ASSESSMENT OF POPULATION STATUS OF HINDE'S BABBLER *(Turdoides hindei)* IN RELATION TO ITS HABITAT IN MERU NATIONAL PARK, NGAYA FOREST AND THE ADJACENT AGRICULTURAL LANDSCAPE, KENYA

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A thesis submitted to Graduate School in partial fulfilment for the requirements of the award of Master of Science Degree in Natural Resources Management of Egerton University

EGERTON UNIVERSITY

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DECLARATION AND APPROVAL

DECLARATION

I hereby declare that this is my original work and it has not been submitted or published for any award of a diploma or a degree in this University or any other University

Signature _____ **Date** _____

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RECOMMENDATION

This thesis has been submitted to with our recommendation as University supervisors

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DEDICATION

To my father, Mr. Jeremiah Onyancha, mother Mrs. Naomi Sarange, sisters Ms. Anne Saragi, Ms. Emma Kwamboka, brothers Jeremiah Mokua, Stafford Ayiema and Duncan Bichang'a, fiancée Keziah Kwamboka Mongare and aunt Mrs. Caren Kibagendi for their financial and moral support.

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ABSTRACT

Populations of avian species continue to decline worldwide due to the various types of habitat degradation. This is the case with Hinde's Babbler which is listed as Vulnerable in the IUCN Red List with isolated populations confined to some parts of central and eastern Kenya. The purpose of this study was to asses and compare its current population status in MNP, Ngaya Forest Reserve and agricultural landscapes. This survey was conducted between June and December, 2015 covering dry and wet season. Data was collected at points along predetermined transects where playback of Hinde's Babbler was used to elicit response of Hinde's Babbler groups. A cumulative transect length of 19km was surveyed in the three landscapes where quadrats of 20 x20m were set at constant intervals. At each point of detection, total number of adults, offsprings, disturbances, threats and vegetation attributes were recorded. Mann-Whitney, Kruskal Wallis, mean, frequencies and Spearman Rank Test were used to analyze data. The results indicated a mean group size of 4.7 at Ngaya Forest Reserve, 4.6 in MNP and 3.4 at the AS during dry season. These resulted in a population estimate of 127 individuals (Ngaya), 91 individuals (MNP) and 98 individuals (AL). During wet season the mean group size in Ngaya Forest Reserve was 5.2, 3.9 in MNP and 4.0 in AS. This resulted in population estimate of 84 individuals at Ngaya Forest, 123 in MNP and 38 individuals at AS. There was no significant statistical difference between group density during dry and wet sampling season (W = 241.5, P =0.08). In terms of relationship with habitat, only shrub cover was positively correlated with mean group size of Hinde's Babbler in both seasons (dry, r_s = 0.70, P=**0.01**; wet, r_s = 0.80, P=**0.02**). The other variables of tree, herbaceous and grass cover (r_s = -0.57, P= **0.03**; r_s = -0.83, P = **0.00**, r_s = - 0.54, P = **0.04**) were negatively correlated during the dry season while no correlation was established between mean group size with bare and with crop cover. During the wet season, only tree cover was negatively correlated with mean group size. In terms of disturbance and threats to Hinde's Babbler, only vegetation trampling in MNP was correlated with mean group size during the wet season (r_s = - 0.26, P =**0.03**). These results imply that continuous monitoring of these three landscape and habitat is necessary to keep track of trends in population and the impact of disturbance on the conservation of the Hinde's Babbler. The results are crucial in underscoring the importance of protected, partially protected and agricultural landscape as well as habitat structure and condition in the conservation of threatened avifauna population.

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AL	Agricultural Landscape
CBD	Convention on Biological Diversity
GPS	Global Positioning System
HB	Hinde's Babbler
IBAs	Important Bird Areas
IUCN	International Union of Conservation for Nature
KFS	Kenya Forest Service
KNBS	Kenya National Bureau of Statistics
KWS	Kenya Wildlife Service
MNP	Meru National Park
PAs	Protected Areas

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Habitat loss is the single threat to birds though other factors like alien species and hunting have been implicated in the decline of many bird populations (Njoroge & Bennun, 2000). According to BirdLife International (2011) human actions are putting pressure on species' populations and their habitats thus contributing to a decline in population of birds globally. In an assessment of world avifauna 1,375 out of the 10,000-species listed on the IUCN Red List as threatened with extinction based on IUCN criteria and categories (IUCN, 2001). These comprise 217 species classified as Critically Endangered (meaning they are facing an extremely high risk of extinction), 419 species assessed as Endangered (very high risk of extinction) and 741 listed as Vulnerable (IUCN, 2006). An additional 959 species are listed as Near-Threatened because they are assessed as close to qualifying as globally threatened. In Africa, 245 species are threatened with extinction, 29 of which are Critically Endangered. For the Kenya case, 39 avifauna species are threatened, 6 species are Critically Endangered, 15 are Endangered and 18 are Vulnerable (BirdLife International, 2016a).

