out the links between human-induced disturbances and biodiversity measures using birds as indicators of environmental quality despite continued forest disturbances. This study, therefore presents information on species composition, abundance and diversity of birds of four Tanzania coastal forest reserves in respect of anthropogenic disturbances, specifically Pit-sawing, tree lopping, animal snaring and human trails.

1.2 Research Problem and Justification

Coastal forests are increasingly subjected to unsustainable resource extractions by humans such as logging for timber, collection of fuel wood, conversion to agriculture (WWF, 2009) and extensive burns. As result, the size and quality of the forests continue to decline (WWF, 2009). This is happening irrespective of protection status of these forests. Msumbugwe and Gendagenda forests in Pangani- Saadani ecosystem are case examples of protected forests facing a considerable level of disturbance by humans. The cases of Msumbugwe and Gendagenda suggest that even the blocks of Kwamsisi and Zaraninge forests under Saadani National Park are not necessarily immune to the exploitations. Uncontrolled human activities may cause significant changes in forest structure and plant composition (Shahabuddin and Kumar, 2006). Human disturbances may also lead to habitat loss which has important implication on bird species composition, abundance and diversity (Feeley and Terborgh, 2008; Armstrong *et al.*,

2008). To date the consequences of these activities on bird's populations in forest patches of Pangani- Saadani ecosystem have not been assessed and therefore unknown. Understanding the subsequent effect of different disturbances on birds, and how the birds in turn respond to each type and magnitude of human induced environmental perturbations is fundamental to avifauna ecology, given that birds are indicators of environmental quality (Butchart *et al.*, 2004). Therefore, this study is geared towards obtaining information on bird's species composition, abundance and diversity in respect of human disturbances. The information is expected to have important implications on the management of these coastal forests and also serve as a basis for further studies.

1.3 Study Objectives and Hypotheses

1.3.1 Overall objective

The study seeks to investigate the influence of human disturbances on bird species composition, abundance and diversity in four (4) coastal forests of the Pangani- Saadani ecosystem.

1.3.2 Specific objectives

(i) To determine types and assess levels of human disturbance present

(ii) To determine bird communities and assess bird abundance

(iii) To establish relationships between human disturbance and bird parameters

1.3.3 Hypotheses

Ho: Human induced disturbances vary among the four selected forest patches.

Ho: Bird abundance is low in highly disturbed than less disturbed forest patches.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Species Assemblage and Importance of Forest Habitat Quality

Species assemblage is a set of species occurring in a particular area without regard to their ecological interactions (Lopez de Casenave *et al.*, 2008). Species assemblage keeps changing in response to a number of factors including changes in habitat quality (Germaine *et al.*, 1998; Johnson, 2007). Hall *et al.* (1997) considered habitat quality as the ability of the environment to provide conditions appropriate for individual and population persistence. The importance of habitat quality to avian assemblage has been widely documented (MacArthur, 1964; Berg, 1997; González-Gajardo *et al.*, 2009) and positive correlations with species richness and abundance have been found (Venier and Fahrig, 1996; Ferraz *et al.*, 2007). Furthermore, habitat is an area with a combination of resources and environmental conditions that promote occupancy by individuals of a given species and allows those individuals to survive and reproduce (Morrison *et al.*, 2006). Habitats are important as they provide foraging grounds, cover and shelter, breeding sites, corridors to other geographical localities and dispersal area (Kideghesho *et al.*, 2006).

2.2 Effect of Habitat Loss as a Result of Human Disturbances on Bird's Population

Human intrusion has become a dominant form of disturbance in many landscapes (Riffell *et al.*, 1996). Most of these human mediated disturbances are linked to activities meant to further financial goals and increase economic growth, but the consequences on ecosystem processes and biodiversity may be catastrophic (Chapin *et al.*, 2000, Williams *et al.*, 2003). Human activities such as overgrazing, deforestation, bush fires, mining, urbanization and cultivation are the principle causes of habitat loss (Mwalyosi, 1992; Kauzeni,1995) and poses severe threat to biodiversity worldwide (Kideghesho, *et al.*,

2006). Logging for example, which involves extraction of trees for timber, may isolate populations of some species, limit their distribution, and disrupt interactions between or within populations (Thiollay, 1997). Food resources may also decrease or become patchily distributed (Stouffer and Bierregaard, 1995). For birds, these disturbances can seriously alter reproduction, survival, and habitat use (Riffell *et al.*, 1996). The disturbances also have the potential to cause impacts that accumulate through time and manifest as progressive declines in bird's species richness, abundance and diversity (Franklin and Steadman, 2010; Githiru *et al.*, 2007; Lefevre, 2008). Valentine (2006) examined the impacts of repeated burning on bird assemblages and found that, repeated burning significantly reduced bird abundance and species richness. On top of that they also cause local extirpations of bird species associated with native vegetation while increasing the abundance and number of bird species associated with human activity (Donnelly and Marzluff, 2006).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

This study was carried out in Pangani- Saadani Ecosystem in north-eastern Tanzania from October 2010 to January 2011. Four forest fragments: Zaraninge (174 km^2), Kwamsisi (45km^2), Gendagenda (28km^2) and Msumbugwe (44km^2) were studied (Fig.1). The former two forests are partly located in Saadani National Park (SANAPA), which is located at 5°38' to 6°16' South and 38°36' to 38°53' East (SANAPA, 2009). The latter two forests are located north of SANAPA. Gendadenda is between 5°32'and 5°34'South and 38°38'and 38°39' East and occupies partly Handeni and Pangani Districts in Tanga Region whereas Msumbugwe is located at 5°32'South and 38°45'East in Pangani District, also in Tanga region (Stubblefield, 1994).

The rainfall in SANAPA is bi-model with high peak between March and May and a smaller peak between October and December. Humidity is high throughout the year, reaching up to 90% during the rainy season (Bloesch and Klötzli, 2002). Gendagenda has maximum rainfall of 1500 mm/yr and minimum of 1000 mm/yr with dry period from June to September. Contrary, Msumbugwe receives an average rainfall of 1300 mm/yr, and also has dry period from June to September (Stubblefield, 1994).

