EFFECTS OF HABITAT DISTURBANCE ON DISTRIBUTION AND ABUNDANCE OF PAPYRUS ENDEMIC BIRDS IN SIO PORT SWAMP, WESTERN KENYA

By

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DECLARATION

I declare that this thesis is my original work and has not been submitted for examination in any other University for the award of a degree.

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Stellah Nekesa Wanyonyi Date

(Reg. No. I56/80824/2012)

SUPERVISORS

This thesis has been submitted for examination with our approval as the university supervisors.

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DEDICATION

This thesis is dedicated to my family and the community in Sio Port swamp.

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LIST OF ABBREVIATIONS AND ACCRONYMS

E – East

GoK – Government of Kenya

GSW-Greater Swamp-warbler

IBA – Important Bird Area

IUCN – International Union for Conservation of Nature

Km – Kilometres

KE – Kenya

LVB – Lake Victoria Basin

m – Metres

N – North

NBTW- Northern Brown-throated Weaver

NGO – Non-governmental Organization

WRMA – Water Resources Management Authority

WWSW – White-winged Swamp-warbler

PG – Papyrus Gonolek

s.e.m – Standard error of mean

TSC – Timed Species Count

ABSTRACT

Papyrus swamps are found patchily around the shores of Lake Victoria mainly along river inflows. Elsewhere, this habitat is widely scattered with notable patches at Lake Naivasha and Lake Jipe. Sio Port is one of Lake Victoria's *Cyperus papyrus* swamp located at the mouth of River Sio, North of Lake Victoria on the border of Kenya with Uganda. It is an important bird area of Kenya supporting a wide range of birds; however, this swamp lacks formal protection. The swamp and its immediate surrounding have been encroached by forms of disturbances caused by human activities. This study investigated the different forms of habitat disturbance and their effect on the distribution and abundance of papyrus endemic birds. Data on bird counts, habitat quality and forms of disturbance were collected for a period of six months, in October 2013 to March 2014. Total bird counts were established using Timed Species Count (TSC) and playback call technique, done at every fixed point. The points were 50 m apart alternating left and right. At every fixed point count, the researcher waited for 1 minute, calls of the study species were played to elicit response of the secretive papyrus endemic birds; the number of birds of each species seen or heard only within a radius of 25 meters was recorded for the next 9 minutes before moving to the next point count. Habitat quality (height, density and level of maturity) was determined in 1 m^2 plots along transverse transects. Opportunistic observations were made to establish forms of disturbance present during vegetation and bird surveys. Papyrus endemic birds were highly distributed in sites with pure papyrus (55.58%) than in sites with mixed vegetation (44.42%). The abundance of three out of the four endemic birds White-winged Swamp-warbler ($F_{(1, 28)}$ =7.376 p = 0.011), Papyrus Gonolek ($F_{(1, 28)}$ = 5.331, p = 0.029), and Northern Brown throated Weaver ($F_{(1, 28)}$ = 5.734, p = 0.024) was significantly different in mixed and pure papyrus sites. However, the abundance of Greater Swamp-warbler ($F_{(1, 28)}$ =2.718, p = 0.110) were not significantly different in mixed and pure papyrus sites in Sio Port swamp in the study period. Forms of habitat disturbance established were vegetation clearing and invasion by terrestrial and aquatic plants. 76.47% of papyrus vegetation were young and regenerating (0-2 m high), 19.65% were immature papyruses (2-4 m) whereas 3.88% were tall mature papyruses (4-6 m high). Abundance of papyrus endemic birds was negatively correlated with density of vegetation in the height range of 0-2 m (r = -0.018, p = 0.941) and 2-4 m (r = -0.054, p = 0.822), the correlation was not significant. Abundance of papyrus endemic birds was positively and significantly correlated with density of vegetation in the height range of 4-6 m (r = 0.465, p = 0.039), the correlation was significant. Regression equation produced by the relationship was y = 2.590x + 0.465, t = 2.227, p = 0.039. Thus, any change in papyrus density resulted to a change in the abundance of papyrus endemic birds. High level of management of papyrus clearing is required for long term conservation of biodiversity.

Key Words: Sio Port swamp; Habitat Disturbance; Habitat Quality; Papyrus endemic birds.

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

Wetlands are ecosystems that integrate terrestrial and aquatic environments namely; water, soil and vegetation (Lathrop, 2011). Wetlands occupy approximately six percent (6 %) of the earth's surface area (Ramsar Convention Secretariat, 2006). The exact extent of Kenya's wetlands is unknown due to lack of a wetlands inventory; however, it is estimated to be 3-4 percent of Kenya's land mass (Kenya Wetlands Atlas, 2012). This can temporarily rise to 6 percent in the rainy season (Mwakubo & Ikiara, 2006; Kenya Wetlands Forum, 2012).

Papyrus swamps dominated by *Cyperus papyrus* form a distinctive wetland type in tropical Africa, supporting many endemic species (Hughes & Hughes, 1992). In Kenya, papyrus swamps are patchy and are found mainly along river inflows, and at the mouth of major rivers and lakes (Britton, 1978; Bennun & Njoroge, 1999; Boar *et al.,* 1999). Papyrus swamp occurs as intact patches of continuous fringe along the shores of Lake Victoria.

Papyrus swamps have important ecological, hydrological and economic functions (Mafabi, 2000). They provide water and primary productivity upon which large numbers of animal species depend for survival. Around Lake Victoria, they are of great significance for wildlife conservation as they host papyrus specialist birds, including the Papyrus Yellow Warbler *Chloropeta glacilirostris*, Papyrus Gonolek *Laniarius mufumbiri*, White-winged Swamp Warbler *Bradypterus carpalis*, Papyrus Canary *Serinus koliensis* and Carruthers's Cisticola *Cisticola carruthersi* (Van de Weghe, 1981; Nasirwa & Njoroge, 1997; Bennun & Njoroge, 1999; Mafabi, 2000; Byaruhanga *et al.,* 2001; Bird Life International, 2004). Papyrus Yellow Warbler and

Papyrus Gonolek are both listed as globally threatened and require urgent conservation action (Bird Life International, 2004).

Increased human population, especially in the sub-Saharan Africa has led to a decline in wetland goods (Balirwa, 1998). Poverty amongst riparian communities has led to unsustainable encroachment on wetland ecosystems leading to continued drainage, pollution, overexploitation and unsustainable use of wetland resources. It is estimated that the total area covered by papyrus swamps in Africa is 4,000 km^2 (Percy FitzPatrick Institute of African Ornithology, 2005). The extent of most wetlands is probably decreasing because of human encroachment and intensified land use changes around them (Hughes & Hughes, 1992; Mafabi, 2000; Kairu 2001).

1.2 Literature Review

1.2.1 Papyrus swamps in East Africa

Emergent sedge dominates much of the 85,000 km^2 of permanent swamp on the African continent (Beadle & Lind, 1960; Beadle, 1981; Thompson & Hamilton, 1983). *Cyperus papyrus* is the most dominant emergent vegetation in permanently flooded swamps in tropical Africa (Hughes & Hughes, 1992).

In East Africa, papyrus is common and expansively surrounds the perimeters of Lake Victoria (Thompson, 1985). Within Uganda, the most expansive papyrus swamps are found within the littoral regions of several other lakes such as Albert, Kyoga, Victoria and George as well as numerous smaller lakes (Beadle, 1981). In Tanzania, rivers, lakes and valley papyrus swamps are present (Muthuri & Jones, 1997).

In Kenya, a fringing belt of papyrus is continuous along the Lake Victoria shoreline. Large stretches of papyrus also occupy an area of about 162 km^2 in the contiguous Yala swamp around

Lakes Kanyaboli and Sare (Britton, 1978). Papyrus swamps are patchy in other areas in Kenya, along rivers and lakes.

Lake Victoria is the world's second largest freshwater lake. The lake's wetlands constitute about 37% of the total wetland surface area (2,737,790 ha) in Kenya (Koyombo & Jorgensen, 2006; Finlayson *et al*., 1999). According to Katua and M'mayi (2001), several parcels of wetlands are linked to the lakeshore, floodplains and deltas of rivers and streams found flowing into the lake.

Most wetlands bordering Lake Victoria are mainly dominated by *Cyperus papyrus*; other vegetation types which are less dominant include; *Phragmities mauritianus*, *Typha domingensis*, *Laudetia phragmitoides* and *Vossia cuspidata* (Kansiime *et al*., 2007).

For the purpose of water management, Lake Victoria (Lake Victoria Basin) is subdivided into two by Water Resources Management Authority (WRMA); Lake Victoria North Basin and Lake Victoria South Basin.

Lake Victoria North Basin has an area of approximately 32,384 km^2. The main rivers associated with it are Nzoia and Sio-Siteko. The Nzoia river basin is the largest sub-basin in the Lake Victoria North Basin (Nyadawa & Mwangi, 2010). The major wetlands in the Lake Victoria North Basin are Yala swamp, Lake Kanyaboli and Sio port swamp wetland. Sio port swamp is a transboundary wetland [fig. 1.1].

Lake Victoria South Basin is located on the southern part of Lake Victoria from the Yala River past Migori River, up to the border with Tanzania. It has an approximate area of 18,613 km^2. The main wetlands of this basin are associated with rivers Gucha, Migori, Nyando and Sondu–Miriu

(Kenya Wetland Atlas, 2012). Papyrus swamps in the Lake Victoria South Basin include; Nyando (Kusa), Ndere, Dunga and Koguta [fig 1.1].

Fig 1.1: Map showing the location of papyrus swamps in the Lake Victoria Basin (Source: Kenya birds-edited)

1.2.2 Papyrus utilization in East Africa

Papyrus (*Cyperus papyrus*) is the largest sedge in the world and one of the most commonly used macrophytes in the tropics. Normally, it attains heights of 3-4 meters, typically comprising over

95% of the plant biomass of the papyrus swamp (Thompson, 1976; Thompson *et al*., 1979; Ellery *et al*., 1995).

Papyrus is a highly productive plant (Terer *et al*., 2011); it can regain its original biomass probably in less than 12 months (Jones, 1983). The annual production of the most productive papyrus swamps compares to that of forest ecosystem as a biomass source (Jones, 1983). It is a rhizomatous, perennial plant which exhibits a C_4 type of photosynthesis, a characteristic of many highly productive tropical grasses, hence the high productivity of papyrus swamps in East and Central Africa (Jones & Milburn, 1978; Jones & Muthuri, 1997).

Papyrus swamps have been characterized as detritus-based ecosystem (Howard-Williams & Gaudet, 1985). Detritus is produced by the decomposing plants; the decomposition is rather slow due to the anaerobic conditions in the swamp. Detritus provides nutrients which facilitate regeneration of papyrus plants.

Papyrus offer important biodiversity services such as, breeding grounds for fish (Mnaya & Wolanski, 2002), grazing fields for wild herbivores during dry seasons (Morrison & Harper, 2009) and habitat for birds such as Papyrus Yellow Warbler (*Chloropeta glacilirostris*) and Papyrus Gonolek (*Laniarius mufumbiri*) both of which are endemic to papyrus habitat and are listed as near threatened (Birdlife International, 2004; IUCN, 2010).

