WILD BIRD DISTRIBUTION, DIVERSITY AND VIRAL SURVEILLANCE IN INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE, IBADAN

BY

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COVER

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ABSTRACT

The distribution and abundance of niche specific bird species tend to narrow and decline due to habitat fragmentation and alteration attributed to human development. Nonetheless, the proximity of free ranging poultry to Wild Birds (WB) hotspots provide increased opportunity for interaction and disease transmission between wild and domestic birds. However, the diversity and viral prevalence of WB have not been fully documented in Nigeria. Therefore, diversity indices and viral prevalence of some WB species in International Institute of Tropical Agriculture, Ibadan, Nigeria were investigated.

Line transects and mist-netting techniques were used for the WB survey. Complete randomised design was used to assign nine transects 1 km each in forest, farm and dam. Habitat variables were measured in 200m sections. The habitat types were subdivided into ten types of land-use namely; forest, forest edge, cassava, maize, maize-cassava, citrus-cassava-maize, dam-grassland, dam-gallery forest, rice-paddy and ponds. Transects were surveyed monthly and birds trapped quarterly over 22 months. Surveys were carried out from 5.30 am-12.00 noon and 3.00-6.30 pm. Birds seen or heard were identified to species level with the aid of Helmsfield guide of Western Africa and collection of bird calls. Trapped birds were ringed and biometric measurements taken. Cloacal, oropharyngeal and faecal swabs were collected into virus transport medium. Viral RNA was extracted from swabs and reverse transcription PCR performed to test for some viruses. Bird Species Abundance (BSA), Bird Species Richness (BSR), Bird Species Evenness (BSE), Shannon-Wiener diversity index (H), Simpson's diversity index (D) and

Viral Prevalence (VP) were determined. Data was analysed using descriptive statistics and ANOVA at p=0.05.

A total of 985 WB in 66 species were trapped with a recapture of 15.3%, while IITA yielded a species richness of 238 species of WB in 61 families. Highest capture from forest, farm and dam were *Bleda canicapillus* (135), *Ploceus nigricollis* (38) and *Actophilornis africana* (12) with recapture of 35.6%, 0% and 8.3% respectively. *Streptopelia semitorquata* had the highest seasonal sighting index of 36.2±6.7 birds. The BSA (73.5±167.8) was highest in dam, while D (0.3±0.2) was highest in farm. The BSR (9.0±4.5), BSE (0.9±0.1) and H (1.9±0.5) were highest in forest. Conversely, BSA (18.6±13.2) and D (0.1±0.1) were lowest in the forest. In addition, BSR (6.8±4.3) and H (1.4±0.6) were lowest in farm, while BSE (0.8±0.2) was lowest in the dam. Pooling all data, BSR (morning: 8.6±0.4, evening: 7.4±0.8) and H (morning: 1.6±0.1, evening: 1.49±0.2) were higher in the morning, while BSA (morning: 55±13.5 birds, evening: 66.5±45.5 birds) and D (morning: 0.2±0.1, evening: 0.4±0.1) were higher in the evening. The investigated viruses and their prevalence were Newcastle disease, avian influenza, rotavirus, infectious bronchitis, chicken astrovirus, turkey astrovirus I and II with 9.5%, 0%, 0%, 0%, 0%, 0% and 0% respectively.

Habitat diversity was responsible for the high bird species diversity. Monocultures such as farms and ponds did not support high levels of diversity and richness of wild bird species. Bird species increased with habitat diversity. Viral prevalence among wild birds was low, suggesting low possibility of disease transmission from them to domestic birds.

Keywords: Bird diversity, Viral prevalence, Wild bird recapture, Land-use

Word count: 500

DEDICATION

This research is dedicated with praise and thanksgiving to the Almighty God who is the essence of my being and living.

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CERTIFICATION

We certify that this research work was carried out by Mr T. A. Adeyanju in the Department of Wildlife and Ecotourism Management, Faculty of Agriculture and Forestry, University of Ibadan, Ibadan, Nigeria. The work has not been presented elsewhere for the award of a higher degree, diploma or certificate.

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ABBREVIATIONS

AFRING : African Ringing scheme

AIV: Avian Influenza Virus

APLORI : A.P Leventis Ornithological Research Instirute

APMV: Avian paramyxovirus type 1

AVL: Lysis buffer

CITES: Convention on International Trade in Endangered Species

CBD; Convention on Biological Diversity

DAMGAL: Dam Gallery Forest

DAMGRA: Dam Grassland

dNTP: Deoxy Nitro Tri Phosphate

FAO: Food and Agriculture Organization

FOREDGE: Forest Edge

GCRF: Guinea Congolian Rain Forest

HPAI: Highly Pathogenic Avian Influenza

IBA: Important Bird Area

IBV: Avian Infectious Bronchitis

IITA: International Institute of Tropical Agriculture

IUCN: International Union for the Conservation of Nature

LBM: Life Bird Market

LPAI: Low Pathogenic Avian Influenza

LPM: Live Poultry markets

MAZECASS: Maize and Cassava

NDV: Newcastle Disease Virus

NTFP: Non Timber Forest Products

OIE: Office International des Epizooties

PBS: Phosphate Bovine Saline

PCR: Polycromase Chain Reaction

RNA: Ribonucleic Acid

RT-PCR: Reverse Transcription Polycromase chain reaction

SGRS: Sudan Guinea Restricted Species

UI: University of Ibadan

UNDP: United Nations Development Programme

UNICEF: United Nations Children Fund

VP: Viral Prevalence

WHO: World Health Organization

WNV: West Nile Virus

CHAPTER ONE

INTRODUCTION

1.0 GENERAL INTRODUCTION

Wild birds play beneficial roles as insectivores, granivores, nectarinivores and scavengers. They also serve in biological control of some pests, dispersal of seeds, pollination of plants, cleaning, recycling for ecosystem sustenance and ecosystem engineering (Kelly *et al*., 2004). They are regarded as the best known class of vertebrate animals that occur worldwide in nearly all habitats (Whelan *et al*., 2008). There are therefore, no controversies in stating that the African continent is endowed with rich biodiversity. Presently, 1,230 sites across 58 states and associated islands of Africa have been described as Important Bird Areas (IBAs) of global importance for wild birds (Fishpool and Evans, 2001).

However, birds with affinity for wetland habitats make up 60 percent of wild species infected with highly pathogenic avian influenza (HPAI) and account for a better proportion of wildlife casualties from avian influenza (AI) epidemics. Cases of epizootics of HPAI among wild birds in Asia in 2005 led to the death of thousands of waterfowl; yet this does not simply imply that wild birds are the source of the outbreak (Georg *et al*., 2006). Newcastle disease virus (NDV) is also widely accepted among virologists as being resident in African bird populations. However, virological and epidemiological information concerning NDV strains circulating within western and central regions of Africa are extremely scarce (Cattoli *et al*., 20010; Snoeck *et al*., 2009).

The term “wetland” encompasses a variety of inland fresh water and marine coastal habitats that share one common feature; soil and substrates that are at least periodically covered with water. (Ramsar Convention Bureau, 1997). Wild birds have been quick to adapt to altered habitats, and they are commonly seen at water reservoirs, flooded agricultural fields, poultry farms, residential premises and also in all natural landscapes. As the most frequently detected hosts of pathogenic influenza virus, wetland birds represent an appropriate target for active disease surveillance. The Anatidae family, also known as water birds is well studied; they are the only group in which avian influenza virus has been found all year round. (Tankersley and Orvis, 2003; Gaidet *et al.*, 2008; Sims and Narrod, 2008).

The host source of viral infection resulting in continuous epidemics of viruses has been a long-term debate among supporters of wild birds; as well as those in favour of domestic and commercial poultry. Wild birds have in general been indicted as serving as a host for avian influenza but human beings could potentially acquire and or transport infection to local poultry or to wild birds through contaminated equipment and animals (Peiris *et al*., 2007). The challenge is whether our treasured biodiversity hotspots are serving as reservoirs for pathogenic viral strains?

Wild birds of various groups occupy altered landscapes and are the best known tool for interpreting the effects of land use(s) on our ecosystem. Varying types of land use occur all around Nigeria; from backyard farms to large scale plantations, residential houses, schools, hospitals, dams and irrigation projects. In addition, wild birds are an invaluable resource and challenges are arising in the race to conserve quality and viable habitats for wildlife as a result of land use and developmental decisions. The value of these services becomes pronounced when some species of wild birds become extinct or populations get threatened and human community have to provide an alternative surrogate to ensure the continual discharge of these services. In addition, careful monitoring of wild bird species composition and abundance data is important because deforestation and agricultural intensification are still ongoing.

This study has brought to light such bird groups occupying IITA environs, which is a secondary forest reserve. It monitored the change in distribution of bird groups through the two years of the study and determined the incidence and prevalence of some viruses in wild birds using Reverse Transcription Polycromase Chain Reaction (RT-PCR).

1.1 JUSTIFICATION

This study is important because results give evidence on answers that are sought in respect to host reservoir of viruses such as AI and NDV. Inventory of bird species present at the reservoir has provided a working database for monitoring bird distributions throughout the year. This study has outlined some effects of land use on ecosystem processes and services; in general the results can be applied in managing future epidemics and environmental issues on a wider scale.

1.2 MAIN OBJECTIVE

To monitor and compare bird species distribution, diversity, viral incidence and determine possible transmission routes between wild and domestic birds in the International Institute of Tropical Agriculture (IITA) environs.

1.3 SPECIFIC OBJECTIVES

i. To identify bird groups at the study site, determine species abundance, species richness and diversity at IITA environs during each month of the year

ii. To investigate zoonotic viral incidence and virus prevalence in wild birds and domestic poultry around the IITA environs. To determine the possible transmission pathways of viruses between domestic and wild waterfowl around the study site.

CHAPTER TWO

LITERATURE REVIEW

2.1.0 DEFINITION OF A FOREST

There has been confusion about forested protected areas or areas of forest falling within protected areas and in particular what counts as a protected area in a forest biome, particularly when such information is incorporated into wider data collection about forest resources (Dudley, 2008). The following definition draws on that of UNECEF/FAO and adds interpretation from International Union for the Conservation of Nature (IUCN).

A forest is land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 ha. The trees within should be able to reach a minimum height of 5m at maturity *in situ*. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground, or open forest formations with a continuous vegetation cover in which tree crown cover exceeds 10 percent. Young natural stands and all plantations established for forestry purposes which have yet to reach a crown density of 10 percent or tree height of 5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention or natural causes but which are expected to revert to forest. It includes forest nurseries and seed orchards that constitute an integral part of the forest, forest roads, cleared tracts, firebreaks and other small open areas; forest of special scientific, historical, cultural, religious interest; windbreaks and shelterbelts of trees with an area of more than 0.5 ha and width of more than 20 m; plantations primarily used for forestry purposes. However, it excludes land predominantly used for agricultural purposes. Other areas of land covered with vegetation not able to meet these requirements are classified as wooded land or woodland.

The definition should be used in relation to forest being protected for the sustenance of biodiversity and therefore plantation forests whose principal aim is for industrial roundwood, gum or fruit should not be counted as forested protected areas. Nonetheless, land being restored to natural forest should be counted if the principal objective is the maintenance and protection of biodiversity and associated cultural values as is the case of the International Institute of Tropical Agriculture Forest Reserve, Ibadan. In contrast however is the case where exotic plantations within protected areas are counted as forest. This is wrong as the former do not provide habitat suitable for indigenous biota.

2.1.1 TROPICAL FOREST STATUS

Tropical forests have assumed a status of global significance out of the World's entire habitat in recent years. Although the tropical forest account for a relatively small proportion of global land average (about 7% or 10.9 million km^2), they accommodate a very high proportion of species in all major groups. African forests, for example are estimated to hold about 84% of the continent's primates species, 66% of butterflies and about 8,000 species of plants (BirdLife International, 2000). The World Bank (2009) estimates that the fastest rate of forest loss in the world between 1990 and 2005 was the Sub Saharan African region (7.1%), followed closely by Latin America (7.0). Deforestation which is the complete removal of forest cover and replacement with other forms of land use and forest degradation (the impoverishment of the structure and composition of the forest) result in the reduction of potentials of flora and fauna to provide and support environmental processes (FAO, 2007b). Also FAO

(2004) reports that Cape Verde produces industrial supply of hardwood and round wood that top the Sub Saharan region, Nigeria tops the list of countries which produce wood charcoal (2.54 MT).

Recent data show that only 8 countries in SSA have the Maputo target of 10% of public expenditure allocated to the agricultural and rural sectors. In addition, the yield per hectare of food crops is less than the average level in developing countries; most of the land is depleted while fertilizers are scares and expensive (APP, 2009). Therefore curbing the speed of deforestation and degradation of forest ecosystem in general is made difficult because livelihood of the dependents of the remaining forest areas are threatened (UNDP-GEF, 2008). The result is that Millennium Development Goals and targets cannot be met in time. Consequently, alternatives that need to be provided for communities surrounding protected area cannot be supplied and or well maintained, the result is continual dependence upon protected areas for supplementation of livelihood.

Loss of habitat and degradation are the major causes of endangerment in birds, threatening a total of 1,008 birds (85% of all). Of these, 74 % are affected by recent loss of tropical forest. Of the 902 threatened birds that use the forests, 93% occur entirely in the tropics and 82% of these in moist forests. As a result of this, a total of 1,186 bird species (about 12%) of all bird species have a real risk of becoming extinct in the next 100 years because of habitat loss. Most disturbingly, 182 are critically endangered, meaning that, they have only an estimated 50% chance of surviving over the next 10 years, a further 31 are endangered, 680 are vulnerable and 727 (Near Threatened) are close to qualifying as threatened (BirdLife International, 2000).

Africa's forest area is distributed in the order; Central Africa, 37.1%; East Africa, 12.1%; North Africa, 12.1%; Southern Africa, 27%; and West Africa 11.7% (FAO, 2007b).

Large areas of natural forests are being exploited for tree species such as the mahoganies, *Nauclea diderrichii* (opepe), *Terminalia ivorensis* (Odigbo), *Terminalia superba* (Afara), *Triplochiton sceleroxylon* (Obeche) and others known in international market (Nigeria's 4th Biodiversity Report, 2010). High intensity of logging and illegal exploitation of these and other species has continued to pose serious threats to the country's forest resources. Non-timber forest products (NTFPs) are used for food, medicines, oil, resin, tannin, household equipment, fuel wood and furniture and building materials.

The subsistence rural dwellers have continued to exploit these products for income generation. Varieties of NTFPs of other economic uses include the rattan cane (*Laccosperma sedndiflora*), chewing sticks (*Garcinia manii*), wrapping leaves such as *Thaumatococcus danielli* which also produces fruits that are sweeter than sugar. *Triplochiton sceleroxylon* is known to be the host of the larvae of *Enaphae venata*, a moth species which apart from producing cocoons that are good material for local silk ("Sanyan") are also good sources of animal protein to both the urban poor and rural dwellers. There has been a trend of increasing use of medicinal plants amongst both urban and rural dwellers. This trend has grave consequences on the survival of some plant species. This is because of the unsustainable manner in which many species are harvested. Furthermore, the downturns in the national economy and inflationary trend have led to the excessive harvesting of non-timber forest products. Some of the species are now threatened. Examples are *Hymenocardia acida, Kigelia africana* and *Cassia nigricans* (Nigeria's 4th Biodiversity Report, 2010).

2.1.2 INLAND WATER AREAS

Inland water ecosystems occupy only a small area of the planet but are perhaps the most heavily impacted and threatened by human activities of all biomes and habitats (Dudley, 2008). Several efforts have been made by governments and the conservation community in general to conserve inland water species and habitats, but unavoidably these commitments and goals have not been realized fully. In conserving quality habitats, surrounding communities are provided with services especially in areas where there is a shortage of portable water. The term inland waters (inland wetlands), freshwater systems, and simply wetlands are often used interchangeably, but there are some differences. Inland water or inland wetlands refer to non-marine aquatic systems; and whether transitional systems like estuaries are included is a matter of interpretation. Nevertheless, inland wetland is the term used by the CBD. Freshwater is technically defined as "of, relating to, living in, or consisting of water that is not saline". But in practice the term is often used as equivalent to inland wetland (Dudley, 2008).

Wetlands are unique biotic communities involving diverse plants and animals that are adapted to shallow and often dynamic water regimes. The Convention on Wetlands of International importance especially as Waterfowl Habitat, commonly called the "Convention on Wetlands" Ramsar, signed in Ramsar, Iran, 1971, defines wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters" (Ramsar Convention Bureau, 1996). In addition, the convention provides that wetlands "may incorporate marine, riparian and coastal zones adjacent to the wetlands and island or bodies of marine water deeper than six meters at low tide lying within the wetland".

There are also man-made wetlands such as fish and shrimp ponds, farm ponds, irrigated agricultural land, salt pans, reservoirs, gravel pits, sewage pits, sewage farms, and canals (Ramsar Convention Bureau, 1996; Weller, 1999; Amezaga *et al.*, 2002; Dudley, 2008). Nonetheless, natural inland wetlands include permanent and temporary rivers and streams, permanent lakes; seasonal lakes, marshes, and swamps, including floodplains, forested wetlands, marshes, and swamps; alpine and tundra wetlands; springs, oases and geothermal wetlands; and underground wetlands, including caves and groundwater systems.

2.1.3 NIGERIA'S BIODIVERSITY

Nigeria is rich in biodiversity. A country report published by the Federal Environmental Protection Agency (FEPA) indicates that Nigeria possesses more than 5,000-recorded species of plants and over 22,000 species of animals. These species include about 20,000 insects, about 1,000 birds, about 1,000 fishes, 247 mammals and135 reptiles. Of these animals about 0.14% is threatened while 0.22% is endangered including insects. It estimated that 0.4% of the plant species are threatened and 8.5 % endangered (Nigeria's 4th Biodiversity Report, 2010).

Though, Nigeria is known as a global hotspot for primate species, a great proportion of this diversity is found in the Gulf of Guinea forests of Cross River State. Cross River among others states is also a key hotspot area for amphibian biodiversity. Some of the endemic species include three monkeys, the white throated monkey (*Cercopithecus erythrogaster*), Sclater's guenon (*Cercopithecus sclateri*) and the Niger Delta red colobus (*Procolobus pennantii epieni*) and four bird species, the Anambra waxbill (*Estrilda poliopareia*), the Ibadan malimbe, (*Malimbus ibadanensis*), the Jos Plateau indigo-bird (*Vidua maryae*) and the Rock Fire-Finch

Lagonosticta sanguinodorsalis. The most endangered gorilla subspecies on earth, the Cross River gorilla (*Gorilla gorilla diehli*) with an estimated population of less than 250 individuals is found in a couple of protected areas in Cross-River State, south eastern Nigeria and in Cameroon (Nigeria's 4th Biodiversity Report, 2010).

The Nigerian government recognizes the need to conserve its biological diversity and has made a commitment to conserve 25% of Nigeria's total forest area. Emphasis is placed on in situ conservation of biodiversity within protected areas such as Forest Reserves, Game Reserves, National Parks and Wildlife Sanctuaries. In situ conservation outside protected areas is encouraged to complement conservation of biological diversity inside protected areas, to secure Nigeria's biodiversity for future generations. Priority attention is placed on conservation of unique ecological characteristics and ecosystems such as mountain, mangrove, wetlands, savannah, rainforests and transit sites for migratory species. The Plan contains specific priority setting and actions for ex situ conservation of various species of plants and animals of economic importance, including re-introduction of locally extinct animals, lost crops, and conservation of threatened or endangered species. The administrative and policy reforms contained in the Plan provide a vehicle for achieving our biodiversity conservation goals and objectives. (Nigeria's 4th Biodiversity Report, 2010)

2.1.4 PROTECTED AREAS

These could be either national or internationally recognised areas, however nationally designated protected areas are those that are recognised, supported and designated by national legislation and or authority while international sites are areas that are recognised and protected by international agreements, such as treaties or conventions.

However, the collective responsibility of calling nations to the responsibility of protection of important sites in terms of conventions and treaties is thought to assure a greater or stronger protection status than when national governments or their subsidiaries do the same. Funding is however, a key issue and international status does command more attention than local or single government designations such as National Parks and game reserves.

2.1.4.1 UN CONVENTION ON BIOLOGICAL DIVERSITY (CBD)

The objectives of the convention are outlined in Article 1 of the CBD is the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and appropriate funding' (CBD, 2014).

This convention was established in 1992, the Earth summit held in Rio de Janeiro, Brazil, with the aim of bringing nations together to reach global agreement of sustainable development. Today, there are 191 contracting parties to the CBD. The conference of parties is the governing body of the convention and meets every two years to consider the state of implementation of the convention (UNEP-WCMC, 2008; Nigeria's 4th Biodiversity Report, 2010).

Nigeria launched her National Biodiversity Strategy and Action Plan in 1997. The goal of the National Biodiversity Strategy and Action Plan (NBSAP) is to develop appropriate framework and programme instruments for the conservation of Nigeria's Biological Diversity and enhance its sustainable use by integrating biodiversity consideration into national planning, policy and decision-making processes. This strategy is part of our national commitments under the Convention on Biological Diversity and a testimony of our responsibilities to future generations. The NBSAP established an adaptive process that institutes national goals, sets priorities, and provides frameworks for addressing biodiversity conservation; sustainable use of biological resources, equitable sharing of benefits; conservation of agro-biodiversity; biosafety; and biodiversity–industry interface. (Nigeria's 4th Biodiversity Report, 2010).

2.1.4.2 UNITED NATIONS MILENNIUM DEVELOPMENT GOALS (UN-MDG)

These are basically eight goals to be achieved by 2015 in response to the world's main development challenges. The MDGs are drawn from the actions and targets contained in the United Nations Millennium declaration, adopted by 189 nations and signed by 147 heads of state and government's during the UN Millennium summit in September 2000. Protected areas are an explicit part of MDG goal 7, which ensures environmental sustainability and this goal has two targets; firstly, to integrate the principles of sustainable development into country policies and programmes, and reverse the loss of environmental resources, and secondly, to reduce biodiversity loss, achieving by 2010 a significant reduction in the rate of loss (UNEP-WCMC, 2008; UN-MDG, 2014).

2.1.4.3 UNESCO WORLD HERITAGE SITES

The United Nations Educational, Scientific, and Cultural Organisation (UNESCO) World Heritage Programme seeks to 'encourage the identification, protection and preservation of cultural and natural heritage around the world considered to be of outstanding value to humanity.' The Convention encourages the designation of biological and cultural heritage sites as adopted by UNESCO in 1972 and has been ratified by 185 state parties (UNEP-WCMC, 2008).

2.1.4.4 UNESCO MAN AND THE BIOSPHER RESERVES

UNESCO's Man and the Biosphere Programme's (MAB) overriding aim is to improve the global relationship of people with their environment. This was launched in 1970, and its biosphere reserve concept was launched in 1974. Biosphere reserves have three interconnected functions; firstly, conservation of landscapes, ecosystems, species and genetic variation, and secondly, development, economic, human and culturally adapted, and thirdly logistic support by providing research, monitoring, environmental education and training (UNEP-WCMC, 2008; UNESCO-MAB, 2014).

2.1.4.5 THE RAMSAR CONVENTION ON WETALNDS

The convention on wetlands was signed in Iran, in 1971. It aims to conserve and wisely use all wetlands through local, national and regional cooperation in concert with sustainable development. A broad definition of wetlands is used, with protected habitats including lakes, rivers, marshes, peatlands, near-shore marine areas, coral reefs, mangroves, and similar human-made areas such as rice paddies (UNEP-WCMC, 2008; Ramsar Convention Bureau, 1997). The Nguru Lake (and Marma Channel) complex in the Hadejia-Nguru wetlands was designated the first Ramsar Site for Nigeria.

2.1.4.6 IMPORTANT BIRD AREAS IN NIGERIA

Twenty-seven Important Bird Areas (IBAs) have been identified (Figure 2.1, Ezealor 2001), covering about 31,118 km² or 3.4% of the land area of the country, although the area of three sites is undefined. Fourteen are legally protected, two are privately-owned, six are partially protected, and five have no form of legal protection. It should be noted that none of Nigeria's endemic birds have been found to occur in National Parks or other legally protected areas (Ezealor, 2001).

Twelve sites qualify under the A1 criterion, for species of global conservation concern, and three sites do so for both the Cameroon and Gabon lowlands EBA and the Cameroon mountains EBA, holding respectively, all three and all 18 restricted-range species of the EBAs known from Nigeria (Ezealor, 2001). For the biome-restricted assemblages, three sites were designated for the Sahel biome (A03), at which nine of the 13 biome-restricted species were recorded nationally, 12 sites qualify for the Sudan–Guinea Savanna biome (A04) which collectively hold 40 of the 42 species in Nigeria, 14 sites qualify for the Guinea–Congo Forests biome (A05) (holding 182 of the 187 species) and three do so for the Afrotropical Highlands biome (A07).

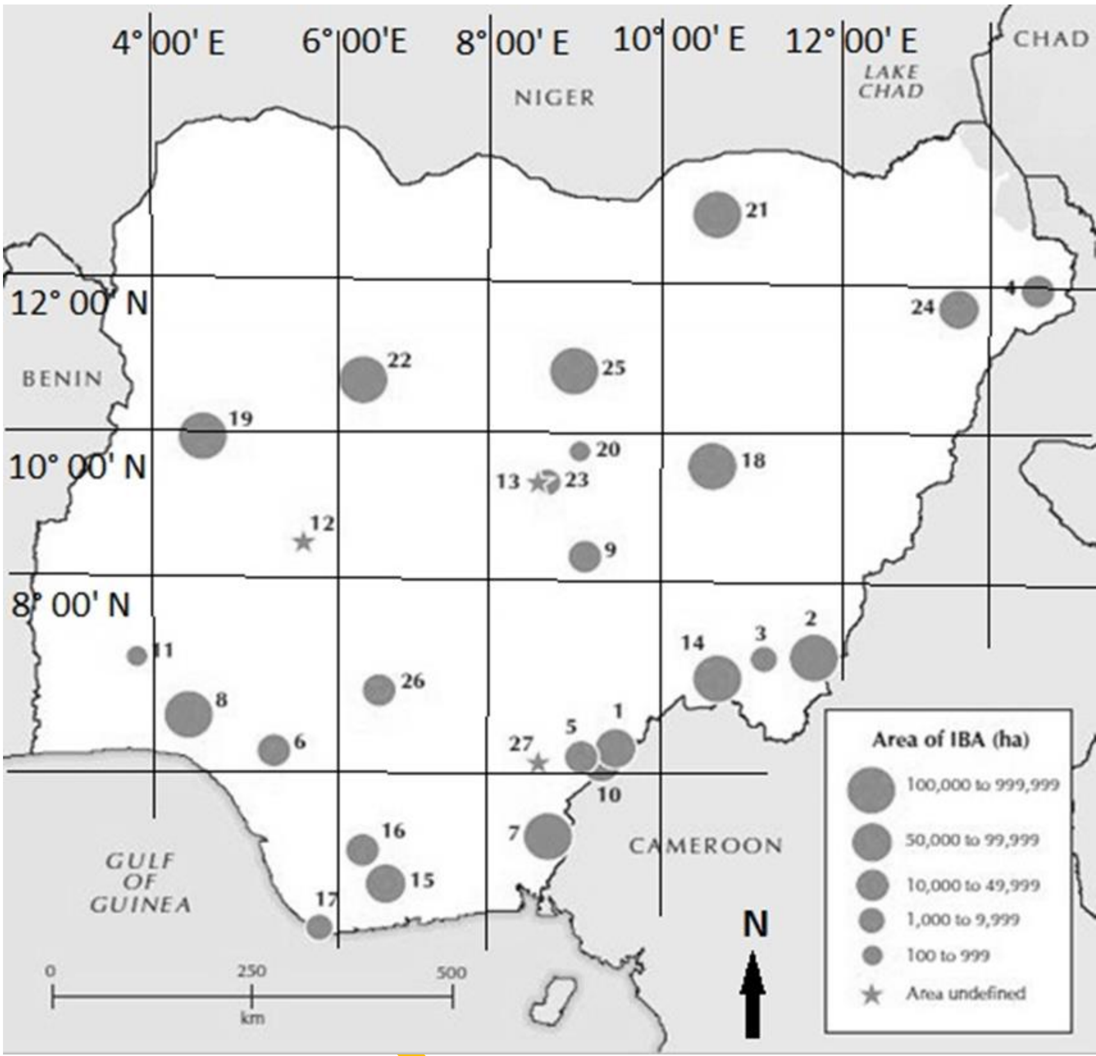

Figure 2.2: Location of Important bird Areas in Nigeria and their sizes. Source: Ezealor, 2001

{1. Obudu Plateau (Cross River) 2. Gashaka-Gumti National Park (Adamawa and Taraba) 3. Ngel-Nyaki Forest (Taraba) 4. Chad basin National Park- Chingurmi-Duguma Sector (Borno) 5. Afi River Forest Reserve (Cross River) 6. Okomu National Park (Edo) 7. Cross River National Park-Oban Division (Cross River) 8. Omo Forest Reserve (Ogun) 9. Pandam Wildlife Park (Plateau) 10. Cross River National Park-Okwango Division (Cross River) 11. IITA Forest Reserve, Ibadan (Oyo) 12. Lower Kaduna-Middle Niger Flood-plain (Niger) 13. Kagoro-Nindam Forest Reserves (Kaduna) 14. Donga River Basin Forests (Taraba) 15. Upper Orashi Forests (Rivers) 16. Biseni Forests (Rivers) 17. Akassa forests (Bayelsa) 18. Yankari Game Reserve (Bauchi) 19. Kainji Lake National Park (Kwara) 20. Amurum Woodlands-Taboru (Plateau) 21. Hadejia-Nguru Wetlands (Yobe, Jigawa and Bauchi) 22. Kamuku National Park (Kaduna) 23. Assop Falls and Hills (Plateau) 24. Sambisa Game Reserve (Borno) 25. Falgore and Lama Burra Game Reserves (Bauchi and Kano) 26. Sunvit Farm (Edo) 27. Ebot-Kabaken (Cross River)}

2.1.4.7 CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES (CITES)

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was established as a response to growing concerns that over-exploitation of wildlife through international trade was contributing to the rapid decline of many species of plants and animals around the world. The Convention was signed by representatives from 80 countries in Washington, DC, US, on 3 March 1973, and entered into force on 1 July 1975 (IISD, 2011).

There are currently 175 parties to the Convention and the primary aim of CITES is to ensure that international trade in wild animal and plant species does not threaten their survival. CITES parties regulate wildlife trade through controls and regulations on species listed in three appendices. Appendix I lists species threatened with extinction, permitting such trade only in exceptional circumstances. Appendix II species are those that may become endangered if their trade is not regulated, thus requiring controls aimed at preventing unsustainable use, maintaining ecosystems and preventing species from entering Appendix I. Appendix III species are those for which a party requests the cooperation of other parties to control international trade in specimens of the species.

In order to list a species in Appendix I or II, a party needs to submit a proposal for approval by the CoP, supported by scientific and technical data on population and trade trends. The proposal must be adopted by a two-thirds majority of parties present and voting. As the trade impact on a species increases or decreases, the CoP decides whether or not the species should be transferred among or removed from the appendices.

There are approximately 5,000 fauna species and 28,000 flora species protected under the three CITES appendices (IISD, 2011). Parties regulate the international trade of CITES species through a system of permits and certificates that are required before specimens listed in the Convention's appendices are imported, exported or introduced from the sea. Each party is required to adopt a national legislation and to designate two national authorities, namely a Management Authority responsible for issuing permits and certificates based on the advice of the second national body, the Scientific Authority. These two national authorities also assist with CITES enforcement through cooperation with customs, police and other appropriate agencies. Parties maintain trade records that are forwarded annually to the CITES Secretariat, thus enabling the compilation of statistical information on the global volume of international trade in appendix-listed species. The operational bodies of CITES include the Standing Committee and two scientific committees: the Plants Committee (PC) and the Animals Committee (AC).

2.1.5 WHAT ARE BIRDS WORTH?

Birds are the best known class of vertebrates; they occur worldwide in nearly all habitats and provide lots of services that benefit human society (Whelan *et al*, 2008). To most ornithologists, birds are an invaluable resource due to the rising challenges and enormous resources utilized in conservation of quality and viable habitats for wildlife. The awareness of the need for wildlife conservation is spreading very fast but this needs to be converted into policy, decision making and not left basically as a research. This is because such decisions will not yield desired effects on land-use projects which threaten the existence of pristine biodiversity.

Ecosystem services are divided into four categories by the Millennium Ecosystem Assessment (Whelan *et al.*, 2008); provisioning services referring to products harnessed from wildlife which are used directly as food, clothing and medicines; cultural services which are indirectly harnessed by their presence such as recreational opportunities and inspiration, arts and music; supporting services which are a direct consequence of wild bird foraging behaviour and these are pollination, seed dispersal, nutrient cycling; and recycling services which are a consequence of foraging behaviour offer pest control services (also termed biological control).

The value of these services becomes pronounced when some vital constituents of wildlife become extinct and human community has to provide an alternative to ensure continual discharge of these services. Each constituent of the ecosystem is important and through much enlightenment has been carried out on other components of the ecosystem such as watershed and pollination by insects, wild birds must take their place as an integral component of the ecosystem (Wenny *et al.*, 2011).

Many wild birds are insectivorous, (over 50 percent of bird species) and nearly 75 percent prey on invertebrates occasionally (Sekercioglu, 2006a).The beneficial role of birds as insectivorous is well summarized by Whelan *et al.*, 2008. To this support, plants respond with higher crop yields. The 1958 extermination of Tree Sparrows (*Passer montanus*) ultimately unleashed an insect pest outbreak rather than improved rice yield (Becker, 1996). Though birds have been widely publicized as pests in agricultural land-use systems, they (granivores) also control weeds by feeding on the seeds (Wenny *et al.*, 2011).

Nearly 33 percent of bird species disperse seeds primarily through foraging and also through scatter-hoarding of nuts (Sekercioglu, 2006b). Therefore by offering this service, numerous numbers of plants benefit from bird seed dispersal in terms of colonization of open sites and enhanced germination (Tomback and Linhart, 1990). Some of these plants serve as source of timber, medicine and food; yet the interaction linking birds and plants is poorly understood (Whelan *et al*., 2008).

Decline in richness of frugivorous birds will lead to negative effects on plants and indirectly man. The result is an increase in the number of large-seeded plants or fruit trees with few or no dispersers. Though fewer birds participate in nectar feeding and associated bird pollination mutualism, the effects on plants will be adverse if bird population mutualism fails and or population decline considerably. The simple result will be the failure of trees to produce seeds. (Wenny *et al*., 2011).

Scavenging birds are generally unappreciated, though they are a good channel for recycling carrion biomass. Vultures are on the decline as a result of human involvement in their indiscriminate trafficking and use for rituals. It is a common sight for extant vultures to command high prices in our local markets; for example in Bode Market Ibadan Nigeria, a living vulture could demand between 10-15 thousand naira and about 9 thousand naira for a dead or dried one. But the actual value of having thriving populations of these scavenging birds far supersedes these market prices and there is no doubt that numbers have declined though demand for them is still on the increase.

By scavenging, vultures, crows and other vertebrates contribute to nutrient cycling and disease regulation. By carrying out this function also, some of the wild birds have contacted viral diseases and perished. Birds contribute to nutrient cycling especially in wetland, nesting and roosting sites where they may congregate in large numbers. They process large amounts of food and release nutrients rich in phosphate-rich droppings which contribute in no small way to the fertility of wetlands and surrounding communities.

The removal of such congregating birds may affect the ecosystem adversely (Whelan *et al*., 2008). Ecosystem engineering is a process whereby birds utilize wide variety of available materials such as; twigs, feathers, plastic-bags, and timber snags to construct nests. Nest burrows are excavated by many taxa, for example kingfishers and swallows, which in the aftermath provide cover for frogs, lizards and snakes. These nests also positively alter soil properties and this affects nutrient cycling. Their mere presence displayed naturally for spectators also provides opportunistic tourist attraction for example; the giant nests of the colonial breeding Buffalo weaver, the massive nest of the solitary Hammerkop are very beautiful engineering models offered by these two species of birds and the list is almost endless.

Case studies have been made to try to estimate the value of some of the services which people benefit from birds and these include the case of the Coffee Berry Borer which is said to be the world's most damaging insect pest of coffee. Birds boosted farm income by about $75-310per hectare each year by foraging on the borers. (Whelan *et al*., 2008).

The replacement cost for the seed dispersal services of Eurasian Jays in Stockholm National Park was estimated by Hougner *et al*. (2006). It is a keystone species that supports unique communities of insects, lichens, mosses and fungi as well as provides nesting space for birds. The minimum replacement cost of a pair of Eurasian Jays was between 4-22,000 dollars depending on whether seeds or saplings were to be planted respectively per hectare for forest regeneration.

Clark's Nutcracker (*Nucifraga Columbiana*) is involved in scatter-hoarding seeds of White-bark pine (*Pinus albicaulus*). The cones of White-bark pine do not open so this conifer depends obligatorily on nutcrackers for its seed dispersal (Tomback and Linhart, 1990). The plant is precisely endangered due to the invasive fungi pathogen. (Tomback and Linhart, 1990). Replacing nutcrackers would cost the U.S Forest Service management a minimum of 2,190 dollars per hectare in two natural forests. However, it would take only 5-6 years in the Yellowstone area for nutcrackers to produce 440 White-bark pine seedlings per hectare.

Lastly, as birds carry out their foraging activity they may come in contact with backyard farms and poultry remains that are contaminated with viruses such as the West Nile virus and Avian Influenza virus. The birds are only carrying out their daily or seasonal foraging activities of which a great percentage contributes positively to the human community as outlined in previous paragraphs. It is important therefore that active surveillance studies be carried to determine the ecological links between birds and viruses to ensure that ecosystem services supplied by birds continue to be harnessed by human communities.

It is been recorded that birds harboring pathogenic strains of viruses are not capable of travelling over long distances due to stress related issues caused by the virus, however it has been recorded by Gaidet *et al*. (2007b) that a bird with H5N2 did travel some distance before it died. Millions of dollars have already been spent in Africa in trying to understand the interrelationships between the three levels i.e. birds, viruses and the ecosystem.

When birds are observed or detected to harbour viruses; what should be the response of authorities towards the birds? The previous paragraphs have outlined the benefits accruing from ecosystem services obtained from birds, while some of the birds involved might be threatened, utmost care must therefore be taken in control measures.

2.1.6 WETLAND BIRDS

The Convention on Wetlands, thus describes "Waterfowl" as species of birds that are ecologically dependent upon wetlands, and 'water bird' as being synonymous with 'waterfowl' (Wetlands International, 2002). Wetland International, the coordinator of the African Waterbird Census has grouped birds based on their dependence on water to fulfil their ecological nitch and these are:- Grebes, Pelicans, Cormorants and Darters, Herons and Egrets, Storks, Ibises, Spoonbills and Hammerkop, Flamingos, Cranes, Finfoot and Jacanas, Geese and Ducks, Rails, Gallinules and Coot, Waders and Shorebirds, Gulls, Terns and Skimmer, Kingfishers and Birds of prey (Wetlands International, 2002).

Wetlands are among the world's most productive environments. They are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. Wetlands provide many vital functions which includes: water storage, storm protection, shoreline stabilization, ground water recharge and discharge and water purification and offer tremendous values such as water supply, fisheries, agriculture and serve as special attributes as part of the cultural heritage to humanity, they are related to religious and cosmological beliefs, provide wildlife sanctuaries, and form the basis of important local traditions (Ramsar Convention Bureau, 1996).

Though wetlands are key habitats, the birds around these wetlands are among the prominent attractions. Wetland birds thus fulfil a very important role as being the main link maintaining a biotic connection between catchments for aquatic plants and invertebrates (Amezaga *et al*., 2002). Birds are indicators of the state of the environment (Bibby *et al*., 2000). If a wetland is in jeopardy, the birds will be among the first indicators of dangers ahead for such wetland; and they are also important as agents of dispersal. Spores and seeds with adhesive structures may be transported externally, though internally in the digestive tract also seems to be most efficient (Green *et al*., 2002).

2.2.0 FACTORS AFFECTING BIRD SPECIES DISTRIBUTION AND DENSITY

One of the most interesting qualities of biodiversity is that it is not evenly distributed. Each species has its own unique range, determined by the interactions among existing ecological conditions and the species' evolutionary history. The distribution of biodiversity is influenced by ecological factors such as temperature, moisture and soil, as well as seasonality and the amount of variation in topography and prevailing climatic conditions. Besides natural factors, anthropogenic factors that alter natural habitats also influence the pattern of distribution of biodiversity (Strattersfield *et al*., 1998). The number of species that occur in an area is strongly correlated with the spatial heterogeneity of the area (Strattersfield *et al*., 1998). Birds provide an excellent example of the relationship between species richness and diversity and habitat diversity. For example, high bird species richness has been found to coincide with areas of high habitat diversity and steep topography (Strattersfield *et al*., 1998; Fishpool and Evans, 2001; Luoto *et al*., 2004).

Many studies of biological populations require estimates of density or size that could be used to measure population change over time. Population density estimates also allow direct comparisons to be made between different species within a habitat, and between same species in different habitats, providing a better understanding of the habitat requirements of different species necessary for their management. Population density estimates vary over space in response to environmental factors (Buckland *et al*., 2001). Among other factors (e.g. altitude, season), habitat type affects the population density of species.

2.2.1 EFFECTS OF HABITAT TYPE AND VEGETATION VARIABLES

Habitats are often identified and defined by their principal vegetation types, which are in turn products of adaptation by plants to temperature, rainfall, soil and other environmental factors (Maclean, 1990). Habitat type has been shown to be the most important factor determining species distribution (Davidar *et al*., 2001). The physical structure (physiognomy) of vegetation is considered an important habitat component for birds both directly through the provision of food, shelter and nesting resources and, indirectly, in providing potential cues about the onset of conditions suitable for successful breeding (Karr and Roth, 1971; Weins and Rotenberry, 1981; Adeyanju *et al*., 2011).

Bird species density and diversity have been related to various aspects of vegetation structure (Mills *et al*., 1991; Manu *et al*., 2007). As the structural complexity of the habitat (especially the vegetation component) increases in terrestrial environments, the number of many animal groups including birds increases (Karr and Roth, 1971). The distribution of birds in an area is affected by the horizontal variation in the structure and floristic composition of the vegetation, which results in different habitat types. Several studies have compared bird communities in different habitat types to demonstrate the effect of habitat on their composition (Sallabanks *et al*., 2000; Shochat *et al*., 2001)

2.2.2 WILD BIRDS AND VIRUSES

Birds with affinity for wetland habitats make up nearly 60 percent of the wild bird species infected with H5N1 virus and also account for a better proportion of wildlife causalities from Avian Influenza epidemics (Ramsar Convention Bureau, 1996).

Wild birds are quick to adapt to altered wetlands and are commonly seen at water reservoirs, salt ponds, and flooded agricultural fields such as wet poultry farm and aquaculture ponds. As the most frequently detected hosts of the H5N1 virus, waterbirds represent an appropriate target for disease surveillance (FAO, 2007a).

Ducks, geese and swans of the family Anatidae, collectively known as waterfowl are well studied. They are the only group in which the virus has been detected all year round. Waterfowl have a long history of exploitation by humans both as a wild game and as a domesticated poultry (swans and mallards). A few species, most notably Mallard (*Anas platyrhynchos*) and Greylag goose (*Anser anser*), have been raised as domesticated birds for many years. They are gregarious and converge in sizeable flocks on wetlands, foraging grounds and even in the tropics where some are resident for example the White-faced whistling duck (*Dendrocygna viduata)*, Spur-winged goose (*Plectropterus gambensis*).

Waterfowl chicks are highly precocial. They are well developed, active and alert at hatching and are capable of foraging with parents a few hours after hatching. All waterfowl undergo a brief post-breeding flightless period in which flight feathers are shed (molted) simultaneously. During these periods they congregate in wetland areas relatively safe from predators. They are categorized as either “divers, grazers or dabblers” depending on their foraging strategy. White-faced whistling duct is a dabbler while Spur-winged goose is a grazer. Shorebird (waders) chicks are also precocial. In herons egrets and storks, the H5N1 virus has been found in at least four heron and egret species. They are primarily carnivorous and wade through shallow water; stalking prey with imperceptible movement and their strikes are very precise.

Gallinules are solitary birds and stalk in heavily vegetated wetlands and are very shy. All Rallidae species are generalist feeders. Dabbling ducks forage at or below the surface depending on the length of their necks and they feed in shallow water. Diving ducks dive below the surface to forage deeper than the dabblers. Grazing water birds are characterized by upland foraging.

Shorebirds and Waders belong to the families of the order Charadriiformes, a large order that includes plovers, pratincoles, and sandpipers. Only one species has so far been detected with H5N1, the Green sandpiper (*Tringa ochropus).* They are adapted to feeding in mudflats and shallow water along the margins of wetlands. Examples are Common sandpiper, Black-winged stilt and Spur-winged plover. They are gregarious outside the breeding season and congregate in wetland areas to forage in non-breeding season. Their elongated bills are slender and are adapted for probing for invertebrates in damp substrata.

Cormorant are diving birds and considered to be often infected with Newcastle virus (Paramyxoviridae), which form little or no interaction with poultry. Chicks are altricial and require continous parental care for several weeks after hatching. They are generally covered with a dark morph and extended necks bearing a medium sized head with hooked bills.

Raptors are birds of prey such as the kestrels, falcons and eagles from the order Falconiformes. They are predators and scavengers of other bird species which make them vulnerable to viruses through consumption and exposure when foraging. They can get the virus by either feeding on sick birds or tissues from carcasses of infected birds that are not properly disposed of during disease outbreaks. Prey varies with the size of the raptor; the females are sometimes up to twice the size of males (sexual dimorphism). They are solitary and are monogamous and have altricial chicks.

With respect to epidemiology, "Bridge species" are groups of birds which generally have no affinity for wetlands but have a high preference for human settlements and have been known to be infected with viruses. Some members of this group are the Pied crow, Laughing dove and Northern grey-headed sparrow. Open back-yard farms expose these birds to incidence of viruses and because they are generalist foraging birds, they occupy a wide range of habitats and could serve as a link between domestic poultry and wild bird groups not known to the human settlements.

2.2.3 MIGRATORY BIRDS AND VIRUSES

During the early outbreaks of AI in poultry, there was little or no link between migratory birds and domestic poultry in south-east Asia in 2003-2004. The movement of infected birds was isolated as specifically a trade phenomenon. In 2004, raptors smuggled into Belgium were the first H5N1 infected birds detected in Europe. The discoveries of such birds in Europe in 2005/06 suggested that wildbirds could play a role which is still not fully understood. (Krauss *et al*., 2007)

2.3.0 AVIAN INFLUENZA VIRUS

AIV is an RNA virus with a segmented genome, occurring in different subtypes and genetic lineages. There are presently 16 haemagluttinin (HA) and 9 neuraminidase (NA) glycol-proteins that are used to characterize the various subtypes of avian influenza virus (Webster *et al*., 1992*;* Fouchier *et al*., 2005; Olsen *et al*., 2006*)*. Each virus has one HA and one NA antigen, apparently in any combination. i.e. H1N1and

H7N3. A respiratory disease of birds is caused by the low pathogenic AIV whereas the high mortality epizootic or complicated infection (resulting in up to 100 percent mortality among poultry) is initiated by the highly pathogenic AIV, a condition commonly called "bird flu" and formerly "fowl plague". This infection was first isolated in the 1930's but has now become a global phenomenon (Webster *et al*., 1992).

The precursor protein HAO in low pathogenic avian influenza (LPAI) is known to have a single basic amino acid at its cleavage site and another at -4 or -3 position from the cleavage site (Steinhauer, 1999; Vey *et al.*, 1992), whereas the HPAI possesses multiple basic amino acids at its cleavage site possibly as a result of insertion or substitution (Vey *et al.*, 1992; Wood *et al.*, 1993). Cleavage therefore ensures that the HA take up a structure that is best suitable for fusion; though it is not the only factor determining virulence (Bowes *et al*., 2004; Villareal, 2006; Londt *et al*., 2007).

The detection of HPAI in free living wild birds (mostly waterfowl) over the last decade does complicate the present understanding of the ecology of the virus; as this results in a modified eco-epidemiology and increased zoonotic potential of the virus (Capua and Alexander, 2006; Chen *et al.*, 2006 a, b; Salzberg *et al*., 2007; Sims and Narrod, 2008). In 2007, avian influenza spread to 8 new countries and reoccurred in 23 countries and the number of reported human cases has kept on soaring (Uiprasertkul *et al*., 2007; World Health Organization, 2008).

2.3.1 PREVALENCE OF VIRUSES

Measurements of avian influenza virus prevalence in wild birds in Africa provide new insights into the host ecology of avian influenza viruses in tropical regions. LPAI viruses were detected in both Palearctic and Afrotropical water birds in several sampling sites, reflecting that viruses were possibly circulating in Africa during the Northern Winter (November to March in Nigeria) (Gaidet *et al.*, 2007b). Thus the presence of the virus in tropical regions in both Afro-tropical and Palearctic wintering birds show that there is a circulation of LPAI viruses prior to Northern Spring migration (April to June in Nigeria). There is thus a persistence of the virus in wild birds all year round.

Extensive surveillance of wild ducks in the Northern Hemisphere have revealed high LPAI virus prevalence primarily in juvenile birds, with a peak in early fall just prior to the southbound migration. However, little is known about the prevalence of influenza viruses in wild ducks in the southern hemisphere or potential transmission between the two hemispheres. It is however argued that some birds remain in their breeding continent all year round (Olsen *et al.*, 2006). The Blue-winged teal is one of the few North American species that has a winter distribution that includes South America, there are other ducks that could serve as hosts of influenza virus in South America (Alexander, 2000) but surveillance data is lacking. The Garganey (*Anas quequerdula*) and Northern Pin-tail (*Anas acuta*) are among few of the ducks that have over one million birds wintering in sub-saharan Africa. However none of the 22 breeding Anatid species breeding in the African continent spend the winter outside the continent though they do migrate within the continent (Olsen *et al.*, 2006).

2.4.0 WEST NILE VIRUS

The West Nile virus belongs to the flavivirus family Flaviviridae, and is related to the viruses that cause Yellow fever and Dengue fever. Affected animals, and humans, can develop encephalitis which can be fatal. Its distribution and host range in nature is not fully known, but the virus has been detected in both tropical and temperate regions. West Nile Virus is vector borne, primarily through mosquitoes, but possibly also ticks, and mainly infects birds, although a range of mammals are recorded as accidental hosts.

The recovery of infectious WNV from the brain of a hawk in New York, during a period of mosquito inactivity, raised questions as to potential persistent infection within the hawk, or alternatively, oral transmission to the hawk via consumption of persistently infected prey, probably a rodent or bird (Garmendia *et al*., 2000). Further evidence of a non-mosquito source of transmission during cold periods in a temperate region, again New York, was the detection of lethal infections among communally roosting crows (Dawson *et al*., 2007). The principal mechanism for annual spring emergence and initiation of WNV transmission remains unknown (Nemeth *et al*., 2009). Only recently, it has been associated with an increasing number of outbreaks of encephalitis in humans and equines as well as an increasing number of infections in vertebrates of a wide variety of species (van der Meulen *et al*., 2005)

2.5.0 NEWCASTLE DISEASE VIRUS

Newcastle disease is a highly contagious and fatal viral disease affecting most species of birds (Owoade *et al*., 2006). Because chickens are the most susceptible birds, the disease is frequently responsible for devastating losses in poultry (Alexander, 2000, 2001). For this reason, isolation of a virulent strain requires reporting to the 'Office International des Epizooties' (OIE) (Alexander, 1997). This avian disease is caused by Newcastle disease virus (NDV), an avian paramyxovirus that has recently been assigned to the new genus Avulavirus within the family Paramyxoviridae (Mayo, 2002a, 2002b). The aetiological agent is a single stranded, non-segmented negative-sense RNA virus.

Newcastle disease (ND) is an OIE listed disease caused by virulent avian paramyxovirus type 1 (APMV-1) strains, which affect many species of birds and may cause severe economic losses in the poultry sector. The disease has been officially and unofficially reported in many African countries and still remains the main poultry disease in commercial and rural chickens of Africa. Unfortunately, virological and epidemiological information concerning ND strains circulating in the Western and Central regions of Africa is extremely scarce (Cattoli *et al.*, 20010; Snoeck *et al.*, 2009)

This genus contains the 9 serogroups of avian paramyxoviruses (APMV-1–9) described so far. According to their virulence in poultry, APMV-1 isolates may be classified as highly virulent (velogenic), intermediate (mesogenic) or non-virulent (lentogenic). This classification is based on the results of the mean death time in chicken eggs (Beard and Hanson, 1984; Aldous *et al.*, 2003; Abolnik *et al.*, 2004). The clinical signs of a highly virulent NDV infection in chickens can be extremely different depending on the strain of virus. Virulent strains that cause diarrhoea and frequently haemorrhagic intestinal lesions are called viscerotropic velogenic. Strains that cause respiratory and neurotropic signs are called neurotropic velogenic (Alexander, 1997).

The non-segmented single-stranded, negative-sense RNA genome encodes six proteins. Like many other RNA viruses that have an RNA polymerase that lacks proof-reading, APMV-1 has evolved into genetically highly diverse lineages (Domingo and Holland, 1997). Aldous *et al.* (2003) proposed 6 phylogenetic lineages, further subdivided into 13 sublineages. Lineages 1 and 6 contain mainly avirulent viruses, while most virulent viruses are found in lineages 3, 4 and 5. Lineage 2 includes both avirulent and virulent strains. While some lineages seem to be geographically constrained, others circulate worldwide (Aldous *et al*., 2003). On the African continent, outbreaks are rampant, but only a few strains from Mozambique, South Africa and Uganda have ever been investigated (Herczeg *et al*., 1999, Otim *et al*., 2004).