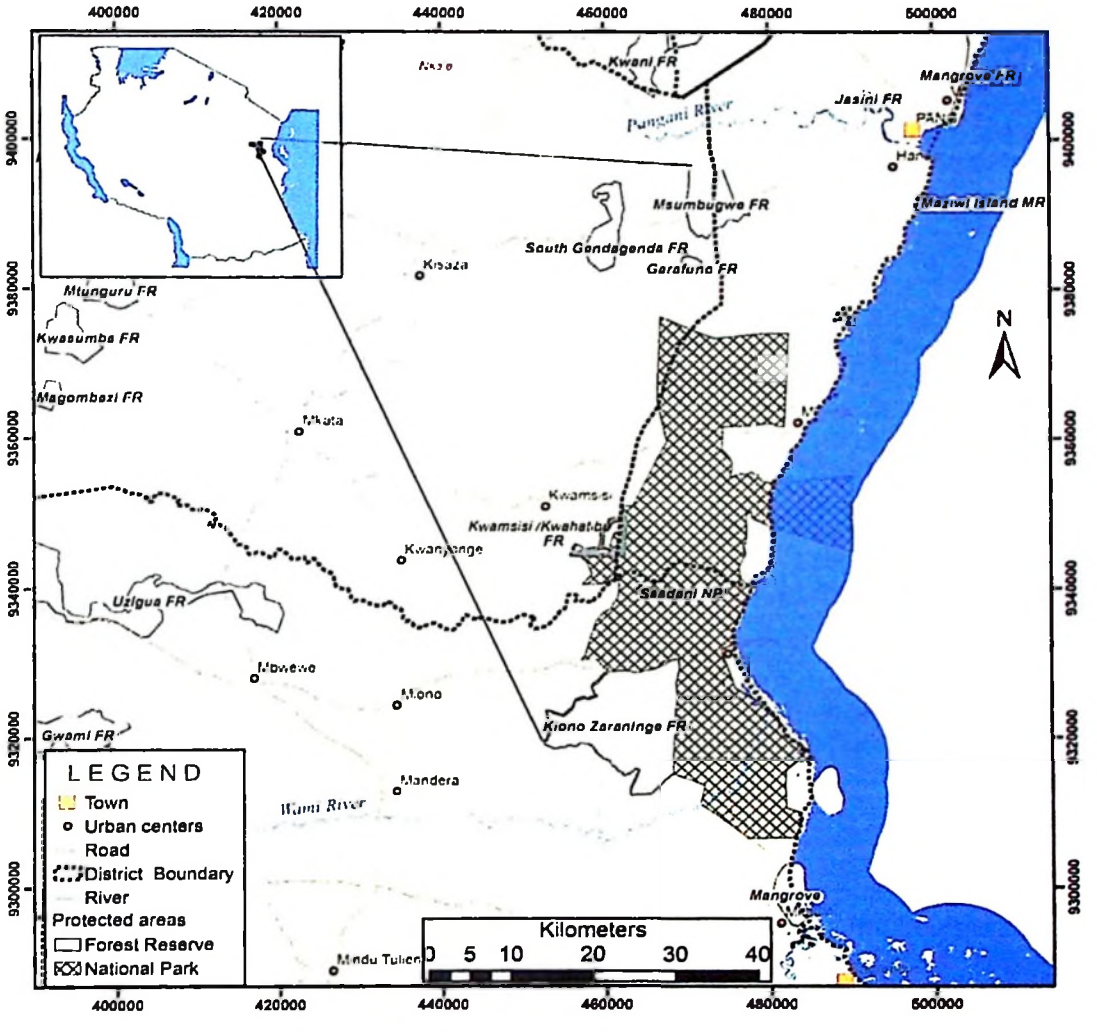

Figure 1: Map showing location of the four studied forest patches in Pangani-Saadani ecosystem

3.2 Study Design

The four forest patches were considered as study plots and each was stratified into forest core (300m from the edge) and forest edge. Then, permanent transects of 500 m each were randomly established in the core area and the forest edge of each forest for 4 months period. Selection of sites for placement of transects followed judgment sampling procedure, where a researcher subjectively selects sampling sites that are representative of the study area (Morrison *et al.*, 2001). However, the minimum inter transect distance was 100 m. Three plots, each with 20-m radius were established along transects: one at the start, centre and the end of transect, leading to an inter-point distance of approximately 170 m (Shahabuddin and Kumar, 2006). Positions of all transects (starting point and at the end) and the plots were recorded using a hand held GPS unit. Identification of birds in the plots was done with the aid of a pair of binoculars and field guides (Zimmerman *et al.*, 1996; Stevenson and Fanshawe, 2002).

Kiono/Zaraninge Forest had 6 transects in the national park and 2 on the village land whereby 4 were in the forest core and 4 at the forest edge. Similarly, Msumbugwe and Gendagenda forests, each had 4 transects in the core and the other 4 at forest edge. However, Kwamsisi/Kwahatibu had 4 transects in the national park and 4 on the village land, resulting to 5 transects in the core and 3 at forest edge. Therefore, the design amounted to a total of 96 circular plots. In each circular plot, species number and human disturbance indicators, date, time of day and weather condition (cloud over, temperature, and rainy condition) were recorded.

3.4 Data Collection

3.4.1 Species composition, abundance and bird diversity

To employ point count method (Pomeroy, 1992; Raman, 2003), the 20-m radius plots served the purpose. On reaching a point, about 10 minutes were passed before sampling commenced to allow disturbed birds to settle down. Recording of birds (seen and heard) within each plot was also carried out for a period of 10 minutes. Unidentified calls were recorded using a micro-cassette tape recorder for identification of the species later on. Data collection was carried from 6.30-10.00 am and from 4.00 to 6.00 pm when the activities of birds are prominent (Aynalem and Bekele, 2008).

3.4.2 Human disturbances

Indicators of human disturbances encountered as a result of forest utilization by humans were recorded on the same plots used for bird sampling by determining their frequencies. Four indicators: (i) trees showing signs of lopping, (ii) human trails traversing the site, (iii) pit-sawing, and (iv) snares were used (Shahabuddin and Kumar, 2006). The lopping score for each tree was measured on a scale of 0–4 as follows: 0, no lopping; 1, rudimentary signs of lopping; 2, up to half of the main branches lopped; 3, more than half of the main branches lopped; 4, the tree reduced to a stump.

3.5 Data Analyses

3.5.1 Species composition, abundance and bird diversity

A check list of birds for each forest patch was compiled in Microsoft Office Excel 2007. To see whether there was similarity in species composition between the forest patches, Bray-Curtis Cluster analysis (Bloom, 1981) was used in Paleontological statistics software package (PAST version 2.12). Also, individuals of all species in each forest patch were summed up to obtain total number of birds counted for all four forest patches.

Shannon-Wiener Diversity Index was used to compute diversity and evenness of birds at each forest (Brower *et al.*, 1990) also in PAST version 2.12.

3.5.2 Effect of human disturbance

Percent score of a disturbance indicator for a particular forest was computed by dividing the observed frequency of the indicator in that forest by the total number of the frequency of the indicator in all forests. Therefore, $\geq$50% implied high disturbance while <50% implied less disturbance. These indicators reflect the intensity of disturbance in the course of various activities in the forests. One-way ANOVA was used to assess difference in level of human disturbance between the forest patches in the statistical package for SPSS (version 14). Furthermore, Univariate ANOVA was used to assess difference in lopping between forests with lopping scale and forest patches as fixed and random factors respectively. Pearson Correlation Coefficient test was used to investigate association between levels of disturbance with bird abundance.

CHAPTER FOUR

4.0 RESULTS

4.1 Type and Level of Human Disturbance

Forests patches differed in type and level of human disturbances experienced. Overall, Zaraninge forest experienced the minimum types and level of human disturbances, contrary to Msumbugwe forest patch, which was the most disturbed with lopping and pit-sawing being high on the list (Table 1 and Plate 1). Of the four indicators of human disturbance; animal snaring, human trails, tree lopping and pit-sawing, the latter two were not observed at all in Zaraninge, however, snaring, which was absent at Msumbugwe and Kwamsisi, was instead a severe problem in Zaraninge (Table 1).

Table 1: Types and extent of human disturbances as observed in Gendagenda, Kwamsisi, Msumbugwe and Zaraninge forest patches in the Pangani-Saadani ecosystem from October 2010 to January 2011

Forest patch	Human Disturbance indicator	Frequency	Percentage
Gendagenda			
	Lopping	8	18
	Human trail	2	29
	Pitsawing	2	20
	Snare	1	20
Kwamsisi			
	Lopping	7	15
	Human trail	1	14
	Pitsawing	1	10
	Snare	0	0
Msumbugwe			
	Lopping	31	67
	Human trail	3	43
	Pitsawing	7	70
	Snare	0	0
Zaraninge			
	Lopping	0	0
	Human trail	1	14
	Pitsawing	0	0
	Snare	4	80

Plate 1: Pitsawing in Msumbugwe Forest Reserve

4.2 Bird Species Composition and Abundance

A total of 564 individuals composed of 88 bird species in ten Orders were recorded from 96 plots distributed in the four forest patches. Twenty seven (27) bird species were recorded in all forest patches (Appendix 1). However, Msumbugwe had the highest number of birds counted while Gendagenda and Kwamsisi recorded the lowest. On the other hand, species richness ranged from 48 to 62 while Shannon–Weiner diversity and evenness ranged from 3.232 to 3.89 and 0.5504 to 0.8418, respectively. Both diversity and evenness were lowest in Msumbugwe forest patch while Kwamsisi had the highest diversity in addition to species richness. On the other hand, evenness was highest in Gendagenda forest (Table 2).

Table 2: Bird species richness (S), Shannon-Wiener Diversity index (H') and Evenness index (E), and Abundance (A) in Gendagenda, Kwamsisi, Msumbugwe and Zaraninge in the Pangani-Saadani ecosystem from October 2010 to January 2011

Forest patch	S	H'	E	A
Gendagenda	48	3.699	0.8418	136
Kwamsisi	62	3.89	0.7892	136
Msumbugwe	46	3.232	0.5504	173
Zaraninge	60	3.829	0.7673	149

According to Bray-Curtis Cluster analysis, only three pairs of forest; Gendagenda and Zaraninge, Gendagenda and Kwamsisi and Zaraninge and Kwamsisi overlapped in variety of species with the values $\geq$ than 50% whereas Msumbugwe was relatively dissimilar from the rest of the forests with the values < than 50% (Table 3 and Fig. 2).