In the recent past, papyrus biomass has been exploited on a small scale mainly for mats, baskets, ropes, roofing material and firewood (Gichuki *et al*., 2001; Kaggwa *et al*., 2001). Today, this practice has graduated to exploitation of papyrus for commercial purposes (Abila, 1998; Otieno *et al*., 1998). Baskets and mats are common in markets in Busia County, while thatch and reeds

are common products in markets in Siaya County (Otieno *et al*., 1998). Most communities use papyrus as building materials (Abila, 1998). Papyrus may also be used as paper (Muthuri & Kinyamario, 1989). Papyrus swamps are also net carbon sinks (Jones & Muthuri, 1997).

1.2.3 Papyrus swamp bird species

Papyrus swamps support a wide range of bird species, which are categorised depending on the level of reliance on papyrus swamps.

Papyrus specialist species are birds which are restricted only to the papyrus dominated habitat. They are also known as the papyrus endemic birds. Papyrus Gonolek, Papyrus Canary and White-winged Swamp Warbler are entirely restricted to papyrus (Vande Weghe, 1981). Carruthers's Cisticola, Greater Swamp-warbler *Acrocephalus rufescens* and Papyrus Yellow Warbler are restricted locally to papyrus but may also occupy swamp grass habitat (Britton, 1978; Vande Weghe, 1981; Fry *et al*., 2000).

Swamp reliant species are bird species which rely on tall emergent swamp vegetation which is not necessarily papyrus. In some cases, they may be found along the edges of papyrus swamp (Maclean *et al*., 2003). An example is the Lesser Swamp Warbler *Acrocephalus gracilirostris.*

Swamp opportunist species are bird species which are found in swampy areas, which may not necessarily have tall emergent swamp vegetation. They may also be found away from swamps (Maclean *et al*., 2003). An example is Winding Cisticola *Cisticola galactotes.*

Open water associated species are bird species often found in swamps. They forage in or around open waters. Most of these species are piscivorous which use the emergent vegetation for

roosting or as hunting perches, for example Kingfisher. Another example is the Jacana which relies on water lilies and floating vegetation on the lakeside swamps (Maclean *et al*., 2003).

Generalist species are bird species which are found in a wide variety of habitats and are not typical of lake side or swamp habitats (Maclean *et al*., 2003).

1.2.4 Other wildlife

Lake Victoria wetlands also host wildlife such as the Sitatunga antelope *Tragelaphus spekei* and African python *Python sebae* besides the papyrus endemic birds [refer to page 13 on wildlife resources].

1.2.5 Effect of anthropogenic disturbances on papyrus swamps

Papyrus (*Cyperus papyrus*) swamps are the most widespread type of wetland in East and Central Africa (Thompson, 1976). They provide important ecosystem goods and services to millions of people in sub-Saharan Africa (Van Dam *et al*., 2007), but have a long history of human disturbance. According to Turner (1996), smaller fragments of habitat may be more accessible and consequently more heavily disturbed. Similarly, papyrus swamps are naturally fragmented and are increasingly threatened by human activities (Crisman *et al*., 1996; Mafabi, 2000). Alteration of natural landscapes such as papyrus swamps by human activities poses many conservation problems (Perrings *et al*., 1992).

Kenyan papyrus habitats are important and highly productive, but none of them is formally protected (Fanshawe & Bennun, 1991; Johnstone & Githongo, 1997; Nasirwa & Njoroge, 1997; Bennun & Njoroge, 1999). In such habitats, papyrus is often harvested intensively for handcrafts and thatching. Papyrus harvesting and drainage of swamps are increasing as a consequence of

expanding human populations (Maclean *et al.,* 2003c). As a result, papyrus swamp habitats are reducing in size.

Bird communities in papyrus habitats are amongst the least well protected birds in East Africa (Muriuki *et al.,* 1997; Bennun & Njoroge, 1999). In many places, their habitat is under immediate threat of degradation or loss (Britton, 1978; Vande Weghe, 1981; Muriuki *et al.,* 1997; Boar *et al*., 1999).

Degradation and loss of papyrus habitats largely affects papyrus bird species that are entirely or almost entirely restricted to papyrus (Britton, 1978; Vande Weghe, 1981).These birds are thought to be among the most threatened of all bird species in East and Central Africa (Muriuki *et al*., 1997; Bennun & Njoroge, 1999; Byaruhanga *et al*., 2001). One of these, Papyrus Yellow Warbler *Chloropeta gracilirostris* is threatened globally and is classed as vulnerable. Papyrus Gonolek *Laniarius mufumbiri* is considered near threatened (Bird Life International, 2000).

1.2.6 Justification

Papyrus *Cyperus papyrus* swamps support many bird species some of which are endemic to papyrus swamp habitat. Kenyan papyrus swamps are not formally protected. There has been continued extraction of papyrus leading to destruction of this habitat. In addition, encroachment of swamp areas for agriculture and settlement by surrounding communities has led to a reduction in the size of these habitats. Long term destruction of papyrus swamps and reduction of their sizes will affect their quality and ability to support biodiversity, especially the endemic birds. Therefore, there is urgent need to carry out site specific studies on papyrus endemic birds and utilisation of their habitat by local communities. Threats to wetlands around the lake should also be monitored to protect suitable habitat for the species. This study at Sio Port swamp provides

information on the effect of habitat disturbance on papyrus and their biodiversity. This information will be useful to stakeholders in the environmental conservation sector in protecting papyrus habitats and papyrus endemic birds.

About the study site

Sio Port swamp is an Important Bird Area facing degradation. This swamp is *Cyperus papyrus* dominated and lies on the northern shores of Lake Victoria, on the border of Kenya with Uganda. It is a significant biodiversity site with focus particularly on birds. The swamp supports Lake Victoria bird species endemic to this region including Papyrus Gonolek (*Laniarius mufumbiri*), White-winged Swamp Warbler (*Bradypterus carpalis*), Papyrus Canary (*Serinus koliensis*), Carruthers's Cisticola (*Cisticola carruthersi),* Black-lored Babbler *(Turdoides sharpie),* Red-chested Sunbird *(Nectarinia erythrocerca)* and Northern Brown-throated Weaver *(Ploceus castanops)* among others. However, the swamp lacks formal protection that would allow for coherent conservation action and management. It is threatened by intensive human activities such as papyrus cutting, burning, sand harvesting, siltation and cultivation on swamp edges which result into habitat disturbance. The effect of different forms of disturbance on the papyrus specialist birds need to be assessed.

1.2.7 Main objective

To determine the effects of habitat disturbance on the distribution and abundance of papyrus endemic birds in Sio Port swamp in Busia County, Western Kenya.

1.2.8 Specific objectives

1. To estimate the population size of papyrus endemic birds in Sio Port Swamp.

2. To identify the various forms of disturbance in Sio Port swamp.

3. To assess the effects of the quality of the habitat on the distribution and abundance of papyrus endemic birds in Sio Port swamp.

1.2.9 Hypothesis

Habitat disturbance does not affect distribution, abundance and population size of papyrus endemic birds in Sio Port Swamp.

CHAPTER TWO

STUDY AREA, MATERIALS AND METHODS

2.1 Study area

2.1.1 Location and size

Sio port swamp is located in the Lake Victoria North Drainage basin on the Kenya-Uganda border, at latitude 0.2242^0N and longitude 34.0217^0E, at an altitude of 1,130 m above sea level (Bennun & Njoroge, 1999). It is located in Busia County in the western part of Kenya.

Sio Port swamp is an inland wetland, a permanent herbaceous swamp and bog. It consists of other interconnected subsystems that drain in Lake Victoria (Kenya Wetland Atlas, 2012). This swamp is dominated by papyrus *Cyperus papyrus* vegetation.

The swamp has an area of 400 hectares and it is fed by river Sio [fig 2.1], which originates from the southern slopes of Mt. Elgon (Barasa *et al*., 2011). The river is permanent and has a total length of 85 km and a catchment area of 1,388 Km^2 (GoK, 2009).

2.1.2 Ecosystem services and products

Sio Port swamp as an ecosystem has both consumptive and non-consumptive use benefits. Consumptive use benefits include extraction of papyrus culms for firewood, construction of houses especially the roof, making of mats and baskets. Water is also collected from the swamp for domestic use, such as cleaning.

Sio Port swamp is a habitat to both plants and animals some of which are a source of food to the local community. For instance, the local community's main economic activity is fishing, which is done within the lake and also in the swamp by use of fish traps. Due to its status as an Important Bird Area, it has attracted tourists who visit for nature photography and bird watching.

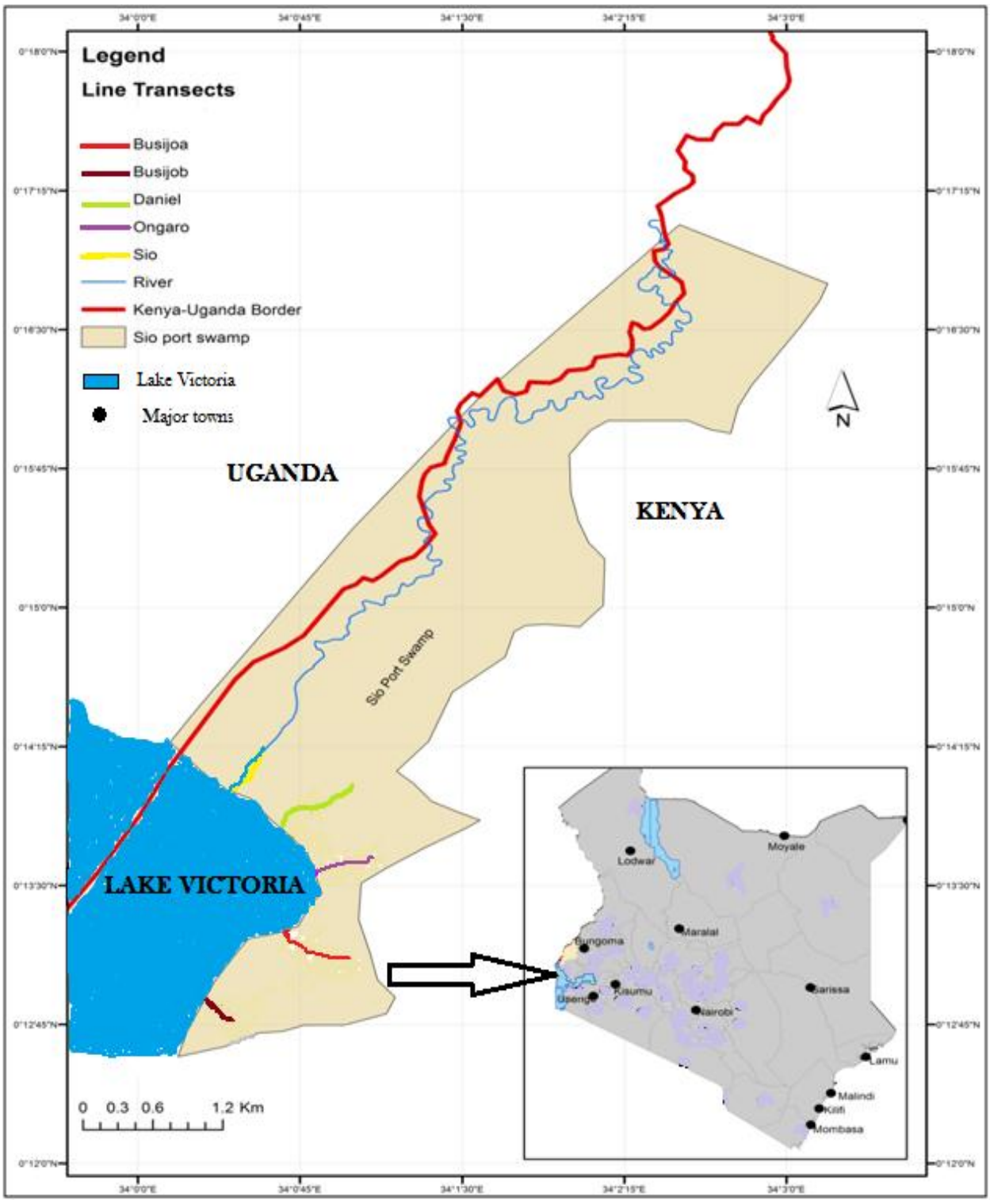

Fig 2.1: Study area showing features and line transects at Sio Port Swamp, Busia County.