According to BirdLife International (2014a), of the 1,375 threatened bird species, 963 species of threatened birds have populations of fewer than 10,000 individuals, while 520 species have populations below 2,500 individuals. In total, 58 species of threatened birds have tiny populations that possibly number fewer than 50 individuals. For instance, there are 40–45 adult Tahiti Monarchs *Pomarea nigra* left on Tahiti, French Polynesia, and only 30–35 Puerto Rican Amazons *Amazona vittata* on Puerto Rico (BirdLife International, 2013). Thus, for most avifauna species with small populations, their numbers are also believed to be declining. Only 280 threatened species have populations that are estimated to exceed 10,000 individuals. Most of these species qualify as threatened because their populations are undergoing rapid declines (BirdLife International, 2011). In Kenya, the restricted range and critically Endangered Taita Apalis (*Apalis fuscigularis)* population has declined due to habitat fragmentation (Githiru, 2003). It is listed as Critically Endangered in the IUCN Red List because it has a tiny occupied range of 500 hectares with a population of not more than 150 individuals. It's montane forest habitat has become severely fragmented and continues to decline in both extent and quality.

Surveys by Githiru, *et al*. (2014) indicated that the very small population of the Taita Apalis has consequently been fragmented into extremely small sub-populations.

Habitat suitability influences species' distribution in space (Moyle *et al.*, 2012). Habitats that are better and attractive in terms of cover from predators, food availability and nesting sites influence species' preference (Eddy *et al.*, 2014). Avifauna species vigorous defend their territories with attractive resources to enhance their attractiveness in formation of breeding bonds. Thus, habitats with better resources are expensive to defend and some cost has to be foregone. Some have to expand their range to unoccupied sites with some resources or avoid forming bonds (Chalfoun & Martin, 2007). According to Plumb (1979), when species move to new environments they may take long to breed and thereby forego breeding. This is probably the case in Hinde's Babbler range extension to Ngaya Forest, an area with high altitude in contrast to the former sites of lowland woodland and thickets (Njoroge & Bennun, 1998). Surveying new sites and comparing populations between different strongholds of the species becomes priority for conservation of these species at site level and landscape level.

The decline in populations is as a result of contracting ranges (Bonn *et al.*, 2002). Habitat loss has been linked directly with bird population decline, with forestland being cleared and put under arable land (Njoroge *et al.*, 1998). This has puts species under pressure to expand the range in order to seek refuge or try to co-exist with humans (Didham *et al.*, 2007). Habitat condition directly and indirectly affect the population status of avian species, their traits and preferences which in turn determine their distribution (Both *et al.*, 2006). Some birds have expanded their range depending on habitat suitability (Shaw *et al.*, 2003). Though this might not be the case as surveys have not be carried out to prove whether they existed before (Njoroge & Bennun, 2000). Surveys in unsurveyed habitats can produce numbers necessary for conservation status of a species to be uplisted or downlisted in the IUCN RedList.

Hinde's Babbler is a small bird measuring 23 cm from head to tail, sturdy and thrush-like in appearance (Plumb, 1979). It occurs in two forms; some are pale while others are dark. Pale form is mottled white-and-black on head, neck and breast, sometimes with asymmetrical blotching, belly and vent off-white (BirdLife International, 2015). Dark form has reduced white 'scaling' on head and breast, with rusty vent, but white belly (Plate 1). Orange-red eyes in adult, brown or dark grey in immature. Babblers within the range of this species have white or orange-yellow eyes and lack scaling on head and breast (Shaw *et al.*, 2003). Hinde's Babbler produces a chattering voice; it often stays silent for long periods. Good areas for this species are around

Mukurweini and Kianyaga (Bennun & Njoroge, 1999). It is highly sedentary and occurs in groups of individuals all year-round (Njoroge & Bennun, 2000).

Hinde's Babbler is listed as Vulnerable on the IUCN RedList since it is known from a small number of locations within a small range, where its habitat is undergoing severe fragmentation (Collar *et al*., 2016). Its current population is believed to be between 1000-3700 mature individuals with a decreasing trend because of perceived habitat fragmentation within its range (BirdLife International, 2012). Its endemic to parts of 'central and eastern Kenya', thus it carries two tags that calls for conservation (Bennun *et al*., 1996). Its conservation within a severely modified agricultural landscape is a substantial challenge than it seems in to policy makers(Njoroge & Bennun, 2000).