Table 3: Results of Bray-Curtis cluster analysis showing similarity measures between forest patches on bird species composition

	Gendagenda	Kwamsisi	Msumbugwe	Zaraninge
Gendagenda	1.00	0.50	0.45	0.61
Kwamsisi	0.50	1.00	0.49	0.58
Msumbugwe	0.45	0.49	1.00	0.48
Zaraninge	0.61	0.58	0.48	1.00

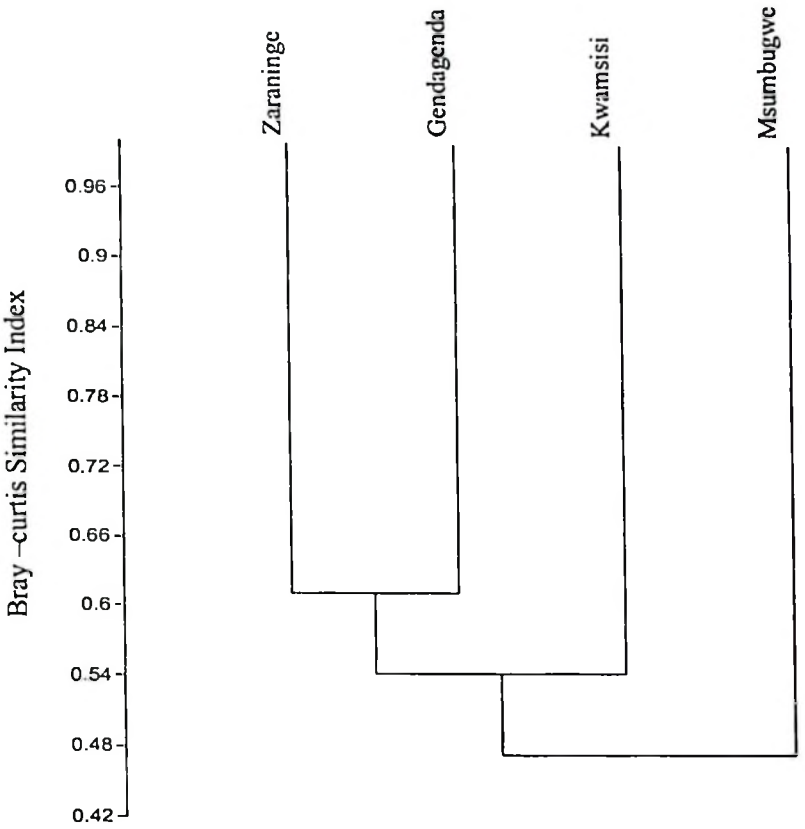

Figure 2: A Dendrogram showing similarity in bird species composition in the four forests in Pangani- Saadani ecosystem from October 2010 to January 2011.

Two nearly threatened species, Fischer's Turaco *Tauraco fischeri* and Plain-backed Sunbird *Anthreptes reichenowi* Plate (2a) and (2b), and one endangered species, Sokoke pipit *Anthus sokokensis* (Plate 2c) both endemic to East African coastal forests, were recorded (Appendix 1 and 6).

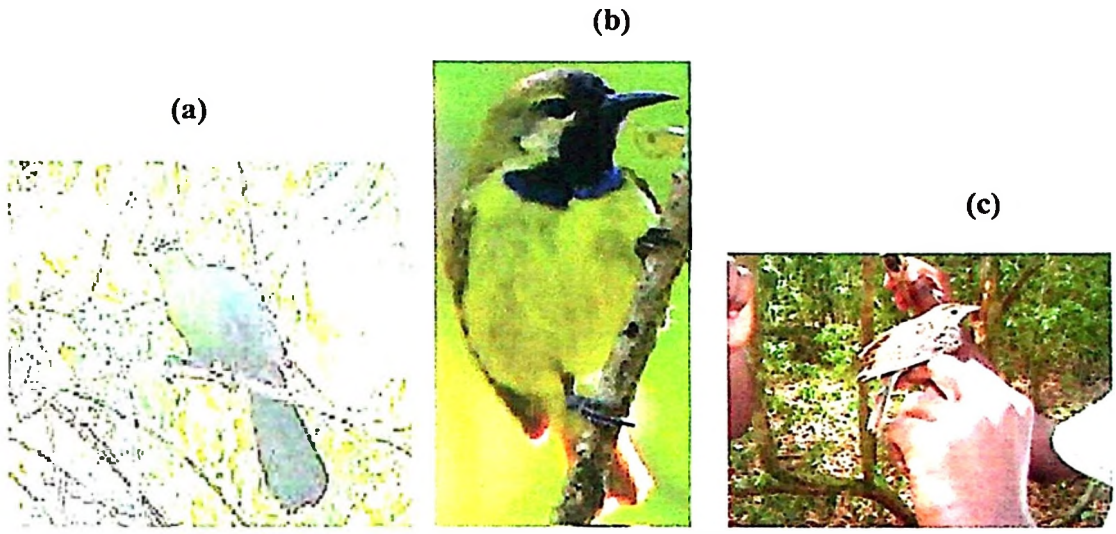

Plate 2: (a) Fischer's Turaco *Tauraco fischeri* and (b) Plain backed Sunbird *Anthreptes reichenowi* are nearly threatened species; and (c) Sokoke pipit *Anthus sokokensis* is endangered, all three are endemic to East African coastal forests

Moreover, the study revealed significant difference in bird abundance among the forest patches (Table 4).

Table 4: Mean bird abundance and standard deviation, lower and upper bonds at 95% CI for mean, and result of One-way ANOVA test for difference in bird abundance among the four forest patches in the Pangani-Saadani ecosystem from October to January 2010 (±S.D=standard deviation).

Forest patch	Mean±S.d	p-value	95% Confidence Interval for Mean	
			Lower bound	Upper bound
Gendagenda	1.400±1.082	0.024*	1.27	1.53
Kwamsisi	1.800±2.498		1.53	2.07
Msumbugwe	2.120±5.399		1.39	2.85
Zaraninge	1.640±1.531		1.52	1.77

* Significant at 0.05 level

4.3 Relationships between Human Disturbance and Bird Parameters

Pit-sawing and lopping varied among the four forest patches (Table 5), but only the effect of pit-sawing did correlate positively with bird abundance ($p=0.006$ and $r=0.074$. Significant difference for Pit-sawing was detected between Gendagenda and Msumbugwe, Kwamsisi and Msumbugwe and Zaraninge and Msumbugwe and for lopping, the difference occurred between Kwamsisi and Msumbugwe, Gendagenda and Msumbugwe, and Zaraninge and Msumbugwe (Table 6).

Table 5: Mean level of disturbance and the standard deviation, lower and upper bonds at 95% CI for mean, and results of one-way ANOVA test for difference in level of human disturbance among the four forest patches in the Pangani-Saadani ecosystem from October to January 2010

Disturbance indicator	Forest patch	Mean±S.d	p-value	95% Confidence Interval for Mean	
				Lower bound	Upper bound
Human trail	Gendagenda	0.010±0.082	0.266	0.00	0.02
	Kwamsisi	0.000±0.051		0.00	0.01
	Msumbugwe	0.030±0.188		0.00	0.03
	Zaraninge	0.000±0.000		0.00	0.00
Pit -sawing	Gendagenda	0.010±0.082	<0.001*	0.00	0.02
	Kwamsisi	0.000±0.051		0.00	0.01
	Msumbugwe	0.030±0.188		0.00	0.05
	Zaraninge	0.000±0.000		0.00	0.00
Snare	Gendagenda	0.000±0.058	0.771	0.00	0.01
	Kwamsisi	0.000±0.000		0.00	0.00
	Msumbugwe	0.000±0.000		0.00	0.00
	Zaraninge	0.010±0.157		0.00	0.02
Lopping	Gendagenda	0.030±0.245	<0.001*	0.00	0.06
	Kwamsisi	0.020±0.211		0.00	0.04
	Msumbugwe	0.120±0.519		0.06	0.19
	Zaraninge	0.000±0.000		0.00	0.00

*Significant at 0.05

Table 6: Mean difference in level of disturbance, lower and upper bonds at 95% CI for mean, and results of Post hoc (Bonferroni test) on difference in level of a) pitsawing and b) lopping between forest patches in Pangani-Saadani ecosytem from October 2010 to January 2011

Forest patch (I)	Forest patch (J)	p-value
PIT-SAWING		
Gendagenda	Kwamsisi/Kwahatibu	1.000
	Msumbugwe	<0.027*
	Kiono/Zaraninge	1.000
Kwamsisi/Kwahatibu	Gendagenda	1.000
	Msumbugwe	<0.002*
	Kiono/Zaraninge	1.000
Msumbugwe	Kion/Zaraninge	<0.001*
LOPPING		
Gendagenda	Kwamsisi/Kwahatibu	1.000
	Msumbugwe	<0.001**
	Kiono/Zaraninge	0.349
Kwamsisi/Kwahatibu	Msumbugwe	<0.001**
	Kiono/Zaraninge	1.000
Msumbugwe	Kino/Zaraninge	<0.001*

*Significant at 0.05
**The mean difference is significant at the 0.01 level

Three lopping scales i.e. no lopping, rudimentary sign of lopping and tree reduced to a stump were observed. Msumbugwe forest had all three while Gendagenda and Kwamsisi had two, and only one at Zaraninge forest (Fig. 3). The difference in scale of lopping occurred significantly between Gendagenda and Kwamsisi, Gendagenda and Msumbugwe, Gendagenda and Zaraninge, Kwamsisi and Msumbugwe, Kwamsisi and Zaraninge, and between Msumbugwe and Zaraninge (Table 7). Msumbugwe forest had more trees reduced to a stump than the rest of the forest patches (Fig.3). The number of trees reduced to stump in Msumbugwe forest constituted 61% of all trees reduced to stumps in the four forest patches pooled together.

