EFFECTS OF GRASSLAND EDGES AND PLOT SIZES ON DISTRIBUTION, NESTING AND OCCURRENCE OF GRASSLAND-DEPENDENT BIRDS IN KINANGOP PLATEAU, NYANDARUA COUNTY, KENYA

By

Martin W. Mwangi

N50/CTY/PT/28559/2013

(B.Sc. Community Resource Management)

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DECLARATION

This is my original work and has not been submitted to any other university for a degree or any other award.

Signature………………………………………………..Date………………………..

Martin W. Mwangi

Reg. No.: N50/CTY/PT/28559/2013

We confirm that the work reported in this thesis was carried out by the student under our supervision.

1. Signature …………………………………..Date…………………………..

   Prof. Paul Kamau Mbugua

   Department of Plant Sciences

2. Signature ……………….............................Date …………………………..

   Dr. Geoffrey Macharia

   Department of Environmental Science and Education

DEDICATION

This thesis is dedicated to the private grassland owners of Kinangop Plateau whom conservation of these grassland specialist birds largely depends on.

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LIST OF ACRONYMS AND ABBREVIATIONS

CT	Cultivated Transect
FoKP	Friends of Kinangop Plateau
FT	Forest Transect
IBA	Important Bird Area
IUCN	International Union for Conservation of Nature
JW	Jackson’s Widowbird
LT	Longtailed Widowbird
RT	Road Transect
SLC	Sharpe’s Longclaw
T1	(Transect 1) 100m Wide Grassland Belt Next to the Edge
T2	(Transect 2) 100m Wide Grassland Belt Next to Transect 1
T3	(Transect 3) 100m Wide Grassland Belt Next to Transect 2
T4	(Transect 4) 100m Wide Grassland Belt Next to Transect 3

ABSTRACT

Kinangop Plateau is an Important Bird Area (IBA) hosting globally threatened bird species and lies west of Aberdare Ranges and east of Lake Naivasha, in Kenya. Fragmentation of the grassland since human occupation in the 1960s has created grassland edges with forest, road, and cultivated areas, yet little was known about how these edges affect bird distribution, nesting behavior, density and occurence. The study investigated the effects of habitat fragmentation on grassland-dependent birds, focusing on three umbrella species: Sharpe's Longclaw (*Macronyx sharpei* Jackson 1904), Jackson's Widowbird (*Euplectes jacksoni* Sharpe 1891), and Long-tailed Widowbird (*Euplectes progne* Boddaert 1783). Using purposive sampling of 23 plots covering 573.2 acres, bird population surveys, nest searches and nest monitoring were conducted along edges via belt transects and rope-drag methods. Results showed that birds preferred cultivated edges most (38%), followed by road edges (35%), with forest edges (27%) least preferred. Only 1 individual Sharpe's Longclaw was recorded from a Forest-edged grasslands out of 44 individuals recorded during the study. Jackson's Widowbird nested predominantly in cultivated edges (61%), with nest predation highest at road edges (75%) and lower (57%) in both Forest and Cultivated-edged grasslands. Plot size influenced Sharpe's Longclaw occurrence strongly, with 75% found in large plots (>20 acres), while Long-tailed and Jackson's Widowbirds were unaffected by plot size. The study recommends prioritizing conservation of large cultivated-edged grasslands, promoting medium to large - sized plots (medium = 5–20 acres and larger = >20acres) for Sharpes Longclaw, limiting forest encroachment into grasslands, protection and restoration of native tall grass species such as *Themeda triandra*, *Hyparrhenia filipendula*, *Andropogon amethystinus* and *Pennisetum cladestinum* used for nesting. Further research should be carried on Sharpe's Longclaw breeding and nest predation factors as well as engaging local communities in bird-friendly practices to reduce grassland fragmentation.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Biodiversity conservation is done across the globe within and without protected area. Grasslands across the world are the least represented in protected areas for conservation. Grassland conservation in privately owned land is a voluntary practice adopted by land owners and therefore conservation practices must consider opportunity cost foregone and ensure profitability (Cromwel and Van, 2000 and Askins *et al.,* 2007).

Anthropogenic land uses of the private grasslands in Kinangop which include; cultivation, animal grazing, artificial forest development, constructions e.g. houses and roads have led to natural habitats declining. Fragmentation has resulted in the remaining grassland plots being too small, highly affected by edge effects and/or too isolated. The loss of natural habitats is the worst threat to species conservation in this area as in most other areas of wildlife conservation. Decline in bird population in this region is expected and extinction of the endangered species has a higher stake than survival if management is not effectively done.

Kinangop Plateau is the stronghold habitat of the endangered Sharpe's Longclaw *Macronyx Shapei* Jackson, (1904) which prefers short grass with tussock (Ndang'ang'a, 2001), the near threatened Jackson's Widowbird *Euplectes jacksoni* Sharpe, (1891) and the locally common Longtailed Widowbird *Euplectes progne* Boddaert, (1783), BirdLife International, (2016). The grassland is not in a protected area and is rapidly vanishing. 50% of the grassland remained by the year 2000 with only 25% of the remaining grassland with tussock a favorable habitat for the endangered Sharpe's Longclaw

Macronyx Shapei. A 6th of the grassland was expected to have remained by 2012, (Ndan'gan'ga, 2001). Large farms subdivision is rampant in the grassland and different land uses are bordering the remaining grasslands creating different edge types.

Kinangop grassland was allocated to private farmers in the 1960s after independence (Republic of Kenya, 2009). Since then, anthropogenic land uses in the private grassland have resulted in the natural habitats decline (remaining grassland plots being too small, highly affected by edge effects and/or too isolated). Decline in bird population and diversity in this region is expected (Kruess and Tscherntke, 1994) and extinction of the endangered species has a higher stake than survival if management is not effectively done.

"Edge loving" or "edge avoiding" has been the categorization of different species in history (Imbeau *et al.,* 2003). This categorization means some species will generally avoid edge while others will have higher densities at habitat edges. Recent investigations show inconsistencies in response of species to different edges questioning previous knowledge (Bakker *et al*., 2002). The sensitivity of a species to edges is largely based on resource use of species in the ecological borders and nest predation rate at different edges (Ries and Sick, 2004). Boundaries between grasslands and forest, roads and cultivated fields form the common phenomenon in Kinangop and were used for this investigation. Grassland plots with suitable characteristics are expected to vary in size in the study area and this will be analyzed in co-relation to nest fate, density and occurrence of species.

A study by Mwangi *et. al.* 2022 estimated the percentage of grassland suitable for hosting the endangered Sharpe's Longclaw in Kinangop Plateau to be 1%. This grassland decline has trigerd conservation efforts of the highland plateau grasslands with several partners working towards salvaging the grassland. A local conservation group, Friends of Kinangop Plateau (FoKP) working with the Nature Kenya and other conservation partners, has secured four conservation reserves (200 acres). The reserves are managed with an objective of demonstrating favorable grassland management to the locals for conservation and economic gain. This is in addition to creating awareness and training farmers and grassland owners on optimal grassland utilization for livestock grazing and conservation for biodiversity. Besides these efforts, Kinangop grasslands is currently under serious threats and the habitat continues to be converted for other land uses. This has continued to create different grassland-edge types by the different anthropogenic land uses in Kinangop. A model by Hirschfeld (2013) predict that population that is isolated is at higher risk of going to extinction than population that are slightly connected. Therefore, knowledge of the habitat fragmentation effects i.e. edge, area and isolation is vital and very important to reserve designs, grassland and wetland managements.

1.2 Problem Statement

Like with all other species, bird species habitat requirements differ and generalization is impossible. Habitat edge effect is an underlined factor affecting the distribution of bird species. With habitats edges, positive, neutral and negative reaction from different bird species is expected. Different edge types are expected to have different effects to the distribution of a species in a habitat. This is as a result of the species difference in preference and use of neighboring habitat. Nest fate is also expected to be different in the present edge types in Kinangop grassland that include Forest, Roads and Cultivated Edges.

The success of management of any species habitat is influenced by the knowledge available for the specific species habitat requirement and understanding edge effects to threatened grassland species is an improtant tool in grassland management for these species.

The preference of the species to the different edge types, nest predation differences at Edge Setting and Interior Setting and the sensitivity of different species to different types of edges will be assessed in this study. Preferences and sensitivity to the different grassland edge types was measured using the birds' populations at belt transects established along the grassland edges. This had not previously been studied and this investigation will fill knowledge gap of great importance to grassland conservation in Kinangop and beyond.

A sixth of the natural grassland was expected to have remained in Kinanagop by the year 2012 (Ndan'gan'ga, 2001). Little is known about the effects of plot size on nest predation, occurrence and density of species in these grasslands. This investigation will provide an optimal grassland plot size suitable for species conservation.

There lies a critical research gap in understanding how the highland grassland species are affected by the edge types created as a result of habitat fragmentation. Many research works that focus on area sensitivity and edge effects across the globe are based on forests and tall grass prairie and there falls a gap on other ecosystems. This has in turn resulted in a higher percent of assumption by grassland habitat managers. This investigation will improve the understanding and inform decision makers in reserves and private plot owners on best practices of grassland management. There is no available information on the effects of plot size and edges in these grasslands. More research is therefore needed to inform conservationist and grassland managers on the effects expected if certain edges and plot sizes are in existence.

1.3 Research Questions

1. What edge does each species prefer and how sensitive are the species to Forest, Cultivated or Road Edges?

2. How nest distribution in the study sites is and is nest predation higher at edges than at Interior Settings?

3. Do plot sizes determine predation rates, density and occurrence of the birds?

1.4 Overall Objective and Specific Objectives

The main aim of this research was to find out how habitat fragmentation and other alterations by land owners affect the birds and nest distribution and success of grassland bird species with a view to enhance habitat management and conservation in Kinangop Plateau Nyandarua County. Specific Objectives:

1. To evaluate species preference and sensitivity to grasslands with forest, road and cultivated edge types.
2. To determine nest distribution and nest success in the study sites.
3. To assess plot size effects on nest fate, density and occurrence of the species.

1.5 Research Hypothesis

H_{01}: There is no significance difference insensitivity of the birds to the three edge types.

H_{02}: There is no significance difference in sensitivity of the birds to the three edge types.

H_{03}: There is no significance difference in nest distribution between Edge Setting and the Interior Setting.

H_{04}: There is no significance difference in nest predation between Edge Setting and the Interior Setting.

H_{05}: Plot size has no significance effect to birds occurrence.

H_{06}: Plot size has no significance effect to nest fate.

H_{07}: Plot size has no significance effect to birds' density.

1.6 Significance of the Study

Effective and efficient habitat management for the benefits of species management require clear understanding of habitat requirement of the species in question. Therefore, it is paramount to understand how fragmentation affect the distribution and nest success of species. The findings of this study are a powerful tool for grassland habitat management. Correct decisions using the right information ranging from edge preference of different species to optimal plot sizes will be made. Conservation interventions for highland grassland bird species will use these results to inform program designing for better species and habitat conservation.

1.7 Definition of Operational Terms

Biodiversity Conservation-the management and maintenance of biosphere and ecosystem functions to ensure optimum diversity of species and genetic variability within species.

Preference- the liking and selection of a specific grassland Edge type over other grassland Edge types

Sensitivity- Measure of general avoidance species to edge types measured by the difference in numbers of individuals found at edge and Interior Settings/ different transects

Edge- a distinct habitat boundary created as a result of intersection of two habitat community structures

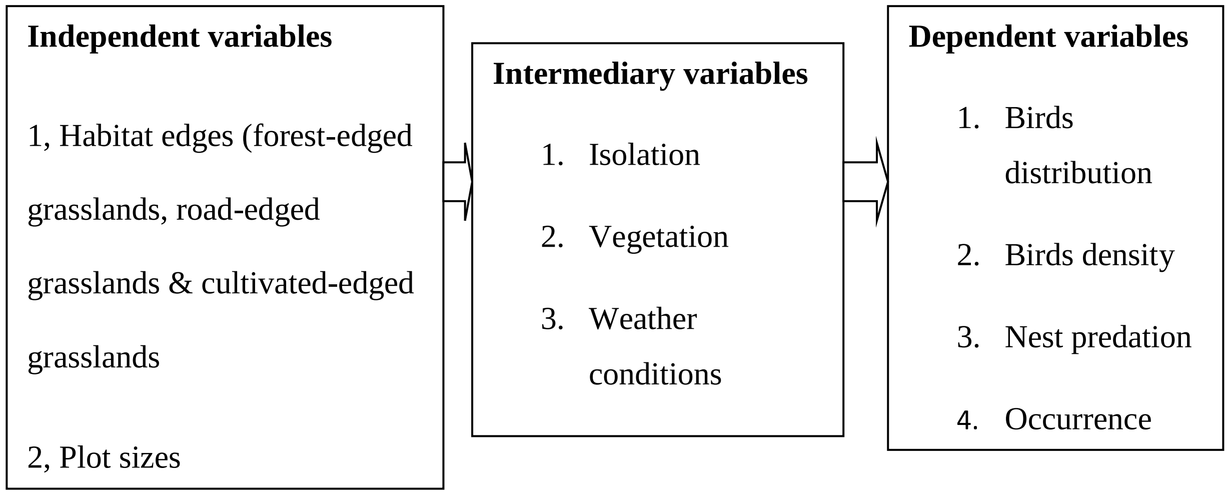
Edge Setting- transect one belt (0-100 meters along the edge of grasslands)

Interior Setting- Transects two, three and four belts (101-200, 201-300 and 301-400 meters along the edges of grasslands)

Grassland Specialists/ Grassland Dependent Birds- Birds that rely strictly on grasslands for their food, security and breeding needs.

1.8 Conceptual Framework

Figure 1. 1 Conceptual Framework Illustration



As in Figure 1.1, anthropogenic land uses including: cultivation, forest development and road construction has led to the three common ecological boundaries (grassland-forest, grassland- cultivated and grassland-road) that have an impact to the distribution, density, occurrence and nest success of the bird's community in Kinangop grasslands. Changes in grassland plot sizes are also expected to affect density, distribution, species occurrence, and nest predation of birds. Distribution of birds in any of the three grassland edges will be determined by the sensitivity of different species to the different edge types.

1.8.1 Conceptual Mode

The model is a researcher's conceptual framework that shows the interaction of variables in the Kinangop grasslands. These variables were used to compare and correlate different observations and changes from the field.

CHAPTER TWO: LITERATURE REVIEW

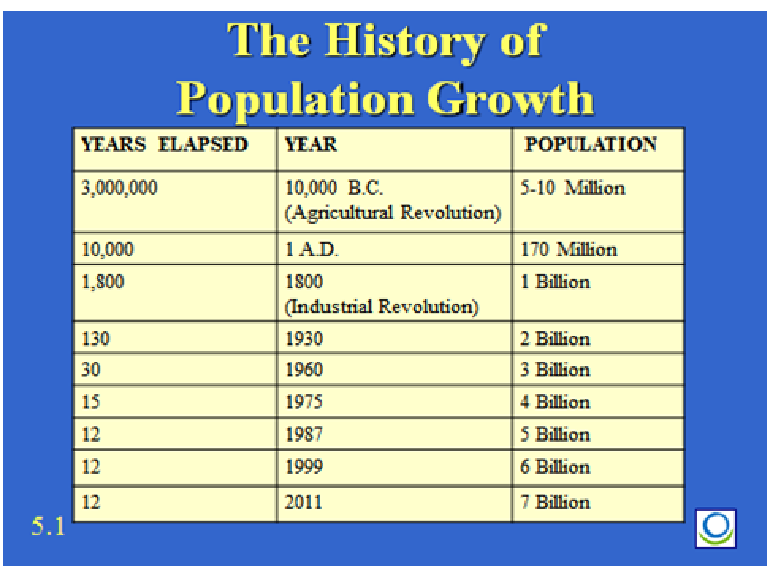
2.1 Introduction

This chapter reviews the available literature on and around the factors of interest in this study. The literature gives an insight of what is known, expected trends in fragmentation, habitat edges and in turn the population of the birds in the grassland.

2.2 Human Population Growth

1 billion people were the number of people by the year 1850. As per Figure 2.0 bellow, this population reached 7 billion by the year 2011 (Kleinman, 1980). This is a clear indication that global population is gradually and continually increasing. Human demographical transition starts in different times in different parts of the world. This change is either slowly or rapidly with internal and international migratory factors taking part.

Figure 2. 0 Population Growth History. Source: www.populationeducation.org



The History of Population Growth

YEARS ELAPSED	YEAR	POPULATION
3,000,000	10,000 B.C. (Agricultural Revolution)	5-10 Million
10,000	1 A.D.	170 Million
1,800	1800 (Industrial Revolution)	1 Billion
130	1930	2 Billion
30	1960	3 Billion
15	1975	4 Billion
12	1987	5 Billion
12	1999	6 Billion
12	2011	7 Billion

5.1

Kenya is not an exception in the world's population trends and the population is rapidly growing. In 1969 the population was 10.9 million people a figure that had more than tripled in the year 2009 to reach a figure of 38,610,097 (Republic of Kenya, 2009). Population increase largely contributes to reduced land ownership for rural communities (The Kenya Population Data Sheet, 2011).

Settlement by small scale farmers in the Kinangop plateau grassland started in 1963 after Kenya gained its independence and now the area is densely populated (Bennun and Njoroge, 1999). It has a population of 192, 367 according to The Republic of Kenya Census, (2009). As with the world population organization, the human population in the Kinangop grasslands is expected to rise as it is the case with the rest of the country increasing the human detrimental effects to the natural habitat in Kinangop (Scanes, 2018).

2.3 Social Economic Status

Man derives economic resources from the biotic and physical environment using skills and technologies (Singh, 2006).Climate change and poor market structures have led to unreliable produce payment leading to farmers in Kinangop to favor cultivation than livestock rearing (Bennum and Njoroge, 1999). This is increasing pressure on land causing a complex economic and environmental combination (Rayman and Pisano, 1999). The pressure is much more with the increasing population leading to fragmentation of the grassland for different land uses. This is having a negative impact to the native biodiversity e.g. the Sharpe's Longclaw (Lens *et al.,* 2000).

2.3.1 Land Ownership and Conservation Plots in Kinangop Plateau

The residents own small pieces of the grassland. This farms being part of their capital, they are used to make a living (Ndang'ang'a, 2001). Land being a production capital, the quality and grassland extent is found to be reducing with decrease in farm size. Remaining patches are degraded due to overgrazing on the already reduced farms. Daily farming labor is reduced when patches have larger pastures and this makes farmers with large pasture prefer retaining it. This though remains a challenge as the population of the people is increasing and there is pressure of subdivision due to cultural and economic reasons (Muchai, 1998).

Friends of Kinangop Plateau (FoKP) a group of volunteers working in partnership with world Land Trust and Nature Kenya has purchased over (200) acres of grasslands. These grasslands are being used for biodiversity conservation and are managed as demonstrations of suitable grasslands to famers in the Kinangop grassland

2.4 Anthropogenic Land Uses in Kinangop Plateau

As stated by Solow (1974), natural resources can be conceived as natural capital. Development therefore can be taken as a process through which assets are selected by society to meet their need. This in-turn means that development causes natural resource imbalance because nature had itself at balance with the 100% assets or resources. Natural stock reduces in a given country as the country goes through development process.

Developing and less developed countries are the places where most of the poor population lives. These people largely depend on rain fed agriculture due to the economic implication of irrigating farmlands. As a result, large parches of land are used to produce food and cash crops than they would have if they used irrigation for production. This causes an increased pressure to natural habitats like grasslands and forest through conversion and introducing new crop species and endangering the native species (Grau *et al.,* 2015).

Kinangop grassland being good quality farming land is largely inhabited by agriculturally based communities. This communities mostly practices small scale farming on the cultivated areas of grassland. They grow beans, maize, potatoes, peas and cabbages for food crops and wheat, pyrethrum and flowers for cash crops. The community also practices daily farming; keeping cattle, goats and sheep, though production in the area is mainly on cultivation (Lens *et al.,* 2000). Last but not least, the plateau is dominated by *Setaria verticillata, Hyparrhenia filipendula Aristida* spp., *Cymbopogon excavatus, Pennisetum* spp., *Eleusine* spp., *Panicum* spp. and *Cyperus rotundus* (Muchai *et al.*, 2002) in the grassland is ploughed as it is not palatable to livestock. This is expected to cause more threat to the already pressured biodiversity in the coming years as demonstrated by Ndang'ang'a (2001) an investigation that this study will add edge information to.

2.5 The Kinangop Grasslands Threat

Habitats across board face different combination of threats making management of each habitat unique to its location, neighborhood, weather patterns and community of species in the specific habitat (Muchai *et al*. 2002). Kinangop grassland was greatly in natural state before the area was given out for human settlement after Kenya gained independence in 1963. Threats of the Kinangop grasslands include: burning (Shown in

Plate 2.1) and/or digging up the tussock grassland due to un-palatability of the tussock, conversion of the grassland to cultivated farms used to grow potatoes, peas, maize and wheat as shown in Plate 2.2 (Muchai *et al*., 2002).

Plate 2. 1 A Regenerating Grassland from an Earlier Intentional Burning

Plate 2. 2 A Freshly Converted (cultivated) Grassland by a Private Owner

Daily farming i.e. open grazing which is compatible to conservation of grassland is being shifted from as farm size decreases with increase in population and lack of secured markets that are reliable for their daily products.