1.2 Statement of the Problem

Hinde's Babbler is endemic to Kenya, confined to central and eastern regions of Kenya. It is listed as Vulnerable in IUCN RedList and due to its small population is thought to be increasing but at a low rate. It is threatened since its habitat is undergoing continuous fragmentation and degradation due human population pressure and associated need for land for agricultural expansion within its range. By being listed as Vulnerable, it bears tags that make it a priority for conservation actions and critical efforts to prevent extinction. The Ngaya Forest population of Hinde's Babbler remained largely unsurveyed and thus unknown. Effective conservation can only be undertaken if current information on conservation status of a species is known. Population trends of the species in protected sites such as Meru National Park, adjacent unprotected agricultural landscape remained unknown. Yet it is important to understand how the species is faring in protected and unprotected landscapes. Surveys at the Ngaya Forest Reserve, MNP and AS will fill existing gaps in biological knowledge of the distribution and population status of the Hinde's Babbler. Threats as well as the habitat structure and variability in protected and unprotected sites are also undocumented. The process of downlisting and uplisting of species in IUCN Red List requires continuous up-to-date data on species population size, trends and distribution across its range. This information is not complete for this purpose when other sites within which a species is assumed to exist remains biologically unsurveyed. This study sought to provide information on the population status of Hinde's Babbler, factors influencing its habitat preference and threats.

1.3 Objectives of the Study

1.3.1 Broad objective

To effectively improve the conservation status of the globally threatened Hinde's Babbler through increased biological knowledge and targeted research and monitoring.

1.3.2 Specific objectives

i. To estimate the current population of Hinde's Babbler and compare it between protected MNP, partially protected Ngaya Forest Reserve and unprotected agricultural landscape;
ii. To assess the influence of vegetation type on habitat preferences of Hinde's Babbler in MNP, Ngaya Forest Reserve and agricultural landscape.
iii. To assess impacts of habitat disturbances on Hinde's Babbler population size in MNP, partially protected Ngaya Forest Reserve and the agricultural landscape

1.4 Research hypotheses

$H0_1$ Population of Hinde's Babbler does not differ between MNP, Ngaya Forest Reserve and agricultural landscape;

$H0_2$ Vegetation cover type does not influence Hinde's Babbler habitat selection and use.

$H0_3$ The impacts of habitat disturbances do not affect the population size of Hinde's Babbler across landscapes.

1.5 Justification

Evidence-based conservation concept requires continuous supply of vital data for use in setting priorities for species conservation, management and planning. For effective conservation of the globally threatened Hinde's Babbler, up-to-date information on the species demography (population size and age composition), spatial distribution, habitat preference, threats and the its severity is vital. Shaw (2007) recommended the need to monitor abundance and habitat quality at managed sites (protected areas), and match these with unmanaged sites (unprotected). Most importantly, for the erstwhile unsurveyed Ngaya Forest information generated could be used in updating the conservation status of the species as well as in the development of the Species Action Plan as well as in the development of the Management Plan for the Ngaya Forest Reserve. This study provides the much-needed information to review the conservation status of on Hinde's Babbler. Through the information, a species can be either downlisted or uplisted in the IUCN RedList. The study provides the much-needed data for a possible

incorporation in site or to scale conservation action and policy-making process. This information is vital for institutions responsible for bird and ecosystem management such as the National Museums of Kenya, Kenya Forest Service, Kenya Wildlife Service, Nature Kenya and BirdLife International in conserving the respective sites. As part of extending protected area boundaries, this study is instrumental in determining areas that can be priority for protected area expansion such as the agricultural landscape around Meru National Park and Ngaya Forest Reserve. This information also forms a crucial baseline for future monitoring trends in species population and habitats at these sites in future.

1.6 Limitation of the Study

Some sites within the park were inaccessible on both foot and car patrol due to thick forest, and pricking thorn as well as rugged terrain. During wet season, it was difficult to access some sites due to flooding and poor weather. Getting off the car was unsecure due to dangerous wild animals. This study also faced management limitation such as finance and time constraints. A strict workplan was followed during the surveys besides incorporation of Meru National Park into the project to reduces the fuel cost. The research department provided a vehicle and a driver to curb on expenditure.

1.7 Assumptions of the study

In terms of the reaction of the focal species on the playback, the assumption was that the species would response to the playback. It was assumed that Hinde's Babbler groups in Meru National Park did not move out into Ngaya Forest and agricultural landscape during the survey. Equally, the Hinde's Babbler groups in Ngaya Forest and agricultural landscape didn't mix with their counterparts in MNP during the survey. It was also assumed that there was no double counting of individuals along the transect and all Hinde's Babbler groups were found along the transect and responded to the playback.

1.8 The Scope of the study

The study was confined to Meru National Park, Ngaya Forest and the adjacent agricultural landscape around Meru National Park. It focused on the Hinde's Babbler the population size, structure, composition (i.e. the number of nestlings, fledglings, immatures and adult Hinde's Babbler) and habitat preferences. The study also focused on the level of disturbance, seasonality and severity of threats in the two protected ecosystems and unprotected agricultural site.

