



**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDUES**

**THE RESPONSE OF RAPTORS TO LANDUSE CHANGES IN
KWAKUCHINJA WILDLIFE CORRIDOR, NORTHERN TANZANIA**

**BY
FRANK ALEXANDER MAWI**

**A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS
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FOR THE DEGREE OF MASTER OF SCIENCE IN DRYLAND BIODIVERSITY**

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Examiner

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DEDICATION

This work is dedicated to my late grandmother; Madame Awedamenyi Malymo for laying down my academic foundation and, to my parents Mr. Alexander Dawson Mawi and Ms. Edna Mika Mawi for making sure my academic morale was never turned down.

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ABSTRACT

The focus of this study was population status and diversity of raptors and linking the two with land use changes in Kwakuchinja wildlife corridor. This corridor connects Manyara and Tarangire National Parks in Northern Tanzania. The vegetation consisted of mainly short grassland, wooded grassland and riverine woodland but highly altered by human activities. Raptors are good indicators of the change of an ecosystem as their population and diversity are expected to vary with the type of land-use. Road count technique was used to obtain data on diversity and abundance of raptors. Tree density and ground cover in the area were obtained from random spaced quadrats. Seventeen species of raptors were observed in Kwakuchinja wildlife corridor. No difference was found in the abundance of raptors in VNRMA's during the dry ($p=0.9649$) and wet ($p=0.9175$) seasons. There was also no difference in the abundance of raptors in Manyara Ranch during the dry ($p=0.8237$) and wet ($p=0.7683$) seasons. No difference was found in the abundance of raptors between VNRMA's and Manyara Ranch during the dry season ($p=0.4778$) and wet season ($p=0.5872$). There was no significant increase in the abundance of raptors with increase in tree density in VNRMA's ($p=0.291$) and in Manyara Ranch ($p=0.171$). The abundance of raptors increased insignificantly with ground cover in VNRMA's ($p=0.6615$) while there was insignificant decrease in Manyara Ranch ($p=0.416$). No difference was found in the diversity of raptors between the two sites ($p=0.2207$). There was also insignificant difference in the diversity of raptors between dry and wet seasons in VNRMA's ($p=0.8819$) as well as in Manyara Ranch ($p=0.6492$). The Raptors utilized wooded grassland more than other habitats both in VNRMA's and Manyara Ranch with more utilization of this habitat during the dry season. Grasshopper Buzzard (*Butastur rufipennis*) was found only in VNRMA's while Steppe Eagle (*Aquila nipalensis*) was confined in Manyara Ranch. The findings imply the current difference in land uses between VNRMA's and Manyara Ranch has not strongly influenced the diversity and abundance in the area. The exclusion of fire in Manyara Ranch appears to influence raptors habitat utilization as evidenced by exclusion of Grasshopper Buzzard (*Butastur rufipennis*) and attraction of Steppe Eagle (*Aquila nipalensis*). Long term studies and involvement of different stakeholder in the conservation of raptors in the area are recommended.

INTRODUCTION

1.1 Background

Land-use change and human encroachment on wildlife corridors is one of the most critical issues facing wildlife conservation today. The increase in human population and demand for more space and resources occur at the expense of wildlife habitat (Mwalyosi, 1991). Migration routes that connect already fragmented habitats are being rapidly severed by human settlements (Borner, 1985; Lewis, 1986; Prins, 1987; Eltringham, 1990; Johnsingh *et al.*, 1990). This encroachment is leading to range constrictions, numerous human-wildlife conflicts, and in some cases, local species extinctions (Kideghesho, 2001; FFI-Africa, 2001; Dobson *et al.*, 1997; Vitousek *et al.*, 1997).

Birds are sensitive to land-use changes (Bird *et al.*, 1996). The breeding pattern, diversity and abundance can be highly impaired (Boren *et al.*, 1999; Bird *et al.*, 1996; Goriup, 1998). Indicator species are potentially useful tools for managers of biodiversity (Rohlf, 1991). Raptors are considered indicators because of their sensitivity to human disturbance, land use change and contamination (Newton, 1979; Taylor, 1984). Raptors as predators play an important role in ecosystems because they can determine the community structure patterns of their prey (Menge *et al.*, 1994). In addition, predators, including facultative scavengers, have been used as "umbrella" species in world conservation strategies because their protection may facilitate the conservation of unaltered habitats (Simberloff, 1987).

Population declines of some raptor species indicate dysfunctional ecosystems because population dynamics of top-order predators often reflect the nature of the ecosystems they inhabit (Newton, 1979; Greene, 1988; Burnham *et al.*, 1990; Terborgh, 1992). Thus, it has been recommended that raptors should be included in the management and conservation plans of any region, especially for threatened habitats (Burnham *et al.*, 1990).

1.2 Problem statement and justification

Kwakuchinja is one of the nine remaining wildlife corridors connecting Tarangire and other areas including the Manyara National Parks (Byarugaba, 1988). Of the nine main migratory routes identified during the 1960s emanating from Tarangire National Park to the dispersal areas, four have been blocked or partially blocked by settlements and cultivated areas (FFI-Africa, 2001). This has led to a decline in species abundance and local extinctions of large mammals; one species in Tarangire National Park, nine in Lake Manyara National Park and eight in the Kwakuchinja area (FFI-Africa, 2001). Unlike other blocked corridors, Kwakuchinja wildlife corridor has remained open due to pastoral activities of three main ethnic groups - the Maasai, Mbugwe and Barbaig. However, in later years the situation changed, where the area attracted agriculturalists, people affiliated with the phosphate mine, which occur in the vicinity of the area and private tourism development firms. Today, over 30 different ethnic groups have settled in the area with a current population growth rate of 3.8% (which is higher than the national growth rate of 2.8%) (FFI-Africa, 2001). Such change in land-use and increase in human population go hand in hand with pressure to natural resources and pose a great threat to the existence of Kwakuchinja wildlife corridor.

Tanzanian Government operated part of Kwakuchinja wildlife corridor as a ranch (Manyara ranch) until the year 2001. Then the area was taken over by a non-profitable institution, the Tanzania Land Conservation Trust (TLCT) which was formed with support from African Wildlife Foundation (AWF, 2001). During the time the government operating in the area, little attention was given to wildlife and/or the ecological resources of the corridor.

Currently, conservation effort is geared towards ensuring the normal ecological set-up of Kwakuchinja wildlife corridor (AWF, 2001). Conservation practices like establishment of Village Natural Resources Management Areas (VNRMs) are now underway including some that have been established around Minjingu, Vilima Vitatu and Mwada wards (AWF, 2001). VNRMs provide increased habitat to wildlife. With increased habitat, it is expected that some wild animals will respond to such changes through

increase in population and as well as in the entire diversity of the animals in the area. Establishment of VNRMA in Kwakuchinja wildlife corridor is in its early stage and no study has been carried out to assess the impact of such initiative to the ecology of the corridor.

Studies on the effect of land-use change in Kwakuchinja wildlife corridor have mainly centred on how large mammals are affected and associated with land use conflicts (Gamassa, 1987; Kideghesho, 2001; Galant *et al.*, 2000). This has left birds unstudied as far as Kwakuchinja land-use change is concerned. However, birds and their responses to land-use changes have been the central theme in conservation biology and landscape ecology elsewhere in the world (Wilcove, 1985; Saunders *et al.*, 1991; McGaril and McComb, 1995).

Birds are known to respond quickly to environmental changes (Furness and Greenwood, 1993; Spellerberg, 1991). In the case of Kwakuchinja wildlife corridor; birds can be used as indicator species. Birds of prey, being top predators, are at the top position in food web. Their diversity and abundance can be used to indicate health ecosystem (Newton, 1979; Rodriguez-Estrella *et al.*, 1998; Sanchez-Zapata *et al.*, 2003). It is on this basis that raptors have been selected to assess the performance of the current land management practices in Kwakuchinja wildlife corridor with their conservation implication.

This study is expected to provide facts on how different raptor species respond to changes in land-use patterns and habitat quality. This study is also expected to form the basis for future ecological monitoring of Kwakuchinja wildlife corridor and will be a reference in the establishment of community based conservation areas like Village Natural Resources Management Areas.

LITERATURE REVIEW

2.1 Raptors Defined

A raptor is a bird of prey that kills by its beak and/or talons (Feduccia, 1999). The feet are described as raptorial. The word is derived from the Latin “rapere” meaning: to seize and carry. Many birds hunt, kill, and eat meat, but they may not be a raptor. There are three distinguishing traits that make raptors different from other birds: Hooked beaks with sharp edges, feet with sharp, curved claws or talons and keen eyesight (Brown and Amadon, 1968).

2.2 Taxonomic Classification and Distribution of Raptors

According to Feduccia (1999), the formal classification of raptors recognizes two unrelated orders, Order Falconiformes (diurnal birds of prey) and Order Strigiformes (nocturnal birds of prey). Raptors are distributed worldwide, but some taxa have restricted distribution. Order Falconiformes has five families: Sagittariidae, Accipitridae, Cathartidae, Pandionidae and Falconidae. Order Strigiformes has only two families, Tytonidae and Strigidae.

Family Sagittariidae has one genus and one species restricted to sub-Saharan Africa, the Secretary Bird (*Sagittarius serpentarius*). The Secretary Bird is instantly recognizable as having an eagle-like body on crane-like legs with short toes. The Secretary Bird is unique among the raptors, hunting its prey by stalking and then running in a zigzag fashion after snakes (its principal prey), lizards and mammals (Feduccia, 1999). From a distance or in flight, it resembles a crane, more than a bird of prey. It is terrestrial and has long legs with short toes (Feduccia, 1999; Kemp, 1994).

Family Accipitridae is one of the largest avian families and the largest family in the order Falconiformes. Dickinson (2003) recognizes 233 species in 67 genera in this family, worldwide. Adult Accipitrids have wing spans ranging from 50 to 300 cm and total body lengths ranging from 25 to 150 cm. The body masses of Accipitrids range from 80 g to 12.5 kg (Thiollay, 1994). The inside surface of the eggshell is green. They have strong hooked talons except the Old World vultures, eyes are yellow, red or hazel and forcefully

eject excreta (Snyder, 2001a). Thirty-four genera of Accipitrids occur in Africa (Kemp and Kemp 1998).

Family Cathartidae has 7 species in 5 genera all occur in South and North America. They have perforated nasal septum, rudimentary hind toe, and large olfactory chambers suggesting they have good sense of smell. Body weight ranges from 1 to 1.5 kg and wingspan ranges from 1.2 to 3.2 m. The inside of eggshell is yellowish and do not build their own nests. They resemble Old World vultures because of convergent evolution but are closely related to storks (Sibley and Ahlquist, 1990).

Family Pandionidae has one genus and one species, Osprey (*Pandion haliaetus*), which is almost worldwide in distribution. The Osprey is 52-60 cm long with a 152-167 cm wing span. It has white under-parts and long, narrow wings with four "finger" feathers at the end of each, which give it a very distinctive appearance (Feduccia, 1999). They resemble some kites in structure of the sternum and absence of bony eye shield, reversible outer toe and talons that are rounded but not grooved.

Family Falconidae has 64 species in 11 genera. Two genera, *Falco* and *Polihierax* are found in Africa. The family is divided into two subfamilies, Polyborinae (Caracaras and forest-falcons) and Falconinae (true falcons and falconets). Falconids are medium-sized to large birds of prey with wing span 55 to more than 125 cm and body weight 28 to 2100 g (Kemp and Newton, 2003). It is a clearly defined family with the reddish surface of eggshell. They have large brown eyes and a yellow cere, eye rings and feet. Falconids do not eject the excreta forcefully and with the exception to Caracaras all Falconids build nests (Snyder, 2001b).