2.1.3 Climatic conditions

Sio Port Swamp is located in a region which receives 1239 mm of rainfall annually. The driest month is July with 50 mm of rainfall whereas the wet month is April with an average of 207 mm of rainfall (Kenya Metrological Department).

The average annual temperature is 22.4 ^{0}C. The month of March is the warmest with an average temperature of 23.2 ^{0}C. July is the month that has the lowest average temperature in the whole year. The difference in precipitation between the driest month and the wettest month is 157 mm. The average monthly temperature varies during the year by 1.7 ^{0}C in different months (Kenya Metrological Department).

2.1.4 Natural vegetation

Sio port swamp consists of mature almost undisturbed; continuous papyrus stands, stretching from the mouth of the Sio River southwards for about 3.5 km along the lake shore (Bennun & Njoroge, 1999). The swamp has been heavily invaded by the water hyacinth, which presently covers a large part of Lake Victoria (Bennun & Njoroge, 1999). Other vegetation includes; Hippo grass *Vossia cuspidata,* herbaceous vegetation such as *Commelina spp., Amaranthus spp., Cyphostemma kilimandscharicum* and *Ipomoea stolonifera*.

2.1.5 Wildlife resources

Its qualification as an Important Bird Area (IBA) comes as a result of its support for a large number of bird species, such as the Blue-breasted Bee Eater, Papyrus Gonolek, White-winged Swamp Warbler, Black-throated Seedeater, Steel blue whydah and the Papyrus Canary. Other wildlife includes the rare Sitatunga antelope *Tragelaphus spekei*, Vervet monkey *Chlorocebus*

pygerythrus, Hipoppotamus *Hipoppotamus amphibius* and African python *Python sebae* (Ouma, 2010).

2.1.6 Socio-economic activities

The socio-economic activities in Sio Port include trade, agriculture and fishing. Most of the goods sold are farm produce such as, sorghum, maize and cassava, some of which come from communities in the neighbouring Uganda. There is also mat and basket weaving for sale. In addition, fish from Lake Victoria are sold. Crops grown include maize, millet, arrow roots, beans, cassava, kales, potatoes and sugarcane. Domestic animals such as cows, sheep, donkeys and dogs are also kept.

2.2 Study species

The papyrus swamp endemic bird species investigated were: Papyrus Gonolek, *Laniarius mufumbiri* which is listed as near threatened on the IUCN Red List of threatened species (Birdlife International, 2012), White-winged Swamp-warbler, *Bradypterus carpalis*, Northern Brown-throated Weaver *Ploceus castanops* and Greater Swamp-warbler *Acrocephalus rufescens* which are of least concern in the IUCN Red List of threatened species.

Papyrus Gonolek

Papyrus Gonolek [fig 2.2] was named by Ogilvie-Grant (1911), in the Order Passeriformes, Family Malaconotidae, Genus Laniarius and species L.mufumbiri. It is locally distributed in North-eastern Democratic Republic of Congo, Uganda, Eastern Rwanda where it is abundant (Vande Weghe, 1981), Burundi and Western Kenya. In Kenya it is restricted to papyrus swamps of up to 1600 m of altitude (Zimmerman *et al*., 1996).

The species population has been estimated to be approximately 2 million adults and about 3 million in total. This estimation has been done using habitat association modelling, a method which estimates the occurrence and density of species across a large portion of their range (Maclean, 2004; Maclean *et al.*, 2014).

According to Fry *et al.*, (2000), Papyrus Gonolek is confined to papyrus *Cyperus papyrus* swamps and beds, in meandering river valleys and along the shores of Lake Victoria. Its diet includes; ants, weevils, small flies, caterpillars, snails and fruits.

The species specialised habitat requirements make it susceptible to threats such as drainage, burning and overexploitation of wetlands. Papyrus Gonolek has become rare due to papyrus habitat loss and pollution through discharge of sewage water into their habitat. It is categorised as near threatened in the IUCN Threat Criteria.

Length: 170-190 mm
Weight: 34 - 46 g

Fig 2.2: Papyrus Gonolek (Source: Maclean)

Papyrus Gonolek is restricted to *Cyperus papyrus* swamps and beds and along lake shores (Fry *et al*., 2000) where it is locally common in Kenya (Zimmerman *et al*., 1996). The global population of this species is approximately 2,000,000 adults (Maclean, 2004).

White-winged Swamp-warbler

The natural habitat of White-winged Swamp-warbler [fig 2.3] is swamp. Its conservation status is classified as one of least concern on the IUCN Red list. The bird was first named by Chapin in 1916 and classified in the Order Passeriformes, Family Locustellidea, Genus Bradypterus and species B. *carpalis*.

It is found in Burundi, Democratic Republic of Congo, Kenya, Rwanda, Tanzania, Uganda and Zambia (Birdlife International, 2012). The global population size has not been quantified but the species is described as locally common in river systems in central and eastern Rwanda (Del Hoyo *et al*., 2006). Its population trend has been decreasing.

Length: 160.5 - 170 mm
Weight: 19 -26 g

Fig 2.3: White-winged Swamp-warbler
(Source: Martin Odino)

The global population of the White-winged Swamp-warbler has not been estimated, however, the population of this papyrus endemic is on the decline (Birdlife International, 2012). Even though the species are described as locally common, destruction of papyrus habitat has forced them to move to alternative habitat. White-winged Swamp-warbler has been recorded in elephant grass following a decline in papyrus beds (Birdlife International, 2012).

Northern Brown-throated Weaver

Northern Brown-throated Weaver (*Ploceus castanops*) [fig 2.4] is found in waterside vegetation along lakes and rivers, particularly papyrus (*Cyperus papyrus*). Its main diet consists of seeds such as millet and also insects. It forages in small flocks with other weavers on the ground, in vegetation and on floating matter (Craig, A. 2016). This bird was first identified by Shelley in 1888 in Wadelai in North Uganda close to the Sudan border. Its conservation status is classified as one of least concern on the IUCN Red list.

Length: 140 mm
Weight: 18-27 g

Fig 2.4: Northern Brown-throated Weaver
(Photo by Stellah Nekesa March 2014)

Greater Swamp-warbler

Greater Swamp-warbler [fig 2.5] was first identified by Sharpe and Bouvier in 1876 (Birdlife international, 2016) in Landana Cabinda in Angola. The bird's conservation status is that of least concern in the IUCN Red list. The global population size has not been quantified but the species is described as rather scarce to locally common (Del Hoyo *et al*., 2006).

The habitat of Greater Swamp-warbler *Acrocephalus rufescens* is papyrus (Cyperus papyrus) swamps, wet elephant grass, reed mace (Typha) stands and reeds. This bird is noted to be

patchily distributed in the papyrus swamps (Dyrcz, A. 2016). It is shy and elusive and usually keeps well within cover of tall and dense papyrus and reed swamp.

Greater Swamp-warbler feeds on insects present on the stems of papyrus (*Cyperus papyrus*) and other reed leaves. Its diet consists of beetle larvae, damsel flies, noctuid moth larvae, and other aquatic insects. It occasionally feeds on small frogs (Hockey, P.A.R. *et al.*, 2005).

The nest is a deep cup built of papyrus *Cyperus papyrus* and other reed leaves. The nest is attached to a number of papyrus stems, usually 1.0 m -2.5 m above the water level (Hockey, P.A.R. *et al.*, 2005).

Length: 160 -180 mm
Weight: 21.6 – 23.9 g

Fig 2.5: Greater Swamp-warbler
(Photo Stellah Nekesa January 2014)

2.3 Materials and methods

This study was carried out during the period between October 2013 through to March 2014 (six consecutive months). The study period comprised two seasons; wet (October to December) and dry (January to March). Five bird species which are endemic to the papyrus habitat were studied. These were White-winged Swamp-warbler *Bradypterus carpalis*, Papyrus Gonolek *Laniarius mufumbiri*, Greater Swamp-warbler *Bradypterus rufescens* and Northern Brown-

throated Weaver *Ploceus castanops*.

2.3.1 General methods

Stratification of study site

Sio Port swamp had vegetation ranging from tall grass to papyrus at different stages of regeneration. The most dominant vegetation was papyrus. There were regions that had pure papyrus vegetation that was almost undisturbed while some areas had a mixture of grass and papyrus vegetation. The variations in papyrus distribution were used as the basis for stratification of the swamp.

Transverse transects were selected from the pathways used by fishermen and other local people to access the lake from the land. Five transects were identified basing on the ability to penetrate the papyrus habitat without necessarily creating new paths, which would otherwise have been tedious, expensive and destructive. Transects had their local names as Ongaro, Sio, Daniel, Busijo a and Busijo b [fig 2.6].

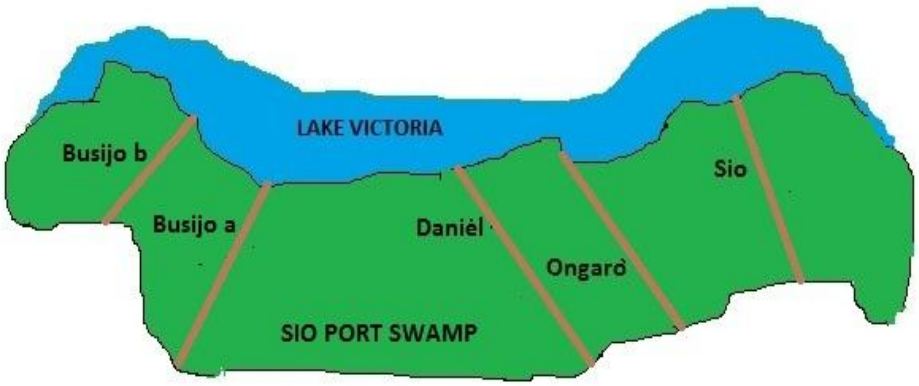

Fig 2.6: Sketch map for the study site in Sio Port swamp showing the transverse transects

Sio, Busijo a and Busijo b had a mixture of papyrus vegetation and grass, they were identified as mixed papyrus (MP) [fig 2.7 (a)]. Ongaro and Daniel had papyrus vegetation that was almost undisturbed; they were identified as pure papyrus (PP) [fig 2.7 (b)].