1.9 Definition of Terms

Agricultural landscape - farms adjacent to Meru National Park that are dominated with human activities.

Critically Endangered – The highest risk category assigned by IUCN RedList of threatened species.

Downlisting –changing the status of a species under IUCN RedList of threatened species from a higher risk category to a lower risk category

Endemic -ecological state of a species being unique to a defined geographic location or be localized within a geographical region.

Habitat Preference –Innate and learned behavioral responses of birds that allow them to distinguish among various components of the environment resulting in the disproportional use of environmental conditions to influence survival and ultimate fitness of individuals.

Habitat structure –the type of vegetation that will consist babbler home, is it a thicket, a woody vegetation, a scrub vegetation, a crop farm, coffee plantation or riverine vegetation.

Important Bird Areas–areas recognized as being globally important sites for the conservation of bird populations under a globally agreed criterion such as globally threatened, range restricted, biome restricted and congregations.

Land use intensity – it will be defined by the nature of activities taking place of the land and the land cover, is it cultivated, uncultivated.

Population status - the population attributes of Hinde's Babbler in terms of current population estimates, mean group size, density, composition, structure, factors influencing habitat preference and disturbances that culminate into threats (biological, physical and anthropogenic).

Range -Geographical region where a species can be found, a species range might change due to changes in ecological and anthropogenic factors.

Threats -the activities that influence the population and habitat preference negative, those that make habitats look unattractive to habitation by Hinde's Babbler.

Protected area -a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means to achieve long-term conservation of nature with associated ecosystem services

Uplisting -changing of conservation status of a species from one that calls for little conservation efforts to one that requires urgent intervention to save it from extinction. For instance, from Endangered to Critically Endangered.

Vulnerable -species that has been categorized by the International Union for Conservation of Nature as likely to become endangered unless the circumstances threatening its survival and reproduction improve.

CHAPTER TWO

LITERATURE REVIEW

2.1 Avian species population declines and habitat loss

Avian population has declined rapidly due habitat loss, degradation, fragmentation, pollution, invasive species, overexploitation, trade in wild species, agricultural expansion and intensification and climate change among other factors (BirdLife International, 2013). This is as a result of human induced changes which has led to reduced foraging grounds, breeding sites, refugee sites and nesting areas for avifauna (Calvert *et al*., 2013). For instance, the Seychelles Magpie-robin *Copsychus sechellarum*, which is endemic to the Seychelles suffered a severe decline in population to just 12- 15 individuals by 1965 due habitat loss. Its population was confined to 210 ha of Fregate Island in Seychelles (BirdLife International, 2013). This species was thought to have been distributed throughout the island before but due to habitat loss it was consigned to extinction (Anon, 2009).

Habitat loss has been singled out as a key driver of species being confined to certain ranges thus increasing their vulnerability to extinction. Its pervasive and disruptive impacts on avifauna population have far-reaching implications (BirdLife International, 2013). The magnitude of the ecological impacts of habitat loss on avifauna population can be exacerbated by fragmentation (BirdLife International 2014a). The population of *Taita apalis* continue to decline because its habitat has been severely fragmented in both extent and quality (Githiru, 2003). Thus, its small population has been fragmented into extremely small subpopulations that does into interact (BirdLife International, 2014a).

Habitat fragmentation pose a challenge to birds in that species that survive in those habitat remnants are confronted with modified and reduced area, increased isolation and arbitrary ecological boundary (Ewers & Didham, 2006). The implications of this for individual organisms are many and varied, because species with differing life history strategies are differentially affected by habitat fragmentation (Bellingeri *et al.*, 2013). A survey carried on migratory birds indicated that birds that use natural breeding habitats are declining due to loss of quality of these ecosystems most especially in the tropics (Robbins *et al.*, 1989). This positive relationship between habitat quality loss and avian population decline in the tropics might be due to large scale clearance of natural habitats and transformation to arable land to feed the growing populations besides competing for natural resources (Ghazoul *et al.*, 2013).

2.2 Avifauna Habitat Preferences and Distribution

Most avian species occupy specific habitat based on availability of food, cover and breeding grounds. These factors vary across space thus dictating the distribution of species (Carrete *et al.*, 2009). When these resources are degraded through habitat loss, species are forced to develop adoptive traits for survival (BirdLife International, 2008). Habitat quality strongly influences species' ability to select habitats based on quality for a given activity such as foraging, breeding, displaying, and protection from adverse threats (BirdLife International, 2014a). Habitat preferences are based on informative cues that allow individuals to reliably predict the relative expected fitness and enemies in different habitats structures (Terorde & Turpie, 2013; BirdLife International, 2008). Avifauna species develop behaviour from previous experiences of habitat characteristic thus leading to selection of entirely new environment either modified of intact (Carrete *et al*., 2009). Habitats rich in resources and secure attract high population of avian species (Cox *et al.,* 2014).