Planting of woodlots is another threat to the Kinagop grassland. The community extensively uses wood for fuel thus prompting them to plant woodlots that in-turn changes the grassland to forested patches. Exotic species like the Eucalyptus has been introduced in the plateau and is being used for firewood and poles (Rayment and Pisano, 1999). This has informed this study to include the forest-grassland edge as one of the edges of interest. It is expected therefore that, with population increase, demand for economic and cultural resources is going to rise and more habitats will be threatened. This calls for more research to be done to streamline habitat requirements knowledge for specific species in the Kinangop grassland.

2.6 Fragmentation

Fragmentation is a phenomenon where alteration of habitats occurs resulting to breakage of a previously existing continuous habitat. Fragmentation by humans is largely caused by deforestation or aforestation, agricultural conversion, introduction of exotic species and/or pollution (Dale *et al,* 1997). Natural processes can also be a causal factor to fragmentation through volcanic activities and glacial advances. This separation effects to the species in the habitats will depend on the distance between the habitat units and the specific species production dynamics.

The problems of fragmentation to biodiversity arise as the resultant habitats are too isolated, too small or are highly affected by their edges. The area of a fragmented habitat is reduced; habitats are separated and sometimes isolated (Jonson, 2001). The distance between habitats and the size of each habitat unit are factors that may affect the population distribution and population size and will therefore partly form a basis of this study.

2.6.1 Species Implication

Habitat fragmentation has been proven to reduce species richness and the efficiency of the ecosystem together with reducing taxon diversity (Kruess and Tscharntke, 1994). Fragmentation causes a reduced habitat functional capacity and isolates species population to sub populations which might be close to minimum variable population size (Kruess and Tscharntke, 1994).

To the grassland bird species, the increased edges in fragmented habitats is likely to lead to avoidance, high rates of predation difference in availability of prey and pairing success differences. All these impacts of fragmentation can affect the occurrence, density and reproductivity success of grassland dependent birds (Winter, 1998). Kinangop grasslands are in rapid fragmentation and this is expected to produce a rolling effect to the individual species of which this study aims to describe and explain.

2.7 Habitat Edges

Habitat edges increase as a result of habitat fragmentation and has been proven to reduce species richness and the efficiency of the ecosystem together with reducing taxa diversity (Kruess and Tscharntke, 1994). Fragmentation causes a reduced habitat functional capacity and isolates species population to sub populations which might be close to minimum variable population size (Kruess and Tscharntke, 1994).

Edges can alter population structures, dynamics, affect conservation efforts and can also affect spread of invasive species. Edges also have an impact on the ecological interaction strength and nature (Koper *et al*., 2007). Community structures and population density is affected by edges (Cooper, 2002). This makes it comparative to study the effects of edges in an objective way to quantify demographic impacts of edges through ecologically based ways (Harper *et al.,* 2005). Research for many decades have classified species as 'edge avoiding', 'edge loving' and 'neutral', but due to different responses to deferent edges by different species, the labels have been call into questions. It is therefore worth and better categorizing species depending on their sensitivity to different edges and not the direction of response (Ries and Sick, 2010). Species labeling according to edge response should therefore consider responses made by the species in different edge types. An extensive review brought to this study a predictor model that different species will probably show a mixture of responses in different edge responses that is negative, positive and neutral (Ries and Sick, 2008).

The most occurring edges types in Kinangop Grasslands are cultivated, Forest (Shown in Plate 2.3) and road (Shown in Plate 2.4) Edge types established by the development of cultivated plots, artificial forest development and road construction.

It is not only important to understand the effects of different edge types to species but also to understand some of the factors that may cause the species to be edge sensitive or insensitive i.e. positive, negative or neutral response (Kettle and Koh, 2014). Organisms will have less or no response to habitat edges with complementary resources and that species should avoid edges with less preferred characteristics. Conservation of species is largely based on its habitat preference (Ries *et al.,* 2004)

Plate 2. 3 Cows Grazing in a Forest Edged-Grassland Study Site

Plate 2. 4 Cows Grazing in a Road-Edged Grassland Study Site

As described by Ries and Sick (2004) these edge types are expected to affect the grassland dependent bird species differently.

2.8 Ornithological Community in Kenya

Kenya is the second in the number of bird species recorded in African Countries from the Democratic Republic of Congo. It is a bird watchers paradise with over 1,100 species. Among these species, 8 are endemic, 40 of global conservation concern with 2 being endangered and 4 are critically endangered (Stattersfield *et al.*, 1998). Kenya has diverse habitats due to its diversity in topography which include Mountains with its snow capped peaks, fresh and alkaline lakes and the rift valley: a coast line of 550km, coral cliffs, wetlands of around 10,700km^2 sand beaches, forests and moorlands. This diversity of habitats holds a large diversity of Bird species with each having its unique combination of species (Fishpool and Evans, 2001).

2.8.1 Ornithological Community in Kinangop Grassland

Diversity of habitats holds a large diversity of Bird species with each having its unique combination of species (Fishpool and Evans, 2001). Kinangop grasslands are among the global conservation areas listed as Important Bird Areas (IBA) No. 4 in the list of 64 IBAs of Kenya. It is the stronghold habitat of the endangered Sharpe's Longclaw *Macronyx sharpei* together with other species of global conservation concern in a list of close to 200 birds species. The grasslands are privately owned and fragmentation and conversion of the grassland to other land uses is happening at an alarming rate, a factor that led to Ndag'ang'a (2001) proposing prioritization of management of large grassland plots in the area for conservation.

The Kinangop grasslands are being lost to conversion and fragmentation, a factor that led to Sharpe's Longclaw being listed as endangered by the Birdlife International

(Birdlife International, 2016). The species only occurs in grassland unlike many other species in these grasslands that also use cultivated land for survival. It also has a high preference to short grass with tussock (Muchai, 1998 and Bennun and Njoroge, 1999).

2.9 Literature Gaps

Despite increasing awareness of the threats posed by habitat fragmentation, most existing studies on edge effects and area sensitivity have predominantly focused on forest ecosystems and tallgrass prairies in North America and Europe. This creates a significant knowledge gap in understanding how similar processes manifest in *highland grassland ecosystems* such as those found in the Kinangop Plateau, Kenya. The unique structure, biodiversity, and land use dynamics of these grasslands demand localized research, yet few empirical studies have been conducted within this context.

Notably, the Sharpe's Longclaw and other grassland-dependent bird species endemic to Kinangop are under increasing threat from anthropogenic land use changes. While it is known that grassland area is rapidly declining with only about 1% remaining as suitable habitat little is understood about how specific edge types (e.g., forest, cultivated, and road edges) influence species distribution, nest success, and predation risk. Previous studies (Ndang'ang'a, 2001 and Mwangi *et al.*, 2022) have documented habitat loss and some broad impacts, but they fall short in analyzing species-specific responses to different edge environments, variation in nest fate, or the influence of plot size on bird population metrics.

Furthermore, there is no published data on the optimal grassland plot size required to sustain viable populations of Kinangop's endemic and endangered bird species. This represents a critical omission, particularly in guiding conservation reserve design and informing best practices for grassland management on private lands.

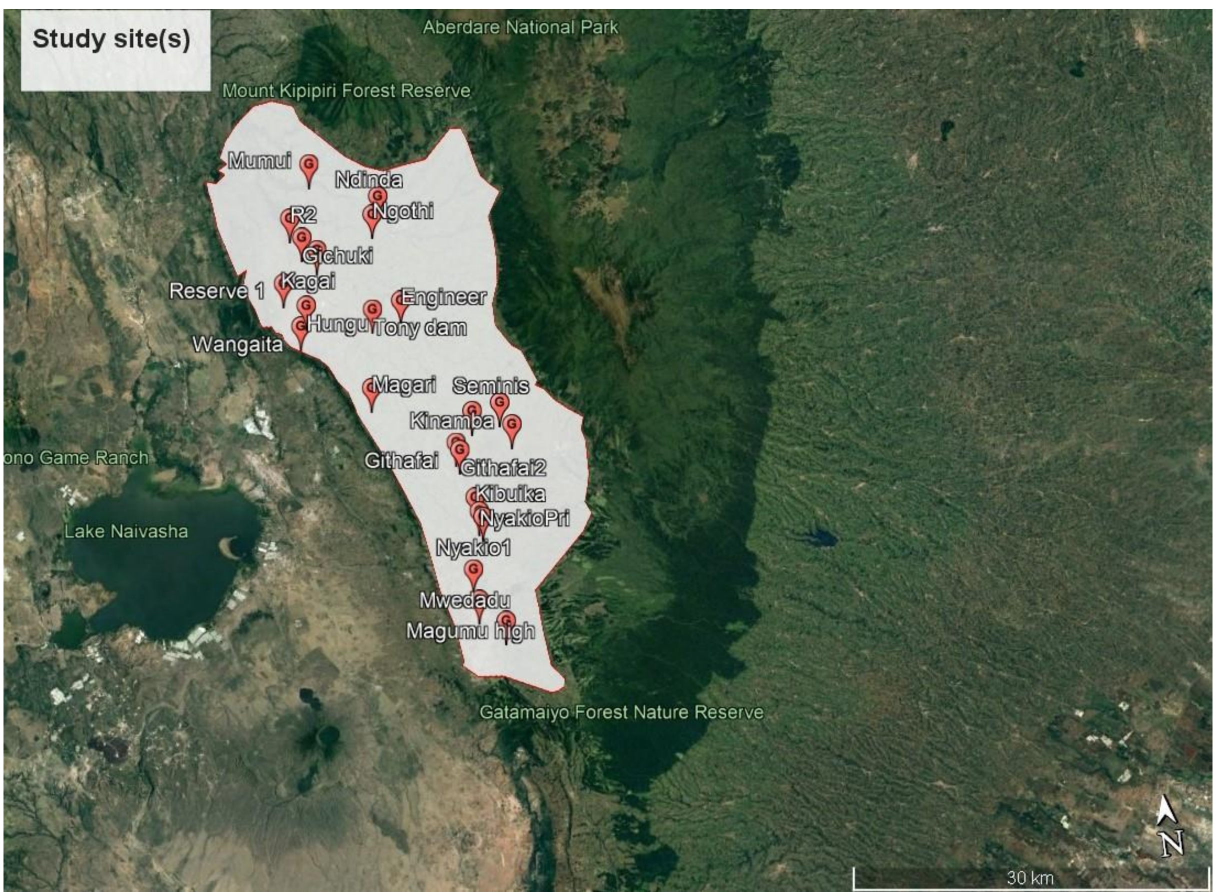
The findings will not only enhance scientific understanding of grassland bird ecology in highland regions but also provide a vital decision-making framework for stakeholders engaged in conservation and sustainable land use planning in Kinangop and other similar ecosystems. The findings will also critically improve the understanding of priority edge type for improved conservation status of grassland bird species in Kinangop and similar grasslands.

CHAPTER THREE: STUDY AREA, MATERIALS AND METHODS

3.1 Description of Study Area

The study was undertaken in the highland grassland of central Kenya; Nyandarua County on the Kinangop Plateau -0.520426, 36.519552 that lies West of the Rift Valley and east of Aberdare Range. The montane grasslands are within the range of 2400 to 3000 meters above sea level and cover an area of 77,000 hectares as in Figure 3.1. The grasslands are on the Aberdare's rain shadow as described by (Bennun and Njoroge, 1999). It has a yearly rainfall of around 1000mm.

Figure 3. 1 Study Sites in Kinangop Plateau Map



The plateau is among the 64 Important Bird Areas in Kenya (IBA No. 4) (Bennun and Njoroge, 1999). The area is the stronghold habitat for the endangered and endemic Sharpe's Longclaw at a density of 40 birds/ km^2 by the year 1996 (Muchai *at al*., 2002).

3.2 Site Selection

Purposive sampling was used to select study sites in the grasslands and to ensure sites with tussock are selected. As in the sample grassland in Plate 3.1m, each study site had all or part of the tussock native grasses including but not limited to: *Setaria vericillata*, *Hyparrhenia hirta, Cybopogon excavatus, Eleusine jaegeri, Eragrostis botruodes, Pennisetum hohenackeri, Andropogon amethystinus and H. tamba* (Muchai *et al.*, 2002).

Plate 3. 1 A Sample Grassland in Kinangop

Grassland–road edges typically exhibit shorter, patchy grass cover, and more invasive species due to disturbance, resulting in lower biodiversity. Grassland–forest edges tend to have taller, denser native grasses, higher humidity, and richer species diversity, including both grassland and forest-edge birds. In contrast, grassland–cultivated edges show variable grass structure, moderate disturbance from farming, and often reduced native biodiversity due to agrochemical use and habitat modification. Each edge type reflects distinct ecological pressures, influencing vegetation, soil, and biodiversity (Ndan'gan'ga *et al*., 2002).

Study sites were distributed across Kinangop plateau as shown in the distribution map in Figure 3.1. The chosen sites had continuous native grass extending from the edge. Study sites with Forest Edges, Cultivated Edges and Road Edges were selected. Roads across plots with disturbed sides will be considered as edges. Tree-strips dividing grasslands beyond 75% were considered a barrier and therefore two plots exist (Winter *et al.,* 2000).

3.5 Study Design

The research adopted descriptive study design to help explain how the three representative grassland dependent species respond to different edges and evaluate the causes of the response through analysis of nest predation in the three different edge types.

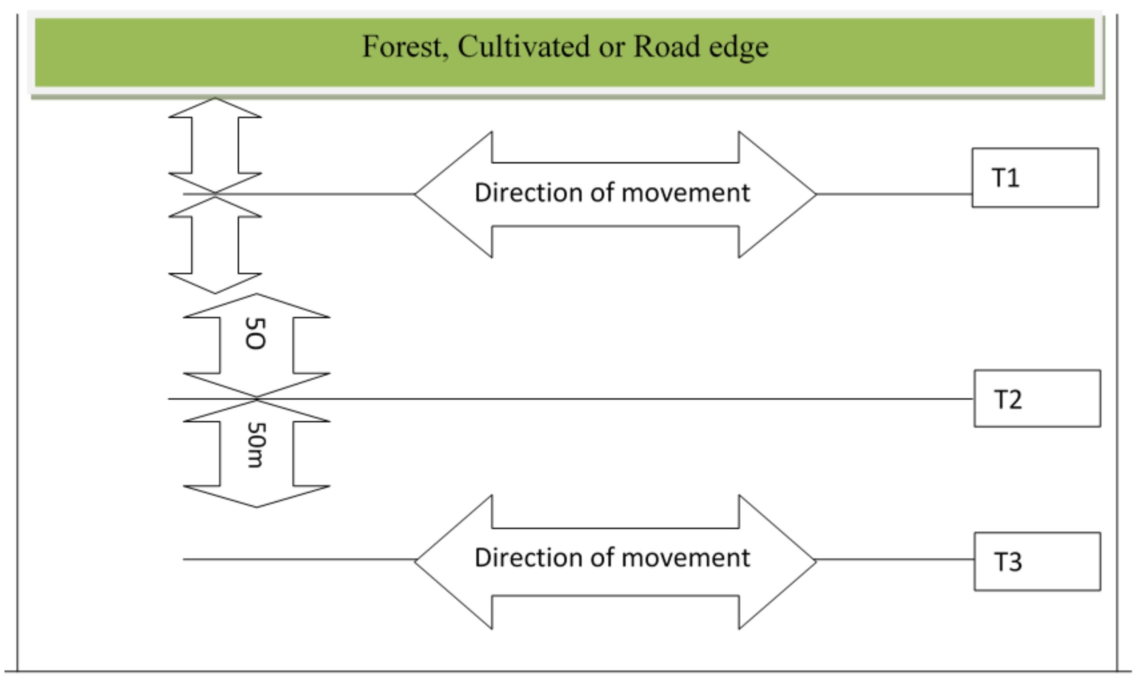
3.6 Sample Determination

Sampling ensured coverage of >10% of the 7700 ha potential habitat in the Kinangop grasslands. This ensured an optimum volume of data much enough to be a representative of the entire grassland and little enough to be collected in the four months study period.

3.7 Bird Counts

Bird counts were done in a standard method in fixed distances along transects as shown in Figure 3.2. Counts were conducted twice at each study site between April-July 2017 breeding seasons. Transects (T) parallel to the edges (Verner, 1985) were established; transect 1 (T1) at 50m (almost twice the *Macronyx sharpei's* home range (Muchai, 1998)) from the edge, transect 2 (T2) at 150M from the edge (100m from T1) and the rest transects with 100M spacing. Bird counts were done from 06:00am-10:30am, as birds are more active at this time. The investigator walked at a standard constant speed of 20m per minute slow enough to ensure accuracy in observation and first enough to avoid double counting (Verner, 1985). The researcher also altered the order of census on transects between interior and edge transects in the two visits to average possibility of changes in activity of the birds. Transect T1 and T3 in one day and T2 and T4 in another day to avoid double count (Cooper, 2002).

Figure 3. 2 Data Collection Transects Illustrations



The birds heard or seen within 50M along each transects were counted and recorded in a data sheet (attached in Appendix 4 regardless of the detection method (i.e. parched or flushed either from nest or ground). Observations were not done during heavy rain to ensure accuracy in visibility and hence data collected.

3.8 Nest Location

Rope method was adopted to find natural nests (systematically dragging a 25m rope) within area adjacent to edges in the study sites (Winter, 1999) as shown in Plate 3.2. Nests of all species found were marked with a flag, 4m to the east and monitored every 2-3 days with special interest to the ones of the three species (umbrella species) to this study. Data on nest distance from edge and fate of nest (successfully fledged or failed to fledge) was recorded.

Plate 3. 2 Rope Method Used to Find Nests

Nest fate was determined by regularly monitoring each located nest every 2–3 days until its outcome could be classified as either successful or failed. A nest was considered successful if at least one chick fledged from it, while failure was recorded if the nest was found empty before the expected fledging date, destroyed, or abandoned with no signs of fledging. Signs such as predation, abandonment, or egg disappearance were used to assess nest failure. Observations were made carefully to minimize disturbance, and monitoring continued until a definitive outcome could be recorded for each nest.

3.9 Plot Sizes

To delineate the size of plots for statistical purposes, the circumferences of all study sites were taken and the area calculated using the Garmin *e*Trex^{R} 20 GPS. Roads across plots with disturbed sides were considered as edges.

3.10 Species Selection

Three species acted as umbrella representative species for other bird species in the grassland using the following criterion of species selection;

a) The IUCN Red List status of the species,

b) Grassland specialists, having almost similar habitat characteristic requirements therefore logical and practical to find them in the same grasslands in some plots,

c) Territorial during breeding- having shorter movements during breeding.

The endangered Sharpe's Long-claw (*Macronyx sharpei)*, Longtailed Widowbird (*Euplectes progne)* and the near threatened Jackson's Widowbird (*Euplectes jacksoni)* were selected as suitable for this study.

Data was collected for all species spoted in the grasslands during the study period with special focus on the three grassland specialists i.e. the endangered Sharpe's Long-claw, Longtailed Widowbird and the near threatened Jackson's Widowbird.

3.11 Study Species

3.11.1 Sharpe's Longclaw *Macronyx sharpei*

Sharpe's Longclaw *Macronyx Shapei* Jackson, 1904. Is a scarce resident of central highland grasslands (in Kinangop Plateau, Mau Narock, Ababerdare and Uasi Ngishu) is a medium sized (7.5=8 inches) bird of the grasslands (Dale, *et al.*, 1999). Shown in Plate 3.3, it is yellowish with black marks to the back and a neck lace of streaks on its neck.

Plate 3. 3 Sharpe's Longclaw; *Macronyx sharpei* on short *Eleusin*e *spp*

Sharpe's Longclaw inhabits short grazed and moist tussock grassland of 1850-3400M above sea level and is a localized endemic resident Kenya species (Stevenson and Fanshawe, 2006). It has a density of 1.2 birds per ha and it nests and forages around tussocks (Bennun and Njoroge, 1999) with a mean home range of c.0.5 ha (Muchai, 1998).

3.11.2 Jackson's Widowbird *Euplectes jacksoni*

Parched in *hyparrhenia filipendula* grass species, the Jackson's Widowbird *Euplectes jacksoni,* Sharpe, (1891) is a black bird on the back and streaked buff which has tawny primary wings and a curved tail with dark streaks on sides and on the breast. Its bill is pale The non-breeding males and females are 5.5 inches in length while a breeding male develops a long tail reaching a maximum of 11-12 inches long as shown in Plate 3.4 (Dale *et al.*, 1999).

Plate 3. 4 Male Jackson's Widowbird; *Euplectes jacksoni*

The species exhibits lekking behavior during breeding season. Males congregate in open grassland leks where they establish small territories and perform elaborate displays to attract females. These displays involve exaggerated vertical flights and the exhibition of their striking breeding plumage, including long, flowing black tail feathers and golden-yellow shoulder patches. The males repeatedly leap into the air from perches or the ground, flaring their plumage in dramatic fashion to compete for female attention. Females visit the leks to observe and select mates based on the quality and vigor of the displays, while the males provide no parental care after mating. The behavior reflects strong sexual selection and plays a critical role in the species' reproductive success.

The Jackson's Widowbird is a resident of the highland grasslands (1500-3000M above sea level) in the North eastern part of Tanzania and west and central part Kenya (e.g. Mara Game Reserve, Nguruman Hills, Loliondo, Nairobi and Kinangop. It is listed as a near threatened species (BirdLife International, 2016). The species situation might be critical due to its grassland habitat loss. The species is polygamous and highly territorial.