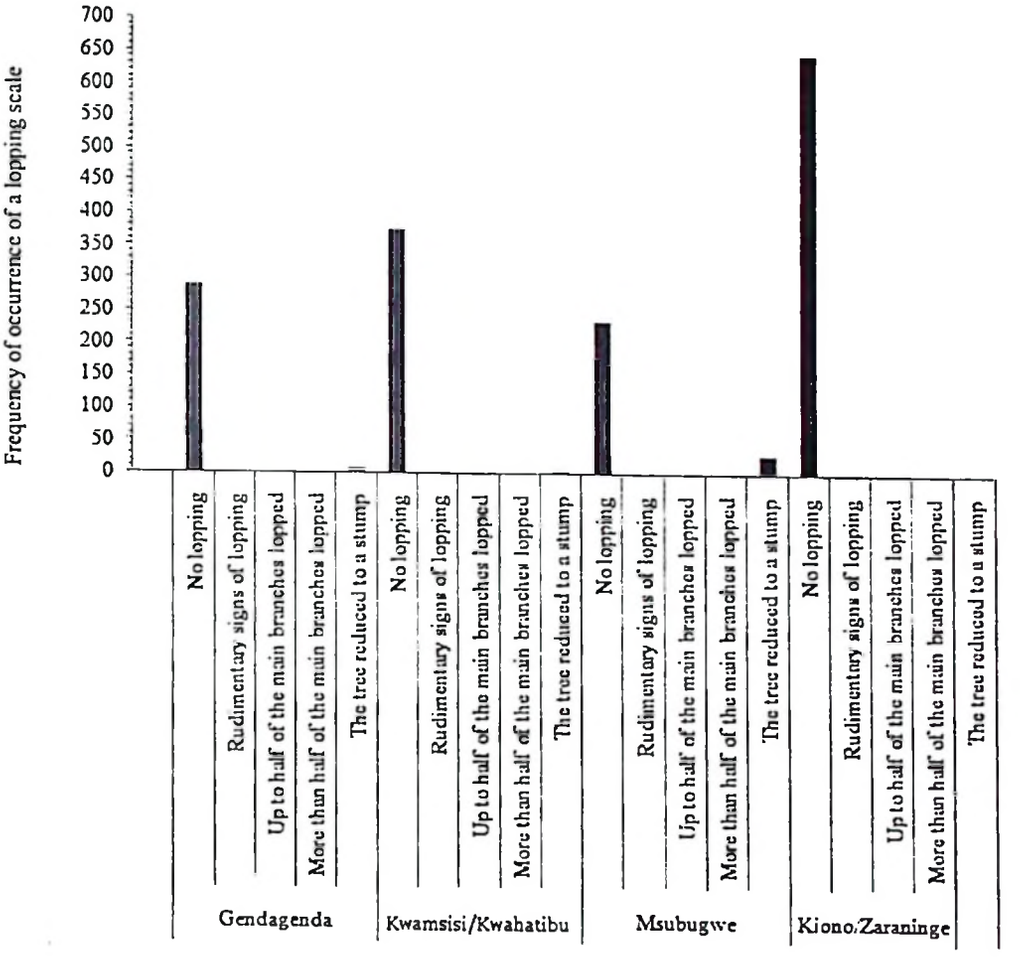

Figure 3: Lopping scale and frequency of occurrence of each lopping scale in Gendagenda, Kwamsisi/Kwahatibu, Msumbugwe and Kiono/Zaraninge forest patches in the Pangani-Saadani ecosystem

Table 7: Results of pair wise comparison (Bonferroni test) on lopping scales between forest patches, and lower and upper bonds at 95% CI for mean difference in lopping scale for contrasting pairs of forests in Pangani-Saadani ecosystem in 2010

Forest patch (J)	Forest patch (J)	Mean Difference (I-J)	p-value	95% Confidence Interval for mean difference	
				Lower bound	Upper bound
Gendagenda	Kwamsisi	0.333	<0.001*	0.404	0.263
Gendagenda	Msumbugwe	0.146	<0.001*	0.225	0.066
Gendagenda	Zaraninge	0.833	<0.001*	0.792	0.875
Kwamsisi	Msumbugwe	0.187	<0.001*	0.098	0.277
Kwamsisi	Zaraninge	1.167	<0.001*	1.225	1.109
Msumbugwe	Zaraninge	0.979	<0.001*	0.910	1.048

* The mean difference is significant at 0.05 level

CHAPTER FIVE

5.0 DISCUSSION

Discussions on the avifauna communities, abundance and influence of anthropogenic activities on birds in the four forests along Tanzania coast are presented.

5.1 Types and Level of Human Disturbance

Generally, lopping was the largest form of disturbance in nearly all forest patches except for Zaraninge. Howewer, Msumbugwe forest faced the highest level of lopping and pit-sawing, and the frequency of human trails in the forest was greater than its neighbour, Gendagenda forest. The high vulnerability of Msumbugwe forest is probably due to the commercial value of susceptible tree species. Local people are the great dealer in charcoal, hardwood poles and timber production thus accounting for the significant difference in pit-sawing and lopping between Msumbugwe and the rest of the forest patches. Msumbugwe forest reserve is a government forest under Pangani council. Unfortunetly, this institution does not confer adequate protection of its reserves due to insufficient equipment, and funds to pay patrolling rangers. Such less protective management, together with the easy accessibility of the area on foot, bicycles or motor cycle due to its proximity to communities in villages (Matongo village, which is approximately 5km away from the forest) exacerbate the extent of resource extraction hence the observed level of disturbance. Clarke and Stubblefield (1995) showed that even some years back, Msumbugwe forest used to experience extensive logging, implying that the forest has never been free from disturbances. Pole cutting and felling of large trees has also been a big concern in Lower river Tana Forest reserves in Kenya. Due to human growth trends in the area, the demand for forest product has been increasing enormously

and thus high human pressures despite the forest being legally protected (Owino *et al.*, 2008).

On the other hand, snaring was a severe problem in Zaraninge forest. The snares were of rope and wire materials. Snares were set to capture ground dwelling mammals such as warthogs, buffalo, red duiker and forest hogs. However, a previous study in Zaraninge showed that, in the past, commercial logging operations of valuable timber trees were undertaken (Sheil, 1992). Currently, absence of commercial logging in Zaraninge forest suggests improvement in management of the forest.

The interaction of forest location, local economic activities of villagers in the neighbourhood of a forest and protection status of an area account for the variation in intensity of human induced disturbances. In general, parts of Zaraninge and Kwamsisi that fall under Saadani National Park were comparative secured from illegal entry and exploitation of resources by humans. Park ranger's patrols along and within the park boundaries are undertaken. Contrary, lopping and pit-sawing were observed mainly in part of Kwamsisi that falls on the village land. This substantiates the effectiveness of Tanzania National Parks in conserving the forest under her jurisdiction compared to other authorities responsible with the forests.

5.2 Bird Species Composition and Abundance

This study demonstrates that Pangani - Saadani ecosystem supports a variety of birds. Among them, 9 bird species are endemic to eastern Africa coastal forests (see Appendix1). Six of the nine species were also observed in Kwamsisi forest reserve, which had not been studied before. However, other 3 endemic bird species formerly known to occur in Zaraninge, Msumbugwe and Gendagenda forests were not observed anywhere in

the ecosystem including Kwamsisi. These are Fischer's Greenbul *Phyllastrephus fischeri*, Eastern Green tinkerbird *Pogoniulus simplex* and Southern-banded snake Eagle *Circaetus cinerascens* (Ansell and Dickson, 1994; Burgess and Muir, 1994). Their absence may be associated with the view that the study was conducted for relatively short period (4 months) and delay in starting of short rains (December instead of late October). It is presumed with a study that covers full year along with good quantity and distribution of rains, the missed species may be observed.