The intensity of anthropogenic activities and disturbance has a great effect on habitat preference and selection by avifauna (Ghazoul *et al.,* 2013). These activities modify the habitats either through vegetation clearance or samplings thus making such habitat unsuitable (BirdLife International, 2008). Thus, anthropogenic and other predation threats on landscape-level changes in most regions have tailored habitat selection by avian species (Misenhelter *et al.*, 2000). A study carried out on wetlands and forestlands showed that avian species diversity was high due to their attractiveness as species could avoid threats and get protection for their nests (Doligez *et al.*, 2008). Therefore, the resources and security of the habitat will affect the ability of avifauna to select habitats with desirable attributes (Doligez *et al*., 2008).

Territory size and attractiveness influences avifauna species' habitat selection and preferences (Misenhelter *et al.*, 2000). For instance, Sharpe's longclaw (*Macronyx sharpei*) inhabit montane grassland is a severely threatened habitat in Kenya. A study carried out on habitat selection in a threatened grassland endemic bird species in a severely modified landscape of Kinangop Plateau showed that it preferred some habitats (Cox *et al.*, 2014; Stattersfield *et al.,* 1998) The species avoided non-grassland areas entirely, and within grassland showed a strong preference for short grass with tussocks. Territory sizes and foraging ranges were smaller, and rates of pecking for food higher, in this grassland type than in open short grass or long grass (Muchai *et al.,* 2002. This shows clearly that avifauna have strong taste for some habitat will favourable resources especially territorial species will prefer space rich in foraging resources (Doligez *et al.*, 2008).

2.3 Effect of legal protection on conservation of globally threatened species

Protected areas (PAs) are central to global species conservation as they ensure survival of avian species especially in areas where avifauna species are in contact with humans (Barnes *et al.*, 2014). Though important in biological diversity conservation, their effectiveness has not been assessed (Hansen *et al.*, 2007). A case study comparing data of avifauna biodiversity found inside and outside PAs in South Africa showed bird assemblages were richer, with a higher density, and a different structural and functional composition inside than outside the protected areas (Greve *et al.*, 2014). With the increased human population and transformation of natural habitats, legal protected areas might have the greatest outcomes in avifauna population conservation (Dahal *et al.*, 2014) .

Protected areas are cornerstones of biodiversity conservation, critical for achievement of the 2010 target significant reduction in the rate of biodiversity loss (BirdLife International, 2014b). Despite the growth of PAs globally, the population of avifauna continue to decline, thus increasing the number of threatened species (Ko *et al.*, 2014). This forced the parties to Convention on Biological Diversity (CBD) to adopt a programme to support the establishment and maintenance of a comprehensive PAs networks (BirdLife International, 2008). A target of 12% of the global terrestrial landscape by signatories to CBD was surpassed; an indication that countries believe in the designation of protected areas as a mechanism to turn the tide in species extinction and threat. In Africa, there are about 1,254 PAs covering more than two million km^2 according to BirdLife International (2008).

Legal protection aims to provide security to key biological diversity sites like IBAs against invasion (Greve *et al.*, 2014). Such areas act as refugee areas for rare and globally threatened avifauna species (BirdLife International, 2011). Protection is effective in reducing land-cover change on sites of conservation importance supports previous studies that have suggested that site protection has a positive effect on natural land-cover across Africa (Beresford *et al.*, 2013; Gardner *et al*., 2009), though it is not tested across the globe. A study carried out to assess the conservation importance in Africa and in buffer zones surrounding them results showed that protection is effective at reducing but not halting the loss of natural habitats which is essential in conservation of birds (Hegazy *et al.*, 2010; Murn *et al.*, 2016). For instance, only a small percentage (8%) of Hinde's Babbler population is found within legally PAs (Shaw *et al.*, 2003). Thus, legal protected areas might not be a solution to population decline of species (Njoroge *et al*., 1998). This is a small fraction of the entire population put in mind that these are areas that should provide refuge to this threatened species (BirdLife International, 2014a).

2.4 Conservation of birds in human dominated sites.

Human dominated landscapes are important for biodiversity conservation. This has been demonstrated through studies on birds (BirdLife International, 2014b), mammals (Kinnaird *et al.,* 2012), plants and other taxonomic groups that are of global conservation importance. Conservation management can no longer rely on protecting pristine habitats only, but must consider the wider landscape (Muchai *et al.,* 2002). This is especially true for habitats where endemic species are believed to be particularly susceptible to the extinction risks that accompany land conversion (Dallimer *et al.,* 2012). Human-modified habitats presented one of the greatest disturbances to avian communities (Shaw *et al*., 2013). These modifications lead to variations in avifauna species' richness and distribution in time and space (Farwig *et al.,* 2008). Thus, subpopulations that are suited to some environments with special traits to cope with changes (Njoroge & Bennun, 2000).