(a) (b)

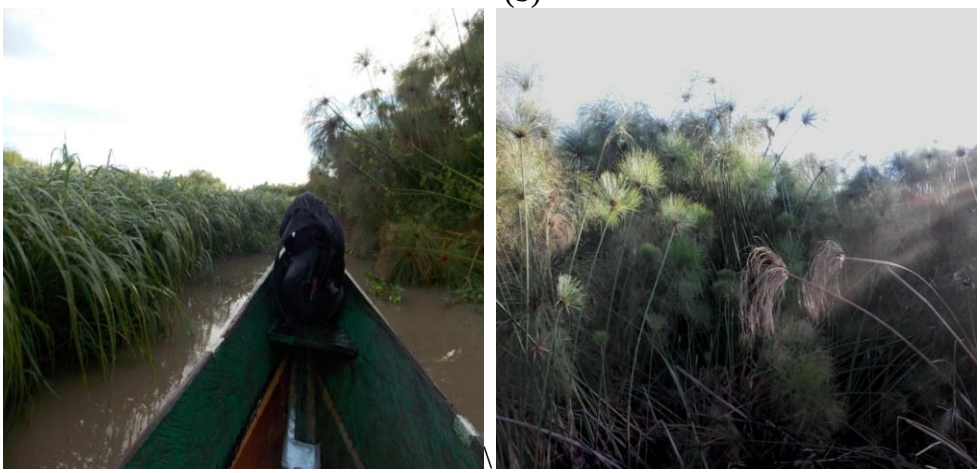

Fig 2.7: Sections of mixed papyrus (a) and pure papyrus stratum (b)
(Photos by Stellah Nekesa, January 2014)

This summarized the strata into two, mixed papyrus (MP) and pure papyrus (PP). Transects were of varying lengths and had different number of sampling points [Table 2.1].

Table 2.1: Transect name, length and the number of points present

Stratum	**Transect name**	**Transect length (m)**	**Number of points per transect**
Mixed papyrus (MP)	Sio	300	7
Mixed papyrus (MP)	Busijo a	200	5
Mixed papyrus (MP)	Busijo b	50	2
Pure papyrus (PP)	Ongaro	200	5
Pure papyrus (PP)	Daniel	500	11

Establishment of observation points

Observation or fixed points were identified systematically according to the nature of the habitat and marked using a GPS along the transverse line transects, at least 50m apart. The observation points were set up alternating left and right along the transects [fig 2.8].

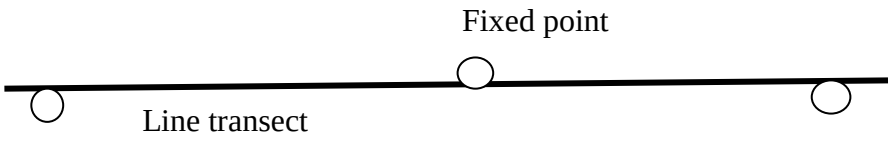

Fig 2.8: Fixed points set up along a line transect

2.3.2 Specific methods

Estimation of population size of endemic birds

The birds were observed between 0700 hrs and 0900 hrs every morning of each day of the study period. During this time, most fishermen would have returned to the beach after their catch, hence there was minimal disturbance while conducting the counts.

Timed species count technique and play back calls were used to detect and estimate the number of individual bird species using the habitat. Timed species count (TSC) method involves repeated species lists, on which each species is recorded the first time it is positively identified by either sight or sound (Bennun & Howell, 2000; Sutherland, 1996). Play back call technique involves playing recorded sounds of the target bird species. It is mainly used to elicit response from secretive birds which on hearing the calls will call back or move in search for the 'other' bird.

At every fixed point count, the researcher waited for 1 minute, calls of the study species were played to elicit response of the secretive papyrus endemic birds; the number of birds of each species seen or heard within a radius of 25 meters was recorded for the next 9 minutes before

moving to the next point count. Birds seen or heard beyond the set distance were ignored. Observations were made in all directions, with observers standing back to back to minimize chances of double counting, especially in cases where a bird flew from one side to the other. A pair of binoculars was used to make observations in cases where a bird could not be easily recognized due to interception by vegetation. This was done at all the fixed points along all transects.

Identification of forms of disturbance

Opportunistic observations were made along transects to establish any form of disturbance present. The forms of disturbance were placed into two main categories; vegetation clearing and invasion by terrestrial or invasive plants. Vegetation clearing involved activities such as, vegetation cutting, vegetation burning, cultivation and livestock grazing. The frequency of occurrence of each form of disturbance was recorded during the vegetation and bird surveys along all transects.

Determination of quality of habitat

Vegetation height and density were used to describe the quality of habitat in Sio Port swamp. A study by Owino and Ryan (2006) indicated that local papyrus habitat-specific characteristics, such as height and percentage cover provided the best means of predicting the occurrence of papyrus specialist birds, since the birds are sensitive to papyrus physical structure. The height of papyrus culm was also described in terms of the stages of maturity that is; young, immature and mature [appendix III] (Sutton & Hudson, 1981).

At every fixed point, a plot of 1m by 1m was set up using the pieces of marked wood. The number of papyrus culms in each plot were counted and recorded to give density. A long pole

and piece of stick marked at different length intervals (in meters) was used to estimate the height of papyrus vegetation. The height of each stem or culm sampled was recorded in either of the three height ranges; 0-2 m, 2-4 m and 4-6 m coinciding with the range of young papyrus, immature papyrus and mature papyrus respectively.

2.4 Data analysis

Data on bird counts; vegetation density and vegetation height were entered into excel spread sheets. The data were then subjected to descriptive statistics whereby, the size, mean and standard deviation were calculated. The data were tested for normality using the Shapiro-Wilk test of the p-value followed by log transformation of skewed data where necessary (Zar, J.H., 2010). Data analysis was conducted using IBM SPSS Statistical software version 20.

The number of birds counted at each vegetation stratum was assumed to be independent. Density of individual bird species was determined by dividing the number of birds of each species by the total area sampled (5.89 ha).

Population size of individual bird species was estimated using the incomplete count method which does not involve use of the number of birds occurring beyond the estimated radius (25 metres). The nature of papyrus vegetation in the habitat could not allow observations to be made beyond 25 metres .This method is as follows: Population size $N = \frac{AZ}{XY}$ (Burnham *et al*., 1980) where;

N = estimated bird population size

A = total area of study site (ha)

Z = number of individual of a species counted

X = total distance covered

Y = double width of radius

Analysis of Variance test was used to compare the distribution of papyrus endemic birds in points along transects; to determine the difference in the abundance of the endemic birds in pure and mixed papyrus stratum and to compare the density of vegetation of different height ranges in mixed and pure papyrus strata.

Bar graphs were constructed using the density of endemic birds counted in all sites, to show the mean distribution of the birds in points along transects.

The birds' habitat quality was determined from two vegetation attributes; culm height and culm density. These are important characteristics for papyrus specialist birds, as they provide suitable habitat conditions for nesting and feeding (Owino & Ryan, 2006). Data on height of vegetation was organized into the various classes (0-2 m, 2-4 m and 4-6 m). The mean height for each class was then determined in all transects for all the vegetation sampled. Correlation analysis was used to establish the relationship between vegetation density and vegetation height while regression analysis (carried out only for significant correlation) was used to determine the relationship between numbers of birds of each individual species with vegetation density.

CHAPTER THREE

RESULTS

3.1 Papyrus endemic bird species and their abundance

A total of four papyrus endemic birds namely; Papyrus Gonolek, White-winged Swamp-warbler, Northern Brown-throated Weaver and Greater Swamp-warbler were observed in Sio Port swamp and studied during the period between October 2013 and March 2014.

A total of 501 individuals of the four species (White-winged Swamp-warbler; Papyrus Gonolek; Northern Brown-throated Weaver and Greater Swamp-warbler) were recorded during the study. Out of this, 114 were White-winged Swamp-warbler, 101 were Papyrus Gonolek, 222 were Northern Brown-throated Weaver while 64 were Greater Swamp-warbler. The estimated density, population size and proportion of the four endemic bird species studied in Sio Port swamp (400 ha) are shown in table 3.1.

Table 3.1 Estimated densities and population size of papyrus endemic birds studied in Sio Port swamp (Oct 2013-March 2014)

Bird name	**Density (birds/ha)**	**Estimated population size**	**Proportion (%)**
White-winged Swamp-warbler	19.36	7296	23
Papyrus Gonolek	17.16	6464	20
Northern Brown-throated Weaver	37.71	14208	44
Greater Swamp-warbler	10.87	4096	13

Northern Brown-throated Weaver had the highest population size followed by White-winged Swamp-warbler, Papyrus Gonolek and finally Greater Swamp-warbler.

3.2 Habitat disturbance in Sio Port swamp

Forms of disturbance in Sio Port swamp

The forms of vegetation disturbance identified during the study were; vegetation clearing and invasion by terrestrial and aquatic plants. Vegetation clearing was the most common form of disturbance compared to invasion by terrestrial and aquatic plants [table 3.2].

Table 3.2 Forms of disturbance in points along transects (October 2013 to March 2014)

Transect name	**Form of disturbance**	**Points where recorded**
Sio	Vegetation clearing	II, IV, V and VI
	Invasion	All points
Busijo a	Vegetation clearing	III
	Invasion	All points
Busijo b	Vegetation clearing	I and II
	Invasion	II
Ongaro	Vegetation clearing	II, III, IX and X
	Invasion	None of the points
Daniel	Vegetation clearing	II, III, IV and V
	Invasion	III, IV and V

Vegetation clearing

Vegetation clearing was mainly done through burning of vegetation, cutting of papyrus culms, livestock grazing and cultivation along the edges of the swamp.

Vegetation burning was one of the most common forms of vegetation clearing observed throughout the study period and it occurred in patches in parts of the swamp [fig 3.1]. Papyrus

was the main vegetation affected. However, other vegetation species such as *Vossia cuspidata* were also affected. Vegetation burning was noted to be common in the dry season compared to the wet season.

Fig 3.1: Burnt vegetation in a part of Sio Port swamp (Photo by Stellah Nekesa, February 2014)

Besides vegetation burning, vegetation cutting was also a common form of vegetation disturbance in Sio Port swamp during the period October 2013 to March 2014. Several patches of cut papyrus were observed in different parts of the swamp [fig 3.2]. Mature and old papyruses were the main stages of growth that were cut.

Fig 3.2: Harvested papyrus in a part of Sio Port swamp (Photo by Stellah Nekesa, February 2014)

Vegetation cutting was mainly done to obtain culms for making baskets, mats and for thatching houses. Besides this, vegetation clearing was done to create space for putting up fish traps within the swamp.

Clearing of vegetation to set up fish traps was common in the transect named Daniel. Besides fishing deep in the lake, trap fishing was noted to be common, especially by locals who were in need of fish mainly for domestic use. The fish traps located across transects were mainly made of papyrus culms [fig 3.3 (a)]. Bundles of dry papyrus culms were seen piled next to the fish traps [fig 3.3 (b)].

(a) (b)

Fig 3.3: Fish trap set up in Daniel transect (a), piles of papyrus culms next to a fish trap (b) (Photos by Stellah Nekesa, December 2013)

Vegetation was cleared in a part of the swamp to create room for cultivation, which was mainly carried out along the edges of the swamp. The main crops planted were sugarcane, kales [fig 3.4(a) and (b)] and maize.

(a) (b)

Fig 3.4: Cultivation along the edges of Sio Port swamp, stumps of sugarcane (a), kales and sugarcane (b) (Photos by Stellah Nekesa, December 2013)

The crops grown were a source of food and income to the local community.

Vegetation clearing through livestock grazing was common in the transect named Ongaro and Busijo b. A total of 50 cows and 73 sheep could be seen grazing along the edges of the swamp, where the ground was dry and firm during the period October 2013 to February 2014. These animals seemed to forage closer to the edge of the swamp during the dry season than during the wet season. Livestock grazing resulted into trampling and removal of vegetation along the edges of the swamp, thereby slowing down regeneration. Large concentration of grazing animals poses harmful effects on plants due to selectivity and overgrazing (Kamau, 2004).