Additionally, three pairs of forests (Table 6) showed high degree of similarity in bird species composition. This overlap reflects the widespread habitat use exhibited by the several common bird species in these forests (Appendix1). This is in contrast to Msumbugwe forest, which lacks sufficient number of bird species that traverse the other three forests thus dissimilar (Appendix 1).

5.3 Relationships between Human Disturbance and Bird Parameters

The study demonstrated that the less disturbed forests had highest bird species diversity compared to the highly disturbed one while the highly disturbed forest (Msumbugwe), recorded highest abundance and registered positive correlation between pit-sawing and bird abundance. Forest disturbance not only causes loss of large trees but also leads to clearance of understory vegetation and thus reduce the habitat quality for persistence of understory birds. Therefore, high abundance in a highly disturbed habitat contradicts with the prediction of this study, that there would be more birds in less disturbed than highly disturbed forest patch hence failure to accept the hypothesis. According to Lees and Peres (2008), Shahabuddin and Kumar (2006) human disturbance has been reported to negatively affect several bird species, but there is evidence that some species still show higher densities in disturbed areas than in protected sites. Higher density in disturbed

areas exhibited by resident birds is associated with the new ecological resources created following the disturbance (Sauvajot *et al.*, 1998). But, the fact remains that continued logging and pole harvesting along with other uncontrolled extraction of plant resources may lead to further reduced size of the existing forest patches hence affect the long-term survival of forest dependent birds in the ecosystem. The birds include Fischer's Turaco, *Tauraco fischeri* (near threatened) and Sokoke pipit *Anthus sokokensis* (endangered) (Birdlife International, 2012).

Unlike Msumbugwe, Kwamsisi showed highest diversity and species richness in the presence of moderate disturbance. These results agree with intermediate-disturbance hypothesis, which predicts that biotic diversity will be greatest in communities subjected to moderate levels of disturbance (Ward and Stanford, 1983).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study provides information that is important for conservation actions in Zaraninge, Kwamsisi, Msumbugwe and Gendagenda coastal forests of Tanzania through low species richness and diversity but higher abundance in a highly human disturbed forest. Moreover, the study refutes the notion that disturbances due to anthropogenic activities often result to reduced bird abundance, which was also the prediction of this study. The study also reinforces the ecological concept that an intermediate human disturbance favors higher species diversity. Although positive responses may be registered as a response to human induced disturbance severe destruction of vegetation structure will finally threaten some of bird species particularly forest specialists.

6.2 Recommendations

From the results and discussions of this study, the following are recommended:

(i) Based on the importance of coastal forests in terms of biodiversity, ecological services and forest goods, further studies on the flora and fauna together with intensity of human disturbances are required to increase our understanding on life still unknown and threats to life, services and goods offered by the forests.

(ii) Conservation education should be extended to human communities adjacent to the forests for effective conservation.

(iii) Further effort should be undertaken by the central government, town councils and conservation authorities at national and global levels to ensure that all coastal forests receive a reasonable level of protection through either Joint

Forest Management (JFM) or Community Based Forest Management (CBFM) as Participatory Forest Management (PFM)

(iii) Moreover, conservation authorities including non-governmental organizations should strive to ensure that various legislations, conventions, regional and international agreements are enforced

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APPENDICES

Appendix 1: Bird's species recorded in Gendagenda, Kwamsisi, Msumbugwe and Zaraninge in the Pangani-Saadani ecosystem from October to January 2010.

Order	Family	Common name	Species	Forest reserve			
				Gen	Kwm	Msu	Zar
FALCONIFORMES	Accipitridae	Bat Hawk (fdg)	*Macheiramphus alcinus*				x
	Accipitridae	Long-crested Eagle (fdg)	*Lophaetus occipitalis*		x		
	Accipitridae	African Goshawk (fc)	*Accipiter tachiro*		x		
	Accipitridae	African Harrier-Hawk (fc)	*Polyboroides typus*		x		x
GALLIFORMES	Numididae	Crested Guineafowl (fc)	*Guttera pucherani*		x		x
GRUIFORMES	Otididae	Black-bellied Bustard (fdg)	*Eupodotis melanogaster*			x	
COLUMBIFORMES	Columbidae	Red-eyed Dove (fc)	*Streptopelia semitorquata*		x	x	x
	Columbidae	Eastern Bronze-naped Pigeon (fc)	*Columba delegorguei*				x
	Columbidae	Emerald-spotted Wood-Dove (fc)	*Turtur chalcospilos*	x	x	x	x
	Columbidae	Tambourine Dove (fc)	*Turtur tympanistria*	x	x	x	x
	Columbidae	Ring-necked Dove (fdg)	*Streptopelia capicola*		x	x	
CUCULIFORMES	Musophagidae	Purple- crested Turaco (fc)	*Tauraco porphyreolophus*	x	x	x	x
	Musophagidae	Fischer's Turaco (fc)*	*Tauraco fischeri*		x	x	x
	Cuculidae	Klaas's Cuckoo (fdg)	*Chrysococcyx klaas*	x	x		x
	Cuculidae	White-browed Coucal (fdg)	*Centropus superciliosus*	x	x	x	x
	Cuculidae	Yellowbill (fdg)	*Ceuthmochares aereus*	x		x	
CAPRIMULGIFORMES	Caprimulgidae	Eurasian Nightjar (fdg)	*Caprimulgus europaeus*		x		x
TROGONIFORMES	Trogonidae	Narina Trogon (fc)	*Apaloderma narina*	x	x	x	x
CORACIIFORMES	Coraciidae	Broad billed Roller (fdg)	*Eurystomus glaucurus*				x
	Alcedinidae	African Pygmy Kingfisher (fc)	*Ispidina picta*				x
	Alcedinidae	Brown-hooded Kingfisher (fc)	*Halcyon albiventris*	x	x	x	x
	Alcedinidae	Half-collared Kingfisher (fdg)	*Alcedo semitorquata*				x
	Alcedinidae	Grey-headed Kingfisher (fdg)	*Halcyon leucocephala*	x			
	Bucerotidae	Trumpeter Hornbill (fc)	*Bycanistes bucinator*	x	x	x	x

	Bucerotidae	Crowned Hornbill (fdg)	*Tockus alboterminatus*	x	x	x	x
	Meropidae	Little Bee-eater (fdg)	*Merops pusillus*	x			
	Meropidae	White-throated Bee-eater (fdg)	*Merops albicollis*	x	x		x
	Phoeniculidae	Green Wood-hoopoe (fdg)	*Phoeniculus purpureus*	x	x	x	x
	Phoeniculidae	Common Scimitarbill (fdg)	*Phoeniculus cyanomelas*		x	x	x
PICIFORMES	Picidae	Mombasa Woodpecker (fc)*	*Campethera mombassica*		x	x	
	Picidae	Cardinal Woodpecker (fc)	*Dendropicos fuscescens*	x	x		x
	Capitonidae	Brown-breasted Barbet (fdg)	*Lybius melanopterus*		x	x	
	Capitonidae	Black-collared Barbet (fdg)	*Lybius torquatus*			x	x
	Indicatoridae	Greater Honey-guide (fc)	*Indicator indicator*		x		
	Capitonidae	Yellow-rumped Tinkerbird (fdg)	*Pogoniulus bilineatus*	x	x	x	x
	Capitonidae	Red-fronted Tinkerbird (fdg)	*Pogoniulus pusillus*		x		
PASSERIFORMES	Monarchidae	African Paradise-flycatcher (fdg)	*Terpsiphone viridis*	x	x		x
	Monarchidae	Blue-mantled Crested-flycatcher (fc)	*Trochocercus cyanomelas*	x	x	x	x
	Monarchidae	Little Yellow Flycatcher (fc)*	*Erythrocercus holochlorus*	x	x	x	x
	Muscicapidae	Spotted Flycatcher (fdg)	*Muscicapa striata*		x	x	
	Muscicapidae	Ashy Flycatcher (fc)	*Muscicapa caerulescens*		x		x
	Eurylaimidae	African Broadbill (fc)	*Smithornis capensis*	x	x		x
	Nectariniidae	Purple-banded Sunbird (fdg)	*Cinnyris bifasciata*		x		
	Nectariniidae	Scarlet-chested Sunbird (fdg)	*Chalcomitra senegalensis*		x		
	Nectariniidae	Collared Sunbird (fc)	*Hedydipna collaris*	x	x	x	x
	Nectariniidae	Plain-backed Sunbird (fc)*	*Anthreptes reichenowi*	x	x	x	x
	Nectariniidae	Amethyst Sunbird (fdg)	*Chalcomitra amethystina*		x		x
	Nectariniidae	Uluguru Violet-backed Sunbird (fc)*	*Anthreptes longuemarei*	x			
	Nectariniidae	Variable Sunbird (fdg)	*Cinnyris venusta*		x		x
	Nectariniidae	Olive Sunbird (fc)	*Cyanomitra olivacea*	x	x		x
	Oriolidae	Eurasian Golden Oriole (fdg)	*Oriolus oriolus*				x
	Oriolidae	African Golden Oriole (fdg)	*Oriolus auratus*	x	x		