Socio-economic constraints that include poverty and need for more arable land are believed to be key drivers of natural habitat clearance to pave way for food production (Hansen *et al.*, 2007) agricultural intensity is important in assessing how avifauna population respond to changes in habitat condition and cope with increased human population density (Ewers & Didham, 2006). A study carried out in Burkina Faso to assess the response of bird communities to agricultural intensity and human population showed that avifauna richness was highest in disturbed landscape that is areas that were intensely grazed or left fallow (Shaw *et al.,* 2003). Availability of nest sites and food were the principal factors affecting bird distribution. For birds to survive in a human dominated environment they have to develop special behaviour to utilize available resources (Soderstrom *et al.,* 2003).

Conservation of avifauna species on human dominated environs is not guaranteed success (Shaw *et al.,* 2003). It faces conservation problems and requires a lot of inputs in terms of awareness creation and incentives which may be hard to come by (Anon, 2009). One of the species that has co-existed with humans Sharpe's longclaw (BirdLife International, 2014b). This species has shown ability to co-exist with people provided the landscape is managed appropriately (Shaw *et al.,* 2014). It can co-exist with livestock provided the pasture contains tussock grasses, thus protecting avifauna species on human dominated will directly compete with other land-use activities and human settlement (Njoroge & Bennun, 2000)

2.5 Conservation initiatives and preventing extinction of the avifauna.

A number of avifauna species have been saved from extinction through well formulated conservation initiatives (BirdLife International, 2015). For instance, Black Robin, Seychelles Magpie-robin, Mauritius Parakeet, Rarotonga Monarch, Asian Crested *Ibis* and Lear's Macaw were all once believed to have been reduced to a few individuals, but through well formulated recovery programme healthier populations were achieved (Jones, 2010). These species were downlisted from Critically Endangered to Endangered category in the IUCN RedList after their population grew to sustainable numbers (IUCN, 2006; BirdLife International, 2012).

Well organized programmes have assisted in rescuing avifauna species from imminent extinction threats. Such programmes like nest protection, supplementary feeding and predator eradication may aid in recover of populations steadily (Aikman *et al.*, 2001). The Black Robin (*Petroica traverse)* that is endemic to Chatham Islands (New Zealand), was rescued from the little Mangere Island where it was facing extinction (Massaro *et al*., 2013; Butler & Merton, 1992). This species had rapidly declined in population due to habitat loss and predation from introduced cats. When the population had declined to just seven birds, the remaining individuals were relocated to nearby Mangere Island, where thousands of trees had been planted to provide suitable habitat (Venables & Brooke, 2015). Through organized programmes of nest protection and supplementary feeding were then established, and the population began to recover steadily to stability levels (BirdLife International, 2014a). This led to its downlisting on the IUCN RedList (BirdLife International, 2008).

Additionally, through captive breeding and release, control of invasive predators, provision of artificial nest cavities, and brood manipulations saved Mauritius Parakeet (*Psittacula eques)* population had reduced to less than a dozen birds in 1986 that included just three females. This was because habitat destruction and introduction of alien species contributed to this decline (Thorsen & Jones, 1998). However, through these programmes the wild population increased to 343 birds by 2007, leading to its downlisting from Critically Endangered to Endangered (IUCN, 2006). This shows clearly that through combative and well directed programmes species can be saved from extinction (BirdLife International, 2014b).

Other initiatives such as habitat creation, nest defense, translocation and control of predators aided in saving Seychelles Magpie-robin *Copsychus sechellarum*. The species had only 12-15 individuals remaining at eight islands in the Seychelles (Anon, 2009). In 1994, following eradication of introduced cats, a recovery programme was initiated, involving habitat creation,

supplementary feeding, nest defense, provision of nest boxes, control of introduced species and translocations to other islands. This allowed the population size to increase to around 178 birds on four islands in 2006. Three of the four populations reached carrying capacity leading to the downlisting of this species from to Endangered in 2005 (Gane & Burt, 2016).

2.6 Diversity, distribution and conservation status of babblers

The babbler family is a species rich and diverse family of African and Asian tropical forests; with one species in western North America (BirdLife International, 2015). They occupy the forest, forest edge, scrub and grassland within the tropics (Shaw *et al.,* 2003). Members of this family range from tiny to rather large passerines with pronounced variation, most with short and rounded wings, usually relatively long tail often graduated, generally rather robust but not very deep bill, sturdy legs; plumage widely variable, many species rather plain and some dull brown, others strikingly patterned in contrasting and/or bright colours (BirdLife International, 2012).