3.11.3 The Longtailed Widowbird; ***Euplectes progne***

Perched in a small shrub within the long *hyparrhenia filipendula* grass species, Longtailed Widowbird *Euplectes progne* Boddaert, (1783) is also known as 'Sakabula'. It is a highland grassland species in altitudes 1800m and above.

Plate 3. 5 Male Longtailed Widowbird; *Euplectes progne*

As shown in Plate 3.5, it has scarlet and buff wing coverts, with the non-breeding males and female at 8 and 6 inches respectively and breeding males developing a long tail (24-28 inches) during the breeding season. The bill is pale grey-blue with wings broad in the slow flights during breading (Dale *et al.*, 1999). It is a common species in African grasslands with three known isolate populations; one in the Kenyan central highlands, the second in Angola, Southern Zaire and Zambia and the third one in South Africa. It feeds on seeds with arthropod as supplements mostly on ground (Hockey *et al.*, 2005) It is polygamy and highly territorial with no long movements during breeding seasons

3.12 Nest and Eggs Description

Nests of grassland bird species were carefully examined to record their structural and dimensional characteristics. Using a Vernier caliper and ruler, measurements of nest length and width were taken, with emphasis on the exterior dimensions to assess overall nest size. Additionally, the diameter and height of the nest entrance and the nest materials were recorded. Egg characteristics were also documented in detail. Egg shape was noted and color patterns were described. A digital weighing scale was employed to measure egg mass (in grams), ensuring precision. These measurements provide critical insights into species-specific nesting strategies and reproductive investment in highland grassland habitats.

3.13 Photography

The photography imagery used in this report was intended to give detailed illustrations and clarification of aspects of the study that needed further details that could be well captured by use of imagery. The images are also used for data backup for use in feature.

3.14 Data Analysis

Data analysis considered the hypothesis and objectives. A list of all birds recorded in the study sites and the location from edges was generated. Testing of edge effects was done through comparing bird count data for abundance, nest densities and distribution.

Species population data in different transects, was analyzed using Microsoft Excel Packages and SPSS. The chi-square tests were done to compare species population at same transects in different grassland-edge types. Frequency tests were done to analyze the number of nests at same transects in different grassland-edge types.

Multiple logistic regressions were done to check for differences in nest fate (success versus failure) in the edge and Interior Settings of the three edge types. Nests <100m from edges were considered nests at Edge Setting while >100m from edge were considered as Interior Setting nests.

Plot sizes effects on density, occurrence and nest predation of the species was also analyzed by linear regression. The study site sizes were compared to the total number of species sported the occurrence of the three desired species (Sharpe's Long-claw, Longtailed Widowbird and Jackson's Widowbird) and the predation rates to the nests in the specific sites.In designing this study, there were efforts to minimize limitations. However, only the desired edge types (Cultivated-Edge, Forest-Edge, and Road-Edge) were investigated, with less consideration to the topography and difference in vegetation coverage in the study sites. The budgetary and time constraints made it impossible to investigate vegetation in the study sites which changes in density with the seasons and therefore more time would be needed to investigate.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results of preference of species to different habitat edges during foraging and breeding. The distribution and densities of Sharpe's Long-claw, Longtailed Widowbird and Jackson's Widowbird species in grasslands with different edges is also presented. Nest predation rates, differences at Interior and Edge Settings and the effects of plot sizes to the occurrence, distribution and density of Sharpe's Long-claw, Longtailed Widowbird and Jackson's Widowbird in Kinangop grasslands is also presented. In addition, this chapter gives results of hypothesis testing as well as detailed discussions of the interpreted data sets.

4.2 Study Sites

For a period of four (4) months starting early April to Late July 2017, a total of 23 grasslands were used as study sites for this investigation. These are normally high rainfall months for this region (Muchai, 1998) and a breading season for the three umbrella species used in this investigation. 10 were Cultivated Edged, 6 were Road Edged and 7 were Forest Edged as shown in Table 4.1.

Table 4. 1 Break Down of Study Sites as per Edge Types

Grassland Edge Types	Number of Grasslands	Total Area covered (Acres)
Forest Edges	7	68.1
Road Edges	6	277.2
Cultivated Edges	10	227.9
Study Total area covered	23	573.2

A total area of 573.3 Acres ware covered for this investigation. Notably, the season did not receive the anticipated heavy rainfall and this affected the breeding and local migration seasons of birds specifically for the Sharpe's Longclaw and the Jackson's Widowbird respectively

4.3 Species Edge Preference and Sensitivity

Species preference and sensitivity was indicated by the population at different transects shown in Table 4.2 below.

Table 4. 2: Population of All Bird Species Recorded in the Respective Transects

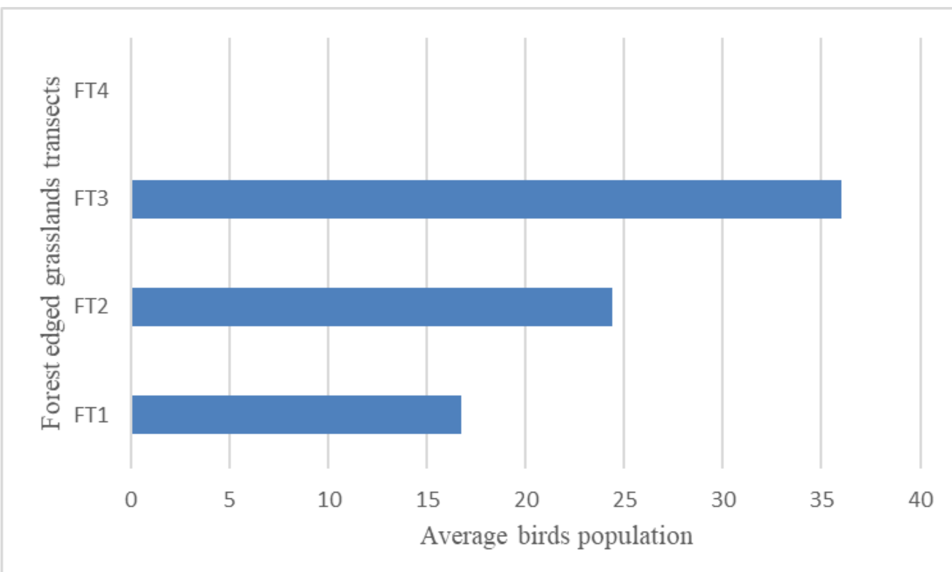
Forest Edges	No. of Plots	Sum of All Birds Recorded
FT1	7	177
FT2	5	122
FT3	1	36
FT4	0	0
Road Edges		
RT1	6	195
RT2	5	79
RT3	3	104
RT4	3	204
Cultivated Edges		
CT1	10	340
CT2	9	414
CT3	2	55
CT4	1	23

The bird's population at differcent edges and transects was used to generate the population averages in Appendix 2. The averages of birds in transects of the different grassland grassland edges was used to generate species preferences and sensitivity graphs in Figures 4.1, 4.2 and 4.3 below; forest effects, road effects and Cultivated grassland edge effects respectively.

4.4.1 All Species Sensitivity to Grassland-Forest Edges

As indicated by Figure 4.1 the average population of all species recorded in the Forest Edged grasslands increased consistently for the three transects recorded i.e. FT1, FT2 and FT3

Figure 4. 1 Birds Average Population at Forest Transects

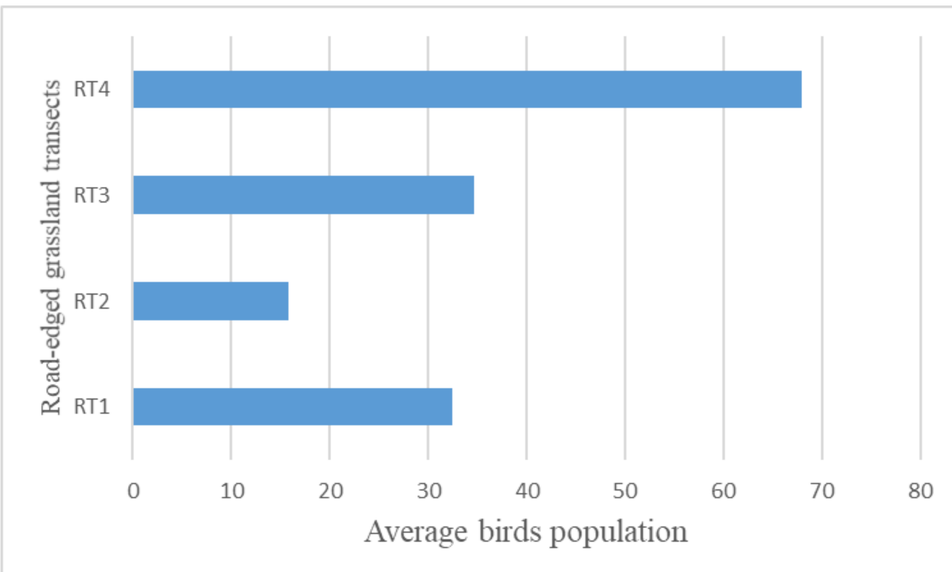


This indicates systematic sensitivity to the Forest Edge by all the species recorded in these grasslands. The number of species recorded at this edge was less than those that avoided. At the first transect T1, few birds were recorded indicating that they preferred the Interior Setting to the edge-setting of these grasslands.

4.4.2 All Species Sensitivity to Road Edges

At the road-edged grasslands, a slight increase of the population of birds recorded at the Edge Setting was noted with a consistent increase in population as one moved towards the Interior Setting of the grassland as shown in Figure 4.2.

Figure 4. 2 Birds Average Population at Road Transects



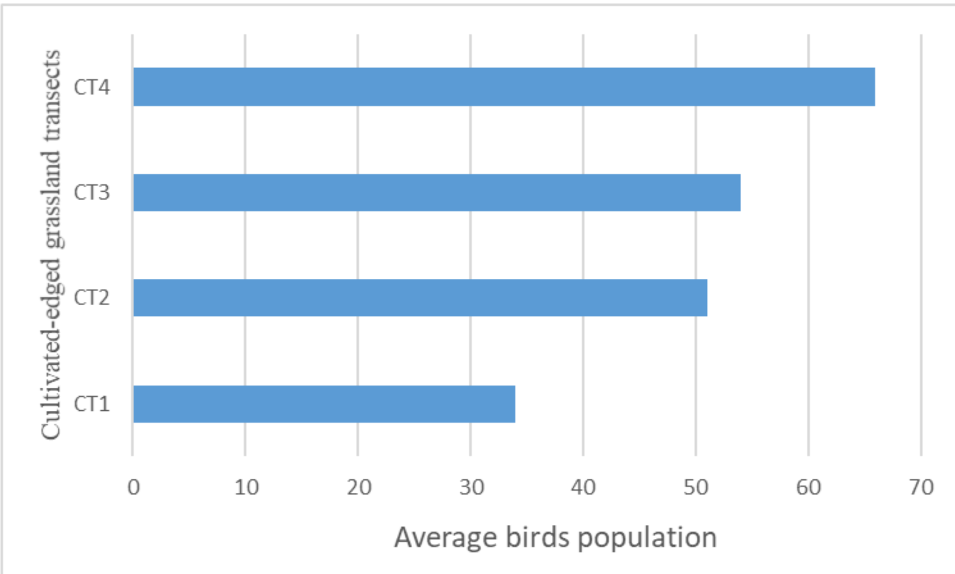
The presence of many edge loving species by the Road Edged grasslands made the first transect T1 have many birds way above the second transect T2 from which the following transects (T3 and T4) had their population numbers increase with distance from the edge. This observation indicates preference of some birds to the road edges which was differcnt comparison to the grasslands with forest and Cultivated Edges.

4.4.3 All Species Sensitivity to Cultivated Edges

High population of birds was recorded in grasslands with cultivated Edge type than the road and Forest Edges as depicted in figure 4.3 implying high preference to this edge type by most bird species

As with the Forest and Road Edged grasslands, the Cultivated Edged grasslands had a consistent increase in population from the Edge Setting into the interior transects.

Figure 4. 3 Birds Average Population at Cultivated Transects



This was seen despite the grasslands having different vegetation characteristics and somewhat different terrain.

As describe in Figure 4.1 and 4.3 the population of all birds species recorded in two different edge types (Forest and cultivated) increased systematically from the numbers recorded in transect one (T1) through to transect four (4). This was different in the Road

Edge an observation associated to presence of many edge loving bird species at the Road Edges of the grassland.

This result indicates that there is an expected avoidance to edges by many species. This is shown by the relatively low population of birds at the Edge Setting to the Interior Setting at all the three investigated edge types.

The average population at all transects in the Cultivated Edge had the highest value showing a preference of many species to the Cultivated Edge. The Forest Edge had the least number of birds at transects investigated. This gives an indication of high sensitivity of the birds to the Forest Edged grasslands, moderate sensitivity to the Road Edged grasslands and less sensitivity to grasslands with a Cultivated Edge.

The generalization of all species sensitivity to the three edge types gives a picture of an adverse impact of either of the edge types to most species bringing into the equation a less population at all the three Edge Settings than the population at the Interior Setting.

4.4.4 Correlation Analysis of the Edges and Species Sensitivity

Table 4. 3 All Species Edges-Species Sensitivity Correlation Analysis

	Pearson Correlation	**FT**	**RT**	**CT**
Forest Edge	Sig. (2-tailed)		.259	.039
Road Edge	Sig. (2-tailed)	.259		.103
Cultivated Edge	Sig. (2-tailed)	.039	.103	

To test the null hypothesis on species sensitivity at the edges, an analysis of all species together at different transects in the different edge types was done. A correlation analysis

(2-tailed) was done and interpreted by comparing the p-values (sig. row) with *a*=0.05. The p-values of correlation test between forest and cultivated grassland edges were found to be less < *a* = 0.05 at 0.039. The null hypothesis was therefore rejected for this test. This therefore implied that, the difference edge types have a significant influence on a combination of all species preference between forest and Cultivated Edged grassland.

A different result was observed with the analysis of Forest Edges against Road Edges and Road Edges against Cultivated Edges which had an *a* value greater than 0.05 at 0.259 and 0.103 respectively. This indicates that the null hypothesis was accepted for sensitivity of species at Forest Edge against Road Edges and Road Edges against Cultivated Edges.

The generalization of all species sensitivity to the three edge types gives a picture of an adverse impact of either of the edge types to most species bringing into the equation a less population at all the three Edge Settings than the population at the Interior Setting.

4.5 Sharpe's Longclaw Edge Preference and Sensitivity

Derived from the individual population of Sharpe's Longclaw at forest, road and cultivated grassland edge types as shown in average population Appendix 2, Figures 4.4, 4.5 and 4.6 are generated.

4.5.1 Preference and Sensitivity of Sharpe's Longclaw at Forest Edges

Absence of a species (Sharpe's Longclaw) in a transect with the right grassland characteristic for its habitat in seven study sites as it is the case with transect one T1, transect three T3 and transect four T4, indicates a severe sensitivity to the edge type; for this case the Forest Edged grasslands.

Figure 4. 4 Sharpe's Longclaw Average Population at Forest Edge Transects

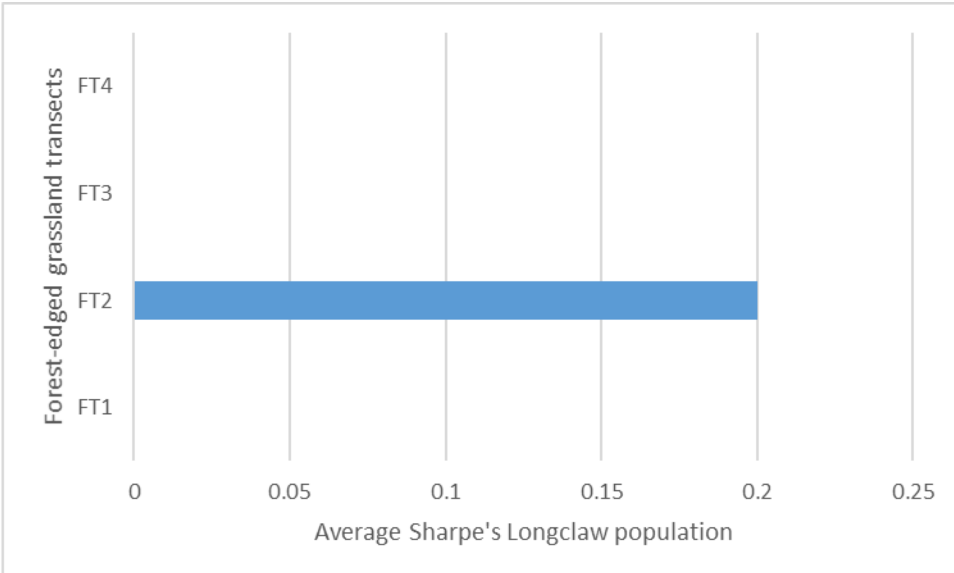
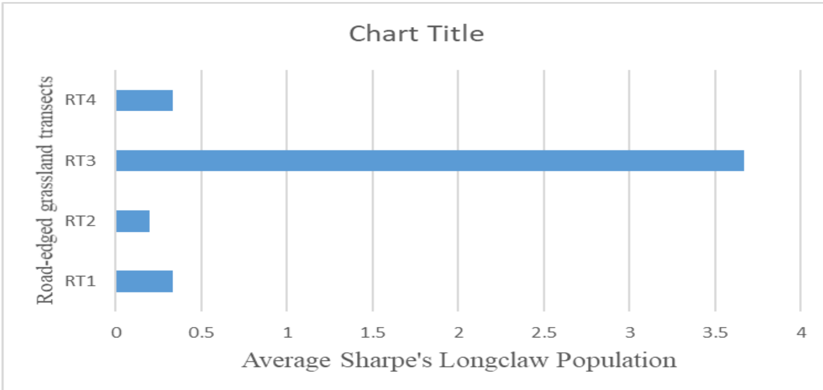


Figure 4.4 above indicates few numbers in population and presence of Sharpe's Longclaw in the grasslands having Forest Edges only at T2 with 0.2. There was no bird sported at T1, T3 and T4 in all the investigated plots with only a few birds sported in the second transect T2

4.5.2 Preference and Sensitivity of Sharpe's Longclaw at Road Edges

Figure 4.5 indicates a low but consistent presence of the Sharpe's Longclaw in the first and second transects T1 and T2. The scenario is different in transect three T3 where a high population is recorded followed by low numbers in transect four T4.

Figure 4. 5 Sharpe’s Longclaw Average Population at Road Edge Transects

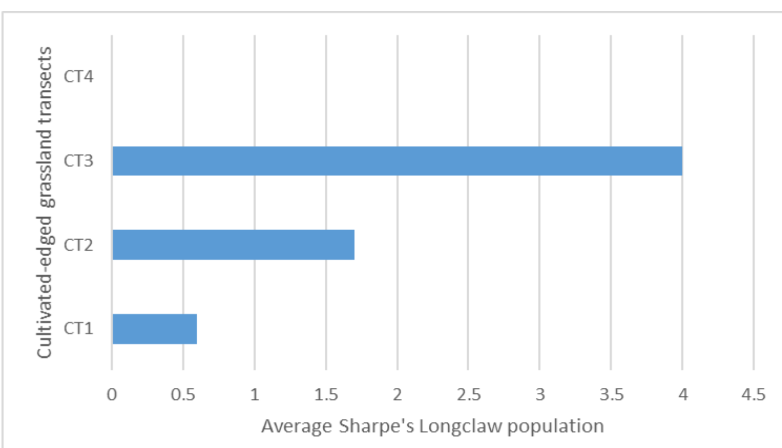


Indicatively, most of the birds will keep of the road with a few not much concerned of the edge implying a moderate sensitivity to the Road Edge. Although with different grassland characteristics, the first transect T1 consistently had more birds recorded than transect two T2 with transect three T3 with a relatively high number of individuals (3.67).

4.5.3 Preference and Sensitivity of Sharpe’s Longclaw at Cultivated Edges

A systematic increase in population of Sharpe’s Longclaw from the Edge Setting into the Interior Setting was recorded in the grasslands with Cultivated Edges.

Figure 4. 6 Sharpe’s Longclaw Average Population at Cultivated Edge Transects



The population at all transects investigated with the Cultivated Edge had the highest population of Sharpe's Longclaw T1 with 0.6, T2 with 1.67 and T3 with 4 (captured in Figure 4.6) compared to same transect of other grassland edge types. The presence of high numbers of the species at the first transect indicates a high preference to this edge and low sensitivity to the edge.

Despite the fact that the three edge types investigated had a negative effect to the population of the Sharpe's Long-claw, the Forest Edged grassland recorded the least birds of this species in all the investigated plots. Only one individual was recorded in all the seven study sites used for this investigation. This is an indication of high sensitivity of the Sharpe's Longclaw to the Forest Edged grassland. The Cultivated Edged grasslands investigated recorded up to 30 individuals in all the 10 study sites; the highest number of birds in all investigated edge types. This is an indication of low sensitivity of the birds to the Cultivated Edged grassland with the Road Edged grasslands having a moderate (15 individuals) sensitivity to this bird species.

Transect three T3 of the Cultivated Edged grassland yielded the maximum recordings as per this investigation with 8 individuals in only 2 study sites an early indication that large sized plots are suitable potential habitats for this species.