Oriolidae	African Black-headed Oriole (fdg)	*Oriolus larvatus*		x		
Malaconotidae	Grey-headed Bush-shrike (fdg)	*Malaconotus blanchoti*				x
Malaconotidae	Tropical Boubou (fdg)	*Laniarius aethiopicus*	x		x	x
Malaconotidae	Four-coloured Bush-shrike (fc)	*Malaconotus quadricolor*	x		x	
Malaconotidae	Brown-crowned Tchagra (fdg)	*Tchagra australis*		x		
Malaconotidae	Black-backed Puffback (fc)	*Dryoscopus cubla*	x	x	x	x
Sturnidae	Black-bellied Starling (fc)	*Lamprotornis corruscus*	x	x	x	x
Campephagidae	Black Cuckoo-shrike (fdg)	*Campephaga flava*		x	x	x
Prionopidae	Retz's Helmet-shrike (fdg)	*Prionops retzii*			x	x
Prionopidae	Chestnut-fronted Helmete-shrike (fdg)*	*Prionops scopifrons*		x	x	x
Ploceidae	Black-headed Weaver (fdg)	*Ploceus cucullatus*		x		
Ploceidae	Spectacled Weaver (fdg)	*Ploceus ocularis*	x			
Ploceidae	Dark-backed Weaver (fc)	*Ploceus bicolor*	x	x	x	x
Sylviidae	Grey-backed Camaroptera (fc)	*Camaroptera brachyura*	x	x	x	x
Sylviidae	Rattling Cisticola (fdg)	*Cisticola chiniana*		x		
Sylviidae	Black-headed Apalis (fc)	*Apalis melanocephala*	x	x		
Sylviidae	Kretschmer's Longbill (fdg)*	*Macrosphenus kretschmeri*	x			
Sylviidae	Tawny-flanked Prinia (fdg)	*Prinia subflava*		x		
Pycnonotidae	Eastern Nicator (fdg)	*Nicator gularis*	x	x	x	x
Pycnonotidae	Common Bulbul (fdg)	*Pycnonotus barbatus*	x	x	x	x
Pycnonotidae	Terestrial Brownbull (fdg)	Phyllastrephus terrestris			x	x
Pycnonotidae	Tiny Greenbul (fc)*	*Phyllastrephus debilis*	x	x	x	x
Pycnonotidae	Yellow-streaked Greenbul (fc)	*Phyllastrephus flavostriatus*	x		x	x
Pycnonotidae	Zanzibar Sombre Greenbul (fdg)	*Andropadus importunus*			x	
Pycnonotidae	Northern Brownbul (fdg)	*Phyllastrephus strepitans*	x			
Pycnonotidae	Yellow-bellied Greenbul (fc)	*Chlorocichla flaviventris*	x	x	x	x
Turdidae	Eastern Bearded Scrub-Robin (fc)	*Cercotrichas quadrivirgata*			x	
Turdidae	Red-capped Robin-Chat (fdg)	*Cossypha natalensis*	x	x	x	x
Turdidae	Red-tailed Ant-Thrush (fc)	*Neocossyphus rufus*	x	x	x	x

Turdidae	White-browed Scrub-Robin **(fdg)**	*Cercotrichas leucophrys*	x			x
Motacillidae	Sokoke Pipit **(fc)***	*Anthus sokokensis*				x
Dicruridae	Fork-tailed Drongo **(fc)**	*Dicrurus adsimilis*	x	x	x	x
Dicruridae	Square-tailed Drongo **(fc)**	*Dicrurus ludwigii*	x	x	x	x
Platysteiridae	Forest Batis **(fc)**	*Batis mixta*	x		x	x
Estrildidae	Peters's Twinsport **(fdg)**	*Hypargos niveoguttatus*	x	x		x
Estrildidae	Black-and-white Mannikin **(fdg)**	*Lonchura bicolor*	x	x		x

The species are organized in their respective Orders, Families and Common names (Habitats (H): **F** = forest; Fe = forest edge; √= presence of bird species, and * = endemic bird species).

Key to forest patches:
Gen = Gendagenda Forest; Kwm = Kwamsisi Forest; Msu = Msumbugwe Forest; and Zar = Zaraninge Forest.

Appendix 2: Bird species of Gendagenda Forest

Order	Family	Scientific name	Common name
COLUMBIFORMES	Columbidae	*Turtur chalcospilos*	Emerald spotted Wood Dove
	Columbidae	*Turtur tympanistria*	Tambourine Dove
CORACIIFORMES	Alcedinidae	*Halcyon albiventris*	Brown hooded Kingfisher
	Bucerotidae	*Tockus alboterminatus*	Crowned Hornbill
	Phoeniculidae	*Phoeniculus purpureus*	Green Wood Hoopoe
	Alcedinidae	*Halcyon leucocephala*	Grey headed Kingfisher
	Meropidae	*Merops pusillus*	Little Bee eater
	Bucerotidae	*Bycanistes bucinator*	Trumpeter Hornbill
	Meropidae	*Merops albicollis*	White throated Bee eater
CUCULIFORMES	Cuculidae	*Chrysococcyx klaas*	Klaas's Cuckoo
	Musophagidae	*Tauraco porphyreolophus*	Purple crested Turaco
	Cuculidae	*Centropus superciliosus*	White browed Coucal
	Cuculidae	*Ceuthmochares aereus*	Yellowbill
PASSERIFORMES	Eurylaimidae	*Smithornis capensis*	African Broadbill
	Oriolidae	*Oriolus auratus*	African Golden Oriole
	Monarchidae	*Terpsiphone viridis*	African Paradise flycatcher
	Estrildidae	*Lonchura bicolor*	Black and white Mannikin
	Malaconotidae	*Dryoscopus cubla*	Black backed Puffback
	Sturnidae	*Lamprotornis corruscus*	Black bellied Starling
	Sylviidae	*Apalis melanocephala*	Black headed Apalis
	Monarchidae	*Trochocercus cyanomelas*	Blue mantled Crested flycatcher
	Nectariniidae	*Hedydipna collaris*	Collared Sunbird
	Pycnonotidae	*Pycnonotus barbatus*	Common Bulbul
	Ploceidae	*Ploceus bicolor*	Dark backed Weaver
	Pycnonotidae	*Nicator gularis*	Eastern Nicator
	Platysteiridae	*Batis mixta*	Forest Batis
	Dicruridae	*Dicrurus adsimilis*	Fork tailed Drongo
	Malaconotidae	*Malaconotus quadricolor*	Four coloured Bush shrike
	Sylviidae	*Camaroptera brachyuran*	Grey backed Camaroptera
	Sylviidae	*Macrosphenus kretschmeri*	Kretschmer's Longbill
	Monarchidae	*Erythrocercus holochlorus*	Little Yellow Flycatcher
	Pycnonotidae	*Phyllastrephus strepitans*	Northern Brownbul
	Nectariniidae	*Cyanomitra olivacea*	Olive Sunbird
	Estrildidae	*Hypargos niveoguttatus*	Peters's Twinsport
	Nectariniidae	*Anthreptes reichenowi*	Plain backed Sunbird
	Turdidae	*Cossypha natalensis*	Red capped Robin Chat
	Turdidae	*Neocossyphus rufus*	Red tailed Ant Thrush
	Ploceidae	*Ploceus ocularis*	Spectacled Weaver
	Dicruridae	*Dicrurus ludwigii*	Square tailed Drongo
	Pycnonotidae	*Phyllastrephus debilis*	Tiny Greenbul
	Malaconotidae	*Laniarius aethiopicus*	Tropical Boubou
	Nectariniidae	*Anthreptes neglectus*	Uluguru Violet backed Sunbird
	Muscicapidae	*Erythropygia leucophrys*	White browed Scrub Robin
	Pycnonotidae	*Chlorocichla flaviventris*	Yellow bellied Greenbul
	Pycnonotidae	*Phyllastrephus flavostriatus*	Yellow streaked Greenbul
PICIFORMES	Picidae	*Dendropicos fuscescens*	Cardinal Woodpecker
	Capitonidae	*Pogoniulus bilineatus*	Yellow rumped Tinkerbird
TROGONIFORMES	Trogonidae	*Apaloderma narina*	Narina Trogon