2.6.0 TRANSMISSION OF VIRUSES

The mechanisms by which viruses pass from one bird to the other and bring about infection are poorly understood (Olsen *et al*., 2006). It has been proposed that the little understanding of the role wild birds' play in influenza transmission and or spread will limit the incorporation of wild birds in preventative strategies to basically keeping domestic birds away from wild birds. (BirdLife International, 2008; Olsen *et al*., 2006; Dodman and Diagana, 2007; Sims and Narrod, 2008).

2.6.1 FACTORS RESPONSIBLE FOR TRANSMISSION OF SOME VIRUSES

A lot of factors come into play in bringing about viral transmission such as environmental factors, bird species, and the strain of the virus, presence of susceptible vectors/reservoirs, poor bio-security/bio-safety, mechanical transport of infected particles/contaminated water, contact between wild /domestic livestock with either or both wild and domestic livestock infected, delay in reporting/detecting outbreaks and refusal to report outbreaks (Sim and Narrod, 2008). Therefore given the right environment, HPAI can thrive and possibly result in the much feared human pandemic if genetic reassortment between avian and human viruses does occur. Yet, HPAI is known to spread directly from poultry to humans and this is evident in the human cases and associated mortalities experienced so far (FAO/OIE/WHO, 2005; Normile, 2008; World Health Organization, 2008).

We should therefore be prudent and take the necessary actions to strengthen bio-security in poultry production at all levels, prevent contact of poultry with wild birds as much as possible, utilize vaccines to increase resistance to HPAI in both humans and birds (although there are varying views regarding this option, the opposing view being that use of vaccines will increase frequency of false positive detection of viruses) and finally share information available on outbreaks.

2.6.1.1 INTEGRATED INDOOR COMMERCIAL POULTRY

Though contentions arise as to whether or not the actual source of avian influenza is poultry, it has been noted that whenever there is an epizootic of HPAI, large scale losses are experienced in this sector. The reduction in diversity of commercial poultry stocks has been proposed as the fundamental reason for such losses in the industry; millions of birds are being generated from the same stocks or parental strains. Hence, very little or no resistance (immunity) can be developed against the presence of HPAI (EMPRES WATCH, 2006; GRAIN, 2006). Mechanical transmission from contaminated equipment used in one farm when transferred to others could result in the spread of infection. Bio-safety levels are thus very low and this is evident in some areas in Nigeria. The operation of non-licensed commercial hatcheries and the illegal imports by some citizens has also been suggested as a potential source of the introduction of AIV (GRAIN, 2006).

2.6.1.2 LIVE POULTRY MARKETS (LPM)

Live poultry markets are a source of comparatively cheap animal protein and also a source of supplementing the livelihood of many traders, farmers and villagers (Sims and Narrod, 2008); various types of domestic livestock are bought and sold on a daily basis in the LPM. However, the poor bio-safety measures often applied in these markets have continually been a source of concern (Mounts *et al*., 1999). In Hanoi, Vietnam in 2001, 4 HP avian influenza viruses were isolated from healthy ducks and two from healthy geese suggesting that waterfowl do not always show symptoms of infection (Nguyen *et al*., 2005; FAO/OIE/WHO, 2005). It is common practice in LPM for live birds of varied species to be kept in the same cages thereby facilitating the spread of avian influenza virus to potential susceptible species (Sims and Narrod, 2008; Webster, 2004). Of contention is the daily introduction of birds possibly infected with avian influenza viruses into the LPM (Mounts *et al*., 1999). These markets (LPM) very often serve to support backyard poultry farms in many rural areas.

2.6.1.3 BACKYARD POULTRY

Small-scale poultry production is critical to the livelihood and food-security of millions of people in developing nations and also practiced even within developed nations. Part of the genetic diversity of commercial poultry is being preserved in backyard poultry (CBN, 2004; GRAIN, 2006). It is common for domestic poultry to be let loose in the extensive system of farming; hence contact of domestic birds with wild birds is increased permitting spread of infection from either wild bird to domestic birds or vice-versa. However, supporters of rural stakeholders have opposed this notion, proposing that backyard poultry possess higher immunity to HPAI and that this method of rearing poultry is cheaper and affordable (GRAIN, 2006). Most rural areas are located in areas of relatively high biodiversity, offering a higher encounter rate of domestic poultry with wild birds. Backyard poultry farms in Asia account for almost 70% of the poultry population in Asia and most of the outbreaks in

2006 were in this sector (EMPRES WATCH, 2006). Backyard poultry farms often practice little or no bio-security measures and are vulnerable to HPAI. Access to veterinary services is limited and low compensation schemes could prevent locals from reporting sudden outbreaks among local poultry (Capua and Alexander, 2006; Peiris *et al*., 2007). Opposition to mass culling of birds is also on the increase among backyard poultry farmers who have very little resources to re-establish their source of livelihood due to the believed misappropriation of funds set aside for their compensation post-culling.

2.6.1.4 GAME HUNTING AND COLLECTION

Birds are targeted by hunters and gamers who see hunting as a source of pleasure or a means of livelihood. There have been reports of HPAI virus isolation from free living parrots being trafficked into Europe from Thailand and captive caged birds (Mountain Hawk-eagle, *Spizaetus nipalensis*) held in quarantine in England from Taiwan in 2004 (Borm *et al*., 2005). Studies reveal that game hunters and professionals exposed to wild birds have a high chance of contacting avian influenza. Surveillance studies have concentrated efforts on wild bird populations and domestic poultry, there is therefore need to conduct more extensive studies on risk assessments of illegal and legal wildlife trade within Nigeria. It is noted that trade in wild animals is relatively higher in developing countries where biodiversity is often exploited illegally. The illegal trade continues unabated, and very rarely are hunters served a full blow of the laws that are supposed to protect and preserve such biodiversity.

2.6.1.5 CLIMATE

The detection of avian influenza (both HPAI and LPAI) in various parts of the tropics may give evidence that climate does not prevent perpetuation of avian influenza among waterfowl resident in Africa, though it does limit epizootics to particular seasons. Low-pathogenic AIV have been detected and isolated in several species of wild birds from major wetlands of northern, western and eastern Africa, and this points out that Afrotropical ecosystems are favourable for the persistence and transmission of AIV (Gaidet *et al*., 2007a; b).

2.6.1.6 ILLEGAL TRAFFICKING OF POULTRY

International trade in birds both legal and illegal have been pointed to as being responsible for some of the major outbreaks of avian influenza (BirdLife International, 2008). Lapses by border patrols could serve as bases for the infiltration of products from Asia into Europe and possibly Africa, some of which have been confiscated and proven to be H5N1 positive.

2.6.1.7 MANURE

The frequent use of waste from poultry houses to serve as natural fertilizers and feed for fish and pigs is said to be a high risk activity, Birdlife International has called for research into the potential transmission of avian diseases via poultry waste (BirdLife International, 2008; Capua and Alexander, 2006). The greatest threat in the spread of avian influenza viruses is by the mechanical transfer of infected faeces, in which viruses may be present in high concentrations and survive longer than 44 days (Utterback, 1984).

2.7.0 POLYCROMASE CHAIN REACTION (PCR)

PCR for many virus detections have already been described for many clinically relevant viruses. The sensitivity and specificity is however determined by the choice of the primer sequences. Data shows that the newly designed PCR offer more sensitive and faster tool for the diagnosis of influenza virus than virus isolation (Fouchier *et al*., 2005).

The use of molecular techniques to directly detect virus in samples from animals facilitates the rapid identification and genetic characterization of avian influenza A viruses (AIV) (WHO, 2002). Beyond these molecular techniques, Polymerase Chain amplification using a thermostable Taq DNA polymerase is very sensitive and is able to identify virus genetic material in a lot of different samples, including oral and feacal swabs. Positive and negative controls are included to ensure reliability of the results. All samples are tested for presence of avian influenza virus by a real-time RT-PCR targeting the matrix (M) gene. Haemaglutinin (HA or H) and neuraminidase (NA or N) subtypes of the positive influenza samples are determined by the use of specific primer pairs. Nucleotide sequences are obtained after specific PCR products sequencing and then compared to available sequences in the Genetic Bank database.

2.8.0 CAPTURE TECHNIQUES FOR WILD BIRDS

Extensive reviews of capture techniques have been carried out, but the health and welfare of the captured birds is most important. Presently, there are few, if any bird species that cannot be captured. Traps often utilize lures, recorded calls to attract birds to the trapping site while others use baits. It is advised that the equipment capable of inflicting damage to the birds should not be used or should be avoided at all costs. Traps are always checked at regular intervals and when not in use should be folded and closed to avoid birds being trapped unintentionally. Trapping of birds should also be conducted only when weather is favourable to prevent excessive cold or dehydration to the birds.

2.8.1 MIST NETTING

This is the most widely utilized method of capturing birds and it is also used for other flying vertebrates for example, bats. The principle basically is placing an inconspicuous net vertically on poles and fitted or positioned in areas where bird activity is very high. Mist nets are available in many different lengths, mesh sizes and fiber quality. This is determined by the size of the target species or group of birds to be captured. Short nets are very good for forest undercover while long nets are good for cleared areas. The nets are designed to slowly decelerate birds on impact with the net. Mist nets have at least 3 to 5 pockets or shelves running along the length of the net on to which the bird drops when it makes contact or impact with the net which it obviously did not previously notice.

The mounting poles are mostly made from bamboo or metal but in any case should be thin and strong and light for ease of transportation in the field. Mist nets should be place where they are concealed i.e shaded sites are preferable to sun lit areas. Activity in birds is highest at dawn and dusk and these time regimes should be targeted for the best bird capture results.

A good knowledge of the species or group of species to be trapped is fundamental to a good capture as this will serve as a guide to placement of traps. Sighting of a location spacious enough to contain the length of nets to be used to keep the nets taught at both ends and the poles upright. The ease with which the mist nets can be set up has also provided lots of modifications and as such floating nets mounted on boats, submerged nets and even canopy nets with pulley system have now been designed to capture a wide array of birds.

Silence is always maintained at mist net sites and this prevents birds from being suspicious of where the trap is located. Bird extraction from the net should be done carefully, firstly detecting the route with which the bird enters the net, picking out its feet by the tarsus and carefully then removing the net from over the body, wings and finally the head. Extracted birds are quickly placed in bird bags which vary depending on the size of the bird captured. The use of mist-nets requires training by licensed individuals and after mastering its use, it can easily be deployed for use. Other methods available for trapping include the duck trap, cannon netting, coral taps and dive in traps.

2.8.2 BIRD HANDLING AND RINGING

Depending upon the objective of trapping birds in the field, lots of research techniques including ringing, banding, biometric measurement, sample collection for laboratory analysis, radio tagging can be carried out and this involves handling birds without allowing the bearer nor the bird be harmed. The general acceptable methods of holding a bird is termed ringer's grip. The use of this grip ensures minimal stress to the bird and therefore after release the bird returns to its foraging activity normally. The use of personal protective equipment appropriate for the level of risk is strongly advised even when clinical signs are not obvious. (FAO, 2006; FAO, 2007a).

Generally tools used during ringing include the following; rings to fit the bird group of interest, ringing pliers, needle nosed pliers for removing improperly fitted rings, data notebook and pencil for recording, veneer callipers, stopped ruler, tail ruler, bird guide, weighing scale, weighing bags and nylon fishing line.

The AFRING organization is responsible for ringing data in Africa. Rings possess unique number code systems which ensure that birds are properly identified when trapped or retrapped or sighted (mostly with colour rings) the placing of rings on birds involve a ringing license and should not be carried out by amateurs as data collected would be inaccurate and out of precision and this will reduce the integrity of the ringing system.

2.8.3 VIRUS SURVEILLANCE

Proper specimen collection is essential for providing samples that ensure reliable isolation and identification of any pathogens found present. Tracheal and cloacal swabs are taken from the birds' trachea and cloaca (vent). They can be used for viral cultures or RNA extracted and used in reverse transcription polymerase chain reaction RT-PCR to test for the presence of many viral pathogens. Research reveals that AI subtypes replicate to high levels and longer periods in the respiratory tract compared to the intestinal tract (Sturm-Ramirez *et al*., 2004). Tracheal and cloacal swabs are currently the preferred samples for H5N1 surveillance in wild birds (FAO, 2006; FAO, 2007a).

The sampling of wildbirds also requires training and should only be carried out by trained personnel. Cryovials (about 1.5 ml tubes) containing viral transport medium can be prepared locally and should be stored at low temperatures (< 4ºC) in the field before use.

Faecal sampling is a less expensive way of collecting large number of samples especially when trapping the target bird is not feasible. It is also called an environmental sample.

The poultry meat trade in Egypt depends heavily upon the live bird markets (LBM) because of insufficient slaughtering houses, lack of market infrastructure, cultural preference for consumption of freshly slaughtered poultry (Abdulwahab, 2010). There are two types of LBM in Egypt, retail shops and traditional LBM where minimal or no food safety standards are implemented. Surveillance of LBM resulted in 12.5 percent of 573 LBM being positive for H5N1. This poses a threat to public health and poultry industry. The LBM in Egypt had three categories of birds with waterfowl sold as a solitary species contributing to 70.4 percent of the market, waterfowl mixed with chicken contributing 26.8 percent and turkey sold separately contributing 2.8 percent. Higher incidence was detected during the cold month of Febuary. The role of LBM has been extensively studied during the last decade. Several attempts have been made to eradicate AI from LBMs with limited success and AI remains endemic in Egypt.

It has been opined that cleaning and disinfection should be carried out weekly to reduce the spread of viral transmission. The epidemiological role of LBM involves collection of various species of waterfowl from various sources which could serve as a medium for the transmission. It is possible that mutational changes as a result of recombination of various strains occur at this phase and lastly the birds are then sold to buyers who could also decide to begin to rear such animals in the backyard farms. Individuals who are exposed to infected animals also stand a chance of harboring the viruses. Women and children are often a higher percentage when censuses are made at such markets.

In Egypt presently, legislation has been made to ban the trade of wildbirds in LBM because sufficient slaughter houses have not been available. Also, compensation for infected products is not forth coming and as a result, traders are involved in smuggling of live birds into the markets where they are concealed to prevent their confiscation by local authorities (Abdulwahab, 2010). Joanis *et al*. (2008) detected only 12 cases of H5N1 from 13,597 within Nigeria. Studies on LBM are well documented (Nguyen *et al*., 2005, Chen *et al*., 2004, Li *et al*., 2004, Feare, 2007, and Amonsin *et al*., 2008).

There are three hypotheses concerning the epidemiology of viruses in wild birds. Firstly, they could be carried by wild birds asymptomatically, secondly they could be carried for some periods before death and thirdly virus remains very lethal and hence wildbirds die at the spot of contacting infection because they get very sick. In the first scenario, wildbirds will be able to spread the virus to every location they get to and this would be traceable to their migratory routes. Domestic birds and other wild vertebrates obtain the virus from such locations. In the second scenario, wildbirds die in their migratory routes and there would be evidence of deaths of several birds along the routes and poultry infection would be evident along the routes. In the last scenario, wildbirds would not be able to carry the infection once they get infected.

Laboratory bred geese all died 7 days post–infection (Chen *et al*., 2006a). Most wild birds died at their wintering sites or during breeding season when their movement was hindered, indicating that they may have contacted infection from that point where they died. There was however, no poultry disease outbreak where they died.

2.9.0 BIRD DIVERSITY INDICES

The concept of diversity, including biodiversity itself as well as the narrower concept of species diversity, is a human derived term and has no mathematical meaning (Wilson and Peter, 1988; Magurran, 2004; Colwell, 2009). Although the simplest measurement of species diversity is species richness, evenness is also as important. An area containing ten species in which only one species occupies about 95 % of the territory cannot be said to be as rich or diverse as another with the same number of species but with an averagely even number of individuals contributing to the diversity. However, diversity indices are mathematical functions that combine both richness and evenness in a single measure, although not explicitly (Rosenzweig, 1995, Colwell, 2009). Diversity indices include Shannon diversity, Simpson diversity and Fisher's alpha diversity, though there are other indices also used in ecology. Both Shannon and Simpson diversities increase as richness increases, for a given pattern of evenness, and increase as evenness increases, for a given richness (Maguran, 2004; Colwell, 2009). However the two indices do not always rank areas being compared in the same way. The Simpson's diversity index is the probability that two individuals sighted or observed in a given sample are not from the same species or group; therefore values with lower values show that with less effort more species are observed, the Simpson's index range between zero and one with values closer to zero having a higher diversity and those closer to one having less diversity. Simpson diversity is more partial to evenness and less to richness when compared with Shannon diversity which is even more partial to evenness than the Simpson diversity.

Another diversity index is the Berger-Parker index which is the inverse of the proportion of individuals in the community that belong to the single most common species. However, because rare species may be missing from smaller samples, the sensitivity of this index to correctly measure diversity depends on its sensitivity to species richness.

Fisher's alpha diversity on the other hand depends only on species richness and abundance but nevertheless, depends on substantial computation because iterative methods must be used. It is much less sensitive to rare species and the relative abundance computation is too conservative.

Species richness is a measure of the number of species (of birds) in a given sample and is not affected or does not show any relationship to the number of individuals in either group of species. A site with higher number of species might not necessarily have a higher number of individuals but more value is placed here on variety of species present in the sample. Bird species diversity was calculated using Shannon-Weiner diversity index, H and Simpson's diversity index D (Begon *et al*., 1996).

$$H = -\sum_{i=1}^{S} P_i \ln P_i$$

Where: P_i = proportion of individual species,

S is the total number of species in the community (Number seen plus number heard),

ln = natural logarithm

i = ith species and

$$D_s = S(n_i(n_i - 1)/N(N-1))$$

Where:

D_s = Bias corrected form for Simpson Index

n_i = number of individuals of from the i^{th} species

N = Total number of species in the community

CHAPTER THREE

MATERIALS AND METHODS

3.1.0 DESCRIPTION AND LOCATION OF STUDY AREA.

The IITA is located along the old Oyo road in Moniya, Ibadan at longitude 07° 30´N and latitude 03° 55´E (see Figure 3.1). IITA is an Important Bird Area (IBA) in Nigeria (Ezealor, 2002) and falls within the moist semi-deciduous forest zone, characterized by two annual rainfall seasons and a dry season. The annual rainfall for the year is 1500-2000 mm (Ezealor, 2002) but records from 2003-2008 puts the average annual rainfall between 1,000 to 1400 mm (IITA Meteorological station).

The length of the John Craig Lake, which receives inflow from the Awba River, is 2.6 km, while the length of the embankment is 359.7 m. The surface area of the lake at full capacity is 70 Ha (175 acres) (IITA Meteorological station). The lake was created for irrigation of farmland meant for research purpose and secondarily for domestic use. This lake provides food, water supply and serves as roosting site for both migratory (of which *Dendrocygna viduata* is the most numerous) and resident water birds such as *Phalacrocorax africanus, Actophilornis africana, and Adeola ralloides*.

The forest is located on the west bank of the lake (See Figure 3.2). It consists of secondary forest and derived savannah vegetation as a result of the deterioration of a previous evergreen tropical forest of the south-western region of the country (Ezealor, 2002). The forest consists of tree species such as *Anitaris toxicaria, Cola nitida, Sterculia trangacantha, Milicia excelsa, Ficus vogeliana, Ficus exasperata and Morinda lucida.* It is rich in fauna, which include reptiles, duikers, squirrels, bats, and provides cover and food for the fauna. The forest serves as habitat for the endemic and critically endangered Ibadan malimbe (*Malimbus ibadanensis*).

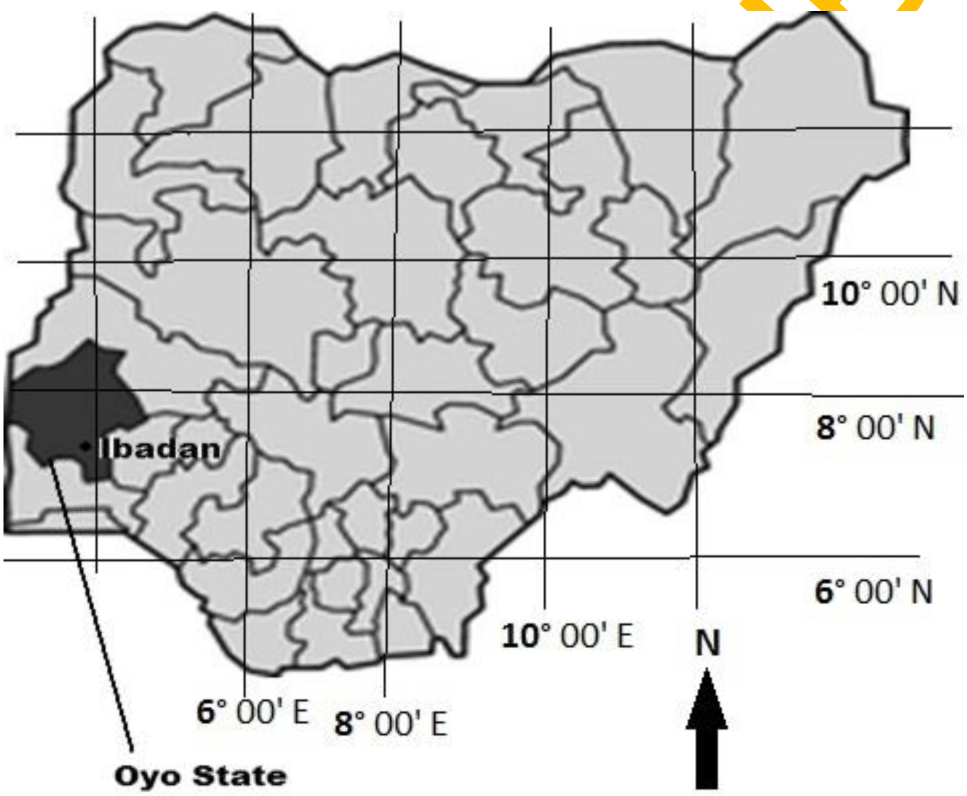

Figure 3.1: Map of Nigeria showing location of Ibadan in Oyo State.

Figure 3.2: IITA West Bank and forest trails

3.2.0 CENSUS METHOD

Line transects were cut along the perimeter of water bodies, farmland and forest habitats as Bibby *et al.* (2000) showed it to be the most efficient method in terms of data gathered per unit effort.

3.3.1 DATA COLLECTION

A complete random design (CRD) was used in this study. Nine transects of 1000 m length each were cut around the John Craig lake, forest reserve and farm lots.

3.3.2 SURVEY OF WILD BIRDS

a. Census of all bird species was taken from vantage points around the lake, rice paddies each month and when taking faecal samples from roosting birds.

b. Line transects were visited 2 times each month of the year (in the mornings between 0600 hrs and 1200 hrs and evenings 1500 hrs and 1900 hrs). Birds seen outside these time schedules and transects were included in species list (Borrow and Demey, 2001).

c. All birds observed (both seen and heard) were identified to species level, counted and recorded in a field notebook and this was carried out with the aid of a field guide, (Borrow and Demey, 2008), a pair of binoculars (magnification 10 × 42) and a telescope.

d. A combination of wader nets (used for waterbirds) and mist nets (forest birds) with playbacks (to serve as lure) were used to trap wild birds.

e. Most of the birds trapped were ringed and biometric records and measurements were taken of age, sex, wing length, fat score, moult score, head moult, body moult, pectoral muscle and brood patch.

f. Hip-waders, life jacket and rain boots were used to have access to areas of the wetland that were wet.

3.3.3 MEASURING HABITAT VARIABLES

Within each 200 m section of each transect a 20 X 20 m quadrat was laid out. All trees within the quadrat were counted and recorded. Within the 20 X 20 m quadrat, four 2 X 2 m quadrats were laid out. Within these quadrats the following measurements were taken following Manu *et al*. (2007) and Manu and Imong (2006).

a. The number of saplings and small trees (diameter <1 cm and at least 1 m tall, 1-10 cm, and >10 cm).
b. The percentage canopy cover (to the nearest 5%) estimated by looking through the objective lens of a pair of binoculars. This gives a small view area of the canopy allowing an assessment of cover to be made.
c. The percentage ground cover by ocular estimation (to the nearest 5%).
d. Number of lianas or woody climbers.
e. Grass height (<0.5 m tall, 0.5-1.0 m tall, and > 1 m tall)

3.3.4 SAMPLE COLLECTION FROM BIRDS

a. Oropharyngeal and Cloacal Sampling were done according to the Food and Agricultural Organization standards (FAO, 2006; FAO, 2007a) by securing the bird in one hand, taking a sterile cotton swab in the other, opening the bill of the bird carefully, wiping the throat of the bird (oropharyngeal swabbing) and then turning the bird upside down and taking a swab of its cloaca (cloacal swabbing). Swabs were placed in a virus transport medium (in screw capped vials) and the base of the swab was cut with a scissors. Gloves were not used during ringing as it slows the down processing of trapped birds; however when faecal samples were being taken a pair of gloves was used.

b. Faecal swabs were taken after identifying and stalking large resting flocks of waterfowl; surrounding vegetation was searched carefully for deposits of faeces. Sterile cotton swabs were used to gently wipe faeces found. After taking a faecal sample, the faecal deposit was trampled upon with the aid of my field boot as a precaution, to prevent me taking the same sample twice.

c. All vials (1.5 mm cryovials) were labeled to ensure that samples taken from each bird or faecal deposit align with recorded information taken on each visit.

d. Samples were placed in a transport medium called isotonic phosphate buffered saline (PBS), pH 7.0-7.4, consisting of antibiotics and antimycotics (Penicillin 10,000 U/ml, Streptomycin 1mg/ml, Nystatin 1000 µ/ml and Gentamycin 250 µg/ml) supplemented with 20% Glycerol (see Table 3.0.1 for alternative Virus Transport Medium).

e. All swabs were taken to university of Ibadan avian disease detection laboratory of the Department of Veterinary Medicine (laboratory) where I carried out detection PCR for viruses present in the samples and PCR products were taken to the Laboratory National De Santé in Luxembourg for sequencing.

f. Communities surrounding IITA were visited and at each settlement, permission was taken from District Chiefs and household heads to carry out sampling of domestic poultry.

Table 3.0.1: Composition of the viral transport medium.

3.3.4 SAMPLE STORAGE AND PRECAUTIONS

a. Prior to sampling, vials were stored in a freezer from which they were transferred into a cool box with ice packs when transported to the field. The sample vials were taken out of the cool box during sampling, and placed back after sampling to maintain a cold chain.

b. The sample vials were transported back to the laboratory where they were stored in -20°C freezers until analysis was carried out.

c. Data collected on each sampling day were inputted into a computer when back at the base station.

d. Precautions against zoonotic disease transmission were taken in the field during sample collection by use of facemasks, hand gloves, detergents and antiseptics during and after sampling.

3.4.1 RNA ISOLATION, AMPLIFICATION AND ANALYSIS

RNA were extracted at the laboratory with an RNA virus kit and eluted into 50 µl nuclease free H_2O according to the protocols outlined below.

3.4.2 RNA ISOLATION

Ribonucleic acids (RNAs) of the samples collected where extracted using Qiamp Viral RNA minikit and eluted into 50 µl nuclease free H_2O. Extraction was carried out in an extraction hood, and other necessary precautions to prevent contamination of samples were taken. The AVL (lysis buffer) was prepared by adding 1ml of AVL buffer to a carrier RNA red tube and mixed properly to re-suspend the powder. The solution was then transferred into the AVL bottle and the red tube was then rinsed with 1ml of AVL buffer and again transferred into the

AVL bottle and the carrier RNA was added on the bottle lid. Aliquot of the solution (AVL + carrier) were made into 1.5ml eppendorf: 560µl/tube and labelled AVL; this was then stored at 4°C. Ethanol was added to the buffers AW1 and AW2, all in preparation for the extraction. The samples were decontaminated by placing on tissue paper and spraying with Virkon, wiped with tissue paper and labelled appropriately. The samples were equilibrated at room temperature and vortexed. The AVL buffer aliquots were then removed and re-dissolved (5min at 80°C with the heater block) and allowed to cool to room temperature before it was used. This was to dissolve any crystals that were formed from the freezing. 140µl of the samples were added each to 560µl of AVL and mixed properly by pulse vortexing for 15 seconds and incubated for 10 minutes at room temperature to lyse the virus. The mixture was spined to remove drops from the lids and 560µl of Ethanol was added and vortexed for 15 seconds. The mixture was spined and 630µl of the mixture was transferred into the labelled spin columns and spined in a centrifuge at 8000 rpm for 1 minute. The collection tubes were then discarded and replaced with new ones. The remaining 630µl of the mixture (140µl of sample + 560µl of AVL + 560µl of ethanol) were transferred into the same labelled spin columns and spined at 8000rpm for 1 minute and the collection tubes were again discarded and replaced with new ones. After this repeated process, 500µl of AW1 wash buffer was added to the spin column and then transferred to a centrifuge and spined at 8000rpm for 1 minute, and the collection tubes were changed. 500µl of AW2 wash buffer was then added to the spin columns, placed in the centrifuge again and spined at 13000rpm for 3 minutes and the tubes changed. The labelled spin columns were then spined for 1 minute at 13000rpm in a centrifuge and collection tubes were discarded once more. Each labelled spin columns was then placed on a 1.5ml labelled eppendorf tube and to it, 60µl of elution buffer was added to the centre of each column and incubated at room temperature for 1 minute and then spined at 8000rpm for another 1 minute. The labelled spin columns were then discarded and the RNA was stored at -20°C.

3.4.3 DETECTION PCR

3.4.3.1 RT-PCR

RNA was then screened for the presence of genomic nucleic acid from types A AIV, NDV, IBV, Rota, Astro 1 and 2 by means of reverse transcription RT- PCR optimized with respect to primer sets (Table 3.1), enzymes, and concentration of reagents (Table 3.2) as well as cycling parameters (Spackman *et al*., 2002). Amplification was then carried out on cDNA followed by 1st round and in the case of IBV and NDV detection, nested PCRs or directly on RNA, with One-step PCR protocol followed by nested PCRs. Reverse transcription was then carried out for 80min at 55°C in a 20µl reaction containing 200U of superScript^{TM} III Reverse Transcriptase, 40 U of RNaseOUT^{TM} recombinant Ribonuclease Inhibitor, 5mM DTT, 1x First-Strand Buffer, 0.5mM dNTP mix, 7.5mg/L of random nucleotide hexamers (Invitrogen, Merelbeke, Belgium), 2µl of distilled water and 5µl of extracted RNA.

All 1st round and nested PCR reactions were performed on a mastercycler gradient (eppendorf, Hamburg, Germany) in a total volume of 25µl. A premix containing 17.3 µl of ddH20, 2.5µl of 10X Buffer, 2 mM dNTPs and 1U Platinum Taq (Invitrogen, Merelbeke, Belgium) and 0.5µl of cDNA or first round PCR product. PCR reactions were carried out using the same cycling conditions for each virus type, for example for AIV detection the conditions were as in Table 3.2: initial denaturation at 95°C for five min, five cycles of amplification at 95°C for 30s, 58°C for 30s and 72°C for one min, 40 cycles of amplification at 95°C for 30s, 56°C and 72°C for one min, five cycles of amplification at 95°C for 30s, 53°C for 30s and 72°C for one min and a final extension at 72°C for 10min. PCR product sizes were visualized by UV illumination Agarose gels stained with syber safe as compared to the 1kb^{+} size marker (Invitrogen, Merelbeke, Belgium).

Step by step procedure for Reverse transcription using Superscript III

- Prepared mix one (see Table 3.1)
- Added 8µl of mix one in each well
- Added 5µl of RNA
- Mixed (vortex or by pipeting) and spinned down
- Denaturation : 10min at 72°C
- Chilled directly on ice
- Prepared mix two (see Table 3.1)
- Added 7µl of mix two in each well
- Incubated for 80min at 50°C
- Inactivation for 15min at 70°C (see Table 3.1)

Step by step procedure for Reverse transcription using MMLV

- Diluted the RNA 1:1
- Prepared the mix one (Table 3.1)
- Added 7ul of mix one to each PCR tube
- Added 5ul of extracted and diluted RNA
- Incubated at 65°C for 5mins
- Chilled on ice (i.e. Quickly place tubes on ice block)

- Prepared Mix two (Table 3.1)
- Added 7ul of mix two to each of the PCR tubes from mix one
- Incubated at 37°C for 2mins
- Added 1ul of M-MLV to the mix (then task to PCR machine)
- Incubated at 25°C for 10mins
- Performed reverse transcription at 37°C for 50mins
- Then 70°C for 15 mins

} Continuous program in PCR machine

Table 3.1: RT-PCR mixture 1 and 2

Reagents	Superscript Mix 1	Superscript Mix 2	MMLV Mix 1	MMLV Mix 2
Primer (RP 0,03 ug/ul) (1:100)	5ul		5ul	
10 mM dNTP Mix	1ul		1ul	
Sterile, distilled water	2ul		1ul	
5X first-strand buffer		4ul		4ul
0.1 M DTT		1ul		2ul
RNase OUT (40 U/ml)		1ul		1ul
Superscript III (200U/ml)		1ul		0ul
MMLV		0ul		1ul
Total volume per sample	8ul	7ul	7ul	8ul

Note: denaturation 72°C, 10 min and quick on ice, before adding Mix two for either superscript or MMLV. Mix one and two for either superscript or MMLV make up 15ul to which 5ul of diluted extracted RNA is added

3.4.3.2 PCR REACTION

PCR reaction was carried out for various virus types using laid down procedures (see Table 3.2). The PCR mixes and the thermal cycles used were as optimized at the Department of Veterinary Medicine, University of Ibadan and Institute of Immunology, Luxembourg. The PCR mix was vortexed and 23µl was transferred into each PCR tube, 2µl of the DNA was added to the PCR mix and was vortexed and put in the thermocycler to undergo PCR thermal procedure. Nested PCR (nPCR) was performed for NDV and IBV on the product of the first round PCR using primers specific for each of the virus types. An agarose gel electrophoresis and stain (5 µl /sample) followed. Sybersafe was used instead of the Ethidium Bromide to highlight dsDNA on an agarose gel. The Although Sybersafe is less carcinogenic, the same precautions were taken when handling Sybersafe. I always wore gloves, discarded them immediately afterwards, and tried not to touch anything with my gloves, like the computer, the desk.

Table 3.2: Primers required for running PCR templates

Table 3.3: General PCR plate set-up

	1	2	3	4	5	6	10	11	12
A	1	9	17	25	33	41	49		
B	2	10	18	26	34	42	50		
C	3	11	19	27	35	43	RTNC		
D	4	12	20	28	36	44	PCRNC		
E	5	13	21	29	37	45			
F	6	14	22	30	38	46			
G	7	15	23	31	39	47			
H	8	16	24	32	40	48			

Where RTNC= RT negative control, PCRNC= PCR negative control and each well has a unique code for e.g. A1 to A49

3.4.4.0 DETERMINATION OF POSITIVE SAMPLES

3.4.4.1 Gel Casting

Thirty milliliter (30ml) of 2% agarose gel was prepared by adding 0.6g of Agarose (Invitrogen®) into 30ml of 0.5% TBE, boiled for 1 minute in the microwave to melt the agarose. It was allowed to cool and 3µl of SYBR Safe was added, rocked gently and poured into the gel rack containing combs (14 slots "Horizon 58 by Life technologies") which formed wells in the gel and was allowed to solidify. The comb was removed and the gel placed in an electrophoresis tank containing 0.5% TBE.

3.4.4.2 Gel Loading and Electrophoresis

The first and the last well of each lane of the gel were loaded with 5µl of ladder. Each sample (5µl) was mixed with 1µl of loading dye and was into the well. This was done using a single channel micropipette without breaking up the gel. The electrophoresis tank was connected to the power pack (Consort E455) and was run by applying constant current at 120V for 30 minutes.

3.4.4.3 DNA band detection

The DNA band was viewed by placing the gel on a UV transilluminator (UVP TS-20) beneath a Kodak camera connected to a computer. The image displayed was captured with the Kodak camera and viewed on the display unit of the connected computer. A 1kb DNA ladder was used (Figure 3.3).

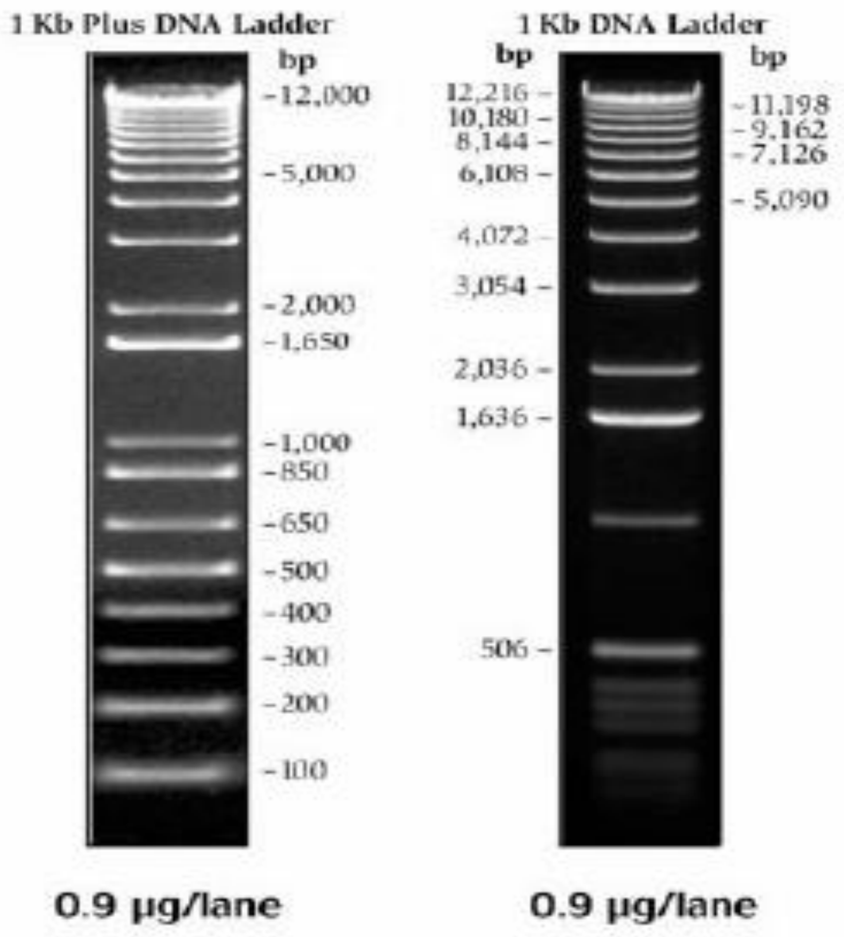

Figure 3.3: 1kb DNA Ladder

3.4.4.4 DNA SEQUENCING

In this study, no positive samples were detected for H5 and H7 subtype (Spackman *et al*., 2002; Slomka *et al*., 2007). The obtained sequences were then aligned together with contemporary and sequences (Bio Edit and Seqscape) and their phylogenetic relationship inferred using the Neighbor-Joining algorithm (MEGA 4.0; 1,000 bootstrapping) (Ducatez *et al*., 2006). Sequences were then deposited in a public database.

3.5.0 STATISTICAL DATA ANALYSIS

i. Species-effort curve was plotted for the first survey in each of the sites, to determine if survey effort was sufficient.

ii. The birds observed (seen and heard) during the survey were pooled and an estimate was made of bird species abundance, richness, evenness and diversity for each habitat.

iii. Bird species diversity was calculated using Shannon-Weiner diversity index, H and Simpson's diversity index D (Begon *et al*., 1996).

$$H = -\sum_{i=1}^{S} P_i \ln P_i$$

where: P_i = proportion of individual species,

S is the total number of species in the community (Number seen plus number heard),

ln = natural logarithm

$_i$ = i^{th} species and

$$\mathbf{D_s = \Sigma(n_i(n_i - 1)/N(N-1))}$$

where:

D_s = Bias corrected form for Simpson Index

n_i = number of individuals of the i^{th} species

N = Total number of species in the community

iv. Prevalences of virus types and subtypes (AIV, NDV) were calculated as a ratio of the number of positive samples to the total samples screened.

v. Data was tested with One-sample Kolmogorov test to determine whether or not the data are normally distributed and Homogeneity of variances was tested using Levine's test.

vi. Tests of correlation were used to determine significant associations between habitat variables and mean bird diversity, abundance and richness.

vii. Comparison was made to determine differences between bird species richness, abundance and diversity indices across seasons, habitat and time of day using One way Anova (ANOVA).

viii. A post hoc test was used to determine where differences come from.

ix. Descriptive statistics were also used.

3.5.1 POSSIBLE BIASES IN METHODOLOGY

From bird census methods reviewed, it is apparent that no single bird survey or vegetation sampling technique is perfect. Therefore, all bird species in the study area may not be recorded and number of species recorded may vary with time (Manu, 2002). The possible biases are effects of variation in survey effort, effect of time of day on species number, biases due to the observer, landscape or the nature of the habitat, the birds themselves, duration of study, season, weather, and the equipment used. During this survey, the effect of variation in effort was checked by allocating equal amount of time to the survey of each transect.

CHAPTER FOUR

RESULTS

4.0 BIRD SPECIES INVENTORY

A total of 398 bird species from at least 71 families is now recorded for the Ibadan area, of which the IITA campus holds at least 269 species (68%) from 64 families, of which 75 species have been mist-netted during our study between Febuary 2010 and November 2012 (See Plates 1 to 15; Appendix 3; Appendix 4). Bird species richness, abundance, Shannon and Simpson's diversity indexes and evenness index are presented in the Table 4.1. The forest site had the highest mean bird species richness per section with the lake and farmland having relatively less number of species per section. The number of species per sample is a measure of richness. The more species present in a sample, the 'richer' the sample.

Table 4.1: Bird species diversity, abundance, richness and evenness index across habitats

	Forest	S.E	SD	Lake	S.E	SD	Farm	S.E	SD
N=Sections	220			240			184		
Diversity(Shannon's)	1.888*	0.034	0.509	1.466	0.038	0.583	1.370	0.046	0.606
Diversity(Simpson's')	0.114*	0.007	0.096	0.297	0.015	0.237	0.295	0.018	0.241
Abundance	18.562	0.892	13.229	73.514*	10.831	167.791	56.124	13.345	176.034
Richness	8.964*	0.303	4.490	8.304	0.285	4.407	6.868	0.327	4.313
Evenness index	0.913*	0.006	0.088	0.746	0.016	0.242	0.779	0.017	0.220

Plate 1: *Macrosphenus kempi* Kemp's Longbill*

Plate 2: *Cossypha cyanocampter* Blue-shouldered Robin Chat*

Plate 3: *Phyllastrephus baumanni* Baumann's Greenbul*

Plate 4: *Alcedo cristata* Malachite kingfisher

Plate 5: *Ploceus nigricollis* Black-necked Weaver

Plate 5: *Cisticola erythrops* Red-faced Cisticola

Plate 6: *Halcyon senegalensis* Woodland Kingfisher

Plate 7: *Streptopelia semitorquata* Red-eyed Dove

Plate 8: *Cinnyris minullus* Tiny Sunbird

Plate 9: *Terpisiphone rufiventer* Red-bellied Paradise Flycatcher*

Plate 10: *Dyaphorophyia castanea* Chestnut Wattle-eye*

Plate 11: *Halcyon malimbica* Blue-breasted Kingfisher

Plate 12: *Ptilopsis leucotis* Northern White-faced Owl

Plate 13: *Ploceus cucullatus* Village Weaver Colony

Plate 14: *Saxicola rubetra* Whinchat, a Palearctic migrant

4.1.0 TESTS OF NORMALITY

Variances were equal for bird species diversity for Levine's test and $F_{(68,577)} = 1.059$, $P > 0.05$, but variances were not equal for bird species richness abundance. Levine's test for bird species richness and abundance were $F_{(68,577)} = 1.92$ and 3.31, respectively and $P < 0.05$.

4.1.1 BIRD SPECIES DIVERSITY

For the Shannon's index, bird species diversity was highest in the forest and comparison with other habitats showed a significant difference in comparison with bird species diversity in the Lake site ($P < 0.05$). The difference in bird species diversity for lake site was not significant in comparison with the farm site $P = 0.074$ (See Figure 4.1 and 4.2). Simpson's diversity index also gave similar results with forest being significantly lower for the indices (Simpsons) therefore interpreted as highest bird species diversity compared to the lake site and farm area $P < 0.05$ (See Figure 4.1 and 4.2). Simpsons bird species diversity was relatively higher in 2010 than in 2011 for both farm and lake habitats (See Figure 4.1 and 4.2).

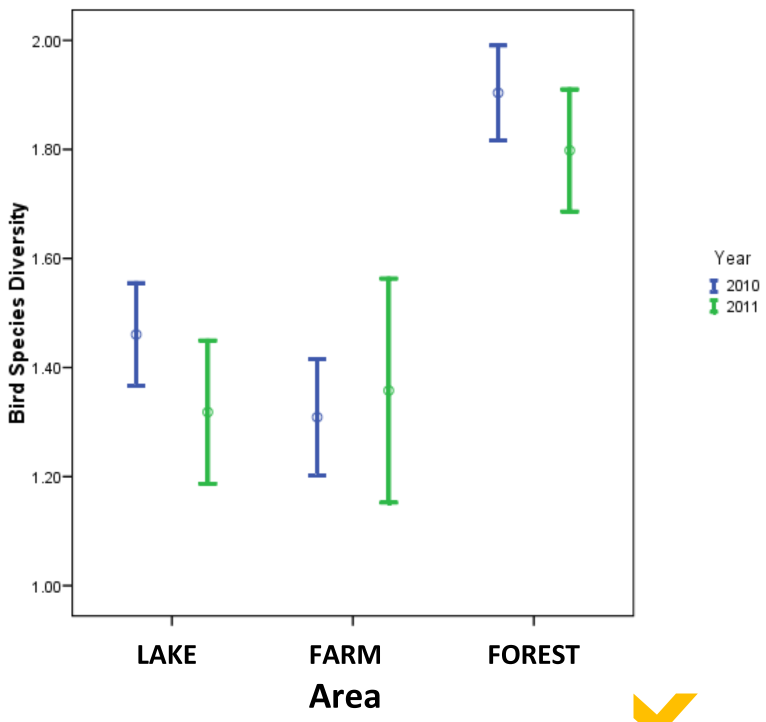

Figure 4.1: Bird species diversity across habitats (Shannon's index).

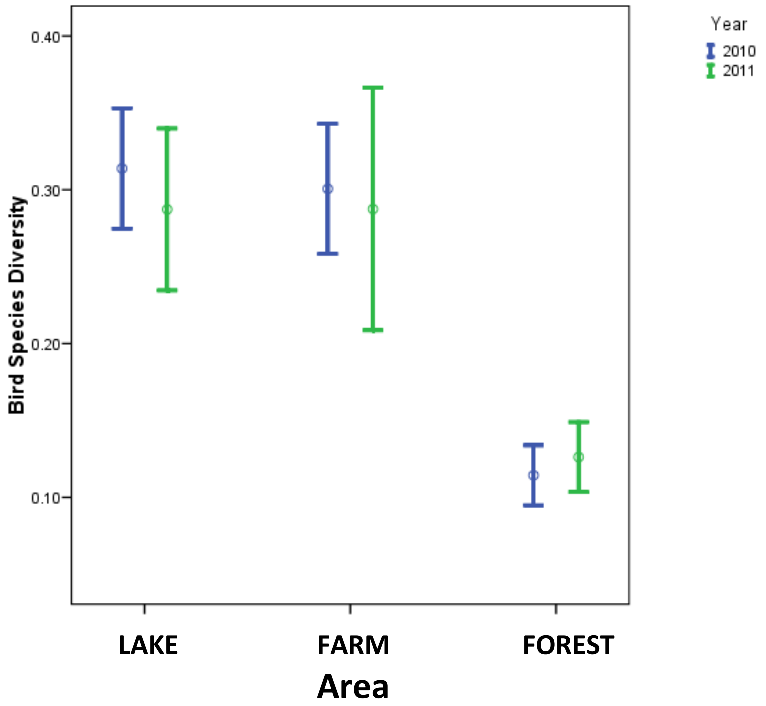

Figure 4.2: Bird species diversity across habitats (Simpson's index).

4.1.2 BIRD SPECIES RICHNESS

Bird species richness was highest in the forest, with a significant difference in comparison with bird species richness in the Lake site $P<0.05$ and there was also significant difference on comparison with the farm site $P<0.001$. Bird species richness was relatively higher in 2010 than in 2011 for both the lake site and forest habitats, while bird species richness was higher in 2011 in comparison with 2010 for the farm site as displayed in Figure 4.3. There were averagely 9, 8 and 7 birds in each section respectively for forest, lake and farm habitats as seen in Table 4.1 and Figure 4.3. However, overall species accumulation over the first 40 transects showed a relatively higher species richness in 2011 (See Figure 4.26).

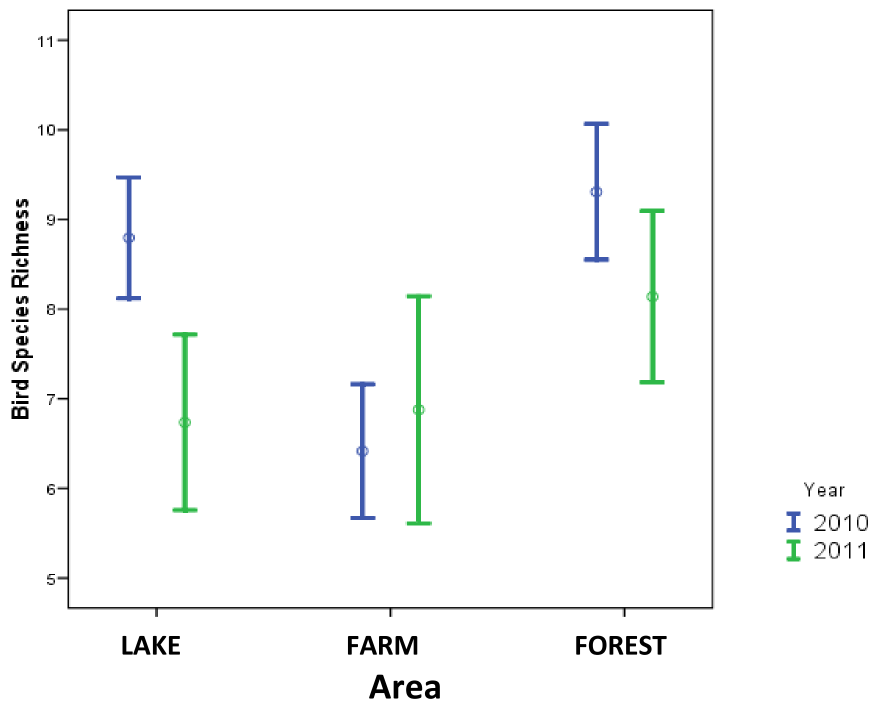

Figure 4.3: Bird species richness across habitats

4.1.3 BIRD SPECIES ABUNDANCE

Bird species abundance was highest at the lake. Comparison with other habitats showed a significant difference in bird species abundance relative to the forest P<0.05 and was close to significance on comparison with the farm site P=0.05 (See Figure 4.4). Bird species abundance was relatively higher in the first year (2010) in all the habitats (farm, lake and forest; See Figure 4.4). Averagely, bird species abundance per section for the three habitats was 18, 73 and 56 respectively for forest, lake and farm; See Table 4.1.

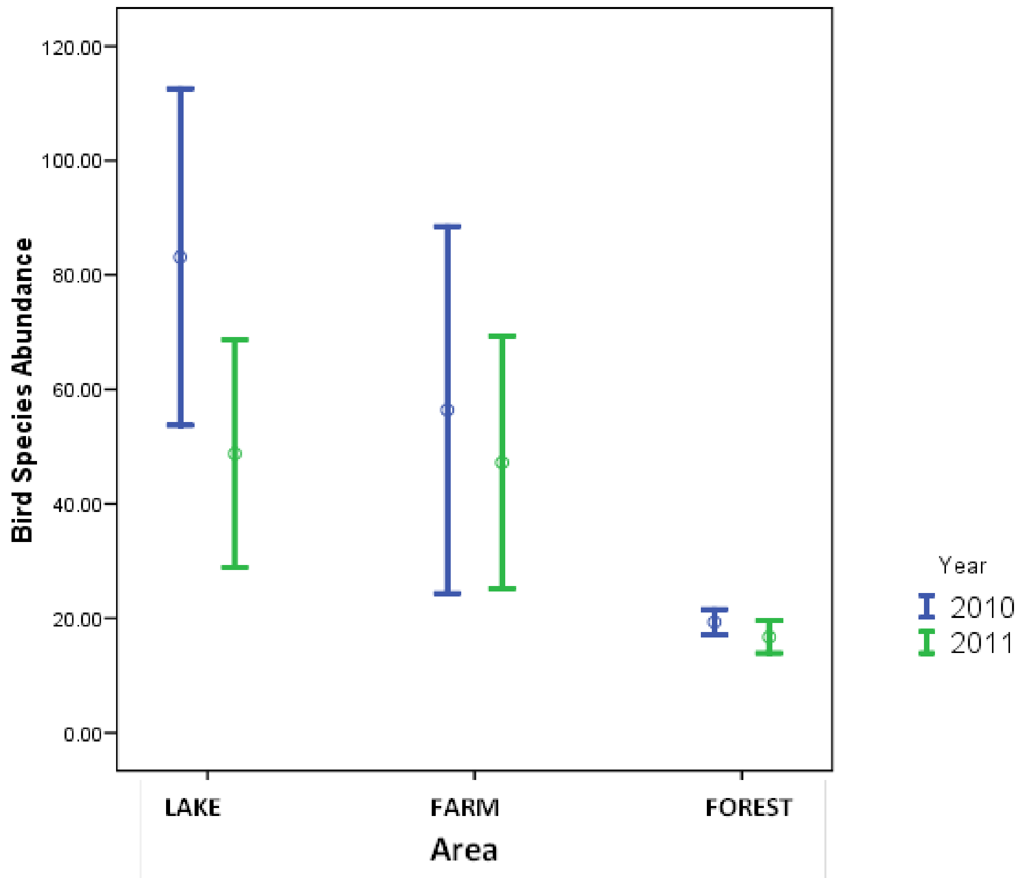

Figure 4.4: Bird species abundance across habitats.