Family Tytonidae has 17 species in two genera, *Tyto* and *Phodilus*. Tytonids have heart-shaped facial disc, the claw on the centre toe with a comb-like edge (pectinate) and the bill is long and projects downwards. The solid sheet of bone between the eyes is a characteristic taxonomic feature of this family (Feduccia, 1999). Genus *Tyto* (Barn-owls) are found in India, Australasia, Africa and Madagascar. Grass owls have long

unfeathered legs presumably adapted to terrestrial life in grasslands (Feduccia, 1999). The Bay Owls (Genus *Phodilus*) inhabit wet tropical forests, ranging from India to Indonesia. Bay Owls have short feathered-legs and are capable of acoustic location of prey in total darkness (Konishi, 1993).

Family Strigidae comprises 190 species distributed among 25 genera of which seven (*Otus*, *Bubo*, *Scotopelia*, *Glaucium*, *Athene*, *Strix* and *Asio*) are found in Africa. Classification, based on skull morphology, divides them into three subfamilies: Striginae (13 genera), Surniinae (8 genera), and Asioninae (2 genera) (Sibley and Ahlquist, 1990). The Strigid owls are a diverse family, ranging in size from 40 g to 4 kg. Strigid owls have characteristic thin or perforated bone between the eyes, circular facial disk, ear tufts, thickly feathered legs, well-developed talons with smooth edge on the claw of the central toe (in contrast to the pectinate claw of the tytonids). They have large heads often with distinctive ear tufts, slightly elongated eyes, an unfolkeed rounded tail, and a short bill (Feduccia, 1999).

2.3 Land-Use Changes and Raptors

Transformation of natural habitats into pastures, agricultural and urbanized areas has reduced the spaces for bird survival and has resulted in a decline of their populations (Foster, 1996; Kahn and McDonald, 1997; Hostetler and Knowles-Yanez, 2003). Rapidly changing land-use patterns have potential direct and indirect impacts on raptors. Human-caused habitat alteration through land-use changes can influence raptor abundance through direct changes in habitat characteristics (e.g. perch density and nest site availability) or indirectly through impacts on prey abundance and availability (Sorley and Andersen, 1994). Deleterious impacts on raptors have been documented through habitat loss and fragmentation (Thiollay and Rahman, 2002) or due to direct disturbances derived from human presence and associated infrastructures (Brown and Stevens, 1997; Bautista *et al.*, 2004).

Land-use changes result in environmental disturbances, which can influence the community's composition through the disappearance of a lot of species, causing a

significant loss of biodiversity (Olrog, 1985; Thiollay, 1999; Lovejoy *et al.*, 1986). These disturbances mainly cause changes in extant interspecific relationships (Ricklefs, 1989; Ferrari, 1990; Egler, 1991; Krakauer and Krakauer, 1999; Zhang and Wang, 2000) and may even lead to future local extinctions (Brown, 1995; Chapin III *et al.*, 2000; McCann, 2000). Less diverse raptor communities have been described at landscapes progressively more anthropogenic (Brandl *et al.*, 1985; Sorley and Andersen, 1994; Julien and Thiollay, 1996; Herremans and Herremans-Tonnoeyr, 2000; Sánchez-Zapata *et al.*, 2003).

Land-use changes affect raptor populations differently depending either on type and intensity of disturbance, and on the characteristics of the species involved. Specialist raptor species, depending on extensive native habitats or on particular preys mostly avoid man-altered landscapes (Hiraldo, *et al.* 1993). This makes specialist raptors to be more negatively affected with land-use changes. Many studies have documented an increase in habitat generalists as human development increases (Emlen, 1974; Aldrich and Coffin, 1980; Bessinger and Osborne, 1982; Wilcove, 1985; Andrén *et al.*, 1997; Allen and O'Connor 2000; Drapeau *et al.*, 2000).

Andrén *et al.* (1997) have stated the conceptual reasons for increased generalist aggregation in altered landscapes. The degree to which a species is specialized in utilizing different landscape elements will affect the numerical population response to the landscape changes (Andrén *et al.*, 1997). Declines in proportions of suitable habitat for specialized species (e.g., woodland habitat for tree nesters) may also result in increases of suitable habitat for other species (e.g., open-spaces for ground nesters). Thus, a critical threshold (With and Crist, 1995) may be crossed wherein guilds of birds, including generalist species, may change in proportional representation as habitat requirements are removed or increased. Species turnover and replacement may also reflect the availability of certain habitat types, further altering bird community structure. However, the increase in representation by more common species does little to preserve local biodiversity.

The heterogeneity of natural environments is one of the most important factors that contributes to an increase in biodiversity (Karr, 1976). It is well known that moderate

levels of landscape alteration can favor the occurrence of many species, mostly due to edge effects resulting from increased habitat heterogeneity (Vannini, 1989; Ellis *et al.*, 1990; Hiraldo *et al.*, 1993; Rodríguez-Estrella *et al.*, 1998; Reynaud and Thioulouse, 2000; Anderson, 2001). Moderate land-use changes apart from promoting landscape heterogeneity can provide new foraging and/or nesting opportunities for some species (Knight and Kawashima, 1993; Dykstra *et al.*, 2000; Anderson 2001; Dean and Milton, 2003). Black Kite and Black-shouldered Kite for instance, are positively influenced by moderate levels of human impacts, mainly due to its scavenging habits and hunting opportunism (Brandl *et al.*, 1985; Sorley and Andersen, 1994; Herremans and Herremans-Tonnoeyr, 2000; Meunier *et al.*, 2000; Dean and Milton 2003; Sánchez-Zapata *et al.*, 2003).

2.4 Response of Raptors to Annual Changes

Raptors like other birds respond to cyclic changes in their environment. Raptors respond to annual changes (e.g. weather), which influence habitat and food availability by using a different set of habitats in different seasons or years. In response to changing environmental conditions, individual raptor performance (e.g. reproductive success) can vary between years in different habitats (Lohmus, 2003). Over time with annual changes, the ranges of species expand and contract, and abundance patterns shift. Ranges can expand when suitable new habitat becomes available or when population pressure forces migration to new areas. Contractions can occur when populations decline and individuals abandon less-than-ideal habitats, which are often along the edges of species' ranges.

The movement in response to annual changes can take a form of short or long distances. Migratory raptors are grouped as complete, partial and local-irruptive (Kerlinger, 1989). Complete migrants are species in which more than 90% of all individuals leave the breeding range during the non-breeding season. Partial migrants are those in which 90% or fewer of all individuals leave the breeding range. Local-irruptive migrants are species whose movements are correlated with less predictable environmental fluctuations, and whose migratory habits are less regular than those of complete or partial migrants (Kerlinger, 1989; Del Hoyo *et al.*, 1994).

Most migratory raptors are partial rather than complete migrants (Kerlinger 1989), and it is not always possible to determine the extent to which raptors migrate into and out of an area, particularly in regions where migration occurs across a broad front. Nevertheless, it appears that populations of at least 48 of 99 species of New World, and 120 of 201 species of Old World raptors migrate on a regular or irregular basis. In the New World, all 36 species of Nearctic breeders are known or suspected migrants, as are 39 of 86 Neotropical breeders, and 30 of 62 Austral breeders. In the Old World, 22 Australian, 60 African, 66 Asian, 19 Pacific Islands, and 38 European breeders are suspected or confirmed migrants (Keith *et al.*, 2000). The continental distribution of known complete and partial migrants is depicted in Fig. 1.

During the process of migration, raptors follow less permanent aerial pathways known as flyways (Kerlinger, 1989). Whenever possible, raptors prefer to migrate over land along mountain ranges, valley and coastlines rather than crossing large water bodies. In Africa raptors flyways coincide with the Great Rift Valley (Zalles and Keith, 2000) (Fig. 2). Over the land, raptors encounter more prey and safe places to rest, as well as updrafts and thermals that aid them in soaring migration. Thermals are rising columns of hot air created by the sun heating the Earth's surface (Kerlinger, 1989). Large birds like raptors need the rising hot air to lift and carry them, as they are too heavy to flap their wings continuously over long distances or for long periods.

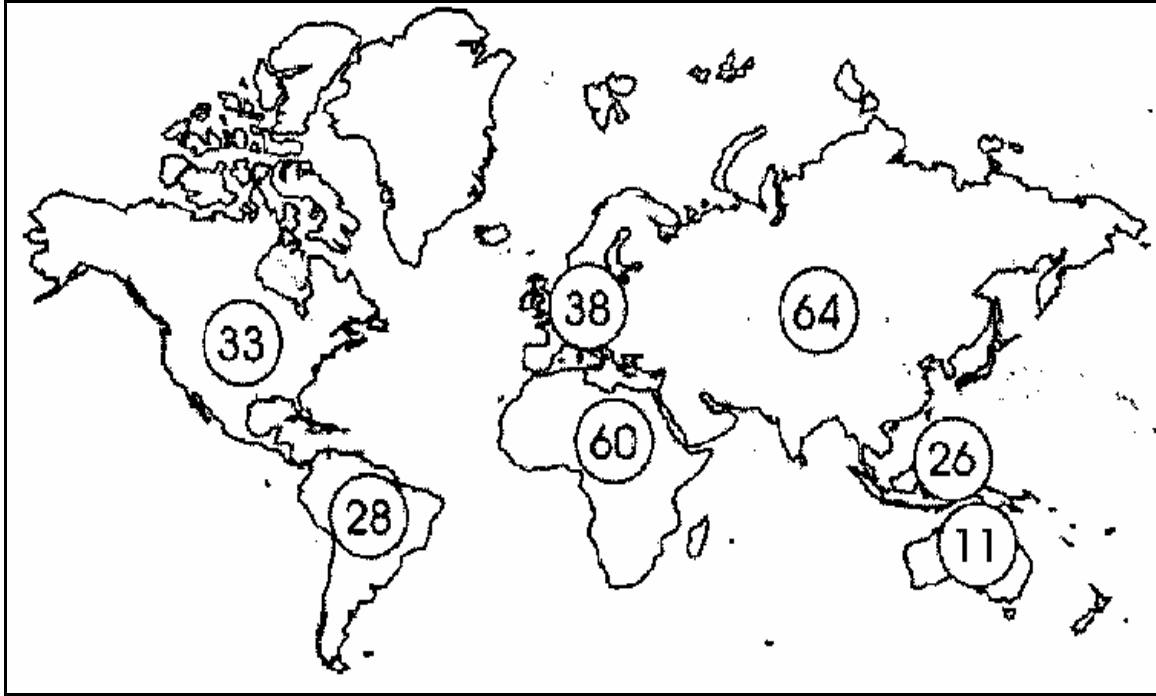


Figure 1: Number of complete and partial migratory raptors around the world.

(Source: Keith *et al.*, 2000)

The African continent is very important wintering area for migratory raptors in the world. The continent hosts 34 species of endemic, intracontinental migrants, together with significant populations of 34 European and 42 Asian breeders, several of which travel from as far as Scandinavia, Siberia, and Amurland to over-winter in Africa's grasslands, savannas, and wet and dry forests (Zalles and Keith, 2000).