Invasion by terrestrial and aquatic plants

Invasion by woody terrestrial plants was common in transects located in the mixed papyrus stratum. Hippo grass (*Vossia cuspidata*) [fig 3.5 (a)] was the most common invasive grass growing to heights of about 3–4 m. The other wide spread invasive plant was the water hyacinth (*Eichhornia crassipes*) [fig 3.5 (b)]. Other invasive plants observed in Sio Port swamp in

October 2013 to March 2014 included; morning glory (*Ipomoea stolonifera*), bulrush (family Cyperaceae) and wandering jew (*Commelina spp.*).

(a) (b)

Fig 3.5: Invasive aquatic grass *Vossia cuspidata* at a distributary of River Sio (a) and Invasive aquatic plant; water hyacinth *Eichhornia crassipes* (b) (Photo by Stellah Nekesa, November 2013 and January 2014)

Persistence of such plants could lead to alteration of the structure of papyrus swamps in the long run. Invasion was enhanced by siltation where vegetative material was swept down the slope from the land to the lake.

Siltation was common in the transect named Sio where River Sio enters Lake Victoria from upstream. The colour of the water in this part of the swamp was brown indicating the presence of soil particles; compared to the colour of water in other parts of the swamp. Siltation was facilitated by agricultural activities in the upstream. The brown colour of the water however faded as Sio transect opened into Lake Victoria. This part of the swamp where siltation was common had also the highest rate of sand harvesting activity.

3.3 Birds' habitat quality

The quality of the birds' habitat was described in terms of the structural characteristics of height and density of vegetation. The height of papyrus culms was also described in terms of the growth stages; young, immature and mature. Forms of habitat disturbance such as clearing of vegetation, affected the habitat quality (height and density) directly for example, by reducing the vegetation cover. The other form of disturbance that is, invasion by terrestrial and aquatic plants, affected the habitat quality indirectly for example, through changing its vertical and horizontal structure.

Vegetation height and density are important characteristics for breeding birds, especially the papyrus specialist birds. Therefore, disturbance effects on papyrus height and density could negatively affect papyrus endemic birds.

3.3.1 Vegetation height in mixed and pure papyrus sites

Pure papyrus sites had the highest mean ($\pm$SD) height of vegetation in all the three height ranges compared to mixed papyrus sites [table 3.3]. There was no significant difference in vegetation with a height in the range of 0-2 m ($t = -2.088$, $df = 18$, $p = 0.081$) in mixed and pure papyrus sites. However, there was a significant difference in vegetation with a height in the range of 2-4 m ($t = -5.966$, $df = 18$, $p = 0.000$) and 4-6 m ($t = -2.424$, $df = 9$, $p = 0.038$) in mixed and pure papyrus sites.

Table 3.3: Mean ($\pm$SD) height of vegetation in three ranges in mixed and pure papyrus sites

Height range / **Stratum**	**0-2 m (n)**	**2-4 m (n)**	**4-6 m (n)**
Mixed papyrus site	1.246 $\pm$ 0.439 (419)	2.45 $\pm$ 2.235 (86)	4.356 $\pm$ 0.167 (8)
Pure papyrus site	1.327 $\pm$ 0.411 (153)	4.070 $\pm$ 1.304 (61)	4.457 $\pm$ 0.238 (21)

Pure papyrus sites recorded the highest mean height of vegetation in all ranges compared to the mixed papyrus sites. Pure papyrus sites were least disturbed, hence the highest mean height for vegetation was recorded in all height ranges.

3.3.2 Vegetation density in mixed and pure papyrus sites

Mixed papyrus sites had the highest mean ($\pm$ SD) density of vegetation compared to pure papyrus sites [table 3.4]. Despite the difference in the mean densities of vegetation in mixed and pure papyrus sites, t-test results showed that there was no significant difference in the density of vegetation in mixed and pure papyrus sites ($t = 2.079$, $df = 18$, $p = 0.052$).

Table 3.4: Mean ($\pm$ SD) density of vegetation in mixed and pure papyrus sites

Site (n)	**Mean density (stems/m^2)**
Mixed papyrus site (513)	42.75 ± 15.23
Pure papyrus site (235)	29.38 ± 8.86

n = total number of vegetation culms

Mixed papyrus sites had the highest mean ($\pm$ SD) density compared to the pure papyrus site in all height ranges [table 3.5]. There was a significant difference in the density of vegetation with a height in the range of 0-2 m ($t = 2.495$, $df = 18$, $p = 0.023$) in mixed and pure papyrus sites.

Pure papyrus sites on the other hand had the highest mean ($\pm$ SD) density of vegetation with a height in the range of 2-4 m and 4-6 m. [table 3.5]. There was no significant difference in the density of vegetation with a height in the range of 2-4 m ($t = -0.223$, $df = 18$, $p = 0.826$) in mixed and pure papyrus sites. However, there was a significant difference in the density of vegetation with a height in the range of 4-6 m ($t = -2.387$, $df = 9$, $p = 0.041$) in the mixed and pure papyrus sites.

Table 3.5: Mean ($\pm$ SD) density (stems/m^2) of vegetation in three height ranges in mixed and pure papyrus sites

Height range / **Stratum**	**0-2 m (n)**	**2-4 m (n)**	**4-6 m (n)**
Mixed papyrus sites	34.92 $\pm$ 16.64 (419)	7.17 $\pm$ 2.887 (86)	0 (8)
Pure papyrus sites	19.13 $\pm$ 5.276 (153)	7.63 $\pm$ 3.739 (61)	2.63 $\pm$ 2.387 (21)

Mixed papyrus sites had the highest mean density of young papyrus vegetation (0-2 m high) compared to the pure papyrus sites. Both strata had a small number of immature papyrus vegetation (2-4 m high). Tall mature papyrus vegetation (4-6 m high) was scanty in the two strata, though higher in pure papyrus sites than in mixed papyrus sites [table 3.5].

3.3.3 Relationship between vegetation height and vegetation density

Vegetation height in the range of 0-2 m was positively but not significantly correlated ($r = 0.129$, $p = 0.589$) with vegetation density. Vegetation height in the range of 2-4 m was negatively but not significantly correlated ($r = -0.066$, $p = 0.787$) with vegetation density. Vegetation height in the range of 4-6 m was positively correlated ($r = 0.896$, $p = 0.000$) with vegetation density, the correlation was highly significant. Regression equation produced by the relationship was $y = 0.714x + 0.605$, $t = 4.331$, $p = 0.000$ and the relationship was statistically significant.

A change in the height of papyrus vegetation resulted into a corresponding change in the density of papyrus vegetation. However, the change was not significant for papyrus vegetation in the range of 0-2 m and 2-4 m. But, the change was significant for papyrus vegetation in the range of 4-6 m.

3.4 Distribution of papyrus endemic birds in Sio Port swamp

3.4.1 Frequency of occurrence of birds along transects

Distribution of papyrus endemic birds along transects varied in various parts of the swamp. This could have been as a result of the presence of different forms of disturbance influencing the nature of vegetation along each transect.

Sio

Papyrus endemic birds did not occupy all points along Sio transects. Greater-swamp Warbler did not appear in points VI and VII along transect Sio. Northern Brown-throated weaver was the only papyrus endemic bird that was recorded in point VII [fig 3.6].

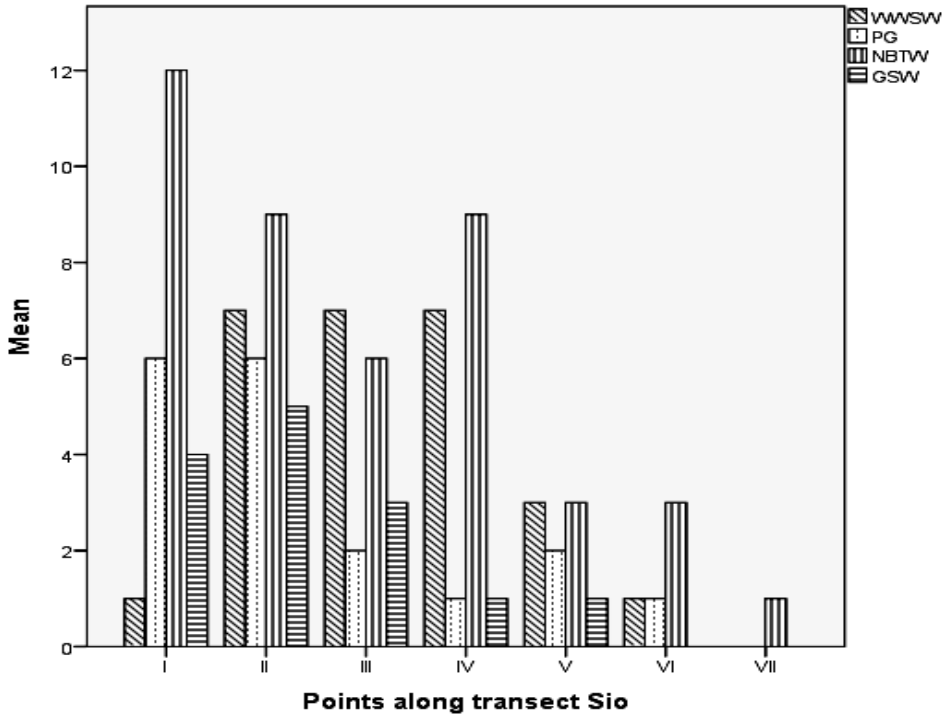

Fig 3.6: Distribution of papyrus endemic birds along transect Sio, Sio Port swamp (Oct 2013-Nov 2014) **(Key**: WWSW-White-winged Swamp Warbler, GSW-Greater Swamp Warbler, NBTW-Northern Brown-throated Weaver, PG- Papyrus Gonolek**)**

Analysis of Variance test results showed that the distribution of papyrus endemic birds in point IV ($F_{(3,\ 24)}$ =3.542, p = 0.033) was significantly different. However, the distribution of the

papyrus endemic birds in point I ($F_{(3, 24)}$ =2.237, p = 0.115), point II ($F_{(3, 24)}$ =0.333, p = 0.801), point III ($F_{(3, 24)}$ =1.382, p = 0.277), point V ($F_{(3, 24)}$ = 0.333, p = 0.801), point VI ($F_{(3, 24)}$ =1.022, p = 0.404) and point VII ($F_{(3, 24)}$ = 1.000, p = 0.413) was not significantly different along Sio transect.

Points II, III, V and VI were mainly affected by clearing of vegetation through burning and harvesting. This in turn reduced the vegetation cover hence the low number of some of the birds such as the Greater Swamp-warbler. Invasion by terrestrial and aquatic plants was highly recorded in points I, II and III but did not affect greatly the distribution of the endemic birds along Sio transect.

Busijo a

In transect Busijo a, at least all points were occupied by the papyrus endemic birds. However, the distribution of papyrus endemic birds along the transect was uneven. For instance, the distribution of White-winged Swamp-warbler and Northern Brown-throated Weaver was high in point II of the transect but low in point V of the same transect. Greater Swamp-warbler and Papyrus Gonolek were highly distributed in point I of the transect. The distribution of Greater swamp warbler was low in point III while that of Papyrus Gonolek was low in point V. Point II recorded the highest distribution while point V recorded the lowest distribution of three of the five endemic birds [fig 3.7].