4.1.4 BIRD SPECIES EVENNESS

Bird species were relatively more evenly distributed in the forest site as compared to the other two habitats, lake and farm ($P<0.05$). Bird species evenness was relatively higher in the first year 2010 as compared to the second year 2011 for the lake and the forest habitats, but the reverse was the case for the farm habitat (See Figure 4.5). Averagely, the evenness index for all three habitats were as follows; 0.90, 0.75 and 0.78 for the forest, lake and farmland habitats respectively (see Table 4.1 and Figure 4.5).

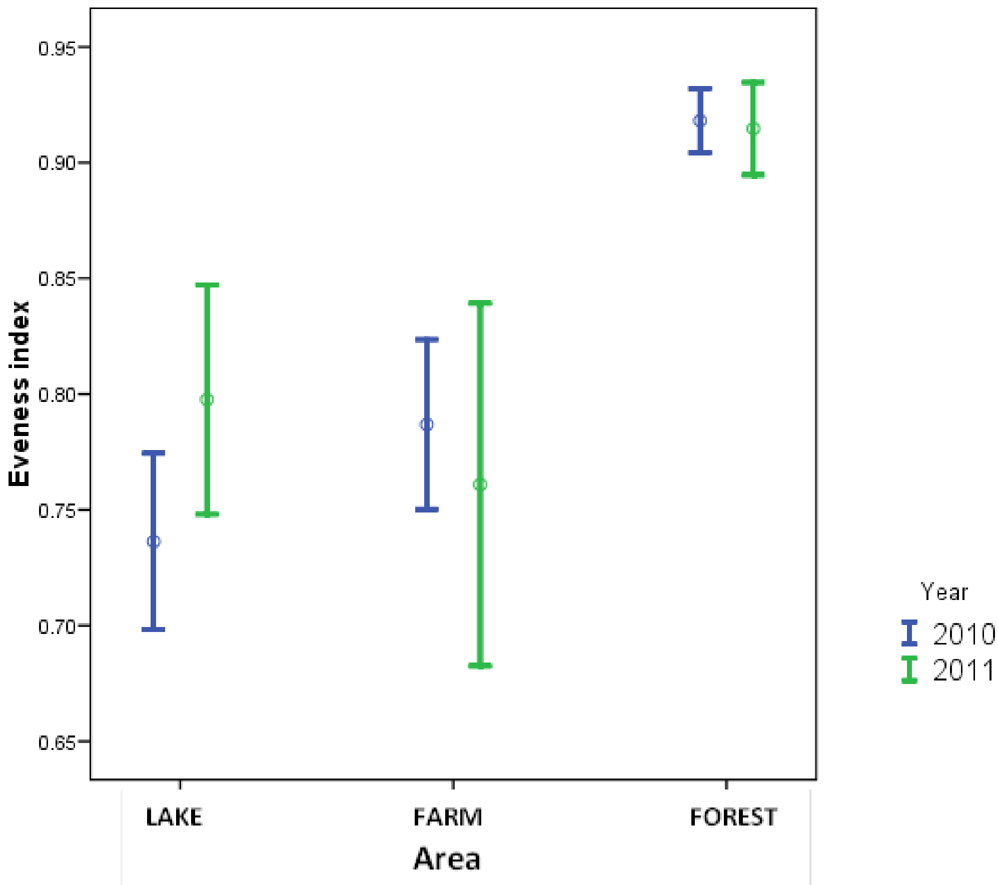

Figure 4.5: Bird species evenness across habitats.

4.2.0 EFFECT OF TIME OF DAY ACROSS HABITATS

4.2.1 EFFECT OF TIME OF DAY ON BIRD SPECIES DIVERSITY

Bird species diversity was not significantly affected by time of day in the three habitats. Comparison of the differences in the Simpson's index for bird species diversity for the two time periods (morning and evening) is displayed in the Figure 4.6 and 4.7. Relatively higher variances were however observed during the evening surveys. Differences in bird species diversity between time periods of survey was significant using the Shannon's diversity index for the farm and lake habitats between morning and evening survey periods as displayed in Figure 4.6 and 4.7. Bird species diversity using Shannon's diversity index was relatively higher in the morning survey period as when compared to evening for the lake site. For the farm habitat there was relatively higher bird species diversity in the evening survey period as compared to the morning. The forest habitat showed no relative difference in bird species diversity for the two time periods but variance was relatively higher for the evening survey period (see Figure 4.6 and 4.7). Comparison of bird species diversity using Shannon's diversity index showed that although differences in bird species diversity between the morning survey period for lake and farm habitats showed a relative difference with the former having a higher diversity index. The differences in bird species diversity between the evening survey periods for lake and farm habitats showed no relative difference (see Figure 4.6 and 4.7). However, bird species diversity using the Shannon's index was relatively higher in the forest on comparison with either lake or farm for the two time periods (See Figure 4.6 and 4.7).

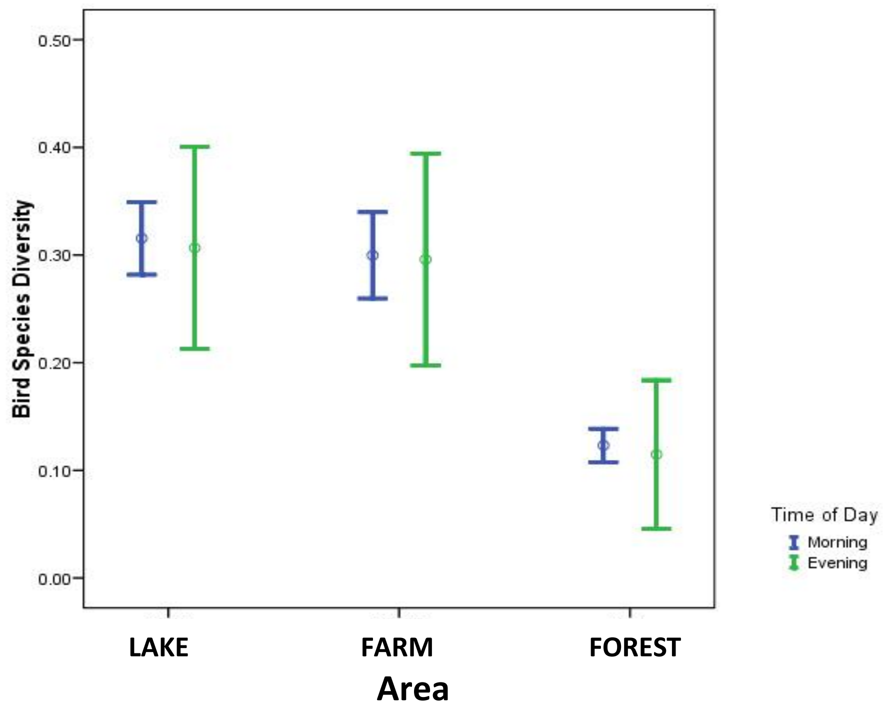

Figure 4.6: Bird species diversity and time of day (Simpson's index).

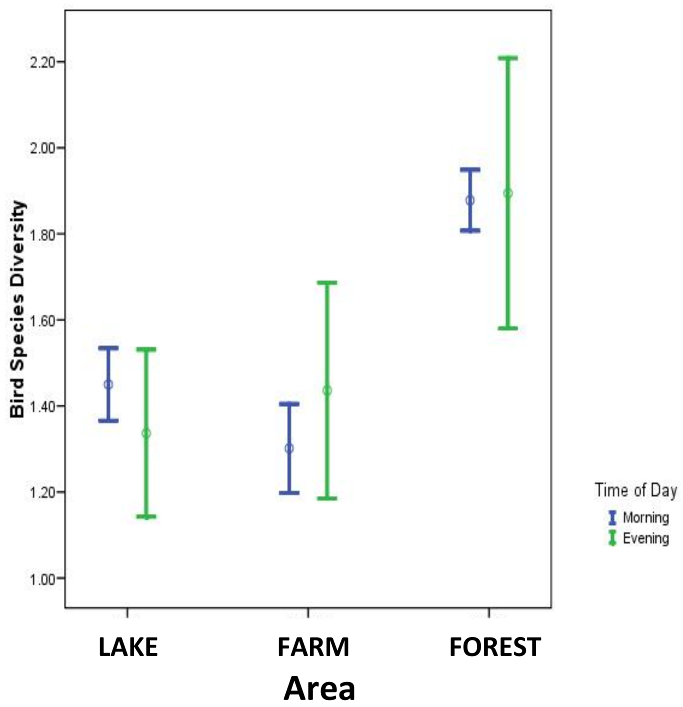

Figure 4.7: Bird species diversity and time of day (Shannon's index).

4.2.2 EFFECT OF TIME OF DAY ON BIRD SPECIES RICHNESS

Relatively higher bird species richness was observed in the morning survey period as compared to the evening surveys for the lake habitat (Figure 4.8), but the opposite relation was observed in the farm and forest habitats where evening surveys yielded higher bird species richness.

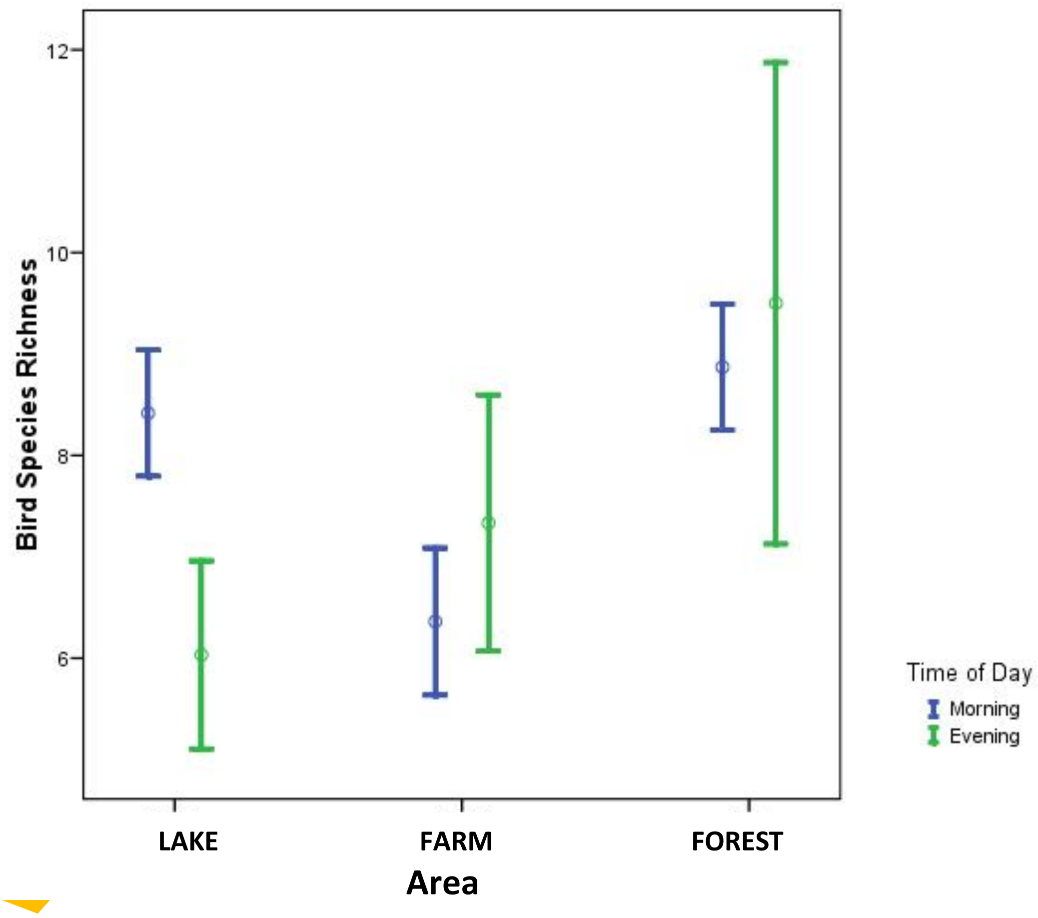

Figure 4.8: Bird species richness and time of day.

4.2.3 EFFECT OF TIME OF DAY ON BIRD SPECIES ABUNDANCE

Bird species were relatively higher in abundance during the morning survey period as compared to the evening for the lake habitat as shown in Figure 4.9, but farm habitat showed a relatively higher bird species abundance in the evening survey period. The difference in abundance of birds per section was not relatively different for the forest habitat.

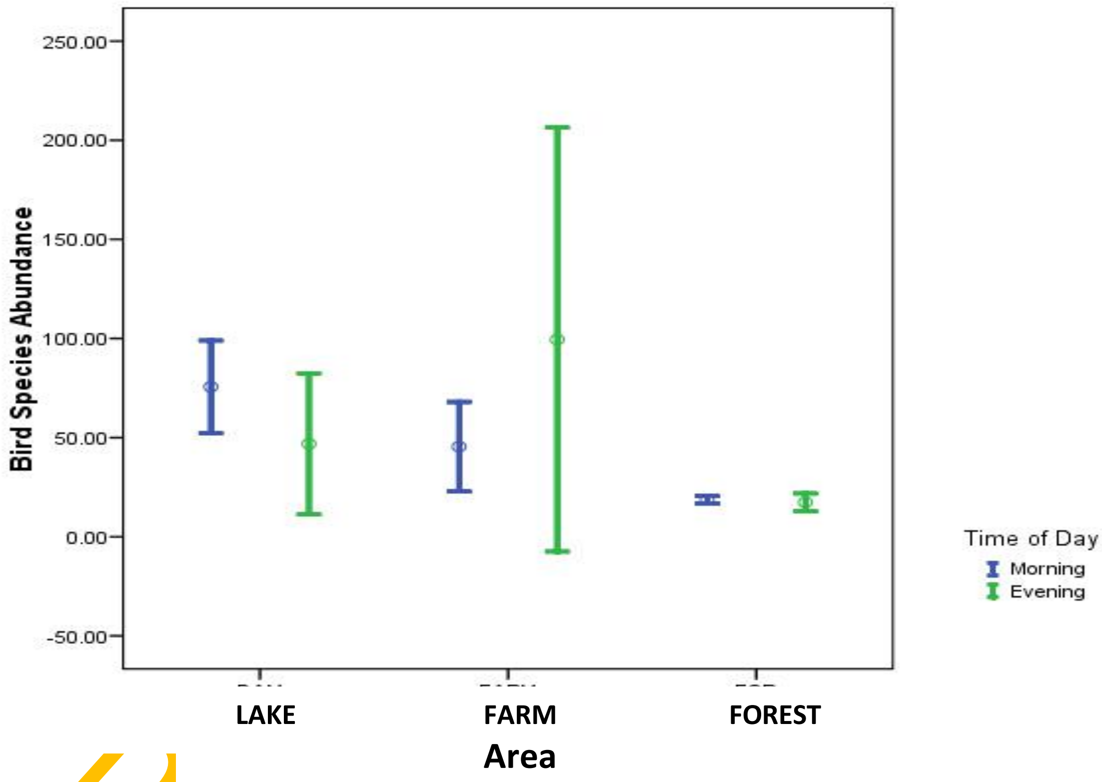

Figure 4.9: Bird species abundance against time of day

4.2.4 EFFECT OF TIME OF DAY ON BIRD SPECIES EVENNESS

Birds showed relatively higher evenness in the evening surveys period for the lake habitats as compared to the morning surveys as shown in Figure 4.10, whereas the forest and farm habitats showed a relatively higher evenness index for the morning survey period (Table 4.1). For both time periods, the forest habitat showed significantly higher evenness index as compared with either of the other two habitat (see Figure 4.10).

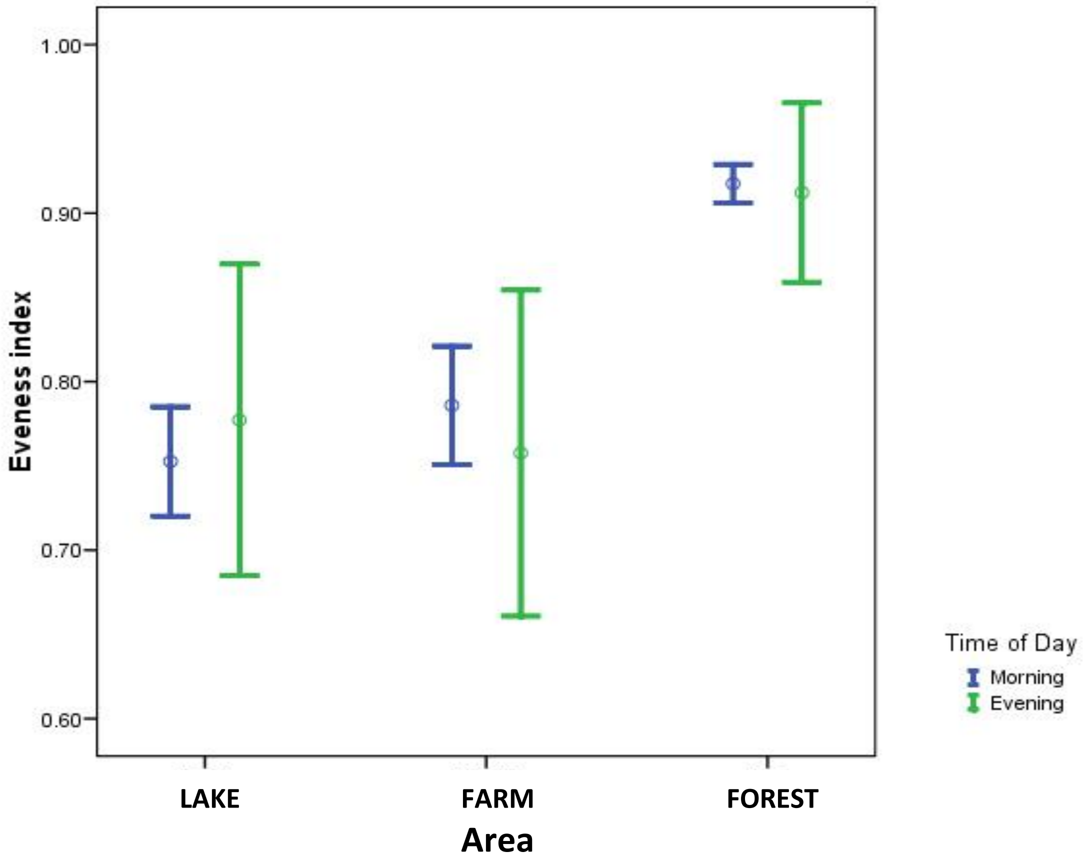

Figure 4.10: Bird species evenness against time of day

4.3.0 EFFECT OF TIME OF DAY POOLING ALL HABITATS

4.3.1 EFFECT OF TIME OF DAY ON BIRD SPECIES DIVERSITY

Pooling all bird diversity data together as observed in Figure 4.11 and 4.12, evening survey had relatively lower mean bird species diversity as compared to the morning survey, irrespective of habitat.

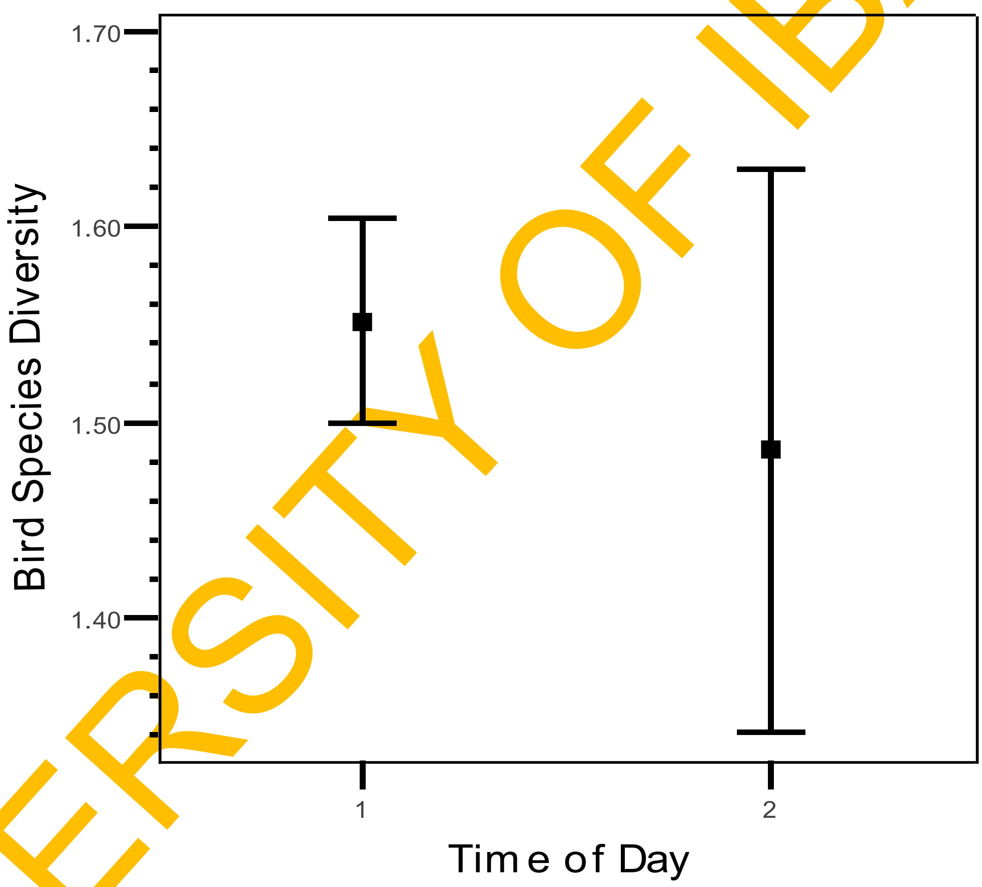

Figure 4.11: Shannon's bird species diversity index against time of day (Pooled data).
Note: 1=Morning and 2= Evening

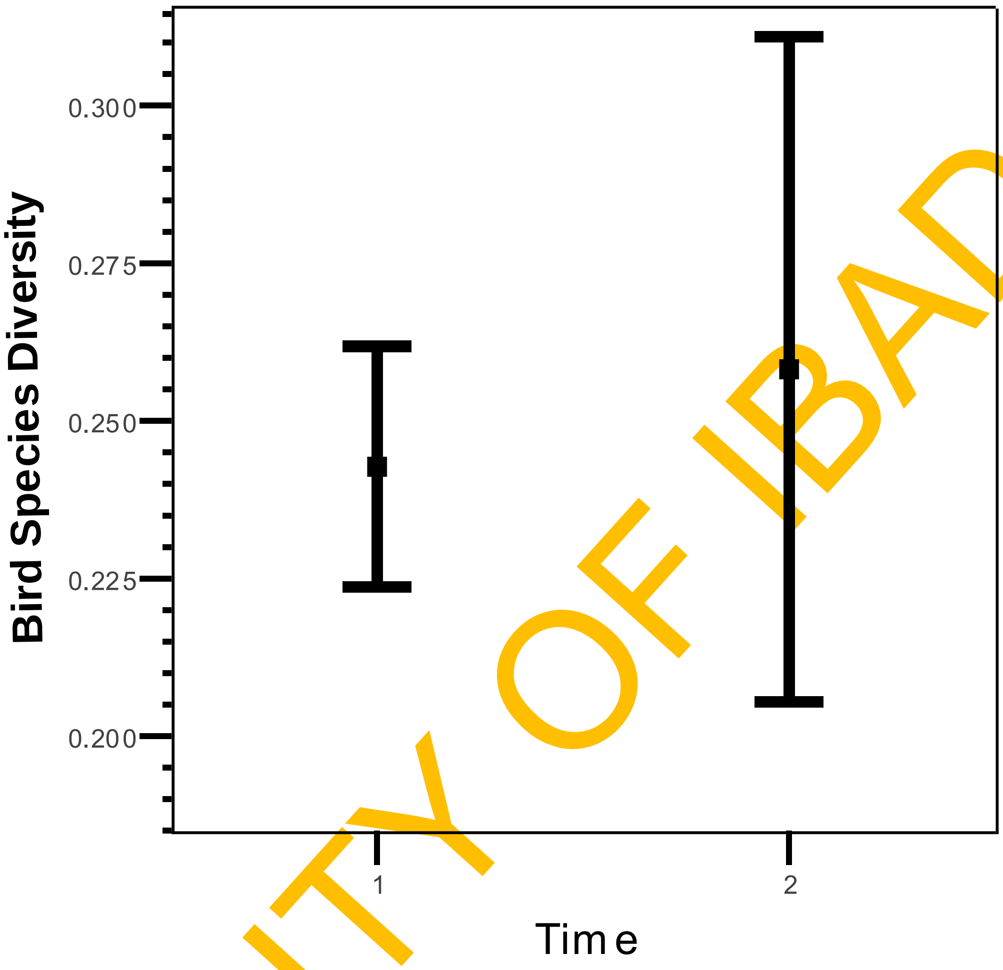

Figure 4.12: Simpson's bird species diversity index against time of day (Pooled data).
Note: 1=Morning and 2= Evening

4.3.2 EFFECT OF TIME OF DAY ON BIRD SPECIES RICHNESS

Bird species richness was relatively higher in the morning as compared to the evening survey as observed in Figure 4.13. Mean species richness per section was about 8 birds per section and about 7 birds for the evening survey.

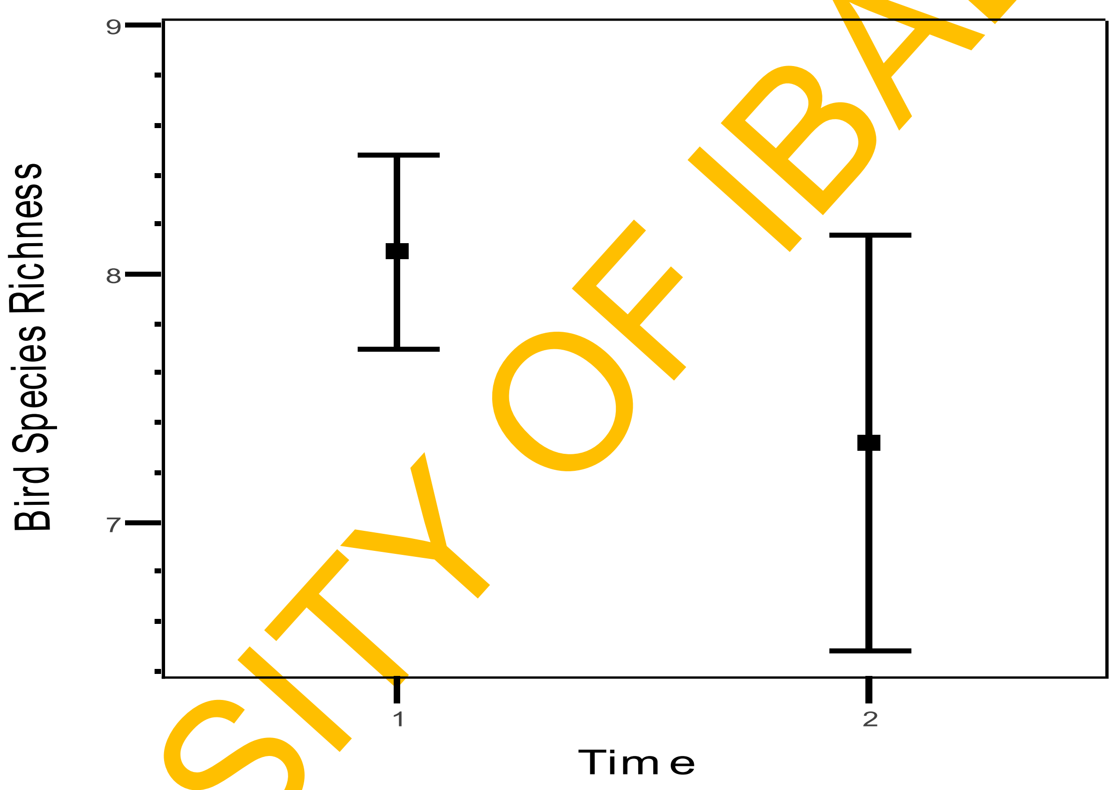

Figure 4.13: Bird Species richness against time of day (Pooled data).
Note: 1=Morning and 2= Evening

4.3.3 EFFECT OF TIME OF DAY ON BIRD SPECIES ABUNDANCE

Bird species abundance was relatively higher in the evening as shown in Figure 4.14.

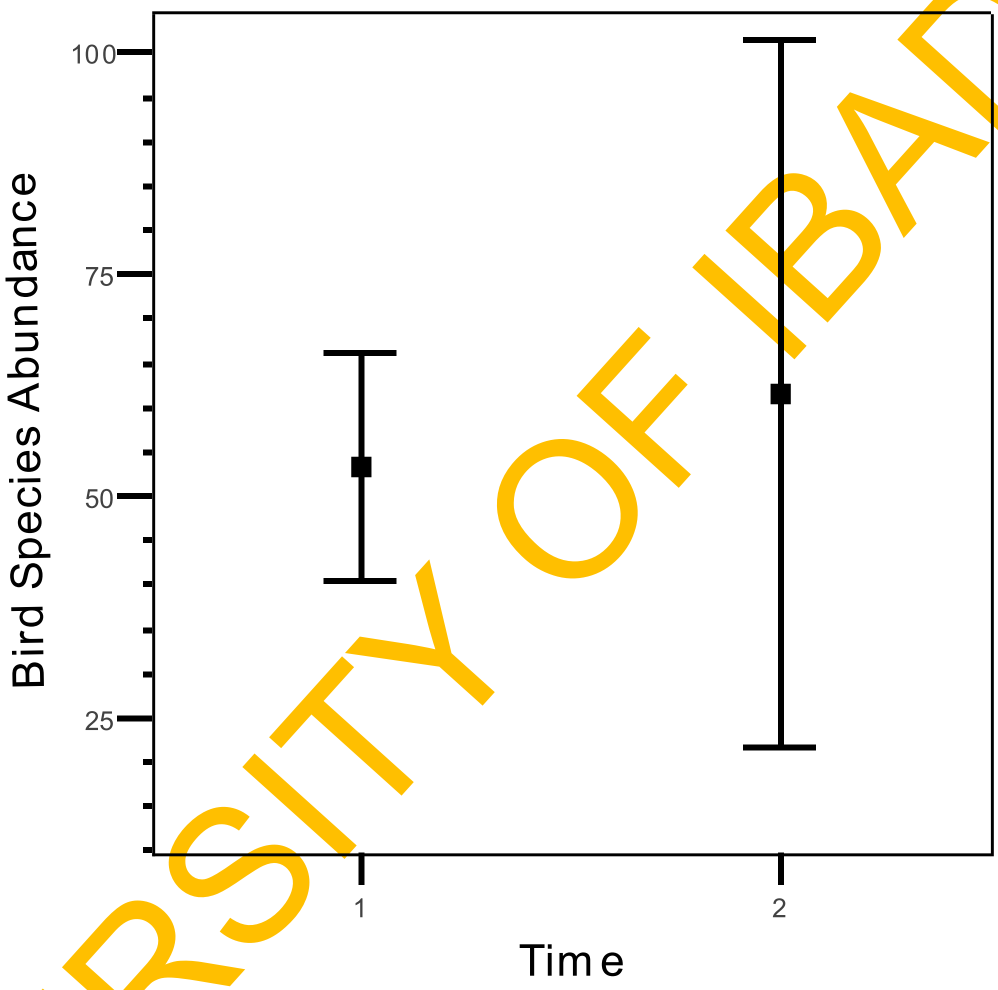

Figure 4.14: Bird Species abundance against time of day (Pooled data).
Note: 1=Morning and 2= Evening

4.3.4 EFFECT OF TIME OF DAY ON BIRD SPECIES EVENNESS

When all data were pooled, evenness was relatively higher in the morning survey (see Figure 4.15).

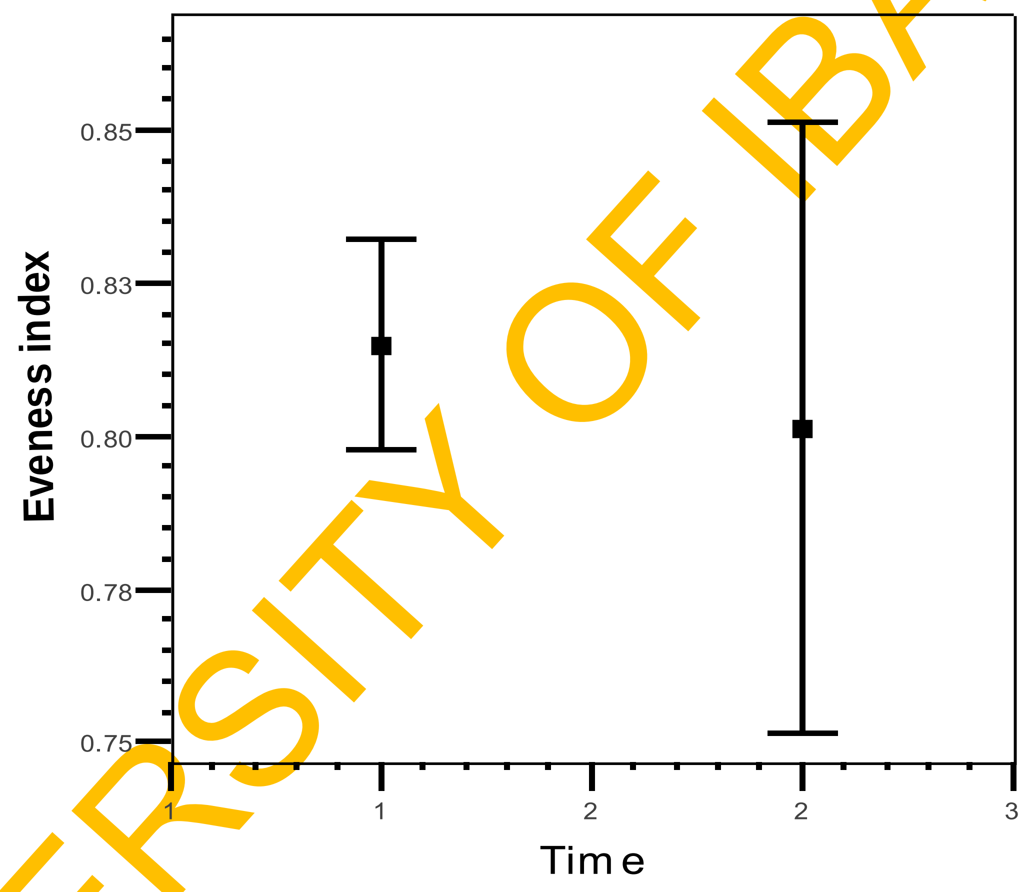

Figure 4.15: Evenness index against time of day (Pooled data).
Note: 1=Morning and 2= Evening

4.4.0 EFFECT OF QUARTERS OF THE YEAR ON DIVERSITY INDICES ACROSS HABITATS

4.4.1 EFFECT OF QUARTERS OF THE YEAR ON BIRD SPECIES DIVERSITY

The study area experiences two major seasons (wet and dry seasons) during each year. The wet season spans the period of March to October and the dry season November to Febuary of every year. However, for the purpose of this study, a year has been divided into four seasons, namely season one: January to March or late dry season, season two: April to June or early rain season, season three: July to September or late rain season; and season four: October to December or early dry season. Bird species diversity using the Shannon's and Simpson's diversity index was compared across seasons for the two years as displayed in Figure 4.16 and 4.17. For the first year, bird species diversity for season one (January-March) had a relatively higher bird species diversity than the other three seasons for the lake and farm habitats see figure; while season two (April-June) showed a relatively higher bird species diversity for the forest habitat. For all seasons and in the two years, bird species diversity was relatively higher in the forest habitat as compared to either of the other two habitats. The overall difference in bird species diversity between season one and either of season two (April-June) and four (Oct-Dec) were significantly different $P<0.05$, but bird species diversity was not significantly different on comparison of season one with season three $P=0.246$. Bird species diversity was relatively higher in season three as compared to season two for year 2010.

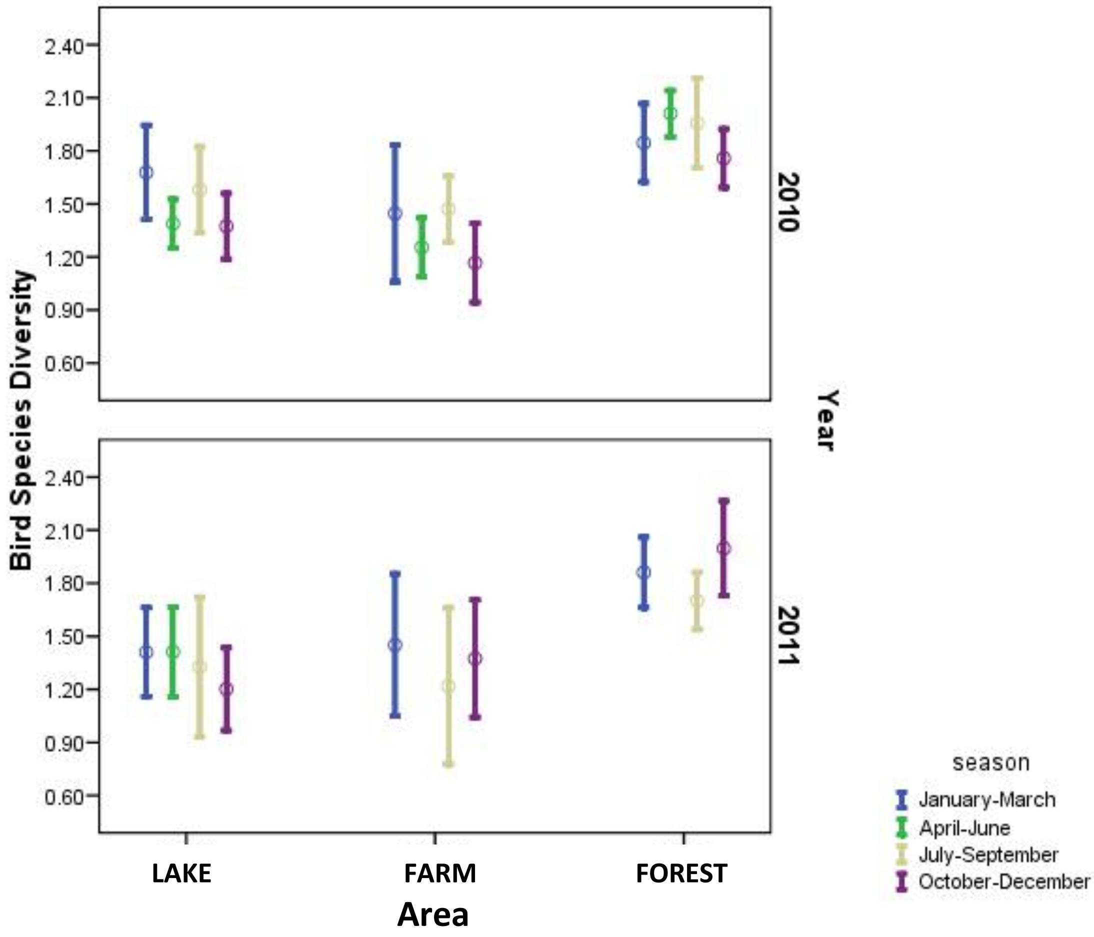

Figure 4.16: Bird species diversity against season in the various habitats for the two years (Shannon's index).

Note: January-March=Late dry season, April-June=Early wet season, July-September=Late wet season and October-December=Early dry season

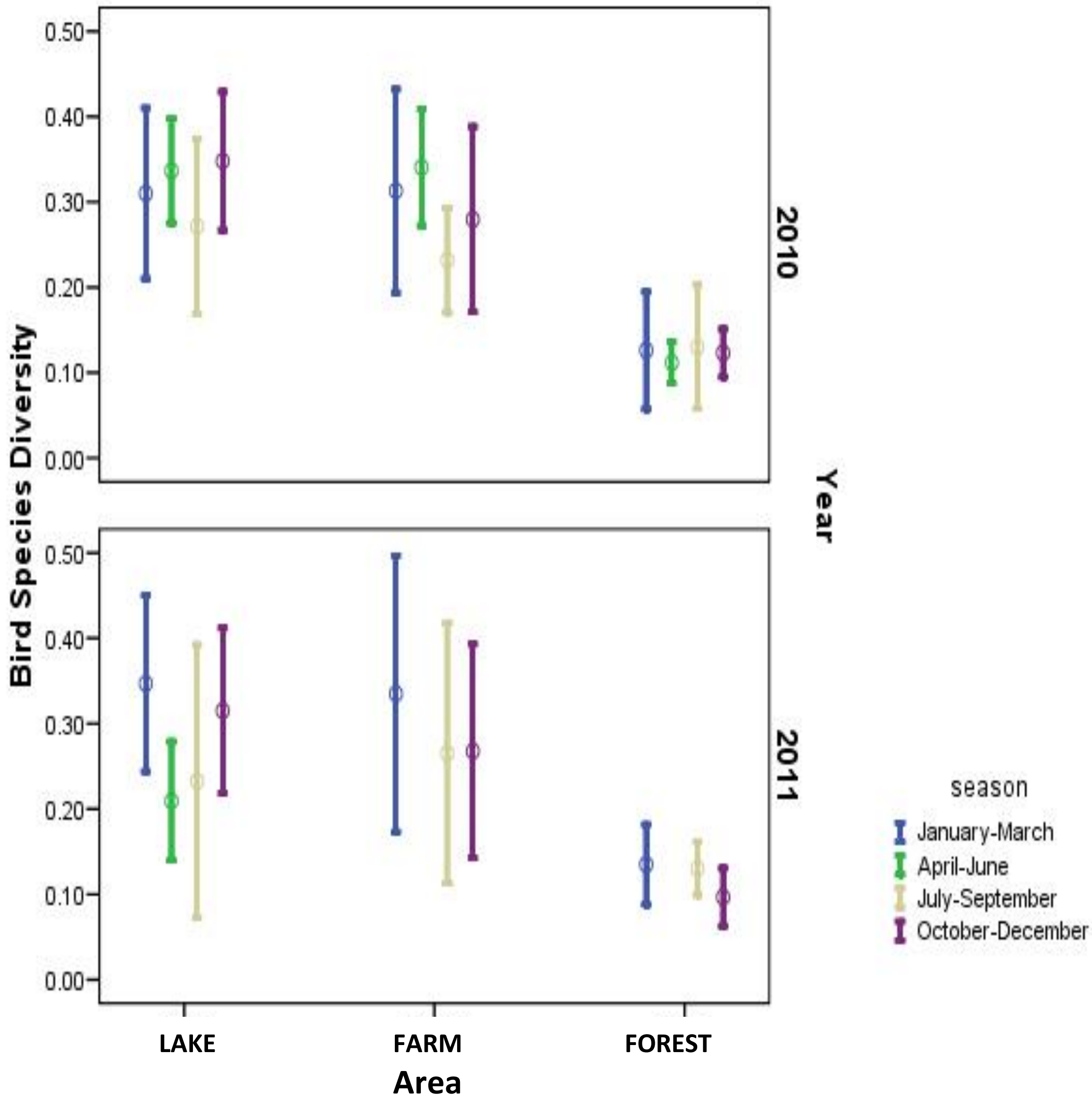

Figure 4.17: Bird species diversity against season in the various habitats for the two years (Simpson's index).

Note: January-March=Late dry season, April-June=Early wet season, July-September=Late wet season and October-December=Early dry season

4.4.2 EFFECT OF SEASON ON BIRD SPECIES RICHNESS

Bird species richness across season was significantly higher in season one than all the other seasons for the lake and farm habitat, and for the two years with P<0.001. For the forest habitat, season two had relatively higher species richness compared to the other seasons for the year 2010 alone. This relationship is illustrated in Figure 4.18.

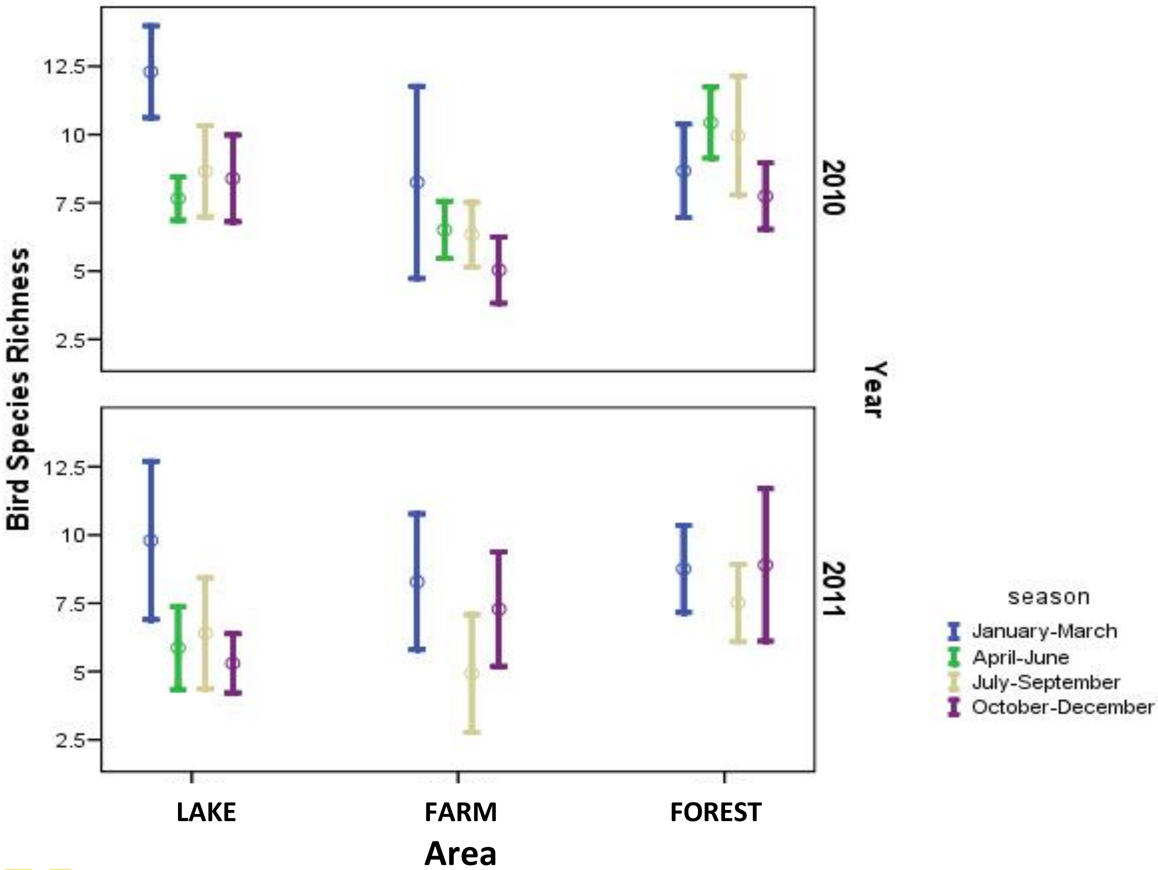

Figure 4.18: Bird species richness against season in the various habitats.
Note: January-March=Late dry season, April-June=Early wet season, July-September=Late wet season and October-December=Early dry season

4.4.3 EFFECT OF SEASON ON BIRD SPECIES ABUNDANCE

Bird species abundance was relatively higher in season one than in all other seasons for the lake habitat in both years (see Figure 4.19). Farm and forest habitat had season two with a relatively higher abundance than all other seasons for the first year.

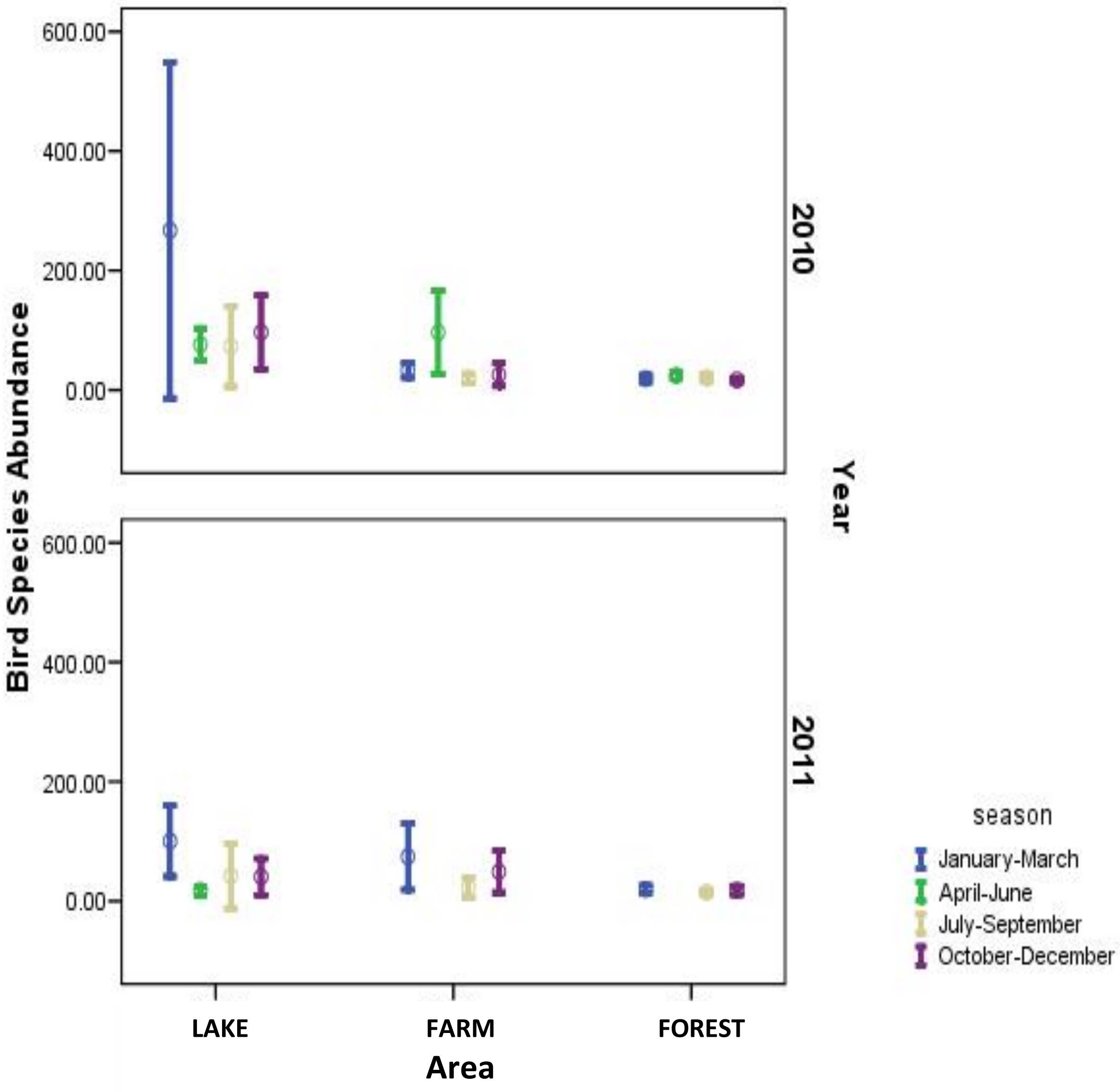

Figure 4.19: Bird species abundance against season in the various habitats.
Note: January-March=Late dry season, April-June=Early wet season, July-September=Late wet season and October-December=Early dry season

4.4.4 EFFECT OF SEASON ON BIRD SPECIES EVENNESS

Bird species evenness was relatively higher in season three for the lake and farm habitats, while the forest habitat had season one highest in bird species evenness in the first year (See Figure 4.20). The second year showed a relatively higher bird species evenness in season two than in all other seasons for the lake habitat. Farm habitat showed relatively higher bird species evenness for season three as compared to seasons one and four. Forest habitat showed a higher bird species evenness for the fourth season.