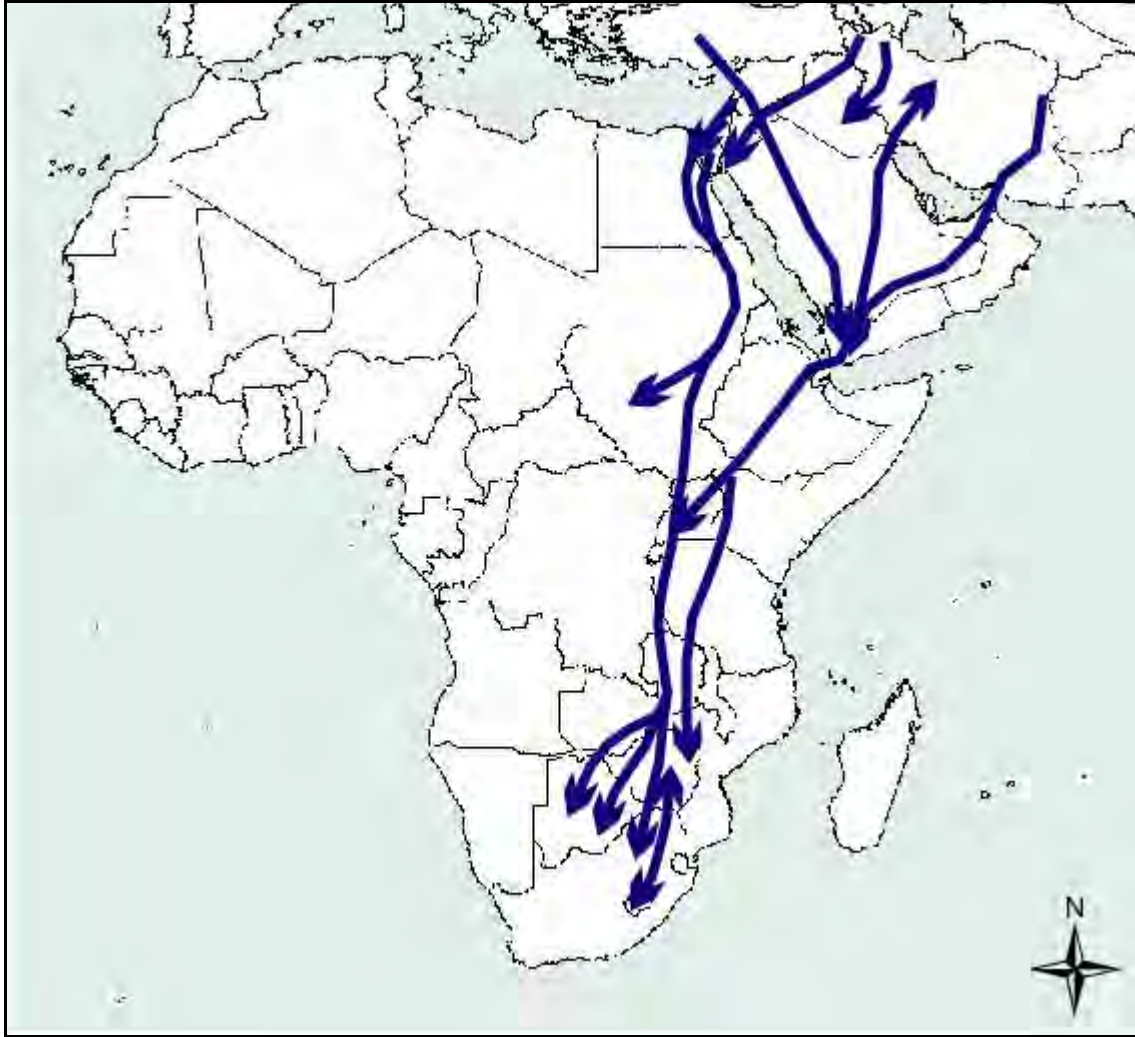


Figure 2: Raptors flyways between Eurasia and Africa. (Source: Zalles and Keith, 2000)

Four African countries, -Kenya, Ethiopia, Sudan, and Tanzania rank among the world's top 10 in overall numbers of species of raptors; while 9 countries, -Kenya, Ethiopia, Sudan, Uganda, South Africa, Tanzania, Zaire, Eritrea, and Mozambique rank among the top 10 in terms of numbers of species of migratory raptors (Keith *et al.*, 2000; Zalles and Keith, 2000). Along the flyways, some areas (watchesites) have been identified for monitoring the migration of raptors (Bildstein, *et al.* 1995). Raptors watchesites in Eastern Africa region are Lake Langano (Ethiopia), Lewa Downs and Tsavo (Kenya), Akagera (Rwanda), Murchison Falls-Budongo Forest and Kibale Forest (Uganda) and, Mti Mwili and Lake Manyara (Tanzania) (Keith *et al.*, 2000).

2.5 Raptors and Humans

Most raptors are directly beneficial to human as they feed on pests and carrion, animals that do not directly affect humans (Brandl *et al.*, 1985; Sorley and Andersen, 1994). Entirely beneficial species include Vultures, Kites, Kestrels and other small insectivorous falcons, most buzzards (*Buteo* and related species), and many small eagles (Brandl *et al.*, 1985). Neutral species, such as Snake Eagles and Chanting Goshawks, can safely be ignored (Davies, 1994). Few species, usually large and uncommon, may prey on domestic stock or poultry or on game birds or fish (Davies 1994). However, because of ignorance and unreasoning prejudice, it is not uncommon for all species in an area to be indiscriminately killed, even rendered locally extinct (Allan, 1989; Brown, 1991; Davies 1994).

Detailed quantitative studies invariably have shown that the harm done to human interests by raptors have been grossly exaggerated; even the supposedly harmful species often kill other potentially harmful species like pest birds and rodents (Hartley *et al.*, 1996). The predation effect of any species is relatively small in relation to the total number of potential prey in any home range. Moreover, even in potentially harmful species, few individuals of potential or actual interest to humans are taken (Hartley *et al.*, 1996).

Agriculture destroys some types of habitat, especially forests, but creates others in the process (Bird, *et al.*, 1996). For instance, some forest and woodland falconiforms may be eliminated, but much larger populations of adaptable species such as Black Kites, Hooded Vultures, and Long-crested Eagles may move in (Brandl *et al.*, 1985; Sorley and Andersen, 1994; Herremans and Herremans-Tonnoeyr, 2000). The effect of agriculture is not always detrimental, especially when a mixed landscape of closed stands of woodlands and open habitats results (Ellis *et al.*, 1990; Hiraldo *et al.*, 1993; Rodríguez-Estrella *et al.*, 1998). For instance, before the advent of pesticides, Peregrine and avian prey were most numerous in habitats close to agricultural areas with mixed landscapes (Ratcliffe, 1993). This implies a sparse population of agriculturalist practicing organic cultivation or safe usage of agricultural implements may have no appreciable effect on a mixed population of raptors over long periods of time.

Toxic agricultural chemicals are the most difficult conservation problems because of their subtle and widespread effects affecting even migrant populations of some Hawks that breed in uninhabited areas (Allan, 1989; Mundy, *et al.*, 1982). The best hope, other than the development of less-toxic substances, is an understanding of the serious effect of long-lasting poisons on the whole environment. If chemicals eventually affect humans adversely, control of these chemicals will follow, and the raptors will benefit indirectly.

2.6 Conservation of Raptors in Kwakuchinja Wildlife Corridor

All raptors in Tanzania are protected by Wildlife Conservation Act of 1974 (URT, 1974), which define wildlife as undomesticated animals, game and game birds and their habitats and ways of life, and includes bees, fish, birds, insects and other animals. Raptors in Kwakuchinja wildlife corridor are also protected indirectly by part of the corridor being conservation area.

Some raptors like Eagles and vultures need huge territories and some species breed in areas of 30-190 km² (in extremes up to 400 km²) (Newton, 1979; Van Zyl, 1992). Kwakuchinja wildlife corridor having a total area of 40,000 ha (400 km²) is large enough for the conservation of raptors. Kwakuchinja wildlife corridor borders three Important Bird Areas (Lake Manyara-IBA no.4, Tarangire National Park-IBA no.10 and Lake Burunge-IBA no.20) (BLI, 2006), and so stands to be a focus to bird conservation and hence conserving raptors indirectly. Kwakuchinja wildlife corridor lies between two of the Hawks Aloft worldwide raptors watchsites (Mti Mwili and Lake Manyara) of which Mti Mwili is among the world top ten in migratory raptor count, with more than 100,000 annual migratory raptor count (Zalles and Keith, 2000). Raptors in Kwakuchinja Wildlife Corridor are hence directly conserved through Hawks Aloft Worldwide raptor watchsites annual counts.

OBJECTIVES

3.1 General objective

To assess the impact of different land use systems on the ecosystem as reflected by response of raptors in Kwakuchinja wildlife corridor.

3.2 Specific Objectives

1. To find out the abundance of raptors in the study area.
2. To find out the diversity of raptors in the study area.
3. To relate the occurrence of raptors with tree density and ground cover in the two study sites
4. To find out how different raptor species utilize different habitats.

3.3 Hypotheses

1. There is no difference in relative abundance of raptors in each study area
2. There is no difference in the diversity of raptors between the two study sites.
3. The diversity of raptors is the same during the dry and wet seasons in the study area.
4. There is no relationship between the occurrence of raptors and tree density or ground cover.
5. Raptor species utilize different habitats equally in the two study sites.

METHODOLOGY

3.1 The Study Area

3.1.1 Location

Kwakuchinja wildlife corridor is located in Northern Tanzania, Manyara region, within the Maasai Steppe ecosystem. It lies between 3° 28' - 3° 48'S and E 35° 48' - 35° 59'E. The corridor is in between Tarangire and Lake Manyara National Parks. The corridor encompasses 40,000 hectare. It includes 17,800 hectares of Manyara Ranch and part of Mbugwe-Kwakuchinja Open Game Area. Part of Mbugwe-Kwakuchinja Open Game Area is currently managed as Village Natural Resources Management Areas (VNRMA) of which two VNRMA (Minjingu and Vilima Vitatu) are part of this study with approximately 17,000 hectares. The area shares border with Tarangire National Park to the East, Lake Burunge and Mwada village to the South, Lake Manyara to the West, Esilalei village to the North West and Makuyuni-Ngorongoro road to the North (Fig. 3).

3.1.2. Topography

The area is located in an in-land drainage basin and surrounded on three sides by high landmasses, which influence the prevailing winds and the area's precipitation. The landscape is mainly a flat plain; altitude varying from 960 to 1196 m a.s.l. The prominent features Almasi hill (1196 m a.s.l.), the pyramids locally known as *Vilima Vitatu* (1144 m a.s.l.) and soda lakes: Lake Manyara and Burunge which partly dries up during the dry season leaving an apparent spread of white soda. The area is bisected by the Great North Road from Northeast to southwest into two parts with different development patterns.

3.1.3 Geology and soils

The area is formed by volcanic rocks of Tertiary to recent origin, Precambrian and Quaternary sediments (Pratt and Gwynne, 1977). The large part of the area is within the Cenozoic era rocks composed of lacustrine sediments (Survey and Mapping Division, 1967). The soils are halomorphic not fully differentiated but include saline-alkaline soils and zones of vertisols mixed with ferruginous soils and some sandy parent materials (Survey and Mapping Division, 1967).