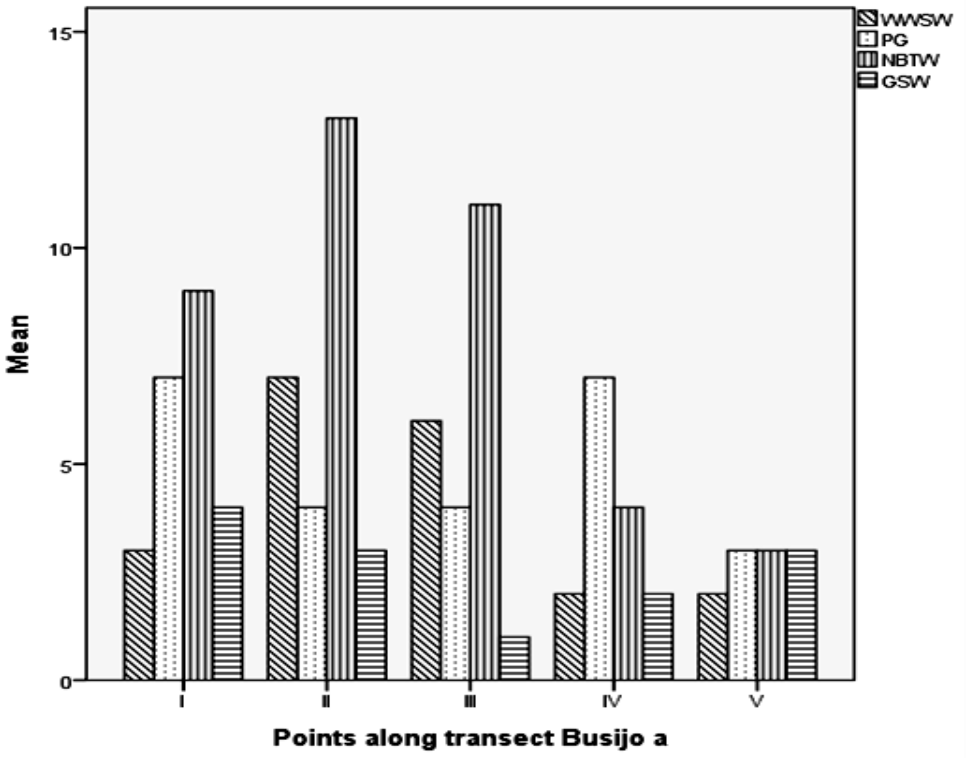

Fig 3.7: Distribution of papyrus endemic birds along transect Busijo a, Sio Port swamp (Oct 2013- Mar 2014) **(Key**: WWSW-White-winged Swamp Warbler, GSW-Greater Swamp Warbler, NBTW-Northern Brown-throated Weaver, PG- Papyrus Gonolek**)**

Analysis of Variance test results showed that the distribution of papyrus endemic birds in point II ($F_{(3, 24)} = 3.649$, $p = 0.030$) was significantly different along transect Busijo a. However, the distribution of papyrus endemic birds in point I ($F_{(3, 24)} = 1.319$, $p = 0.296$), point III ($F_{(3, 24)} = 2.560$, $p = 0.084$), point IV ($F_{(3, 24)} = 1.718$, $p = 0.195$) and point V ($F_{(3, 24)} = 0.085$, $p = 0.968$) along transect Busijo a was not significantly different.

All points along transect Busijo a were invaded by terrestrial and aquatic plants hence the unequal distribution of the papyrus endemic birds in the five points along the transect .Point III was the only point affected by clearing of vegetation, thus affecting the distribution of papyrus endemic birds which was dropped in this point for most of the birds [fig 3.7].

Busijo b

Transect Busijo b had a low number of all the five papyrus endemic birds. Northern Brown-throated Weaver was highly distributed in both points along the transect, followed by Papyrus Gonolek and Greater Swamp-warbler. White-winged Swamp-warbler was only distributed in one point along the transect [fig. 3.8].

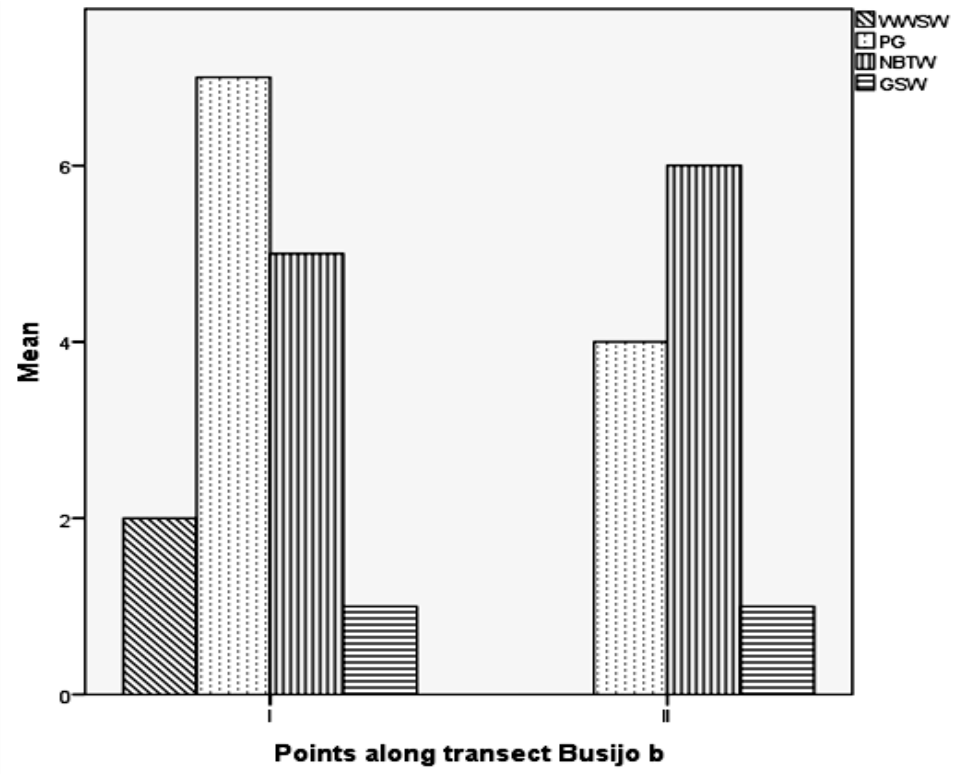

Fig 3.8: Distribution of papyrus endemic birds along transect Busijo b, Sio Port swamp (Oct 2013 to Mar 2014) **(Key**: WWSW-White-winged Swamp Warbler, GSW-Greater Swamp Warbler, NBTW-Northern Brown-throated Weaver, PG- Papyrus Gonolek**)**

Analysis of Variance test results showed that the distribution of papyrus endemic birds in point I ($F_{(3, 24)} = 1.827$, $p = 0.175$) and point II ($F_{(3, 24)} = 2.078$, $p = 0.135$), along transect Busijo a, was not significantly different.

Point II was affected by the two forms of disturbance, vegetation clearing and invasion by terrestrial and aquatic plants while point I was only affected by clearing of vegetation. However,

the endemic birds were lowly distributed in the two points as a result of low vegetation cover and low density of tall papyrus vegetation.

Daniel

Papyrus endemic birds were distributed unevenly in all points along transects Daniel. Point V recorded the lowest distribution of Papyrus Gonolek, Northern Brown-throated Weaver and Greater Swamp-warbler. White-winged Swamp-warbler was highly distributed in point II, Northern Brown-throated Weaver, Papyrus Gonolek and Greater Swamp-warbler were highly distributed in point III [fig. 3.9].

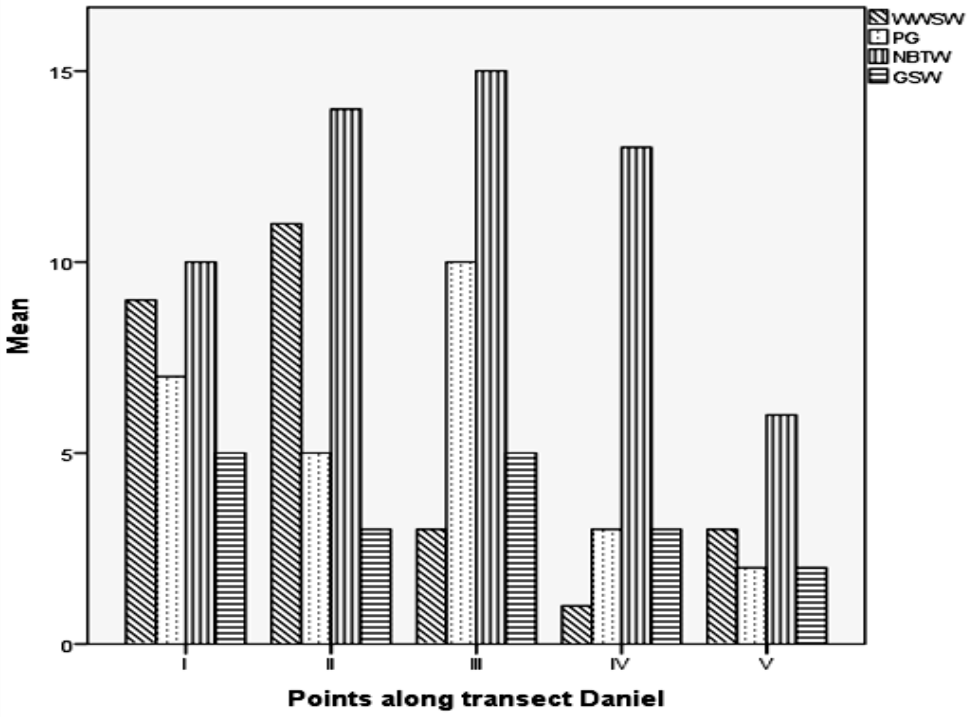

Fig 3.9: Distribution of papyrus endemic birds along transect Daniel, Sio Port swamp (Oct 2013 to Mar 2014) **(Key**: WWSW-White-winged Swamp Warbler, GSW-Greater Swamp Warbler, NBTW-Northern Brown-throated Weaver, PG- Papyrus Gonolek**)**

Analysis of Variance test results showed that the distribution of papyrus endemic birds in point III ($F_{(3, 24)} = 3.093$, $p = 0.050$) and point IV ($F_{(3, 24)} = 4.731$, $p = 0.012$) along transect Daniel was significantly different. However, the distribution of papyrus endemic birds in point I ($F_{(3, 24)} = 0.728$, $p = 0.547$), point II ($F_{(3, 24)} = 2.692$, $p = 0.074$) and point V ($F_{(3, 24)} = 0.982$, $p = 0.421$) along transect Daniel was not significantly different.

Points IV and V were affected by both vegetation clearing and invasion by terrestrial and aquatic plants hence the low number of papyrus endemic birds recorded in this points. Although vegetation clearing was noted in most of the points along the transect, papyrus endemic birds still occupied some of these points. Mature papyrus was the main stage of growth that was cut leaving behind the young and immature papyrus which was still inhabited by the endemic birds.

Ongaro

Distribution of papyrus endemic birds along transect Ongaro was uneven. Papyrus endemic birds were not distributed in some points of the transect. Greater Swamp-warbler, Papyrus Gonolek and White-winged Swamp-warbler did not occur in some parts along the transect.

Greater Swamp-warbler did not occur in points II, III, IX and X. White-winged Swamp-warbler did not occur in points IX, X and XI. Papyrus Gonolek did not occur in points VIII, IX and X. However, Northern Brown-throated Weaver occurred in all points along the transect [fig 3.10].