4.6 Edge Sensitivity to Sharpe's Longclaw

Sensitivity to an Edge Setting refers to the extent of effect displayed by a species towards a habitat edge. This means that the more a species lives, feeds and nests close to an edge of a habitat, the less sensitive it is to that edge. This is as a result of consideration of safety and resource use by a species.

The sensitivity analysis below is based on the populations recorded at different transects of different edge types within the different edge types used in this study.

Table 4. 4 Sharpe's Longclaw Sensitivity

Edge type/transects	**T1**	**T2**	**T3**	**T4**
Sharpe's Long-claw Average Population at Forest-edge Transects	0	0.2	0	0
Sharpe's Long-claw Average Population at Road-edge Transects	0.3	0.2	3.67	0.33
Sharpe's Long-claw Average Population at Cultivated Edge Transects	0.6	1.67	4	0

Although the population of this species was low in the averages of population in all the studied sites, as shown in the Table 4.5, the numbers of birds recorded in the different grasslands edges had a difference. The numbers in all transects of Cultivated Edged-grasslands were higher than the rest of the grasslands. The Forest Edged grasslands had least bird population. The observation in this data, Table 4.5 is that the Sharpe's Long-claw prefers grasslands with Cultivated Edges to grasslands with road and Forest Edges.

4.6.1 Hypothesis H_0 Testing

Table 4. 5 Sharpe's Longclaw Sensitivity H_0 Testing

		SF	**SR**	**SC**
Sharpe's Longclaw at Forest Edge (SF)	Sig. (2-tailed)		.633	.961
Sharpe's Longclaw at Road Edge (SR)	Sig. (2-tailed)	.633		.094
Sharpe's Longclaw at Cultivated Edge (SC)	Sig. (2-tailed)	.961	.094	

As depicted above in Table 4.6, p=0.633, 0.961 and 0.094. At *a*=0.05, sig. numbers larger than 0.05 implies that there is no significant difference. Therefore, the analysis shows that there is no significant different in preference of Sharpe's Longclaw population to forest and Road Edged grasslands. This is no different between Road and Cultivated populations as p=0.094 implying there is no significance difference statistically. The H_0 is therefore accepted in the forest and Road Edged grasslands also in the Road and Cultivated Edged grasslands. This means that there is no significant difference in preference of Sharpe's Long-claw to the three edge types.

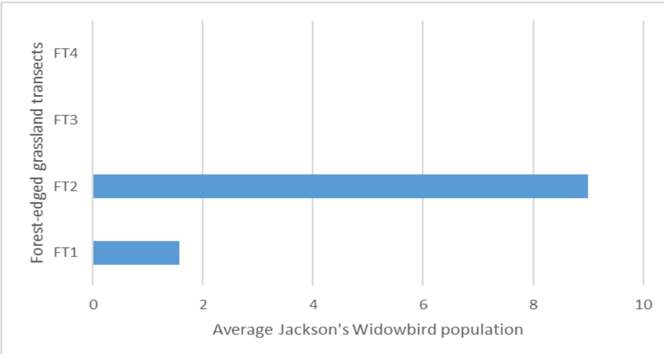
4.7 Jackson's Widowbird Edge Preference and Sensitivity

Average population of the species in the different edge types in Appendix 2 was used to illustrate the edge preferences and sensitivity of Jackson's Widowbird to forest, road and Cultivated Edges types in Figures 4.7, 4.8 and 4.9 below.

4.7.1 Jackson's Widowbird Edge Preference and Sensitivity at Forest Edges

Figure 4.7 bellow shows the population average of Jackson's Widowbird at Forest Edges of the grassland plots investigated. All the grassland with Forest Edges had transect one and two 1 and 2 transects and therefore transect 3 and 4 had no recordings.

Figure 4. 7 Jackson's Widowbird Population at Forest Edge Transects



Low numbers (1.57) of birds were recorded at the first transect T1 with the second transect T2 recording a high average at 9 of Jackson's Widowbird species.

4.7.2 Jackson's Widowbird Edge Preference and Sensitivity Road Edges

A systematic increase in the numbers birds recorded in transects two, three and four; at the Road Edged grasslands leaves transect one with a distorted higher number (1.17) than transect number two which had (0.4) attributed to presence of longer grass at the Edge Setting than the Interior Setting.

Figure 4. 8 Jackson's Widowbird Population at Road Edge Transects

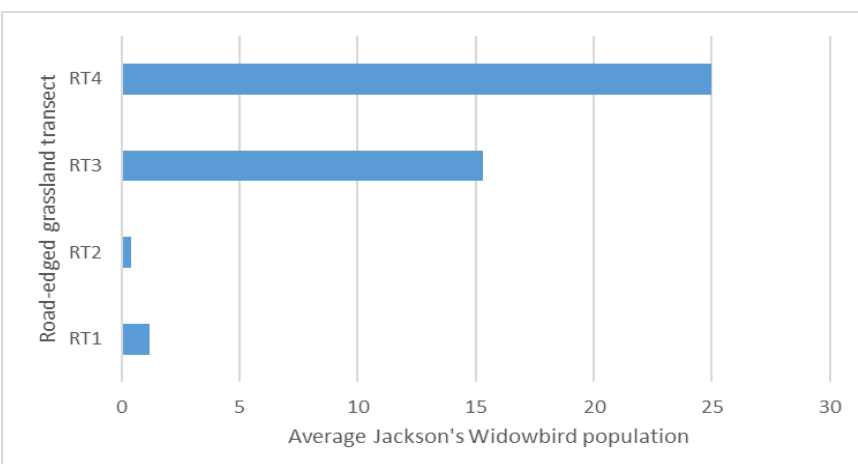
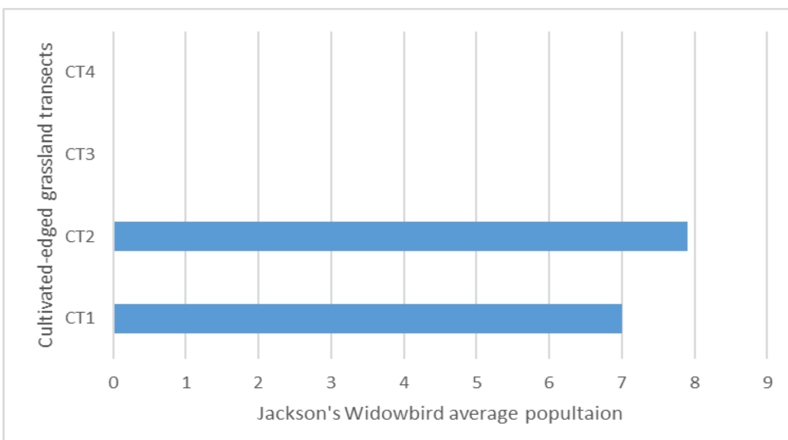


Figure 4.8 above shows very low population of the Jackson's Widowbird species (1.17) at transect one T1 and transect two T2 (0.4) i.e. 200m from Road Edge, these results proves that the species is shy from living at Road Edges of the grasslands. This in-turn indicates a high sensitivity to this edge.

4.7.3 Jackson's Widowbird Edge Preference and Sensitivity at Cultivated Edges

The numbers at transect one and two were high at 7 and 7.89 respectively with the 3rd and 4th transects recording a zero value in population of Jackson's Widowbird.

Figure 4. 9 Jackson's Widowbird Population at Cultivated Edge Transects



As depicted in figure 4.9, grasslands with Cultivated Edges recorded high numbers of Jackson's Widowbird at the first T1 and second T2 transects. Despite having an effect too to this species, the edge type has less effect to the birds i.e. the birds are less sensitive to this edge.

This investigation's report deduces that the Jackson's Widowbird is very sensitive to Road Edge and it avoids living at habitats with Road Edges. The Road Edged grasslands optimum population is reached at the fourth transect T4.

The grasslands with Cultivated Edges are more preferred by the Jackson's Widowbird as more numbers are found at the first transect T1 of the Cultivated Edged grasslands. This outcome might be attributed to the utilization of resource at the Cultivated Edges where the Jackson's Widowbird utilizes farmlands as feeding grounds which individuals were seen feeding in wheat and oat farms (Renfrew *et al.,* 2005).

Notably, the population of Jackson's Widowbird at the first transect in the Road Edged grasslands was higher at 1.17 than that at the second transect 0.4. This can be attributed to the vegetation characteristic of longer grasslands (Curnningham and Johnson, 2006) at the Edge Setting than the interior which the Jackson's Widowbird prefers.

Forest and Cultivated Edged grasslands transect two T2 population is relatively high at 9 and 7.89 respectively unlike in the Road Edges with 0.4. This indicates that there are mild effects despite the low impact felt from Forest and Cultivated Edges to the Jackson's Widowbird.

4.8 Edge Sensitivity to Jackson's Widowbird

Table 4. 6 Jackson's Widowbird Sensitivity

Edge type/transects	T1	T2	T3	T4
Jackson's Widowbird Average at Forest Edge Transects	1.57	9	0	0
Jackson's Widowbird Average at Road Edge Transects	1.17	0.4	15.3	25
Jackson's Widowbird Average at Cultivated Edge Transects	7	7.89	0	0

Table 4.6 above shows the population of Jackson's Widowbird at different edge types and different transects of the grasslands. Unlike the Sharpe's Longclaw and Longtailed population in Tables 4.4 and 4.6 that showed a clear difference in the populations at the different edge types, the data does not indicate a definite preference to either of the three

Edge types. Other factors including but not limited to vegetation characteristics in these grasslands may have acted to affect the distribution of the Jackson's Widowbird.

4.8.1 Hypothesis H_0 Testing

Table 4. 7 Jackson's Widowbird Sensitivity H_0 Testing

		JW F	JW R	JWC
Jackson's Widowbird at Forest Edge (JWB F)	Sig. (2-tailed)		.313	.234
Jackson's Widowbird at Road Edge (JWB R)	Sig. (2-tailed)	.313		.058
Jackson's Widowbird at Cultivated Edge (JWB C)	Sig. (2-tailed)	.234	.058	

As shown in the Table 4.10, all the sig. values are larger than 0.05. *a*=>0.05 indicates no significant difference statistically between the numbers in question. This therefore implies that, the null hypothesis is accepted i.e. there is no statistical significant difference in preference of Jackson's Widowbird to the three edge types with the p values being 0.313, 0.234 and 0.58 all of which are greater than a=0.05.

4.9 Longtailed Widowbird Edge Preferences and Sensitivity

The preference and sensitivity of Longtailed Widowbird in the study sites used for this investigation was established by the numbers recorded at the different grassland-edged sites investigated and their averages recorded appendix 2 and is used to depict preference and sensitivity of Longtailed Widowbird in Figures 4.10, 4.11 and 4.12 below.

4.9.1 Longtailed Widowbird Edge Preferences and Sensitivity at Forest Edges

Different from the cultivated and Road Edged grasslands used in this investigation, the forest-edged grasslands had none of transect three and four and therefore no recordings for these transects.

Figure 4. 10 Longtailed Widowbird Population at Forest Edge Transects

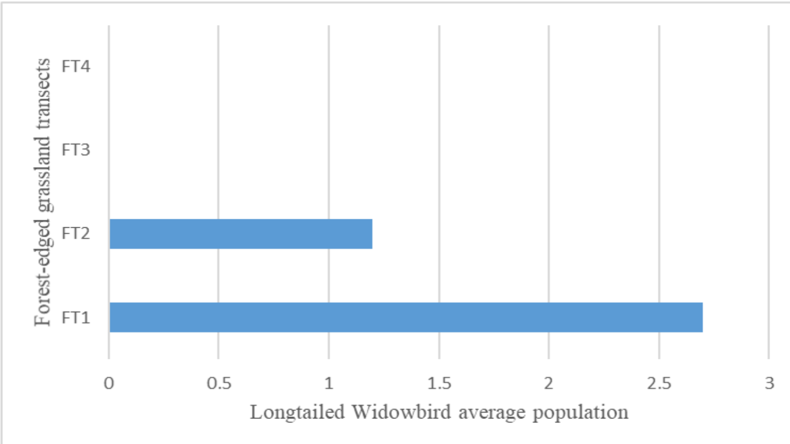
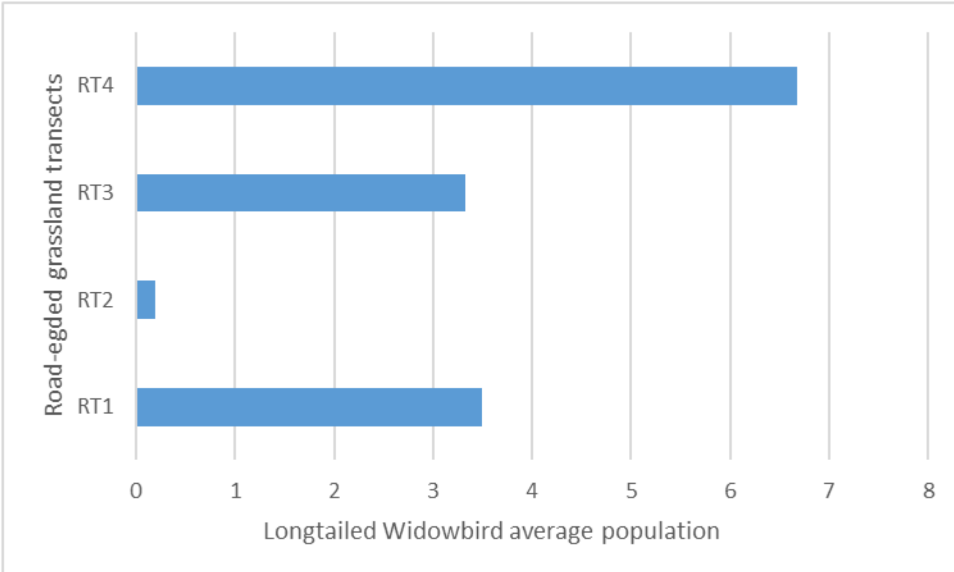


Figure 4.10 show high population in the first transects T1 at 2.7 than in the second transect T2 at 1.2. This shows that the Longtailed Widowbird is not sensitive to the Forest Edges. The Longtailed Widowbird will therefore live at Edge Setting than at the Interior Setting at Forest Edged grasslands as shown in Figure 4.9.

4.9.2 Longtailed Widowbird Edge Preferences and Sensitivity at Road Edges

Figure 4.11 give a 3.5 as the average population of Longtailed Widowbird at the first transect T1, significantly low (0.2) population at transect two T2 and a consistent increase in population at the subsequent transects. The high value at transect one T1 was attributed to the vegetation characteristics. These grassland edges had constant long grass than the subsequent transect two T2, which is preferable by the Longtailed Widowbird.

Figure 4. 11 Longtailed Widowbird Population at Road Edge Transects

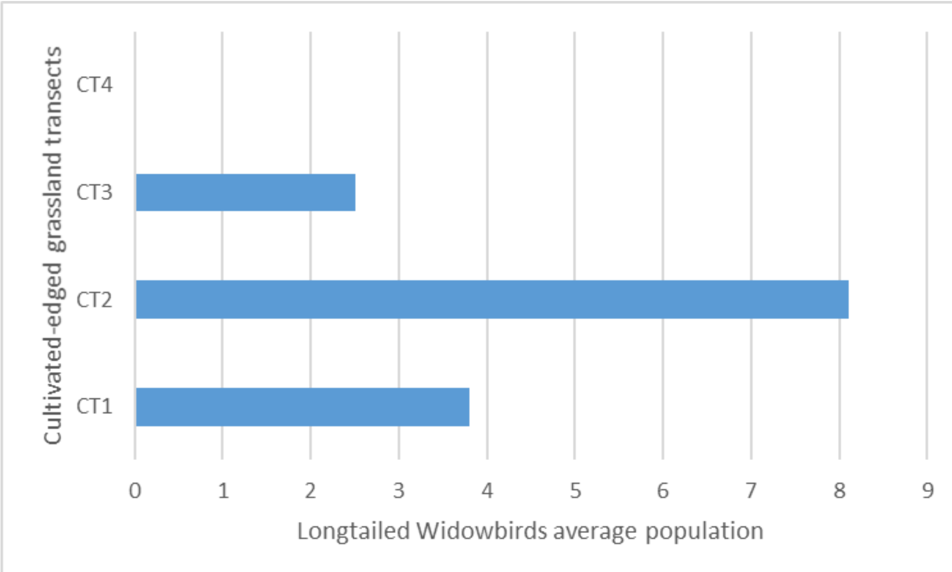


As indicated by T2, T3 and T4, the population in these transects increases consistently this can be attributed to the automated distance of transects from the edge; more individuals as you move away from the Road Edge. T4 had most individuals (6.67) showing that the Longtailed Widowbird prefers to live far T4 from the Road Edge.

4.9.3 Longtailed Widowbird Edge Preferences and Sensitivity at Cultivated Edges

Comparatively, Figure 4.12 below shows high numbers (3.8) of Longtailed Widowbird at first transect CT1 with the population average at forest transect one FT1 and road transect one RT1 being 2.7 and 3.5 respectively with a much higher number (8.11) at transect two CT2.

Figure 4. 12 Longtailed Widowbird Population at Cultivated Edge Transects



This shows that despite the high population at the Edge Setting of the Cultivated Edged grasslands, the Longtailed Widowbird prefer to live at the Interior Setting T2 than at the Edge Setting T1.

The decrease in numbers at transects three T3 and T4 is an implication that the Longtailed Widowbird prefers to live not so far from the Cultivated Edge which it utilizes as a feeding ground complement which was a common seen. That is Longtailed Widowbird feeding in wheat and oat farms next to grasslands.

Notably, is that the Longtailed Widowbird is less sensitive to the three edges owing to the population recorded in the three edge types which was high at transect one in forest and Road Edged grasslands which was higher than in transect to T2 of the same grasslands.

Despite that, the species is more sensitive to the Forest Edged grasslands with 2.7 in transect one T1 than in the road and Cultivated Edged grasslands which had 3.5 and 3.8

respectively in transect one T1. These results can be attributed to the resource utilization of this species of bird to the Edge Settings and neighboring habitats as feeding grounds a common sighting throughout the study time

The inconsistent distribution of Longtailed Widowbird in the forest and Road Edged grassland types can is associated with the species affinity to long grass which it utilizes as nesting and feeding resources a factor that made recordings to be concentrated on small portions of the investigated grasslands. This distribution was different from the rest species observed.

4.10 Edge Sensitivity to Longtailed Widowbird

Table 4. 8 Longtailed Widowbird Sensitivity

Edge type/transects	**T1**	**T2**	**T3**	**T4**
Longtailed Widowbird average Population at Forest Edge Transects	2.7	1.2	0	0
Longtailed Widowbird average Population at Road Edge Transects	3.5	0.2	3.3	6.7
Longtailed Widowbird average Population at Cultivated Edge Transects	34	51.8	55	0

Table 4.8 gives details to the populations of Longtailed Widowbird recorded at different transects of different edge types. As shown, the population of Longtailed Widowbird average at Cultivated Edge transects is highest at all transects followed by the population of the Road Edged grasslands and finally the Forest Edged grasslands had the least numbers of Longtailed Widowbird. This implies a high preference of Longtailed Widowbird at the Cultivated Edged grasslands and a high sensitivity at grasslands with Forest Edges.

4.10.1 Hypothesis H_0 Testing

Table 4. 9 Longtailed Widowbird Sensitivity H_0 Testing

		LTF	LT R	LT C
Longtailed Widowbird at Forest Edge (LT F)	Sig. (2-tailed)		.639	.828
Longtailed Widowbird at Road Edge (LT R)	Sig. (2-tailed)	.639		.151
Longtailed Widowbird-Cultivated Edge (LT C)	Sig. (2-tailed)	.828	.151	

The null hypothesis is accepted in this case as all the p=values (0.639, 0.828 and 0.639) are greater than *a*=05 as shown in Table 4.9. The population of Longtailed Widowbird at Forest Edge and Longtailed Widowbird at Road Edge population correlation give a p=value larger than 0.05. This is duplicated with the population correlation of between the other edge types. There is therefore no significant difference in preference of Longtailed Widowbird to the three different edge types.

4.11 Bird Nests in Study Sites

Nests were found using rope method (dragging a rope 25m across grasslands) and marked and GPS coordinates taken. To easily locate the nests during monitoring, all found nests were marked with a flag four (4m) meters to the east for further monitoring.

4.11.1 Sharpe's Longclaw and Nests Identification

Sharpe's Longclaw is a passerine 16-17 cm bird which displays bright yellow underparts, a distinct black breast band, streaked olive-brown upperparts, and in flight it has white outer-tail feathers. Sharpe's Longclaw is a sexually monomorphic bird species, meaning males and females appear nearly identical in size and plumage. However, during breeding males are typically more vocal and conspicuous, often seen performing display flights or singing from elevated perches to attract mates and defend territories, while females tend to be more secretive, particularly when nesting. The species is a monogamous breeder with a short up and down airial breeding display. Short songs are made during drop flights (Birdlife International, 2016, Dale *et al.*, 1999 and Lens *et al*., 2000).

The nests of the Sharpe's Longclaw are placed at the base of a grass and tussock. They are grass woven well-concealed, cuplike shaped within dense tussocks of native grass in open highland grasslands. It is constructed primarily from fine grass stems and lined with softer materials such as rootlets or finer grass fibers to provide insulation and comfort for the eggs and chicks.