Appendix 3: Bird species of Kwamsisi Forest

Order	Family	Scientific name	Common name
Anseriformes	Accipitridae	*Lophaetus occipitalis*	Long crested Eagle
Caprimulgiformes	Caprimulgidae	*Caprimulgus europaeus*	Eurasian Nightjar
Columbiformes	Columbidae	*Turtur chalcospilos*	Emerald spotted Wood Dove
	Columbidae	*Streptopelia semitorquata*	Red eyed Dove
	Columbidae	*Streptopelia capicola*	Ring necked Dove
	Columbidae	*Turtur tympanistria*	Tambourine Dove
Coraciiformes	Alcedinidae	*Halcyon albiventris*	Brown hooded Kingfisher
	Phoeniculidae	*Phoeniculus cyanomelas*	Common Scimitarbill
	Bucerotidae	*Tockus alboterminatus*	Crowned Hornbill
	Phoeniculidae	*Phoeniculus purpureus*	Green Wood Hoopoe
	Bucerotidae	*Bycanistes bucinator*	Trumpeter Hornbill
	Meropidae	*Merops albicollis*	White throated Bee eater
Cuculiformes	Cuculidae	*Chrysococcyx klaas*	Klaas's Cuckoo
	Musophagidae	*Tauraco porphyreolophus*	Purple crested Turaco
	Cuculidae	*Centropus superciliosus*	White browed Coucal
Galliformes	Numididae	*Guttera pucherani*	Crested Guineafowl
Musophagiformes	Musophagidae	*Tauraco fischeri*	Fischer's Turaco
Passeriformes	Eurylaimidae	*Smithornis capensis*	African Broadbill
	Oriolidae	*Oriolus auratus*	African Golden Oriole
	Accipitridae	*Accipiter tachiro*	African Goshawk
	Accipitridae	*Polyboroides typus*	African Harrier Hawk
	Monarchidae	*Terpsiphone viridis*	African Paradise flycatcher
	Nectariniidae	*Nectarinia amethystine*	Amethyst Sunbird
	Muscicapidae	*Muscicapa caerulescens*	Ashy Flycatcher
	Oriolidae	*Oriolus larvatus*	African black headed Oriole
	Estrildidae	*Lonchura bicolor*	Black and white Mannikin
	Malaconotidae	*Dryoscopus cubla*	Black backed Puffback
	Sturnidae	*(Lamprotornis corruscus*	Black bellied Starling
	Campephagidae	*Campephaga flava*	Black Cuckoo shrike
	Sylviidae	*Apalis melanocephala*	Black headed Apalis
	Ploceidae	*Ploceus cucullatus*	Black headed Weaver
	Monarchidae	*Trochocercus cyanomelas*	Blue mantled Crested flycatcher
	Malaconotidae	*Tchagra australis*	Brown crowned Tchagra
	Prionopidae	*Prionops scopifrons*	Chestnut fronted Helmet shrike
	Nectariniidae	*Hedydipna collaris*	Collared Sunbird
	Pycnonotidae	*Pycnonotus barbatus*	Common Bulbul
	Ploceidae	*Ploceus bicolor*	Dark backed Weaver
	Pycnonotidae	*Nicator gularis*	Eastern Nicator
	Dicruridae	*Dicrurus adsimilis*	Fork tailed Drongo
	Sylviidae	*Camaroptera brachyuran*	Grey backed Camaroptera
	Monarchidae	*Erythrocercus holochlorus*	Little Yellow Flycatcher
	Nectariniidae	*Cyanomitra olivacea*	Olive Sunbird

Order	Family	Scientific name	Common name
	Estrildidae	*Hypargos niveoguttatus*	Peters's Twinsport
	Nectariniidae	*Anthreptes reichenowi*	Plain backed Sunbird
	Nectariniidae	*Nectarinia bifasci*	Purple banded Sunbird
	Sylviidae	*Cisticola chiniana*	Rattling Cisticola
	Turdidae	*Cossypha natalensis*	Red capped Robin Chat
	Turdidae	*Neocossyphus rufus*	Red tailed Ant Thrush
	Nectariniidae	*Nectarinia senegalensis*	Scarlet chested Sunbird
	Muscicapidae	*Muscicapa striata*	Spotted Flycatcher
	Dicruridae	*Dicrurus ludwigii*	Square tailed Drongo
	Sylviidae	*Prinia subflava*	Tawny flanked Prinia
	Pycnonotidae	*Phyllastrephus debilis*	Tiny Greenbul
	Nectariniidae	*Cinnyris venustus*	Variable Sunbird
	Pycnonotidae	*Chlorocichla flaviventris*	Yellow bellied Greenbul
Piciformes	Capitonidae	*Lybius melanopterus*	Brown breasted Barbet
	Picidae	*Dendropicos fuscescens*	Cardinal Woodpecker
	Indicatoridae	*Indicator indicator*	Greater Honeyguide
	Picidae	*Campethera mombassica*	Mombasa Woodpecker
	Capitonidae	*Pogoniulus pusillus*	Red fronted Tinkerbird
	Capitonidae	*Pogoniulus bilineatus*	Yellow rumped Tinkerbird
Trogoniformes	Trogonidae	*Apaloderma narina*	Narina Trogon

Appendix 4: Bird species of Msumbugwe Forest

Order	Family	Scientific name	Common name
Columbiformes	Columbidae	*Turtur chalcospilos*	Emerald spotted Wood Dove
	Columbidae	*Streptopelia semitorquata*	Red eyed Dove
	Columbidae	*Streptopelia capicola*	Ring necked Dove
	Columbidae	*Turtur tympanistria*	Tambourine Dove
Coraciiformes	Alcedinidae	*Halcyon albiventris*	Brown hooded Kingfisher
	Phoeniculidae	*Phoeniculus cyanomelas*	Common Scimitarbill
	Bucerotidae	*Tockus alboterminatus*	Crowned Hornbill
	Phoeniculidae	*Phoeniculus purpureus*	Green Wood Hoopoe
	Bucerotidae	*Bycanistes bucinator*	Trumpeter Hornbill
Cuculiformes	Musophagidae	*Tauraco porphyreolophus*	Purple crested Turaco
	Cuculidae	*Centropus superciliosus*	White browed Coucal
	Cuculidae	*Ceuthmochares aereus*	Yellowbill
Gruiformes	Otididae	*Eupodotis melanogaster*	Black bellied Bustard
Musophagiformes	Musophagidae	*Tauraco fischeri*	Fischer's Turaco
Passeriformes	Malaconotidae	*Dryoscopus cubla*	Black backed Puffback
	Sturnidae	*(Lamprotornis corruscus*	Black bellied Starling
	Campephagidae	*Campephaga flava*	Black Cuckoo shrike
	Monarchidae	*Trochocercus cyanomelas*	Blue mantled Crested flycatcher
	Prionopidae	*Prionops scopifrons*	Chestnut fronted Helmet shrike
	Nectariniidae	*Hedydipna collaris*	Collared Sunbird
	Pycnonotidae	*Pycnonotus barbatus*	Common Bulbul
	Ploceidae	*Ploceus bicolor*	Dark backed Weaver
	Turdidae	*Cercotrichas quadrivirgata*	Eastern Bearded Scrub Robin
	Pycnonotidae	*Nicator gularis*	Eastern Nicator
	Platysteiridae	*Batis mixta*	Forest Batis
	Dicruridae	*Dicrurus adsimilis*	Fork tailed Drongo
	Malaconotidae	*Malaconotus quadricolor*	Four coloured Bush shrike
	Sylviidae	*Camaroptera brachyuran*	Grey backed Camaroptera
	Monarchidae	*Erythrocercus holochlorus*	Little Yellow Flycatcher
	Nectariniidae	*Anthreptes reichenowi*	Plain backed Sunbird
	Turdidae	*Cossypha natalensis*	Red capped Robin Chat
	Turdidae	*Neocossyphus rufus*	Red tailed Ant Thrush
	Prionopidae	*Prionops retzii*	Retz's Helmet shrike
	Muscicapidae	*Muscicapa striata*	Spotted Flycatcher
	Dicruridae	*Dicrurus ludwigii*	Square tailed Drongo
	Pycnonotidae	*Phyllastrephus terrestris*	Terestrial Brownbull
	Pycnonotidae	*Phyllastrephus debilis*	Tiny Greenbul
	Malaconotidae	*Laniarius aethiopicus*	Tropical Boubou
	Pycnonotidae	*Chlorocichla flaviventris*	Yellow bellied Greenbul
	Pycnonotidae	*Phyllastrephus flavostriatus*	Yellow streaked Greenbul
	Pycnonotidae	*Andropadus importunes*	Zanzibar Sombre Greenbul
Piciformes	Capitonidae	*Lybius torquatus*	Black collared Barbet
	Capitonidae	*Lybius melanopterus*	Brown breasted Barbet
	Picidae	*Campethera mombassica*	Mombasa Woodpecker
	Capitonidae	*Pogoniulus bilineatus*	Yellow rumped Tinkerbird
Trogoniformes	Trogonidae	*Apaloderma narina*	Narina Trogon