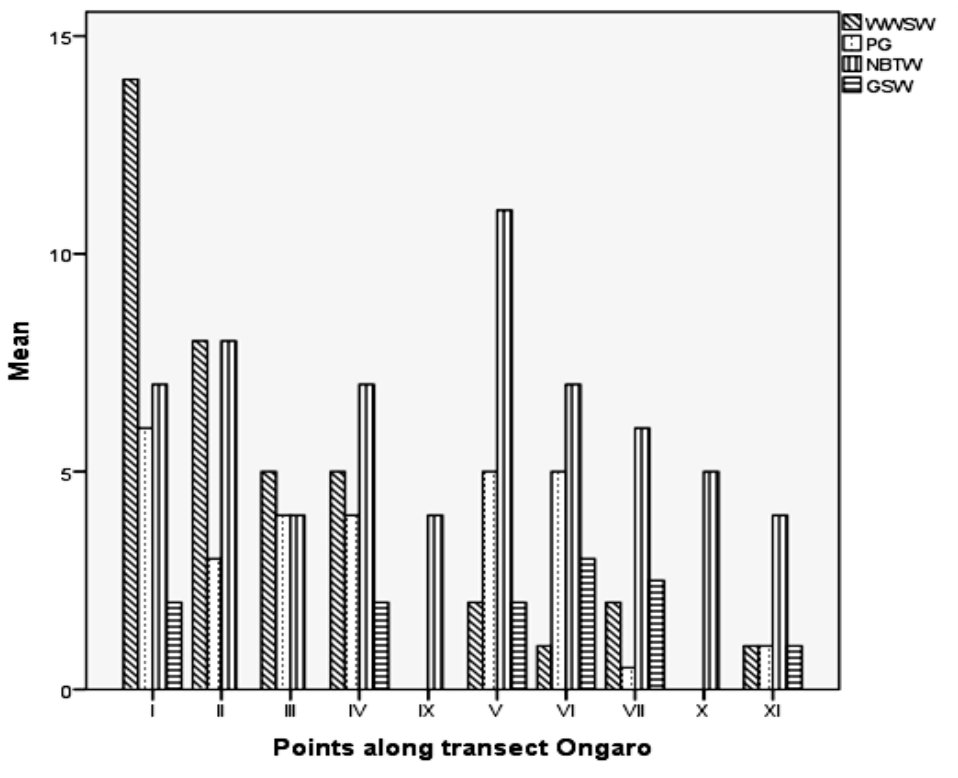

Fig 3.10: Distribution of papyrus endemic birds along transect Ongaro, Sio Port swamp (Oct 2013 to Mar 2014) **(Key**: WWSW-White-winged Swamp Warbler, GSW- Greater Swamp Warbler, NBTW-Northern Brown-throated Weaver, PG- Papyrus Gonolek**)**

Analysis of Variance test results showed that the distribution of papyrus endemic birds in point I ($F_{(3, 24)} = 6.152$, $p = 0.004$), point II ($F_{(3, 24)} = 3.667$, $p = 0.030$), point V ($F_{(3, 24)} = 3.273$, $p = 0.042$), point IX ($F_{(3, 24)} = 10.000$, $p = 0.000$) and point X ($F_{(3, 24)} = 7.353$, $p = 0.002$) was significantly different along transect Ongaro. However, the distribution of papyrus endemic birds in point III ($F_{(3, 24)} = 1.425$, $p = 0.265$), point IV ($F_{(3, 24)} = 0.510$, $p = 0.680$), point VI ($F_{(3, 24)} = 2.222$, $p = 0.117$), point VII ($F_{(3, 24)} = 1.528$, $p = 0.238$) and point XI ($F_{(3, 24)} = 1.286$, $p = 0.307$) was not significantly different along transect Ongaro.

Vegetation clearing was noted in points II, III,VI, IX and X, tall mature papyrus were highly affected. Some papyrus endemic birds were not distributed in some of these points at all since they preferred tall, dense papyrus vegetation because they are very secretive.

3.4.2 Distribution of birds across Sio Port swamp

Papyrus endemic birds were unevenly distributed across Sio port swamp, from transect Busijo a to the left to transect Sio to the right. There was an increasing trend in the distribution of most of the papyrus endemic birds across Sio Port swamp. The distribution of all the endemic birds was low in transect Busijo b and highest in transect Ongaro [fig 3.11].

Papyrus endemic birds were lowly distributed in areas across the swamp where disturbance effects were huge. Effect of disturbance on vegetation height and density lowered the quality of the habitat to support papyrus endemic bird species.

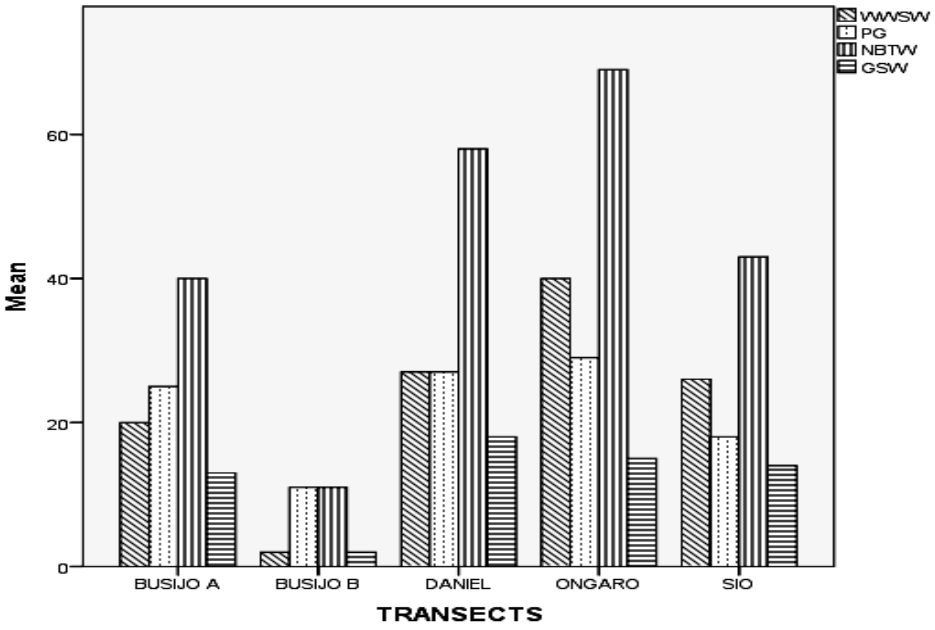

Fig 3.11: Distribution of papyrus endemic birds across the swamp in the five transects **(Key**: WWSW-White-winged Swamp Warbler, GSW-Greater Swamp Warbler, NBTW-Northern Brown-throated Weaver, PG- Papyrus Gonolek**)**

Analysis of Variance tests showed that the distribution of papyrus endemic birds; White-winged Swamp-warbler ($F_{(4, 16)} = 0.331$ $p = 0.852$), Papyrus Gonolek ($F_{(4, 16)} = 1.182$, $p = 0.367$), Northern Brown-throated Weaver ($F_{(4, 16)} = 0.826$, $p = 0.533$) and Greater Swamp-warbler ($F_{(4, 16)} = 1.907$, $p = 0.174$) was not significantly different across the swamp in all the five transects.

3.5 Abundance of papyrus endemic birds along disturbance gradient in Sio Port swamp

Out of a total of 501 individuals of the target bird species, 44% were found in mixed papyrus sites while 56% were recorded in pure papyrus sites. The abundance of individual species in the two habitats did not vary significantly [table 3.6]. However, the Northern Brown-throated Weaver, White-winged Swamp-warbler and Papyrus Gonolek predominantly occurred in pure papyrus stands.

Table 3.6 Abundance of papyrus endemic birds in mixed and pure papyrus sites in Sio Port swamp Oct 2013 – Mar 2014

Papyrus endemic bird	**Number in mixed papyrus sites**	**Abundance (%)**	**Number in pure papyrus sites**	**Abundance (%)**
Northern Brown-throated weaver	95	39.09	127	41.78
White-winged Swamp-warbler	49	20.16	65	21.38
Papyrus Gonolek	45	18.52	56	18.42
Greater Swamp-warbler	31	12.76	33	10.86

Analysis of Variance tests showed that the abundance of three out of the four endemic birds White-winged Swamp-warbler ($F_{(1, 28)} = 7.376$, $p = 0.011$), Papyrus Gonolek ($F_{(1, 28)} = 5.331$, $p = 0.029$), and Northern Brown-throated Weaver ($F_{(1, 28)} = 5.734$, $p = 0.024$) was significantly different in mixed and pure papyrus sites. However, the abundance of Greater Swamp-warbler ($F_{(1, 28)} = 2.718$, $p = 0.110$) was not significantly different in mixed and pure papyrus sites.

Papyrus endemic birds preferred sites with pure papyrus over sites with mixed papyrus. Pure papyrus sites had some tall dense papyrus culms thus creating a good environment for their survival. The tall and dense papyruses were necessary for their breeding and nesting.

Relationship between the abundance of papyrus endemic birds and vegetation density

Abundance of papyrus endemic birds was positively but not significantly correlated ($r = 0.031$, $p = 0.898$) with vegetation density in the sampled area. An increase in the density of vegetation could therefore lead to an overall increasing trend in the abundance of papyrus endemic birds.

Abundance of papyrus endemic birds was negatively correlated with density of vegetation in the height range of 0-2 m ($r = -0.018$, $p = 0.941$) and 2-4 m ($r = -0.054$, $p = 0.822$).However, the correlation was not significant. An increase in the density of vegetation in the height range of 0-2 m and 2-4 m would lead to a decrease in the abundance of papyrus endemic birds. Thus, high vegetation density associated young papyrus and grass, was not favourable to papyrus endemics.

Abundance of papyrus endemic birds was positively correlated with density of vegetation in the height range of 4-6 m ($r = 0.465$, $p = 0.039$). This correlation was significant. A change in the density of vegetation in the height range of 4-6 m could lead to a change in the abundance of papyrus endemic birds. Regression analysis between stem culm density and number of birds produced a statically significant relationship $y = 2.590x + 0.465$, $t = 2.227$, $p = 0.039$. Change in culm density explained the 44 % of the variation in bird abundance.

CHAPTER FOUR

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

4.1 Discussion

4.1.1 Factors influencing population of papyrus endemic birds

Papyrus swamps are buffers between terrestrial and aquatic ecosystems acting as silt traps and nutrient filters conserving the quality of water (Gaudet, 1980). Natural papyrus wetlands are characterised by tall stems with or without inflorescence. They also consist of areas of green water, dense reeds of young, mature and immature reeds interspersed with grass and other semi-aquatic herbaceous vegetation. There are also some sections with dead papyrus culms and inflorescence.

In Sio Port swamp, the dominant vegetation was papyrus *Cyperus papyrus* with tall culms of about 5.5 m. Papyrus vegetation was densely distributed in some parts of the swamp but patchily distributed in other parts. 76.47 % of papyrus vegetation were young and regenerating (0-2 m high), 19.65 % were immature (2-4 m) whereas 3.88% were tall mature papyruses (4-6 m high).

Results of this study showed that the population of papyrus endemic birds was influenced by distribution of papyrus, composition of papyrus, culm height, culm density and presence of forms of disturbance.

Papyrus endemic birds were abundant in sites with a high distribution of papyrus. Pure papyrus sites, which had papyrus as the main vegetation species had the highest number of papyrus endemic birds compared to disturbed sites. Mixed papyrus sites had a mixture of vegetation, especially papyrus and grass species, such as *Vossia cuspidata*. Papyrus endemic birds had the lowest number along the edges of the swamp. Papyrus birds appear to respond to changes in

papyrus conditions, by distributing themselves in more pristine papyrus stands (Owino & Ryan, 2006).