The 2 Sharpe's Longclaw nests found in 2025 in 2 different grasslands in North Kinangop had 2 eggs each. The nests had an average entrance diameter of 78mm and depth of 55.4mm. Both nests were made on ground at the base of *Pennisetum mezianum* of an average height of 0.45m. The nest construction materials primarily included fine grass stems and lined with softer materials such as rootlets of *Themeda triandra*, *Festuca abyssinica, Digitaria sanguinalis*, *Hyparrhenia filipendula* and *Cynodon dactylon*, grass species mostly found in Kinangop (Goodman, 2023, Muchai *et al.*, 2002 and Munyekho *et al*., 2004) to provide insulation and comfort for the eggs and chicks.

The eggs were oval shaped as shown in Figure 4.13 of 22.7-24.5mm on long axis and 15.9-16.8mm on the shorter axis.

Plate 4. 1 A Sharpe's Longclaw Nest with 2 Eggs at North Kinangop

They had dark brown base, mottles on light green sides and weighed an average of 2.9-3.2 grams.

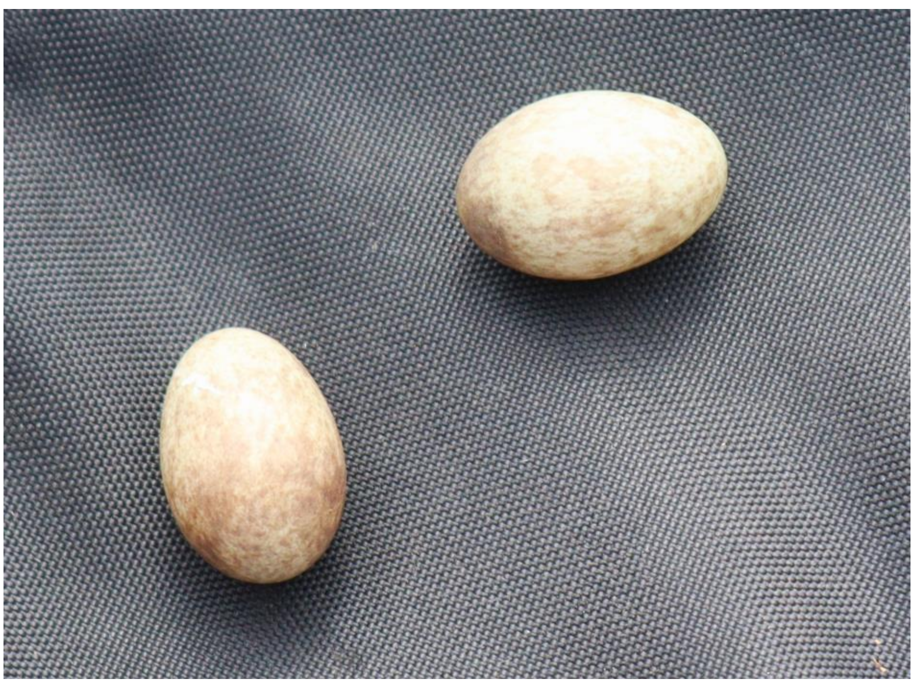
4.11.2 Jackson's Widowbird and Nests Identification

Jackson's Widowbird is a medium sized bird measuring 14-16cm length. Males in breeding plumage are markedly larger attaining a total length of up to 32–36 cm, including their characteristic elongated decurved tail feathers which can reach 20 cm and weigh 40-50mg while males weigh between 25-30 mg. The female has a streaked brown plumage with buff underparts, short tail and a conical bill suited for seed-eating (Dale *et al.*, 1999 & Andersson, 1989). Identification of female *Euplectes jacksoni* was facilitated through behavioral associations with lekking males. Females were typically observed visiting established leks, where males were actively displaying.

Nests of Jackson's Widowbird are a ball of grass, oval dome shaped with a side entrance measuring 25 – 50mm, 150-180mm length and 120-150mm width (Andersson, 1998). It is built on or near ground between 0 – 66cm within dense tussocks of tall native grasses, such as *Themeda triandra, Eragrostis botroudes* and *Pennisetum clandestinun*. The inner part of the nest is made of fine parts of *Andropogon amethystinus, Cynodon dactylon and Pennisetum clandestinun* (Goodman, 2023, Muchai *et al.,* 2002 and Munyekho *et al*., 2004)

The eggs of Jackson's Widowbird are oval and slightly elongated. Clutch size is 2-3 eggs of pale bluish or greenish-white eggs with light speckles more concentrated on at the broader end of the egg as shown in Plate 4.2. The eggs had a weight of 18-25 grams.

Plate 4. 2 Jackson's Widowbird Eggs at North Kinangop



Female Jackson's Widowbirds (*E. jacksoni*) are generally smaller and paler, with finer streaking and a more slender bill, whereas female Long-tailed Widowbirds (*E. progne*) tend to be larger, more heavily streaked, and bulkier overall. Crucially, association with lekking males provided reliable identification (Craig, 1980).

4.11.3 Longtailed Widowbird and Nests Identification

The Longtailed Widowbird *Euplectes progne* is a mideum sized bird 15-28 cm females and males upto 40-70 cm. The females upper portion of the body is streaked with buff or tawny and black. Thetail fethers are narrow and pointed; chests, breasts and flanks are slightly paler than their above colouring. Males are boadly streaked above and below with wing shoulder similar to its breeding plumage. Non-breeding males are slightly larger than females and most part, males are coloured in the same manner as the females (Birdlife International, 2016, Dale *et al.*, 1999). *Euplectes progne* has a polygynous mating system. It exhibits pronounced sexual dimorphism, particularly during the breeding season. Adult breeding males develop a striking appearance characterized by an entirely black plumage and an orange-red epaulets and extraordinarily elongated tail feathers that can reach up to 50 cm in length. This elongated tail, used in elaborate aerial display flights, plays a critical role in female mate choice and sexual selection. In contrast, females are significantly smaller, with a body length of approximately 15–18 cm and a weight of 25–30 g, lacking the ornamental tail and exhibiting cryptically streaked brown plumage adapted for camouflage in grassland habitats. Outside the breeding season, males molt into an eclipse plumage that resembles that of females (Davies *et al.*, 2012).

Longtailed Widowbird nests are pocket-like oval shaped suspended on upright grass between 2 – 70 cm above ground. Found nests of Longtailed Widowbird were suspended on *Eleusine jaegeri Themeda triandra*, *Hyparrhenia filipendula* while the inner parts were padded using dried parts of, *Pennisetum clandestinun*, *Andropogon amethystinus and Eragrostis bicolor* (Goodman, 2023 and Munyekho *et al*., 2004). Nests had side entrance measuring 65-71.0 mm, 179-191.0mm deep and 135-143.2mm wide. The females buids the nests utilizing the available grass species to make the outer layer of the nest without plucking it out (Shown in Plate 4.3) and using dry thin grass stems and fine leaves to cushion the iner part of the nest for the nest and chicks. Nests were primarily in tall indigenous grass species that offer both structural support and hiding it predators.

The clutch size of the Long-tailed Widowbird was between 2-3 eggs. The eggs were oval, had a brown at base, bluish-green to bluish-grey, oval-shaped and are faintly speckled at sides.

Plate 4. 3 A Longtailed Widowbird Nest with 2 Eggs at North Kinangop

They measured an avarege weight of 3.3-3.5 grams, 22-23.5mm on the long axis and 14.8-16.0mm on the long axis.

4.12 Nest Distribution

Nest locations in the different edge types i.e. Road, Forest and Cultivated-edged grasslands were searched and recorded. Monitoing of the nests was documented as per the transects in which the nests were found and the data for analysis. As depicted in Plates 4.1 and 4.2 below.

Plate 4. 4 and Plate 4. 5 Author and Assistants Using GPS to Locate Nests

The analysis in this section includes analysis of nests found during the study period. This excludes the data for Sharpe's Long-claw which did not bread during the four months (April-July) of the study.

All nests at transect one T1 of the three Edge types are referred to as nests at Edge Setting while nests found in the other transects i.e. T2, T3 and T4 are referred to as nest at the Interior Setting.

Table 4. 10 Sums of All Nest Recorded in Different Transects of the Three Edges

	FT 1	RT 1	CT 1	FT 2	RT 2	CT 2	FT 3	RT 3	CT 3	FT 4	RT 4	CT 4
All Nest Sum	18	12	63	26	2	83	0	29	3	0	34	0
Long-tailed Widowbird Nest Sum	10	6	19	5	0	50	0	5	3	0	6	0
Jackson's Widowbird Nest Sum	7	4	35	19	0	26	0	22	0	0	32	0
Sharpe's Longclaw Nest Sum	0	0	0	0	0	0	0	0	0	0	0	0

The number of nests recorded in all the grasslands used in this study captured in Table 4.10 below was used to generate an average of all nests found at different transects in different grassland edge types as captured in Appendix 3.

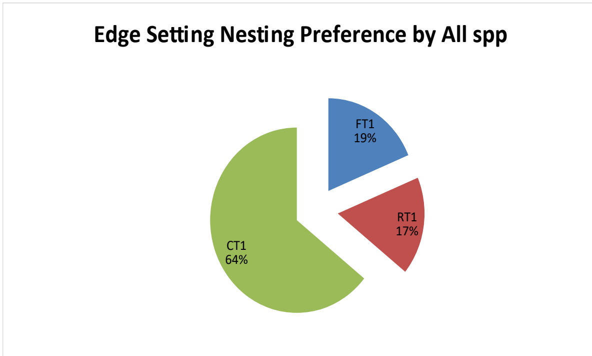
These averages have been used for analysis of nest distribution in grasslands of different edge types.

4.12.1 Distribution of All Recorded Nests at Edge Settings (T1)

Different edge types had a difference in nest numbers recorded at the Edge Setting T1. This difference was interpreted as the preference in nesting location of difference birds in the difference edge types.

Figure 4.13 below shows the percentage of numbers of nests of all species recorded in the study at transect one T1 of the three investigated edge types, i.e. Forest FT1, Road RT1 and Cultivated CT1. The results showed a preference of nesting at the Cultivated Edge Setting at 64%, with the Forest and Road Edge Setting sharing the remaining percent.

Figure 4. 13 Edge Setting Nest Distribution



This is a clear indication that most of the species that were in their breeding period and had their nest investigated by this study. They did not prefer to build their nest at the Road and Forest Edge Setting but instead they built their nest at the Cultivated Edged grasslands owing to the fact that they felt safe at this edge type and also utilized the neighboring farms as their feeding grounds as observed in Fletcher *et al.*, 2002.

4.12.2 Distribution of Longtailed Widowbird Nest's at Edge Settings (T1)

The nesting distribution of Longtailed Widowbird at the different Edge Types was dependent on different factors including but not limited to; the vegetation characteristics, safety of the nests and the species individuals in general and utilization of the edge as a food resource.

Figure 4. 14 Distribution of Longtailed Widowbird Edge Setting

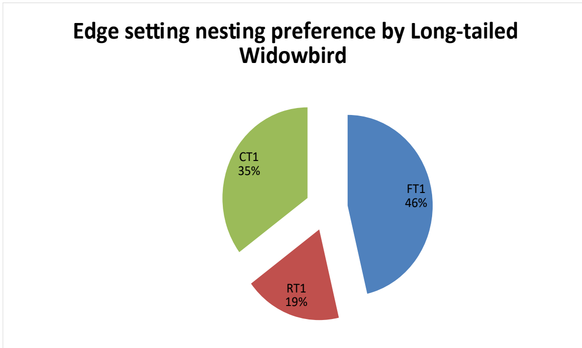
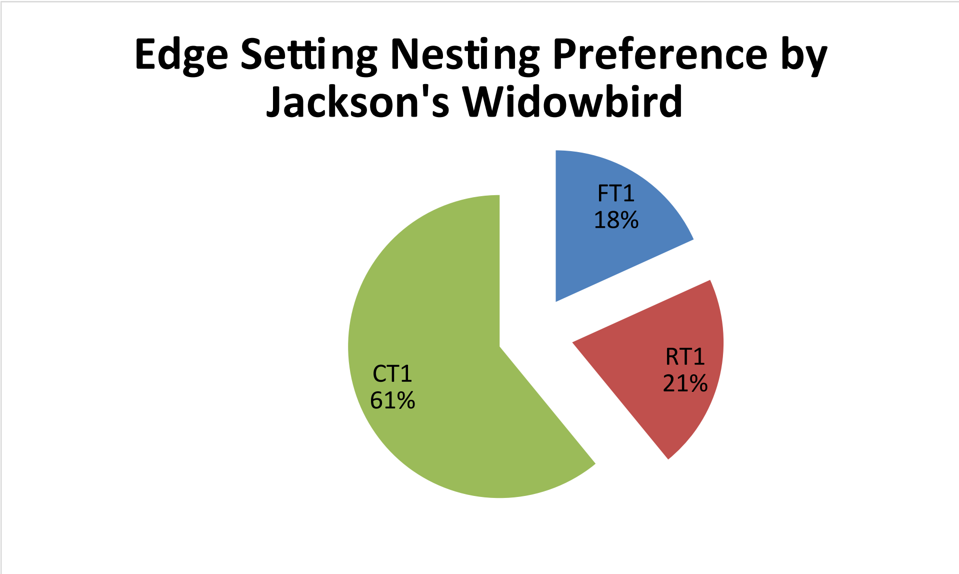


Figure 4.14 above shows the nest numbers of Longtailed Widowbird at the Edge Setting of the investigated edges i.e. Forest FT1, Road RT1 and Cultivated CT1. The results indicate a high preference of this species to the Forest Edge Setting at 46% followed by the Cultivated Edge Setting at 46% and Road Edge Setting at least position with 19%. This implies that the Longtailed Widowbird is most sensitive to the Road Edge than in the other two edge types.

4.12.3 Distribution of Jackson's Widowbird Nests at Edge Settings (T1)

The nests recorded in the first transect of all the three edge types CT1, FT1 and RT1 was used to determine the preference of nesting by Jackson's Widowbird.

Figure 4. 15 Jackson’s Widowbird Edge Setting Nesting Preference

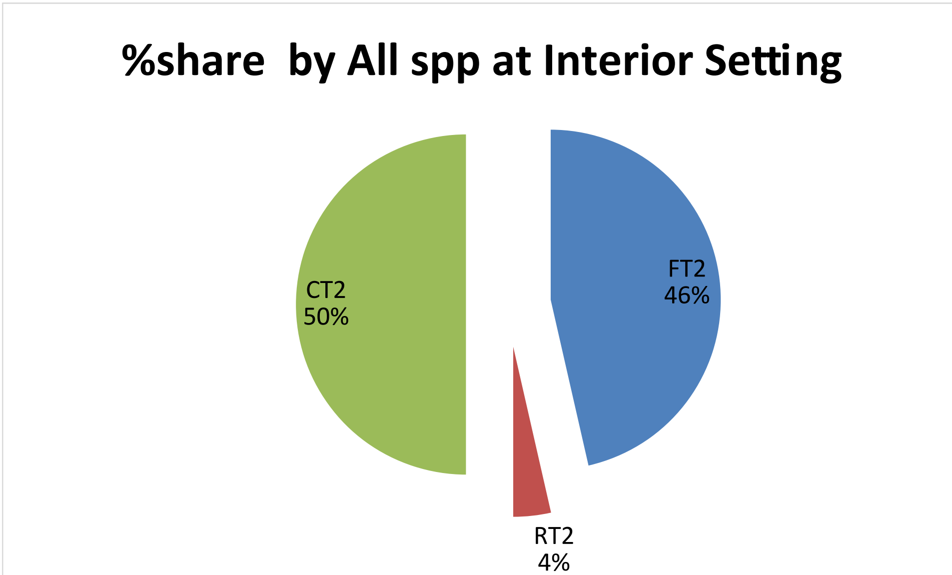


The number of Jackson’s Widowbird nests at the Edge Settings of the investigated edges i.e. Forest FT1, Road RT1 and Cultivated CT1 is represented above in Figure 4.15. This chart shows a great percentage of nests were recorded at the Cultivated Edge Setting CT1 at 61% with the Road Edge Setting FT1 recording the least percentage at 18%. This indicates a high preference of nesting at the Cultivated Edge Setting by the Jackson’s Widowbird and low take towards nesting at the Road Edge Setting.

4.12.4 Distribution of All Recorded Nests at Interior Settings (T2)

As illustrated in Figure 4.16 the Interior Setting of Cultivated CT2 and forest FT2 edge are almost equal at 50 and 46% in preference of nesting by most of the species in the grasslands investigated.

Figure 4. 16 Distibution of Nests at Interior Setting

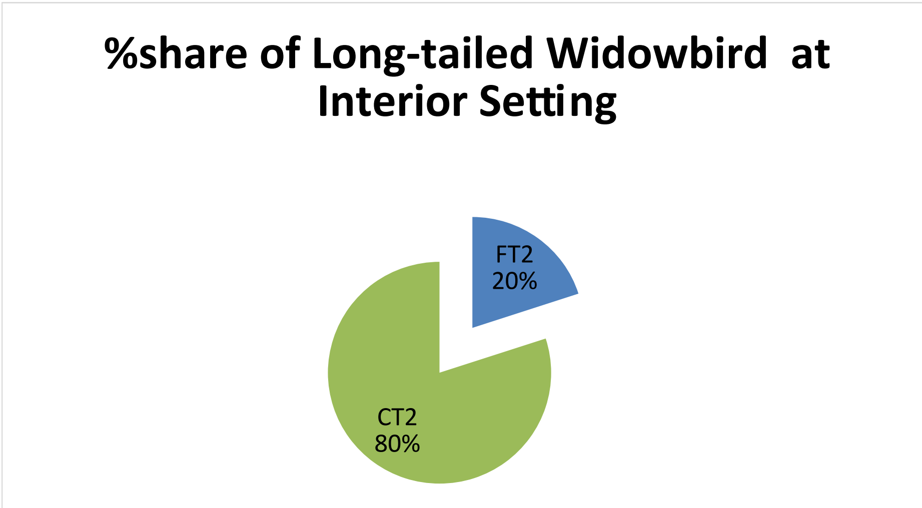


The road Interior Setting T2 is less preferred for nesting at 4% by most species. This was so because most of the birds at the Road Edged grasslands were either at the Edge Setting or at transects three T3 and four T4. This was so because of different vegetation characteristics which favored nesting at the Interior Settings of Cultivated and Road Edges.

4.12.5 Distribution of Longtailed Widowbird Nests at Interior Settings (T2)

As shown in the Figure 4.17 there were no nests at the second transect RT2 of the Road Edges investigated. A high preference of nesting at cultivated Interior Setting CT2 was noted for this species at 80%. The forest Interior Setting FT2 had 20% of the recorded nests.

Figure 4. 17 Long Tailed Widowbird Interior Setting Nesting Preferences



Absence of nests at the Interior Setting of the Road Edge was attributed to the vegetation characteristics; Edge Setting had a higher preference due to the relatively tall grass compared to the Interior Setting.

4.12.6 Distribution of Jackson's Widowbird Nests at Interior Settings (T2)

Uniquely different, the Jackson's Widowbird had a big number of nests at 66% in the Forest Interior Setting.

Figure 4. 18 Jackson's Widowbird Interior Setting Nesting Preferences

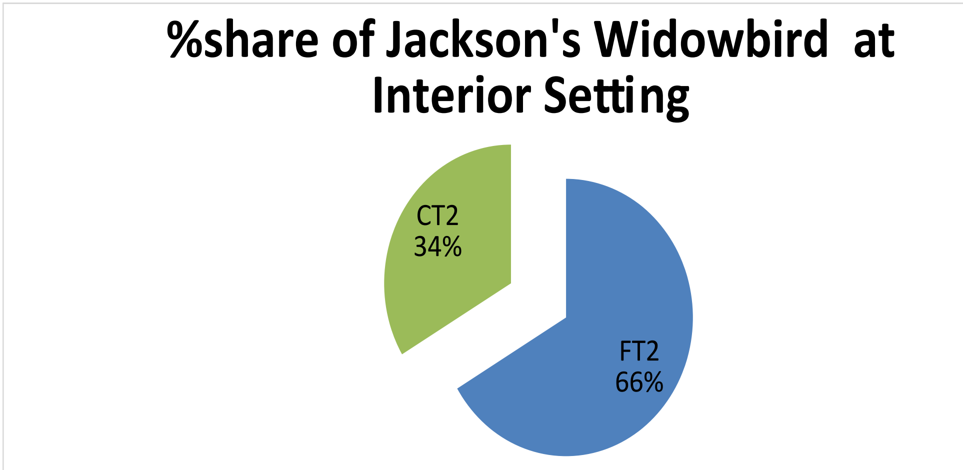
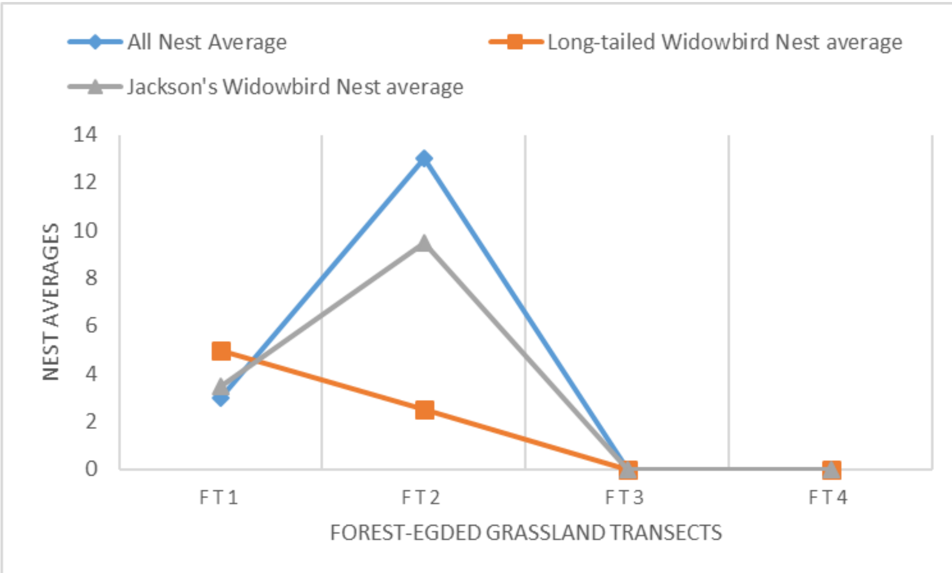


Figure 4.18 above shows the percentage share of Jackson's Widowbird nesting preference at the Interior Settings in the three investigated Edges. It shows a high preference of nesting at the Forest Interior Setting at 66% and a very low preference (0%) of nesting at the road Interior Setting at 0% in the grasslands investigated. The Cultivated Interior Setting CT2 had a relatively higher preference (66%) to the Road Interior Setting (0%).