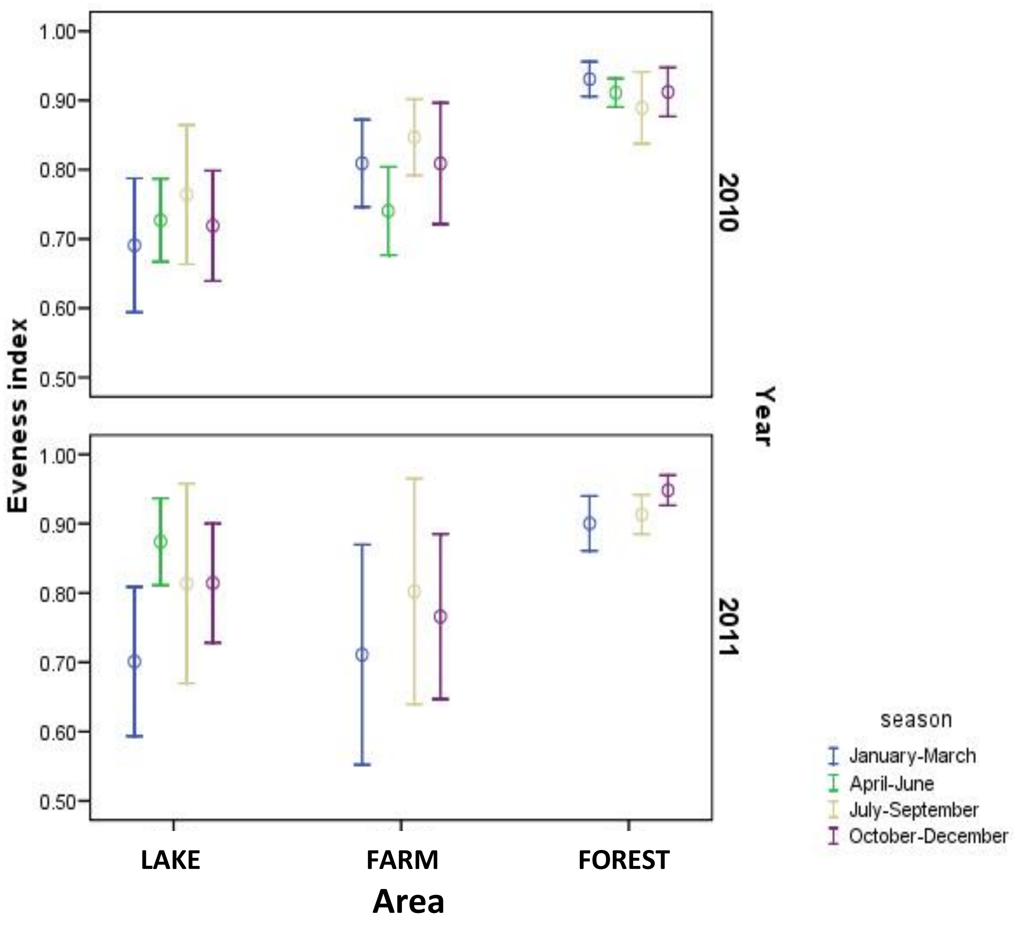

Figure 4.20: Bird species evenness against season in the various habitats.
Note: January-March=Late dry season, April-June=Early wet season, July-September=Late wet season and October-December=Early dry season

4.5.0 EFFECT OF LAND USE

4.5.1 EFFECTS OF LAND USE ON BIRD SPECIES DIVERSITY BASED ON TRANSECTS

Bird species diversity was significantly higher in the forest habitat than in all the other land use systems ($P<0.05$). Bird species diversity was also significantly higher in the forest edge than in all the other land use systems with the exception of the forest, ($P<0.05$). The pond showed the least bird species diversity as seen in Figure 4.21. Forest and forest edge had mean bird species diversity of higher than 3.0 for Shannon's bird diversity and between 0 and 0.1 for Simpson's diversity index. Other land-use types in the exception of the lake gallery forest (LAKEGAL which had about 2.6 for Shannon's bird diversity and 0.17 for Simpson's index) had a mean bird species diversity of less than 2.0 for Shannon's bird diversity and between 0.2-0.4 for Simpson's index. Pond had mean bird diversity of less than 1.0 for Shannon's bird diversity and above 0.6 for Simpson's index (Figure 4.21).

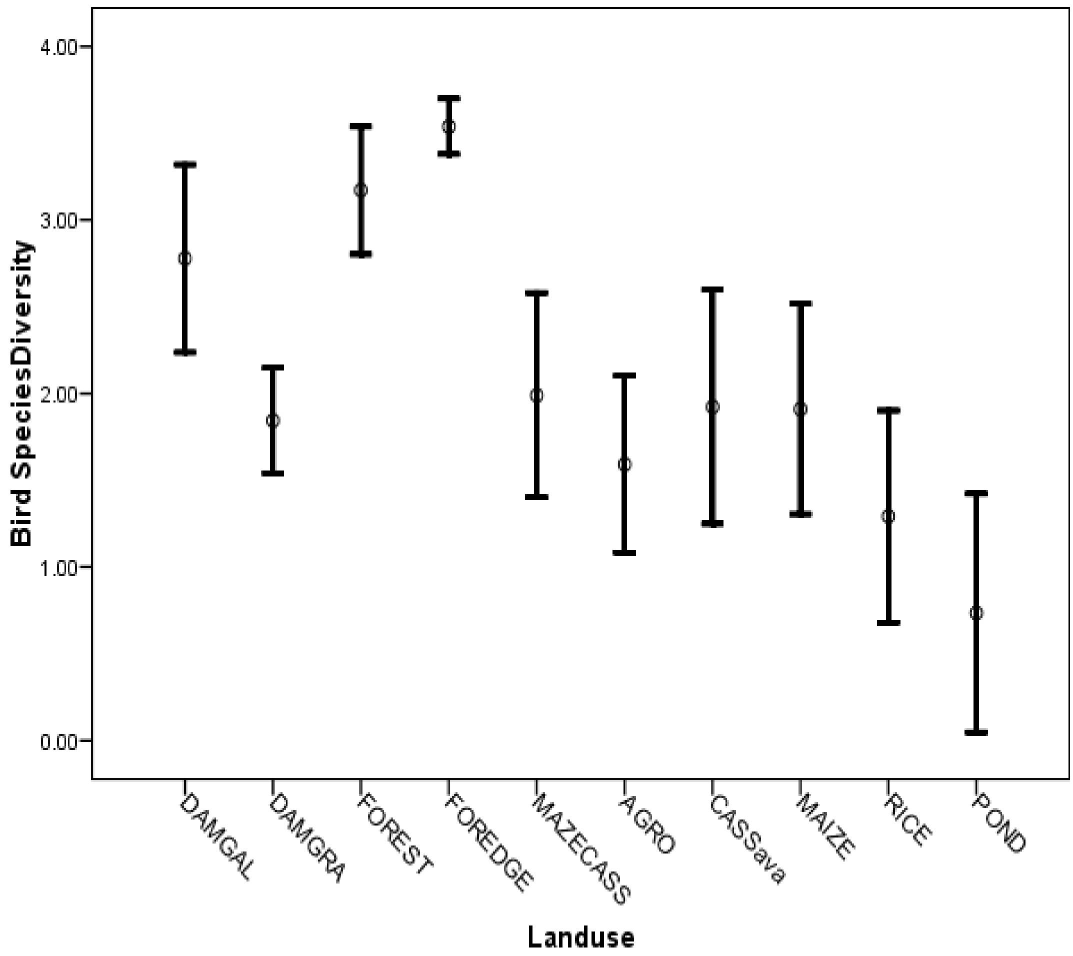

Figure 4.21: Bird species diversity in land-use systems (Shannon's index).
Note: DAMGAL= Lake gallery forest areas, DAMGRA= Lake grassland areas, FOREDGE= Forest edge areas, MAZECASS= Maize cassava plots, AGRO= Orchard containing citrus, CASSava= Cassava farm plots, MAIZE= Maize farm plots, RICE= Rice paddy plots, POND= Ponds

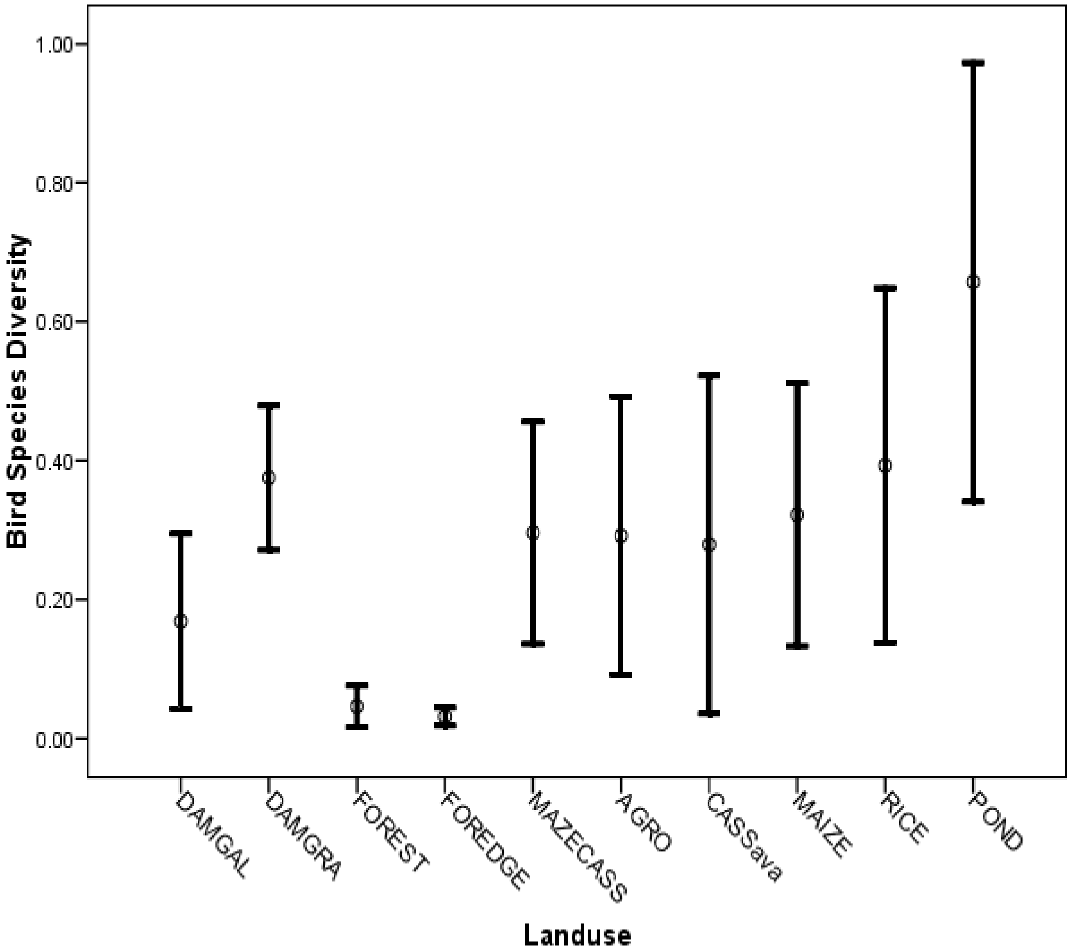

Figure 4.22: Bird species diversity in land-use systems (Simpson's index).
Note: DAMGAL= Lake gallery forest areas, DAMGRA= Lake grassland areas, FOREDGE= Forest edge areas, MAZECASS= Maize cassava plots, AGRO= Orchard containing citrus, CASSava= Cassava farm plots, MAIZE= Maize farm plots, RICE= Rice paddy plots, POND= Ponds

4.5.2 EFFECT OF LAND-USE ON BIRD SPECIES RICHNESS

Forest edge had the highest bird species richness and differences when compared with other land-use systems were significant, P>0.05. Forest edge had a mean bird species richness of 45 birds per transect, while "lake-gallery" and lake grassland had a species richness of 40 birds per transect (see Figure 4.23). Agro and rice land-use types had a species richness of only 10 birds per transect each.

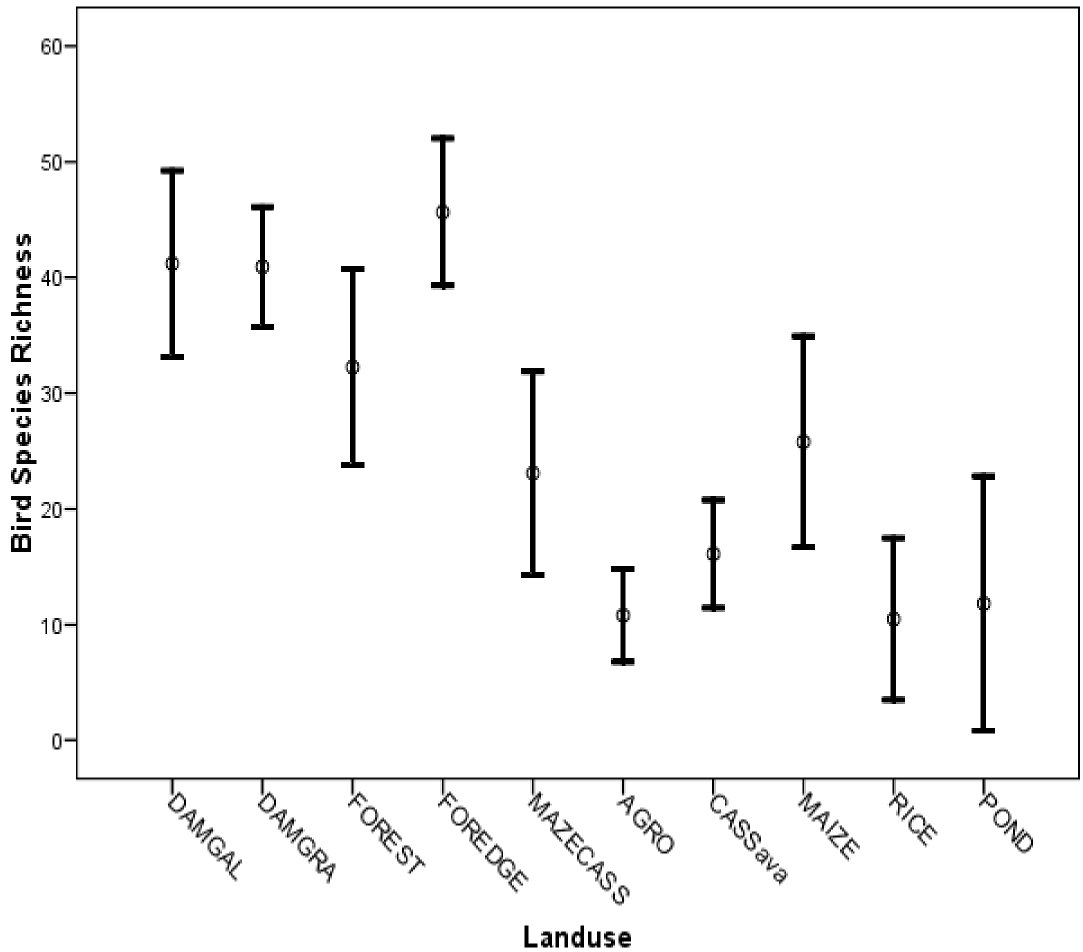

Figure 4.23: Bird species richness in land-use systems.
Note: DAMGAL= Lake gallery forest areas, DAMGRA= Lake grassland areas, FOREDGE= Forest edge areas, MAZECASS= Maize cassava plots, AGRO= Orchard containing citrus, CASSava= Cassava farm plots, MAIZE= Maize farm plots, RICE= Rice paddy plots, POND= Ponds

4.5.3 EFFECT OF LAND-USE ON BIRD SPECIES ABUNDANCE

Bird species abundance was relatively higher in the lake-grassland, and differences were significant in comparison with Lake-gallery, forest, forest edge, maize-cassava and cassava land-use systems (see Figure 4.24). Comparison of bird species abundance between with maize, P=0.61; difference with Agro land use system were also not significant P=0.214. Forest habitat had the least abundance when compared with the other land-use systems.

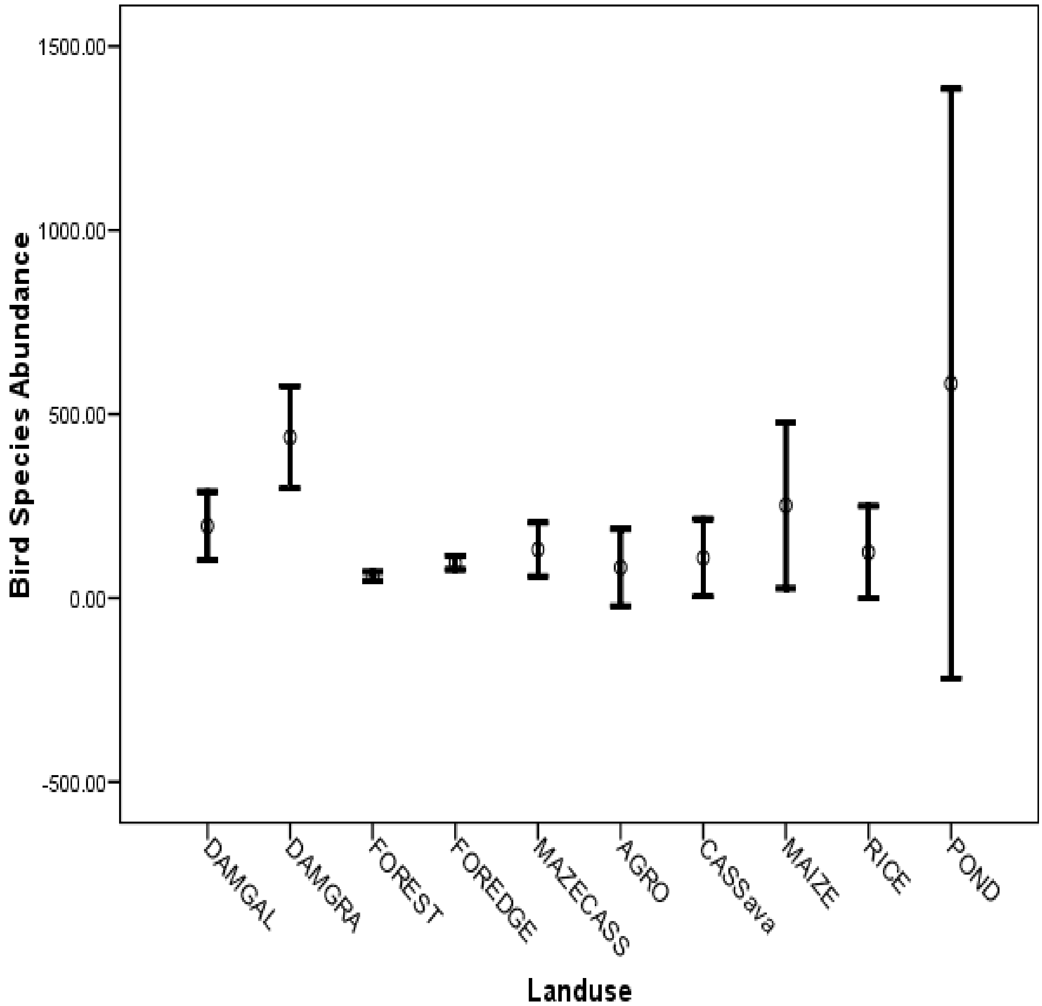

Figure 4.24: Bird species abundance in land-use systems.

Note: DAMGAL= Lake gallery forest areas, DAMGRA= lake grassland areas, FOREDGE= Forest edge areas, MAZECASS= Maize cassava plots, AGRO= Orchard containing citrus, CASSava= Cassava farm plots, MAIZE= Maize farm plots, RICE= Rice paddy plots, POND= Ponds

4.5.4 EFFECT OF LAND-USE ON BIRD SPECIES EVENNESS

Forest and forest-gallery had relatively higher species evenness (above 0.9) when compared with other land-use categories and evenness was lowest in the pond land-use category (0.4). Mean bird species evenness of lake-gallery, maize-cassava, Agro, cassava, maize and rice land-use categories were all within 0.6 and 0.8 (see Figure 4.25). Lake-grassland had a mean bird species evenness of 0.5.

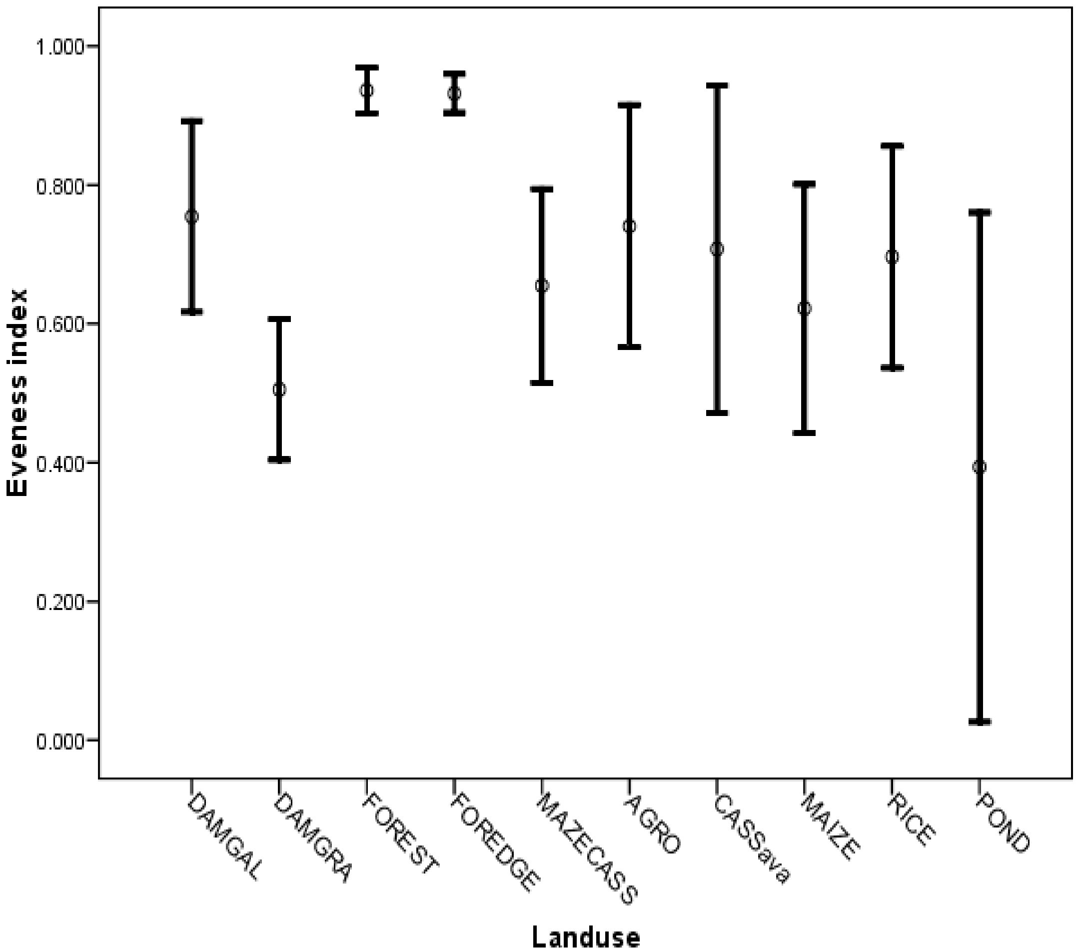

Figure 4.25: Bird species evenness index in land-use systems.
Note: DAMGAL= Lake gallery forest areas, DAMGRA= Lake grassland areas, FOREDGE= Forest edge areas, MAZECASS= Maize cassava plots, AGRO= Orchard containing citrus, CASSava= Cassava farm plots, MAIZE= Maize farm plots, RICE= Rice paddy plots, POND= Ponds

4.6.0 SPECIES EFFORT CURVE

Birds were steeply added to the list at the beginning of the survey with the first six transects yielding about 100 and 80 bird species for the years 2010 and 2011 respectively as shown in Figure 4.26. The slope began to get gentle after about 40 transect monitorings with about 150 bird species being accumulated already. After 116 transect only about 170 bird species had been accumulated showing that only 20 more bird species were added to the original 150 after an additional 76 transect monitorings were conducted in the year 2011. This relationship and trend can be observed in Figure 4.26. The first transect showed that more birds were seen in the order of forest, lake and farm (see Figure 4.27).

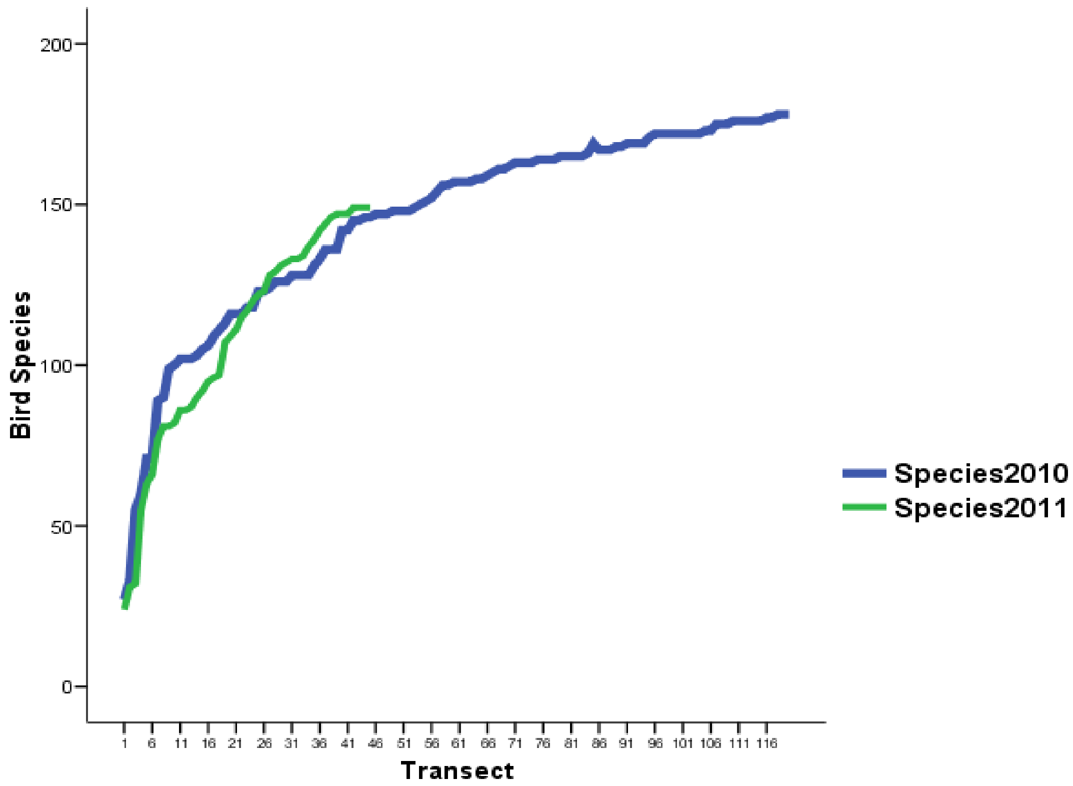

Figure 4.26: Bird Species effort curve for all transects
Note: Transect= number of transects monitored, and Bird species= Number of bird species accumulated

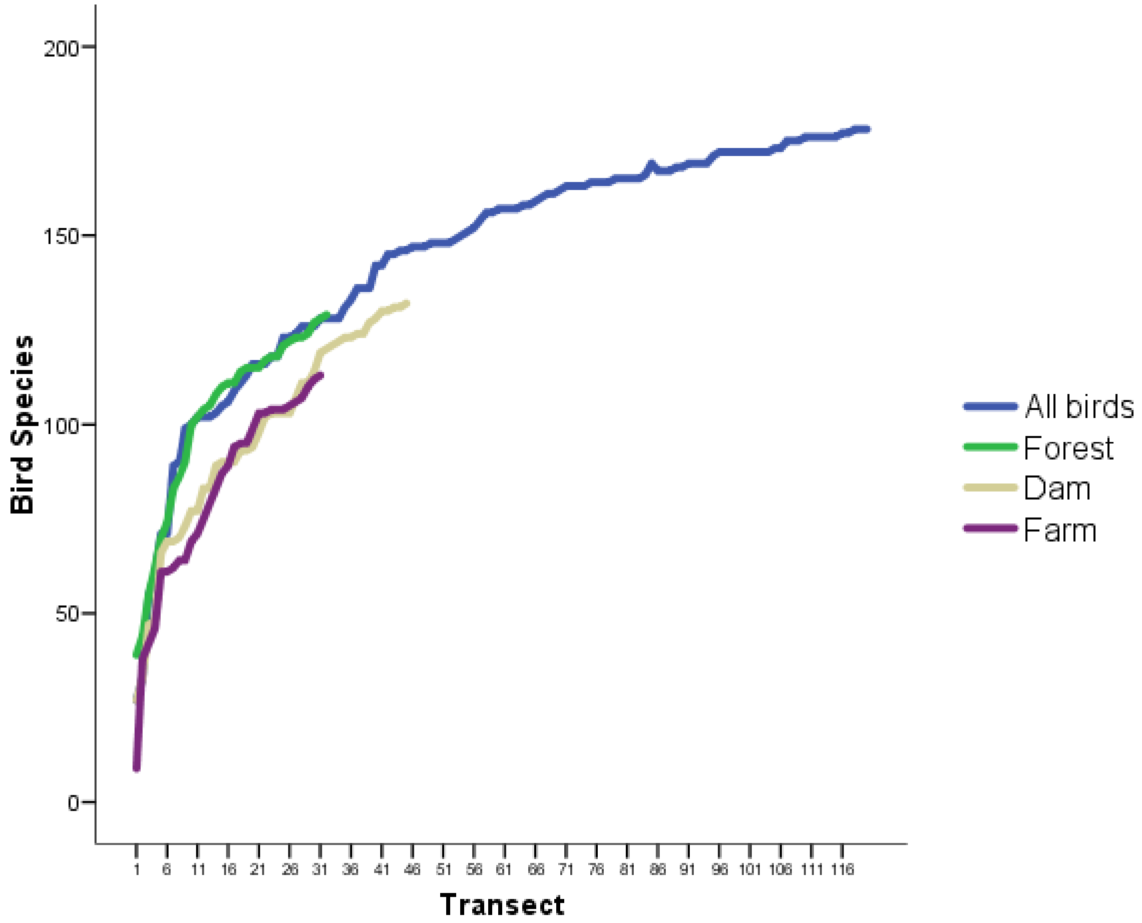

Figure 4.27: Species effort curve for habitats and all birds
Note:Transect= number of transects monitored, and Bird species= Number of bird species accumulated

4.7.0 WILDBIRD VIRUS SURVEILLANCE

Prevalence of viruses that cause avian influenza was zero for all wild bird samples collected. It was also negative for all samples collected and tested for rota, Chicken astrovirus I and II, Turkey astrovirus and IBV. Nevertheless, a prevalence of 9.5% was observed for Newcastle Disease Virus. Positive samples originated from domestic poultry and waterfowl (White-faced whistling ducks). Samples originating from the waterfowl were all field samples (Faecal swabs). Table 4.2 shows the viral prevalence among wildbird species sampled in the environs of the IITA.

Table 4.2: Viral Prevalence among sampled birds in IITA environs

CHAPTER FIVE

DISCUSSION

5.1.0 INVENTORY OF BIRD FAMILIES IN THE IITA

A total of 398 bird species from at least 71 families is now recorded for the Ibadan area, of which the IITA campus holds at least 269 species (68%) from 64 families, of which 75 species have been mist-netted during our study, while the IBA forest reserve holds at least 138 species, of which 36 species have been mist-netted there during our study. Twenty-five species plus 13 vagrants are new to the IITA campus, having not been detected on the site prior to 2002 (See Appendix 4). However, 68 species plus an additional 62 vagrant species reported in the Ibadan area or in IITA by earlier studies have not been detected on the site recently. In general, the diversity of some groups of large birds (*e.g.* Anatidae) has declined, although many of these were vagrants, whereas many forest edge or generalist species (*e.g. Francolinus bicalcaratus*) have increased in abundance and range. Forest specialists, including many Pycnonotidae and Bucerotidae, appear to have declined. The use of mist-nets aided the detection of several species previously unknown from the IITA campus, including *Indicator maculatus*, *Campethera nivosa*, *Smithornis rufolateralis*, *Andropadus gracilis*, *Neocossyphus poensis*, *Macrosphenus kempi*, *M. concolor* and *Cinnyris minullus*.

Ezealor (2001) listed 67 species restricted to the Guinea Congo Rain Forest (GCRF) biome and 7 restricted to the Sudan Guinea Savanna Biome (SGSB) for the site. Biome restricted species was defined as species having 70 percent or more of their range within a particular biome (Fishpool and Evans 2001, see Appendix 4). This study reports an additional 29 biome-restricted species to the previous known 74 for Ibadan, of which 27 belong to the GCRF (17 occur in the IBA) and two to the SGSB, bringing the total GCRF species in the Ibadan area to 94 (84 in the IBA plus 10 without), although nine (plus five classed as vagrants) of the GCRF species mentioned by Ezealor (2001) as occurring in the IBA have not been sighted recently (*i.e. Pteronetta hartlaubii*, *Gymnobucco peli*, *G. calvus*, *Melichneutes robustus*, *Dendropicos gabonensis*, *Coracina azurea*, *Ixonotus guttatus*, *Phyllastrephus icterinus*, *Criniger ndussumensis*, *Cisticola anonymus*, *Muscicapa tessmanni* and *Cinnyris superbus*, and the SGSB species *Musophaga violacea* and *Hirundo leucosoma*). These changes, if genuine losses occurred over little more than a decade. Ten GCRF species, observed in Ibadan by earlier studies but not at the IBA by Ezealor (2001), have not been sighted recently in Ibadan either, *i.e. Francolinus lathami*, *Columba iriditorques*, *Prodotiscus insignis*, *Erythrocercus mccallii*, *Megabyas flammulatus*, *Illadopsis puveli*, *Turdoides reinwardtii*, *Anthreptes rectirostris*, *Plocepasser superciliosus* and *Nigrita luteifrons*. Nonetheless, the loss of these species depicts the importance of conserving sites such as IITA where their forest habitat is being preserved and now extended. Many of the forest fragments mentioned by Elgood & Sibley (1964) are now a shadow of their former selves, with some now occupied by plantations of fast-growing exotics such as *Gmelina*, *Tectona* and *Eucalyptus* species.

The 17 new GCRF species now occurring at the IBA are *Bubo poensis*, *Pogoniulus atroflavus*, *Indicator maculatus*, *Campethera nivosa*, *Smithornis rufolateralis*, *Andropardus gracilis*, *Cossypha cyanocampter*, *Neocossyphus poensis*, *Macrosphenus kempi*, *M. concolor*, *Sylvietta denti*, *Fraseria ocreata*, *Muscicapa olicascens*, *Cinnyris minullus*, *Oriolus brachyrhynchus*, *Dicrurus atripennis and Nigrita fusconotus* The two new SGSB species are *Eremomela pusilla* and *Ptilostomus afer*. The apparent arrival of these species at the site might be attributed to genuine colonisation or to their having been overlooked in previous surveys. The identification of most of these species was confirmed by mist netting, with ringing data available for verification.

Elgood and Sibley (1964) recorded 266 species for the Ibadan area and this area was defined as within a 10 mile radius of Mapo Hall at the centre of the city, and more particularly those found within and adjacent to the extensive grounds of the University of Ibadan (UI). It is important to note that during their study neither IITA nor IBA now enshrined within had been defined and therefore not mentioned in their records (Elgood and Sibley, 1964) though IITA is mentioned in Elgood *et al*. (1994). The IITA and UI environs are within 7 km, separated by communities though tracts of vegetation capable of linking the two areas are present. Nonetheless, some birds are capable of flying between the two communities daily as observed for the Cattle Egrets *Bubulcus ibis* and White-faced Whistling Ducks *Dendrocygna viduata* which roost at UI and IITA respectively.

The number of bird species recorded over time at the site is evidence that the IITA environs is an ornithological important site. Nonetheless, several bird species from previous surveys such as Elgood and Sibley (1964) and Phill Hall pers. comm. (*An avid bird watcher who has carried out bird viewing for over 30 years in and around Ibadan*; see Adeyanju *et al*., 2014; subsequently PH) have not been recorded in recent times (Appendix 4). Comparisons of records from recent studies on the avifauna of IITA in the last decade show that about 59 species are now probably lost from the site (Appendix 4) though it is much easier to prove presence than absence of a species within a site. Reasons advanced for some of these discrepancies in observation include the fact that some of these species are typically high forest forms and are not usually found outside this habitat. Many others are conspicuous and will therefore not be easily overlooked in the study site though a few may often return as vagrants (Elgood *et al*., 1994). Our study confirms this as some of the most notable species at IITA are vagrants while many others are Rare or very cryptive in habit and able to evade detection (Elgood and Sibley, 1964; Elgood *et al*., 1994). A good number are also migrants and therefore recorded seasonally. The use of mist-nets aided the detection of several species of which some were previously unknown from the site and they include: Buff-spotted Woodpecker *Campethera nivosa*, Little Grey Greenbul *Andropadus gracilis*, Cameroon Sombre Greenbul *A. montanus*, Kemp's Longbill *Macrosphenus concolor*, Grey Longbill *M. flavicans*, Tiny Sunbird *Cinnyris minullus*, and Velvet-mantled Drongo *Dicrurus modestus*.

The comparisons of this survey with those of Elgood and Sibley (1964), Ezealor (2001) and PH. reveal significant changes have taken place in the avifaunal composition of the IITA and environs. Some of these changes might not be directly attributed to the immediate surroundings of the IBA but also due to the ongoing destruction of forest patches outside the IITA area (preventing recolonization or gene flow). The city of Ibadan is expanding and many of the areas that were patches of forests around the reserve are now being replaced by houses or housing projects, and corridors are thinning out. Environmental changes are not a wholly modern development, they have been occurring over time due to the practice of subsistence agriculture and other human-biotic interference. Also, the extent of the derived savanna outside the IBA has permitted an increasing number of birds formally unknown to forest area (Elgood and Sibley, 1964, Elgood *et al*., 1994).

I now present an overview of all the bird families observed at the site, and draw inferences about their present status as compared with that reported in literature.

Phalacrocoracidae: The Long-tailed Cormorant *Phalacrocorax africanus* is frequent to the site and one to two birds may be seen around the lake. They were observed in each year of this study as well as other previous studies (Elgood and Sibley, 1964, PH).

Anhingidae; Elgood and Sibley (1964) recorded the African darter *Anhinga rufa* for Ibadan environs as frequent though, but it has not been resighted around the IBA.

Ardeidae: Resident birds in this family are frequent while migrants are occassional (Appendix 4.). Species that have not been sighted recently include the Dwarf Bittern *Ixobrychus sturmii* (rare by Elgood and Sibley 1964) and Eurasian Bittern *Botaurus stellaris* which have not been resighted recently though sighted by PH in 1998 and 2001.Black Heron *Egretta ardesiaca* recorded on three occasions from 1993-95 by PH has not been recorded since. Black-crowned Night Heron *Nycticorax nycticorax* observed recently included juveniles which indicate they are successfully fledging young. Over 600 individuals of the Cattle Egret *Bubulcus ibis* are known to roost in UI environs. Elgood and Sibley (1964) also recorded the White-backed Night Heron *N. leuconotus* once in the Ibadan area but has not been resighted since.

Scopidae: The only member of the group Hammerkop *Scopus umbretta* is uncommon. Nonetheless, it occurs frequently at Ilorin (Elgood and Sibley, 1964).

Ciconiidae: Abdim's Stork *Ciconia abdimii* (Elgood and Sibley 1964, passing visitor) and Wooly-necked Stork *Ciconia episcopus* are visitors to the area with the former possibly using the area as a stopover site during migration. White Stork *Ciconia Ciconia* was observed by PH in 1998 and 2000. The African Openbill Stork *Anastomus lamelligerus* was observed by Elgood and Sibley (1964) who recorded it as sporadic, and it has not since been resighted.

Threskiornithidae: The Hadada Ibis *Bostrychia hagedash* is common and favors the small lake area beside the Golf course in IITA. The Glossy Ibis *Plegadis falcinellus* was recorded once in 2010 and included a group of about 6 birds. The Sacred Ibis *Ibis ibis* was recorded as a rare vagrant for Ibadan by Elgood and Sibley (1964) though not resighted since.

Anatidae: White-faced Whistling ducks are present all year round though numbers were previously observed to increase in the dry season, they have been observed in large flocks in the rains of 2011 and 2012. Little Grebe *Pluvianus aegyptius* was observed once by Gus Huk pers. comm. in 2012, sporadic in habit (Elgood and Sibley, 1964). Spur-winged Goose was observed breeding in 2009. PH also observed them in 1995 but breeding status was not confirmed. However, numbers are few and in 2010 and 2011 only a single individual was observed. PH has however observed several other members of this group which have not been sighted recently and therefore viewed as locally lost (Appendix 4) and they include Hartlaub's Duck *Pteronetta hartlaubii*. A pair was recorded once in 1995. Knob-billed Goose *Sarkidiornis melanotos* was recorded on 3 occasions in 1987, 1993 and 1995. African Pygmy Goose *Nettapus auritus* were sporadically present from 1987 to 1995 (Elgood and Sibley, 1964 also recorded it as sporadic). Common Teal *Anas crecca*, a pair present in January 1994. Pintail *A. acuta* recorded on two occasions in 1989 and 1998. Garganey *A. Querquedula* was recorded on two occasions in 1993 and 1994.

Pandionidae: The Osprey *Pandion haliaetus* is an uncommon seasonal visitor to the site. It is a monospecific family. Few individuals recorded from 2009 to 2012 and earlier by Elgood and Sibley (1964).

Accipitridae: Nineteen species now recorded for this IBA with two species ringed (Appendix 4). A pair of Bat Hawks *Macheiramphus alcinus* is present and possesses a nest within the IBA but sightings of young have not been made. Some members of this group sighted only by PH include Honey Buzzard *Pernis apivorus* with one record in May 2010 and African Hawk-Eagle *Hieraetus spilogaster* recorded on one occasion. Others are observed occasionally with the Black Kite *Milvus migrans* being the most common of the group and include both resident and migratory populations (Appendix 4). Elgood and Sibley (1964) recorded 12 species including the Black Sparrow Hawk *Accipiter melanoleucus* which have not been resighted.

Falconidae: Lanner Falcon *Falco biarmicus* pairs have been observed in the IBA during this study on very high trees (>40 m). Other members of the group are common (Appendix 4). Elgood and Sibley (1964) recorded all four in the Ibadan area (Appendix 4).

Numinididae: The Helmeted Guinefowl *Numida meleagris* is the only member of the group known to occur around the environs of IITA, in farm and bushes. Juveniles have been observed among the flocks. It has not been recorded within the IBA and as it's obviously a savanna species (Elgood and Sibley, 1964). They are always observed in groups sometimes flushed while moving along trails. Feathers are very common around the Cassava farm plots in the IITA fields.

Phasianidae: There are only three species of the group known to occur in the IBA with the Double-spurred Francolin *Francolinus bicalcaratus* being Abundant. It is now observed very close to forest edge. Ahanta Francolin *F. ahantensis* is only observed frequently in the forest interior while Scaly Francolin *F. squamotus* has been recorded from the forest on the West Bank by PH. However, Elgood and Sibley

(1964) recorded Latham's Francolin *Latham francolin* once in forest area in Ibadan and Stone Partridge *Ptilopachus petrosus* (rare) in Ojoo Hills within 2 km of the IBA; though the latter has not been sighted in IITA since.

Rallidae: Lesser Moorhen *Gallinula angulata* has been ringed at IITA and other members are more common (Appendix 4). African Finfoot *Podica senegalensis* has been recorded breeding in Aug 1999 and has not been resighted at IITA since, though a single individual is been reported by TEA from Awba lake in UI in 2009. The Buff-spotted Flufftail *Sarothrura elegan* observed by Swedish team has not been resighted yet. Two other members of the group were observed by PH include Spotted Crake *Porzana porzana* with one record in Feb 1996 (with a pair present on two occasions) and Purple Gallinule *Porphyrio porphyrio* with a few sightings in 1999 and 2000. Three of the species were reported by Elgood and Sibley, (1964) in the Ibadan area (Appendix 4).

Jacanidae: They are very abundant in the lake and rice paddies around IITA and the only member of the group confirmed to be present (Elgood and Sibley, 1964). Juveniles have been observed in early rains.

Burhinidae: The only member of the group known to occur is the Senegal Thicknee *Burhinus senegalensis* (Elgood and Sibley, 1964). They are observed in mixed flocks of plovers at the Generator house area of IITA Lake.

Recurvirostridae: The most common of the group is the Greater painted-Snipe *Rostratula benghalensis* (Appendix 4). A few individuals are resident all year round and breeding at IITA (Appendix 4). However Elgood and Sibley, (1964) recorded them as African Migrants in Ibadan area between March and June.

Glareolidae: The two species known to occur in the study area are vagrants with only a single individual sighted. They are the Grey Praticole *Glareola cinerea* observed by

PH in Sept 1994 and Much earlier by Elgood and Sibley, (1964 and the Collared Pratincole *G. pratincola* observed in Jan 2011 during this study**.**

Charadriidae: Seven species are recorded for this family in IITA (Appendix 4)**.** The most abundant, is the Spur-winged Lapwing *Charadrius senegalus*.. Two others not sighted recently but observed by PH include Little Ringed Plover *C. dubius* of which a few birds were present during the dry season in every year of 1987-1995 and the Ringed Plover *C. hiaticula*, one present in Sept 1994. Elgood and Sibley (1964) observed that the former was frequent while the latter was rare.

The Egyptian Plover was also rated as vagrant though occasional by PH, Elgood and Sibley (1964) recorded it as rare. Black-winged Stilt *Himantopus himantopus* recorded by Elgood and Sibley (1964) as rare is classified in this study as an occasional visitor at IITA.

Scolopacidae: These are mainly Palearctic Migrants with 11 species recorded for the family in IITA (Elgood and Sibley (1964) recorded 5 species). The common visitors include the Wood Sandpiper *Tringa glareola* and Common Sandpiper *T. hypoleucos* with the latter consisting of resident population throughout the year. Numbers generally increase during the dry season. Temminck's Stint *Calidris temminckii* was observed by Demey *et al*. (2003) but has not been resighted since then. Those sighted by PH include Curlew Sandpiper *C. ferruginea* recorded once in September 1994, Turnstone *Arenaria interpres* one record in September 1991, Ruff *Philomachus pugnax* recorded once in Oct 1996, Marsh Sandpiper *T. stagnatilis* two recorded in October 1994. PH refers to some others as regular dry season visitors and they include Spotted Redshank *T. erythropus*, common Redshank *T. tetanus* and Green Sandpiper *T. ocherous*. It is thus possible that some of the visitors use the site as a stop-over for very short periods hence could be termed vagrants (Appendix 4). Eurasian Curlew was sighted once by Elgood and Sibley (1964).

Sternidae: No member of the group has been recorded recently. PH has recorded Gull-billed Tern *Gelochelidon nilotica* with one record in October 1994 and White-winged Tern *Chlidonias leucopterus* recorded in 1988, 1989 and October 2000.

Laridae: The only record of members of the group at the site is from *Demey et al.* (2003) of the Black-backed Gull *Larus ridibundus.* Though Elgood and Sibley (1964) and Elgood *et al*. (1994) both recorded one individual of African Skimmer *Rynchops flavirostris* once for Ibadan area and IITA respectively, they have since not been resighted at the site. They are therefore vagrants at the site .

Turnicidae: Only one record of a member of this group for Ibadan by Elgood and Sibley (1964) of the Little Button Quail *Turnix sylvatica.*

Columbidae: Red-eyed Dove *Streptopelia semitorquata* still remains the most abundant and conspicuous member of the group. It can be observed in all habitat types present in the study site. Laughing Dove *S. senegalensis* is restricted to residential areas. PH recorded Blue-headed Wood-Dove *Turtur brehmeri* infrequently in the West Bank and heard Bronze-naped Pigeon *Columba iriditorques* uncommonly during the rains in 2000. They have both not been re-recorded during the most recent surveys and were not recorded by Elgood and Sibley (1964) for Ibadan.

Vinaceous Dove *S. vinacea* (a savanna species) is now occasionally sighted in IITA environs, giving further evidence to the changing environment around Ibadan. It will thus be important to know if it is more common outside the reserve as Elgood and Sibley (1964) noted that it was abundant at Ilorin.

Psittacidae: Only the Senegal Parrot *Poicephalus senegalus* has been recorded for the site (Ezealor 2001), It is a savanna species (Elgood and Sibley, 1964) and this is the possible reason for the infrequent sighting within this forest IBA. It could not easily have been overlooked due to its conspicuous calls. However it has been sighted a few kilometres out of the reserve once during this study.

Musophagidae: Only three members of the group are recorded for IITA, of which Violet Tauraco *Musophaga violacea* was recorded by Ezealor (2001) but was not resighted during our study (Appendix 4). It is common in Ilorin (Elgood and Sibley, 1964).

Cuculidae: Black-throated Coucal *Centropus leucogaster* which is listed by Elgood and Sibley (1964) and Ezealor (2001) was resighted in this study. PH had few sightings of Red-chested Cuckoo *Cuculus solitarius* during the rains, one record of Common Cuckoo *C. canorus* in May 1998 and occasional records of African Cuckoo *C. gularis* throughout the dry season. The latter is common in Ilorin (Elgood and Sibley, 1964). A possible reason for not meeting with it during this study could be its tendency to be quieter outside its breeding season. The black variant of Senegal Coucal *C. senegalensis epomidis* is present around IITA environs.Elgood and Sibley (1964) note that the latter is restricted to south western Nigeria.

Tytonidae: The Barn Owl *Tyto alba* is rare within IITA environs though sighted by Elgood and Sibley (1964) as frequent and indifferent in habitat association for Ibadan. PH recorded it in 1991.

Strigidae: Elgood and Sibley (1964) record six species of this form for Ibadan. I observed four of these for IITA environs (Appendix 4). The Pearl-spotted Owlet *Glaucidium perlatum* was observed last in 2000 by in which a pair was calling throughout the rains, while Frazer's Eagle Owl *Bubo poensis* was recorded in this study in 2011. Others known for Ibadan include savanna species such as European

Scops Owl *Otus scops* and Spotted Eagle Owl *B. africanus* both recorded as rare (Elgood and Sibley, 1964).

Caprimulgidae: Five species (all migratory but possessing resident populations for Long-tailed Nightjar *Caprimulgus climacurus*, Appendix 4) has been recorded for the site. The Black-shouldered Nightjar *C. nigriscapularis* and Plain Nightjar *C. inornatus* are recorded throughout dry season with the former restricted to the West Bank area (PH). One sighting of the European Nightjar *C. europaeus* was made in 2010. Elgood and Sibley (1964) noted the initial three.

Apodidae: Five species recorded at IITA (Appendix 4). PH recorded a flock of ten European Swifts *Apus apus* and a pair of breeding White-rumped Swift *A. caffer* in October 1990.

Alcedinidae: Nine species recorded, with the Woodland Kingfisher *Halcyon. senegalensis* being the most abundant at IITA. Elgood and Sibley (1964) recorded the Stripped Kingfisher *H. chelicuti* as occasional and seven others which also been recorded during this study (See Appendix 4). *H. chelicuti* has however not been resighted in IITA possibly because it is a savanna loving species. The African Dwarf Kingfisher *Ceyx lecontei* was observed once during the study.

Meropidae: We recorded only two species in IITA, both being African migrants and one being a GCRF restricted species (Appendix 4). Elgood and Sibley (1964) recorded two other species which are savanna loving in Ibadan the Little Bee-eater *Merops pusillus* and Northern Carmine Bee-eater *M. nubicus*, though this has not been resighted in this area.

Coraciidae: The species were recorded for IITA (Appendix 4) one of which is restricted to the GCRF (Ezealor 2001). Though Elgood and Sibley (1964) had earlier

earlier recorded these and an additional two for Ibadan area, the Abyssinia Roller *Coracias abyssinica* once (vagrant) and European Roller *C. garrulus* (rare).

Phoeniculidae: One species recorded for this IBA (Appendix 4) though Elgood and Sibley (1964) had earlier recorded this and White-headed Wood Hoopoe *Phoeniculus bollei*. The latter though a forest species has not been resighted at IITA.

Bucerotidae: Four species recorded for this group of birds with two restricted to GCRF (Appendix 4, Ezealor 2001). PH recorded a few individuals of Piping Hornbill *Ceratogymna fistulator* between January and March 1999 and October 2000. Elgood and Sibley (1964) earlier recorded all four with the Red-billed Dwarf Hornbill *Tockus camurus* occasional. African Pied Hornbill *T. fasciatus* has remained the most abundant member for over 50 years. However Piping Hornbill *Bycanistes fistulator* and *T. camurus* have not been resighted since, though both are forest birds; rather the Grey Hornbill *T. nasutus*, a migratory savannah species is seen. Hornbills are majorly very good indicators of true forest ecosystem (Elgood and Sibley, 1964) and the absence of the larger species could be due to increasing environmental inadequacy (more of savanna and less of high forest) and or poaching by hunters.

Capitonidae: Eight species recorded, six of which are restricted to the GCRF (Ezealor 2001, Appendix 4), one of which Red-rumped Tinkerbird *Pogoniulus atroflavus* is new to the IBA. Though mostly forest birds, an exception is the Vieillots Barbet *Lybius vieilloti* (a savanna species). Elgood and Sibley (1964) recorded the Double-toothed Barbet *L. bidentatus* in forest as frequent. However it has not been observed on site, but in relicts of forests in Ibadan about 1km from UI. The Naked-faced Barbet *Gymnobucco calvus* was recorded as frequent by Elgood and Sibley (1964) and as a common breeding bird in the 1990's by PH though it has not been resighted since.

Indicatoridae: Three species were recorded. Spotted Honeyguide *Indicator maculatus* a GCRF species (Appendix 4) has been resighted and individuals ringed. Others are Lesser Honeyguide *I. minor* of which a pair was observed parasitizing Naked-faced Barbet nests in February 1995 by PH and Lyre-tailed Honeyguide *Melichneutes robustus* (Ezealor 2001). Elgood and Sibley (1964) recorded four species for Ibadan area three of which were rare (not yet recorded at IITA) and *I. minor* frequent.

Picidae: Five species recorded of which two have been resighted (Appendix 4). PH recorded one Green-backed Woodpecker *Campethera cailliautii* in May 1998, a pair of Gabon Woodpecker *Dendropicos gabonensis* feeding chicks in August 1999 and two records of Grey Woodpecker *D. goertae* in 1987 and 1988 respectively. Elgood and Sibley (1964) recorded five species with Gabon Woodpecker observed as a savanna species and Buff-spotted Woodpecker *C. nivosa* as rare though we have observed them as frequent at IITA with six ringed individuals and two retraps (Appendix 4). The latter was not sighted by Ezealor (2001) or PH but is also one of the GCRF restricted species. They also observed Fine-spotted Woodpecker *C. punctuligera* a savanna species occasionally and *C. permista* both of which have not been resighted in IITA (Elgood and Sibley, 1964).

Eurylamidae: Only one member recorded, Rufous-sided Broadbill *Smithornis rufolateralis* a GCRF restricted species, though not recorded by Ezealor (2001) or Elgood and Sibley (1964).