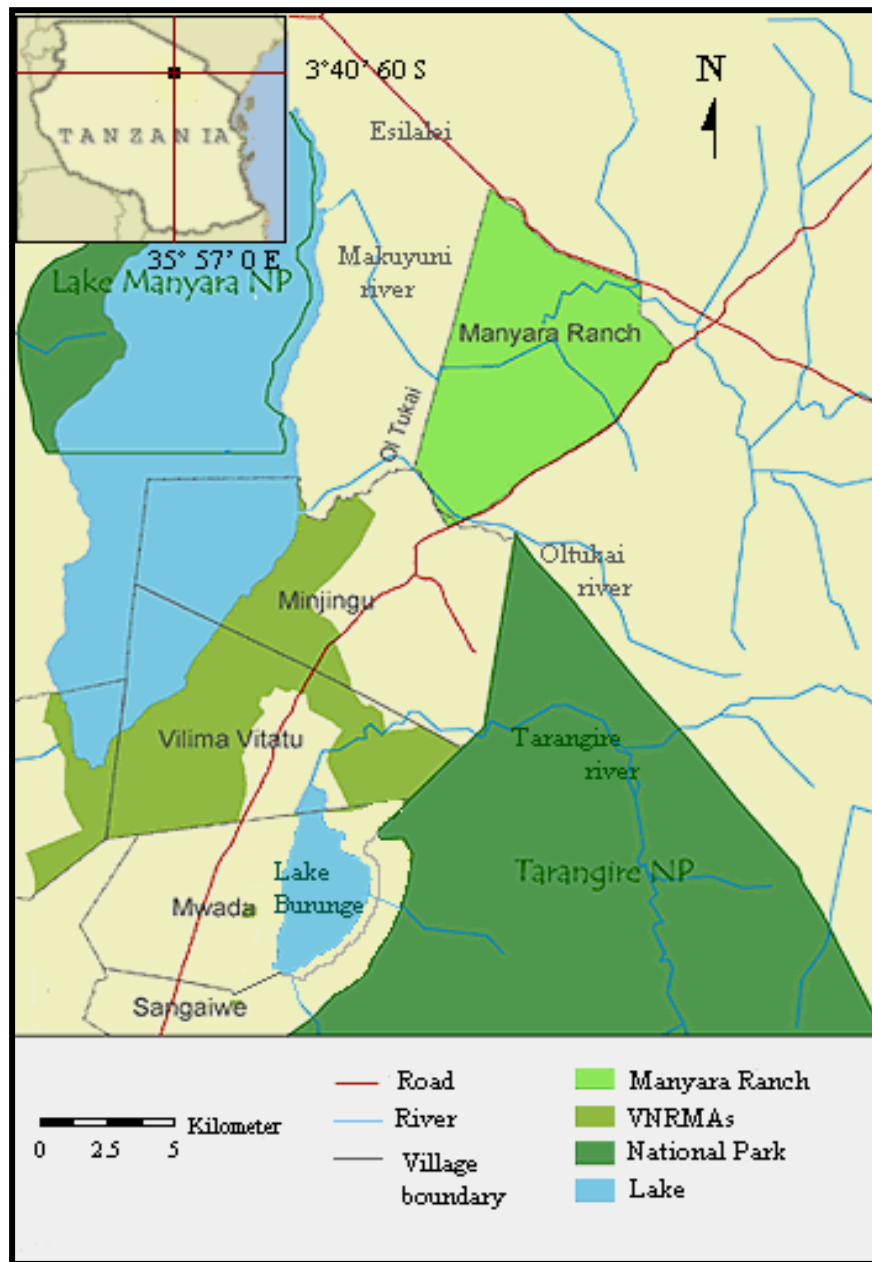


Figure 3: Study area map showing the study sites and relative position in Tanzania (inset). (Modified from: AWF, 2001).

3.1.4 Drainage

The large part of the area is part of the interior drainage basin of Lake Manyara while the south-eastern part drains into Lake Burunge (see Fig. 3). Tarangire River, Lake Manyara and Burunge are the major water bodies in the area but the lakes dry up in extreme drought. The water of both lakes is of acute salinity due to very high evaporation rates and supply of saline of ground water from hot springs (Baker, 1986). Tarangire River also dries up during the dry season but leaves scattered pools of water, making it a refuge for the Maasai steppe wildlife. Other water bodies in the area include Makuyuni, Mdori and Oltukai Rivers, which drain into Lake Manyara, but both rivers dry up completely during the dry season

3.1.5 Climate

The area falls in eco-climatic zone V but at micro level, it is intermediate between zone IV and V (Pratt and Gwynne, 1977). This implies the area to range from a semi-arid to an arid as a result of being surrounded by elevated landmasses. The rainfall pattern of the area is bimodal with average annual rainfall of 660 mm (Davison, 1991). The area has seven months of humid period from November to mid-May. The humid period can be divided into two: the short rains (November - February) and the long rains (March – May) with peak in March-April. June – October are dry months. The area experiences high temperature with a monthly mean of 28°C. The hottest month is January with 33°C and July is the coolest with 27°C. The mean annual evaporation rate is 1500-2500 mm. This high evaporation is attributed to the area's low elevation and prevailing high temperatures (Pratt and Gwynne, 1977).

3.1.6 Vegetation

The natural vegetation of the area has been highly altered by anthropogenic activities mainly through conversion of woodland into farms and charcoal burning. Gamassa (1987) reported loss of riparian and wooded vegetation based on remote sensing assessment. According to White (1983) and based on phytogeographical classification, the area belongs to the Somali-Maasai phytochorium region. The present vegetation can be classified into three major vegetation types: short grassland, wooded grassland and

riverine woodland. *Sporobolus*, *Penisetum* and *Bonthriochloa* spp. are the dominant grass species while *Acacia* and *Borassus* spp. are the woody plants.

3.1.7 Land-Use

The land-use in Kwakuchinja wildlife corridor has been changing over time. Traditionally, the area was Maasai-Mbugwe dominated land with pastoralism and subsistence farming as major land-uses in the area (Gray, 1955) while hunting at subsistence level was a minor land-use practiced by Mbugwe and Barbaig tribes (Gray, 1955; Fosbrook, 1955). Human population increase and attraction by land resources available in the area have forced land-use changes, representing a profuse diversity of land related activities (Gamassa 1987).

3.1.7.1 Pastoralism

This is a traditional land-use practiced by the Maasai and Barbaig pastoralists. Pastoralism is practiced both in Manyara ranch and Village Natural Resources Management Areas (VNRMA). In VNRMA Pastoralism is practiced in set aside area based on conservation area land-use zonation while in Manyara ranch is open throughout the area. This type of land-use is in harmony with wildlife conservation, provided the number of livestock is held within the carrying capacity of the land.

3.1.7.2 Agriculture

Agriculture is a traditional land-use in Kwakuchinja wildlife corridor. However, different from the past, it is now practiced both for subsistence living and income generation. It has excised large traditional wet season grazing lands for livestock and wildlife creating land-use conflicts. Agriculture has attributed by large to shrinking of the corridor and habitat loss for wildlife in general. Agriculture is practiced in village lands but adjacent to VNRMA (pers. observation) but, there is no provision for agriculture in Manyara ranch (Sumba *et al.*, 2005). This implies that in VNRMA, agriculture has a potential of modifying the habitat since it is practiced at the vicinity of the VNRMA. Agriculture induced habitats favour some bird species while others are marginalized and hence disparity in abundance and diversity.

3.1.7.3 Settlement

Settlement is a traditional land-use in Kwakuchinja wildlife corridor. With partial nomadism in past, settlement areas were not a threat to other land-uses. With human population increase and land resources attraction in Kwakuchinja, settlement areas have been rapidly increasing at threatening level (FFI-Africa, 2001). Temporary settlements are being replaced by permanent and semi-permanent ones coupled with rapid growth of townships and village centres (pers. observation). Townships and village centres have taken up more land which would otherwise be available for agriculture, livestock and wildlife use.

3.1.7.4 Ranching

Ranching is conducted in Manyara ranch. Manyara ranch was established in 1964 to raise Boran/Zebu cross breeds for meat. Since its establishment, the National Ranching Company (NARCO), a government of Tanzania parastatal organization, managed it as commercial livestock ranch until 2001. Starting in early 90s, the ranch was operating at a loss and forced the Government of Tanzania to privatize it (Sumba *et al.*, 2005). In April 2001, the ownership of the ranch was shifted to Tanzania Land Conservation Trust (TLCT), with 99 years title deed (Sumba *et al.*, 2005). The Trust is managed by a board of trustees under the Chairmanship of the local Member of the Parliament and its trustees are representatives from AWF, WWF, Tanzania National Park, UNDP, the local Maasai community and the private sector with AWF serving as the secretariat. The objective of the trust is to promote nature preservation and economic activities compatible with conservation for the benefit of present and future generations throughout Tanzania (Sumba *et al.*, 2005). To achieve this, the trust carries out wildlife conservation activities and allows traditional pastoralism in the area along side with the inherited cattle ranching.

3.1.7.5 Mining

Phosphate mining is the land-use development, which has attracted a good number of people to Kwakuchinja wildlife corridor. Minjingu Phosphate Company (MIPCO) was established in 1982 with 1,750 ha of mining lease area, of which 280 ha is actual mining area. Agriculture and pastoralism are not allowed in the lease area, but the area is open

for wildlife use. The mining area is outside the actual reference area of this study but due to its location and terrain, it influences the adjacent habitats through runoffs to lake Manyara and Burunge and hence impacting wildlife in the area.

3.1.7.6 Wildlife

Traditionally, wildlife hunting at subsistence level was carried out by Mbugwe and other minor tribes (Gray, 1955). At present, wildlife related land-use activities are highly developed and have an important economic and conservation role both at local and national level. Wildlife related land-uses are developing both in Manyara ranch and VNRMAs. In Manyara ranch, habitat restoration and resource protection are the prime wildlife related land-use activities. TLCT has been implementing a no-burn policy in Manyara ranch since 2001 in an attempt to allow grassland recovery from intense grazing (Ranch Manager, pers.com). TLCT has employed Game Rangers, who conduct anti-poaching patrols and ensure law enforcement in the area (Sumba *et al.*, 2005).

Wildlife related land-use activities in VNRMAs take different forms depending on the decision taken by the local people. In Minjingu VNRMA, photographing and game viewing are the main activities while in Vilima Vitatu VNRMA wildlife hunting is conducted. Commonly, both VNRMAs have village game scouts (VGS) who are responsible for conducting anti-poaching patrol, enforcing law and carrying out other conservation activities like fire management.

3.2 Methods

3.2.1 Site selection

Two study sites were selected based on their differences in land-uses. Manyara ranch and “Minjingu & Vilima Vitatu” VNRMAs, which are part of Kwakuchinja wildlife corridor, were selected for this study. At present, pastoralism, ranching and wildlife conservation are under practise in Manyara ranch while in Minjingu & Vilima Vitatu VNRMAs land is set aside for wildlife utilization as community based conservation areas.

3.2.2 Reconnaissance survey

Reconnaissance survey was conducted in the two study sites in September 2005 to get familiar with the study area and select roads to be used in the survey. Global Positioning System (GPS) readings for starting and ending of each road selected were recorded as well as corresponding lengths of the roads. In each site, five roads, at least 2 km apart were selected randomly from the set all drivable roads and used as road transects. A total of 61.06 km and 56.6 km road transect lengths were selected in VNRMA and Manyara Ranch respectively. The number of roads selected was limited by road network in the area and the distance-apart the transects, as a measure of avoiding double counting in subsequent transects. Dry season survey was conducted in October 2005 and wet season survey from November to December, 2005.

3.2.3 Raptor Survey

3.2.3.1 Identification

Raptors were visually detected with unaided eye and then for clear identification 10x50 binoculars were used. References were made to standard guidebooks of bird (Allan, 2000; Kemp and Kemp, 1998 and Stevenson and Fanshawe, 2004) for correct identification. The nomenclature of raptors followed Stevenson and Fanshawe (2004), which is based on official East African list.

3.2.3.3 Diversity

Raptors diversity was described using Shannon-Weaver diversity index, equitability and Sørensen's similarity coefficient. Shannon-Weaver Index (H') was used to estimate raptor species diversity. Shannon-Weaver index was selected because species abundance is standardized to proportions and is based on species richness and evenness (Shannon and Weaver, 1949; Magurran, 1988) and hence providing a better insight on species diversity. Shannon-Weaver Index (H') was calculated as follows:

$$H' = - \sum (P_i \ln P_i)$$

Whereby:

H' = Shannon-Weaver index,

- = minus sign,
 Σ = summation symbol,
 P_i = proportion of the i^{th} species and
 \ln = Natural logarithm

Equitability (E) was used to check for raptor distribution evenness in the study sites and was calculated using Shannon Evenness index (Shannon and Weaver, 1949) using the equation:

$$E = H'/H_{\max}$$

Whereby:

E = Shannon Evenness index,

H' = Shannon diversity index,

$H_{\max} = \ln S$,

$\ln S$ = Natural logarithm of the total number of species in each site and

S = Number of species in each site

Sørensen's similarity coefficient (S) was used to compare the diversity of raptors in the two study sites. Sørensen's similarity coefficient was preferred because common species were given more weight than those confined to one site (Magurran, 1988) and was calculated as follows:

$$S' = 2c/s_1 + s_2$$

Where by:

S' = Sørensen's similarity coefficient

c = number of species common in sites and

s_1 and s_2 = number of species in site 1 and 2, respectively.