The *Timaliidae* family is composed of 310 species which are spread globally along the tropical sites. A total of 27 are threatened by various habitat and climatic changes though none has become extinct since 1600 (BirdLife International, 2008). Threat status are bound to change through continuous monitoring and assessment (IUCN, 2006). There might be more or less threatened species than the actual figures known. These babblers inhabit the tropics which are characterized with abundance of resource for protection, foraging and nesting (Njoroge *et al.,* 1998).

Most of the threatened individuals have been consigned to specific locality making the carriers of more tags thus increasing their vulnerability to the ever changing habitats (Massaro *et al*., 2013). Their distribution has been linked with river valleys, woodlands and swamps, and to the presence of dense thicket vegetation (Ghazoul *et al.*, 2013). Though some studies indicate that many species of this family have widened their range to other ecological zones (Njoroge & Bennun, 2000). Hinde's Babbler was reported in Embu and Thika (Boy, 2003), where are agricultural landscapes and most at times left fallow during dry seasons. This shows that members of *Timaliidae* family are not sedentary to ecosystems but can adopt to any ecological conditions (BirdLife, International, 2014b).

2.7 Ecology and conservation initiatives of Hinde's Babbler

Hinde's Babbler is a small bird measuring 23 cm from head to tail, sturdy and thrush-like in appearance (Plumb, 1979). It occurs in two forms; some are pale while others are dark. Pale

form is mottled white-and-black on head, neck and breast, sometimes with asymmetrical blotching, belly and vent off-white (BirdLife International, 2015). Dark form has reduced white 'scaling' on head and breast, with rusty vent, but white belly (Plate 1). Orange-red eyes in adult, brown or dark grey in immature. Babblers within the range of this species have white or orange-yellow eyes and lack scaling on head and breast (Shaw *et al.*, 2003). Hinde's Babbler produces a chattering voice; it often stays silent for long periods. Good areas for this species are around Mukurweini and Kianyaga (Bennun & Njoroge, 1999). It is highly sedentary and occurs in groups of individuals all year-round (Njoroge & Bennun, 2000).

Plate 1: Hinde's Babbler on a thicket ©*Curtis Davis*

Hinde's Babbler is listed as Vulnerable on the IUCN RedList since it is known from a small number of locations within a small range, where its habitat is undergoing severe fragmentation (Collar *et al.*, 2016; Collar & Stuart, 1985). Its current population is believed to be between 1000-3700 mature individuals of Hinde's Babbler with a decreasing trend because of perceived habitat fragmentation within its range (BirdLife International, 2012). Its endemic to 'Central Kenya', thus it carries two tags that calls for conservation (Bennun *et al.*, 1996)

Initiatives to conserve Hinde's Babbler with a private conservation sanctuaries in Nyeri, Wajee camp and a group of individuals monitoring babblers have recorded a slight increase in population of babblers (Shaw *et al.*, 2003). Its conservation within a severely modified agricultural landscape is a substantial challenge than it seems in to policy makers(Njoroge & Bennun, 2000).

2.8 Conceptual Framework

Level of protection, extent of disturbances to the habitat, vegetation cover type and seasonal variation directly affect population size, mean group sizes of Hinde' s Babblers, their

distribution, composition and habitat preference. The landscapes assessed included the protected MNP, the partially protected Ngaya Forest Reserve and the unprotected agricultural landscapes of Murera springs and Kiruyu farms. Disturbances included farming, vegetation trampling, hunting, over-browsing and overgrazing, vegetation clearance and incidences of fire (Figure 1). These disturbances were thought to have a direct impact on Hinde's Babblers' population size, mean group sizes, composition, habitat preference and distribution of Hinde's Babblers. The intervening variables included the level of awareness, the alien species management, law enactment and land use systems. These variables might have impacted on Hinde's Babbler population status but they were not assessed during the survey.