4.12.7 Nest Distribution at Forest-edged Grasslands

As with the Cultivated and Road Edges, the Forest Edged grassland transects had different nest distribution. To have simpler look at the nest distribution of this individual species in the grassland, Figure 4.18, 4.19 and 4.20 we developed.

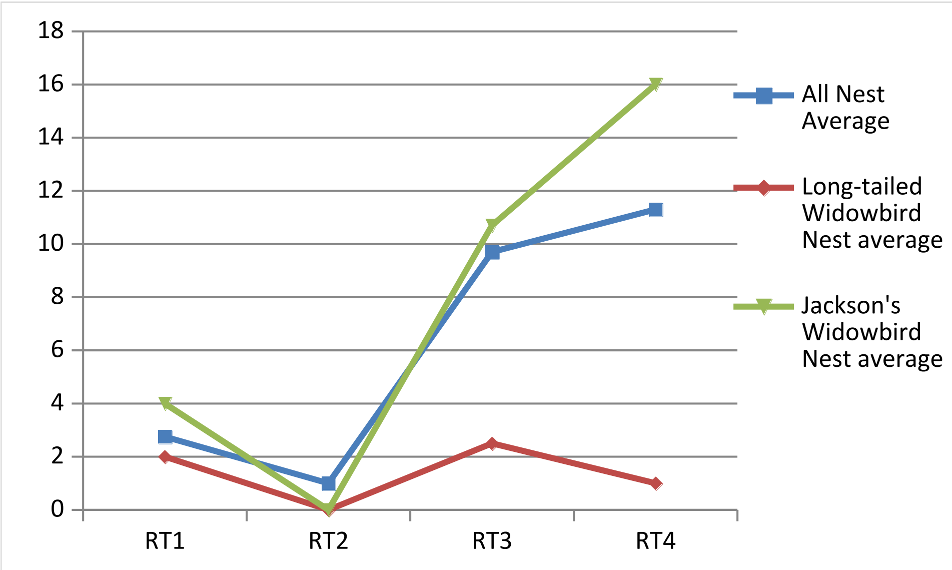
Figure 4. 19 Nest Distributions at Forest-Edged Grasslands



Graph 4.19 above shows the nesting trends at the forest F transects T for all species recorded and for specific species. There were no nests at all for the Sharpe's Longclaw (the graph shows a zero reading) during this investigation. A relatively high nesting preference was recorded at the Edge Setting for the Longtailed Widowbird at 5 which had a lower preference of nesting at the Interior Setting at 2.25 of the Forest Edged grasslands. Contrary, the Jackson's Widowbird as with most of the other recorded species had a low preference of nesting at the Edge Setting (100m from edge) of the Forest Edged grasslands and the Interior Setting recorded more (with 9.5 and 13) nests which reduced as one moved further interior past the 200m distance from the edge.

4.12.8 Nest Distribution at Road-edged Grasslands

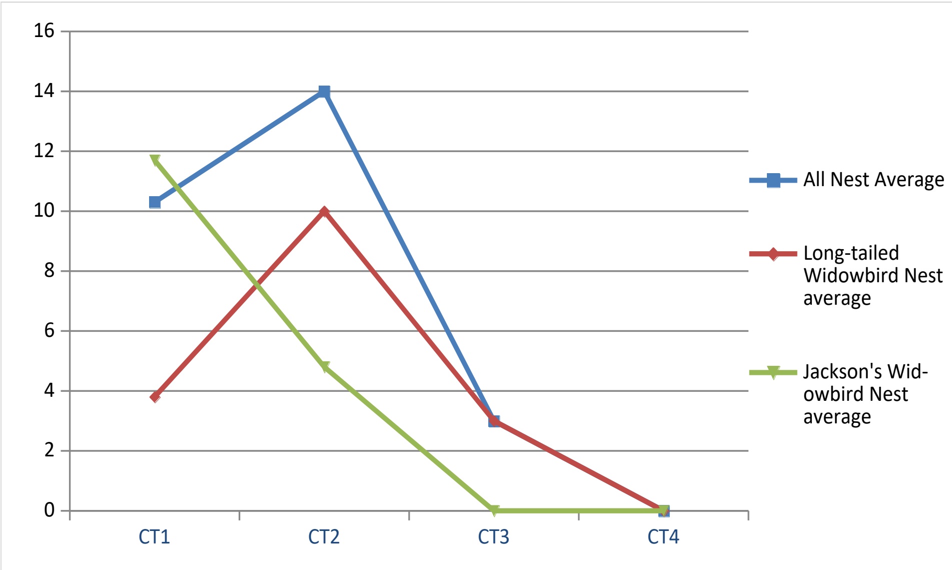
Figure 4. 20 Nest Distributions at Road-Edged Grasslands



Graph 4.20 above depicts nesting trends for all birds' together and specific species that were used as umbrella species for this investigation. Although with difference in number of nests recorded, a consistent trend is noted where a drop in the number of nests recorded in transect one RT1 is seen in transect two RT2 and an increase thereafter. The Jackson's Widowbird as with the most of the other species recorded, clearly prefers nesting at the far interior while the Longtailed Widowbird nest numbers at first transect RT1were the same as nest numbers at the third transect RT3 with a drop in the fourth transect RT4.

4.12.9 Nest Distribution at Cultivated-edged Grasslands

Figure 4. 21 Nest Distribution at Cultivated-edged Grasslands



Graph 4.21 above represents the nesting trend in grasslands with Cultivated Edges. There was no nest recorded for the Sharpe's Longclaw species during the study at grasslands with Cultivated Edges. The second transect CT2 i.e. between 100m-200m had the highest recorded numbers of most species including the Longtailed Widowbird which was an increase in recordings from the first transect CT1 of 4 and a drastic drop in nest numbers was recorded in CT3=3 and four CT4=0. The Jackson's Widowbird preferred nesting at the Edge Setting recording highest nest numbers at transect one CT1= 11.7 and a consistent drastic drop of nest numbers was recorded in transect two CT2=4.8 and three CT3=0.

4.13 Nest Predation

During the study period, several potential nest predators were recorded. Avian predators included raptor species such as the Black-shouldered Kite (*Elanus caeruleus*), African Harrier-hawk (*Polyboroides typus*), Common Buzzard (*Buteo buteo*), Long-crested Snake-eagle (*Lophoaetus occipitalis*), Pallid Harrier (*Circus macrourus*), Black-chested Snake-eagle (*Circaetus pectoralis*), and Gabar Goshawk (*Micronisus gabar*) (Dale *at al.*, 1999). Other predatory taxa observed included snakes such as *Philothamnus battersbyi* and *Psammophylax multisquamis* (Broadley, 2006), as well as mammalian predators like the Common Slender Mongoose (*Herpestes sanguineus*) and the White-tailed Mongoose (*Ichneumia albicauda*).

4.13.1 Distribution of All Successful Nests Recorded

Table 4.11 below shows the distribution of all successful nests in the three edge types investigated. The Road Edged grassland plots had the least number of successful nests in the first two transects i.e. RT1 with 6 and RT2 with 0.

Table 4. 11 Successful Nest in Different Transects of the Three Edge Types

	F T1	**RT 1**	**C T1**	**FT 2**	**R T2**	**C T2**	**F T3**	**R T3**	**C T3**	**F T4**	**R T4**	**C T4**
All Nest Successful	11	6	40	14	0	56	0	23	2	0	24	0
Long-tailed Widowbird successful Nest	7	6	15	2	0	37	0	3	2	0	5	0
Jackson's Widowbird successful Nests	4	1	20	10	0	19	0	20	0	0	19	0

As shown in Table 4.12 below, the road transect T1 had a high number of unsuccessful nests of Jackson's Widowbird at 3 as compared to the successful one 1 shown in Table 4.12

Table 4. 12 Unsuccessful Nest in Different Transects of the Three Edge Types

	FT1	RT1	CT1	FT2	RT2	CT2	FT3	RT3	CT3	FT4	RT4	CT4
All Nest Unsuccessful	7	6	14	12	1	14	0	4	1	0	14	0
Long-tailed Widowbird Unsuccessful Nest	3	3	4	3	0	7	0	2	1	0	1	0
Jackson's Widowbird Unsuccessful Nests	3	3	10	9	0	4	0	2	0	0	13	0

The Cultivated Edged grassland plots had the highest recorded successful nest numbers in transect one CT1 at 40 and transect CT2 at 56. The successful nests at Forest Edged grasslands numbers in transect one FT1 at 11 and two FT2 at 14 were the second with the Road Edged grasslands left last at RT1=6 and RT2=0.

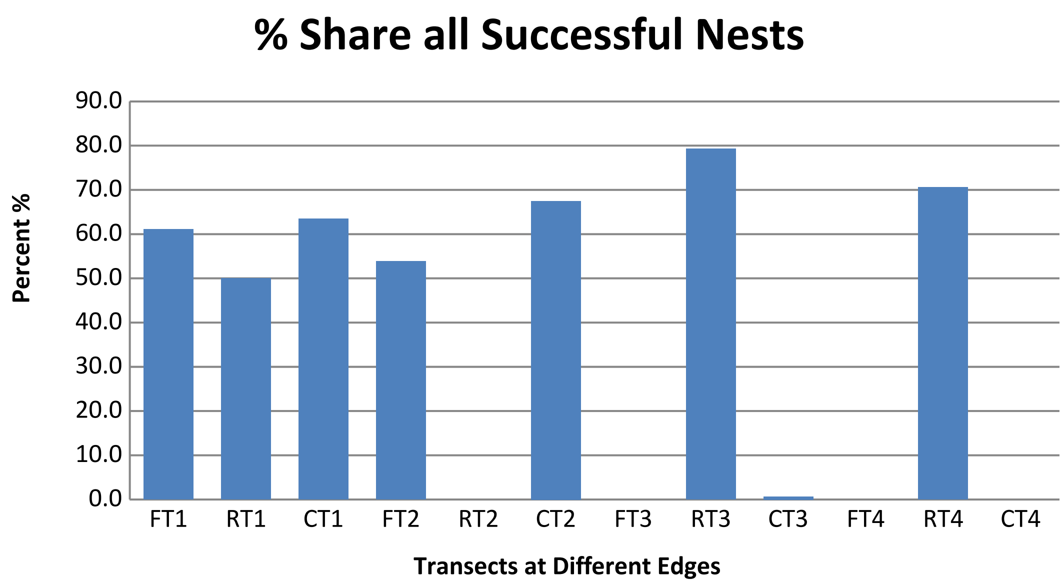
Notably, successful nests at transect three of the Road Edges RT3 had the highest record at 24 of successful nests in the Road Edged grassland transects RT. This shows a high preference of birds to nest at the Interior Settings of the road transects.

4.13.2 All Recorded Nests Percentage of Success at Different Edge Types

In transect one, the Cultivated Edged grasslands CT1 had the highest nest success percentage at 63.5% followed by the Forest Edged grasslands FT1 at 61% and lastly Road Edged grasslands RT1 at 50%. The same trend followed in the second transects with the cultivated (68%), forest (53%) road RT2 having a zero recording of nest.

Figure 4.22 below shows the percentage share of all successful nests for all recorded species in the three edge types forest FT, road RT and cultivated CT. The graph clearly shows that success of nests was 50% and above in all transects that nests were recorded.

Figure 4. 22 Percentage of All Successful Nests



This means that success rate of nests at Edge Setting and Interior Setting of a Cultivated Edged grassland CT plot is highest among the three edge types followed by the nests at Forest Edged grasslands and Road Edged grassland plots has least nest success rate.

RT3 had the highest success rate of nest at 79%. This implies that predation is low far from the edge at road transect three RT3 which may be attributed to the difference in vegetation characteristics and noise in the Edge Setting of the Road Edge i.e. RT1.

The preference of nesting in all species is always dependent on the safety of the nests and resource utilization of the neighboring habitat (Fromberger, 2020). These two factors play a great role in determining where in a habitat a species builds it nest. The Cultivated Edge was preferred by most species to the road and Forest Edges. This may be attributed to the resource use of these cultivated neighboring plots as feeding grounds for many species as observed during data collection.

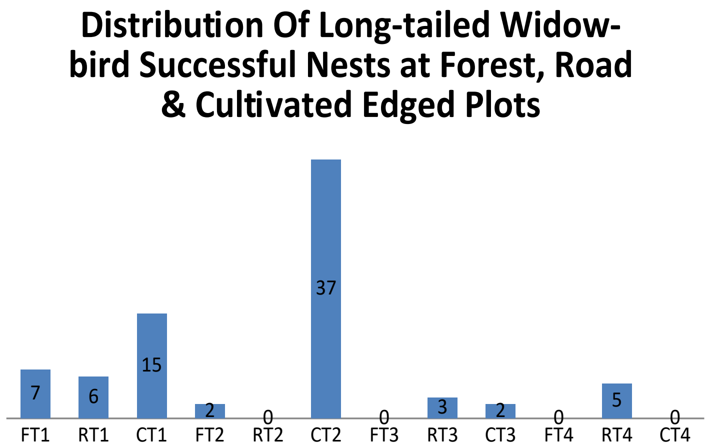
The Interior Setting brings a clear picture of the sensitivity experienced by the species where the Jackson's Widowbird and the Longtailed Widowbird species prefer Interior Settings of a cultivated or Forest Edged grasslands to Interior Settings of Road Edged grassland. The effect at the Road Edged grasslands may be associated to a difference in vegetation characteristic between interior and Edge Setting and noise from the activities by the roads which were frequently used by motorists including vehicles, motor cycles, pedestrians and animals.

All through the investigation period, there was no (zero) Sharpe's Longclaw nest recorded. This was contrary to the expectation of having this time as the breeding season for the species. This was attributed to the low rainfall experienced during this time which normally receives heavy rainfall prompting breading of the Sharpe's Long-claw. This is so as the heavy rainfall provides a better habitat (overgrowth in the grassland vital for security of the fledglings) for breading and offers enough food for the parents and their nestlings.

4.13.3 Distribution of Longtailed Widowbird Successful Nests

At the different edge types and transects in these grasslands, success of nest of Longtailed Widowbird was different as recorded during the study period.

Figure 4. 23 Longtailed Widowbird Successful Nests Percentage

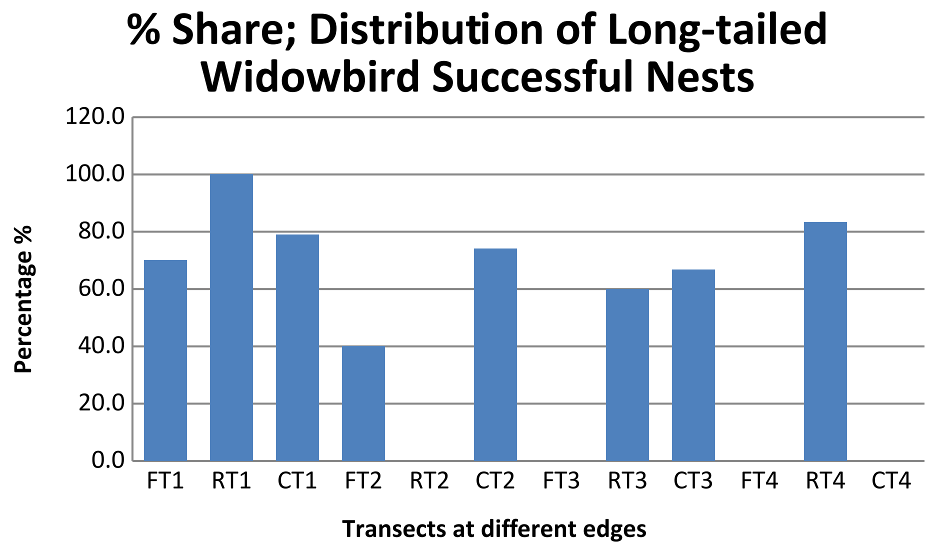


As shown above in Figure 4.23, the Cultivated Edged grassland plots recorded the highest number of successful nests at transects one CT1 with 15 and transects two CT2 with 37 for the Longtailed Widowbird. This was significantly higher than the number of successful nests at the Road (at 6, 0 and 5) and Forest Edged grassland plots at (7, 2 and 0) respectively.

4.13.4 Distribution of Longtailed Widowbird Succesful Nests

Although with less number of nests as depicted in the graph 4.24 the Road Edged grasslands has the highest nest success rate at the first transect RT1 (100%) shown in Figure 4.23. This was followed by the Cultivated Edged grasslands at 79% and Forest Edged grasslands at 70%. Despite having the highest nest successful rate at the Road Edged grasslands, the second transect recorded zero nest RT2=0. This indicates that there was high success rate at the Edge Setting than the interior as nesting by Longtailed Widowbird was prioritized at the Edge Setting.

Figure 4. 24 Distribution of Longtailed Widowbird Successful Nests at Edges

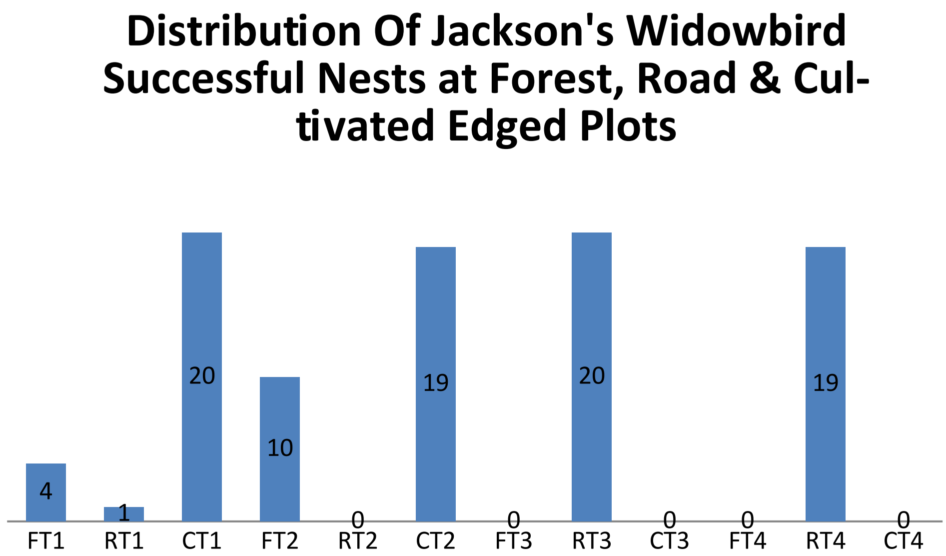


The Cultivated Edged grasslands maintained a high nest success rate. This indicated that, given the same number of Longtailed Widowbird nests at all the three edge type, nests at the road and Cultivated Edge Setting will have a high chance of success than the nests at the Forest Edges setting. Nest success is necessary for the maintenance of sustainable population of Longtailed Widowbird.

4.13.5 Distribution of Jackson's Widowbird Successful Nests

As with the Longtailed Widowbird, the Jackson's Widowbird successful nests were few at the first and second transect of the Road Edged grasslands RT1=1 and RT0 respectively. As shown in Figure 4.25, this was changed at the far interior transects RT3=20 and RT4=19 which recorded high numbers of successful nests. This numbers of nesting location shows a high preference of nesting at the Interior Setting i.e. transects three and four; CT3 and CT4.