Hirundinidae: Eight species recorded, Pied-winged Swallow *Hirundo leucosoma* was recorded by Elgood and Sibley (1964) and then Ezealor (2001) as a SGSB restricted species but has not been resighted. Sand Martin *Riparia riparia* was recorded by PH on 2 occasions in March 1992 and October 1994 while the Mosque

Swallow *H. senegalensis* was recorded regularly year round by PH and Elgood and Sibley (1964). Elgood and Sibley (1964) also recorded seven species, of which all have been resighted at the IBA with the exception of the Wire-tailed Swallow *H. smithii*.

Motacillidae: Seven species recorded (Appendix 4) of which only four have been resighted by the recent survey as well as Elgood and Sibley (1964). Two were observed during the dry season by PH. These are the Tree Pipit *Anthus trivialis* uncommon and Red-throated Pipit *A. cervinus* which is fairly common, while Long-legged Pipit *A. pallidiventris* was sighted in 2012.

Campephagidae: Two species recorded, one has been sighted recently (an African migrant Elgood and Sibley 1964, Appendix 4) while the other *Coracinea azurea* a GCRF species not resighted after Ezealor (2001).

Pycnonotidae: Twenty species recorded of which fourteen are GCRF restricted species (Ezealor 2001, Appendix 4). All except Bearded Bulbul *Criniger barbatus*, Icterine Greenbul *Phyllastrephus icterinus* and White-bearded Bulbul *C. ndussumensis* (recorded by Ezealor 2001, Appendix 4) have been sighted recently during this study, with the Yellow-whiskered Greenbul *Andropadus latirostris* remaining the most conspicuous and possibly most abundant from the group. Yellow-throated Leaflove *Chlorocichla flavicollis* a savanna species was observed as common by Elgood and Sibley (1964) in the Ibadan area. However only a single pair was observed in 2011 around the Bush/Farm by the side of the lake in IITA. Red-tailed Greenbul *Criniger calurus* was recorded as Occasional by Elgood and Sibley (1964) but has not been resighted. Slender-billed Greenbul *A. gracilirostris* are also much more common; though rated rare by Elgood and Sibley (1964).

Turdidae: Eight species recorded, with Nightingale *Luscinia megarhynchos* occasionally seen during the dry season and Finsch's Flycatcher-Thrush *Neocossyphus finschi* was sighted sporadically in the forest throughout the year 2000 by PH (Appendix 4). However it is possible to confuse the later with White-tailed Ant-thrush *N. poensis*. *L. megarhynchos* is a Palearctic migrant and was recorded as rare by Elgood and Sibley (1964). Other rare migrants not recorded in this study but recorded by Elgood and Sibley (1964) are Wheatear *Oenanthe oenanthe* and Redstart *Phoenicurus phoenicurus* both in the Ibadan environs. Blue-shouldered Robin Chat *Cossypha cyanocampter* a GCRF restricted species was not recorded by Ezealor (2001) and Elgood (1964) is also present frequently in interior forest and we have 5 individuals ringed presently. Forest Robin *Stiphrornis erythrothorax* is more frequent though recorded earlier by Elgood and Sibley (1964) as rare.

Sylviidae: Twenty-three species recorded (Appendix 4) out of which 18 have been sighted recently. Two are new GCRF restricted species Grey Longbill *Macrophenus concolor* (Elgood and Sibley (1964) rare in Ibadan area) and Kemp's Longbill *M. kempi* while Senegal Eremomela *Eremomela pusilla* a SGSB restricted species was sighted once. Chattering Cisticola *Cisticola anonymus* was recorded for the IBA by Ezealor 2001, while Melodious Warbler *Hippolais polyglotta* an uncommon dry season visitor, Whistling Cisticola *C. lateralis* fairly common, Winding Cisticola *C. galactotes* uncommon in reed-beds and Zitting Cisticola *C. juncidis* fairly common have been recorded by PH. Elgood and Sibley (1964) recorded 20 species of which two savanna species have not been resighted by us, Red-winged Warbler *Heliolais erythroptera* and Singing Cisticola *C. cantans* (recorded as frequent and rare for Ibadan respectively Elgood and Sibley (1964)).

Muscicapidae: Six species have been recorded for the site of which four have been sighted recently (Appendix 4). Spotted Flycatcher *Muscicapa striata* is an uncommon visitor during the dry season by PH. Northern Black Flycatcher *Melaenornis edolioides* frequent in 2009 but now uncommon while one sighting of the Olivaceous Flycatcher was made in this study in 2011. Ezealor (2001) also had the Tessman's Flycatcher *Muscicapa tessmanni* for the IBA but it has not been resighted by during this study. The entire species of the group seem to be uncommon in the site and are not usually trapped in the mist-nets except for one Dusky-blue Flycatcher *M. comitata* in 2012, last observed by Ezealor (2001) as a restricted GCRF species. Elgood and Sibley (1964) had both Dusky-blue and Northern Black Flycatchers recorded for Ibadan area but observations during this study has not resighted two others from their list at IITA, Spotted and Cassin's Flycatcher *Alseonax cassini*.

Monarchidae: Four species recorded of which two are frequent to abundant at the site (Appendix 4). The two others Chestnut-capped Flycatcher *Erythrocercus mccallii*, several sightings during 1999 and 2000 and African Paradise Flycatcher *Terpsiphone viridis* fairly common have been recorded by PH and previously by Elgood and Sibley (1964). Though very unlikely the latter in non-breeding plumage might be confused with the Red-bellied Flycatcher *T. rufiventer*, otherwise we would have trapped it by mist nets.

Platysteridae: Four species known with one Black-and-white Shrike-Flycatcher *Bias musicus*, being uncommon observed on several occasions in mixed-bird parties by PH (Appendix 4) and previously by Elgood and Sibley (1964). It is however unlikely to still be present otherwise it would have been trapped or at least sighted because of its conspicuous habits, and its being an edge species. Shrike Flycatcher *Megabyas* *flammulatus* was recorded by Elgood and Sibley (1964) for Ibadan area but has not been sighted recently.

Timaliidae: Three species are recorded; observed Pale-breasted Illadopsis *Illadopsis rufipennis* as a common member of mixed bird parties, more often heard than seen. It is plausible that its call was initially confused for Brown Illadopsis *I. fulvescens* which is common on the site. Ezealor (2001) recorded two species for the IBA which are GCFR restricted species (Appendix 4). Elgood and Sibley (1964) include the record of a rare Blackcap Babbler *Turdoides reinwardti* for Ibadan which was not been recorded in this study.

Paridae: Two species recorded. PH recorded Yellow White-eye *Zosterops senegalensis* as fairly common in IITA as did Elgood and Sibley (1964) for the Ibadan area. PH also recorded several Tit-Hylia *Pholidornis rushiae* from the West bank of the IBA.

Nectariniidae: Twelve species recorded, with three being GCRF restricted species (Appendix 4). PH recorded Blue-throated Brown Sunbird *Nectarinia cyanolaema* as fairly common on the West Bank, though it seems to be much more

less common. One juvenile was trapped from the site in this study. Elgood and Sibley (1964) record ten species for the Ibadan area of which Superb Sunbird *N. superba* was confirmed for the site by Ezealor (2001). Scarlet-chested Sunbird *Chalcomitra senegalensis* and Tiny Sunbird *Cinnyris minullus* are newly sighted for the area though the former is rare. It was found to be much more common in Ilorin by Elgood and Sibley (1964).

Laniidae: Two species recorded (Appendix 4), Elgood and Sibley (1964) also record the same for Ibadan area, with Woodchat Shrike *Lanius senator* recorded as a fairly common dry season visitor by PH.

Prionopidae: Only one species recorded (Ezealor 2001) and recently resighted in our surveys (Appendix 4), Elgood and Sibley (1964) record two species (occassional) with the addition of White-helmet Shrike *Prionops plumatus* for the Ibadan area.

Malaconotidae: Five species are now recorded from this group, of which two species are GCRF restricted (Appendix 4). PH recorded Fiery-breasted Bush-Shrike *Telephorus cruentus* fairly common on the West Bank and has been recorded less frequently recently (Just one sighting of a group in the West bank. Tropical Boubou *Laniarius aethiopicus* was recorded as new to the site. Elgood and Sibley (1964) record 6 species for Ibadan area with the addition of a savanna species Sulphur-breasted Bush-shrike *Malaconotus sulphureopectus* and *L. ferrugineus.*

Oriolidae: Three species recorded of which two members are GCRF restricted (Appendix 4, Ezealor 2001); PH recorded African Golden Oriole *Oriolus auratus* a savanna species also recorded by Elgood and Sibley (1964) fairly common. Elgood and Sibley 1964 recorded two of the species observed re-recorded in this study (see Appendix 4).

Dicruridae: All four species now recorded for the site. Two have been ringed so far (Appendix 4) and voices of the Drongos were observed to be different on the site (Elgood and Sibley, 1964). Shinning Drongo *Dicrurus atripennis* a GCRF restricted species was sighted. Elgood and Sibley (1964) record only two of the species from this group (the Fork-tailed Drongo *D. modestus adsimilis* and Square-tailed Drongo *D. sharpie,* now *D. ludwigii*) for the Ibadan area, and they argued that there is an indeterminate population for *modestus* in Ibadan due to less contrast between the degree of glossiness of the crown and mantle than one would expect in the hand (Elgood and Sibley, 1964).

Corvidae: Only one species recorded. The Piac Piac *Ptilostomus afer* is sporadic outside the environs of the reserve though it was not observed by Elgood and Sibley (1964) in Ibadan.

Sturnidae: Five species now recorded, PH recorded Violet-backed Starling *Cinnyricinclus leucogaster* in the dry season of 1999 but there has since been no resighting at the IBA (Appendix 4). It is therefore more likely vagrant to the area as described by Elgood and Sibley (1964). The Long-tailed Glossy Starling *Lamprotornis caudates* was observed in 2009, during this study.

Passeridae: One species recorded in IITA as well as by Elgood and Sibley (1964) (Appendix 4).

Ploceidae: Thirteen species recorded with seven being restricted GCRF species (Appendix 4). PH recorded Crested Malimbe *Malimbus malimbicus* as fairly common on the West Bank. Elgood and Sibley (1964) also recorded thirteen species for this group in Ibadan though their records include one species Compact Weaver *Pachyphantes superciliosus* not resighted here The Northern Red Bishop *Euplectes franciscanus*was recorded as new to the site during this study.

Estrildidae: Ten species recorded; PH recorded African Fire-Finch *Lagonosticta rubricata* in small flocks often seen and this study recorded the White-breasted Negrofinch *Nigrita fusconota* as new to the IBA (Appendix 4, closest observation was at Gambari forest by Elgood and Sibley, 1964), as it was not reported by Ezealor (2001) It is also a GCRF restricted species.. Elgood and Sibley recorded eight species for this group in the Ibadan area but this study did not resight the Pale-fronted Negrofinch *N. luteifrons* a forest species in the IBA.

Viduidae; Two species recorded; PH recorded the Village Indigobird *Vidua chalybeata* as fairly common. Elgood and Sibley (1964) recorded these two species, but opined that only one species was available in Ibadan though difficult to tease apart.

Fringillidae: Only one species the Yellow-fronted Canary *Serinus mozambicus* recorded to date for the IBA, infrequently by PH. . In comparison, Elgood and Sibley (1964) only recorded Cabanis Bunting *Emberiza cabanisi, a* rare savanna species.

5.1.1 BIRD SPECIES DIVERSITY IN RELATION TO HABITAT STRUCTURE

The structurally richer habitats supported higher bird species diversity than structurally less diverse systems like the farm. Imong and Manu (2011) and Adeyanju *et al.* (2011) reported significantly higher species diversity within forest areas in comparison to disturbed areas. Bird species diversity was lowest in farmed areas, showing that it offers least resources for sustaining a high diversity of bird species. The group that contributed most to the diversity of farm habitats were granivores (comprising of *Ploceus cucullatus* Village weavers, *Streptopelia semitorquata* Red-eyed dove, *Francolinus bicalcaratus* Double-spurred francolin). These take advantage of the large amount of cereals during harvest periods. They also cause serious havoc to cereals cultivated in the site. On the other hand the forest specialists contributed to the diversity of both forest ecosystem and most of the time could only be detected in areas in close proximity with their preferred forest habitat. The forest ecosystem is made up of an open canopy in some areas and very few areas of closed canopy as the forest is still regenerating after long periods of deforestation and degeneration that were halted about 50 years ago when the area became protected. Bird species diversity at the lake was also strongly boosted by waterbirds such as herons, waders and a common duck species (*Dendrocygna viduata*). However, the lake is bordered to the west bank by a gallery forest which has also added greatly to increasing the diversity of the lake. As a result of reduced detection due to cover, assessing species richness was most difficult in the forest as compared to farm and lake which are open. The use of bird calls and mist nets were however efficient over time in aiding detection of most bird species. Farm areas close to forest cover also showed a higher bird species diversity as bird species could easily move between forest fragments and farm, thereby increasing bird diversity of the farm. Farm transect 3 had the highest bird species diversity when comparison is made between farms.

The forest edge also had significant effect on bird species diversity. Bird species diversity was higher in forest than in edge and more forest specific species were found within the forest than in sections close to the periphery of forest.

5.1.2 BIRD SPECIES RICHNESS IN RELATION TO HABITAT STRUCTURE

Species richness is the number of species of a particular taxon or life form that characterize a particular community, habitat or ecosystem type. The high bird species richness in IITA could be attributed to the availability of several habitat types all interspersed and juxtaposed in an area, surrounded by areas inhospitable to most bird species in general. The maintenance of the ecological integrity of this matrix is essential because of its intrinsic ability to support biological diversity and maintain the viability of the embedded protected areas (Hunter, 2005).

Bird species richness though difficult to measure because of some less known species which are either shy or rare and therefore not quickly easily detected for inclusion in species lists during sampling. While some birds are large and conspicuous with either colourful plumage or loud calls, others are very small or inconspicuous and not easily teased apart from other conspecifics (e.g., sunbird females).

However the use of bird calls improved to a great extent the identification of bird species during this survey e.g., *Trochocercus nitens* Blue-headed crested Flycatcher. Also the use of mist nets aided the capture and identification of several birds that were not initially detected or known to occur in the reserve such as the *Phyllastrephus baumanni* Bauman's Greenbul. In addition though nets quickly added species to the list, some birds became accustomed to nets and soon began evading them.

Therefore the combination of both transect walks and mist-netting of birds improves bird species richness detection and measurement in this study. Mist netting alone detected sixty six (66) bird species, five of which were never seen during transect walks as they occur in the ground layer of the forest and or savannah area of the IITA site. In general over 260 species have been detected in the site (Adeyanju *et al*., 2014 in press). Some of the species sighted by other researchers during previous studies were however not observed revealing that some of the species have either moved or no longer known to occur in the reserve. Some species known to be common about twenty years ago are no longer known to occur. Plausible reasons for their appeared disappearance include hunting and the reduction of preferred habitat outside of the IITA environs. This quickly made IITA an ecological island. Furthermore, the distance of other forest patches from IITA makes it, making it difficult for species to move between the different sites.

5.1.3 BIRD SPECIES ABUNDANCE IN RELATION TO HABITAT STRUCTURE

The species that characterize any natural community differ in relative abundance, usually with a few species quite common and most species much less so. In other words most individuals in a community belong to a group of vey common species. A rank abundance of perfect evenness would be flat instead of declining, indicating that all species in the distribution possess the same abundance. Rare species are important because they are more vulnerable to changes in the ecosystem. Nonetheless some species that are rare in one ecosystem or habitat type are very common in others, because of species specific needs in the ecosystem.

Most of the waterbirds in this survey are partial to the water logged (rice paddies, lake) areas though some sometimes venture outside these areas, when in search of food or roosting sites or when in movement from roosts to other sites. Nonetheless, some others are generally uncommon and this indicates that the species possible either has a large territory, i.e. raptors or their representatives are low in density at the site. Ecologically it could also mean that the preferred habitat of the species have been seriously disturbed, thus confining it to the last remaining sites that can support its existence. This appears to be the case for the Ibadan Malimbe. Though other congeners (Malimbes) are common throughout the forest area, the Ibadan malimbe remains a very rare bird. Other species that are very common are mostly colonial; or live and roost in groups or a gregarious and therefore feed in groups; some examples of such species include the *Quelea erythrops* Red-headed Quelea and *Ploceus cucullatus* Village weavers. Nonetheless some of these species are only gregarious during part of their life history, and this includes but is not limited to the migratory waders and ducks. The mix of habitats in the riparian zone attracts more species in comparison to other habitats. Wymenga and Zwarts (2010) suggested that the high bird numbers in wet areas during the dry season is an ecological compensation for the loss of other wetlands.

The rice fields at IITA were not cultivated throughout the year as observed during this study and as a result, field were sometimes overgrown with grasses, so waterbirds which could not adjust to this left. Birds like the *Tringa hypoleucos* Common Sandpiper, and *Rostratula benghalensis* Greater Painted-snipe all love areas that are marshy and cleared, where they can easily have access to mudflats. Once this habitat type is succeeded by another, their numbers fall drastically. They also tend to concentrate in mudflats that are at low tide.

5.1.4 BIRD SPECIES EVENNESS IN RELATION TO HABITAT STRUCTURE

Evenness is a measure of the relative abundance of the different species making up the richness of an area. The higher the evenness the less likely it is to find two birds simultaneously on transect or at a point belonging to the same species. The forest area supported a high evenness of bird species meaning that species abundance was well distributed over the survey area. This can be attributed to the high number of specialists in the forest habitat. The number of birds seen per unit time is also much less than that obtained in either farm or lake as the latter two habitats are more open. Visibility in the forest is mainly between 5 and 20 metres while in the lake and farm habitats, detection could rise to over 100. Tree density is higher in the forest whereas in farm and lake most trees have been removed to create this sort of land use system.

In addition very few forest birds aggregate in large flocks as observed in farm and lake where some species aggregate into groups numbering up to >500 individuals e.g., the White-faced whistling Ducks and Village Weavers in lake and farm habitat respectively.

5.2.0 EFFECT OF TIME OF DAY ON BIRD SPECIES DIVERSITY INDICES ACROSS HABITATS

Time of day was significant in bringing about differences in diversity indices across habitat types. Bird activity is generally known to rise in the morning and decline through the day and finally rise again in the evening (Manu and Cresswell, 2007). Activities carried out in the morning include feeding in order to replenish the lost or burnt up energy used in respiration through the night when most birds are at rest (with the exception of nocturnes and crepuscular species such as *Ptilopsis leucotis* Northern White-faced Owl and *Macheiramphus alcinus* Bat Hawk respectively). Others are territory defence, mating and courtship behaviours.

As a result of increased activity, higher bird species diversity was observed in most habitat types when morning and evening surveys were compared. This is supported by reports from Adeyanju *et al*. (2011) and Manu and Creswell (2007), where bird species diversity was generally higher in the morning across four sites.

Similarly, bird species richness was higher in the morning when compared to evening. The greater activity translated into more birds becoming more conspicuous as they moved out of hiding to search. Some got trapped in nets while others were observed in pursuit of prey. At other times of the day when temperature got higher and environment got warmer, birds tended to remain under cover to reduce the amount of energy loss due to evaporation and increased metabolic activity. However some raptor species were only seen when the sun was up, as they used thermals to soar and reduce energy loss due to wing flapping over long distances in search of prey or in movement from place of roost to areas where food is available.

However, in all habitats and at either time of the day bird species richness was still higher in areas that had high habitat complexity. In this survey, birds species richness was highest in the forest when compared to other habitats in either the morning or evening.

Wild bird abundance was highest in the lake and farm habitats with abundance being least in forest habitat. In the evenings when activity rose because birds took the last meals before going to roost. Activity may continue until dark for some generalists such as the Village weavers. At first light activity began again. Abundance was highest in the lake because the Weavers, Quealeas and White-faced whistling Ducks utilized these areas for roosting and their large numbers shifted the abundance in favour of the lake.

Bird species evenness remained highest in the forest as time of day changed from morning to evening. This possible reveals that habitat is much more an ultimate factor in determining bird species evenness and abundance than time of day.

5.2.1 EFFECT OF TIME OF DAY ON BIRD SPECIES DIVERSITY INDICES, POOLING DATA OF ALL HABITATS

Overall bird species diversity indices compared across time of day showed significant differences. Bird species diversity was relatively higher in the morning than in the evening, the variations were higher in the evening than in the morning showing that diversity was more constant in the morning when compared in the evening. Shannon's and Simpsons diversity indices revealed the same trend. Bird species richness was significantly higher in the morning in comparison with the evening data.

Bird species abundance remained relatively higher in the evening when compared with the morning survey and the same reason can be given which remains that birds move out to take advantage of the last meal before it get dark. Bird species evenness remained higher in the morning on comparison with the evening data across all habitat types. Food availability usually changes between seasons, and correspondingly, the bird species diversity.

In the evenings, birds generally tend to increase activity and eat as much as possible to accumulate energy reserve for the long night without food. Nonetheless, this only affects birds that are diurnal and therefore active during the day time. There are however different schools of thought on the period that supports higher activity for wild birds, morning or evening? Though food is required for making up lost energy during the day time and night when energy is used up, Birds calls and movement are observed to be lower in the evenings than in the morning. This could be as a result of birds having to rest wherever the night meets up with them (during bad weather) or their need to challenge for territory. It could also be because predators are readily active during the day and night than during the mornings.

5.3.0 EFFECT OF SEASON ON BIRD SPECIES DIVERSITY INDICES ACROSS HABITATS

Bird species diversity was relatively higher in farm and lake in season one (late dry season) for the first year which fell between January and March and this season was the period of peak Parlearctic migration. All Palearctic migrants had arrived at this stage and contributed additional diversity to the resident (non-migrant) bird population in the farm and lake. Some of the species which added to the diversity during that period include Whinchat, Wood warbler, Osprey, and Yellow wagtail.

They were only recorded in this survey in the farm and lake and never in forest. Nonetheless, forest bird species diversity remained highest in both years for all seasons.

Bird species diversity in the farm habitat was least in the fourth season (Early dry season) which fell between October and December and this was the end of the rains. Most farm fields were dried up at this point and had very little to offer birds. Bird species richness was relatively higher in the dry season for the two years of the study consecutively for both farm and lake. The forest habitat was not affected by the Palearctic migrants' introduction in the dry season as the farm and lake known to be occupied by them. In season one (late dry season) which fell between January and March, bird species richness was highest for forest in the rainy season (season two or early rains and three or late rains) which fell between April to June and July to September respectively. However more detailed analysis would be required to tease out the feeding guilds which contributed to the differences in richness across season. Bird species abundance remained higher in the lake and farm in comparison with forest area in both years and in all seasons. However abundance in year one was higher than in year two for lake in season one and this could be attributed to the number of White-faced whistling Ducks that roosted in the lake in that year (about 3000 birds). Evenness remained higher for the forest habitat than other habitats in both years and in all seasons. This reveals that seasonal effects were sufficient enough to contribute more birds to other habitats to upset the earlier significance of habitat**.**

5.4.0 EFFECT OF LAND USE ON BIRD SPECIES DIVERSITY INDICES

Major changes in land use, water management and infrastructure development are lowering the conditions of fresh water ecosystems and by association, hindering food production, harming human health (MEA, 2005; UNDP, 2007; Sutherland *et al.*, 2009). Removal of forest ecosystem inadvertently affects the fresh water ecosystem on which three quarters of the global poor depend upon for their water supply, and global demands are rising by four-fold over the last 50 years (MEA, 2005).

Halle (1990) stated about 22 years ago "there is no doubt that primary rainforests are vanishing and that we are now living through the last decades of vegetation dating back as far as 300 million years". The consistent conversion of tropical forests of which presently there cannot be said to be any pristine primary forest in Nigeria into various land use systems has heavy consequences which are in general negative for distribution, community structure and population characteristics of flora and fauna (Waltert *et al*., 2004, Bobo *et al*., 2006).

In order for this trend to be reversed or halted, it becomes crucial to redesign anthropogenic habitats so that their use is in congruence with the need of many other wild species (reconciliation ecology). Rather than solely protecting some areas from human use, human modified areas need to embrace reconciliation ecology to ensure sustenance of a great majority of our wild species (Rosenzweig, 2003).

In Cameroon, reports from Zapfack *et al*. (2003) also support that farmlands have the poorest plant species rich habitat which support other biota such as wild birds in this study. Walter *et al*. (2005) and Schulze *et al.* (2004) also agree with with the findings of this study when they averred that there are strong correlations between tree diversity and diversity of birds and other forest dependent biota.

5.4.1 EFFECT OF LAND USE ON BIRD SPECIES DIVERSITY BASED ON TRANSECTS

Bird species diversity was significantly highest in forest and forest edge compared with the other eight land use types. The gallery forest (LAKEGAL) also showed a higher bird species diversity as compared to the lake grassland (LAKEGRA). This further supports the trend that as habitat heterogeneity or complexity increases, more species diversity is supported. Also with increase in cover, more bird species are supported.

5.4.2 EFFECT OF LAND USE ON BIRD SPECIES RICHNESS BASED ON TRANSECTS

The Agro and rice land use systems supported the least number of bird species while habitats possessing greater cover and complexity such as the forest and lake gallery supported significantly the highest amount of bird species richness in the study. This further indicates the need for providing areas of cover in order to maintain bird richness.

The benefits of maintaining populations of native bird species in the countryside are twofold. Firstly this diversity is likely to supply valuable resources for surrounding population of communities and these include pollination, seed dispersal, biological control (of pests) for the maintenance of vegetation cover. Secondly since there is no substitute for forest (native), the conservation of forest plots will provide reserves for biodiversity to keep thriving. Intensification agriculture is needed for increase in food production but landscape management needs to be integrated into agricultural policy making to ensure the conservation of biological diversity for future generations.

Agricultural plots with a mixture of cultivated and natural woodlands or agricultural plots in close proximity to forests, wetlands can support high number of species of both flora and fauna composition. However, the composition might only be as a result of source and sink interrelationships with neighbouring fragmented native habitats (Greenberg *et al*., 1997).

Hughes *et al*. (2002) and Adeyanju *et al*. (2011) support the view that plantations with annual crops do not generally support high number of bird species richness. Waltert *et al*. (2003) concurs with result from this study that species richness in land-use systems was lower than in nearby primary and secondary forest for all bird species observed, including endemic birds, frugivorous/nectar feeding birds and insectivorous birds.

The ability of forest specialists to persist over the long term in secondary habitats depends on the availability of nesting sites, availability of food fruits, insects, nectar, sizeable prey, competition, predation for which only generalized inferences can presently be made.

5.4.3 EFFECT OF LAND USE ON BIRD SPECIES ABUNDANCE BASED ON TRANSECTS

Bird species abundance was relatively highest in the lake grassland, further revealing the guilds responsible for increased abundance at the lake. However, maize land-use areas supported high bird species abundance and this can be attributed to the gregarious groups of weavers and queleas that move in the grasses that surround the Maize plots.

Rice paddies had relatively high bird species abundance and this is of course due to the year round production of rice by the Africa Rice network making ample amount of food to be available for Weavers and Queleas. Crop depreciation by the birds is a source of conflict between the farm unit and the Afforestation unit. Though relatively smaller in size when compared to the other land use areas, large numbers of birds congregated at rice paddies daily for food.

5.4.4 EFFECT OF LAND USE ON BIRD SPECIES EVENNESS BASED ON TRANSECTS

Bird species evenness remained highest in Forest in comparison with other land use types and evenness was relatively higher in forest compared to forest edge. It was also significantly higher in areas around lake gallery, in comparison to areas around lake grassland. Bird species evenness was highest in agro land use revealing that again habitats that are more complex offer more for wild birds than the other single crop land use systems

5.5.0 WILDBIRD SPECIES ACCUMULATION CURVE

Number of bird species generally increased steadily with increase in the number of transects monitored and began slowing down as the curve peaked. This shows that the curve did not level off, meaning that more species could still be added as more transects were sampled in each of the sites in the survey. However most of the species were recorded as only singletons were now being added.

The first ten transects resulted in over 100 species for the 2010 survey and about 80 for the 2011 survey, however it took about 40 additional transects to record an additional 50 species. This shows that efficiency was reducing and more effort was required to give rise to more of new species. This could be as a result of the source sink relationship that is present in any given population. At any given time some individuals or species are moving into the population and others are leaving while some remain indefinitely (Manu *et al*., 2007).

For the forest site it can be seen from Figure 4.27, that more new species were added faster than in the other two sites and this is definitely because the forest possess a lot more niches for a varying number of species of birds, the multiplier effect of edge effect also means bird species resident in other habitats may decide to take advantage of some of the resources available in the forest or forest edge. The first transect in both the forest and lake sites resulted in over 45 bird species while that of the farm resulted in only about 15 bird species. This shows that relatively the forest and lake sites supported and potentially were home to more species given equal number of transects are surveyed in all the three sites.

5.6.0 WILDBIRD VIRUS SURVEILLANCE

In a sero-epidemiology study carried out between 2002 and May 2004 in 65 south-west Nigerian commercial chicken farms, approximately 1000 birds were tested for antibodies against six virus types including avian influenza virus. No antibodies were confirmed against AIV, though sero-prevalence for other viruses were high (Owoade *et al*, 2004).

Though the study provided zero percent prevalence for AIV, it is a sign that either the virus loads in the wild were low or there was actually no AIV circulating in the investigated bird populations as at the time of that study. On the contrary in the northern hemisphere, surveillance of wild ducks has revealed a high LPAI virus prevalence primarily in juvenile birds and where HPAI subtypes have been involved in outbreaks in poultry, wildbirds have shown very low or no incidence (Chen *et al.* 2006). Prevalence in North America falls from about 60% in ducks sampled at marshalling sites close to the Canadian breeding areas in early fall, from 0.4 to 0.2% at the wintering grounds in the southern U.S.A and 0.25 % on the ducks returning to the breeding grounds in spring (Olsen *et al*., 2006).

The most common of the AIV subtypes in North America and Europe have been H3, H4 and H6 (Olsen *et al.*, 2006). Prevalence in Northern Europe can be significantly higher (up to 6.5%), while that of nesting grounds of ducks in Siberia before winter migration revealed the presence of influenza viruses in up to 8% of birds (Gaidet *et al*., 2007b, Olsen *et al*., 2006). It has been argued that the high temperature and environmental conditions in the tropics might be able to hinder the rapid acclimatization and residency of this virus group which is very sensitive to temperature. Gaidet *et al*. (2007a) however, supported the opposite view when they gave evidence of LPAI circulating in both Eurasian and Afro-tropical ducks which they termed possible 'reservoirs'. They suggested that Eurasian ducks could carry AIV during their northern spring migration but also raised the possibility that AIV could persist in the tropical region and be disseminated over Africa through intra-African migratory ducks. This survey supports that wildbirds in the study site do not harbour high prevalence of viruses since several surveys carried out from 2009 to 2012 have found no evidence of HPAI in Forest areas in Nigeria. It is like in the temperate region, where it is thought that the infectious influenza viruses could be preserved in frozen lakes which ensures the continual existence of infective agents for the virus to keep circulating (Webster *et al*., 1992).

In conclusion though LPAI can be found in numerous wild birds outside Nigeria, it is still unclear in which of these species 'AIV is endemic' and in which it is a temporary pathogen. AIV prevalence has been generally low in Nigeria (Joanis *et al*., 2008). Large scale surveillance in 2008 in Africa in sites very close to Nigeria, screened 4,553 waterbirds, both Eurasian migrants and Afrotropical birds, for the presence of AIV. The prevalence of positive birds reached 3.5% and different LPAI AIV subtypes were identified namely: H8N4, H5N3, H11N9, H12N5 and H1N1 (Gaidet *et al*. 2007a and b). One of the ducks which was sampled (*Dendrocygna viduata*) showed a 3.2% prevalence. Our sampling showed zero prevalence in this species for AIV even though 379 faecal samples from this species was screened over two years. A subsequent surveillance in Nigeria revealed a general prevalence ten times lower than that reported by Gaidet *et al.* (2007b) and Snoeck *et al.* (2011), but positive birds have been found in Chad, Mali, Mauritania, Niger, Senegal and Ethiopia (Gaidet *et al.*, 2007a; Stroud *et al.,* 2004; Fouchier *et al.,* 2003). However the high prevalence of NDVs in the White-faced Whistling Duck and in domestic poultry still showed that some viruses may still be in circulation in the wild as well as in our domestic poultry. Nonetheless all birds sampled during this study appeared to be healthy except for one sick domestic chicken which was, nevertheless, negative for AIV.

The assumption that wildbirds can undertake long-distance movements while carrying and shedding HPAIV and are thus likely to be agents of international spread though proven, still needs to be interpreted with caution. This survey included within its surveillance both high risk species (Waterbirds), bridge species and forest birds which are known to be of little or no risk. The acquisition of an infectious agent stimulates the host immune system, and when there are no antibodies existing prior to an infection large reservoirs of energy is needed by the invaded host to stamp out the intrusion and or maximise immune response. If the host fails to halt the pathogen, reserves will be depleted, leading to inability of the host to meet its daily requirements, i.e moulting, reproduction, feeding, flying and escape from predators.

Aggregation also increases the risk of infectious agents, and this behaviour is often observed in migratory birds whether Intra African or Parlearctic (Feare, 2007). Generally though the survey turned out with no positive for AIV, there is still need for active surveillance as this provides information on LPAIV circulation, including H5 and H7 subtypes that have the potential to become highly pathogenic. The erroneous or uncertain implication of wildbirds as the source of outbreaks of viral infections such as AIV needs to be done with caution. This is because some of these calls have deteriorated into wanton culling of wildbirds and destruction of roosting or breeding areas in a bid to halt spread of virus. Such action will only lead to conservation and adverse environmental issues and or consequences. Investigations should be made at the sites of outbreaks and possible avenues for introduction should be checked and the risk of speculation should be avoided as it holds serious costs if the real source of infection is not discerned.

Very few wildbirds have been reported dead or infected with the HPAI virus in Africa and especially Nigeria, even during periods of global scares of avian influenza outbreaks (Olsen *et al*., 2006; Gaidet *et al*., 2007a; Snoeck *et al*., 2011). With most of the reports in wild birds being of LPAI, though this is also in line with the absence of the H5N1 virus reports and or very limited detection rate from healthy wild bird populations (Chen *et al*., 2006b) from past surveillance programs in European countries (EFSA, 2006, Gaidet *et al*., 2007a). The use of vaccinations by some poultry farmers is also thought to be resulting in the possible generation of strains that have progressively drifted away from the original antigenic profile (Lee *et al*., 2004). Nonetheless, it is unclear how the immunological pressure generated by the variety of seed strains contained in the applied vaccines end up affecting the antigenic properties of isolates (Capua and Alexander, 2006). The sample swabs on which this study was based for PCR detection comprise of diverse sample types; namely Cloacal, Oropharyngeal, Feacal, and Cloacal/Oropharyngeal in the manner of (Gaidet *et al*., 2007b). Therefore, viruses could not have escaped detection as concentrations are known to be higher in trachea than in cloaca (Sturm-Ramirez *et al*., 2004, Hulse-Post *et al*., 2005). Nevertheless logistic constraints in Nigeria including unexpected long periods of electricity outages in the lab could have been responsible for the low detection, even when liquid Nitrogen was used.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The Ibadan area still holds many bird species, although some 68 species (plus 62 vagrants) recorded prior to 2002 have not been recorded recently and now appear to be missing from the area. Reasons may include the fact that some of these are inconspicuous species of high forest, not usually found outside this habitat. However, many others are conspicuous and would therefore not be easily overlooked. A few others may return as vagrants, while a good number are migrants and therefore recorded seasonally.

Protected areas suffer from numerous threats such as poaching, invasive non–native species and expansion of human settlements. This means that the Ibadan area has on the average lost a bird species each year since the last comprehensive survey in the 1960's**.** This figure refers only to wild birds and does not include the vast diversity of other fauna and flora that also exist in this site, or elsewhere in Nigeria. Protected areas like the IITA reserve provide one of the best tools for education and research, necessitating that our management of human modified landscape must improve rapidly to prevent incessant loss of species diversity.

The comparison of recent with earlier records reveals significant changes in the avifauna of the IITA campus and the surrounding Ibadan area. Some of these changes might not be directly attributed to changes within the campus but rather to the ongoing destruction of forest patches outside it. The city of Ibadan is expanding and many of the patches of forest around the reserve have now been replaced by housing, and natural corridors are thinning out. On the other hand, the extension of the derived savanna up to the edges of the campus and IBA, as a result of farmland degradation and clearance of forest and bush, has permitted colonization by an increasing number of birds formerly unknown to the area when it was forested.

Although the IITA campus is protected by a fence from cattle grazers and loggers, the farming activities of the research institute itself are beginning to encroach into forest reserve areas. Reasons given for this include low productivity from old farm plots, therefore new sites for farm plots are often taken from areas formerly covered by secondary forest. In support of conservation on the site, reforestation over the last four years has begun increasing the area covered by forest though it has not been made clear whether the forest is primarily managed to improve the productivity of soils for agriculture or to conserve soil and wildlife.

The benefits of maintaining populations of native bird species in the countryside are twofold. Firstly this diversity is likely to supply valuable resources for surrounding population of communities and these include pollination, seed dispersal, biological control (pest control) for the maintenance of vegetation cover. Secondly, since there is no substitute for forest (native). Hence, the conservation of forest plots will provide reserves for biodiversity to keep thriving. Agricultural intensification is needed for increase in food production but landscape management needs to be integrated into agricultural policy formulation to ensure the conservation of biological diversity for future generations.

Agricultural plots with a mixture of cultivated and natural woodlands or agricultural plots in close proximity to forests, wetlands can support high number of species of both flora and fauna composition. However, the composition might only be as a result of source and sink interrelationships with neighboring fragmented native habitats.

There is however the need to maintain wildlife diversity within farmland and concurrently allow support for agricultural production. Nonetheless, the ability of forest specialists to persist over the long term in secondary habitats depends on the availability of nesting sites, availability of food fruits, insects, nectar, sizeable prey, competition, predation for which only generalized inferences can presently be made. Therefore focus should be given to species specific interrelationships within land use areas so that effects can be more easily identified.

Habitat type is important in determining the distribution of wild birds in IITA environs and each habitat type is important for the sustenance of habitat specialists which cannot survive outside such nitches. Terrestrial ecosystems are where most people live and where most food, fiber and biofuels are produced, consumed and disposed of. Multiple use of land such as agriculture, aesthetics are governed by a high diversity of legal systems. The rise in competition for land for other uses will keep increasing to satisfy the need for human occupation and production, therefore, there is a need for improved understanding of how to develop our management of land use to yield the much desired dividends. Agricultural practices must be developed and managed to contribute positively to conserving overall biodiversity and thereby reduce pressure on conversion of natural ecosystems.

The IITA area is important for bird watchers from all around the world as the IITA management have provided an accommodating atmosphere that meets International standards. The record of over 260 bird species for IITA, in an area of less about 1000 hectares means the site is still rich and supports a good representative of wild bird species occurring in south west Nigeria. Bird diversity is very high early in the morning just after sun rise depending on prevailing weather. However in open areas such as rice paddies it is possible to view birds even in the warm afternoons as waterbirds take shade from the growing plants. In the evenings bird diversity rises due to conspicuous activity and again nature lovers can have fun at sighting rare to common species as they quickly disperse to take up a last meal before sunset.

The rain and dry season both support high diversity of bird species. Nonetheless, during the early dry season there is an influx of Palearctic migrants which add to the diversity present on the site. Though more bird species are recorded during the dry season, tourists and bird lovers still have lots of birds to decipher when they visit the site.

The Ibadan malimbe (*Malimbus ibadanensis*) continues to be a species of international interest at the site. The Endemic and endangered *M. ibadanensis* is native to south western Nigeria; more importantly, its low population has contracted significantly due to fragmentation of its preferred secondary forest. The species possesses a maximum projected population of 2,469 individuals and its envisaged that effects of climate change and replacement of required nitch will gain ground. Its presence is however tied to the remaining forest relics of the south west, this area centres on Ibadan area of which IITA has been known to be a stronghold for the species. However, its rare sighting during the previous years including during this study calls for another comprehensive survey to bring out new information concerning the species present distribution and density.

Natural and man-made threats, socio-cultural problems as well as direct and indirect consequences of socio-economic development have contributed to the erosion of biodiversity at all levels. Within the last 25 years, it is believed that about 43% of the forest ecosystem has been lost through human activities. Nigeria, with a population of over 140 million people constitutes nearly a quarter of the total population of sub-

Saharan Africa. A population growth rate of more than 3% and increasing poverty (especially in rural areas) has put severe demand on the country's natural resources and the institutional structures and the resources available to manage them.

There has been a general institutional weakness and lack of technical capacity to effectively tackle the nation's environmental issues, including threat to biological diversity. Although Nigeria derives about 80% of its external earnings from the oil sector, agriculture contributes about 38% of the GDP. More importantly, about 70% of the population derives their means of livelihood from agriculture, and the economy is characterized by a large rural based traditional sector. Most of the rural poor derive their livelihood from wild species of biodiversity. The urban population also benefit from the exploitation of the country's biological resources, particularly in the construction industry.

The viability of the agricultural sector is crucial to the growth and development of the nation. The agriculture sector strongly impacts food security, industrialisation efforts, quality of life, economic growth, political stability and, to a certain extent, a nation's position in international relations and trade. The sustainability of this important sector should, therefore, be of paramount importance. Consequently, it is essential to establish a balance between efficient agricultural enterprise and environmental protection.

The emphasis should be on the promotion of ecologically sound and profitable farming systems and suitable rural development programmes principally aimed at small scale farmers. In order to increase agricultural productivity, vigorous programmes have to be established and supported to ensure proper use of natural resources and judicious application of agricultural inputs.

Low incidence of viral diversity among wildbirds investigated in this study reveal that none of indeed one of more of our important bird areas does not support the conclusion that wild birds are reservoirs of viruses in general. Nevertheless, the presence of Newcastle disease virus among wild birds, especially waterfowl does necessitate that wild birds should be monitored to keep a check on association with domestic poultry. The results from this study support strongly that wild birds do possess one of the viruses investigated but with a low prevalence.

6.2 RECOMMENDATIONS

A balance between land use and biological diversity needs to be agreed upon to ensure continuous support for biodiversity at the site.

Further studies are needed to monitor changes in avifaunal diversity along land use gradients including outside the IITA campus, and longer-term studies are required to monitor bird populations within the IBA.

Within the IITA vicinity an afforestation programme has been ongoing for the last four years by the Leventis-IITA forest project and now IITA forest project. About 300 hectares of agriculturally disturbed areas are being replanted with indigenous trees (Deni Bown per. comm.). A nursery has also been established to serve as source of raising trees to serve for the project and other external needs. It is vital that this project is encouraged and used to feed communities around the vicinity in order to reduce forest isolation indices which have been indicated to affect the density and distribution of the Ibadan Malimbe. This is because Community based forests were the only surviving forests where Ibadan Malimbe was observed over ten years ago by Manu *et al.* (2005).

Ringing program at the site should be encouraged and this can be maintained by fostering a good relationship between the A. P Leventis Ornithological Research Institute and the University of Ibadan's Department of Wildlife and Ecotourism Management and the Zoology Department. Students from these educational units should be encouraged to take interest in the field of ornithology, and the site used as a platform for developing such interests.

Secondary forest is becoming increasingly difficult to protect as the demand of land for agricultural production increases. Building materials sourced from indigenous forest are also rising in demand therefore, policy on protection of forests need to be upgraded because sites such as the IITA area will become increasingly isolated. This will decrease habitat suitable for our endangered but endemic *Malimbus ibadanensis*.

Though the survey turned out with no positive samples for AIV, there is still need for active surveillance as that will provide information on LPAIV circulation, including H5 and H7 subtypes which have the potential to become highly pathogenic. Nonetheless funding is required to carry this out, though others have opined for passive surveillance of die-offs as the best means of detecting HPAIV in wild birds.

Monitoring of wildbird population at lower thresh holds of management decision will bring to open view more of the effects of management decisions than large-scale monitoring. Also effects on wild bird population and on individuals are different and the final decision should be what is good for the population and not only the individual. This is both cheaper and cost effective in the long run.

Piles of weed removed from the dam should not be left at the edges of the dam as this not only inhibit view of tourists but also serve as seed banks for increasing the dispersal of weeds across the dam. Water weeds are good in removing excess nutrients from water bodies but leaving them at the edges only serves to backstab the previous effort in the first place.

The reforestation of the edges of the dam should be encouraged as this will provide windbreaks, prevent siltation of the dam and also provide shade for nature viewing tourists

REFERENCES

Abdelwahab, E. M., Arafa, A., Selim, A., Shereen, W. H,. and Kilany, W. H.2009. Highly pathogenic avain influenza in H5N1 in Egypt: current situation and challenges. *In Proceedings of the 5th International meeting of the Working Group 10 (Turkey) of WPSA, Berlin, Germany, May 28-30*. H. M. Hafez, ed. Mensch and Buch verlag, Berlin, Germany. 308-316.

Adeyanju, A. T., Manu, S. and Ottosson, U. 2011. Effects of introduced tree plantations on the density and diversity of bird species in some parts of the Jos Plateau, Nigeria. *ROAN The Journal of Conservation Foundation*. 5.1:63-75.

Adeyanju, T. E. and Adeyanju, T. A. 2012. Avifauna of University of Ibadan Environs Ibadan, Nigeria *Proceedings of 3rd Annual Seminar of Nigerian Tropical Biological Association*. pp 27-34.

Africa Progress panel (APP). 2009. An agenda for progress at a time of global crisis. A call for African leadership, *Annual report for the African progress panel*. 47pp.

Akin, A., Lin, T. L., Wu, C. C., Bryan, T. A., Hooper, T. and Schrader, D.2001. Nucleocapsid protein gene sequence analysis reveals close genomic relationship between turkey coronavirus and avian infectious bronchitis virus. *Acta Virol* 45, 31–38.

Aldous, E. W., Mynn, J. K., Banks, J. and Alexander, D. J. 2003. A molecular epidemiological study of avian paramyxovirus type 1 (Newcastle disease virus) isolates by phylogenetic analysis of a partial nucleotide sequence of the fusion protein gene. *Avian Pathology* 32:239–256.

Alexander, D. J. 1997. Newcastle disease and other paramyxovirus infections. In *Diseases of Poultry*, pp. 541–569. Edited by M. S. Hofstad. Iowa: Iowa State University Press.

_____________. 2000. A review of avian influenza in different bird species.*Veterinary Microbiology* 74:3-13.

______________. 2001. Newcastle disease. *British Poultry Science* 42:5–22.

Amezaga, J. M., Santamaria, L. and Green, A. L. 2002. Biotic wetland connectivity supporting a new approach for wetland policy. *Acta Oecologica* 23: 213-223.

Amonsin, A., Choatrakol, C., Lapkuntod, J., Tantilertcharoen, R. and Thanawongnuwech, R. 2008. Influenza virus (H5N1) in live bird markets and food markets, Thailand. *Emerging Infectious Diseases* 14:1739-1742.

Ash, J. S. 1990. Additions to the avifauna of Nigeria, with notes on distributional changes and breeding. *Malimbus* 11: 104–116.

Ashford, R. W. 1968. Hirundine records from University of Ibadan campus. *Bull. Nig. Orn. Soc*. 5: 48.

_____________. 1969. Two species new to Ibadan and associated records. *Bull. Nig. Orn. Soc*. 6: 30–31.

_____________ and Parker, R.W. 1968. Reed warblers at Ibadan: two species new to the area. *Bull. Nig. Orn. Soc.* 5: 96.

Bannerman, D. A. 1930–51. *The Birds of Tropical West Africa*, vols 1–8. Crown Agents, London.

Bass, H.G.M. 1967. Notes on birds at Ibadan and elsewhere. *Bull. Nig. Orn. Soc.* 4(13): 31–35.

Beard, C. W., and Hanson, R. P. 1984. Newcastle disease. *Diseases of Poultry*. M. S. Hofstad. Ed. Iowa: Iowa State University Press.452–470.

Becker, J. 1996. *Hungry Ghosts. Mao's Secret Famine*. The Free Press. New York, NY.

Begon, M., Harper, J. L. and Townsend, C. R. 1996. *Ecology: Individuals, Populations and Communities*. Oxford: Blackwell Science Ltd.

Bibby, C. J., Burgess, N. D., Hill, D. A. and Mustoe S. H. 2000. *Bird Census Techniques*. Academic Press, London.

BirdLife International. 2000. *Threatened Birds of the World*. Barcelona and Cambridge, UK: Lynx Edicions and Bird Life International.

_________________. 2008. The H5N1 avian influenza virus: a threat to bird conservation, but indirectly. Presented as part of the BirdLife State of the world's birds website. Available from: http//www.birdlife.org/datazone/sowb/casestudy/176. Accessed: 11/03/2014.

Bobo, K.S., Waltert, M., Sainge, M., Njokagbor, J. and Muhlenberg, M. 2006. From forest to farmland: species richness patterns of trees and understory plants along a gradient of forest convertion in Southwestern Cameroon. *Biodiversity and conservation* 15:4097-4117.

Borm, S. V., Thomas, I., Hanquet, G., Lambrecht, B. and Boschmans, M. 2005. Highly Pathogenic H5N1 Influenza Virus in Smuggled Thai Eagles, Belgium. *Emerging Infectious Diseases* 11:702-705.

Borrow, N., and Demey, R. 2008. *Field Guide to the Birds of Western Africa*. Christopher Helm, London.

Bowes, V. A, Ritchie, S. J, Byrne, S., Sojonky, K. and Bidulka, J. J. 2004. Virus Characterization, Clinical Presentation, and Pathology Associated with H_7N_3 Avian Influenza in British Columbia Broiler Breeder Chickens in 2004. *Avian Diseases* 48:928.

Broadbent, J.A. 1972. Interesting records for the Ibadan area. *Bull. Nig. Orn. Soc.* 8: 54–58.

Buckland S. T., Anderson, D. R., Burnham, K. P., Laake, J. L. and Borchers, D. L. 2001. *Introduction to distance sampling: estimating abundance of biological populations*, Oxford University Press, Oxford.

Button, J.A. 1965. Harlequin Quail at Illaro and Ibadan. *Bull. Nig. Orn. Soc.* 2: 53.

Cattoli. G., Fusaro, A., Monne, I., Molia. S., Le Menarch, A., Maregeya, B., Nchare, A., Bangana, I., Maina, A.G., N'Goran, K.J.-N., Thiam, H., Bezeid, O.E.M.A., Salviato, A., Nisi, R., Terregino, C., and Capua, I. 2010. Emergence of a new genetic lineage of Newcastle disease virus in West and Central Africa- Implications for diagnosis and control. *Veterinary Microbiology*. 142:168-176

Capua, I. and Alexander, D. J. 2006. Avian influenza infections in birds- a moving target. *Influenza* 10:1750-2659.

Central Bank of Nigeria (CBN). 2004. A*nnual Report and Statement of Account*. Abuja: Central bank of Nigeria.

Chen, H., Deng, Z., Li, G., Tian, Y., and Li, P. 2004. The evolution of H5N1 influenza viruses in ducks in Southern China. *Proceedings of the National Academy of Science* 101:10452-10457.

_________, Li, Y., Li, Z., Shi, J. and Shinya K.. 2006a. Properties and Dissemination of H5N1 Viruses Isolated during an Influenza Outbreak in Migratory Waterfowl in Western China. *Journal of virology* 80:5976.

_________, Smith, G. J. D., Li, K. S., Wang, J, and Fan, X. H.. 2006b. Establishment of multiple sublineages of H5N1 influenza virus in Asia: Implications for pandemic control. *Proceedings of the National Academy of Sciences* 103:2845-2850.

Colwell, R. K. 2009. *Biodiversity: concepts, patterns, and measurement.* Pages 257-263 in S. A. Levin, editor. *The Princeton Guide to Ecology*. Princeton Univ. Press, Princeton, NJ.

Convention on Biological Diversity (CBD) 2014. *The Convention on Biological Diversity*. The CBD website. www.cbd.int/convention/ Accessed on 13/3/2014.

Davidar, P., Yoganand, K., and Ganesh, T. 2001. Distribution of Forest Birds in the Andaman Islands: Importance of Key Habitats. *Journal of Biogeography*, 28 (5):663-671.

Dawson, J. R., Stone, W. B., Ebel, G. D., Young, D. S., and Galinski, D. S. 2007. Crow deaths caused by West Nile virus during winter. *Emerging Infectious Diseases* 13:1912–1914.

Demey, R., Dowsett-Lemaire, F. and Dowsett, R.J. 2003. Notable bird observations from Nigeria, including the first records of Spot-breasted Ibis *Bostrychia rara* and Yellow Longbill *Macrosphenus flavicans*. *Malimbus* 25: 85–94.

________. 2006. Recent Reports. *Bull. Afr. Bird Club* 13: 228.

Dodman, T. Waterbird family estimates in Africa. Waterbird population estimates. 4th edition (the Netherlands): Wetlands International. In Gaidet *et al.*, 2007 Avian influenza Viruses in Water birds, Africa. *Journal of Wildlife Diseases* 43:22-28.

________. and Diagana, C. H. 2007. Movements of waterbirds within Africa and their conservation implications. *Ostrich* 78 (2): 149-154.

Domingo, E. and Holland, J. J. 1997. RNA virus mutations and fitness for survival. *Annual Reviews in Microbiology* 51:151–178

Dranzoa, C. 1998. The Avifauna 23 years after logging in Kibale National park, Uganda. *Biodiversity and Conservation* 7:777-797.

Ducatez, M. F., Olinger, C. M., Owoade, A. A., De Landtsheer, S. and Ammerlaan, W. Niesters, H. G., Osterhaus, A. D., Fouchier, R. A. and Muller, C. P. 2006. Avian Flu: Multiple introductions of H5N1 in Nigeria. *Nature* 442:37-37.

Dudley, N. (Ed). 2008. *Guidelines for applying protected area management categories*. Gland, Switzerland: IUCN. x + 86.