3.2.3.4 Abundance

Survey of raptors in the two study sites was conducted using road count technique, a method widely used in raptor survey (Fuller and Mosher, 1987; Donazar *et al.*, 1993;

Sorley and Andersen, 1994; Travain *et al.*, 1995). The survey was carried out along randomly selected roads using a vehicle driving at speed of 10 km/hr with two observers counting raptors, one on each side. The survey was carried out between 8:00 am and 5:00 pm covering the road transects sequentially for ten consecutive days in each site. Reverse counting ‘census starting at “far end” of the counting route’ (Bibby *et al.*, 1998) was adopted. Reverse counting allows detection of raptor species which could have been missed at the beginning and/or the ending of counting route as a result of raptor activity pattern (Bibby *et al.*, 1998). Every raptor detected on either side of the road was identified and recorded. The habitats where the raptors were seen were also recorded. Abundance of raptors was calculated as relative abundance (expressed as birds/100 km) using the following formula:

$$\mathbf{R.A = 100N/TL}$$

Whereby:

R.A= Relative abundance

N = Number of raptors

TL = Length of transect surveyed in kilometre

and TL is determined by multiplying the length of the transect by the number of times it was surveyed (Buckland *et al.*, 1993).

Further, nesting habitat was assigned to each raptor species recorded according to their respective breeding natural history following Del Hoyo *et al.* (1994).

3.2.4 Vegetation Survey

Vegetation survey was conducted in the two study sites to find vegetation types, tree density and ground cover. Vegetation types were identified based on East African vegetation description following Pratt and Gwynne (1977). Tree density was obtained from 20x20 m random plots spaced over the area with the counting roads. All trees 5 m and above were counted, and tree density was calculated and expressed as trees/ha. Ground cover was obtained by visual estimation from 20x20 m plots and expressed as average percentage ground cover (%).

3.2.5 Data Analyses

Chi-square test was used to analyze differences in relative abundance (measured as raptors observed per 100 km) in each site. Paired t-test was used to analyse the difference in the abundance of raptors between dry and wet seasons in each site. Paired t-test was also used in testing the differences in relative abundance and diversity between the two study sites. The relative abundance of raptors was related to tree density and ground cover using linear regression analysis. Abundance of raptors in different habitats in the two study sites in different seasons was analysed by Kruskal-Wallis and Dunn's multiple tests.

RESULTS

4.1 Composition of Raptors

The composition of raptors in the two identified sites varied. A total of 234 and 258 individuals were detected in Village Natural Resources Management Areas (VNRMA) and Manyara Ranch, respectively. In VNRMA, 104 and 130 individuals consisting of 16 species were recorded during the dry and wet seasons, respectively (Table 1).

Table 1: Frequency of occurrence of raptors in VNRMA.

Species	Dry season	Wet season
Black Kite (<i>Milvus migrans</i>)	7	8
Black-shouldered Kite (<i>Elanus caeruleus</i>)	1	6
Secretary Bird (<i>Sagittarius serpentarius</i>)	7	9
African Fish Eagle (<i>Haliaeetus vocifer</i>)	2	4
African White-backed Vulture (<i>Gyps africanus</i>)	12	3
Rueppell's Griffon Vulture (<i>Gyps rueppelii</i>)	16	10
Brown Snake Eagle (<i>Circaetus cinereus</i>)	6	8
African Marsh Harrier (<i>Circus ranivorus</i>)	3	2
Eurasian Marsh Harrier (<i>Circus aeruginosus</i>)	4	5
Pallid Harrier (<i>Circus macrourus</i>)	12	22
Lizard Buzzard (<i>Kaupifalco monogrammicus</i>)	2	4
Grasshopper Buzzard (<i>Butastur rufipennis</i>)	9	17
Augur Buzzard (<i>Buteo augur</i>)	7	6
Long-crested Eagle (<i>Lophaetus occipitalis</i>)	7	9
Pygmy Falcon (<i>Polihierax semitorquatus</i>)	2	6
Red-necked Falcon (<i>Falco chiquera</i>)	7	11
Total	104	130

In Manyara Ranch, 118 and 140 individual raptors consisting of 12 species were recorded during the dry and wet seasons, respectively (Table 2). Four raptor species, African Fish Eagle (*Gyps africanus*), Rueppell's Griffon Vulture (*Gyps rueppelii*), African Marsh Harrier (*Circus ranivorus*), Eurasian Marsh Harrier (*Circus aeruginosus*)

and Grasshopper Buzzard (*Kaupifalco monogrammicusi*) were observed only in VNRMA while Steppe Eagle (*Aquila nipalensis*) was restricted to Manyara Ranch. All raptor species observed in Kwakuchinja wildlife corridor were migratory. In VNRMA, 10 species were partial migrants while 6 species were local-irruptive (Table 3). In Manyara ranch, there was equal number of partial and local-irruptive migrants (Table 4). In both VNRMA and Manyara Ranch, tree-nesting raptors were the most frequent. Raptors of all nesting behavior were encountered in VNRMA, while tree/rock nesting raptors were devoid in Manyara Ranch (Fig. 4).

Table 2: Frequency of occurrence of raptors in Manyara Ranch.

Species	Dry season	Wet season
Black Kite (<i>Milvus migrans</i>)	6	7
Black-shouldered Kite (<i>Elanus caeruleus</i>)	3	9
Secretary Bird (<i>Sagittarius serpentarius</i>)	9	6
African White-backed Vulture (<i>Gyps africanus</i>)	7	-
Brown Snake Eagle (<i>Circaetus cinereus</i>)	5	10
Steppe Eagle (<i>Aquila nipalensis</i>)	20	25
Pallid Harrier (<i>Circus macrourus</i>)	20	23
Lizard Buzzard (<i>Kaupifalco monogrammicusi</i>)	7	11
Augur Buzzard (<i>Buteo augur</i>)	4	6
Long-crested Eagle (<i>Lophaetus occipitalis</i>)	11	19
Pygmy Falcon (<i>Polihierax semitorquatus</i>)	12	15
Red-necked Falcon (<i>Falco chiquera</i>)	14	9
Total	118	140

Table 3: Occurrence of raptors with different migration behavior in VNRMA.s.

Species	Complete	Partial	Local- irruptive
Black Kite (<i>Milvus migrans</i>)	-	√	-
Black-shouldered Kite (<i>Elanus caeruleus</i>)	-	√	-
Secretary Bird (<i>Sagittarius serpentarius</i>)	-	-	√
African Fish Eagle (<i>Haliaeetus vocifer</i>)	-	-	√
African White-backed Vulture (<i>Gyps africanus</i>)	-	√	-
Rueppell's Griffon Vulture (<i>Gyps rueppelii</i>)	-	√	-
Brown Snake Eagle (<i>Circaetus cinereus</i>)	-	-	√
African Marsh Harrier (<i>Circus ranivorus</i>)	-	√	-
Eurasian Marsh Harrier (<i>Circus aeruginosus</i>)	-	√	-
Pallid Harrier (<i>Circus macrourus</i>)	-	√	-
Lizard Buzzard (<i>Kaupifalco monogrammicusi</i>)	-	-	√
Grasshopper Buzzard (<i>Butastur rufipennis</i>)	-	√	-
Augur Buzzard (<i>Buteo augur</i>)	-	-	√
Long-crested Eagle (<i>Lophaetus occipitalis</i>)	-	-	√
Pygmy Falcon (<i>Polihierax semitorquatus</i>)	-	√	-
Red-necked Falcon (<i>Falco chiquera</i>)	-	√	-
Total	0	10	6

Table 4: Occurrence of raptors with different migration behavior in Manyara Ranch.

Species	Complete	Partial	Local-irruptive
Black Kite (<i>Milvus migrans</i>)	-	√	-
Black-shouldered Kite (<i>Elanus caeruleus</i>)	-	√	-
Secretary Bird (<i>Sagittarius serpentarius</i>)	-	-	√
African White-backed Vulture (<i>Gyps africanus</i>)	-	√	-
Brown Snake Eagle (<i>Circaetus cinereus</i>)	-	-	√
Steppe Eagle (<i>Aquila nipalensis</i>)	-	√	-
Pallid Harrier (<i>Circus macrourus</i>)	-	√	-
Lizard Buzzard (<i>Kaupifalco monogrammicusi</i>)	-	-	√
Augur Buzzard (<i>Buteo augur</i>)	-	-	√
Long-crested Eagle (<i>Lophaetus occipitalis</i>)	-	-	√
Pygmy Falcon (<i>Polihierax semitorquatus</i>)	-	-	√
Red-necked Falcon (<i>Falco chiquera</i>)	-	√	-
Total	0	6	6

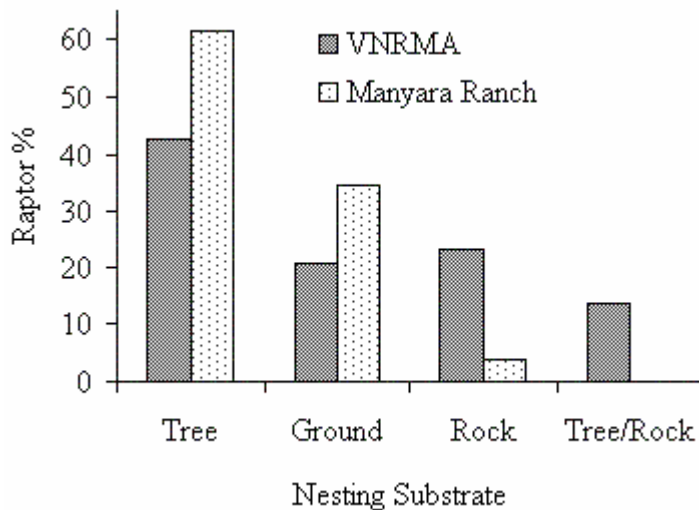


Figure 4: Percentage of raptors nesting on tree, ground, rock and tree/rock in VNRMA and Manyara Ranch.

Pallid Harrier (*Butastur rufipennis*), Rueppell's Griffon Vulture (*Gyps rueppelii*) and Grasshopper Buzzard (*Circus macrourus*) were the most frequent raptor species in VNRMA with percentage of occurrence 14.53%, 11.11% and 11.11%, respectively (n=234). African Marsh Harrier (*Circus ranivorus*), African Fish Eagle (*Haliaeetus vocifer*) and Lizard Buzzard (*Kaupifalco monogrammicus*) were the least occurring raptors in VNRMA with percentage of occurrence 2.14%, 2.56% and 2.56%, respectively (n=234). In Manyara Ranch, Steppe Eagle (*Aquila nipalensis*) and Pallid Harrier (*Circus macrourus*) were the most frequent raptors with percentage of occurrence 17.44% and 16.67% (n=258), while African White-backed Vulture (*Gyps africanus*) was the least frequent with percentage of occurrence 2.27% (n=258).

4.2 Abundance of Raptors

The relative abundance of raptors in Kwakuchinja wildlife corridor was higher in Manyara Ranch than in VNRMA (Table 5). The relative abundance ranged from 17.06 birds/100 km in VNRMA during the dry season to 25.20 birds/100 km in Manyara Ranch during the wet season. Raptor abundance in both VNRMA and Manyara Ranch was higher during the wet season than during the dry season (Table 5).

During the dry season in VNRMA, Rueppell's Griffon Vulture (*G. rueppelii*) was the most abundant (2.62 birds/100 km) and Black-shouldered Kite (*Elanus caeruleus*) was the least abundant (0.16Birds/100 km). During the wet season, Pallid Harrier (*C. macrourus*) was the most abundant (3.6 birds/100 km) and African Marsh Harrier (*C. ranivorus*) was the least abundant (0.33 birds/100 km). However, there was no significance difference in the abundance of raptors in either season ($\chi^2 = 6.7506$, d.f= 15, p=0.9649 dry season and $\chi^2 = 8.1529$, d.f= 15, p=0.9175 wet season). Comparing the two seasons, the mean abundance of raptors was 1.066 ± 0.1732 birds/100 km and 1.330 ± 0.2126 birds/100 km during the dry and wet seasons, respectively. This difference was also not statistically significant (t=0.9620, d.f= 30 p=0.3438).