The population of papyrus endemic birds was influenced by composition of papyrus vegetation that is young, immature and mature. Pure papyrus sites were mainly composed of immature and mature papyrus. Such sites had a high population size of the papyrus endemic birds. Papyrus specialist birds occur in large numbers in areas with tall, dense and least disturbed papyrus stands (Owino & Ryan, 2006).

Results of this study also show that papyrus culm height has an influence on the population of papyrus endemic birds. Pure papyrus sites had the highest mean height of vegetation in all height ranges compared to mixed papyrus sites. Papyrus endemic birds occurred in large numbers in pure papyrus sites compared to mixed papyrus sites.

Papyrus culm density also had an influence on the population size of papyrus endemic birds. Pure papyrus sites had a high density of vegetation in the height range of 2-4 m and 4-6 m. Mixed papyrus sites on the other hand had a high density of vegetation in the height range of 1-2 m. Papyrus endemic birds showed significant association with the vegetation density in sites especially with tall papyrus vegetation in the range of 4-6 m. These results indicate that the endemic birds preferred dense pure papyrus vegetation over very dense mixed vegetation.

Results of this study also showed that presence of various forms of disturbance influenced the population density of papyrus endemic birds. Anthropogenic disturbances on habitats affected the habitat structural characteristics, especially vegetation height and density. These are

important characteristics, which influence distribution and abundance of papyrus endemic birds in general (Owino & Ryan, 2007).

Forms of habitat disturbance, such as papyrus clearing, affected the habitat quality directly by reducing vegetation cover and height. Papyrus is usually cut to provide material to thatch roofs, build fences and to make handicrafts such as mats and trays (Maclean *et al*., 2003c).

Other forms of disturbance such as invasion by terrestrial and aquatic plants, affected the habitat quality indirectly through alteration of the vertical structure. The abundance of papyrus endemic birds in mixed papyrus sites was lower than the abundance in pure papyrus stands.

The type and nature of each form of disturbance affected the nature of habitat particularly vegetation cover, which in turn influenced the abundance of papyrus endemic birds. In tropical regions, species that profit from disturbance are often widespread generalists. Generally, disturbance does not favour specialist species confined to one habitat type (Thiollay, 1992; Hammer *et al*., 1997; Hammer & Hill 2000; Barlow *et al*., 2002).

4.1.2 Factors influencing habitat distribution and structure

From the survey done in Sio Port swamp, habitat distribution was influenced by accessibility of the swamp by the locals. Areas easily accessed by the locals had a mixture of vegetation species compared to those areas that had minimal visits. For instance, parts of the swamp closer to the edges where the locals assembled to sell and buy fish had more of *Vossia cuspidata* compared to *Cyperus papyrus.*

In addition, accessibility encouraged activities such as livestock grazing and cultivation along the edges of the swamp, which in some areas, extended deep into the swamp. This may have

contributed extensively to the presence of invasive terrestrial and aquatic plants and reduction in papyrus cover since locals use it for fuel, mat-making and thatching of roofs (Abila, 1998; Otieno *et al*., 1998).

According to the results of this study, structure of the habitat is influenced by the forms of disturbance present and their effect on the habitat. Clearing of vegetation greatly contributed to the decrease in vegetation cover and domination of young papyrus vegetation in the height range of 0 -2 m and 2-4 m.

This study also revealed that the height and stage of growth of vegetation species present in a habitat influenced the structure of the habitat. For instance, mixed papyrus sites had a higher mean value of vegetation density compared to pure papyrus sites. Most vegetation were in the range of 0-2 m, they had a smaller girth and short height compared to mature papyrus culms of 2-4 m and 4-6 m high, hence a high number per meter square. There exist a negative correlation between the number of adult and senescing culms, and papyrus culm height. However, young culms are positively correlated with culm density (Maclean *et al*., 2006)

4.1.3 Impacts of human disturbance on habitats and birds

Impacts on habitats

The results of this study show that forms of human disturbance such as vegetation clearing lower vegetation cover in habitats, hence lowering their quality to support biodiversity. Papyrus habitat loss represents a significant threat to the conservation of biodiversity (Muthuri *et al*., 1989; Boar *et al*., 1999; Fishpool & Evans, 2001).

During the survey at Sio Port swamp, it was noted that the locals washed clothes along the edges of the swamp, at the landward end of some transects. Livestock grazing, cultivation, regular visits and human activities along edges of the swamp, led to trampling of vegetation in such regions. This could result to reduction in the size of a habitat in the long run. The reductions in areas of habitat have direct implications on their quality to support species (Andre`n, 1994; Fahrig & Merriam, 1994; Noss & Csuti, 1997; Bender *et al*., 1998; Esikuri, 1998; Benoit & Askins, 2002; Davis, 2004).

Impacts on birds

According to the results of this study, human disturbance affects bird distribution and abundance. Various forms of disturbance play a key role in determining the kind of species and their respective numbers that will utilise the affected sites. Generally, papyrus endemic birds were most abundant in pure papyrus sites compared to mixed papyrus sites.

Results of this study showed that Northern Brown-throated Weaver occurred in large numbers in almost all sites both disturbed and undisturbed. These results therefore indicate that papyrus specialist birds may survive to some extent in a habitat with various forms of disturbance, but the degree of disturbance will determine the abundance of these birds.

Continued degradation of papyrus swamps may affect the ecological requirements of papyrus endemic birds while creating habitats for generalists and even predator species in and around the swamps. Reduced nesting sites for instance may reduce the breeding success of these species (Owino & Ryan, 2006).

4.2 Conclusion

44% of the papyrus endemic birds utilised mixed papyrus sites while 56% utilised pure papyrus sites. Pure papyrus sites therefore were the most utilised of the two habitats.

The habitat structure in Sio Port swamp was mainly composed of papyrus, *Cyperus papyrus*. However, other vegetation types such Hippo grass *Vossia cuspidata* and Water hyacinth *Eichhornia crassipes* were also present. Papyrus vegetation was densely distributed deep within the swamp compared to the edges of the swamp.

Papyrus clearing and invasion by terrestrial and aquatic plants were the main forms of disturbance observed in Sio Port swamp.

Papyrus endemic birds preferred sites with tall, dense and least disturbed papyrus culms. Even though they seemed to appear in disturbed regions, their abundance in such regions was low and limited to the level of disturbance.

Habitat disturbance affects the population size of the biodiversity supported by the given habitat. When the population size is affected, the animals or plants are distributed selectively in the different parts of the habitat depending on the level of habitat degradation. Their abundance is low in highly disturbed sites and high in least disturbed sites.

High level of management of papyrus clearing is required for long term conservation of biodiversity. Since papyrus vegetation is known to regenerate rapidly and has a high productivity following disturbance (Muthuri *et al.,* 1989; Boar *et al*., 1999), the conservation of papyrus can still be compatible with human use if papyrus clearance is regulated.

4.3 Recommendations

Sio Port swamp is disturbed by intense human activities and requires urgent conservation measures. The following is recommended based on the results of this study and other studies on papyrus swamps:

- All habitats should be protected irrespective of their sizes and the number of animal and plant species they support. Habitat protection should greatly involve the local communities who use the resources directly from the habitat.
- Further research should be carried out by conducting regular site surveys to get information on the total population estimate of bird species and to monitor their population trends. Threats to wetlands around the lake should also be monitored to protect suitable habitat for the species.
- Management actions such as public awareness should be increased especially on the importance of biodiversity conservation through educational programmes, incentive programmes and voluntary programmes. The locals should be involved more in conservation of natural resources by encouraging utilisation and management of the same. The community should be educated about the ecological role of birds in the swamp ecosystem and in the surrounding farmlands, as well as their economic potential.
- Policy actions should be put into consideration by relevant stakeholders. Kenya Wildlife Service should seek a permanent protection and restoration of important habitats in Kenya such as the IBA's for example through creating and following laws governing the management of habitats.

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APPENDICES

Appendix I: Common and scientific names of species of birds recorded in Sio Port swamp during the study period

Common name	**Scientific name**
African jacana	*Actophilornis africanus*
African mourning dove	*Streptopelia decipiens*
African reed warbler	*Acrocephalus baeticatus*
African moustached warbler	*Melocichla mentalis*
Black-headed gonolek	*Laniarius erythrogaster*
Black bishop	*Euplectes gierowii*
Barn swallow	*Hirundo r.rustica*
Blue spotted wood dove	*Turtur afer*
Blue cheeked bee eater	*Merops p. Persicus*
Black crake	*Amaurornis flavirostris*
Broad-billed roller	*Eurystomus glaucurus*
Common bulbul	*Pycnonotus barbatus*
Diederik cuckoo	*Chrysococcyx caprius*
Fan-tailed widowbird	*Euplectes axillaris*
Greater swamp warbler	*Acrocephalus rufescens ansorgei*
Green sandpiper	*Tringa ochropus*
Grey-backed fiscal	*Lanius excubitoroides*
Grey-capped warbler	*Eminia lepida*
Greater reed warbler	*Acrocephalus arundinaceus*

Common name	**Scientific name**
Hamerkop	*Scorpus u. Umbretta*
Little egret	*Egretta g.garzetta*
Lesser swamp warbler	*Acrocephalus gracilirostris*
Malachite kingfisher	*Alcedo cristata galerita*
Marsh tchagra	*Tchagra minuta*
Blue-naped mousebird	*Urocolius macrourus*
Northern brown throated weaver	*Ploceus castanops*
Papyrus gonolek	*Laniarius mufumbiri*
Pied kingfisher	*Ceryle r.rudis*
Purple heron	*Ardea p. Purpurea*
Red-cheeked cordon-bleu	*Uraeginthus bengalus*
Reed cormorant	*Phalacrocorax a. Africanus*
Red chested sunbird	*Cinnyris erythrocerca*
Red-headed weaver	*Anaplectes rubriceps*
Senegal coucal	*Centropus s. Senegalensis*
Swamp flycatcher	*Muscicapa aquatica infulata*
Spectacled weaver	*Ploceus ocularis*
Saddle-billed stork	*Ephippiorhynchus senegalensis*
Slender-billed weaver	*Ploceus p. Pelzelni*
Southern red bishop	*Euplectes orix nigrifrons*
Village weavers	*Ploceus cucullatus*

Common name	Scientific name
Winding cisticola	*Cisticola galactotes*
White-rumped swift	*Apus caffer*
White-winged swamp warbler	*Bradypterus carpalis*
Wattled starling	*Creatophora cinerea*
Yellow-backed weavers	*Ploceus melanocephalus fischeri*

Appendix II: Common and scientific names of vegetation species recorded in the study area

Common name	Scientific name
Papyrus	*Cyperus papyrus*
Hippo grass	*Vossia cuspidata*
Water lily	*Nymphaea spontanea*
Water hyacinth	*Eichhornia crassipes*
Cat-tail or bulrush	*Typha domingensis*
East India globe thistle	*Sphaeranthus africanus*
Fountain grass	*Pennisetum spp.*
Wandering jew	*Commelina spp.*
Cobas	*Cyphostemma kilimandscharicum*
Morning glory	*Ipomoea stolonifera*

Appendix III: Stages of growth of papyrus (*Cyperus papyrus*) plant

Immature papyrus

Mature papyrus without inflorescence

Mature papyrus with inflorescence

Drying mature papyrus (senescent)