EFSA. 2006. EFSA Scientific report on Migratory Birds and their Possible Role in the Spread of Highly Pathogenic Avian Influenza. Adopted by written procedure 12 May 2006. EFSA-Q-2005-243. Annex to *The EFSA Journal* (2006) 357, 1-46. European Food Standards Agency, Milan.

Elgood, J.H. and Sibley, F.C. 1964. The tropical forest edge avifauna of Ibadan, Nigeria. *Ibis* 106: 221–241.

______., Fry, C. H. and Dowsett, R. J. (1973) African migrants in Nigeria. *Ibis*: 115:375-409

______., Heigham, J. B., Moore, A. M., Nason, A. M., Sharland, R. E. and Skinner, N. J. 1994. *The Birds of Nigeria. Checklist* 4, 2nd ed., British Ornithologists' Union, Tring.

EMPRES WATCH. 2006. Updated situation of Highly Pathogenic Avian Influenza (H5N1) in Asia. http://www.fao.org/eims/secretariat/empres/eims_search/simple_s_result.asp?topic_docrep=174. Accessed on 11/03/2014.

Ezealor, A.U. 2001. Nigeria. In *Important Bird Areas in Africa and associated islands: Priority sites for conservation.* L.D.C. Fishpool and M.I. Evan. Eds. Newbury and Cambridge, UK: Pisces Publications and BirdLife International BirdLife Conservation Series No.11. 661-692.

Enserink, M. 2006. Avian Influenza: H5N1 Moves Into Africa, European Union, Deepening Global Crisis. *Science* 311:932-940.

Feare, C. J. 2007. The role of Wild Birds in the spread of HPAI H5N1. *Avian Diseases* 51:440-447.

Fishpool, L. D. C. and Evans, M. E. 2001. *Important Bird Areas in Africa and associated islands: Priority sites for Conservation*. Cambridge, UK: Pisces publication and BirdLife International.

Food and Agricultural Association (FAO). 2004. Selected forest products. Table B.10, Rome Italy. www.http:/fao.org/ess/yearbook/vol1pdf/bio.pdf. Accessed January, 12 2012.

______________________________. 2006. *Wild bird HPAI Surveillance: sample collection from healthy, sick and dead birds*. Rome, Italy.1-55.

___________________________________. 2007a. *Wild Birds and Avian Influenza: An instruction to applied field research and disease sampling techniques*. D. Whiteworth., S. H Newman., T. Mundkur and P. Harris. Eds. FAO Animal Production and Health manual, No 5. Rome.

____________________________________.2007b. Africa, state of the worlds forests, FAO, Rome, Italy. 4-13.

FAO/OIE/WHO (Food and Agricultural Organization/Office International des Epizooties/World Health Organization). (2005). *consultation on avian influenza and human health: risk reduction measures in producing, marketing, and living with animals in Asia.* Rome. FAO.

Fouchier , R. A. M., Bestebroer, T. M., Herfst, S., van der Kemp, L., Rimmelzwaan, G. F. and Osterhaus, A. D. M. E. 2000. Detection of influenza A viruses from different species by PCR amplification of conserved sequences in the matrix gene. *J. Clin. Microbiology*. 38, 4096-4101.

_________________., Munster, V., Wallensten, A., Bestebroer, T. M, and Herfst, S. 2005. Characterization of a Novel Influenza A Virus Hemagglutinin Subtype (H16) Obtained from Black-Headed Gulls. *Journal of Virology* 79:2814-2822.

________________., Olsen, B., Bestebroer, T. M., Herfst, S., van der Kemp, L, and Rimmelzwaan, G. F. 2003. Influenza A virus surveillance in wild birds in northern Europe in 1999 and 2000. *Avian Diseases* 47:857-860.

Gaidet N., Dodman T, Caron A., Balanca G., Desvaux S., and Goutard F. 2007a. J Influenza Surveillance in Wild Birds in Eastern Europe, the Middle East, and Africa: Preliminary Results from an Ongoing FAO-led Survey. *Journal of Wildlife Disease* 43:22-28.

_________, ___________, _________, _________, ___________, and ________.. 2007b. Avian Influenza Viruses in Water Birds, Africa. *Emerging Infectious Diseases* 13: (4) 626-629.

_________, Newman, S.H., Hagemeijer., W., Dodman, T., and Cappelle, J. 2008. Duck Migration and Past Influenza A (H5N1) Outbreak Areas. *Emerging Infectious Diseases* 14.

Garmendia, A. E., Van Kruiningen, H. J., French, R. A., Anderson, J. F., and Andreadis, T. G. 2000. *Recovery and identification of West Nile virus from a hawk in winter*. *Journal of Clinical Microbiology* 38:3110–3111.

Georg, B., René, G., Lutz, G, Timm, C. H. and Christian, H. 2006. Influenza Report 2006. S. K Bernd, H. Christian, P. Wolfgang, Eds. www.InfluenzaReport.com; 1-255.

Globig, A., Staubach, C., Beer, M., Koeppen, W., and Fidler, V. 2009. Anatidae migration in the western paleartic and spread of highly pathogenic avian influenza H5N1 of Asian origin in wildbirds in Germany, 2006 and 2007. *Transboundary Emerging Diseases* 56:57-72.

GRAIN. 2006. Fowl play: The poultry industry's central role in the bird flu crisis, GRAIN Briefing, Febuary 2006. http//www.grain.org/briefings/?id=194 Accessed 11/03/2014.

Green, A. J., Figueroa, J. and Sanchez, M. I. 2002. Implications of waterbird ecology for the dispersal of aquatic organisms. *Acta Oecologica* 23: 201-213.

Greenberg, R., Bichier, P., Cruz Angon, A. and Reitsma, R. 1997. Bird populations in shade and sun cofee plantations in central Guatamala. *Conservation Biol*ogy. 11:448-459.

Halle, F. 1990. Tropical rain forests: structure and growth dynamics relative to utilization by birds. In *Biogeography and Ecology of Forest Bird*

Communities. A. Keast. Eds. SPB Academic Publishing by The Hague, The Netherlands. 27-33.

Hanson, B. A., Stallknecht, D. E., Swayne, D. E., Lewis, L. A. and Senne, D. A. 2003 in Olsen, B., Munster, V. J., Wallensten, A., Waldenstrom, J., and Osterhaus, A. D. M. E. 2006. Global Patterns of Influenza A Virus in Wild Birds. *Science* 312:384-388.

Herczeg, J., Wehmann, E., Bragg, R. R., Dias, P. M., and Hadjiev, G.. 1999. Two novel genetic groups (VIIb and VIII) responsible for recent Newcastle disease outbreaks in Southern Africa, one (VIIb) of which reached Southern Europe. *Archives of Virology* 144:2087–2099.

Hougner, C., Colding, J, and Soderqvist, T. 2006. Pages 1-14 in Perspectives in Ornithology, the need to quantify ecosystem services provided by birds. Wenny, D. G., DeVault, T. L., Johnson, M. D., Cagan, D. K., and Sekercioglu, C. H. 2011. *The Auk* 128.1:1-14.

Hughes, J. B., G. C. Daily. and Ehrlich. P. R. 2002. Conservation of tropical forest birds in countryside habitats. *Ecology Letters* 5:121-129.

Hulse-Post, D. J., Sturm-Ramirez, J. H., Seiler, P., Govorkova, S. K., Scholtissek, P. P. 2005. Role of domestic ducks in the propagation and biological evolution of highly pathogenic H5N1 influenza viruses in Asia. *Proceedings of the National Academy of Sciences of the United States* 102:10682-10687.

Hunter, M. L., Jr. 2005. A Mesofilter complement to coarse and fine filters. *Conservation Biology* 19:1025-1029.

IISD, 2011. Annual report. *Earth Negotiations Bulletin* 2011:Vol 21 (70):1-15.

Downloaded on 30th April 2013 from http://www.iisd.ca/cites/sc61/,

Imong, S. I and Manu, S. A. 2011. Effects of habitat types and antropogenic disturbance on the density and disatribution of bird species in the Sankwala Mountains, Cross River State, Nigeria. *Roan* 5 (1): 50-62.

Joanis, T. M., Meseko, C. A., Oladokun, A. T., Ularamu, H. G., and Egbuji, A. N. 2008. Serologic and virologic surveillance of avain influenza in Nigeria, 2006-2007. *European Surveillance* 13:1-4.

Karr, J. R. and Roth, R. R. 1971. Vegetation Structure and Avian Diversity in Several New World Areas. Th*e American Naturalist* 105.945:423-435.

Kelly, D., Ladley, J. J. and Robertson, A. W. 2004. Is dispersal easier than pollination? Two tests in new Zealand Loranthaceae. *New Zeal. J. Bot*. 42: 89–103.

Kho, C. L., Mohd Azmi, M. L., Arshad, S. S and Yusoff, K.2000. Performance of an RT-nested PCR ELISA for detection of Newcastle disease virus. *J. Virol. Meth*., 86: 71-83.

Krauss, S., Obert, C. A., Frank, H., Walker, D., and Jones, K. 2007. Influenza in Migratory Birds and and Evidence of Limited Intercontinental Virus Exchange. *PLOS Pathogens* 3:1687-1693.

Lee, C. W., Senne, D. A., Suarez, D. L. 2004. Effect of vaccine use in the evolution of Mexican lineage H5N2 avain influenza virus. *Journal of Virology* 78:8372-8381.

Li, K. S., Guan, Y., Li, K. S., Wang, J., and Smith G. J. D.. 2004. Genesis of a highly pathogenic and potentially pandemic H5N1 influenza virus in eastern Asia. *Nature* 430:209-213.

Londt, B., Banks, J., and Alexander, D. 2007. Highly pathogenic avian influenza viruses with low virulence for chickens in in vivo tests. *Avian Pathology* 36:347.

Luoto, M., Virkkala, R., Heikkinen, R. K. and Rainio, K. 2004. Predicting bird species richness using remote sensing in boreal agricultural-forest mosaics. *Ecological Applications* 14. 6:1946-1962.

Maclean, G. L. 1990. *Ornithology for Africa*. University of Natal Press, Pietermaritzburg.

Magurran, A. E. 2004. *Measuring Biological Diversity. The standard reference for conceptual and quantitative aspects f diversity measurement*. Oxford: Blackwell Publishing.

Manu, S. 2002. Effects of habitat fragmentation on the distribution of forest Birds in South Western Nigeria with Particular reference to Ibadan malimbe and other malimbes. PhD Thesis, Edward Grey Institute, Oxford University, UK.

________., Peach, W. and Cresswell, W. 2005. Notes on the natural history of the Ibadan Malimbe *Malimbus ibadanensis*, a threatened Nigerian endemic. *Malimbus* 27: 33–39.

_________. and Cresswell, W. 2007. Addressing sampling bias in counting forest birds: a West African case study. *Ostrich* 78 (2): 281-286.

________ and Imong I. S.. 2006. *An ornithological survey of the Cameroon Highlands in Cross River state, Nigeria: Afi mountain wildlife sanctuary, Cross River National Park, Mbe Mountains and Sankwala Mountains*. A survey report submitted to NCF-WCS Biodiversity Research Programme.

_______, Peach, W., and Cresswell, W. 2007. The effects of edge, fragment size and degree of isolation on avian species richness in highly fragmented forest in West Africa. *Ibis* 149 (2):287.

Mayo, M. A. 2002a. Virus taxonomy. *Archives of Virology* 147:1071–1076.

_________. 2002b. *A summary of taxonomic changes recently approved by ICTV. Archives of Virol*. 147. 1655–1663.

________________________________2005. *Ecosystems and human well-being: synthesis.* Island Press, Washinton. D.C.

Mills, G. S., Dunning Jr, J. B., and Bates, J. M. 1991. The relationship between breeding bird density and vegetation volume. *Wilson Bull*. 103.3:468-479.

Mounts, A. W., Kwong, H., Izurieta, H. S. 1999. Case-control study of risk factors for avian influenza A (H5N1) disease, Hong Kong. *Journal of Infectious Diseases* :505-508.

Nemeth, N., Young, G., Ndaluka, C., Bielefeldt-Ohmann, H., and Komar, N. 2009. Persistent West Nile Virus infection in the House Sparrow (*Passer domesticus*). *Archives of Virology* 154:783-789.

Nguyen, D. C., Uyeki, T. M., Jadhao, S., Maines., T, and Shaw, M. 2005. Isolation and Characterization of Avian Influenza Viruses, Including Highly Pathogenic H5N1, from Poultry in Live Bird Markets in Hanoi, Vietnam, in 2001. *Journal of Virology*. 79:4201-4212.

Nigeria's 4th *Biodiversity Report.* 2010. http//www.cbd.int/doc/world/ng/ng-nr-04-en.pdf. Accessed 11/03/2014.

Normile, D. 2008. Flu Virus Research Yields Results But No Magic Bullet for Pandemic. *Science* 319:1178-1179.

Olsen, B., Munster, V. J., Wallensten, A., Waldenstrom, J., and Osterhaus, A. D. M. E. 2006. Global Patterns of Influenza A Virus in Wild Birds. *Science* 312:384-388.

Otim, M. O., Christensen, H., Jorgensen, P. H., Handberg, K. J., and Bisgaard, M. 2004. Molecular characterization and phylogenetic study of Newcastle disease virus isolates from recent outbreaks in eastern Uganda. *Journal of Clinical Microbiology* 42:2802–2805.

Owoade, A. A., Oluwayelu, D. O., Fagbohun, O. A., Ammerlean, W., Mulders, M. N. and Muller, C. P. 2004. Serologic evidence of chicken infectious anemia in commercial chicken flocks in southwest Nigeria. *Avian Diseases* 48:202-205.

___________., Ducatez, M. F. and Muller, C. P. 2006. Seroprevalence of Avian Influenza Virus, Infectious Bronchitis Virus, Reovirus, Avian Pneumovirus, Infectious Laryngotracheitis Virus, and Avian Leukosis Virus in Nigerian Poultry. *Avian Diseases* 50:222-227.

Parker, R. H. 1967. Additions to local avifaunas Ibadan. *Bull. Nig. Orn. Soc*. 4(15): 16.

__________. 1968. Two interesting migrants at Ibadan *Bull. Nig. Orn. Soc.* 5: 96.

__________. 1970. Additions to the local avifauna — Ibadan. *Bull. Nig. Orn. Soc*. 7: 38.

Peiris, J. S. M., De Jong, M. D., and Guan, Y. 2007. Avian Influenza Virus (H5N1): a Threat to Human Health. *Clinical Microbiology Reviews* 20:243-267.

Pettet, A. 1968a. Miscellaneous bird records for the Ibadan area. *Bull. Nig. Orn. Soc.* 5: 52.

________. 1968b. New records for the Ibadan area. *Bull. Nig. Orn. Soc*. 5: 51.

________. 1975. Breeding behavior of *Clamator glandarius* at Ibadan in southern Nigeria. *Bull. Nig. Orn. Soc*. 11: 34–40.

Ramsar Convention Bureau. 1996. www.ramsar.org downloaded 14th March 2010.

________________________. 1997. *A guide to the convention on wetlands (Ramsar, Iran, 1971)*. (Ed) Blasco. D., 2nd edition. Switzerland: Ramsar Convention Bureau.

Robinson, D. M. 1966. Wood Ibis at Ibadan. *Bull. Nig. Orn. Soc.* 3: 13.

Robinson, N. 1970. A bird bath in an Ibadan compound: Jericho reservation. *Bull. Nig. Orn. Soc*. 7: 27–30.

Rosenzweig, M. 1995. *Species Diversity in Space and Time. An overview and analysis of the geography of species richness, especially species-area relations*. New York: Cambridge University Press.

__________. 2003. Reconciliation ecology and the future of species diversity. *Oryx* 37: 194-205.

Sallabanks, R., Walters, J. R., and J. A. Collazo. 2000. Breeding bird abundance in bottomland hardwood forests: habitat, edge, and patch size effects. *The Condor* 102. 4:748-758.

Salzberg, S., Kingsford, C., Cattoli, G., Spiro, D., and Janies, D. 2007. Genome analysis linking recent European and African influenza (H5N1) viruses. *Emerging Infectious Diseases* 13:713-718.

Schulze, C. H., Waltert, M., Kessler, P. J.A, Pitopang, R., Shahabuddin, V.M.. 2004. Biodiversity indicator groups of tropical land-use systems: comparing plants, birds and insects. *Ecological Applications* 14:1321-1333.

Sekercioglu, C. H. 2006a. Ecological significance of bird populations. Page 1-14 in Perspectives in Ornithology, the need to quantify Ecosystem services provided by birds. Wenny, D. G., DeVault, T. L., Johnson, M. D., Cagan, D. K., and Sekercioglu, C. H. 2011. *The Auk* 128.1:1-14.

_________________. 2006b. Increasing awareness of avian ecological function. Trends Ecol. Evol. 21: 464–471.

Serle, W. 1950. Notes on the birds of south-western Nigeria. *Ibis* 92: 84–94.

Shochat, E., Abramsky, Z., and Pinshow, B. 2001. Breeding bird species diversity in the Negev: effects of scrub fragmentation by planted forests. *Journal of Applied Ecology* 38:1135-1147.

Sims, L. and Narrod C. 2008. *Understanding avian influenza.* FAO Animal

Production and Health Division.

Slomka, M.J., Pavlidis, T., Banks, J., Shell, W., and McNally, A. 2007. Validated H5 Eurasian realtime reverse transcriptase–polymerase chain reaction and its application in H5N1 outbreaks in 2005–2006. *Avian Diseases* 51. (1 Suppl): 373-377.

Snoeck, C. J., Ducatez, M. F., Owoade, A. A., Faleke, O. O., Alkai, B. R., Tahita,

Snoeck, C. J., Adeyanju, A. T., De Landtsheer, S., Ottosson, U., Manu, S., Hagemeijer, W., Mundkur, T. and Muller, C. P. 2011. Reassortant low-pathogenic avian influenza H5N2 viruses in African wild birds. *J Gen Virol* 92, 1172-1183.

Spackman, E., Senne, D. A., Myers, T. J., Bulaga, L. L., and Garber, L. P. 2002. Development of a Real-Time Reverse Transcriptase PCR Assay for Type A Influenza Virus and the Avian H5 and H7 Hemagglutinin Subtypes. *Journal of Clinical Microbiology* 40: 3256-60.

Steinhauer, D. A. 1999. Role of Hemagglutinin Cleavage for the Pathogenicity of Influenza Virus. *Virology* 258:1-10.

Strattersfield, A. J., Crossby, M. J., Long, A. J. and Wege, D. C. 1998. *Endemic Bird areas of the World: Priorities for Biodiversity Conservation.*, Cambridge, UK, BirdLife International.

Stroud, D. A., Davidson, N. C., West, R., Scott, D. A., Haanstra, L., and Thorup, O. 2004. (compilers, on behalf of the international wader Study Group 2004).

Status of migratory wader populations in Africa and western Eurasia in the 1990s. International *Wader Studies*. 15: 1-259,

Sturm-Ramirez, K. M., Ellis, T., Bousfield, B., Bissett, L., Dyrting, K., Rehg, J. E. 2004. Reemerging H5N1 influenza viruses in Hong Kong in 2002 are highly pathogenic to ducks. *Journal of Virology* 78: 4892-4901.

_____________., Hulse-Post, D.J., Govorkova, E. A, Humberd, J., and Seiler, P. 2005. Are Ducks Contributing to the Endemicity of Highly Pathogenic H5N1 Influenza Virus in Asia? *Journal of virology* 79:112-169.

Sutherland, W.J., Alakes, W. M., Aronson, R. B., Aveling, R., Blackburn, T.M., and Broad, S. 2009. One hundred questions of importance to the conservation of global Biological Diversity. *Conservation Biology* 23.3:557-567.

Tarnagda, M. C., Z., Ouedraogo, J. B, Maikano, I., Mbah, P. O., Kremer, J. R. and Muller, C. P.. 2009. Newcastle disease virus in West Africa: New virulent strains identified in non-commercial farms. *Archives of Virology* 154: 24-54.

Tankersley, Jr. R. and Orvis, K. 2003. *Modelling the Geography of Migratory Pathway and Stopover habitats for neotropical Migratory Birds. Conservation Ecology* 7:7-15.

Thibault, M., Defos du Rau, P. and Welch, S. 2012. First records of Long-legged Pipit *Anthus pallidiventris* for Nigeria and Benin. *Bull. Afr. Bird Club* 19: 206–208.

Tomback, D.F and Linhart, Y.B. 1990. Dispersal of Whitebark pine seeds by Clark's nutcracker: a mutualism hypothesis. *Journal of Ecology* 51**:** 451–467.

Uiprasertkul, M., Kitphati, R., Puthavathana, P., Kriwong, R., and Kongchanagul, A. 2007. Apoptosis and pathogenesis of avian influenza A (H5N1) virus in humans. *Emerging Infectious Diseases* 13:708-712.

UNDP (United Nations Development Programme). 2007. *Human development report 2007/2008. Fighting climate change: human solidarity in a divided world*. Palgrave Macmillan, New York.

UNDP-GEF 2008. *Biodiversity: Delivery results*. UNDP-GEF. Global Environment facility Unit, UNDP, New York, USA.

United Nations-Millennium Development Goals (UN-MDG) 2014. The United Nations Millennium Goals. The website of the UN Millenium goals. www.un.org/milleniumgoals/. Accessed on 13/03/2014

UNEP-WCMC 2008. State of the worlds protected areas: an annual review of global progress. UNEP-WCMC, Cambridge.

UNESCO-MAB, 2014. (United Nations Educational, Scientific and Cultural Organization) Man and Biospere Reserve. The website of UNESCO-MAB. www.unesco.org/mab/. Accessed on 13/03/2014.

Utterback, W. 1984. Update on avian influenza through febuary 21, 1984 in Pennsylvania and Virginia. In *the 33rd Western Poultry Disease Conference.* (Davis CA, ed). University of California. pp 4-7.

van der Meulen, K. M., Pensaert, M. B., and Nauwynck, H. J. 2005. West Nile Virus in the Vertebrate world Review. *Arch. Virol*. 150:637-657.

Vey, M., Orlich, M., Adler, S., Klenk, H. D., Rott, R., and Garten, W. 1992. Hemagglutinin activation of pathogenic avian influenza viruses of serotype H7 requires the protease recognition motif R-X-K/R-R. *Virology* 188:408-416.

Villareal, C. L. 2006. Control and eradication strategies of avian influenza in Mexico: In Understanding Avian Influenza by {Sims, 2008 #118} *Developments in Biology (Basel)* 124:125-126.

Waltert, M., Lien, F.K., and Muhlenberg, M. 2004. Effects of land use on bird species richness in Sulawesi, Indonesia. *Conservation Biology* 18:1339-1346.

_________., Bobo, K.S., Sainge, M.N., Fermon, H. and Muhlenberg, M. 2005. From forest to farmland; habitat effects on afrotropical forest bird diversity. *Ecological Applications*. 15.4: 1351-1366.

Webster, R. G., Bean, W. J., Gorman, O. T., Chambers, T. M., and Kawaoka, Y. 1992. Evolution and ecology of influenza A viruses. *Microbiology Molecular Biological Reviews* 56:152-179.

_____________. 2004. Wet markets a continuing source of severe acute respiratory syndrome and influenza? *Lancet (British edition)* 363:234.

Weins J. A. and J. T. Rotenberry, J. T. 1981. Habitat associations and community structures of birds in scrub-steep environments. *Ecological Monographs* 51:21-41.

Weller, M. W. 1999. *Wetland Birds*: Cambridge University Press, Cambridge, UK.

Wells. D.R. 1966a. A Striped Crake *Porzana marginalis* at Ibadan. *Bull. Nig. Orn. Soc*. 3: 13.

__________. 1966b. Migrant Scops Owls *Otus scops* at Ibadan. *Bull. Nig. Orn. Soc*. 3: 10–11.

__________. 1967. Additions to local avifaunas, Ibadan. *Bull. Nig. Orn. Soc*. 4(13/14): 41.

Wenny, D. G., de Vault, T. L., Johnson, M. D., Cagan, D. K., and Sekercioglu, C. H. 2011. Perspectives in Ornithology, the need to quantify ecosystem services provided by birds. *The Auk* 128.1:1-14.

Wetlands International. 2002. www.wetlands.org/.../RamsarConventiononWetlands40th\

___________________. 2005. Wetlands International Position Statement on Avian meeting. Influenza. In update per 4/11/05.

Whelan, C. J., Wenny, D. G, and Marquis, R. J. 2008. *Ecosystem services provided by birds New York Academy of Sciences* 1134:25-60. 2008.

Wilson, E.O., and Peter, F.M. (Eds.) 1988. *Biodiversity. An important collection of papers that launched public awareness of biodiversity and its importance*. Washinton, DC. National Academy Press.

Willoughby, R. W. H. 1949. Birds of Ibadan Reservoir. *Niger. Field* 14: 142–145.

Wood, G. W., McCauley, J. W., Bashiruddin, J. B., and Alexander, D. J. 1993. Deduced amino acid sequences at the haemagglutinin cleavage site of avian influenza A viruses of H 5 and H 7 subtypes. *Archives of Virology* 130:209-216.

World Bank, 2009. *Global monitoring report 2009. A development Emergency of the World Bank.* Washinton D. C., U.S.A.

World Health Organization. 2002. *WHO manual on Aniamal Influenza Diagnosis and Surveillance*. 2 ed. WHO Geneva, Department of Communicable Disease Surveillance and control.

______________________. 2008. Cumulative Number of Confirmed Human Cases of Avian Influenza A? (H5N1) Reported to WHO. 19/06/08. http//www.who.int/influenza/surveillance_monitoring/updates/latest. Accessed 11/03/2014.

Wymenga E. and Zwarts L. 2010. Use of Rice fields by Birds in Africa. *Waterbirds* 33:97-104.

Appendix 1: Sighting frequency of bird species per 100 sections across seasons and landuse types

1	*Phalacrocorax africanus* Long-tailed Cormorant	3.5	3.85	2.48	4.96	7.32	7.46	1.04	*	*	*	*	*	*
2	*Ixobrychus minutus* Little Bittern	*	5.77	2.48	0.83	6.1	5.97	*	*	*	*	*	*	*
3	*Nycticorax nycticorax* Black-crowned Night Heron	3.5	4.49	*	5.79	4.88	7.46	4.17	*	*	*	*	*	*
4	*Ardeola ralloides* Squacco Heron	30.77	31.41	7.44	14.05	31.71	56.72	12.5	*	*	*	*	*	25
5	*Bubulcus ibis* Cattle Egret	16.78	7.05	1.65	11.57	10.98	18.66	4.17	*	4.55	12.5	2.94	5.66	25
6	*Butorides striata* Green-backed Heron	0.7	5.77	8.26	5.79	13.41	8.96	2.08	*	*	*	*	3.77	*
7	*Egretta garzetta* Little Egret	6.29	0.64	*	2.48	2.44	5.97	*	*	*	*	*	*	25
8	*Egretta intermedia* Intermediate Egret	11.19	12.18	3.31	4.96	8.54	23.88	1.04	*	2.27	*	*	1.89	12.5
9	*Ardea purpurea* Purple Heron	11.89	12.18	4.96	3.31	19.51	12.69	12.5	0.95	*	*	*	*	*
10	*A. cinerea* Grey Heron	9.79	4.49	1.65	6.61	12.2	5.22	9.38	*	*	4.17	2.94	1.89	*
11	*A. melanocephala* Black-headed Heron	4.2	3.21	*	9.92	1.22	7.46	3.13	*	4.55	8.33	*	1.89	37.5
12	*Ciconia abdimii* Abdim's Stork	*	*	*	0.83	*	*	*	*	*	*	2.94	*	*
13	*Bostrychia hagedash* Hadada Ibis	2.8	*	2.48	4.13	3.66	1.49	5.21	*	*	*	2.94	1.89	*
14	*Dendrocygna viduata* White-faced Whistling Duck	12.59	24.36	8.26	10.74	15.85	37.31	4.17	0.95	*	*	*	3.77	25
15	*Pandion haliaetus* Osprey	0.7	*	4.13	0.83	*	2.99	2.08	*	2.27	*	*	*	*
16	*Elanus caeruleus* Black-shouldered Kite	0.7	5.77	3.31	*	*	2.99	*	*	6.82	*	*	7.55	37.5
17	*Milvus migrans* Yellow-billed Kite	31.47	12.18	2.48	32.23	23.17	18.66	15.63	8.57	15.91	33.33	26.47	28.3	25
18	*Gypohierax angolensis* Palm-nut Vulture	3.5	6.41	4.13	3.31	9.76	2.24	8.33	2.86	4.55	*	*	1.89	12.5
19	*Polyboroides typus* African Harrier Hawk	2.8	1.92	*	0.83	*	0.75	6.25	0.95	*	*	*	*	*
20	*Circus aeruginosus* Eurasian Marsh Harrier	3.5	0.64	*	1.65	1.22	3.73	1.04	*	*	*	*	1.89	*
21	*Micronisus gabar* Gabar Goshawk	*	2.56	0.83	*	1.22	0.75	1.04	2.86	*	*	*	1.89	*
22	*Accipiter tachiro* African Goshawk	7.69	6.41	9.92	5.79	7.32	0.75	16.67	38.1	*	*	*	1.89	*
23	*A. badius* Shikra	1.4	1.92	*	2.48	1.22	*	2.08	0.95	2.27	8.33	2.94	*	*
24	Kaupifalco monogrammicus Lizard Buzzard	3.5	0.64	3.31	3.31	2.44	*	8.33	1.9	4.55	*	*	*	*

25	*Buteo auguralis* Red-necked Buzzard	0.7	*	*	*	*	*	*	2.86	*	*	*	*	*
26	*Lophaetus occipitalis* Long-crested Eagle	*	*	1.65	0.83	1.22	*	2.08	*	*	*	*	*	*
27	*Falco tinnunculus* Common Kestrel	*	1.28	1.65	0.83	*	*	*	*	2.27	*	2.94	5.66	*
28	*F. ardosiaceus* Grey Kestrel	3.5	1.28	4.13	5.79	2.44	4.48	1.04	*	9.09	4.17	*	7.55	12.5
29	*F. biarmicus* Lanner Falcon	*	1.28	*	*	*	*	1.04	*	*	*	*	1.89	*
30	*F. ahantensis* Ahanta Francolin	*	1.28	0.83	2.48	1.22	*	3.13	1.9	*	*	*	*	*
31	*F. bicalcaratus* Double-spurred Francolin	16.08	25.64	19.01	23.14	3.66	11.94	6.25	3.81	31.82	70.83	55.88	58.49	37.5
32	*Numida meleagris* Helmeted Guineafowl	1.4	1.92	3.31	*	*	*	*	*	2.27	*	14.71	5.66	*
33	*Crex egregia* African Crake	0.7	0.64	*	*	1.22	0.75	*	*	*	*	*	*	*
34	*Amaurornis flavirostra* Black Crake	6.99	11.54	5.79	12.4	18.29	13.43	13.54	*	2.27	*	*	*	25
35	*Porphyrio alleni* Allen's Gallinule	1.4	11.54	14.05	3.31	12.2	14.93	9.38	*	*	*	*	3.77	*
36	*Gallinula chloropus* Common Moorhen	2.1	5.77	2.48	1.65	9.76	5.22	*	*	*	*	*	*	25
37	*Actophilornis africanus* African Jacana	37.76	48.08	26.45	40.5	53.66	97.01	22.92	0.95	*	*	*	1.89	75
38	*Rostratula benghalensis* Greater Painted-snipe	0.7	1.28	0.83	1.65	*	2.99	*	*	*	*	*	*	25
39	*Himantopus himantopus* Black-winged Stilt	0.7	*	*	1.65	*	2.24	*	*	*	*	*	*	*
40	*Burhinus senegalensis* Senegal Thick-knee	12.59	15.38	2.48	9.92	12.2	29.1	4.17	*	*	4.17	*	3.77	12.5
41	*Glareola pratincola* Collared Pratincole	0.7	*	*	*	*	*	*	*	*	*	*	*	12.5
42	*Charadrius forbesi* Forbes's Plover	1.4	*	*	1.65	*	*	*	*	*	*	*	7.55	*
43	*Vanellus albiceps* White-headed Lapwing	6.99	7.69	8.26	10.74	28.05	11.94	3.13	*	*	*	*	*	*
44	*V. spinosus* Spur-winged Lapwing	25.17	40.38	9.09	33.88	14.63	88.06	1.04	*	6.82	8.33	5.88	11.32	75
45	*Gallinago gallinago* Common Snipe	4.2	*	*	3.31	*	6.72	*	*	*	*	*	*	*
46	*G. media* Great Snipe	*	*	*	0.83	*	0.75	*	*	*	*	*	*	*
47	*Tringa nebularia* Common Greenshank	0.7	*	*	*	*	0.75	*	*	*	*	*	*	*
48	*T. glareola* Wood Sandpiper	6.29	1.92	0.83	4.13	2.44	8.96	1.04	*	*	*	*	*	25
49	*T. hypoleucos* Common Sandpiper	13.29	1.92	3.31	25.62	13.41	31.34	*	*	2.27	*	*	*	25
50	*Treron calvus* African Green Pigeon	*	1.28	0.83	1.65	1.22	*	2.08	2.86	2.27	*	*	*	*
51	*Tutur tympanistria* Tamborine Dove	3.5	1.28	1.65	4.96	4.88	0.75	5.21	9.52	2.27	*	*	*	*
52	*T. afer* Blue-spotted Wood Dove	14.69	27.56	19.83	20.66	17.07	3.73	43.75	51.43	13.64	4.17	11.76	24.53	25

53	*Columba guinea* Speckled Pigeon	0.7	4.49	*	*	*	1.49	4.17	2.86	*	4.17	*	*	*
54	*Streptopelia semitorquata* Red-eyed Dove	39.16	63.46	49.59	48.76	30.49	35.07	79.17	102.86	56.82	25	47.06	52.83	37.5
55	*S. senegalensis* Laughing Dove	*	0.64	0.83	*	*	*	*	*	2.27	*	2.94	*	*
56	*Tauraco persa* Green Tauraco	5.59	10.26	9.92	2.48	*	*	10.42	63.81	*	*	*	*	*
57	*Crinifer piscator* Western Grey Plantain-eater	8.39	5.77	5.79	9.92	9.76	1.49	14.58	2.86	9.09	4.17	2.94	13.21	*
58	*Oxylophus jacobinus* Jacobin Cuckoo	0.7	*	*	*	*	*	1.04	*	*	*	*	*	*
59	*O. levaillantii* Levaillant’s Cuckoo	*	1.92	1.65	*	2.44	*	2.08	2.86	*	*	*	*	*
60	*Clamator glandarius* Great Spotted Cuckoo	*	1.28	*	*	*	*	1.04	*	*	*	*	1.89	*
61	*C. clamosus* Black Cuckoo	0.7	1.28	2.48	*	3.66	*	*	2.86	*	*	*	3.77	*
62	*Chrysococcyx klaas* Klaas’s Cuckoo	1.4	5.77	2.48	*	2.44	*	6.25	1.9	4.55	*	2.94	1.89	*
63	*C. caprius* Didric Cuckoo	0.7	7.05	9.09	1.65	6.1	3.73	5.21	2.86	11.36	*	2.94	3.77	*
64	*Ceuthmochares aereus* Yellow bill	11.89	13.46	17.36	9.09	8.54	0.75	23.96	83.81	2.27	*	*	*	*
65	*Centropus grillii* Black Coucal	2.1	1.92	*	0.83	1.22	1.49	*	0.95	*	*	*	1.89	12.5
66	*C. senegalensis* Senegal Coucal	24.48	54.49	36.36	29.75	28.05	14.93	53.13	73.33	38.64	37.5	47.06	47.17	62.5
67	*C. monachus* Blue-headed Coucal	0.7	1.28	0.83	0.83	*	0.75	1.04	2.86	*	*	2.94	*	*
68	*Telacanthura ussheri* Mottled Spinetail	2.1	1.92	5.79	2.48	4.88	1.49	1.04	1.9	6.82	*	*	3.77	*
69	*Halcyon leucocephala* Grey-headed Kingfisher	*	*	*	1.65	*	1.49	*	*	*	*	*	*	*
70	*H. malimbica* Blue-breasted Kingfisher	0.7	1.92	2.48	0.83	1.22	*	2.08	11.43	*	*	*	1.89	*
71	*H. senegalensis* Woodland Kingfisher	16.08	22.44	19.83	14.88	30.49	5.97	34.38	37.14	18.18	12.5	*	11.32	*
72	*Ceyx lecontei* African Dwarf Kingfisher	0.7	*	*	*	1.22	*	*	*	*	*	*	*	*
73	*Alcedo cristata* Malachite kingfisher	4.9	2.56	1.65	8.26	15.85	7.46	*	*	*	*	*	*	*
74	*Megaceryle maxima* Giant Kingfisher	*	*	*	0.83	*	0.75	*	*	*	*	*	*	*
75	*Ceryle rudis* Pied Kingfisher	*	3.21	*	*	1.22	2.99	*	*	*	*	*	*	*
76	*Merops albicollis* White-throated Bee-eater	7.69	1.92	*	6.61	10.98	*	7.29	8.57	2.27	*	*	*	*
77	*M. malimbicus* Rosy Bee-eater	4.2	*	*	*	3.66	*	3.13	*	*	*	*	*	*
78	*Eurystomus glaucurus* Broad-billed Roller	4.9	5.77	1.65	0.83	*	*	9.38	16.19	2.27	*	*	1.89	12.5
79	*Phoeniculus purpureus* Green Wood-hoopoe	*	*	*	0.83	*	0.75	*	*	*	*	*	*	*
80	*Tropicranus albocristatus* White-crested Hornbill	*	*	0.83	*	*	*	*	0.95	*	*	*	*	*

81	*Tockus fasciatus* African Pied Hornbill	22.38	27.56	28.1	28.93	28.05	5.97	46.88	111.43	20.45	8.33	*	5.66	12.5
82	*T. nasutus* African Grey Hornbill	11.89	8.33	*	9.09	12.2	7.46	10.42	16.19	*	4.17	*	3.77	*
83	*Pogoniulus scolopaceus* Speckled Tinkerbird	*	1.92	0.83	0.83	*	*	3.13	1.9	*	*	*	*	*
84	*P. atroflavus* Red-rumped Tinkerbird	0.7	*	*	3.31	1.22	*	2.08	3.81	*	*	*	*	*
85	*P. subsulphureus* Yellow-throated Tinkerbird	*	0.64	*	*	*	*	1.04	*	*	*	*	*	*
86	*P. bilineatus* Yellow-rumped Tinkerbird	2.8	1.28	2.48	*	*	*	5.21	3.81	4.55	*	*	*	*
87	*Tricholaema hirsuta* Hairy-breasted Barbet	*	1.28	*	*	1.22	*	1.04	*	*	*	*	*	*
88	*Lybius vieilloti* Vieillot's Barbet	*	0.64	*	*	*	0.75	*	*	*	*	*	*	*
89	*Trachyphonus purpuratus* Yellow-billed Barbet	0.7	1.28	*	*	*	*	1.04	3.81	*	*	*	*	*
90	*Campethera nivosa* Buff-spotted Woodpecker	0.7	0.64	1.65	0.83	1.22	*	2.08	5.71	*	*	*	*	*
91	*Dendropicoss pyrrhogaster* Fire-bellied Woodpecker	1.4	*	3.31	0.83	1.22	*	2.08	9.52	*	*	*	*	*
92	*Smithornis rufolateralis* Rufous-sided Broadbill	*	0.64	0.83	*	1.22	*	*	2.86	*	*	*	*	*
93	*Hirundo semirufa* Rufous-chested Swallow	*	3.21	*	*	*	0.75	*	*	4.55	*	*	*	12.5
94	*H. abyssinica* Lesser Striped Swallow	0.7	1.92	3.31	0.83	3.66	2.24	*	*	4.55	*	*	1.89	*
95	*H. fuligula* Rock Martin	*	0.64	*	*	*	*	*	*	*	*	*	*	12.5
96	*H. aethiopica* Ethiopian Swallow	0.7	6.41	2.48	*	1.22	1.49	*	*	2.27	*	8.82	5.66	25
97	*H. rustica* Barn Swallow	2.1	0.64	*	3.31	2.44	2.24	*	*	4.55	*	*	1.89	*
98	*Motacilla flava* Yellow Wagtail	11.19	*	*	6.61	2.44	10.45	*	*	*	12.5	*	7.55	*
99	*M. aguimp* African Pied Wagtail	*	1.92	*	0.83	*	2.99	*	*	*	*	*	*	*
100	*Anthus leucophrys* Plain-backed Pipit	7.69	8.97	3.31	12.4	1.22	13.43	*	*	4.55	25	*	32.08	*
101	*Macronyx croceus* Yellow-throated Longclaw	6.29	7.05	7.44	6.61	*	7.46	*	*	9.09	25	8.82	20.75	25
102	*Campephaga phoenicea* Red-shouldered Cuckoo-	0.7	*	*	*	*	*	*	0.95	*	*	*	*	*
103	*Andropadus virens* Little Greenbul	40.56	34.62	19.01	17.36	29.27	0.75	64.58	126.67	20.45	*	*	5.66	*
104	*A. gracilirostris* Slender-billed Greenbul	1.4	3.85	4.96	0.83	1.22	*	6.25	17.14	*	*	*	*	*
105	*A. latirostris* Yellow-whiskered Greenbul	4.2	4.49	10.74	8.26	3.66	*	9.38	64.76	*	*	*	*	*
106	*Baeopogon indicator* Honeyguide Greenbul	0.7	0.64	0.83	0.83	*	*	3.13	2.86	*	*	*	*	*
107	*Chlorocichla simplex* Simple Leaflove	9.09	5.13	5.79	4.96	4.88	0.75	17.71	1.9	9.09	*	8.82	3.77	*
108	C. flavicollis Yellow-throated Leaflove	*	*	0.83	*	*	0.75	*	*	*	*	*	*	*

109	*Thescelocichla leucopleura* Swamp-palm Bulbul	0.7	2.56	0.83	2.48	1.22	*	5.21	3.81	2.27	*	*	*	*
110	*Pyrrhurus scandens* Leaflove	5.59	10.26	8.26	9.09	15.85	2.99	15.63	22.86	*	*	*	1.89	*
111	*Phyllastrephus baumanni* Baumann's Greenbul	*	*	*	0.83	*	*	*	2.86	*	*	*	*	*
112	*P. albigularis* White-throated Greenbul	*	*	1.65	*	*	*	*	5.71	*	*	*	*	*
113	*Bleda canicapillus* Grey-headed Bristlebill	2.1	1.28	1.65	4.96	1.22	*	2.08	28.57	*	*	*	*	*
114	*Pycnonotus barbatus* Common Bulbul	30.07	28.85	24.79	25.62	39.02	13.43	39.58	20.95	29.55	29.17	26.47	28.3	12.5
115	*Nicator chloris* Western Nicator	0.7	3.21	1.65	0.83	*	*	3.13	13.33	*	*	*	*	*
116	*Stiphrornis erythrothorax* Forest Robin	1.4	0.64	*	0.83	1.22	*	*	5.71	2.27	*	*	*	*
117	*Cossypha cyanocampter* Blue-shouldered Robin Chat	0.7	*	*	*	*	*	*	2.86	*	*	*	*	*
118	*C. niveicapilla* Snowy-crowned Robin Chat	3.5	6.41	3.31	4.13	1.22	1.49	3.13	5.71	13.64	4.17	2.94	15.09	*
119	*Saxicola rubetra* Whinchat	29.37	3.85	*	19.01	*	17.91	1.04	*	27.27	25	20.59	33.96	25
120	*Turdus pelios* African Thrush	9.79	16.67	13.22	8.26	3.66	5.97	11.46	3.81	27.27	20.83	23.53	30.19	*
121	*Melocichla mentalis* African Moustached Warbler	1.4	1.92	0.83	0.83	*	0.75	*	*	9.09	*	2.94	1.89	*
122	*Acrocephalus arundinaceus* Great Reed Warbler	4.9	*	3.31	1.65	*	4.48	*	*	6.82	4.17	2.94	3.77	*
123	*Cisticola erythrops* Red-faced Cisticola	9.79	22.44	11.57	10.74	1.22	5.97	*	*	36.36	25	32.35	52.83	62.5
124	*C. brachypterus* Short-winged Cisticola	0.7	6.41	7.44	2.48	*	5.22	*	*	4.55	8.33	17.65	11.32	*
125	*Prinia subflava* Tawny-flanked Prinia	0.7	*	0.83	0.83	1.22	*	*	*	*	*	*	1.89	12.5
126	*Camaroptera brachyura* Grey-backed Camaroptera	19.58	32.05	13.22	4.96	15.85	2.99	35.42	22.86	25	12.5	26.47	16.98	12.5
127	*C. superciliaris* Yellow-browed Camaroptera	4.2	6.41	9.92	14.05	6.1	*	19.79	52.38	*	*	*	*	*
128	*C. chloronota* Olive-green Camaroptera	0.7	*	2.48	3.31	1.22	*	1.04	10.48	*	*	*	1.89	*
129	*Eremomela pusilla* Senegal Eremomela	*	0.64	*	*	*	*	*	2.86	*	*	*	*	*
130	*Sylvietta virens* Green Crombec	5.59	12.18	15.7	14.05	12.2	*	30.21	40	4.55	*	2.94	1.89	*
131	*S. denti* Lemon-bellied Crombec	*	0.64	*	*	*	*	*	2.86	*	*	*	*	*
132	*Phylloscopus sibilatrix* Wood Warbler	4.2	*	*	2.48	2.44	1.49	3.13	2.86	2.27	*	*	*	*
133	*Hypergerus atriceps* Oriole Warbler	2.1	1.28	1.65	*	1.22	*	*	2.86	2.27	*	2.94	5.66	*
134	*Sylvia borin* Garden Warbler	0.7	*	*	*	*	*	*	*	*	*	*	1.89	*
135	*Hylia prasina* Green Hylia	4.9	7.69	5.79	5.79	4.88	*	11.46	38.1	*	*	*	*	*
136	*Muscicapa olivascens* Olivaceous Flycatcher	0.7	*	*	*	*	*	*	*	2.27	*	*	*	*

137	*Trochocercus nitens* Blue-headed Crested Flycatcher	1.4	1.92	1.65	1.65	*	*	*	25.71	*	*	*	*	*
138	*T. rufiventer* Red-bellied Paradise Flycatcher	16.08	20.51	19.01	13.22	17.07	0.75	23.96	116.19	6.82	4.17	*	3.77	*
139	*Dyaphorophyia castanea* Chestnut Wattle-eye	*	1.28	0.83	0.83	*	*	*	11.43	*	*	*	*	*
140	*D. blissetti* Red-cheeked Wattle-eye	2.8	0.64	0.83	0.83	*	*	1.04	7.62	*	*	*	*	*
141	*Platysteira cyanea* Common Wattle-eye	0.7	*	*	*	*	0.75	*	*	*	*	*	*	*
142	*Illadopsis fulvescens* Brown Illadopsis	*	*	0.83	0.83	*	*	1.04	2.86	*	*	*	*	*
143	*Phyllanthus atripennis* Capuchin Babbler	2.1	0.64	3.31	2.48	2.44	*	*	21.9	*	*	*	*	*
144	*Cyanomitra verticalis* Green-headed Sunbird	*	3.85	*	*	*	*	1.04	1.9	4.55	*	*	*	*
145	*C. obscura* Western Olive Sunbird	4.9	7.69	4.96	4.96	3.66	*	8.33	22.86	4.55	4.17	5.88	5.66	*
146	*Chalcomitra adelberti* Buff-throated Sunbird	*	0.64	*	*	*	*	*	*	*	4.17	*	*	*
147	*C. senegalensis* Scarlet-chested Sunbird	4.2	1.92	*	*	2.44	*	2.08	12.38	*	*	*	*	*
148	*Hedydipna collaris* Collared Sunbird	27.97	28.85	23.97	27.27	28.05	0.75	63.54	77.14	15.91	12.5	8.82	18.87	*
149	*Cinnyris chloropygius* Olive-bellied Sunbird	0.7	4.49	4.96	7.44	6.1	*	13.54	7.62	2.27	*	*	*	*
150	*C. minullus* Tiny Sunbird	1.4	2.56	0.83	2.48	3.66	0.75	6.25	*	*	*	*	*	*
151	*C. venustus* Variable Sunbird	0.7	*	*	*	*	*	*	*	2.27	*	*	*	*
152	*C. coccinigastrus* Splendid Sunbird	4.9	7.69	6.61	5.79	6.1	*	8.33	4.76	22.73	8.33	*	11.32	*
153	*C. cupreus* Copper Sunbird	2.8	5.77	10.74	4.96	*	0.75	1.04	2.86	11.36	8.33	23.53	26.42	*
154	*Corvinella corvina* Yellow-billed Shrike	0.7	2.56	7.44	1.65	*	1.49	*	*	6.82	12.5	5.88	11.32	*
155	*Malaconotus multicolor* Many-coloured Bush-Shrike	*	1.28	0.83	*	*	*	2.08	0.95	*	*	*	*	*
156	*Dryoscopus gambensis* Northern Puffback	0.7	*	*	*	*	*	*	2.86	*	*	*	*	*
157	*Laniarus aethiopicus* Tropical Boubou	4.9	2.56	1.65	1.65	2.44	1.49	3.13	17.14	*	*	*	3.77	*
158	*Prionops caniceps* Red-billed Helmet-shrike	0.7	0.64	0.83	*	*	*	1.04	0.95	*	*	2.94	*	*
159	*Oriolus nigripennis* Black-winged Oriole	0.7	0.64	0.83	1.65	2.44	*	2.08	0.95	*	*	*	*	*
160	*O. brachyrhynchus* Western Black-headed Oriole	2.8	5.13	5.79	3.31	2.44	*	11.46	17.14	*	*	*	*	*
161	*Dicrurus ludwigii* Square-tailed Drongo	*	2.56	*	0.83	2.44	*	2.08	0.95	*	*	*	*	*
162	*D. atripennis* Shining Drongo	2.1	1.92	0.83	4.13	2.44	*	4.17	9.52	*	*	*	*	*
163	*D. modestus* Velvet-mantled Drongo	2.1	5.77	9.09	2.48	6.1	*	9.38	20	2.27	4.17	*	1.89	*
164	*D. adsimilis* Fork-tailed Drongo	9.09	5.77	6.61	6.61	10.98	0.75	10.42	27.62	2.27	*	*	3.77	*

165	*Corvus albus* Pied Crow	16.08	26.92	19.01	19.83	21.95	22.39	10.42	15.24	11.36	33.33	20.59	43.4	*
166	*Poeoptera lugubris* Narrow-tailed Starling	*	1.92	0.83	*	*	*	*	6.67	*	*	2.94	*	*
167	*Lamprotornis purpureus* Purple Glossy Starling	2.1	*	5.79	1.65	3.66	1.49	4.17	3.81	2.27	*	*	*	*
168	*Passer griseus* Northern Grey-headed Sparrow	*	0.64	*	*	*	*	*	*	*	*	*	1.89	*
169	*Ploceus nigricollis* Black-necked Weaver	1.4	3.85	3.31	*	*	*	3.13	*	9.09	*	2.94	7.55	*
170	*P. nigerrimus* Vieillot's Black Weaver	2.8	1.28	*	*	2.44	*	*	*	4.55	*	*	1.89	*
171	*P. cucullatus* Village Weaver	23.78	25.64	8.26	11.57	8.54	24.63	14.58	0.95	18.18	16.67	8.82	39.62	75
172	*P. tricolor* Yellow-mantled Weaver	4.9	7.69	6.61	0.83	4.88	*	4.17	16.19	9.09	*	2.94	3.77	*
173	*Malimbus nitens* Blue-billed Malimbe	6.99	12.18	19.83	14.05	18.29	*	41.67	16.19	4.55	*	*	3.77	*
174	*M. scutatus* Red-vented Malimbe	5.59	3.85	0.83	2.48	3.66	*	7.29	9.52	9.09	*	*	*	*
175	*M. rubricollis* Red-headed Malimbe	8.39	10.26	9.09	8.26	12.2	0.75	17.71	29.52	9.09	*	*	3.77	*
176	*Quelea erythrops* Red-headed Quelea	*	8.33	3.31	2.48	*	3.73	*	*	6.82	4.17	8.82	13.21	12.5
177	*Euplectes franciscanus* Northern Red Bishop	*	*	*	0.83	*	*	*	*	*	*	2.94	*	*
178	*E. macroura* Yellow-mantled Widowbird	*	*	1.65	*	*	*	*	*	*	*	5.88	*	*
179	*Nigrita canicapillus* Grey-crowned Negrofinch	*	1.28	1.65	0.83	1.22	*	3.13	*	*	*	*	1.89	*
180	*N. luteifrons* Pale-fronted Negrofinch	*	2.56	*	*	*	*	3.13	0.95	*	*	*	*	*
181	*N. bicolor* Chestnut-breasted Negrofinch	2.1	2.56	*	*	3.66	*	1.04	3.81	2.27	*	*	*	*
182	*Spermophaga haematina* Western Bluebill	*	*	*	4.96	*	*	3.13	5.71	2.27	*	*	*	*
183	*Estrilda melpoda* Orange-cheeked Waxbill	15.38	19.23	20.66	19.83	7.32	18.66	14.58	1.9	25	16.67	41.18	35.85	50
184	*Spermestes cucullatus* Bronze Mannikin	13.99	9.62	10.74	18.18	4.88	11.94	3.13	*	34.09	16.67	23.53	28.3	50
185	*Spermestes bicolor* Black-and-White Mannikin	9.79	2.56	3.31	0.83	1.22	4.48	8.33	1.9	2.27	*	5.88	3.77	*
186	*Vidua macroura* Pin-tailed Whydah	0.7	3.21	4.13	9.92	*	5.22	1.04	*	9.09	20.83	5.88	5.66	12.5