Figure 4. 25 Distribution of Jackson’s Widowbird Successful Nests



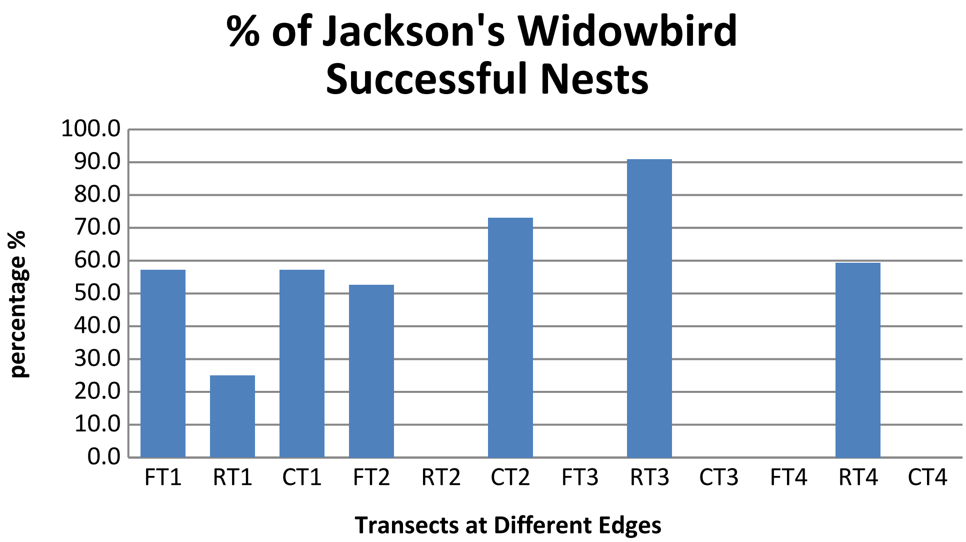
The Cultivated Edged grassland plots maintained a lead in numbers of successful nests by the Edge Setting CT1 at 20 and Interior Setting CT2 at 19 with the Forest Edged grasslands having moderate (FT1=4, FT2=10 and FT3=0) numbers of successful nests.

4.13.6 Distribution of Jackson’s Widowbird Successful Nests

As per Figure 4.2, the nest success rate of Jackson’s Widowbird is relatively low in all the three Edge Setting transects (FT1=57, RT1=25 & CT1=57); having both the forest and Cultivated Edges at 57% nest success rate and the Road Edge Setting at 25%.

The Interior Setting for the cultivated and Road Edged recorded a higher success rate at 72 and 91 than the Edge Setting. The forest Interior Setting recorded lower nest success rate at (51) at the second transects.

Figure 4. 26 Distribution of Jackson's Widowbird Successful Nests



This implies that, given the same number of Jackson's Widowbird nests at transect one T1 of the three Edge type, nests at the Cultivated And Forest Edged plots and will have high chance of success than those nests at the Road Edge. This will change in the Interior Setting as nest success rate at Cultivated and Road Edged grasslands will rise and success rate at Forest Edge grasslands will be lower.

The Cultivated Edge Setting CT1 (shown in Figure 4.22) had most number of recorded nests from all the species. This can be attributed to a high preference of nesting at this Edge type. The Forest Edge Setting FT1 had the second most nest numbers by all species recorded. This put this edge second in preference of nesting and the Road Edge Setting RT1 least in nesting preference.

The success rate varied in the different Edge Settings. Analysis for all species nests together depicted the Cultivated Edge with the highest nest success rate. The Cultivated Edge success rate was maintained as Road Edged Interior Setting nest success rate improved, this happened as the Forest Edge nest success rate dropped. (Shown in Figure 4.24)

The Longtailed Widowbird had the highest success rate at the Road Edge RT1 (Shown in Figure 4.24) followed by the Cultivated Edge Setting CT1. The success rate of Longtailed Widowbird nest reduced at the Interior Setting implying that nests at the Edge Setting had a better chance of success than nests at the Interior Settings. This success chance is vital for maintenance of a sustainable species population of the species in question.

Despite having a high number of nests at the Cultivated Edge Setting and relatively low nest numbers at the Road Edge Setting (Shown in Figure 4.26), both Edge Settings had same nest success rate at 57%. The Road Edge Setting had the least number of Jackson's Widowbird nests. It also had the least success rate recorded. The Interior Setting of road and Cultivated Edged grassland had a higher the nest success rate contrary to the Forest Edged grassland that dropped in the success rate as one moved to the Interior Setting.

From this analysis therefore, it's deduced that preference of nesting in different transects of a Cultivated Edged grasslands is a consideration of the high nest success rate. This Edge type preference is followed by The Road Edged grasslands and lastly the Forest Edged grassland.

4.14 Grassland Sizes Effects to Species Density

4.14.1 Bird Species and Population

A total of 87 bird species were recorded in the study sites as shown in Appendix 1. The birds were recorded in the different study sites. All birds seen flying, parched and or flashed from the grasslands were identified using a pair of binoculars and a guide book: Birds of Kenya and Northern Tanzania, Dale *et al.*, 1999. Diverse species including birds of prey and water birds were recorded.

A total of 1,664 individuals were recorded with a majority being in the Cultivated Edged grasslands with 807 (49%) individuals, followed by Road Edged grassland with 582 and lastly Forest Edged grassland with 275 individuals as shown in Table 4.14.

Table 4. 13 Bird Numbers at Differently Edged Grasslands

	No. of Individuals
Forest Edged Grasslands	275
Road Edges Grasslands	582
Cultivated Edges Grasslands	807
Total Recorded Individuals	**1,664**

Most of the 1,664 bird's record was a composition of grassland specialist's, cultivated farm lovers and edge loving species. This list of recorded species in the study sites did not have a first time recorded species and therefore identification was easy using a bird guide after spotting them with a pair of binoculars.

This population numbers clearly indicate a high preference of most birds to grasslands with Cultivated Edges and a high sensitivity to grassland with Forest Edges. Indicatively, this shows that birds feel safe and find food easily in grasslands or in cultivated farms neighboring these grasslands than in the other grassland edges.

Derived from the number of birds in particular grassland sites captured in Table 4.15, the densities of all species together and later for individual species has been deduced and used for discussion in Tables 4.16, 4.17 and 4.18 and 4.19, 4.20 and 4.21 respectively.

Table 4. 14 Bird Numbers and Plot Sizes

Forest Edge	Plot Area	No. of All Birds	No. of Long-tailed W	No. of Jackson's W.	No. of Sharpe's L.
<5a FE	0.80	2	0	0	0
<5a FE	1.20	29	16	1	0
<5a FE	2.20	30	3	6	0
5-<20A FE	10.00	73	3	17	0
5-<20A FE	15.20	68	0	0	0
5-<20A FE	19.80	53	6	7	0
5-<20A FE	18.90	20	0	0	1
Road Edge					
<5A RE	4.60	36	10	6	0
5-20A RE	17.90	37	2	0	0
5-20A RE	7.60	102	7	16	0
>20 A RE	177.80	184	12	42	13
>20 A RE	40.00	181	16	64	0
>20 A RE	29.30	42	5	2	2
Cultivated Edge					
5-20A CE	10.20	21	0	2	4
5-20A CE	10.90	70	4	25	0
5-20A CE	12.70	21	0	8	0
5-20A CE	18.00	81	15	27	4
5-20A CE	19.10	202	41	90	1
5-20A CE	7.00	35	5	0	2
>20A CE	41.00	79	24	5	1
>20A CE	31.00	118	0	0	12
>20A CE	30.00	78	7	6	4
>20A CE	48.00	102	24	4	0

4.14.2 Forest-Edged Plot Size Effects to All Species Density

Table 4. 15 Forest-Edged Plot Size Effects to All Species Density

	Plot Number	Forest- edged Plot Size	Density of All Species Recorded
Plots Below 5 Acres (<5A)	1.	0.80	2.50
	2.	1.20	24.17
	3.	2.20	13.64
Plots (5- <20A)	4.	10.00	7.30
	5.	15.20	4.47
	6.	19.80	2.68
	7.	18.90	1.06

The Table 4.16 above represents the different grassland plot sizes with Forest Edges categorized as small plots i.e. below five acres (<5A) and medium sized plot sizes (5-<20 A) i.e. above five acres and below twenty acres (5- <20) against the density of birds in each of these plots.

Despite the Table 4.15 showing high densities in smaller plots than in large plots, further analysis of this table shows that there was no significant difference with p=0.122 at a=0.05 in the densities of different grassland plot size.

4.14.3 Road-Edged Plot Size Effects to All Species Density

Table 4. 16 Road-Edged Plot Size Effects to All Species Density

	Road- edged Plot Size	Density of all species Recorded
Plots (<5A)	4.60	7.83
	17.90	2.07
Plots (5-<20A)	7.60	13.42
	177.80	1.03
Plots above 20 acres (>20A)	40.00	4.53
	29.30	1.43

Table 4.17 shows grassland plot sizes with Road Edges categorized as <5Acres (A), 5-<20Acres (A) and above twenty >20 against bird densities in each grassland plot. Notably from the content of the table, the smaller grassland plots had high number of birds in relation to their sizes and therefore a high density. Testing of the null hypothesis was done and the hypothesis was accepted with *p*=0.294 at *a*=0.05. This implies that there was no significant difference in the density of birds in different grassland plot sizes with Road Edges. These densities differences were observed in the field as data collection was done. It was associated to the isolation of fragments and location of grasslands independently separated (far from other grassland fragments) which drove grassland birds to automatically use the small plots as feeding, nesting grounds (Davis, 2004).

4.14.4 Cultivated-Edged Plot Size Effects to All Species Density

Table 4. 17 Cultivated-Edged Plot Size Effects to All Species Density

	Cultivated- edged Plot Size	Density of all species Recorded
Plots (5-<20A)	18.00	4.50
	19.10	10.58
	7.00	5.00
	10.20	2.06
	10.90	6.42
	12.70	1.65
	41.00	1.93
Plots above 20 acres (>20A)	31.00	3.81
	30.00	2.60
	48.00	2.13

Table 4.18 shows data for all Cultivated Edged grassland plot sizes used for this study. As depicted by the table, there were no small sized plots i.e. <5A and plots above 5A were used ensuring enough distance along the edge and across the grassland. The null

hypothesis was accepted with $p=0.335$ implying that there was no significant difference with the densities in different sized Cultivated Edged grassland plots.

The grassland size classification helped to generalize the densities of all species recorded in the three types of edges. In the forest and road-edge grassland plot types there was a higher density as compared to the larger plots with the same edge types (Shown in Table 4.15, 4.16 and 4.17). The study did not have a study site with area of less than five acres <5A (to ensure an adequate distance along the edge and across the grassland) and there would be a possibility of having a high density too compared to larger plots with Cultivated Edge if sampled.

A combination analysis of all species together against the size of grasslands at different edge types had no statistical significant difference. This could be associated to the presence of many birds with different preferences to edge types and sizes of habitats.

4.15 Grassland Sizes Effects to Individual Species Density

Further analysis of data captured in Table 4.15 gives Table 4.19, 4.20 and 4.21 on densities of individual species of birds in these grasslands with their different sizes.

4.15.1 Forest-Edged Grasslands

Table 4. 18 Forest-Edged Plot Size Effects to Individual Species Density

	Forest-edged Plot Size	Density of Longtailed Widowbird	Density of Jacksons Widowbird	Density of Sharpe's Long-claw
Plots (<5A)	0.80	0	0	0
	1.20	13.3	0.83	0
	2.20	1.36	2.73	0
Plots (5-<20A)	10.00	0.30	1.70	0.00
	15.20	0.00	0.00	0.00
	19.80	0.30	0.35	0.00
	18.90	0.00	0.00	0.05

The table 4.19 shows Forest Edged grassland plots sizes and the density of Longtailed Widowbird, Jackson's Widowbird and Sharpe's Longclaw respectively. There were very few birds of these three species in this edge type and therefore the densities were very low. The Sharpe's Longclaw had only one plot representation implying that it's highly sensitive to this edge type.

There was no significance difference in the densities of all the three species in the different plot sizes with Longtailed Widowbird, Jackson's Widowbird and Sharpe's Longclaw p=0.270, p=0.317 and p=0.275 respectively. This means that the sensitivity and preferences of all the three bird species to the Forest Edged grassland is relatively close thus no significant difference in densities recorded.

4.15.2 Road-Edged Grasslands

Table 4. 19 Road-Edged Plot Size Effects to Individual Species Density

	Road-edged Plot Size	Density of Longtailed Widowbird	Density of Jacksons Widowbird	Density of Sharpe's Long-claw
Plots (<5A)	4.60	2.17	1.30	0.00
Plots (5-<20A)	17.90	0.11	0.00	0.00
	7.60	0.92	2.11	0.00
Plots above20 acres (>20A)	177.80	0.07	0.24	0.07
	40.00	0.40	1.60	0.00
	29.30	0.17	0.07	0.07

The data in Table 4.20 represents the road-edged grassland study sizes used and density of Longtailed Widowbird, Jackson’s Widowbird and Sharpe’s Longclaw recorded in them.

Despite the fact that there was no significant difference in the densities of individual species as recorded in the different grassland plots i.e. Longtailed Widowbird, Jackson’s Widowbird and Sharpe’s Longclaw p=0.350, p=0.447 and p=0.141 respectively, the Sharpe’s Longclaw was not recorded in all plots below twenty acres i.e. <20A. This observation clearly implies that the Sharpe’s Longclaw is a species of large grasslands (20 Acres and above) especially when the grassland had a Road Edge.

4.15.3 Cultivated-Edged Grasslands

Table 4.21 shows the densities of Longtailed Widowbird, Jackson’s Widowbird and Sharpe’s Longclaw in different grassland plot sizes with Cultivated Edges.

Table 4. 20 Cultivated-Edged Plot Size Effects to Individual Species Density

	Cultivated-edged Plot Size	Density of Longtailed Widowbird	Density of Jacksons Widowbird	Density of Sharpe's Long-claw
Plots (5-20A)	10.20	0.00	0.20	0.39
	10.90	0.37	2.29	0.00
	12.70	0.00	0.63	0.00
	18.00	0.83	1.50	0.22
	19.10	2.15	4.71	0.05
	7.00	0.71	0.00	0.29
Plots above 20 acres (>20A)	41.00	0.59	0.12	0.02
	31.00	0.00	0.00	0.39
	30.00	0.23	0.20	0.13
	48.00	0.50	0.08	0.00

Notably from this data there is high density of Sharpe's Longclaw in most of the study sites (at 0.39, 0.29, 0.22 and 0.13). This densities were comparatively high than those at the Forest and Road Edged grasslands which had the highest densities as 0.05 and 0.07 respectively. (Shown in Tables 4.19 and 4.20 respectively)

There was no significance difference in the densities of Longtailed Widowbird, Jackson's Widowbird and Sharpe's Longclaw in the different plot sizes with Longtailed Widowbird, Jackson's Widowbird and Sharpe's Longclaw p=0.932, p=0.421and p=0.391 respectively.

4.15.4 Hypothesis H_o Testing

For all the three species i.e. Longtailed Widowbird, Jackson's Widowbird and Sharpe's Longclaw used as umbrella species, there was no significant difference when tested against each other in the same edge type.

Hypothesis testing for individual species in the different plot sizes with different edge type discovered a significant difference (P=0.000) for the Sharpe's Longclaw when its densities in Forest Edged grasslands were tested against its densities in Road Edged grasslands. However, there was no significant difference when its densities in Forest Edged grasslands were tested against Cultivated Edged grasslands densities P=0.474 and when Road Edged densities were tested against Cultivated Edged densities p=0.367

The hypothesis testing on densities on different sizes of grasslands of Longtailed Widowbird in the grasslands of the three edge types showed that there was no significant difference with Forest Edged grasslands against Road Edged grasslands having P=0.530, Forest against Cultivated Edged densities p=0.636 and Road Edged grasslands against Cultivated Edged grasslands p=0.351.

Finally, the Jackson's Widow bird's densities at the different plot sizes with different Edges also had no significant difference.

This observation shows that the three edge types have no significant impact to Longtailed Widowbird and Jackson's Widowbird densities which are different from the Sharpe's Longclaw which had a significant difference in densities when tested at Forest Edged grassland against Road Edged grassland.

Most of the large trucks of grassland plots had a lower density of birds compared to the medium sized plots (Shown in Tables 4.19, 4.20 and 4.21). This can be associated with the birds using a small portion of the grassland having the suitable grassland characteristics such as grass cover, vegetation height etc required for every species; meaning a greater grassland truck will have a low bird density composed of many species than that of smaller trucks.

The Longtailed Widowbird and Jackson's Widowbird seems to have no consistency in population and density in all the three edge types investigated contrary to the Sharpe's Longclaw which is extremely sensitive to the Forest Edged grassland.

There was no individual of the Sharpe's Longclaw recorded at the small plots of Forest Edged grassland plots. This sensitivity resulted to statistically significant difference between densities in forest and Road Edged grassland a scenario which was different with all the other species.

The Cultivated Edged grassland plots had the highest densities of Sharpe's Longclaw which implies a higher preference of the species to this Edge.

4.16.1 Forest-Edged Grassland Sizes Effects to Nest Success

Table 4. 21 Forest-Edged Grasslands Sizes Effects to Nest Success

	Forest- edged Plot Size	Percentage % of Successful Nests
Plots (<5A)	0.80	0.00
	1.20	80.00
	2.20	85.71
Plots acres (5-<20A)	10.00	50.00
	15.20	100.00
	19.80	75.00
	18.90	0.00

Table 4.22 above shows the percentage of successful nest in different sizes of grassland plots with Forest Edge. The null hypothesis was tested and accepted p=0.984 implying that there was no significant difference statistically between the percentages of success in the different grassland plot sizes with Forest Edge.

4.16.2 Road -Edged Plot Size Effects to Nest Success

The analysis of sizes of Road Edged plots (Shown in Table 4.23) with percentage of successful nests accepted the null hypothesis at *p*=0.792. This means that the sizes of the grassland plot did not determine failure or success of nests.

Table 4. 22 Road -Edged Plot Size Effects to Nest Success

Plots (<5A)	Road- edged Plot Size	Percentage % of Successful Nests
	4.60	33.33
	17.90	100.00
Plots (5-<20A)	7.60	81.25
	177.80	60.00
Plots above 20 acres (>20A)	40.00	70.59
	29.30	66.67

Despite the evidence by Batary and Baldi, 2004 that edges affects grassland birds nest success rates, this result is in line with Paton, 1994; there are other factors that determine success rate which may include vegetation characteristics weather condition and availability of food resources.

4.16.3 Cultivated-Edged Plot Size Effects to Nest Success

As per Table 4.24, plots sizes with Cultivated Edges shows no consistency in plot sizes in relation to the nest success percentage. There was no significance difference *p*=0.736 of successful nest percentage in the different plot sizes in the Cultivated-Edged grassland study sites.

Table 4. 23 Cultivated-Edged Plot Size Effects to Nest Success

	Cultivated-edged Plot Size	Percentage % of Successful Nests
Plots (5-<20A)	18.00	0.00
	19.10	61.11
	7.00	33.33
	10.20	76.47
	10.90	74.36
	12.70	100.00
Plots above 20 acres (>20A)	41.00	80.00
	31.00	0.00
	30.00	58.97
	48.00	55.56

The Forest, Road and Cultivated Edged grassland plot sizes did not influence the success or failure of bird nests. This means that predation of nest is determined by other factors including extreme weather conditions, vegetation characteristics such as the height of the grass and ground cover, anthropogenic interference like overgrazing among others (Walk *et al*., 2010).

4.17 Grassland Size Effects to Individual Species Occurrence

Using the three plot size classification categorization i.e. categorized as small plots i.e. below five acres (<5A), medium sized plot sizes i.e. above five acres and below twenty acres (5- <20) and above twenty acres >20A, average areas at the three edge types were calculated. The occurrence of individual species in difference plot sizes and different Edge types was used to determine the percentage of occurrence as shown in the Table 4.25.

Table 4. 24 Study Site Sizes Effects to Individual Species Occurrence

	Average Grassland Area	Longtailed Widowbird % of Occurrence	Jackson's Widowbird % of Occurrence	Sharpe's Longclaw % of occurrence
Forest Edged Grasslands	1.4	66.66	66.66	0
	15.98	50	50	25
Road Edged Grasslands	4.6	100	100	0
	12.75	100	100	0
	82.37	100	100	66.67
Cultivated Edged Plots	12.98	66.67	83.33	66.67
	37.5	75	75	75

In the Forest Edged grasslands, the small grassland <5A plots had an average of (1.4A). The occurrence percentage was 66.66% for Longtailed Widowbird and Jackson's Widowbird while there was none of Sharpe's Longclaw species recorded. This was different with the medium sized grassland plots (15.98A) with Forest Edge where the Longtailed Widowbird and Jackson's Widowbird had 50% occurrence with Sharpe's Longclaw at 25% occurrence.

In the Road Edged grassland plots, small, medium and large plots were investigated giving a clear picture of effects of size to occurrence. The small and medium grassland plots (4.6 and 12.75A) recorded 100% Longtailed Widowbird and Jackson's Widowbird but had no records of Sharpe's Long-claw. The large grassland plots with Road Edges with an average area of (82.37A) had the same occurrence percentage for Longtailed Widowbird and Jackson's Widowbird at 100% and a different occurrence percentage of Sharpe's Longclaw at 66.66%.

The Cultivated-Edged grassland study sites were represented by medium and large plot sizes. The medium grassland plot sizes average was 12.98A. The Longtailed Widowbird, Jackson's Widowbird and Sharpe's Longclaw had 66.67, 83.33 and 66.67% occurrence respectively in the medium sized grassland plots. The large grassland plots with Cultivated Edges had an average area of 37.5A. The percentage occurrence of Longtailed Widowbird and Sharpe's Longclaw rose from 66.67% to 75% while that of Jackson's Widowbird dropped from 83.33% to 75%.