Table 5: Relative abundance of raptors (birds/100 km) in VNRMA and Manyara Ranch during the dry and wet seasons.

Species	VNRMA		Manyara Ranch	
	Dry season	Wet season	Dry Season	Wet season
Black Kite (<i>Milvus migrans</i>)	1.15	1.31	1.08	1.26
Black-shouldered Kite (<i>Elanus caeruleus</i>)	0.16	0.98	0.54	1.62
Secretary Bird (<i>Sagittarius serpentarius</i>)	1.15	1.47	1.62	1.08
African Fish Eagle (<i>Haliaeetus vocifer</i>)	0.33	0.66	-	-
African White-backed Vulture (<i>Gyps africanus</i>)	1.97	0.49	1.26	-
Rueppell's Griffon Vulture (<i>Gyps rueppelii</i>)	2.62	1.64	-	-
Brown Snake Eagle (<i>Circaetus cinereus</i>)	0.98	1.31	0.90	1.80
Steppe Eagle (<i>Aquila nipalensis</i>)	-	-	3.60	4.50
African Marsh Harrier (<i>Circus ranivorus</i>)	0.49	0.33	-	-
Eurasian Marsh Harrier (<i>Circus aeruginosus</i>)	0.66	0.82	-	-
Pallid Harrier (<i>Circus macrourus</i>)	1.97	3.60	3.60	4.14
Lizard Buzzard (<i>Kaupifalco monogrammicusi</i>)	0.33	0.66	1.26	1.98
Grasshopper Buzzard (<i>Butastur rufipennis</i>)	1.47	2.78	-	-
Augur Buzzard (<i>Buteo augur</i>)	1.15	0.98	0.72	1.08
Long-crested Eagle (<i>Lophaetus occipitalis</i>)	1.15	1.47	1.98	3.42
Pygmy Falcon (<i>Polihierax semitorquatus</i>)	0.33	0.98	2.12	2.70
Red-necked Falcon (<i>Falco chiquera</i>)	1.15	1.80	2.25	1.62
Total	17.06	21.28	21.20	25.20

In Manyara Ranch, during the dry season, Steppe Eagle (*A. nipalensis*) and Pallid Harrier (*C. macrourus*) were the most abundant (3.60 birds/100 km) and Black-shouldered Kite (*E. caeruleus*) was the least abundant (0.54 birds/100 km). During the wet season in Manyara Ranch, Steppe Eagle (*A. nipalensis*) was the most abundant (4.50 birds/100 km), while Secretary Bird (*Sagittarius serpentarius*) and Augur Buzzard (*Buteo augur*) were the least abundant (1.08 birds/100 km). This difference in the abundance of

raptors during the dry and wet seasons was not significantly different (dry season: $\chi^2 = 6.6894$, d.f= 11, p=0.8237) and (wet season: $\chi^2 = 6.5366$, d.f= 10, p=0.7683). The mean raptor abundance in the two seasons was 1.7667 ± 0.2992 birds/100 km for the dry season and 2.1000 ± 0.3872 birds/100 km for the wet season but this difference was not statistically significant (t=0.6812, d.f= 22 p=0.5028).

During the dry season, the mean abundance of raptors in VNRMA and Manyara Ranch was 1.004 ± 0.1743 and 1.247 ± 0.2897 birds/100 km respectively. However the difference was not statistically significant (t=0.7202, d.f= 26 p=0.4778). During the wet season, the mean abundance of raptors was 1.252 ± 0.2144 and 1.482 ± 0.3605 birds/100 km in VNRMA and Manyara Ranch, respectively but it was not statistically different (t=0.5497, d.f= 26 p=0.5872). Dry and wet seasons combined, the mean abundance of raptors was 1.1975 ± 0.1693 and 1.9350 ± 0.3250 birds/100 km in VNRMA and Manyara Ranch, respectively. This difference was also not statistically significant (t=2.013, d.f=16, p=0.0613).

4.3 Diversity of Raptors

4.3.1 Species Richness

Species richness in Kwakuchinja wildlife corridor ranged from 11 species to 17 species. Species richness was higher in VNRMA (S=16) than in Manyara Ranch (S=12). There was no difference in species richness in VNRMA between dry and wet seasons (S=16). In Manyara Ranch, species richness was recorded lower during the wet season (S=11) as compared to the dry season (S=12). In both VNRMA and Manyara Ranch, maximum species richness was recorded in wooded grassland and the minimum in riverine woodland (Fig. 5).

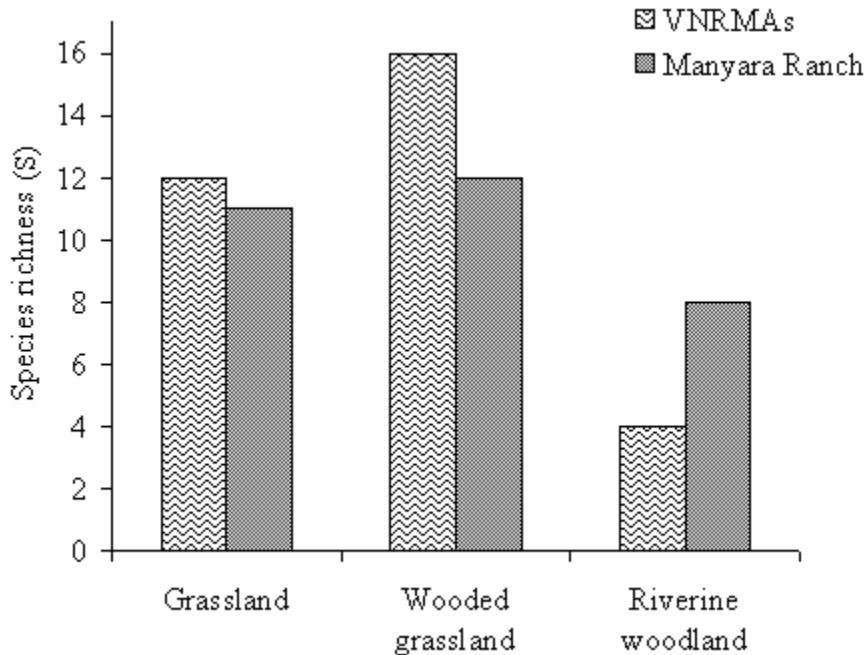


Figure 5: Species richness of raptors in VNRMA and Manyara Ranch in different habitats.

4.3.2 Shannon-Weaver Diversity Index

Diversity of raptors in Kwakuchinja wildlife corridor measured as Shannon-Wiener index was found higher in VNRMA ($H' = 2.6297$) than in Manyara Ranch ($H' = 2.3388$), but this was not statistically different ($t = 1.260$, $d.f = 22$, $p = 0.2207$). There was increase in raptor diversity during the wet season in VNRMA while in Manyara Ranch, raptor diversity decreased (Fig. 6). The difference in raptor diversity between dry and wet seasons was not significantly different in VNRMA ($t = 0.1499$, $d.f = 28$, $p = 0.8819$) as well as in Manyara Ranch ($t = 0.4618$, $d.f = 20$, $p = 0.6492$).

4.3.3 Species Evenness and Sites similarity

Raptor species in Kwakuchinja wildlife corridor were least evenly distributed in VNRMA during the dry season ($E = 0.9134$) and the highest level of evenness was in Manyara Ranch during the wet season ($E = 0.9488$). Generally, raptor species were more evenly distributed in Manyara Ranch than in VNRMA (Fig. 7). In terms of species richness and diversity, VNRMA and Manyara Ranch were more or less similar during the dry season than during the wet season (Fig. 8).

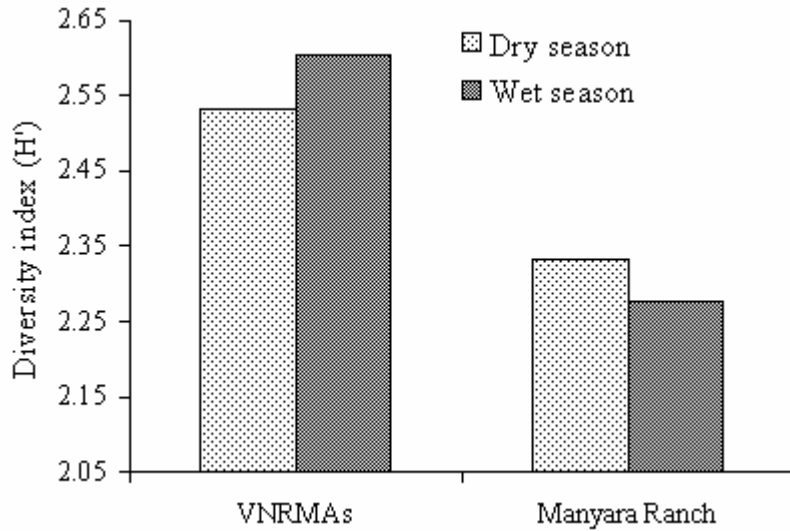


Figure 6: Diversity index of raptors in VNRMA and Manyara Ranch during dry and wet seasons.

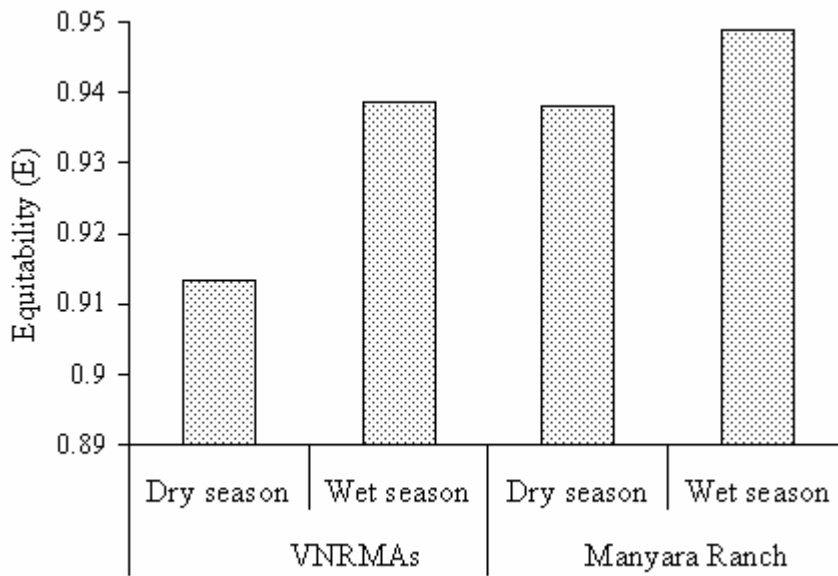


Figure 7: Species evenness (equitability) of raptors in VNRMA and Manyara Ranch during dry and wet seasons.

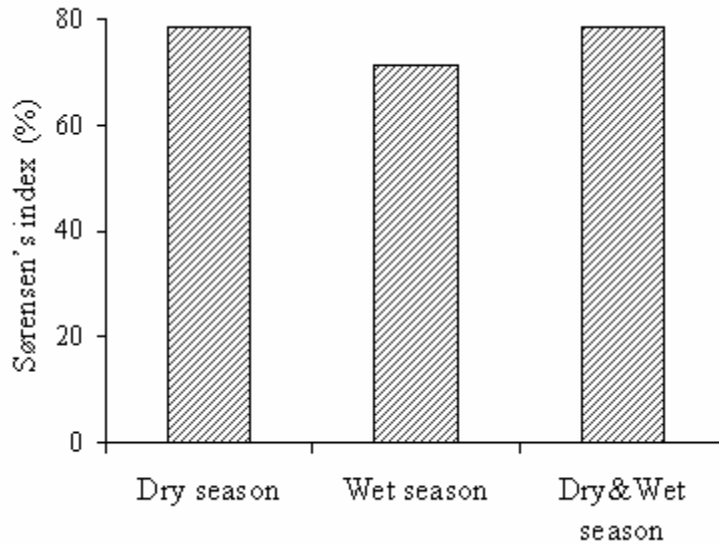


Figure 8: Species richness similarity between VNRMA and Manyara Ranch during dry and wet seasons.