Appendix 5: Bird species of Zaraninge forest

Order	Family	Scientific name	Common name
Caprimulgiformes	Caprimulgidae	*Caprimulgus europaeus*	Eurasian Nightjar
Columbiformes	Columbidae	*Columba delegorguei*	Eastern Bronze naped Pigeon
	Columbidae	*Turtur chalcospilos*	Emerald spotted Wood Dove
	Columbidae	*Streptopelia semitorquata*	Red eyed Dove
	Columbidae	*Turtur tympanistria*	Tambourine Dove
Coraciiformes	Alcedinidae	*Ispidina picta*	African Pygmy Kingfisher
	Coraciidae	*Eurystomus glaucurus*	Broad billed Roller
	Alcedinidae	*Halcyon albiventris*	Brown hooded Kingfisher
	Phoeniculidae	*Phoeniculus cyanomelas*	Common Scimitarbill
	Bucerotidae	*Tockus alboterminatus*	Crowned Hornbill
	Phoeniculidae	*Phoeniculus purpureus*	Green Wood Hoopoe
	Alcedinidae	*Alcedo semitorquata*	Half collared Kingfisher
	Bucerotidae	*Bycanistes bucinator*	Trumpeter Hornbill
	Meropidae	*Merops albicollis*	White throated Bee eater
Cuculiformes	Cuculidae	*Chrysococcyx klaas*	Klaas's Cuckoo
	Musophagidae	*Tauraco porphyreolophus*	Purple crested Turaco
	Cuculidae	*Centropus superciliosus*	White browed Coucal
Galliformes	Numididae	*Guttera pucherani*	Crested Guineafowl
Musophagiformes	Musophagidae	*Tauraco fischeri*	Fischer's Turaco
Passeriformes	Eurylaimidae	*Smithornis capensis*	African Broadbill
	Monarchidae	*Terpsiphone viridis*	African Paradise flycatcher
	Nectariniidae	*Nectarinia amethystina*	Amethyst Sunbird
	Muscicapidae	*Muscicapa caerulescens*	Ashy Flycatcher
	Accipitridae	*Polyboroides typus*	African Harrier Hawk
	Accipitridae	*Macheiramphus alcinus*	Bat Hawk
	Estrildidae	*Lonchura bicolor*	Black and white Mannikin
	Malaconotidae	*Dryoscopus cubla*	Black backed Puffback
	Sturnidae	*(Lamprotornis corruscus*	Black bellied Starling
	Campephagidae	*Campephaga flava*	Black Cuckoo shrike
	Monarchidae	*Trochocercus cyanomelas*	Blue mantled Crested flycatcher
	Prionopidae	*Prionops scopifrons*	Chestnut fronted Helmet shrike
	Nectariniidae	*Hedydipna collaris*	Collared Sunbird
	Pycnonotidae	*Pycnonotus barbatus*	Common Bulbul
	Ploceidae	*Ploceus bicolor*	Dark backed Weaver
	Pycnonotidae	*Nicator gularis*	Eastern Nicator
	Oriolidae	*Oriolus oriolus*	Eurasian Golden Oriole
	Platysteiridae	*Batis mixta*	Forest Batis
	Dicruridae	*Dicrurus adsimilis*	Fork tailed Drongo
	Sylviidae	*Camaroptera brachyuran*	Grey backed Camaroptera
	Malaconotidae	*Malaconotus blanchoti*	Grey headed Bush shrike
	Monarchidae	*Erythrocercus holochlorus*	Little Yellow Flycatcher
	Nectariniidae	*Cyanomitra olivacea*	Olive Sunbird
	Estrildidae	*Hypargos niveoguttatus*	Peters's Twinspot
	Nectariniidae	*Anthreptes reichenowi*	Plain backed Sunbird
	Turdidae	*Cossypha natalensis*	Red capped Robin Chat
	Turdidae	*Neocossyphus rufus*	Red tailed Ant Thrush
	Prionopidae	*Prionops retzii*	Retz's Helmet shrike
	Motacillidae	*Anthus sokokensis*	Sokoke Pipit
	Dicruridae	*Dicrurus ludwigii*	Square tailed Drongo
	Pycnonotidae	*Phyllastrephus terrestris*	Terestrial Brownbull
	Pycnonotidae	*Phyllastrephus debilis*	Tiny Greenbul
	Malaconotidae	*Laniarius aethiopicus*	Tropical Boubou
	Nectariniidae	*Cinnyris venustus*	Variable Sunbird
	Muscicapidae	*Erythropygia leucophrys*	White browed Scrub Robin
	Pycnonotidae	*Chlorocichla flaviventris*	Yellow bellied Greenbul
	Pycnonotidae	*Phyllastrephus flavostriatus*	Yellow streaked Greenbul
Piciformes	Capitonidae	*Lybius torquatus*	Black collared Barbet
	Picidae	*Dendropicos fuscescens*	Cardinal Woodpecker
	Capitonidae	*Pogoniulus bilineatus*	Yellow rumped Tinkerbird
Trogoniformes	Trogonidae	*Apaloderma narina*	Narina Trogon

Appendix 6: Distribution of transects in the study sites

Forest Patch	Transect no	Part of habitat	Position of transect			
			Start		End	
			UTM 1	UTM 2	UTM 1	UTM 2
Zaraninge	1	Forest edge	458029	9325754	457781	9325484
	2	Forest edge	457554	9325548	457066	9325213
	3	Forest edge	457531	9325105	457066	9325213
	4	Forest edge	456963	9325223	457042	9324782
	5	Forest core	456022	9322407	456292	9322537
	6	Forest core	456255	9322031	455985	9322320
	7	Forest core	456793	9322152	456799	9322673
	8	Forest core	457073	9321791	456601	9322011
Kwamsisi	1	Forest edge	456582	9345907	456217	9346002
	2	Forest edge	456204	9346153	456060	9346517
	3	Forest edge	456060	9349754	455000	9347146
	4	Forest core	455716	9346931	456022	9346695
	5	Forest core	456116	9346248	456182	9345076
	6	Forest core	456740	9345925	457057	9346034
	7	Forest core	457197	9345856	457130	9345585
	8	Forest core	456824	9345920	459641	9345614
Msumbugwe	1	Forest edge	471496	9390096	471839	9389932
	2	Forest edge	471966	9387949	472054	9389603
	3	Forest edge	472040	9389475	472315	9389210
	4	Forest edge	472379	9389328	472669	9389493
	5	Forest core	472507	9389659	472506	9390109
	6	Forest core	472710	9390249	472793	9390732
	7	Forest core	472460	939096	472211	9391023
	8	Forest core	472122	9390973	472089	9390536
Gendagenda	1	Forest core	460622	9383807	460208	9383713
	2	Forest core	460733	9383733	460682	9384233
	3	Forest core	460631	9384332	460379	9384394
	4	Forest core	460511	9384380	460300	938460
	5	Forest edge	460674	9383011	460998	9383197
	6	Forest edge	461280	9383356	461269	9383751
	7	Forest edge	461218	9383907	461316	9384296
	8	Forest edge	461347	9384487	461373	9384871