Note: * represents absence of species along those sections

Appendix 2: Composition of bird species observed within IITA environs

No	Species	Family	Order
1	*Phalacrocorax africanus* Long-tailed Cormorant	Phalacrocoracidae	Pelecaniformes
2	*Ixobrychus minutus* Little Bittern	Ardeidae	Ciconiformes
3	*Nycticorax nycticorax* Black-crowned Night Heron	Ardeidae	Ciconiformes
4	*Ardeola ralloides* Squacco Heron	Ardeidae	Ciconiformes
5	*Bubulcus ibis* Cattle Egret	Ardeidae	Ciconiformes
6	*Butorides striata* Green-backed Heron	Ardeidae	Ciconiformes
7	*Egretta garzetta* Little Egret	Ardeidae	Ciconiformes
8	*E. intermedia* Intermediate Egret	Ardeidae	Ciconiformes
9	*Ardea purpurea* Purple Heron	Ardeidae	Ciconiformes
10	*A. cinerea* Grey Heron	Ardeidae	Ciconiformes
11	*A. melanocephala* Black-headed Heron	Ardeidae	Ciconiformes
12	*Ciconia abdimii* Abdim's Stork	Ciconiidae	Ciconiformes
13	*Bostrychia hagedash* Hadada Ibis	Threskiornithidae	Ciconiformes
14	*Dendrocygna viduata* White-faced Whistling Duck	Anatidae	Anseriformes
15	*Pandion haliaetus* Osprey	Pandionidae	Falconiformes
16	*Elanus caeruleus* Black-shouldered Kite	Accipitridae	Falconiformes
17	*Milvus migrans* Yellow-billed Kite	Accipitridae	Falconiformes
18	*Gypohierax angolensis* Palm-nut Vulture	Accipitridae	Falconiformes
19	*Polyboroides typus* African Harrier Hawk	Accipitridae	Falconiformes
20	*Circus aeruginosus* Eurasian Marsh Harrier	Accipitridae	Falconiformes
21	*Micronisus gabar* Gabar Goshawk	Accipitridae	Falconiformes
22	*Accipiter tachiro* African Goshawk	Accipitridae	Falconiformes
23	*A. badius* Shikra	Accipitridae	Falconiformes
24	*Kaupifalco monogrammicus* Lizard Buzzard	Accipitridae	Falconiformes
25	*Buteo auguralis* Red-necked Buzzard	Accipitridae	Falconiformes
26	*Lophaetus occipitalis* Long-crested Eagle	Accipitridae	Falconiformes
27	*Falco tinnunculus* Common Kestrel	Falconidae	Falconiformes
28	*F. ardosiaceus* Grey Kestrel	Falconidae	Falconiformes
29	*F. biarmicus* Lanner Falcon	Falconidae	Falconiformes
30	*F. ahantensis* Ahanta Francolin	Phasianidae	Galliformes
31	*F. bicalcaratus* Double-spurred Francolin	Phasianidae	Galliformes
32	*Numida meleagris* Helmeted Guineafowl	Numididae	Galliformes
33	*Crex egregia* African Crake	Rallidae	Gruiformes
34	*Amaurornis flavirostra* Black Crake	Rallidae	Gruiformes
35	*Porphyrio alleni* Allen's Gallinule	Rallidae	Gruiformes
36	*Gallinula chloropus* Common Moorhen	Rallidae	Gruiformes
37	*Actophilornis africanus* African Jacana	Jacanidae	Charadriformes
38	*Rostratula benghalensis* Greater Painted-snipe	Rostratulidae	Charadriformes
39	*Himantopus himantopus* Black-winged Stilt	Recurvirostridae	Charadriformes
40	*Burhinus senegalensis* Senegal Thick-knee	Burhinidae	Charadriformes
41	*Glareola pratincola* Collared Pratincole	Glareolidae	Charadriformes
42	*Charadrius forbesi* Forbes's Plover	Charadriidae	Charadriformes
43	*Vanellus albiceps* White-headed Lapwing	Charadriidae	Charadriformes

44	*V. spinosus* Spur-winged Lapwing	Charadriidae	Charadriformes
45	*Gallinago gallinago* Common Snipe	Scolopacidae	Charadriformes
46	*G. media* Great Snipe	Scolopacidae	Charadriformes
47	*Tringa nebularia* Common Greenshank	Scolopacidae	Charadriformes
48	*T. glareola* Wood Sandpiper	Scolopacidae	Charadriformes
49	*T. hypoleucos* Common Sandpiper	Scolopacidae	Charadriformes
50	*Treron calvus* African Green Pigeon	Columbidae	Columbiformes
51	*Tutur tympanistria* Tamborine Dove	Columbidae	Columbiformes
52	*T. afer* Blue-spotted Wood Dove	Columbidae	Columbiformes
53	*Columba guinea* Speckled Pigeon	Columbidae	Columbiformes
54	*Streptopelia semitorquata* Red-eyed Dove	Columbidae	Columbiformes
55	*S. senegalensis* Laughing Dove	Columbidae	Columbiformes
56	*Tauraco persa* Green Tauraco	Musophagidae	Cuculiformes
57	*Crinifer piscator* Western Grey Plantain-eater	Musophagidae	Cuculiformes
58	*Oxylophus jacobinus* Jacobin Cuckoo	Cuculidae	Cuculiformes
59	*O. levaillantii* Levaillant's Cuckoo	Cuculidae	Cuculiformes
60	*Clamator glandarius* Great Spotted Cuckoo	Cuculidae	Cuculiformes
61	*Cuculus clamosus* Black Cuckoo	Cuculidae	Cuculiformes
62	*C. klaas* Klaas's Cuckoo	Cuculidae	Cuculiformes
63	*C. caprius* Didric Cuckoo	Cuculidae	Cuculiformes
64	*Ceuthmochares aereus* Yellow bill	Cuculidae	Cuculiformes
65	*Centopus grillii* Black Coucal	Cuculidae	Cuculiformes
66	*C. senegalensis* Senegal Coucal	Cuculidae	Cuculiformes
67	*C. monachus* Blue-headed Coucal	Cuculidae	Cuculiformes
68	*Telacanthura ussheri* Mottled Spinetail	Apodidae	Apodiformes
69	*Halcyon leucocephala* Grey-headed Kingfisher	Alcedinidae	Coraciformes
70	*H. malimbica* Blue-breasted Kingfisher	Alcedinidae	Coraciformes
71	*H. senegalensis* Woodland Kingfisher	Alcedinidae	Coraciformes
72	*Ceyx lecontei* African Dwarf Kingfisher	Alcedinidae	Coraciformes
73	*Alcedo cristata* Malachite kingfisher	Alcedinidae	Coraciformes
74	*Megaceryle maxima* Giant Kingfisher	Alcedinidae	Coraciformes
75	*Ceryle rudis* Pied Kingfisher	Alcedinidae	Coraciformes
76	*Malimbicus albicollis* White-throated Bee-eater	Meropidae	Passeriformes
77	*M. malimbicus* Rosy Bee-eater	Meropidae	Passeriformes
78	*Eurystomus glaucurus* Broad-billed Roller	Coraciidae	Coraciformes
79	*Phoeniculus purpureus* Green Wood-hoopoe	Phoeniculidae	Upupiformes
80	*Tropicranus albocristatus* White-crested Hornbill	Bucerotidae	Coraciformes
81	*Tockus fasciatus* African Pied Hornbill	Bucerotidae	Coraciformes
82	*T. nasutus* African Grey Hornbill	Bucerotidae	Coraciformes
83	*Pogoniulus scolopaceus* Speckled Tinkerbird	Capitonidae	Passeriformes
84	*P. atroflavus* Red-rumped Tinkerbird	Capitonidae	Passeriformes
85	*P. subsulphureus* Yellow-throated Tinkerbird	Capitonidae	Passeriformes
86	*P. bilineatus* Yellow-rumped Tinkerbird	Capitonidae	Passeriformes
87	*Tricholaema hirsuta* Hairy-breasted Barbet	Capitonidae	Passeriformes
88	*Lybius vieilloti* Vieillot's Barbet	Capitonidae	Passeriformes
89	*Trachyphonus purpuratus* Yellow-billed Barbet	Capitonidae	Passeriformes

90	*Campethera nivosa* Buff-spotted Woodpecker	Picidae	Piciformes
91	*Dendropicos pyrrhogaster* Fire-bellied Woodpecker	Picidae	Piciformes
92	*Smithornis rufolateralis* Rufous-sided Broadbill	Eurylamidae	Passeriformes
93	*Hirundo semirufa* Rufous-chested Swallow	Hirundinidae	Passeriformes
94	*H. abyssinica* Lesser Striped Swallow	Hirundinidae	Passeriformes
95	*H. fuligula* Rock Martin	Hirundinidae	Passeriformes
96	*H. aethiopica* Ethiopian Swallow	Hirundinidae	Passeriformes
97	*H. rustica* Barn Swallow	Hirundinidae	Passeriformes
98	*Motacilla flava* Yellow Wagtail	Motacillidae	Passeriformes
99	*M. aguimp* African Pied Wagtail	Motacillidae	Passeriformes
100	*Anthus leucophrys* Plain-backed Pipit	Motacillidae	Passeriformes
101	*Macronyx croceus* Yellow-throated Longclaw	Motacillidae	Passeriformes
102	*Campephaga phoenicea* Red-shouldered Cuckoo-shrike	Campephagidae	Passeriformes
103	*Andropadus virens* Little Greenbul	Pycnonotidae	Passeriformes
104	*A. gracilirostris* Slender-billed Greenbul	Pycnonotidae	Passeriformes
105	*A. latirostris* Yellow-whiskered Greenbul	Pycnonotidae	Passeriformes
106	*Baeopogon indicator* Honeyguide Greenbul	Pycnonotidae	Passeriformes
107	*Chlorocichla simplex* Simple Leaflove	Pycnonotidae	Passeriformes
108	*C. flavicollis* Yellow-throated Leaflove	Pycnonotidae	Passeriformes
109	*Thescelocichla leucopleura* Swamp-palm Bulbul	Pycnonotidae	Passeriformes
110	*Pyrrhurus scandens* Leaflove	Pycnonotidae	Passeriformes
111	*Phyllastrephus baumanni* Baumann's Greenbul	Pycnonotidae	Passeriformes
112	*P. albigularis* White-throated Greenbul	Pycnonotidae	Passeriformes
113	*Bleda canicapillus* Grey-headed Bristlebill	Pycnonotidae	Passeriformes
114	*Pycnonotus barbatus* Common Bulbul	Pycnonotidae	Passeriformes
115	*Nicator chloris* Western Nicator	Pycnonotidae	Passeriformes
116	*Stiphrornis erythrothorax* Forest Robin	Turdidae	Passeriformes
117	*Cossypha cyanocampter* Blue-shouldered Robin Chat	Turdidae	Passeriformes
118	*C. niveicapilla* Snowy-crowned Robin Chat	Turdidae	Passeriformes
119	*Neocossyphus poensis* White-tailed Ant Thrush	Turdidae	Passeriformes
120	*Saxicola rubetra* Whinchat	Turdidae	Passeriformes
121	*Turdus pelios* African Thrush	Turdidae	Passeriformes
122	*Melocichla mentalis* African Moustached Warbler	Sylviidae	Passeriformes
123	*Acrocephalus arundinaceus* Great Reed Warbler	Sylviidae	Passeriformes
124	*Cisticola erythrops* Red-faced Cisticola	Sylviidae	Passeriformes
125	*C. brachypterus* Short-winged Cisticola	Sylviidae	Passeriformes
126	*Prinia subflava* Tawny-flanked Prinia	Sylviidae	Passeriformes
127	*Camaroptera brachyura* Grey-backed Camaroptera	Sylviidae	Passeriformes
128	*C. superciliaris* Yellow-browed Camaroptera	Sylviidae	Passeriformes
129	*C. chloronota* Olive-green Camaroptera	Sylviidae	Passeriformes
130	*Eremomela pusilla* Senegal Eremomela	Sylviidae	Passeriformes
131	*Sylvietta virens* Green Crombec	Sylviidae	Passeriformes
132	*S. denti* Lemon-bellied Crombec	Sylviidae	Passeriformes
133	*Phylloscopus sibilatrix* Wood Warbler	Sylviidae	Passeriformes
134	*Hypergerus atriceps* Oriole Warbler	Sylviidae	Passeriformes
135	*Sylvia borin* Garden Warbler	Sylviidae	Passeriformes

136	*Hylia prasina* Green Hylia	Sylviidae	Passeriformes
137	*Muscicapa olivascens* Olivaceous Flycatcher	Muscicapidae	Passeriformes
138	*Trochocercus nitens* Blue-headed Crested Flycatcher	Monarchidae	Passeriformes
139	*T. rufiventer* Red-bellied Paradise Flycatcher	Monarchidae	Passeriformes
140	*Dyaphorophyia castanea* Chestnut Wattle-eye	Platysteiridae	Passeriformes
141	*D. blissetti* Red-cheeked Wattle-eye	Platysteiridae	Passeriformes
142	*Platysteira cyanea* Common Wattle-eye	Platysteiridae	Passeriformes
143	*Illadopsis fulvescens* Brown Illadopsis	Timaliidae	Passeriformes
144	*Phyllanthus atripennis* Capuchin Babbler	Timaliidae	Passeriformes
145	*Cyanomitra verticalis* Green-headed Sunbird	Nectariniidae	Passeriformes
146	*C. obscura* Western Olive Sunbird	Nectariniidae	Passeriformes
147	*Chalcomitra adelberti* Buff-throated Sunbird	Nectariniidae	Passeriformes
148	*C. senegalensis* Scarlet-chested Sunbird	Nectariniidae	Passeriformes
149	*Hedydipna collaris* Collared Sunbird	Nectariniidae	Passeriformes
150	*Cinnyris chloropygius* Olive-bellied Sunbird	Nectariniidae	Passeriformes
151	*C. minullus* Tiny Sunbird	Nectariniidae	Passeriformes
152	*C. venustus* Variable Sunbird	Nectariniidae	Passeriformes
153	*C. coccinigastrus* Splendid Sunbird	Nectariniidae	Passeriformes
154	*C. cupreus* Copper Sunbird	Nectariniidae	Passeriformes
155	*Corvinella corvina* Yellow-billed Shrike	Laniidae	Passeriformes
156	*Malaconotus multicolor* Many-coloured Bush-Shrike	Malaconotidae	Passeriformes
157	*Dryoscopus gambensis* Northern Puffback	Malaconotidae	Passeriformes
158	*Laniarus aethiopicus* Tropical Boubou	Malaconotidae	Passeriformes
159	*Prionops caniceps* Red-billed Helmet-shrike	Prionopidae	Passeriformes
160	*Oriolus nigripennis* Black-winged Oriole	Oriolidae	Passeriformes
161	*O. brachyrhynchus* Western Black-headed Oriole	Oriolidae	Passeriformes
162	*Dicrurus ludwigii* Square-tailed Drongo	Dicruridae	Passeriformes
163	*D. atripennis* Shining Drongo	Dicruridae	Passeriformes
164	*D. modestus* Velvet-mantled Drongo	Dicruridae	Passeriformes
165	*D. adsimilis* Fork-tailed drongo	Dicruridae	Passeriformes
166	*Corvus albus* Pied Crow	Corvidae	Passeriformes
167	*Poeoptera lugubris* Narrow-tailed Starling	Sturnidae	Passeriformes
168	*Lamprotornis purpureus* Purple Glossy Starling	Sturnidae	Passeriformes
169	*Passer griseus* Northern Grey-headed Sparrow	Passeridae	Passeriformes
170	*Ploceus nigricollis* Black-necked Weaver	Ploecidae	Passeriformes
171	*P. nigerrimus* Vieillot's Black Weaver	Ploecidae	Passeriformes
172	*P. cucullatus* Village Weaver	Ploecidae	Passeriformes
173	*P. tricolor* Yellow-mantled Weaver	Ploecidae	Passeriformes
174	*Malimbus nitens* Blue-billed Malimbe	Ploecidae	Passeriformes
175	*M. scutatus* Red-vented Malimbe	Ploecidae	Passeriformes
176	*M. rubricollis* Red-headed Malimbe	Ploecidae	Passeriformes
177	*Quelea erythrops* Red-headed Quelea	Ploecidae	Passeriformes
178	*Euplectes franciscanus* Northern Red Bishop	Ploecidae	Passeriformes
179	*E. macroura* Yellow-mantled Widowbird	Ploecidae	Passeriformes
180	*Nigrita canicapillus* Grey-crowned Negrofinch	Estrildidae	Passeriformes
181	*N. luteifrons* Pale-fronted Negrofinch	Estrildidae	Passeriformes

182	*N. bicolor* Chestnut-breasted Negrofinch	Estrildidae	Passeriformes
183	*Spermophaga haematina* Western Bluebill	Estrildidae	Passeriformes
184	*Estrilda melpoda* Orange-cheeked Waxbill	Estrildidae	Passeriformes
185	*Spermestes cucullatus* Bronze Mannikin	Estrildidae	Passeriformes
186	*Spermestes bicolor* Black-and-White Mannikin	Estrildidae	Passeriformes
187	*Vidua macroura* Pin-tailed Whydah	Viduidae	Passeriformes

Appendix 3. Composition of bird species trapped within IITA environ

No	Species	Family	Order	Trapped	Retrap	Percentage trapped (N=985)	Percentage retrapped
1	*Ixobrychus minutus* Little Bittern	Ardeidae	Ciconiformes	1	x	0.1	x
2	*Accipiter tachiro* African Goshawk	Accipitridae	Falconiformes	5	x	0.51	x
3	*Kaupifalco monogrammicus* Lizard Buzzard	Accipitridae	Falconiformes	1	x	0.1	x
4	*Amaurornis flavirostra* Black Crake	Rallidae	Gruiformes	3	x	0.3	x
5	*Porphyrio alleni* Allen's Gallinule	Rallidae	Gruiformes	4	1	0.41	25
6	*Gallinula chloropus* Common Moorhen	Rallidae	Gruiformes	2	x	0.2	x
7	*G. angulata* Lesser Moorhen	Rallidae	Gruiformes	1	x	0.1	x
8	*Actophilornis africanus* African Jacana	Jacanidae	Charadriformes	16	1	1.62	6.25
9	*Rostratula benghalensis* Greater Painted-snipe	Rostratulidae	Charadriformes	13	x	1.32	x
10	*Vanellus spinosus* Spur-winged Lapwing	Charadriidae	Charadriformes	4	x	0.41	x
11	*Tutur tympanistria* Tamborine Dove	Columbidae	Columbiformes	2	x	0.2	x
12	*Streptopelia semitorquata* Red-eyed Dove	Columbidae	Columbiformes	1	x	0.1	x
13	*Ceuthmochares aereus* Yellow bill	Cuculidae	Cuculiformes	1	x	0.1	x
14	*Halcyon malimbica* Blue-breasted Kingfisher	Alcedinidae	Coraciformes	2	x	0.2	x
15	*H. senegalensis* Woodland Kingfisher	Alcedinidae	Coraciformes	6	1	0.61	16.67
16	*Ceryl pictus* African Pygmy Kingfisher	Alcedinidae	Coraciformes	1	x	0.1	x
17	*Alcedo cristata* Malachite kingfisher	Alcedinidae	Coraciformes	3	x	0.3	x
18	*Pogoniulus scolopaceus* Speckled Tinkerbird	Capitonidae	Passeriformes	3	x	0.3	x
19	*Indicator maculatus* Spotted Honeyguide*	Indicatoridae	Passeriformes	2	1	0.2	50
20	*Campethera nivosa* Buff-spotted Woodpecker	Picidae	Piciformes	6	x	0.61	x
21	*Smithornis rufolateralis* Rufous-sided Broadbill	Eurylamidae	Passeriformes	1	x	0.1	x
22	*Andropadus virens* Little Greenbul	Pycnonotidae	Passeriformes	70	13	7.11	18.57
23	*A. curvirostris* Cameroon Sombre Greenbul*	Pycnonotidae	Passeriformes	18	3	1.83	16.67

24	*A. latirostris* Yellow-whiskered Greenbul	Pycnonotidae	Passeriformes	134	25	13.6	18.66
25	*Chlorocichla simplex* Simple Leaflove	Pycnonotidae	Passeriformes	1	x	0.1	x
26	*Pyrrhurus scandens* Leaflove	Pycnonotidae	Passeriformes	1	x	0.1	x
27	*Phyllastrephus baumanni* Baumann's Greenbul	Pycnonotidae	Passeriformes	10	1	1.02	10
28	*P. albigularis* White-throated Greenbul	Pycnonotidae	Passeriformes	47	21	4.77	44.68
29	*Bleda canicapillus* Grey-headed Bristlebill	Pycnonotidae	Passeriformes	135	48	13.71	35.56
30	*Pycnonotus barbatus* Common Bulbul	Pycnonotidae	Passeriformes	3	x	0.3	x
31	*Nicator chloris* Western Nicator	Pycnonotidae	Passeriformes	7	x	0.71	x
32	*Stiphrornis erythrothorax* Forest Robin	Turdidae	Passeriformes	15	5	1.52	33.33
33	*Cossypha cyanocampter* Blue-shouldered Robin Chat	Turdidae	Passeriformes	7	2	0.71	28.57
34	*Neocossyphus poensis* White-tailed Ant Thrush	Turdidae	Passeriformes	5	1	0.51	20
35	*Turdus pelios* African Thrush	Turdidae	Passeriformes	5	x	0.51	x
36	*Acrocephalus arundinaceus* Great Reed Warbler	Sylviidae	Passeriformes	2	x	0.2	x
37	*Cisticola erythrops* Red-faced Cisticola	Sylviidae	Passeriformes	3	1	0.3	33.33
38	*Camaroptera brachyura* Grey-backed Camaroptera	Sylviidae	Passeriformes	8	1	0.81	12.5
39	*C. superciliaris* Yellow-browed Camaroptera	Sylviidae	Passeriformes	2	x	0.2	x
40	*C. chloronota* Olive-green Camaroptera	Sylviidae	Passeriformes	64	12	6.5	18.75
41	*Macrosphenus kempi* Kemp's Longbill*	Sylviidae	Passeriformes	5	x	0.51	x
42	*M. concolor* Grey Longbill*	Sylviidae	Passeriformes	2	x	0.2	x
43	*Sylvietta virens* Green Crombec	Sylviidae	Passeriformes	3	2	0.3	66.67
44	*Hylia prasina* Green Hylia	Sylviidae	Passeriformes	11	x	1.12	x
45	*Trochocercus nitens* Blue-headed Crested Flycatcher	Monarchidae	Passeriformes	1	x	0.1	x
46	*T. rufiventer* Red-bellied Paradise Flycatcher	Monarchidae	Passeriformes	48	7	4.87	14.58
47	*Dyaphorophyia castanea* Chestnut Wattle-eye	Platysteiridae	Passeriformes	1	x	0.1	x
48	*D. blissetti* Red-cheeked Wattle-eye	Platysteiridae	Passeriformes	22	1	2.23	4.55
49	*Platysteira cyanea* Common Wattle-eye	Platysteiridae	Passeriformes	1	x	0.1	x
50	*Illadopsis fulvescens* Brown Illadopsis	Timaliidae	Passeriformes	15	1	1.52	6.67
51	*Phyllanthus atripennis* Capuchin Babbler	Timaliidae	Passeriformes	2	x	0.2	x
52	*Cyanomitra obscura* Western Olive Sunbird	Nectariniidae	Passeriformes	80	11	8.12	13.75
53	*Hedydipna collaris* Collared Sunbird	Nectariniidae	Passeriformes	33	1	3.35	3.03

54	*Cinnyris chloropygius* Olive-bellied Sunbird	Nectariniidae	Passeriformes	1	x	0.1	x
55	*C. minullus* Tiny Sunbird	Nectariniidae	Passeriformes	5	x	0.51	x
56	*C. coccinigastrus* Splendid Sunbird	Nectariniidae	Passeriformes	4	x	0.41	x
57	*C. cupreus* Copper Sunbird	Nectariniidae	Passeriformes	2	x	0.2	x
58	*Dicrurus. atripennis* Shining Drongo	Dicruridae	Passeriformes	2	x	0.2	x
59	*D. modestus* Velvet-mantled Drongo	Dicruridae	Passeriformes	1	x	0.1	x
60	*Ploceus nigricollis* Black-necked Weaver	Ploecidae	Passeriformes	38	x	3.86	x
61	*P. cucullatus* Village Weaver	Ploecidae	Passeriformes	11	x	1.12	x
62	*Malimbus nitens* Blue-billed Malimbe	Ploecidae	Passeriformes	19	2	1.93	10.53
63	*Quelea erythrops* Red-headed Quelea	Ploecidae	Passeriformes	6	x	0.61	x
64	*Pyrenestes ostrinus* Black-bellied Seedcracker	Ploecidae	Passeriformes	1	x	0.1	x
65	*Spermophaga haematina* Western Bluebill	Estrildidae	Passeriformes	47	9	4.77	19.15
66	*Spermestes cucullatus* Bronze Mannikin	Estrildidae	Passeriformes	9	x	0.91	x

Appendix 4. Birds of IITA campus recorded in the present study, plus other recent and earlier records from IITA (sources underlined) and from the Ibadan area. Early records: Ban = Bannerman (1930–51); Wil = Willoughby (1949); S = Serle (1950); ES = Elgood & Sibley (1964); EFD= Elgood *et al.*, (1973); EE/EE = Elgood *et al.*, (1994); JB = Button (1965); DR = Robinson (1966); W = Wells (1966a, 1966b, 1967); B = Bass (1967); RP = Parker (1967, 1968, 1970); AP = Ashford & Parker (1968); P = Pettet (1968a, 1968b, 1975); A = Ashford (1968, 1969); NR = Robinson (1970); BB = Broadbent (1972); JA/JA = Ash (1990); AE = Ezealor (2001). Recent records: D = Demey *et al.*, (2003); M = Manu *et al.*, (2005); DB = D. Bengtsson (*in* Demey, 2006); TEA = Adeyanju & Adeyanju (2012); JP = J. Peacock (pers. comm.); GH = G. Huk (pers. comm.); TH = Thibault *et al.*, (2012); TAA = T.A. Adeyanju observations outside IITA. Records from P. Hall (PH) span a long period and each record is classed according to its precise date. "Gained" = species recorded in the Ibadan area since 2002 but not before; "lost" = species recorded before 2002 but not since. * = species restricted to Guinea–Congo Rainforest biome; ** = species restricted to Sudan–Guinea Savanna biome (Ezealor, 2001); † = species observed in this study within the IBA. [ ] = unconfirmed records.

	Observed this study	Netted this study	Other recent records	Early records	Gained	Lost
Podicepididae						
Tachybaptus ruficollis Little Grebe			GH (2012)	ES (sporadic), B, BB		
Phalacrocoracidae						
Phalacrocorax africanus Long-tailed Cormorant	F[1]			ES		
Anhingidae						
Anhinga rufa African Darter				ES		X
Ardeidae						
Botaurus stellaris Great Bittern				PH (2001), EE		V
Ixobrychus minutus Little Bittern	F	1		ES, BB		
I. sturmii Dwarf Bittern				PH (1998), ES		X
Gorsachius leuconotus White-backed Night Heron				ES (once)		V
Nycticorax nycticorax Black-crowned Night Heron	F[2]			BB		
Ardeola ralloides Squacco Heron	A			ES		
Bubulcus ibis Cattle Egret	A[4]			ES, B		
Butorides striata Green-backed Heron	C			ES		
Egretta ardesiaca Black Heron				PH[3]		X
E. gularis Western Reef Heron				EE		V
E. garzetta Little Egret	U			ES		
E. intermedia Intermediate Egret	C			ES, EE		
E. alba Great Egret	C			ES		
Ardea purpurea Purple Heron†	C			ES		
A. cinerea Grey Heron	C			ES		
A. melanocephala Black-headed Heron	C			ES		
Scopidae						
Scopus umbretta Hamerkop			PH, JP (2011)	ES, P		
Ciconiidae						
Mycteria ibis Yellow-billed Stork				ES, DR		V
Anastomus lamelligerus African Openbill Stork				ES		V
Ciconia abdimii Abdim's Stork	V			ES		
C. episcopus Woolly-necked Stork	R			RP		
C. ciconia White stork				PH (1998, 2000)		V
Threskiornithidae						
Plegadis falcinellus Glossy Ibis	V[5]				V	
Bostrychia hagedash Hadada Ibis	C[6]				X	
Threskiornis aethiopicus Sacred Ibis				ES		V
Anatidae						
Dendrocygna viduata White-faced Whistling Duck	A[7]			Ban, EE		
Plectropterus gambensis Spur-winged Goose	F[8]			PH, Wil		
Pteronetta hartlaubii Hartlaub's Duck*				PH (1995, a pair), AE		V
Sarkidiornis melanotos Knob-billed Goose		V		PH (1987, 1993, 1995), Wil		
Nettapus auritus African Pygmy Goose		X		PH (until 1995), ES, ASH, EE		
Anas penelope Eurasian Wigeon				Ban, EE		V
A. crecca Common Teal				PH (Jan 1994, a pair), EE		V
A. acuta Northern Pintail				PH (1989, 1998)		V

A. querquedula Garganey				PH (1993, 1994), Ban, EE		
		V				
Aythya nyroca Ferruginous Duck				P		V
Pandionidae						
Pandion haliaetus Osprey†	U			ES, BB		
Accipitridae						
Aviceda cuculoides African Cuckoo Hawk†	U		PH	ES, EE		
Pernis apivorus European Honey Buzzard†			PH (May 2010)		V	
Macheiramphus alcinus Bat Hawk†	U[9]			ES		
Elanus caeruleus Black-shouldered Kite	F			ES		
Milvus migrans Yellow-billed Kite†	A			ES, W		
Gypohierax angolensis Palm-nut Vulture†	F			ES		
Polyboroides typus African Harrier Hawk†	U			ES		
Circus macrourus Pallid Harrier				Ban		V
C. aeruginosus Eurasian Marsh Harrier†	U			BB		
Micronisus gabar Gabar Goshawk	F				X	
Accipiter tachiro African Goshawk†	C	5		ES, NR		
A. badius Shikra	F			ES, B, NR		
A. erythropus Red-thighed Sparrowhawk*†			PH	AE		
A. minullus Little Sparrowhawk				ES		X
A. melanoleucus Black Sparrowhawk				PH, ES		X
Urotriorchis macrourus Long-tailed Hawk*†			PH, D	AE		
Kaupifalco monogrammicus Lizard Buzzard†	C	1		ES		
Buteo auguralis Red-necked Buzzard†	F			ES		
Aquila rapax Tawny Eagle				EE		V
Hieraaetus spilogaster African Hawk-Eagle†	U		PH (one)		X	
Lophaetus occipitalis Long-crested Eagle†	F		PH	ES, BB		
Falconidae						
Falco tinnunculus Common Kestrel	C			ES, EE		
F. ardosiaceus Grey Kestrel†	F			ES		
F. cuvierii African Hobby†	F			ES, BB, NR		
F. biarmicus Lanner†	U[10]			ES		
Phasianidae						
Coturnix delegorguei Harlequin Quail				JB, EE		V
Ptilopachus petrosus Stone Partridge				ES (rare, Ojo Hills)		X
Francolinus lathami Latham's Francolin*				ES (once)		V
F. squamatus Scaly Francolin				PH[13]		V
F. ahantensis Ahanta Francolin*†	C[12]			AE, Ban		
F. bicalcaratus Double-spurred Francolin†	VA[14]			ES		
Numididae						
Guttera pucherani Crested Guineafowl				EE		V
Numida meleagris Helmeted Guineafowl	F[11]				X	
Turnicidae						
Turnix sylvatica Little Buttonquail				ES (once)		V
Rallidae						
[*Sarothrura elegans* Buff-spotted Flufftail			DB (Oct 2005)		V]	
Crex egregia African Crake	U			ES, W		
Porzana porzana Spotted Crake				PH (pair, Feb 1996)		V
Aenigmatolimnas marginalis Striped Crake				ES, W		X
Amaurornis flavirostra Black Crake	C	3		ES		
Porphyrio alleni Allen's Gallinule	C	3		ES, EE		
P. porphyrio Purple Swamphen				PH (1999, 2000)		V
Gallinula chloropus Common Moorhen	C	2		Ban		
G. angulata Lesser Moorhen	R	1		ES		
Heliornithidae						
Podica senegalensis African Finfoot			TEA	PH[15], ES, BB, W		
Otididae						
Lissotis melanogaster Black-bellied Bustard				W		V
Jacanidae						
Actophilornis africanus African Jacana	VA[16]	15		ES		
Rostratulidae						
Rostratula benghalensis Greater Painted-snipe	C[17]	13		ES, EE		
Recurvirostridae						

Himantopus himantopus Black-winged Stilt	F			ES, BB		
Burhinidae						
Burhinus senegalensis Senegal Thick-knee	C[18]			ES		
Glareolidae						
Pluvianus aegyptius Egyptian Plover	V			PH, ES, EE		
Glareola pratincola Collared Pratincole	V (one, Jan 2011)				V	
G. cinerea Grey Pratincole				PH (Sep 1994), ES, EE		V
Charadriidae						
Charadrius dubius Little Ringed Plover				PH[20], ES (frequent)		X
C. hiaticula Common Ringed Plover				PH (one, Sep 1994), ES (rare)		
		V				
C. forbesi Forbes's Plover	F			ES, EE		
Vanellus senegallus African Wattled Lapwing	V				V	
V. albiceps White-headed Lapwing	C			ES		
V. spinosus Spur-winged Lapwing	A	5		EE		
Scolopacidae						
Calidris temminckii Temminck's Stint			D		V	
C. ferruginea Curlew Sandpiper				PH (one, Sep 1994)		V
Philomachus pugnax Ruff				PH (one, Oct 1996), EE (flock,		
Oct)		V				
Lymnocryptes minimus Jack Snipe	U				X	
Gallinago gallinago Common Snipe	U	2		ES, P, BB, EE		
G. media Great Snipe	U				X	
Numenius arquata Eurasian Curlew				ES (once)		V
Tringa erythropus Spotted Redshank			PH	Ban, W		
T. totanus Common Redshank				W		V
T. stagnatilis Marsh Sandpiper				PH (two, Oct 1994)		V
T. nebularia Common Greenshank	V			W		
T. ochropus Green Sandpiper			PH	ES		
T. glareola Wood Sandpiper	F			ES		
T. hypoleucos Common Sandpiper	C[21]			ES		
Arenaria interpres Ruddy Turnstone				PH (one, Sep 1991)		V
Laridae						
Larus ridibundus Black-headed Gull			D		V	
Sternidae						
Gelochelidon nilotica Gull-billed Tern				PH (one, Oct 1994)		V
Chlidonias leucopterus White-winged Tern				PH (1988, 1989, 2000), EE		
		V				
Rhynchopidae						
Rynchops flavisrostris African Skimmer				EE (one)		V
Columbidae						
Treron calvus African Green Pigeon†	C			ES		
Turtur brehmeri Blue-headed Wood Dove*†			PH[23]	AE		
T. tympanistria Tambourine Dove†	C	2		ES		
T. afer Blue-spotted Wood Dove†	A			ES, NR		
Columba iriditorques Western Bronze-naped Pigeon*				PH[22]		X
C. guinea Speckled Pigeon	C			EE[23a]	X	
Streptopelia semitorquata Red-eyed Dove†	A[24]	1		ES		
S. vinacea Vinaceous Dove	R[25]		PH		X	
S. senegalensis Laughing Dove	C[26]			ES, NR		
Psittacidae						
Poicephalus senegalus Senegal Parrot**†	R		TAA	AE, ES, EE		
Agapornis pullarius Red-headed Lovebird				BB		X
Musophagidae						
Tauraco persa Green Tauraco*†	C		M	AE, ES		
Musophaga violacea Violet Tauraco**				AE, P		V
Crinifer piscator Western Grey Plantain-eater†	C			ES, JA		
Cuculidae						
Oxylophus jacobinus Jacobin Cuckoo†	U				X	
O. levaillantii Levaillant's Cuckoo†	U		M	ES, B		
Clamator glandarius Great Spotted Cuckoo	U			ES, B, P		
Cuculus solitarius Red-chested Cuckoo			PH (few, rains)		X	
C. clamosus Black Cuckoo†	U				X	

C. canorus Common Cuckoo				PH (one, May 1998)	V
C. gularis African Cuckoo†			PH[27]	W, BB	
Chrysococcyx cupreus African Emerald Cuckoo†	U		M	ES	
C. klaas Klaas's Cuckoo†	F			ES, NR	
C. caprius Didric Cuckoo†	F			ES, NR	
Ceuthmochares aereus Yellowbill†	C	1	M	ES	
Centropus leucogaster Black-throated Coucal*	R			AE, ES	
C. grillii Black Coucal†	U				X
C. senegalensis Senegal Coucal†	A[28]			ES, NR	
C. monachus Blue-headed Coucal†	F			ES	
Tytonidae					
Tyto alba Barn Owl	U		PH	ES	
Strigidae					
Otus scops European Scops Owl				ES, W, BB, EE	X
Ptilopsis leucotis Northern White-faced Owl†	C[41]	1		ES	
Bubo africanus Spotted Eagle Owl				ES	X
B. poensis Fraser's Eagle Owl*†	C (2011)			ES, EE	
Glaucidium perlatum Pearl-spotted Owlet			TAA	PH[29], ES	
Strix woodfordii African Wood Owl	C			ES	
Caprimulgidae					
Caprimulgus climacurus Long-tailed Nightjar	C			ES, BB	
C. nigriscapularis Black-shouldered Nightjar*			PH[30]	AE, Ban, ES	
C. inornatus Plain Nightjar			PH (dry season)	ES	
C. europaeus European Nightjar	(once, 2010)			EE	
Macrodipteryx longipennis Standard-winged Nightjar	U			ES, BB	
M. vexillarius Pennant-winged Nightjar				RP	X
Apodidae					
Telacanthura ussheri Mottled Spinetail†	C			P	
Cypsiurus parvus African Palm Swift	C			ES	
Apus pallidus Pallid Swift				P	X
A. apus Common Swift				PH (flock of 10), ES	X
A. caffer White-rumped Swift				PH[31]	X
A. affinis Little Swift	U			ES	
Alcedinidae					
Halcyon leucocephala Grey-headed Kingfisher	R			ES	
H. malimbica Blue-breasted Kingfisher†	C	2		ES, NR	
H. senegalensis Woodland Kingfisher†	A	5		ES, NR	
H. chelicuti Striped Kingfisher				ES	X
Ceyx lecontei African Dwarf Kingfisher	(once)			JA, EE	
C. pictus African Pygmy Kingfisher	R	1		ES, NR	
Alcedo cristata Malachite kingfisher	C	3		ES	
Megaceryle maxima Giant Kingfisher	R			ES	
Ceryle rudis Pied Kingfisher	F			ES	
Meropidae					
Merops pusillus Little Bee-eater				ES	V
M. albicollis White-throated Bee-eater†	C			ES, NR	
M. apiaster European Bee-eater				P, EE	V
M. malimbicus Rosy Bee-eater*†	F		PH	AE, ES, P	
M. nubicus Northern Carmine Bee-eater				ES	V
Coraciidae					
Coracias abyssinicus Abyssinian Roller				ES (once), BB	V
[*C. garrulus* European Roller				ES (rare), P, BB (possible)	
		V]			
Eurystomus gularis Blue-throated Roller*†	R			AE, ES	
E. glaucurus Broad-billed Roller†	F		M	EE	
Phoeniculidae					
Phoeniculus bollei White-headed Wood-hoopoe				ES, EE	X
P. purpureus Green Wood-hoopoe†	F			ES, NR, EE	
Rhinopomastus aterrimus Black Wood-hoopoe				W, EE	X
Bucerotidae					
Tropicranus albocristatus White-crested Hornbill*†	U		M	AE, ES, S	
Tockus camurus Red-billed Dwarf Hornbill				ES	X
T. fasciatus African Pied Hornbill*†	A			AE, ES	

T. nasutus African Grey Hornbill†	C			ES		
Bycanistes fistulator Piping Hornbill				PH[32], ES		X
Capitonidae						
Gymnobucco peli Bristle-nosed Barbet*				AE		X
G. calvus Naked-faced Barbet*†			M	PH, AE, ES		X[33]
Pogoniulus scolopaceus Speckled Tinkerbird*†	C	3		AE, EE		
P. atroflavus Red-rumped Tinkerbird*†	C			EE		
P. subsulphureus Yellow-throated Tinkerbird*†	C			AE, ES		
P. bilineatus Yellow-rumped Tinkerbird†	C				X	
P. chrysoconus Yellow-fronted Tinkerbird				EE		X
Tricholaema hirsuta Hairy-breasted Barbet*†	F		M	AE, ES, EE		
Lybius vieilloti Vieillot's Barbet†	U			ES, EE		
L. bidentatus Double-toothed Barbet			TAA, TEA	ES, EE		
Trachyphonus purpuratus Yellow-billed Barbet*†	U			AE, ES		
Indicatoridae						
Prodotiscus insignis Cassin's Honeyguide*				ES		X
Melichneutes robustus Lyre-tailed Honeyguide*				AE		X
Indicator maculatus Spotted Honeyguide*†	C	1			X	
I. indicator Greater Honeyguide				ES, EE		X
I. minor Lesser Honeyguide			TAA (2013)	PH[34], ES		
I. exilis Least Honeyguide				ES		X
Picidae						
Campethera punctuligera Fine-spotted Woodpecker				ES, EE		X
C. cailliautii Green-backed Woodpecker				PH (one, May 1998)		V
C. nivosa Buff-spotted Woodpecker*†	F	6		ES (rare), EE		
Dendropicos gabonensis Gabon Woodpecker*				PH[35], AE		V
D. fuscescens Cardinal woodpecker				EE		X
D. pyrrhogaster Fire-bellied Woodpecker*†	F	2	PH	AE, ES, EE		
D. goertae Grey Woodpecker			TAA	PH (1987, 1988), ES		
Eurylaemidae						
Smithornis rufolateralis Rufous-sided Broadbill*†	F	1			X	
Pittidae						
Pitta angolensis African Pitta				W		X
Hirundinidae						
[*Riparia paludicola* Plain Martin				A, EE		V]
R. riparia Common Sand Martin	F		TAA (2013)	PH (Mar 1992, Oct 1994), BB, A, EE		
[*R. cincta* Banded Martin				A (one)		V]
Hirundo semirufa Rufous-chested Swallow	F			ES, NR, A, EFD		
H. sengalensis Mosque Swallow		X		PH (frequent all year), ES, A, EFD, EE		
H. abyssinica Lesser Striped Swallow	C			ES, A, EFD		
H. fuligula Rock Martin	F				X	
H. smithii Wire-tailed Swallow				ES		X
H. leucosoma Pied-winged Swallow*				AE, ES, EE		X
H. aethiopica Ethiopian Swallow	C			ES, A		
H. rustica Barn Swallow	F			ES, A		
Delichon urbicum House Martin				ES		X
Motacillidae						
Motacilla flava Yellow Wagtail	F			ES, B, A, NR		
M. aguimp African Pied Wagtail	C			ES, NR		
Anthus leucophrys Plain-backed Pipit	C			ES, EFD		
A. pallidiventris Long-legged Pipit			TH (2012)		V	
A. trivialis Tree Pipit				PH, P, BB		X
A. cervinus Red-throat Pipit				PH, P, BB, A		X
Macronyx croceus Yellow-throated Longclaw	F			ES, EE		
Campephagidae						
Campephaga phoenicea Red-shouldered Cuckoo-shrike†	U		M	ES, B, BB, EFD		
Coracina azurea Blue Cuckoo-shrike*				AE		X
Pycnonotidae						
Andropadus virens Little Greenbul*†	A	57		ES		
A. gracilis Little Grey Greenbul†	U	2	M	ES		
A. curvirostris Cameroon Sombre Greenbul*†	F	15		AE		

A. gracilirostris Slender-billed Greenbul†	C			ES (rare), EE		
A. latirostris Yellow-whiskered Greenbul†	A	109		ES		
Baeopogon indicator Honeyguide Greenbul*†	F	4		AE, ES		
Ixonotus guttatus Spotted Greenbul*				AE, EE		X
Chlorocichla simplex Simple Leaflove*†	C	1		AE, ES		
C. flavicollis Yellow-throated Leaflove†	U[36]			ES		
Thescelocichla leucopleura Swamp-palm Bulbul*†	C			AE, ES		
Pyrrhurus scandens Leaflove*†	C	1		AE, ES		
Phyllastrephus baumanni Baumann's Greenbul*†	U	10		AE, ES		
P. icterinus Icterine Greenbul*				AE		X
P. albigularis White-throated Greenbul*†	F	26		AE, ES		
Bleda syndactylus Red-tailed Bristlebill†				P, EE		X
B. canicapillus Grey-headed Bristlebill*†	C	87		AE, ES		
Criniger barbatus Western Bearded Greenbul*†			M	Ban, AE, EE		
C. calurus Red-tailed Greenbul*	U		M	AE, ES		
C. ndussumensis White-bearded Greenbul*				AE		X
Pycnonotus barbatus Common Bulbul†	A	3	M	ES, NR		
Nicator chloris Western Nicator*†	F	7		ES		
Turdidae						
Stiphrornis erythrothorax Forest Robin*†	C	15		AE, ES (rare), BB		
Luscinia megarhynchos Common Nightingale			PH (occasional)	ES, P, A, EE		
L. svecica Bluethroat				A		V
Cossypha cyanocampter Blue-shouldered Robin Chat*†	F	5		Ban, EE		
C. niveicapilla Snowy-crowned Robin Chat†	C	2		ES, NR, EFD		
Neocossyphus poensis White-tailed Ant Thrush†	F	4			X	
Stizorhina finschi Finsch's Flycatcher Thrush				PH, ES		X
Phoenicurus phoenicurus Common Redstart				ES, A		X
Saxicola rubetra Whinchat	C			ES, A		
Oenanthe oenanthe Northern Wheatear				ES		V
Monticola solitarius Blue Rock Thrush				W		V
Turdus pelios African Thrush†	A	5		ES, NR, EFD		
Sylviidae						
Melocichla mentalis African Moustached Warbler	F			ES		
Acrocephalus schoenobaenus Sedge Warbler				A, BB		X
A. scirpaceus European Reed Warbler				EE		V
A. baeticatus African Reed Warbler				AP, A, BB, EE		X
A. arundinaceus Great Reed Warbler	F	2		ES, AP, A, BB		
Hippolais polyglotta Melodious Warbler			PH	ES, B, A, BB		
H. icterina Icterine Warbler				RP, BB		X
Cisticola erythrops Red-faced Cisticola	A	2		ES, A		
C. lateralis Whistling Cisticola				PH, ES		X
C. anonymus Chattering Cisticola*				AE		X
C. galactotes Winding Cisticola				PH		X
C. brachypterus Short-winged Cisticola	F			ES, A		
C. juncidis Zitting Cisticola				PH		X
Prinia subflava Tawny-flanked Prinia	F			PH, ES		
Heliolais erythropterus Red-winged Warbler				ES		X
Camaroptera brachyura Grey-backed Camaroptera	A	7	D	ES, S		
C. superciliaris Yellow-browed Camaroptera*†	C	2		AE, ES		
C. chloronota Olive-green Camaroptera*†	A	49	D	ES		
Macrosphenus kempi Kemp's Longbill*†	F	5			X	
M. concolor Grey Longbill*†	U	2		ES		
Eremomela pusilla Senegal Eremomela**	U			AE, ES		
Sylvietta brachyura Northern Crombce				EE		V
S. virens Green Crombec*†	C	3		AE, ES		
S. denti Lemon-bellied Crombec*†	F				X	
Phylloscopus trochilus Willow Warbler	F		PH	ES, A, NR		
P. sibilatrix Wood Warbler†	F			ES		
Hypergerus atriceps Oriole Warbler**†	F			AE, ES		
Sylvia borin Garden Warbler	U			ES, A, B, RP		
S. communis Common Whitethroat				BB		V
Hylia prasina Green Hylia*†	C	9		AE, ES		
Muscicapidae						

Fraseria ocreata Fraser's Forest Flycatcher*†			M		X	
Melaenornis edolioides Northern Black Flycatcher†	U (F in 2009)			B		
Muscicapa striata Spotted Flycatcher				PH, ES		X
M. olivascens Olivaceous Flycatcher*†	(once)				X	
M. comitata Dusky-blue Flycatcher*†	U	1		AE, ES, B		
M. tessmanni Tessmann's Flycatcher*				AE		X
Ficedula hypoleuca Pied Flycatcher			PH	ES		
Monarchidae						
Erythrocercus mccallii Chestnut-capped Flycatcher*		X	PH (several, 1999, 2000), ES			
Trochocercus nitens Blue-headed Crested Flycatcher*†	F	1		AE, ES		
Terpsiphone viridis African Paradise Flycatcher†			PH, M	ES, EFD		
T. rufiventer Red-bellied Paradise Flycatcher*†	A	41	M	ES, NR		
Platysteiridae						
Megabyas flammulatus Shrike Flycatcher*				ES		X
Bias musicus Black-and-White Flycatcher				PH[37], ES		X
Dyaphorophyia castanea Chestnut Wattle-eye*†	F	1		AE, ES		
D. blissetti Red-cheeked Wattle-eye*†	C	21		AE, ES, BB		
Platysteira cyanea Common Wattle-eye†	F	1		ES, NR		
Batis senegalensis Senegal Batis				ES		X
Timaliidae						
Illadopsis rufipennis Pale-breasted Illadopsis†	U			PH[38]		
I. fulvescens Brown Illadopsis*†	C	14		AE, ES, BB		
I. puveli Puvel's Illadopsis				S, EE		X
Turdoides plebejus Brown Babbler				ES		V
T. reinwardtii Blackcap Babbler				ES		X
Phyllanthus atripennis Capuchin Babbler*†	F	4		AE, ES		
Remizidae						
Pholidornis rushiae Tit-hylia			PH (several, W Bank)		X	
Nectariniidae						
Anthreptes rectirostris Green Sunbird*				Ban		X
Cyanomitra verticalis Green-headed Sunbird	U			ES, NR		
C. cyanolaema Blue-throated Brown Sunbird*	U[39]	1		PH, AE, ES, B		
C. obscura Western Olive Sunbird†	C	75		ES		
Chalcomitra adelberti Buff-throated Sunbird*†	U			AE, ES		
C. senegalensis Scarlet-chested Sunbird	R				X	
Hedydipna collaris Collared Sunbird†	A	32	M	ES		
Cinnyris chloropygius Olive-bellied Sunbird†	F	1		ES, NR		
C. minullus Tiny Sunbird*†	U	5			X	
C. venustus Variable Sunbird	F			ES, NR, EFD		
C. superbus Superb sunbird*				AE, ES		X
C. coccinigastrus Splendid Sunbird*†	C	5		AE, ES, EFD		
C. cupreus Copper Sunbird	C	2		ES, NR		
Zosteropidae						
Zosterops senegalensis Yellow White-eye		X		PH & ES (common), NR		
Laniidae						
Lanius senator Woodchat Shrike				PH, ES		X
Corvinella corvina Yellow-billed Shrike*	F			AE, ES, A, EE		
Malaconotidae						
Malaconotus cruentus Fiery-breasted Bush-Shrike*†	(one group)		PH (common),	AE, ES, B, NR		
M. multicolor Many-coloured Bush-Shrike†	U		D	ES, NR, EE		
M. sulfureopectus Sulphur-breasted Bush-shrike†			GH (2013)	ES, EFD		
Antichromus minutus Marsh Tchagra				ES, EE		X
Tchagra senegalus Black-crowned Tchagra				ES, B		X
Dryoscopus sabini Sabine's Puffback*†	U		M	AE, ES		
D. gambensis Northern Puffback			TAA (2013)	ES, NR		
Laniarus aethiopicus Tropical Boubou†	F			EE		
Prionopidae						
Prionops plumatus White Helmet-shrike				ES		X
P. caniceps Red-billed Helmet-shrike*†	U		M	AE, EE		
Oriolidae						
Oriolus nigripennis Black-winged Oriole*†	F		M	AE, ES		

O. brachyrhynchus Western Black-headed Oriole*†	F		M			
O. auratus African Golden Oriole†			PH (fairly common)	ES, EFD		
O. oriolus Eurasian Golden Oriole				JA		V
Dicruridae						
Dicrurus ludwigii Square-tailed Drongo†	F	2		ES		
D. atripennis Shining Drongo*†	F				X	
D.adsimilis Fork-tailed Drongo				JA		X
D. modestus Velvet-mantled Drongo†[40]	C	1	M	ES, NR		
Corvidae						
Corvus albus Pied Crow	A			ES, EFD		
Ptilostomus afer Piapiac**			TAA		V	
Sturnidae						
Poeoptera lugubris Narrow-tailed Starling†	F				X	
Onychognathus fulgidus Forest Chestnut-winged Starling*†	F			AE, ES, NR		
Lamprotornis purpureus Purple Glossy Starling				ES		X
L. splendidus Splendid Glossy Starling	C			ES		
L. caudatus Long-tailed Glossy Starling	V (2009)				V	
Cinnyricinclus leucogaster Violet-backed Starling (once)		V	PH (dry season 1999),	ES		
Passeridae						
Passer griseus Northern Grey-headed Sparrow	C			ES, NR		
Ploecidae						
Plocepasser superciliosus Chestnut-crowned Sparrow-Weaver*				Ban		X
Ploceus nigricollis Black-necked Weaver	C	38		NR		
P. nigerrimus Vieillot's Black Weaver*	U			AE		
P. cucullatus Village Weaver†	VA	50		ES		
P. tricolor Yellow-mantled Weaver*†	C		D, M	AE, ES		
Malimbus nitens Blue-billed Malimbe*†	A	17	M	AE, ES		
M. malimbicus Crested Malimbe*†			PH (frequent), M, TAA (2013)	AE, ES		
M. ibadanensis Ibadan Malimbe*†	R		M	PH, AE, ES, JA		
M. scutatus Red-vented Malimbe*†	C		M	AE, ES, NR		
M. rubricollis Red-headed Malimbe*†	C		M	AE, ES, B		
Quelea erythrops Red-headed Quelea	F	10		ES, BB		
Euplectes hordeaceus Black-winged Bishop				Ban		X
E. franciscanus Northern Red Bishop	R			EE		
E. macroura Yellow-mantled Widowbird	U			ES, EFD, EE		
Amblyospiza albifrons Grosbeak Weaver	R			ES, B, BB		
Estrildidae						
Nigrita canicapillus Grey-crowned Negrofinch†	F		M	ES		
N. luteifrons Pale-fronted Negrofinch*				ES		X
N. bicolor Chestnut-breasted Negrofinch*†	F	1		AE, ES		
N. fusconotus White-breasted Negrofinch*†	F				X	
Pyrenestes ostrinus Black-bellied Seedcracker	U	1		ES, EE		
Spermophaga haematina Western Bluebill*†	C	38		AE, ES, BB		
Mandingoa nitidula Green Twinspot				Ban		X
Lagonosticta rufopicta Bar-breasted Firefinch*†	U			AE, ES		
L. rubricata Blue-billed Firefinch				PH (frequent)		X
Estrilda melpoda Orange-cheeked Waxbill†	A			ES, B, BB, EFD		
Spermestes cucullatus Bronze Mannikin†	C	10		ES		
S. bicolor Black-and-White Mannikin†	F			ES		
Viduidae						
Vidua chalybeata Village Indigobird			PH (frequent)	ES		
V. macroura Pin-tailed Whydah	C			ES		
Fringillidae						
Serinus mozambicus Yellow-fronted Canary			PH (uncommon)	EE		
Emberizidae						
Emberiza cabanisi Cabanis's Bunting				ES		X
71 families, 398 spp. (269 in IITA campus, 138 in IBA)	233	75	74	361	25(13)68(62)	

Appendix 5 : LSD Multiple Comparisons of Overall bird species diversity, abundance, richness and evenness indices

Dependent Variable	(I) Area	(J) Area	Mean Difference (I-J)	Std. Error	Sig.
			Lower Bound		
Shannon's Bird Species Diversity	Dam	Farm	0.11209	0.05825	0.055
		For	-.44328(*)	0.05505	0
	Farm	Dam	-0.11209	0.05825	0.055
		For	-.55537(*)	0.05957	0
	For	Dam	.44328(*)	0.05505	0
		Farm	.55537(*)	0.05957	0
Simpson's Bird Species Diversity	Dam	Farm	0.00771	0.02091	0.712
		For	.18718(*)	0.01977	0
	Farm	Dam	-0.00771	0.02091	0.712
		For	.17946(*)	0.02135	0
	For	Dam	-.18718(*)	0.01977	0
		Farm	-.17946(*)	0.02135	0
Bird Species Abundance	Dam	Farm	17.63022	13.50468	0.192
		For	53.57952(*)	12.76212	0
	Farm	Dam	-17.63022	13.50468	0.192
		For	35.94931(*)	13.81175	0.009
	For	Dam	-53.57952(*)	12.76212	0
		Farm	-35.94931(*)	13.81175	0.009
Bird Species Richness	Dam	Farm	1.607(*)	0.436	0
		For	-0.802	0.415	0.054
	Farm	Dam	-1.607(*)	0.436	0
		For	-2.409(*)	0.446	0
	For	Dam	0.802	0.415	0.054
		Farm	2.409(*)	0.446	0
Eveness index	Dam	Farm	-0.02548	0.01929	0.187
		For	-.16128(*)	0.01809	0
	Farm	Dam	0.02548	0.01929	0.187
		For	-.13580(*)	0.01966	0
	For	Dam	.16128(*)	0.01809	0
		Farm	.13580(*)	0.01966	0

*The mean difference is significant at the .05 level.