4.4 Habitat Utilization

Raptors in Kwakuchinja wildlife corridor utilized different habitats differently during the dry and wet seasons. Generally, raptors in VNRMA and Manyara Ranch used wooded grassland more than any other habitat with high frequencies during the dry season than the wet season (Figs. 9 and 10). Kruskal-Wallis test showed significant difference in raptors habitat utilization in VNRMA ($H=27.448$, $p<0.0001$). Further analysis with Dunn's multiple comparison test, showed a significant difference in raptors habitat utilization between grassland and wooded grassland, and between grassland and riverine woodland both during the dry and wet seasons (Table 6).

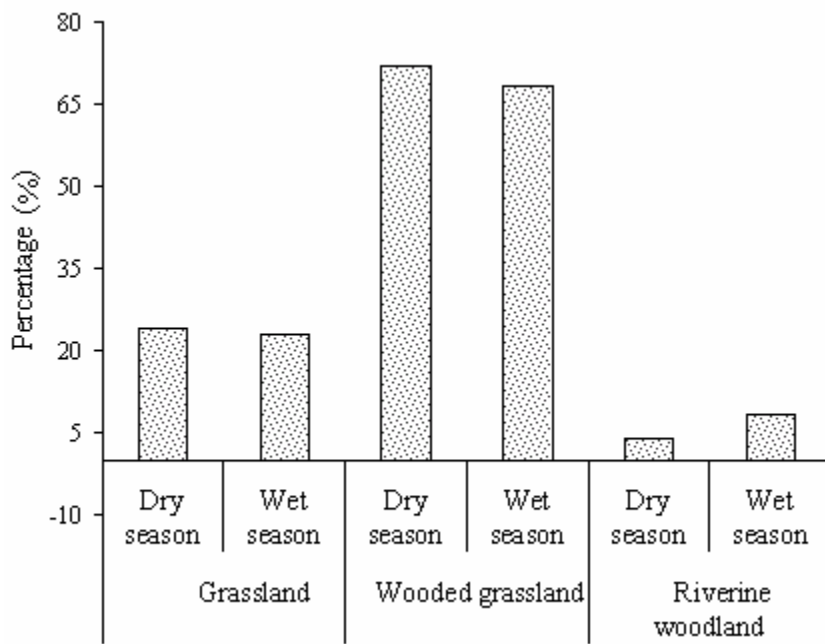


Figure 9: Percentage of raptors observed in different habitats during dry and wet seasons in VNRMA.

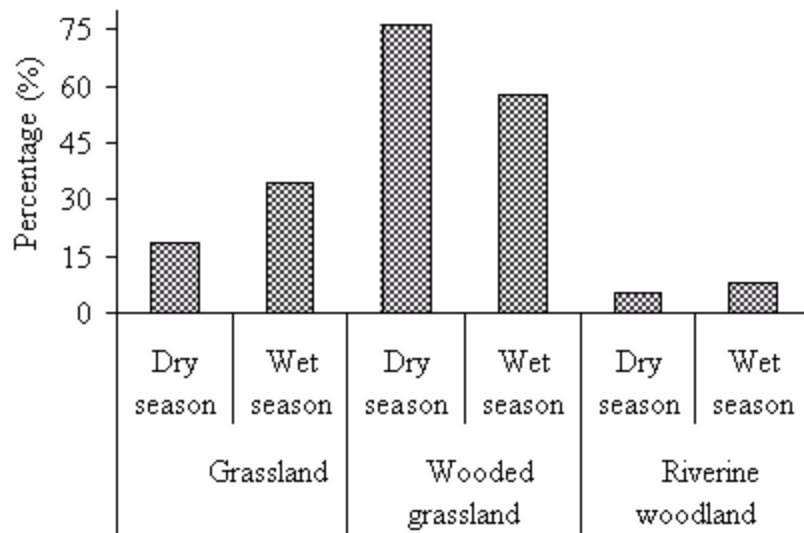


Figure 10: Percentage of raptors observed in different habitats during dry and wet seasons in Manyara Ranch.

Table 6: Multiple comparison of occurrence of raptors in different habitats in VNRMA

Comparison	Dry Season			Wet Season		
	MRD	p- value	Inference	MRD	p- value	Inference
Grassland and Wooded grassland	-17.00	<0.01	sd	-18.50	<0.01	sd
Grassland and Riverine woodland	11.00	>0.05	ns	8.00	>0.05	ns
Wooded grassland and Riverine woodland	28.00	<0.001	sd	26.50	<0.001	sd

MRD: Mean Rank Difference **sd:** Significant difference

ns: No significant difference

In Manyara Ranch, utilization of different habitats by raptors was statistically different ($H=21.256$, $p<0.0001$). Significant differences in habitat utilization were found between grassland and wooded grassland during the dry season and wooded grassland and riverine woodland both during the dry and wet seasons (Table 7).

Table 7: Multiple comparison of occurrence of raptors in different habitats in Manyara Ranch.

Comparison	Dry Season			Wet Season		
	MRD	p- value	Inference	MRD	p- value	Inference
Grassland and Wooded grassland	-15.50	<0.01	sd	-10.50	>0.05	ns
Grassland and Riverine	5.00	>0.05	ns	10.50	>0.05	ns
Wooded grassland and Riverine woodland	20.50	<0.001	sd	21.00	<0.001	sd

MRD: Mean Rank Difference **sd:** Significant difference

ns: No significant difference

4.4 Abundance of Raptors in Relation to Tree Density and Ground Cover

The abundance of raptors in Kwakuchinja wildlife corridor showed an increasing trend with increase in tree density both in VNRMA and Manyara Ranch (Figs. 11 and 12).

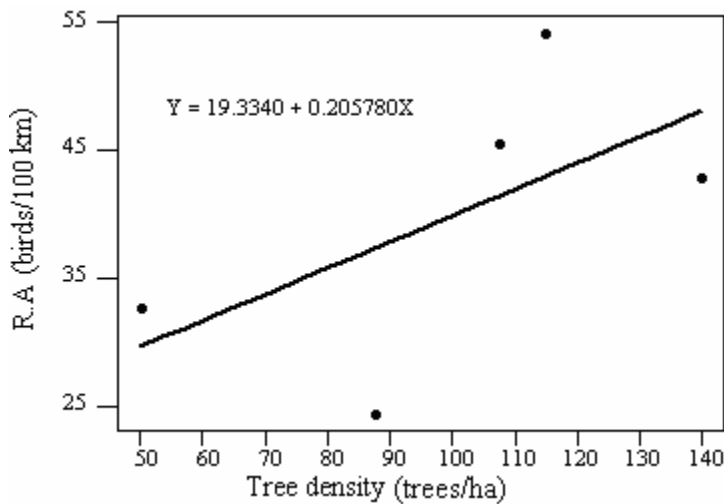


Figure 11: The relationship between relative abundance of raptors and tree density in VNRMA

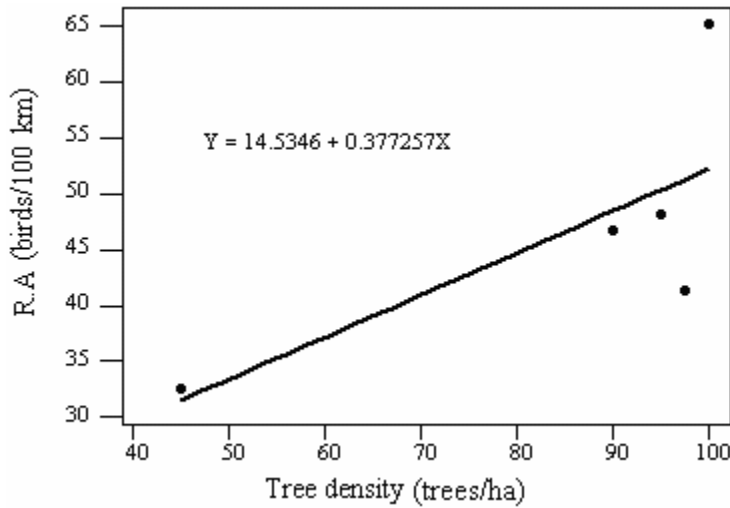


Figure 12: The relationship between relative abundance of raptors and tree density in Manyara Ranch.

Regression coefficient (rate of increase) was higher in Manyara Ranch ($r=0.3772$) than in VNRMA (s) ($r=0.2057$). However, the increase in raptors abundance with tree density was statistically not significant both in VNRMA (s) ($F=1.63$, $d.f=4$, $p=0.291$) and Manyara Ranch ($F=3.21$, $d.f=4$, $p=0.171$). Raptors abundance in relation to average ground cover showed increasing trend in VNRMA (s) (Fig. 13), but a decreasing trend in Manyara Ranch (Fig. 14). The rate of increase (r) was 0.2692 and -0.8508 in VNRMA (s) and Manyara Ranch, respectively. The rate of increase in VNRMA (s) was statistically not significant ($F=0.2343$, $d.f=4$, $p=0.6615$) and so was in Manyara Ranch ($F=0.89$, $d.f=4$, $p=0.416$).

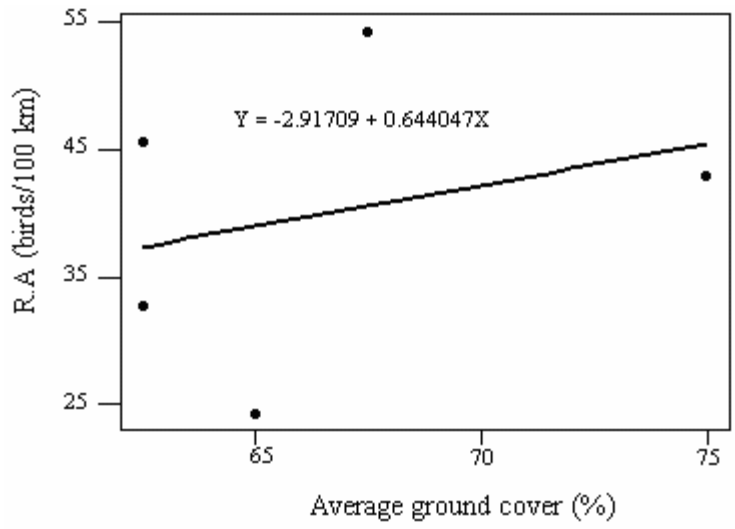


Figure 13: The relationship between relative abundance of raptors and average ground cover in VNRMA.

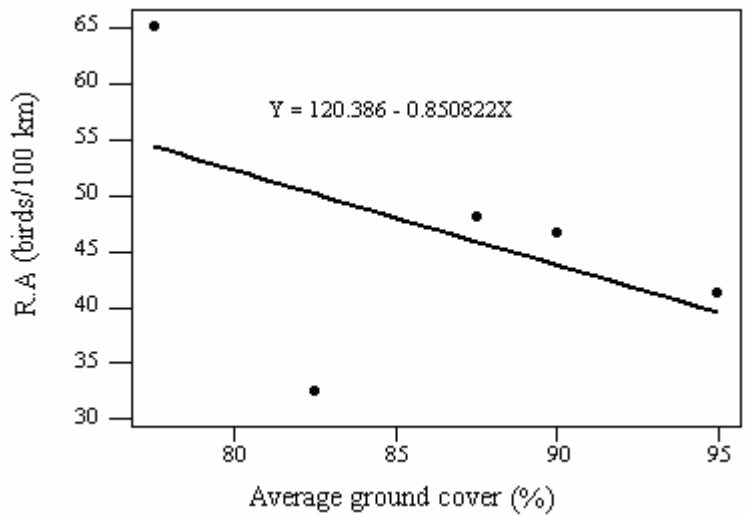


Figure 14: The relationship between relative abundance of raptors and average ground cover in Manyara Ranch.