The Forest Edged grassland small plots 1.4A had a higher occurrence percentage of Longtailed Widowbird and Jackson's Widowbird at 66.67% than the medium sized plots 15.98A which had 50% percentage occurrence. This implies that these two species are not deterred from occupying small grasslands with a Forest Edge. This is different for the Sharpe's Longclaw which was not found in any of the small plots (which had no occurrences at all) and a few medium sized plots with 25% of occurrence by the Sharpe's Long-claw.

The Road Edged grassland plots had 100% occurrence of the Longtailed Widowbird and Jackson's Widowbird for the small, medium and large sized grassland plots. The Sharpe's Longclaw had no individuals in the small and medium sized grassland plot with a Road Edge. This was different in the large grassland plots that had 66.67% Sharpe's Longclaw occurrence. This clearly indicates that the Sharpe's Longclaw avoids small and medium sized grasslands with a Road Edge. This could be so because the Sharpe's Longclaw is a grassland specialist and utilizes grasslands for all its feeding, safety and breeding needs (Hamer, 2006) and therefore requiring more space in grasslands thus larger grasslands are preferable to the species.

Despite the Cultivated Edges having a lower occurrence percentage of Longtailed Widowbird and Jackson's Widowbird in the Medium and large grassland plots, it had the highest percentage occurrence (66.7 and 75 %) of Sharpe's Longclaw in the medium and large grassland plots recorded in the investigation.

The percentage of occurrence of Longtailed Widowbird and Jackson's Widowbird was highest in grasslands with a Road Edge at 100%, followed by grasslands with a Cultivated Edge at 75% and lastly by grasslands with a Forest Edge at 66.67%. This signifies that the Longtailed Widowbird and Jackson's Widowbird has highest preference living in grasslands with Road Edges medium preference in Cultivated Edged grasslands and lowest preference living in grasslands with Forest Edges.

The Sharpe's Longclaw on the other hand had the highest occurrence percentages in the Cultivated Edged grasslands with 75% followed by Road Edged grasslands with 66.67% and lastly Forest Edged grasslands with 25%. Despite thisthe smaller the grassland with Road, Forest or Cultivated Edge, the lesser the probability of occurrence. This is so as the percentage of occurrence and densities have been proven to be lowest with decrease in plot size.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

This chapter presents the summary and conclusions of results in chapter 4 showing their implication to the conservation of grassland specialist birds in general, specific species as well as the grassland habitat. Finally, it outlines the recommendations to be adopted for better grassland management for optimal species benefit.

5.1 Edge Preference and Sensitivity to All Bird Species Together

The results of analysis of Cultivated and Forest Edged grasslands for all recorded species together indicated a systematic increase from transect one, transect two, and three in the number of birds recorded. This result indicates that there is an expected avoidance to edges by many species despite the indivualistic reaction to edges by different species, (Ries and Sick, 2004).

The average population at all transects in the Cultivated Edge had the highest value showing a preference of many species to the Cultivated Edge. The Forest Edge had the least number of birds at transects investigated.

As captured by Annah and Thomas, 2007, preference of nesting in all species is dependent on resource utilization of the neighboring habitat more than nesting safety. A total of 270 Nests were recorded in all transects during the study time. Sixty four percent (64%) of nest at the Edge Setting were found along Cultivated Edge with forest at Nineteen (19%) and road at seventeen (17%) nest share.

5.2 Edge Preference and Sensitivity to Sharpe's Longclaw

Despite the low numbers of Sharpe's Longclaw recorded, Cultivated Edged grasslands hosted the highest numbers followed by the Road Edged grasslands while Forest Edged grasslands had the least numbers. No Sharpe's Longclaw was recorded in transect one of all Forest Edged grasslands investigated. The highest population of Sharpe's Longclaw was recorded in the third transect of Cultivated Edged grasslands at an average of 4 birds per acre followed by the third transect of Road Edged grasslands at 3.6 birds per acre and lastly with a great difference, transect two of Forest Edged grasslands at 0.2 birds per acre. This is an indication of high sensitivity of the Sharpe's Longclaw to the Forest Edged grassland. The Cultivated Edged grasslands investigated recorded up to 30 individuals in all the 10 study sites; the highest number of birds in all investigated edge types. This is an indication of low sensitivity of the birds to the Cultivated Edged grassland with the Road Edged grasslands having a moderate (15 individuals) sensitivity to this bird species.

All through the investigation period, there was no (zero) Sharpe's Longclaw nest recorded. This was contrary to the expectation of having this time as the breeding season for the species (Hamisi *et al.* 2022). This was attributed to the low rainfall experienced during this time which normally receives heavy rainfall prompting breading of the Sharpe's Long-claw. This is so as the heavy rainfall provides a better habitat (overgrowth in the grassland vital for security of the fledglings) for breading and offers enough food for the parents and their nestlings.

The occurrence of Sharpe's Longclaw was highest at 75% in large grassland plots (>20A), Medium sized (>5- <20A) Cultivated Edged grasslands and large (>20A) sized Road Edged grassland plots had the same Sharpe's Longclaw percentage occurrences at 66.67%.

5.3 Edge Preference and Sensitivity to Jackson's Widowbird

The Jackson's Widowbird presented itself as a Cultivated Edge lover especially in grasslands bordered by wheat and oat farms where they feed in the farms and build nests in the grasslands edges bordering the farms.

Notably, the population of Jackson's Widowbird at the first transect in the Road Edged grasslands was higher at 1.17 than that at the second transect 0.4. This can be attributed to the vegetation characteristic of longer grasslands at the Edge Setting than the interior which the Jackson's Widowbird prefers (Koper *et al.*, 2007).

Nesting in the Edge Setting had 61% of all nests recorded in transect one of the three edge types. This stumps that not only does this species prefer to feed in Cultivated Edge type, but also prefers breeding at this Edge Setting.

The occurrence was 100% in all Road Edged grasslands investigated followed by Cultivated Edged grasslands and Forest Edged grasslands had least percent of occurrence.

5.4 Edge Preference and Sensitivity to Longtailed Widowbird

It is notable that Longtailed Widowbird is less sensitive to the three edges owing to the population recorded in the three edge types which was high at transect one in forest and Road Edged grasslands than in transect to T2 of the same grasslands. See appendices 5

FT and 6 RT on Longtailed Widowbird. This was despite having fewer birds than those recorded in the Cultivated Edge.

The inconsistent distribution of Longtailed Widowbird in the forest and Road Edged grassland types was associated with the species affinity to long grass which it utilizes as nesting and feeding resources (Bibby *et al.*, 2000) a factor that made recordings to be concentrated on small portions of the investigated grasslands. This distribution was different from the rest species observed.

Despite the high numbers in Cultivated Edged grasslands, its occurrence was highest in Road Edged grasslands at 100% followed by Cultivated Edged grassland and Forest Edged grassland was least in occurrence percentage.

5.5 Nest and Eggs Description

The nesting ecology of the three grassland specialist birds: Sharpe's Longclaw (*Macronyx sharpei*), Long-tailed Widowbird (*Euplectes progne*), and Jackson's Widowbird (*Euplectes jacksoni*) reveals important adaptive strategies to their open highland grassland habitats. All species exhibited strong preferences for nesting within or on tall native grass species, emphasizing the importance of intact grassland structure for reproductive success. Sharpe's Longclaw constructed well concealed ground nests at the base of tussocks, favoring insulation and camouflage, traits consistent with its monogamous and cryptic breeding behavior. In contrast, both widowbird species exhibited polygynous breeding systems and built elevated nests using structurally supportive grasses such as *Themeda triandra* and *Hyparrhenia* filipendula, possibly as a predator-avoidance strategy. The side-entrance, dome-shaped nests of the widowbirds suggest a convergence in nesting architecture, likely influenced by similar selective pressures such as predation and microclimate regulation. Egg measurements across the species were consistent with body size, with Sharpe's Longclaw producing smaller clutches and lighter eggs, while Jackson's Widowbird had the largest eggs, correlating with its larger body size. Notably, the association of female widowbirds with lekking males was essential for accurate identification due to the cryptic and overlapping female plumage traits, highlighting the importance of behavioral context in field identification. These nesting observations underscore the critical role of native grass species in supporting the breeding ecology of grassland-dependent birds and reinforce the conservation value of preserving structurally diverse and undisturbed grassland habitats.

5.6 Grassland Size Effects to Species Density

The grassland size classification helped to generalize the densities of all species recorded in the three types of edges. In line with previous literature, the forest and road-edge grassland plot types there was a higher density as compared to the larger plots with the same edge types (Shown in Table 4.15, 4.16 and 4.17), Maiken, 2010. The study did not have a study site with area of less than five acres <5A (to ensure an adequate distance along the edge and across the grassland) and there would be a possibility of having a high density too compared to larger plots with Cultivated Edge if sampled.

A combination analysis of all species together against the size of grasslands at different edge types had no statistical significant difference. This could be associated to the presence of many birds with different preferences to edge types and sizes of habitats.

5.7 Grassland Sizes Effects to Individual Species Density

Most of the large trucks of grassland plots had a lower density of birds compared to the medium sized plots (Shown in Tables 4.18, 4.19 and 4.20). This can be associated with the birds using a small portion of the grassland having the suitable grassland characteristics such as grass cover, vegetation height etc required for every species; meaning a greater grassland truck will have a low bird density composed of many species than that of smaller trucks.

The Longtailed Widowbird and Jackson's Widowbird seems to have no consistency in population and density in all the three edge types investigated contrary to the Sharpe's Longclaw which is extremely sensitive to the Forest Edged grassland.

5.8 Grassland Sizes Effects to Nest Fate

The Forest, Road and Cultivated Edged grassland plot sizes did not influence the success or failure of bird nests. This means that predation of nest is determined by other factors which were not studied but may include extreme weather conditions, vegetation characteristics such as the height of the grass and ground cover, anthropogenic interference like overgrazing among others.

5.9 Grassland Sizes Effects to Species Occurrence

The Forest Edged grassland in small plots 1.4A had a higher occurrence percentage of Longtailed Widowbird and Jackson's Widowbird at 66.67% than the medium sized plots 15.98A which had 50% percentage occurrence. This implies that these two species are not deterred from occupying small grasslands with a Forest Edge. Despite the Cultivated

Edges having a lower occurrence percentage of Longtailed Widowbird and Jackson's Widowbird in the Medium and large grassland plots, it had the highest percentage occurrence (66.7 and 75 %) of Sharpe's Longclaw in the medium and large grassland plots recorded in the investigation.

The percentage of occurrence of Longtailed Widowbird and Jackson's Widowbird was highest in grasslands with a Road Edge at 100%, followed by grasslands with a Cultivated Edge at 75% and lastly by grasslands with a Forest Edge at 66.67%. This signifies that the Longtailed Widowbird and Jackson's Widowbird has highest preference living in grasslands with Road Edges medium preference in Cultivated Edged grasslands and lowest preference living in grasslands with Forest Edges.

Despite the preference to Cultivated Edged grassland of the edge type of Sharpe's Long-claw, the smaller the grassland with Road, Forest or Cultivated Edge, the lesser the probability of occurrence. This is so as the percentage of occurrence and densities have been proven to be lowest with decrease in plot size.

5.10 Conclussions

This study provides critical insights into the edge preferences, habitat sensitivity, and occurrence patterns of grassland specialist birds particularly Sharpe's Longclaw, Jackson's Widowbird, and Longtailed Widowbird across grasslands bordered by cultivated lands, roads, and forests. The results reveal that while edge effects vary among species, Cultivated Edged grasslands consistently supported higher bird densities and nest occurrences, indicating lower sensitivity to human-modified boundaries and possibly greater resource availability. In contrast, Forest Edged grasslands were least favored, especially by Sharpe's Longclaw, suggesting high sensitivity to this edge type.

The findings further demonstrate that grassland plot size influences species density and occurrence. Medium-sized plots generally hosted higher bird densities, possibly due to an optimal balance of habitat suitability and edge influence, while larger plots, though more expansive, had lower densities likely due to spatial heterogeneity and uneven resource distribution.

Jackson's and Longtailed Widowbirds showed edge-specific habitat use patterns but no clear density consistency, implying that vegetation characteristics may play a more defining role than edge type alone.

Overall, the study emphasizes the importance of maintaining a mosaic of grassland sizes and edge types particularly Cultivated Edged grasslands with suitable vegetation structure to support diverse grassland bird communities. These insights are vital for shaping targeted conservation strategies in the face of ongoing habitat fragmentation and land-use change.

5.11 Conservation and Research Recommendations

To accomplish efficient and effective management of the Kinangop plateau and similar grasslands for avian based conservation, the study recommends the following:

- Prioritize Protection of Cultivated Edged Grasslands. Grasslands bordering cultivated lands supported the highest densities and nest occurrences for most species, particularly Sharpe's Longclaw and Jackson's Widowbird. These areas should be prioritized for protection and integrated into conservation planning.

- Promote medium-sized grassland plots in land use planning. Medium-sized to large grasslands (medium => 5–20 acres and larger => 20acres) demonstrated higher species densities and more consistent bird presence. Land-use policies should encourage the preservation and restoration of grassland patches within this size range to optimize habitat suitability.
- Protection and restoration of critical native tall grass species such as *Themeda triandra*, *Hyparrhenia filipendula*, *Andropogon amethystinus* and *Pennisetum cladestinum*, which provide essential nesting habitat and structural support for breeding populations of grassland specialist birds
- Minimize Forest Edge encroachment into grasslands. Sharpe's Longclaw showed high sensitivity to Forest Edged grasslands, with low occurrence and density. Forest encroachment should be controlled in key grassland habitats to reduce negative edge effects.
- Incorporate roadside grasslands into conservation planning. Road Edged grasslands, while moderately preferred, supported consistent occurrences, especially of Longtailed Widowbird and Jackson's Widowbird. These areas should be considered supplementary habitats and included in grassland conservation networks.
- Conduct further research on nest success factors. Since nest success was not significantly affected by plot size, further studies should investigate other

influencing factors such as predation, grazing intensity, and microhabitat features to inform comprehensive nest protection strategies.

- Engage local communities and farmers to reduce and stop fragmentation. Local farmers should be engaged in bird-friendly practices through awareness campaigns and incentive-based conservation programs.

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APPENDICES

Appendix 1: Recorded Birds Species

	Species Common Name	Species Scientific Name
1.	Aberdare Cisticola	*Cisticola aberdare*
1.	African Citril	*Serinus citrinelloides*
2.	African Harrier Hawk	*Polyboroids typus*
3.	Amur Falcon	*Falco amurrensis*
4.	African dusky Flycatcher	*Muscicapa adusta*
5.	African pied Wagtail	*Motacilla aguimp*
6.	Augur Buzzard	*Muteo augur*
7.	Baglafetcht Weaver	*Ploceeus baglafecht*
8.	Barn Martin	*Riparia paludicola ducis*
9.	Barn Swallow	*Hirundo rustica*
10.	Black Chested Snake-Eagle	*Circaetus pectoralis*
11.	Black Crowned Crane	*Balearica pavonina*
12.	Black headed Heron	*Ardea melanocephala*
13.	Black saw Wing	*Psalidoprone pristoptera*
14.	Black shouldered Kite	*Elanus c. caeruleus*
15.	Black winged Plover	*Vanellus melanopterus*
16.	Blacksmith Plover	*Vanellus armatus*
17.	Brimstone Canary	*Serinus sulphuratus*
18.	Bronze Mannikin	*Lonchura cucullata*
19.	Bronze Sunbird	*Nectarinia kilimensis*
20.	Cape robin Chat	*Cossypha caffra*
21.	Cape Rook	*Corvus capensis*
22.	Cattle Eglet	*Bubulcus ibis*
23.	Common Bulbul	*Pycnonotus barbatus*
24.	Common Fiscal	*Lanius humeralis*
25.	Common Quil	*Coturnix coturnix erlangeri*
26.	Common Sandpiper	*Actitis hypoleucos*
27.	Common Stonechat	*Saxicola torquata axilllaris*
28.	Common Waxbill	*Estrilda astrild*
29.	Crowned Plover	*Vanellus Coronatus*
30.	Dusky turtle Dove	*Streptopelia lugen*
31.	Egyptian Goose	*Alopochen aegyptiacus*
32.	Gabar Goshawk	*Micronisus gabar*
33.	Grassland Pipit	*Anthus cinnamomeus*
34.	Gray headed Sparrow	*Passer griseus*
35.	Great blue eared Starling	*Lamprotornis chalybaeus*
36.	*Great white Pelican*	*Pelecanus onocratalus*
37.	Grey Heron	*Ardea cinerea*
38.	Hadada Ibis	*Bostrychia hagedash*

39.	Harlequin Quail	*Cotrnix delegorguei*
40.	Hamerkop	*Scopus umbretta*
41.	Hunters Cisticola	*Cisticola hunteri*
42.	Jacksons Widowbird	*Euplectes jacksoni*
43.	Levaillant's Cisticola	*Cisticola tinniens*
44.	Little Swift	*Apus affinis*
45.	Long-Creasted Eagle	*Lophaetus occipitalis*
46.	Longtailed Commorant	*Phalacrocorax a. africanus*
47.	Long-tailed Widowbird	*Euplects progne*
48.	Mountain yellow Warbler	*Chrolopeta similis*
49.	Mourning Dove	*Streptopelia d. perspicillata*
50.	Northern anteater Chat	*Myrmecocichla aethiops*
51.	Olive thrush	*Turdus olivaceus*
52.	Pallid Harrier	*Circus macrourus*
53.	Pectoral patch Cisticola	*Cisticola brunnescens*
54.	Pied Crow	*Corvus albus*
55.	Pintailed Whyder	*Vidua macroura*
56.	Purple Grenadia	*Uraeginthus ianthinogaster*
57.	Rattling Cisticola	*Cisticola chiniana*
58.	Red Knobed Coot	*Fulica cristata*
59.	Red-billed Quelea	*Quelea Quelea quelea*
60.	Red-caped Lark	*Calandrella Cinerea*
61.	Red-collared Widowbird	*Eupletes ardens*
62.	Red eyed Dove	*Streptopelia semitorquata*
63.	Red-rumped Swallow	*Cecropis daurica*
64.	Ring necked Dove	*Streptopelia capicola*
65.	Rock Martin	*Ptyonoprogne fuligula*
66.	Rufous naped Lark	*Mirafra africana*
67.	Rufous Sparrow	*Aimophila ruficeps*
68.	Sacred Ibis	*Threskiornis aethiopicus*
69.	Sharpe's Longclaw	*Macronyx sharpei*
70.	Speckled Mousebird	*Colius striatus*
71.	Speke's Weaver	*Ploceus Spekei*
72.	Steppe Buzard	*Buteo vulpinus*
73.	Stout Cisticola	*Cisticola robustus*
74.	Streaky Seedeater	*Serinus striolatus*
75.	Superb Starling	*Lamprotornis superbus*
76.	Tropical boubou	*Laniarius aethiopicus*
77.	White eye-slaty Flycatcher	*Melaenornis fischeri*
78.	White rumped Swift	*Apus caffer*
79.	White winged Widowbird	*Eupletes albonotatus*
80.	Wing snapping Cisticola	*Cisticola ayresii mauensis*
81.	Yellow billed Duck	*Anas undulata*
82.	Yellow Bishop	*Euplectes pronge*
83.	Yellow crowned Canary	*Serinus flavivertex*
84.	Yellow vented Bulbul	*Pyconotus goiavier*

85.	Yellow Wagtail	*Motacilla flava*
86.	Yellow white-eye	*Zosterops senegalensis*
87.	Yellow throated Longclaw	*Macronyx c. croceus*

Appendix 2: Bird Population Averages Record

Edge Type	Forest Edge				Road Edge				Cultivated Edge			
	FT1	FT2	FT3	FT4	RT1	RT2	RT3	RT4	CT1	CT2	CT3	CT4
All spp Average Population	16.71	24.4	36	0	32.5	15.8	34.67	68	34	51.75	55	0
Long-tailed Widowbird Average	2.7	1.2	0	0	3.5	0.2	3.33	6.67	3.8	8.11	2.5	0
Jackson's Widowbird Average	1.57	9	0	0	1.17	0.4	15.33	25	7	7.89	0	0
Sharpe's Long-claw Average	0	0.2	0	0	0.33	0.2	3.67	0.33	0.6	1.67	4	0

Appendix 3: Nest Averages at Different Transects

	FT1	FT2	FT3	FT4	RT1	RT2	RT3	RT4	CT1	CT2	CT3	CT4
All Nest Average	3	13	0	0	2.75	1	9.7	11.3	10.3	14	3	0
Long-tailed Widowbird Nest Average	5	2.5	0	0	2	0	2.5	1	3.8	10	3	0
Jackson's Widowbird Nest Average	3.5	9.5	0	0	4	0	10.7	16	11.7	4.8	0	0
Sharpe's Longclaw Nest Average	0	0	0	0	0	0	0	0		0	0	0

Appendix 4: Data Collection Sheet

BIRD'S DISTRIBUTION SURVEY IN KINANGOP - DATA SHEET

Plot No ___________________ Plot Name___________________________

Edge Type ___________________ Plot size: ________________________

GPS Coordinates____

Date: ___________________ Start Time_________________ End Time_______________

Weather

%Cloud Cover	**Rain (Tick)**			**Wind (Tick)**				**Temperature (Tick)**		
	None	Light	Heavy	Calm	Slightly Windy	Windy	Very Windy	Cold	Moderate	Hot

Species Assessment

Species Name	**T1/2/3 Tally**	**Total**	**Comment**

Names of Observers	**Contact: Email/Mobile Number**

Notes