Appendix 6: Descriptive and ANOVA of bird species diversity, abundance, richness and evenness indices across habitat

		N	Mean	Std. Deviation	Std. Error		Sum of Squares	df	Mean Square	F	Sig.
Shannon's index	Dam gallery	93	1.5582	0.64067	0.06643	Between Groups	43.719	7	6.246	18.196	0
	Dam grassland	152	1.3615	0.5851	0.04746	Within Groups	218.983	638	0.343		
	Forest	107	1.7577	0.53088	0.05132	Total	262.702	645			
	forest edge	114	1.9937	0.49191	0.04607						
	Maize Cassava	47	1.402	0.70151	0.10233						
	Agro or citrus orchard	26	1.145	0.56633	0.11107						
	Cassava	41	1.2128	0.52081	0.08134						
	Maize	66	1.4083	0.68842	0.08474						
Simpson's Index	Dam gallery	91	0.2491	0.2162	0.02266	Between Groups	5.43	7	0.776	17.328	0
	Dam grassland	152	0.3391	0.26029	0.02111	Within Groups	28.471	636	0.045		
	Forest	107	0.1319	0.1416	0.01369	Total	33.901	643			
	Forest edge	114	0.1054	0.07617	0.00713						
	Maize-Cassave	48	0.2977	0.26657	0.03848						
	Agro or citrus orchard	24	0.2798	0.23758	0.0485						
	Cassava	42	0.2928	0.23864	0.03682						
	Maize	66	0.3073	0.25659	0.03158						
Bird Species Abundance	Dam gallery	93	45.1783	82.20713	8.52448	Between Groups	538699.7	7	76957.1	4.101	0
	Dam grassland	152	88.5175	199.7236	16.19972	Within Groups	11970991	638	18763.31		
	Forest	10	15.063	9.78893	0.94633	Total	12509690	64			

		7	9					5			
	Forest edge	114	21.6996	15.17212	1.421						
	maize-cassava	47	40.266	60.97521	8.89415						
	Agro or citrus orchard	26	39.3846	105.0557	20.60312						
	Cassava	41	34.0976	95.75099	14.95379						
	Maize	66	83.0909	262.4175	32.30137						
Bird Species Richness	Dam gallery	94	8.37	4.52	0.466	Between Groups	1063.564	7	151.938	7.801	0
	Dam grassland	152	7.97	4.491	0.364	Within Groups	12542.22	644	19.475		
	Forest	107	7.78	3.982	0.385	Total	13605.79	651			
	Forest edge	114	10.01	4.725	0.443						
	Maize-cassava	49	7.29	5.504	0.786						
	Agro or citrus orchard	26	5.69	4.231	0.83						
	Cassava	42	4.98	2.858	0.441						
	Maize	68	7.24	4.154	0.504						
Eveness index	Dam gallery	91	0.7978	0.20418	0.0214	Between Groups	3.637	7	0.52	13.911	0
	Dam grassland	149	0.73	0.25548	0.02093	Within Groups	23.382	626	0.037		
	Forest	106	0.9191	0.08465	0.00822	Total	27.019	633			
	Forest edge	114	0.915	0.08589	0.00804						
	Maize-cassava	45	0.763	0.22241	0.03316						
	Agro or citrus orchard	24	0.7994	0.20947	0.04276						
	Cassava	41	0.8059	0.20172	0.0315						
	Maize	64	0.7713	0.23807	0.02976						

Appendix 7: Multiple Comparisons of bird species diversity across habitat using LSD

Dependent Variable	(I) Land use	(J) Land use	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Upper Bound	Lower Bound
Shannon's Bird Species Diversity	DAMGAL	DAMGRA	.19662(*)	0.07713	0.011	0.0452	0.3481
		FOREST	-.19957(*)	0.08306	0.017	-0.3627	-0.0365
		FOREDGE	-.43554(*)	0.08186	0	-0.5963	-0.2748
		MAZECASS	0.15616	0.10485	0.137	-0.0497	0.362
		AGRO	.41318(*)	0.12997	0.002	0.158	0.6684
		CASSAVA	.34535(*)	0.10983	0.002	0.1297	0.561
		MAIZE	0.14989	0.09429	0.112	-0.0353	0.335
	DAMGRA	DAMGAL	-.19662(*)	0.07713	0.011	-0.3481	-0.0452
		FOREST	-.39619(*)	0.07393	0	-0.5414	-0.251
		FOREDGE	-.63216(*)	0.07259	0	-0.7747	-0.4896
		MAZECASS	-0.04047	0.09778	0.679	-0.2325	0.1515
		AGRO	0.21656	0.12434	0.082	-0.0276	0.4607
		CASSAVA	0.14873	0.1031	0.15	-0.0537	0.3512
		MAIZE	-0.04674	0.08636	0.589	-0.2163	0.1229
	FOREST	DAMGAL	.19957(*)	0.08306	0.017	0.0365	0.3627
		DAMGRA	.39619(*)	0.07393	0	0.251	0.5414
		FOREDGE	-.23597(*)	0.07886	0.003	-0.3908	-0.0811
		MAZECASS	.35573(*)	0.10252	0.001	0.1544	0.557
		AGRO	.61275(*)	0.1281	0	0.3612	0.8643
		CASSAVA	.54492(*)	0.10761	0	0.3336	0.7562
		MAIZE	.34946(*)	0.0917	0	0.1694	0.5295

FOREDGE	DAMGAL	.43554(*)	0.08186	0	0.2748	0.5963
	DAMGRA	.63216(*)	0.07259	0	0.4896	0.7747
	FOREST	.23597(*)	0.07886	0.003	0.0811	0.3908
	MAZECASS	.59170(*)	0.10156	0	0.3923	0.7911
	AGRO	.84872(*)	0.12733	0	0.5987	1.0988
	CASSAVA	.78089(*)	0.10669	0	0.5714	0.9904
	MAIZE	.58543(*)	0.09062	0	0.4075	0.7634
MAZECASS	DAMGAL	-0.15616	0.10485	0.137	-0.362	0.0497
	DAMGRA	0.04047	0.09778	0.679	-0.1515	0.2325
	FOREST	-.35573(*)	0.10252	0.001	-0.557	-0.1544
	FOREDGE	-.59170(*)	0.10156	0	-0.7911	-0.3923
	AGRO	0.25703	0.14319	0.073	-0.0242	0.5382
	CASSAVA	0.18919	0.1252	0.131	-0.0567	0.435
	MAIZE	-0.00627	0.11182	0.955	-0.2258	0.2133
AGRO	DAMGAL	-.41318(*)	0.12997	0.002	-0.6684	-0.158
	DAMGRA	-0.21656	0.12434	0.082	-0.4607	0.0276
	FOREST	-.61275(*)	0.1281	0	-0.8643	-0.3612
	FOREDGE	-.84872(*)	0.12733	0	-1.0988	-0.5987
	MAZECASS	-0.25703	0.14319	0.073	-0.5382	0.0242
	CASSAVA	-0.06783	0.14688	0.644	-0.3563	0.2206
	MAIZE	-0.2633	0.13565	0.053	-0.5297	0.0031
CASSAVA	DAMGAL	-.34535(*)	0.10983	0.002	-0.561	-0.1297
	DAMGRA	-0.14873	0.1031	0.15	-0.3512	0.0537
	FOREST	-.54492(*)	0.10761	0	-0.7562	-0.3336
	FOREDGE	-.78089(*)	0.10669	0	-0.9904	-0.5714
	MAZECASS	-0.18919	0.1252	0.131	-0.435	0.0567
	AGRO	0.06783	0.14688	0.644	-0.2206	0.3563

		MAIZE	-0.19546	0.1165	0.094	-0.4242	0.0333
	MAIZE	DAMGAL	-0.14989	0.09429	0.112	-0.335	0.0353
		DAMGRA	0.04674	0.08636	0.589	-0.1229	0.2163
		FOREST	-.34946(*)	0.0917	0	-0.5295	-0.1694
		FOREDGE	-.58543(*)	0.09062	0	-0.7634	-0.4075
		MAZECASS	0.00627	0.11182	0.955	-0.2133	0.2258
		AGRO	0.2633	0.13565	0.053	-0.0031	0.5297
		CASSAVA	0.19546	0.1165	0.094	-0.0333	0.4242
Simpson's Bird Species Diversity	DAMGAL	DAMGRA	-.09002(*)	0.02804	0.001	-0.1451	-0.035
		FOREST	.11720(*)	0.03017	0	0.058	0.1764
		FOREDGE	.14369(*)	0.02974	0	0.0853	0.2021
		MAZECASS	-0.04863	0.03774	0.198	-0.1227	0.0255
		AGRO	-0.03073	0.04855	0.527	-0.1261	0.0646
		CASSAVA	-0.04367	0.03947	0.269	-0.1212	0.0338
		MAIZE	-0.05822	0.03421	0.089	-0.1254	0.009
	DAMGRA	DAMGAL	.09002(*)	0.02804	0.001	0.035	0.1451
		FOREST	.20723(*)	0.0267	0	0.1548	0.2597
		FOREDGE	.23371(*)	0.02621	0	0.1822	0.2852
		MAZECASS	0.0414	0.03503	0.238	-0.0274	0.1102
		AGRO	0.0593	0.04647	0.202	-0.032	0.1506
		CASSAVA	0.04635	0.03688	0.209	-0.0261	0.1188
		MAIZE	0.03181	0.03119	0.308	-0.0294	0.0931
	FOREST	DAMGAL	-.11720(*)	0.03017	0	-0.1764	-0.058
		DAMGRA	-.20723(*)	0.0267	0	-0.2597	-0.1548
		FOREDGE	0.02648	0.02848	0.353	-0.0294	0.0824
		MAZECASS	-.16583(*)	0.03676	0	-0.238	-0.0937

	AGRO	-.14793(*)	0.04779	0.002	-0.2418	-0.0541
	CASSAVA	-.16087(*)	0.03853	0	-0.2365	-0.0852
	MAIZE	-.17542(*)	0.03312	0	-0.2404	-0.1104
FOREDGE	DAMGAL	-.14369(*)	0.02974	0	-0.2021	-0.0853
	DAMGRA	-.23371(*)	0.02621	0	-0.2852	-0.1822
	FOREST	-0.02648	0.02848	0.353	-0.0824	0.0294
	MAZECASS	-.19232(*)	0.0364	0	-0.2638	-0.1208
	AGRO	-.17441(*)	0.04752	0	-0.2677	-0.0811
	CASSAVA	-.18736(*)	0.03819	0	-0.2624	-0.1124
	MAIZE	-.20190(*)	0.03273	0	-0.2662	-0.1376
MAZECASS	DAMGAL	0.04863	0.03774	0.198	-0.0255	0.1227
	DAMGRA	-0.0414	0.03503	0.238	-0.1102	0.0274
	FOREST	.16583(*)	0.03676	0	0.0937	0.238
	FOREDGE	.19232(*)	0.0364	0	0.1208	0.2638
	AGRO	0.0179	0.05289	0.735	-0.086	0.1218
	CASSAVA	0.00496	0.0447	0.912	-0.0828	0.0927
	MAIZE	-0.00959	0.04014	0.811	-0.0884	0.0692
AGRO	DAMGAL	0.03073	0.04855	0.527	-0.0646	0.1261
	DAMGRA	-0.0593	0.04647	0.202	-0.1506	0.032
	FOREST	.14793(*)	0.04779	0.002	0.0541	0.2418
	FOREDGE	.17441(*)	0.04752	0	0.0811	0.2677
	MAZECASS	-0.0179	0.05289	0.735	-0.1218	0.086
	CASSAVA	-0.01294	0.05414	0.811	-0.1193	0.0934
	MAIZE	-0.02749	0.05043	0.586	-0.1265	0.0715
CASSAVA	DAMGAL	0.04367	0.03947	0.269	-0.0338	0.1212
	DAMGRA	-0.04635	0.03688	0.209	-0.1188	0.0261
	FOREST	.16087(*)	0.03853	0	0.0852	0.2365

	FOREDGE	.18736(*)	0.03819	0	0.1124	0.2624
	MAZECASS	-0.00496	0.0447	0.912	-0.0927	0.0828
	AGRO	0.01294	0.05414	0.811	-0.0934	0.1193
	MAIZE	-0.01455	0.04176	0.728	-0.0966	0.0675
MAIZE	DAMGAL	0.05822	0.03421	0.089	-0.009	0.1254
	DAMGRA	-0.03181	0.03119	0.308	-0.0931	0.0294
	FOREST	.17542(*)	0.03312	0	0.1104	0.2404
	FOREDGE	.20190(*)	0.03273	0	0.1376	0.2662
	MAZECASS	0.00959	0.04014	0.811	-0.0692	0.0884
	AGRO	0.02749	0.05043	0.586	-0.0715	0.1265
	CASSAVA	0.01455	0.04176	0.728	-0.0675	0.0966

* The mean difference is significant at the .05 level.

Appendix 8: Multiple Comparisons of abundance, richness and evenness indices across habitat using LSD

Dependent Variable	(I) Land use	(J) Land use	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Upper Bound	Lower Bound
Bird Species Abundance	DAMGAL	DAMGRA	-43.33923(*)	18.03327	0.017	-78.751	-7.9275
		FOREST	30.11445	19.41942	0.121	-8.0193	68.2482
		FOREDGE	23.47875	19.14018	0.22	-14.1066	61.0641
		MAZECASS	4.91236	24.5148	0.841	-43.2271	53.0518
		AGRO	5.7937	30.38785	0.849	-53.8786	65.466
		CASSAVA	11.08075	25.67874	0.666	-39.3443	61.5058
		MAIZE	-37.9126	22.04651	0.086	-81.2051	5.3799
	DAMGRA	DAMGAL	43.33923(*)	18.03327	0.017	7.9275	78.751
		FOREST	73.45368(*)	17.28586	0	39.5096	107.3977
		FOREDGE	66.81798(*)	16.97154	0	33.4911	100.1448
		MAZECASS	48.25159(*)	22.86181	0.035	3.3581	93.1451
		AGRO	49.13293	29.07075	0.091	-7.953	106.2188
		CASSAVA	54.41998(*)	24.10569	0.024	7.0839	101.7561
		MAIZE	5.42663	20.19246	0.788	-34.2251	45.0783
	FOREST	DAMGAL	-30.1145	19.41942	0.121	-68.2482	8.0193
		DAMGRA	-73.45368(*)	17.28586	0	-	-39.5096

					107.398	
	FOREDGE	-6.6357	18.43769	0.719	-42.8416	29.5702
	MAZECASS	-25.2021	23.97034	0.293	-72.2724	21.8682
	AGRO	-24.3208	29.95035	0.417	-83.1339	34.4924
	CASSAVA	-19.0337	25.15949	0.45	-68.4391	30.3717
	MAIZE	-68.02705(*)	21.43946	0.002	-110.128	-25.9266
FOREDGE	DAMGAL	-23.4788	19.14018	0.22	-61.0641	14.1066
	DAMGRA	-66.81798(*)	16.97154	0	-100.145	-33.4911
	FOREST	6.6357	18.43769	0.719	-29.5702	42.8416
	MAZECASS	-18.5664	23.74468	0.435	-65.1936	28.0608
	AGRO	-17.6851	29.77005	0.553	-76.1442	40.7741
	CASSAVA	-12.398	24.94458	0.619	-61.3814	36.5854
	MAIZE	-61.39135(*)	21.18686	0.004	-102.996	-19.7869
MAZECASS	DAMGAL	-4.91236	24.5148	0.841	-53.0518	43.2271
	DAMGRA	-48.25159(*)	22.86181	0.035	-93.1451	-3.3581
	FOREST	25.20209	23.97034	0.293	-21.8682	72.2724

	FOREDGE	18.5664	23.74468	0.435	-28.0608	65.1936
	AGRO	0.88134	33.47962	0.979	-64.8622	66.6249
	CASSAVA	6.1684	29.27219	0.833	-51.3131	63.6499
	MAIZE	-42.825	26.14406	0.102	-94.1638	8.5139
AGRO	DAMGAL	-5.7937	30.38785	0.849	-65.466	53.8786
	DAMGRA	-49.1329	29.07075	0.091	-106.219	7.953
	FOREST	24.32075	29.95035	0.417	-34.4924	83.1339
	FOREDGE	17.68505	29.77005	0.553	-40.7741	76.1442
	MAZECASS	-0.88134	33.47962	0.979	-66.6249	64.8622
	CASSAVA	5.28705	34.34104	0.878	-62.1481	72.7222
	MAIZE	-43.7063	31.71684	0.169	-105.988	18.5757
CASSAVA	DAMGAL	-11.0808	25.67874	0.666	-61.5058	39.3443
	DAMGRA	-54.41998(*)	24.10569	0.024	-101.756	-7.0839
	FOREST	19.0337	25.15949	0.45	-30.3717	68.4391
	FOREDGE	12.398	24.94458	0.619	-36.5854	61.3814
	MAZECASS	-6.1684	29.27219	0.833	-	51.3131

						63.6499	
		AGRO	-5.28705	34.34104	0.878	-72.7222	62.1481
		MAIZE	-48.9934	27.23847	0.073	-102.481	4.4945
	MAIZE	DAMGAL	37.91259	22.04651	0.086	-5.3799	81.2051
		DAMGRA	-5.42663	20.19246	0.788	-45.0783	34.2251
		FOREST	68.02705(*)	21.43946	0.002	25.9266	110.1275
		FOREDGE	61.39135(*)	21.18686	0.004	19.7869	102.9958
		MAZECASS	42.82495	26.14406	0.102	-8.5139	94.1638
		AGRO	43.70629	31.71684	0.169	-18.5757	105.9883
		CASSAVA	48.99335	27.23847	0.073	-4.4945	102.4812
Bird Species Richness	DAMGAL	DAMGRA	0.399	0.579	0.491	-0.74	1.54
		FOREST	0.597	0.624	0.339	-0.63	1.82
		FOREDGE	-1.636(*)	0.615	0.008	-2.84	-0.43
		MAZECASS	1.087	0.778	0.163	-0.44	2.61
		AGRO	2.680(*)	0.978	0.006	0.76	4.6
		CASSAVA	3.396(*)	0.819	0	1.79	5
		MAIZE	1.137	0.703	0.106	-0.24	2.52
	DAMGRA	DAMGAL	-0.399	0.579	0.491	-1.54	0.74
		FOREST	0.198	0.557	0.722	-0.9	1.29
		FOREDGE	-2.035(*)	0.547	0	-3.11	-0.96
		MAZECASS	0.688	0.725	0.343	-0.74	2.11
		AGRO	2.281(*)	0.937	0.015	0.44	4.12
		CASSAVA	2.997(*)	0.769	0	1.49	4.51

	MAIZE	0.738	0.644	0.252	-0.53	2
FOREST	DAMGAL	-0.597	0.624	0.339	-1.82	0.63
	DAMGRA	-0.198	0.557	0.722	-1.29	0.9
	FOREDGE	-2.233(*)	0.594	0	-3.4	-1.07
	MAZECASS	0.49	0.761	0.52	-1	1.98
	AGRO	2.083(*)	0.965	0.031	0.19	3.98
	CASSAVA	2.800(*)	0.804	0.001	1.22	4.38
	MAIZE	0.54	0.684	0.43	-0.8	1.88
FOREDGE	DAMGAL	1.636(*)	0.615	0.008	0.43	2.84
	DAMGRA	2.035(*)	0.547	0	0.96	3.11
	FOREST	2.233(*)	0.594	0	1.07	3.4
	MAZECASS	2.723(*)	0.754	0	1.24	4.2
	AGRO	4.316(*)	0.959	0	2.43	6.2
	CASSAVA	5.033(*)	0.797	0	3.47	6.6
	MAIZE	2.773(*)	0.676	0	1.45	4.1
MAZECASS	DAMGAL	-1.087	0.778	0.163	-2.61	0.44
	DAMGRA	-0.688	0.725	0.343	-2.11	0.74
	FOREST	-0.49	0.761	0.52	-1.98	1
	FOREDGE	-2.723(*)	0.754	0	-4.2	-1.24
	AGRO	1.593	1.071	0.137	-0.51	3.7
	CASSAVA	2.310(*)	0.928	0.013	0.49	4.13
	MAIZE	0.05	0.827	0.951	-1.57	1.67
AGRO	DAMGAL	-2.680(*)	0.978	0.006	-4.6	-0.76
	DAMGRA	-2.281(*)	0.937	0.015	-4.12	-0.44
	FOREST	-2.083(*)	0.965	0.031	-3.98	-0.19
	FOREDGE	-4.316(*)	0.959	0	-6.2	-2.43
	MAZECASS	-1.593	1.071	0.137	-3.7	0.51

		CASSAVA	0.716	1.101	0.516	-1.45	2.88
		MAIZE	-1.543	1.018	0.13	-3.54	0.46
	CASSAVA	DAMGAL	-3.396(*)	0.819	0	-5	-1.79
		DAMGRA	-2.997(*)	0.769	0	-4.51	-1.49
		FOREST	-2.800(*)	0.804	0.001	-4.38	-1.22
		FOREDGE	-5.033(*)	0.797	0	-6.6	-3.47
		MAZECASS	-2.310(*)	0.928	0.013	-4.13	-0.49
		AGRO	-0.716	1.101	0.516	-2.88	1.45
		MAIZE	-2.259(*)	0.866	0.009	-3.96	-0.56
	MAIZE	DAMGAL	-1.137	0.703	0.106	-2.52	0.24
		DAMGRA	-0.738	0.644	0.252	-2	0.53
		FOREST	-0.54	0.684	0.43	-1.88	0.8
		FOREDGE	-2.773(*)	0.676	0	-4.1	-1.45
		MAZECASS	-0.05	0.827	0.951	-1.67	1.57
		AGRO	1.543	1.018	0.13	-0.46	3.54
		CASSAVA	2.259(*)	0.866	0.009	0.56	3.96
Eveness index	DAMGAL	DAMGRA	.06774(*)	0.02571	0.009	0.0173	0.1182
		FOREST	-.12135(*)	0.02762	0	-0.1756	-0.0671
		FOREDGE	-.11725(*)	0.02717	0	-0.1706	-0.0639
		MAZECASS	0.03475	0.03522	0.324	-0.0344	0.1039
		AGRO	-0.00165	0.04435	0.97	-0.0887	0.0854
		CASSAVA	-0.00815	0.03635	0.823	-0.0795	0.0632
		MAIZE	0.02647	0.03153	0.401	-0.0354	0.0884
	DAMGRA	DAMGAL	-.06774(*)	0.02571	0.009	-0.1182	-0.0173
		FOREST	-.18910(*)	0.02456	0	-0.2373	-0.1409
		FOREDGE	-.18499(*)	0.02405	0	-0.2322	-0.1378
		MAZECASS	-0.03299	0.03287	0.316	-0.0975	0.0316

	AGRO	-0.06939	0.04251	0.103	-0.1529	0.0141
	CASSAVA	-.07589(*)	0.03408	0.026	-0.1428	-0.009
	MAIZE	-0.04127	0.02888	0.154	-0.098	0.0154
FOREST	DAMGAL	.12135(*)	0.02762	0	0.0671	0.1756
	DAMGRA	.18910(*)	0.02456	0	0.1409	0.2373
	FOREDGE	0.00411	0.02608	0.875	-0.0471	0.0553
	MAZECASS	.15610(*)	0.03439	0	0.0886	0.2236
	AGRO	.11970(*)	0.04369	0.006	0.0339	0.2055
	CASSAVA	.11321(*)	0.03554	0.002	0.0434	0.183
	MAIZE	.14783(*)	0.03059	0	0.0877	0.2079
FOREDGE	DAMGAL	.11725(*)	0.02717	0	0.0639	0.1706
	DAMGRA	.18499(*)	0.02405	0	0.1378	0.2322
	FOREST	-0.00411	0.02608	0.875	-0.0553	0.0471
	MAZECASS	.15200(*)	0.03402	0	0.0852	0.2188
	AGRO	.11560(*)	0.0434	0.008	0.0304	0.2008
	CASSAVA	.10910(*)	0.03519	0.002	0.04	0.1782
	MAIZE	.14372(*)	0.03019	0	0.0844	0.203
MAZECASS	DAMGAL	-0.03475	0.03522	0.324	-0.1039	0.0344
	DAMGRA	0.03299	0.03287	0.316	-0.0316	0.0975
	FOREST	-.15610(*)	0.03439	0	-0.2236	-0.0886
	FOREDGE	-.15200(*)	0.03402	0	-0.2188	-0.0852
	AGRO	-0.0364	0.04885	0.456	-0.1323	0.0595
	CASSAVA	-0.0429	0.04173	0.304	-0.1248	0.039
	MAIZE	-0.00828	0.0376	0.826	-0.0821	0.0656
AGRO	DAMGAL	0.00165	0.04435	0.97	-0.0854	0.0887
	DAMGRA	0.06939	0.04251	0.103	-0.0141	0.1529
	FOREST	-.11970(*)	0.04369	0.006	-0.2055	-0.0339

	FOREDGE	-.11560(*)	0.0434	0.008	-0.2008	-0.0304
	MAZECASS	0.0364	0.04885	0.456	-0.0595	0.1323
	CASSAVA	-0.0065	0.04967	0.896	-0.104	0.091
	MAIZE	0.02812	0.04626	0.543	-0.0627	0.119
CASSAVA	DAMGAL	0.00815	0.03635	0.823	-0.0632	0.0795
	DAMGRA	.07589(*)	0.03408	0.026	0.009	0.1428
	FOREST	-.11321(*)	0.03554	0.002	-0.183	-0.0434
	FOREDGE	-.10910(*)	0.03519	0.002	-0.1782	-0.04
	MAZECASS	0.0429	0.04173	0.304	-0.039	0.1248
	AGRO	0.0065	0.04967	0.896	-0.091	0.104
	MAIZE	0.03462	0.03866	0.371	-0.0413	0.1105
MAIZE	DAMGAL	-0.02647	0.03153	0.401	-0.0884	0.0354
	DAMGRA	0.04127	0.02888	0.154	-0.0154	0.098
	FOREST	-.14783(*)	0.03059	0	-0.2079	-0.0877
	FOREDGE	-.14372(*)	0.03019	0	-0.203	-0.0844
	MAZECASS	0.00828	0.0376	0.826	-0.0656	0.0821
	AGRO	-0.02812	0.04626	0.543	-0.119	0.0627
	CASSAVA	-0.03462	0.03866	0.371	-0.1105	0.0413

* The mean difference is significant at the .05 level.

Table 3.0.1: Composition of the viral transport medium.

Reagent	Initial concentration	Amount	Final concentration
Medium 199	500ml	500ml	mixture
100x penstrep	200mg/L	10ml	200U Pen + 200mg/km
100x fungizone	2.5mg/ml	10ml	2.5ug/ml
Pennicillin G	2x1066U/L	540ml	1800U/ml dissolved in 10ml medium 199
Polymixin B	2x1066U/L	230mg	2000U/ml dissolved in 10ml medium199
Gentamycin	250mg/L	125mg	250ug/ml dissolved in 10ml medium 199
Oflocacin HCL	60mg/L	30mg	60ug/ml dissolve in 1ml 1NaOH
Sulphamethoxalole	0.2g/L	100mg	200ug/ml dissolve in 1ml 1N NaOH

Note: filter and sterilize

Table 3.2: Primers required for running PCR templates

Virus	Annealing Temperature	MgCl2 (50mM)	Primer sequence	Primer source	Primer volume	Amplified fragment	Remarks	Sensitivity
IBV	55°C	0,75 ul/sample	Fwd: **N784**: 5' AATTTTGGTGATGACAAGATGA 3'	Akin et al. (2001)	25 uM solution:	402 bp	One round	
			Rev: **N114**5: 5' CATTGTTCCTCTCCTCATCTG 3'	Akin et al. (2001)	0.5 ul/sample			
NDV	58°C	2ul/sample	Fwd: **FOP1**: 5' TACACCTCATCCCAGACAGGGTC 3'	Kho et al. (2000)	25 uM solution:	532 bp	1st round	
			Rev: **FOP2**: 5' AGGCAGGGGAAGTGATTTGTGGC 3'	Kho et al. (2000)	0.1 ul/sample			
AIV-A	60°C	1ul/sample	Fwd: **ChenF(M52C)***: 5' CTTCTAACCGAGGTCGAAACG 3'	Fouchier et al. (2000)	25 uM solution:	250 bp	One round	
			Rev: **ChenR(M253R)***: 5' AGGGCATTTTGGACAAAKCGTCTA 3'	Fouchier et al. (2000)	0.5 ul/sample			
IBV	54°C	0,75 ul/sample	Fwd: **N791**: 5' GTGATGACAAGATGAATGAGGA 3'	Akin et al. (2001)	25 uM solution:	380 bp	nested	1.00E-03
			Rev: **N1129**: 5' CAGCTGAGGTCAATGCTTTATC 3'	Akin et al. (2001)	0.5 ul/sample			
NDV	58°C	2 ul/sample	Fwd: **FIP1**: 5' TACTTTGCTCACCCCCCTT 3'	Kho et al. (2000)	25 uM solution:	280 bp	nested	3.00E-08
			Rev: **FIP2**: 5' CATCTTCCCAACTGCCACT 3'	Kho et al. (2000)	0.5 ul/sample			

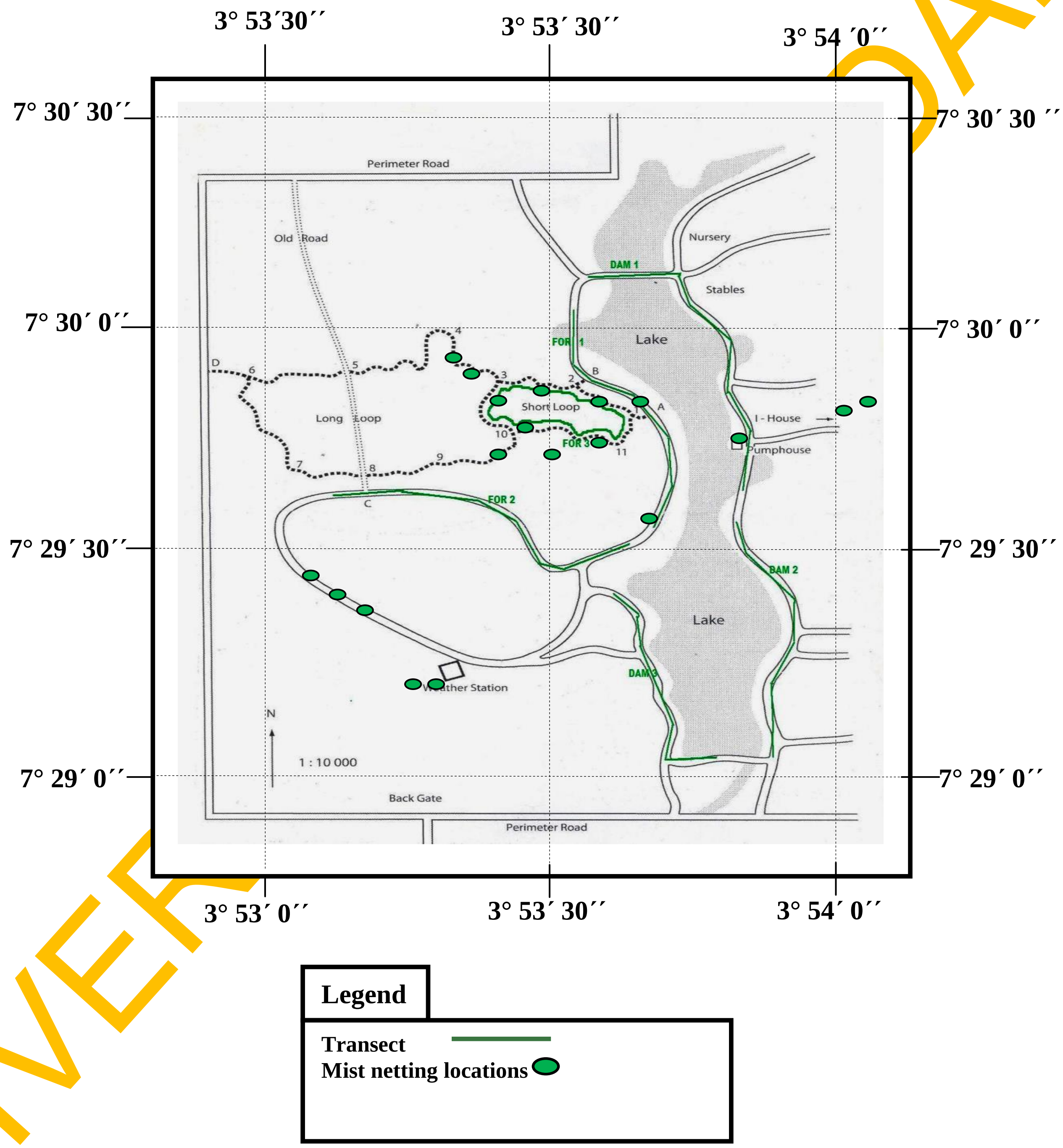

Figure 3.2: IITA West Bank and forest trails

Table 4.1: Bird species diversity, abundance, richness and evenness index across habitats

	Forest	S.E	SD	Dam	S.E	SD	Farm	S.E	SD
N	220			240			184		
Diversity(Shannon's)	1.888*	0.034	0.509	1.466	0.038	0.583	1.370	0.046	0.606
Diversity(Simpson's')	0.114*	0.007	0.096	0.297	0.015	0.237	0.295	0.018	0.241
Abundance	18.562	0.892	13.229	73.514*	10.831	167.791	56.124	13.345	176.034
Richness	8.964*	0.303	4.490	8.304	0.285	4.407	6.868	0.327	4.313
Evenness index	0.913*	0.006	0.088	0.746	0.016	0.242	0.779	0.017	0.220

Note (*) This signifies the highest value

Table 4.2: Viral Prevalence among sampled birds in IITA environs

No.	Common name	Age	Cl	Cl/OR	FE	OR	GT	NDV	AIV	IBV	Rota	Chicken Astro	Turkey Astro 1	Turkey Astro 2
1	*Accipiter tachiro* African Goshawk	4		4			4	0	0	0	0	0	0	0
	African Goshawk Total			4			4	0	0	0	0	0	0	0
2	*Actophilornis africanus* African Jacana	4		7			7	0	0	0	0	0	0	0
		5		1			1	0	0	0	0	0	0	0
	African Jacana Total			8			8	0	0	0	0	0	0	0
3	*Turdus pelios* African Thrush	4		5			5	0	0	0	0	0	0	0
		5		1			1	0	0	0	0	0	0	0
	African thrush Total			6			6	0	0	0	0	0	0	0
4	*Porphyrio alleni* Allen's Gallinule	4		2			2	0	0	0	0	0	0	0
	Allen's Gallinule Total			2			2	0	0	0	0	0	0	0
5	Bates sunbird	5		1			1	0	0	0	0	0	0	0
	Bates sunbird Total			1			1	0	0	0	0	0	0	0
6	*Phyllastrephus baumanni* Baumann's Greenbul	4		8			8	0	0	0	0	0	0	0
		5		2			2	0	0	0	0	0	0	0
	Baumans greenul Total			10			10	0	0	0	0	0	0	0
7	*Amaurornis flavirostra* Black Crake	4		1			1	0	0	0	0	0	0	0
		4??		1			1	0	0	0	0	0	0	0
	Black crake Total			2			2	0	0	0	0	0	0	0
8	*Pyrenestes ostrinus* Black-bellied Seedcracker	4		1			1	0	0	0	0	0	0	0
	Black-bellied seedcracker Total			1			1	0	0	0	0	0	0	0
9	*Ploceus nigricollis* Black-necked Weaver	4		27		1	28	0	0	0	0	0	0	0
		5		10			10	0	0	0	0	0	0	0
	Black-necked Weaver Total			37		1	38	0	0	0	0	0	0	0
10	*Halcyon malimbica* Blue-breasted Kingfisher	4		2			2	0	0	0	0	0	0	0
	Blue-breasted Kingfisher Total			2			2	0	0	0	0	0	0	0

11	*Malimbus nitens* Blue-billed Malimbe	4	11	11	0	0	0	0	0	0	0
		5	1	1	0	0	0	0	0	0	0
	Blue-billed Malimbe Total		12	12	0	0	0	0	0	0	0
12	*Trochocercus nitens* Blue-headed Crested Flycatcher	4	1	1	0	0	0	0	0	0	0
	Blue-headed Crested flycatcher Total		1	1	0	0	0	0	0	0	0
13	*Cossypha cyanocampter* Blue-shouldered Robin Chat	4	4	4	0	0	0	0	0	0	0
		6	2	2	0	0	0	0	0	0	0
	Blue-shouldered Robin chat Total		6	6	0	0	0	0	0	0	0
14	*Spermestes cucullatus* Bronze Mannikin	3	1	1	0	0	0	0	0	0	0
		4	7	7	0	0	0	0	0	0	0
		5	1	1	0	0	0	0	0	0	0
	Bronze Mannikin Total		9	9	0	0	0	0	0	0	0
15	*Illadopsis fulvescens* Brown Illadopsis	4	9	9	0	0	0	0	0	0	0
	Brown Illadopsis Total		9	9	0	0	0	0	0	0	0
16	*Campethera nivosa* Buff-spotted Woodpecker	4	5	5	0	0	0	0	0	0	0
	Buff-spotted Woodpecker Total		5	5	0	0	0	0	0	0	0
17	*Andropadus curvirostris* Cameroon Sombre Greenbul	4	11	11	0	0	0	0	0	0	0
		F	1	1	0	0	0	0	0	0	0
	Cameroon Sombre Greenbul Total		12	12	0	0	0	0	0	0	0
18	*Phyllanthus atripennis* Capuchin Babbler	4	2	2	0	0	0	0	0	0	0
	Capuchin Babbler total		2	2	0	0	0	0	0	0	0
19	*Dyaphorophyia castanea* Chestnut Wattle-eye	4	1	1	0	0	0	0	0	0	0
	Chestnut Wattle-eye Total		1	1	0	0	0	0	0	0	0
20	*Hedydipna collaris* Collared Sunbird	4	26	26	0	0	0	0	0	0	0
		5	5	5	0	0	0	0	0	0	0
	Collared sunbird Total		31	31	0	0	0	0	0	0	0
21	*Pycnonotus barbatus* Common Bulbul	4	3	3	0	0	0	0	0	0	0
	Common Bulbul Total		3	3	0	0	0	0	0	0	0
22	*Gallinula chloropus* Common Moorhen	4	1	1	0	0	0	0	0	0	0
	Common Moorhen Total		1	1	0	0	0	0	0	0	0

23	*Platysteira cyanea* Common Wattle-eye	5	1		1	0	0	0	0	0	0	0
	Common Wattle-eye Total		1		1	0	0	0	0	0	0	0
24	*Cinnyris cupreus* Copper Sunbird	4	1		1	0	0	0	0	0	0	0
		5	1		1	0	0	0	0	0	0	0
	Copper Sunbird Total		2		2	0	0	0	0	0	0	0
25	Domestic chicken	4	36		36	10	0	0	0	0	0	0
	Domestic chicken Total		36		36	0	0	0	0	0	0	0
26	*Stiphrornis erythrothorax* Forest Robin	3	1		1	0	0	0	0	0	0	0
		4	8		8	0	0	0	0	0	0	0
		5	1		1	0	0	0	0	0	0	0
		6	4		4	0	0	0	0	0	0	0
	Forest Robin Total		14		14	0	0	0	0	0	0	0
27	*Acrocephalus arundinaceus* Great Reed Warbler	4	1		1	0	0	0	0	0	0	0
	Great Reed Warbler Total		1		1	0	0	0	0	0	0	0
28	*Rostratula benghalensis* Greater Painted-snipe	4	8		8	0	0	0	0	0	0	0
		5	4		4	0	0	0	0	0	0	0
	Greater Painted-snipe Total		12		12	0	0	0	0	0	0	0
29	*Sylvietta virens* Green Crombec	4	3		3	0	0	0	0	0	0	0
	Green Crombec Total		3		3	0	0	0	0	0	0	0
30	*Hylia prasina* Green Hylia	4	7		7	0	0	0	0	0	0	0
		5	1		1	0	0	0	0	0	0	0
	Green Hylia Total		8		8	0	0	0	0	0	0	0
31	*Macrosphenus concolor* Grey Longbill	4	1		1	0	0	0	0	0	0	0
		5	1		1	0	0	0	0	0	0	0
	Grey Longbill Total		2		2	0	0	0	0	0	0	0
32	*Camaroptera brachyura* Grey-backed Camaroptera	2	1		1	0	0	0	0	0	0	0
		3	2		2	0	0	0	0	0	0	0
		4	5	1	6	0	0	0	0	0	0	0
		5	2		2	0	0	0	0	0	0	0
	Grey-backed Camaroptera Total		10	1	11	0	0	0	0	0	0	0

33	*Bleda canicapillus* Grey-headed Bristlebill	2		1	1	0	0	0	0	0	0	0
		3		1	1	0	0	0	0	0	0	0
		4		88	88	0	0	0	0	0	0	0
		5		6	6	0	0	0	0	0	0	0
		6		12	12	0	0	0	0	0	0	0
	Grey-headed Bristlebill Total			108	108	0	0	0	0	0	0	0
34	*Macrosphenus kempi* Kemp’s Longbill	4		3	3	0	0	0	0	0	0	0
		5		1	1	0	0	0	0	0	0	0
	Kemp's longbill Total			4	4	0	0	0	0	0	0	0
35	*Pyrrhurus scandens* Leaflove	4		1	1	0	0	0	0	0	0	0
	Leaflove Total			1	1	0	0	0	0	0	0	0
36	*Gallinula angulata* Lesser Moorhen	4		1	1	0	0	0	0	0	0	0
	Lesser Moorhen Total			1	1	0	0	0	0	0	0	0
37	*Andropadus virens* Little Greenbul	3		1	1	0	0	0	0	0	0	0
		4	1	51	52	0	0	0	0	0	0	0
		5		6	6	0	0	0	0	0	0	0
		6		1	1	0	0	0	0	0	0	0
	Little Greenbul Total		1	59	60	0	0	0	0	0	0	0
38	*Kaupifalco monogrammicus* Lizard Buzzard	4		1	1	0	0	0	0	0	0	0
	Lizzard Buzzard Total			1	1	0	0	0	0	0	0	0
39	*Alcedo cristata* Malachite Kingfisher	4		3	3	0	0	0	0	0	0	0
	Malachite kigfisher Total			3	3	0	0	0	0	0	0	0
40	*Camaroptera chloronota* Olive-green Camaroptera	4	2	39	41	0	0	0	0	0	0	0
		5		3	3	0	0	0	0	0	0	0
		6		2	2	0	0	0	0	0	0	0
		NA		1	1	0	0	0	0	0	0	0
	Olive-green Camaroptera Total		2	45	47	0	0	0	0	0	0	0
41	*Cyanomitra obscura* Western Olive Sunbird	3		2	2	0	0	0	0	0	0	0
		4	1	44	45	0	0	0	0	0	0	0
		5		11	11	0	0	0	0	0	0	0

		6		6			6	0	0	0	0	0	0	0
	Olive Sunbird Total		1	63			64	0	0	0	0	0	0	0
42	*Cinnyris chloropygius* Olive-bellied Sunbird	4		1			1	0	0	0	0	0	0	0
	Olive-bellied Sunbird Total			1			1	0	0	0	0	0	0	0
43	*Ceryl pictus* African Pygmy Kingfisher	4		1			1	0	0	0	0	0	0	0
	Pygmy Kingfisher total			1			1	0	0	0	0	0	0	0
44	*Terpsiphone rufiventer* Red-bellied Paradise Flycatcher	4		27		1	28	0	0	0	0	0	0	0
		5		9			9	0	0	0	0	0	0	0
		6		3			3	0	0	0	0	0	0	0
	Red-bellied Paradise Flycatcher Total			39		1	40	0	0	0	0	0	0	0
45	*Dyaphorophyia . blissetti* Red-cheeked Wattle-eye	4	1	7			8	0	0	0	0	0	0	0
		5		5			5	0	0	0	0	0	0	0
	Red-cheecked Wattle-eye Total		1	12			13	0	0	0	0	0	0	0
46	*Streptopelia semitorquata* Red-eyed Dove	4		2			2	0	0	0	0	0	0	0
	Red-eyed Dove Total			2			2	0	0	0	0	0	0	0
47	*Cisticola erythrops* Red-faced Cisticola	4		3			3	0	0	0	0	0	0	0
	Red-faced Cisticola Total			3			3	0	0	0	0	0	0	0
48	*Quelea erythrops* Red-headed Quelea	4		4			4	0	0	0	0	0	0	0
		(blank)		1			1	0	0	0	0	0	0	0
	Red-headed Quelea Total			5			5	0	0	0	0	0	0	0
49	*Smithornis rufolateralis* Rufous-sided Broadbill	5		1			1	0	0	0	0	0	0	0
	Rufous-sided Broadbill Total			1			1	0	0	0	0	0	0	0
50	*Burhinus senegalensis* Senegal Thick-knee	4			3		3	0	0	0	0	0	0	0
	Senegal Thick-knee Total				3		3	0	0	0	0	0	0	0
51	*Chlorocichla simplex* Simple Leaflove	5		1			1	0	0	0	0	0	0	0
	Simple Leaflove Total			1			1	0	0	0	0	0	0	0
52	*Pogoniulus scolopaceus* Speckled Tinkerbird	4		3			3	0	0	0	0	0	0	0
	Specked Tinkerbird Total			3			3	0	0	0	0	0	0	0
53	*Cinnyris coccinigastrus* Splendid Sunbird	4		1			1	0	0	0	0	0	0	0
		5		1			1	0	0	0	0	0	0	0

	Splendid sunbird Total			2			2	0	0	0	0	0	0	0
54	*Indicator maculatus* Spotted Honeyguide	4		1			1	0	0	0	0	0	0	0
		6	1				1	0	0	0	0	0	0	0
	Spotted honeyguide Total		1	1			2	0	0	0	0	0	0	0
55	*Vanellus spinosus* Spur-winged Lapwing	4		2	55		57	0	0	0	0	0	0	0
		5		1			1	0	0	0	0	0	0	0
	Spur-winged Lapwing Total			3	55		58	0	0	0	0	0	0	0
56	Square-tailed Drongo	4		2			2	0	0	0	0	0	0	0
				2			2	0	0	0	0	0	0	0
57	*Tutur tympanistria* Tamborine Dove	4		1		1	2	0	0	0	0	0	0	0
	Tamborine Dove Total			1		1	2	0	0	0	0	0	0	0
58	*Cinnyris minullus* Tiny Sunbird	4		3			3	0	0	0	0	0	0	0
	Tiny sunbird Total			3			3	0	0	0	0	0	0	0
59	Unknown (Label removed from vile)	4		2			2	0	0	0	0	0	0	0
		(blank)		1			1	0	0	0	0	0	0	0
		NA		2			2	0	0	0	0	0	0	0
	Unknown Total			5			5	0	0	0	0	0	0	0
60	*Dicrurus modestus* Velvet-mantled Drongo	4		1			1	0	0	0	0	0	0	0
	Velvet-mantled Drongo Total			1			1	0	0	0	0	0	0	0
61	*Ploceus cucullatus* Village Weaver	4		10			10	0	0	0	0	0	0	0
		5		1			1	0	0	0	0	0	0	0
	Village Weaver Total			11			11	0	0	0	0	0	0	0
62	*Spermophaga haematina* Western Bluebill	4		34		1	35	0	0	0	0	0	0	0
		5		3			3	0	0	0	0	0	0	0
	Western Bluebill Total			37		1	38	0	0	0	0	0	0	0
63	*Nicator chloris* Western Nicator	4		3			3	0	0	0	0	0	0	0
		6		3			3	0	0	0	0	0	0	0
	Western Nicator Total			6			6	0	0	0	0	0	0	0
64	*Dendrocygna viduata* White-faced Whistling Duck	4	1		378		379	113	0	0	0	0	0	0
	White-faced whistling duck Total		1		378		379	0	0	0	0	0	0	0

65	*Vanellus albiceps* White-headed Lapwing	4			3		3	0	0	0	0	0	0	0
	White-headed lapwing Total				3		3	0	0	0	0	0	0	0
66	*Neocossyphus poensis* White-tailed Ant Thrush	4		3			3	0	0	0	0	0	0	0
		6		1			1	0	0	0	0	0	0	0
	White-tailed Ant Thrush Total			4			4	0	0	0	0	0	0	0
67	*Phyllastrephus albigularis* White-throated Greenbul	2		1			1	0	0	0	0	0	0	0
		4		27			27	0	0	0	0	0	0	0
		5		6			6	0	0	0	0	0	0	0
		6		6			6	0	0	0	0	0	0	0
	White-throated Greenbul Total			40			40	0	0	0	0	0	0	0
68	*Halycyon senegalensis* Woodland Kingfisher	4		5			5	0	0	0	0	0	0	0
		5		1			1	0	0	0	0	0	0	0
	Woodland Kingfisher Total			6			6	0	0	0	0	0	0	0
69	*Ceuthmochares aereus* Yellow bill	4		1			1	0	0	0	0	0	0	0
	Yellow bill Total			1			1	0	0	0	0	0	0	0
70	*Camaroptera superciliaris* Yellow-browed Camaroptera	4		1			1	0	0	0	0	0	0	0
		5		1			1	0	0	0	0	0	0	0
	Yellow-browed Camaroptera Total			2			2	0	0	0	0	0	0	0
71	*Andropadus latirostris* Yellow-whiskered Greenbul	3		1			1	0	0	0	0	0	0	0
		4	2	82			84	0	0	0	0	0	0	0
		5	1	23			24	0	0	0	0	0	0	0
		6		6			6	0	0	0	0	0	0	0
	Yellow-whiskered Greenbul Total		3	112			115	0	0	0	0	0	0	0
	Grand total		10	844	439	5	115	123	0	0	0	0	0	0
	Percentage		0.8%	65.00%	33.8%	0.4%	1298	100%	9.5%	0.0%	0.0%	0.0%	0.0%	0.0%