DISCUSSION

5.1 Abundance

The abundance of raptors in Kwakuchinja wildlife corridor does not seem to be strongly influenced by the current land-uses. The abundance of raptors in any given area is the function of prevailing set of environmental conditions, the type and intensity of disturbance, and the behavior of the species involved as shown by the ability of the species to adapt to the changing environmental conditions (Sorley and Andersen, 1994; Brandl *et al.*, 1985). With a difference in land-uses, raptors were expected to reflect the influence of the different land-uses to their population in the area. This difference was not apparent in Kwakuchinja wildlife corridor, though some species occurred with higher abundance than others.

Opportunistic hunting behavior of Rueppell's Griffon Vulture (*Gyps rueppellii*) is likely to be the reason for the high abundance of this species in VNRMA during the dry season. Tourism hunting period in Tanzania is in between June to December (MNRT, 1998), the period, which partly coincides with the time of the present study (September – December, 2005). Since tourism hunting is being conducted in Vilima Vitatu VNRMA, it is likely that the vultures were attracted to the area by offal left behind after successful hunting or baits used to attract the animals.

The least abundance of Black-shouldered Kite (*Elanus caeruleus*) in VNRMA during the dry season indicates that this species was not positively influenced by the current land-uses. Black Kite (*Milvus migrans*) is well known to benefit by opportunistic hunting in agricultural field (Brandl *et al.*, 1985; Sorley and Andersen, 1994; Herremans and Herremans-Tonnoeyr, 2000; Sánchez-Zapata and Calvo, 1999). As agriculture is practiced outside the VNRMA, it is likely that this species has shifted its foraging ranges to the nearby agricultural fields.

The high abundance of Pallid Harrier in VNRMA during the wet season is likely to be attributed to the input of Palearctic migrant population of the species from Eurasia region. The time for Eurasia-Afrotropical bird migration (Zalles and Keith, 2000) partly

coincided with the period of this study and hence the Palearctic migrant population of Pallid Harrier is likely to be accountable for increased of population this species in VNRMA. This is in agreement with raptors responding to annual changes like weather by using a different set of habitats in different seasons (Lohmus, 2003). The lowest abundance of African Marsh Harrier during the wet season in VNRMA is likely to be due to underestimation of the species number in the area. Increased grass and marsh height around the species habitats, likely decreased the visibility, leading to some individuals of the species not to be noticed and recorded. Thiollay (1985) also found low densities of Falconiformes species attributed to their inconspicuous habits and decreased visibility as the function of the habitat which make localization of the species difficult in spite of efforts taken to detect them.

The high abundance of Steppe Eagle and Pallid Harrier in Manyara Ranch during the dry season, like in VNRMA, is attributed to Palearctic migration of the species from Eurasia region. The least abundance of Black-shouldered Kite during the dry season in Manyara Ranch indicates that this species is not positively influenced by the current land uses. Similar to VNRMA, it is likely that this species has expanded its foraging ranges to the nearby agricultural fields where it might be benefiting by scavenging and/or hunting opportunistic in agricultural fields.

The high abundance of Steppe Eagle in Manyara Ranch during the wet season, like in dry season, is attributed to input of Palearctic population of the species in the area due to Eurasia-Afrotropical migration. The least abundance of Secretary Bird and Augur Buzzard during the wet season in Manyara Ranch is likely to be due to local movement of the two. Local movement of raptors triggered by seasonal difference in habitat conditions results in changing densities of the species involved. The two species are very conspicuous and easy to locate. The low densities of these two species during the wet season suggest movements out of the area.

The insignificant difference in the abundance of raptors between VNRMA and Manyara Ranch, both during the dry and wet seasons indicates similarity of the two areas in food availability over the seasons irrespective of the differences in land-uses and habitat differences. The increase in raptors abundance with tree density both in VNRMA and Manyara Ranch though not significant, is the function of increase in perches which tend to increase prey availability. With high perches raptors can scan the area around and locate the prey easily. The decrease in raptors abundance in Manyara Ranch with increased ground cover is as a result of decreased prey availability. High grass cover conceals the prey and hence decreased availability though their abundance might be high. Since prey abundance and availability attribute to differences in raptor abundance in different areas and different seasons (Sorley and Andersen, 1994; Lohmus, 2003), the insignificant differences in raptors abundance in Kwakuchinja wildlife corridor implies there is a minimal fluctuation in the occurrence of raptors in the area due to local movement triggered by differences in food availability.

5.2 Diversity

Raptors in Kwakuchinja wildlife corridor showed high species richness, diversity and evenness, and stability over seasons. The number of species (17) found is similar or even higher when compared to similar dry savannas (Sorley and Andersen 1994; Liversidge, 1984). The fact that the species diversity and evenness were high both in VNRMA and Manyara Ranch, with no apparent difference between the two sites and across the seasons, as found in this study indicates that there is minimal influence of land-use change to the diversity of the raptors in the area. Generally, this is an indication of a good conservation status of the area as high diversity of raptors indicates a well functioning ecosystem.

Diversity of raptors occurring in Kwakuchinja wildlife corridor is as a result of both evolutionary and anthropogenic activities. Some raptor species for instance, African Fish Eagle (*Haliaeetus vocifer*) and African Marsh Harrier (*Circus ranivorus*) occur in the area because of evolutionary set up of the area while others e.g. Grasshopper Buzzard (*Butastur rufipennis*), Rueppell's Griffon Vulture (*Gyps rueppelii*) and Steppe

Eagle(*Aquila nipalensis*) have occurrences influenced by anthropogenic activities. This argument agrees with others (e.g. MacArthur and MacArthur, 1961; MacArthur and Wilson, 1967; Lack, 1969; Whelan, 1995) that avian diversity is related to structural complexity of the habitat structure which is an evolutionary product and shaped by anthropogenic activities (Bird, *et al.*, 1996; Brandl *et al.*, 1985; Sorley and Andersen, 1994).

5.3 Habitat Utilization and the Influence of Land-Uses

The differential habitat utilization by raptors in Kwakuchinja wildlife corridor depicts how certain habitats are crucial for the survival of the raptors. The pattern of raptors' habitat utilization found in Kwakuchinja wildlife corridor is the function of both natural habitat set-up and anthropogenic activities. Different raptor species have different habitat preferences linked to their natural history. On the other hand, it is known that habitat management and change in land-uses change the habitat quality and this may shift habitat preference of a given raptor (Lohmus, 2003). The quality of the habitat is the function of the availability of critical requirements e.g. prey availability, perching and nesting sites (Blanco, *et al.*, 1990; Bakaloudis, *et al.*, 1998).

The pattern of habitat utilization in Kwakuchinja wildlife corridor in the two study sites has indicated the significance of wooded grassland for the conservation of raptors in the area. The high utilization of wooded grassland during the dry season compared to the wet season shows that such habitats are refuge for the raptors during the dry season when prey abundance is low. This implies that the wooded grassland in Kwakuchinja wildlife corridor stand to be a keystone habitat providing keystone structure for the survival of raptors. Tews *et al.* (2004) defined keystone structure as a distinct spatial structure providing resources, shelter and services crucial for survival of the species, while keystone habitat is the broad vegetation type associated with the keystone structure. The scattered large trees in wooded grassland in Kwakuchinja wildlife corridor are likely to be the keystone structures as they provide high perches for raptors allowing them scanning the surrounding area for preys and hence increased prey availability.

Availability of open water and marshes in VNRMA's due to the proximity of this area to Lake Burunge is the main factor that leads to African Fish Eagle (*Haliaeetus vocifer*), African Marsh Harrier (*Circus ranivorus*) and Eurasian Marsh Harrier (*Circus aeruginosus*) to occur only in VNRMA's. This view agrees with Hiraldo *et al.* (1993) that specialist species like the above have the tendency to be confined to native habitats, which provide them with particular preys and/or breeding habitats.

Grasshopper Buzzard (*Butastur rufipennis*) and Steppe Eagle (*Aquila nipalensis*) habitat utilization pattern in Kwakuchinja wildlife corridor reflects the difference in habitat management between VNRMA's and Manyara Ranch. The main difference in habitat management between the two sites is the use of prescribed burning in VNRMA's, while in Manyara Ranch a no-burn policy is implemented. This difference has led to higher grass cover in Manyara Ranch, which attracted Palearctic migrant, Steppe Eagle (*A. nipalensis*) in the area. Similarly Sánchez-Zapata *et al.* (2003) found Steppe Eagle (*A. nipalensis*) occurring in high frequencies in areas with higher grass cover. Prescribed burning on the other hand favored the occurrence of Grasshopper Buzzard (*Butastur rufipennis*) in VNRMA's as this species prefers foraging in burnt areas, where it is easy to catch insects. This is in agreement with a long known fact that insectivorous raptors tend to gather at fires or in burnt area because of high food availability in such areas (Komarek, 1969; Gillon, 1972).

CONCLUSION

The insignificant difference found in the abundance and diversity of raptors between VNRMA and Manyara Ranch reflects the minimal difference between the two sites in terms of habitat characteristics and prey availability. Exclusion of fire in Manyara Ranch and tourism activities (hunting and camping) in VNRMA has been, probably, on time scale not enough to differentiate the two areas in terms of habitat characteristics to influence raptors abundance. Raptors in the two sites may be also readily adapting to human-modified habitats and hence similarity of species diversity and abundance between the two sites.

The current completely “no burn policy” in Manyara Ranch needs to be critically looked against the history of the ecosystem. If the current habitat management practice will be left to continue, it is obvious that some raptor population will be highly impaired as observed in fire facilitated species (e.g. Grasshopper Buzzard) disappearing in the area.

The dependence of raptors on wooded grassland during the dry season indicates the significance of the main component of the habitat (the trees) in the conservation of raptors in the area. Both in VNRMA and Manyara Ranch, critical threshold (With and Crist, 1995) has to be taken in consideration when habitat management is put into practice to provide fair opportunities for all kinds of raptors.

Occurrence of raptors with specific habitat requirement e.g. African Fish Eagle (*Haliaeetus vocifer*), African Marsh Harrier (*Circus ranivorus*) and European Marsh Harrier (*Circus aeruginosus*), and the utilization of the area by a number of long distance migrants is an indication of the importance of the area to the conservation of raptors at local and regional level.

RECOMMENDATIONS

To understand well the response of raptors to land-use changes in Kwakuchinja wildlife corridor, there is a need for long-term studies linking raptors with different aspects of land-use changes. This will allow analyzing the response of raptors in Kwakuchinja wildlife corridor based on long-term data, rather than short-term studies.

Detailed study on Grasshopper Buzzard (*Butastur rufipennis*) and Steppe Eagle (*Aquila nipalensis*) habitat utilization in Kwakuchinja wildlife corridor and the influence of fire on these species is recommended as the two species were found to utilize burnt and unburnt areas differently.

Studies on local and/or seasonal movements of raptors in Kwakuchinja wildlife corridor are highly recommended. Such studies will provide better understanding of the influence of land-use changes on raptors abundance and diversity in the area.

Conservation of raptors with specific habitat requirement in Kwakuchinja wildlife corridor needs conservation of their specific habitats, which need involvement of different stakeholders. So there is a need for involvement of different stakeholders at all levels for the sustainability of raptor habitats in Kwakuchinja.

There is a need for involving local people in monitoring raptors in Kwakuchinja wildlife corridor as they can be used to re-construct the past status of raptors in the area and hence a base for measuring the change. The local people are the first to note new and/or disappearance of species and, when and how different species utilize different habitats in their area. So, the local people can be very useful in acquiring information to study species range expansion and constriction as well as their migration.

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DECLARATION

I, Frank Alexander Mawi, I do here by declare this work to be original and truly done by myself. All the sources of materials used have been duly acknowledged. This work has not been submitted any where else for the same purpose and never will be done so.

Frank Alexander Mawi

Name

Signature

Date