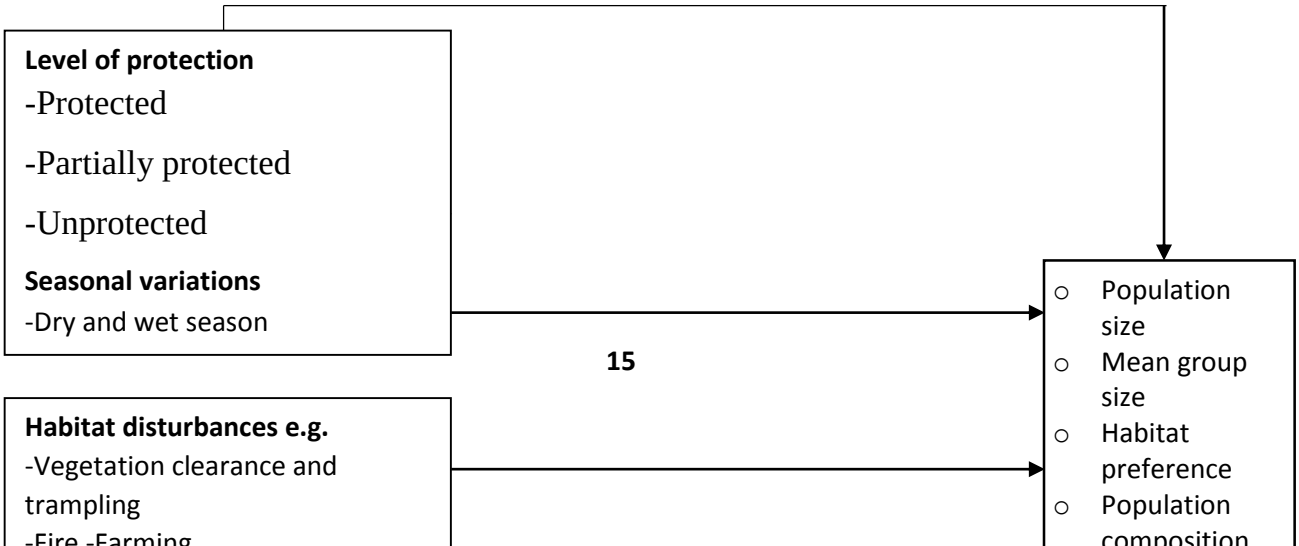

Figure 1: Conceptual framework showing independent and dependent variable relationship

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Meru National Park and adjacent agricultural landscape.

Meru National Park is located in Meru County, 71 km north Meru Town and 292 km from Nairobi, Kenya. It covers an area of 87,000 ha and stands at altitude range of 370–910 m with area co-ordinates of 380 25`E and 00 10`S. The Park is under the management of Kenya Wildlife Service (KWS). Meru National Park and its adjacent environs is criss-crossed by numerous permanent streams, draining from the Nyambene Hills and Ngaya forest. The wetter

north-western sector (rainfall 700 mm/year) is hilly, with rich volcanic soils (Bennun & Njoroge, 1999). The land flattens towards the east, where grey alluvial volcanic soils appear. This area is crossed by numerous permanent streams, draining from the Nyambene and flowing in parallel between tongues of lava, south-eastwards towards the Tana river. There are several prominent inselbergs of basement rock, notably Mughwango and Leopard Rock (BirdLife International, 2016b)

The MNP is characterized by the main vegetation type which is Combretum-wooded grassland, dominated by *Combretum apiculatum*. It grades into Acacia wooded grassland to the east, with *Acacia tortilis* and *Acacia senegal* on the rocky ridges, in riverine thickets and dotted over open country, Doum palms and *Hyphaene coriacea* in the numerous swampy areas near the rivers. *Chloris gayana* is the dominant grass in many places, with *Cyperus spp.* in the swamps (Njoroge & Bennun, 1999). The agricultural landscape is dominated with crops that is khat and maize

Meru National Park has a diverse avifauna, with over 427 species recorded. According to IBA factsheet (2013) the threatened Hinde's Babbler has been recorded near Kindani and Nyati Camps in the south-west part of the park. Meru has one of the eight species of Kenya Mountains Endemic Bird Area and 59 of the 94 Somali-Masai biome species that occur in Kenya. Regionally threatened species recorded here, include the Martial Eagle, African Finfoot, Pel's Fishing-Owl, Grant's Woodhoopoe and the Saddle-billed Stork, which is known to breed in this area. In terms of non-avian species of global conservation importance, it has other species of mammals. They include the *Loxodanta africana*, *Diceros bicornis*, *Acinonyx jubatus*, *Equus grevyi* and *Ceratotherium simum* (BirdLife International, 2016b).

3.1.2 Ngaya Forest Reserve

Ngaya Forest is one of the few remaining stands of indigenous equatorial forest in Kenya. Ngaya Forest is under Community Trust reserve. It is classified as 'Class V–Vegetation' located at an elevation of 1,249 metres above sea level (Torello-Raventos *et al.,* 2013). Its coordinates are 0°22'0" N and 38°1'60" E. The reserve falls under the jurisdiction of the Kenya Forest Service and under Community Trust. The forest is one of the few remaining stands of indigenous equatorial forest in Kenya, and contains a high diversity of tropical hardwood trees. In addition, the reserve is also an important water catchment and source of rivers that flow into the Meru Conservation Area.

Ngaya Forest Reserve experiences bimodal rains with long rains in March and May and short rains occur between October and December. This pattern enables the farmers to grow a wide range of crops for subsistence and commercial purposes. The average rainfall received in a year is 1300mm in the highlands and 380mm in the low-lying areas towards eastern sides of the park (Figure 2). The forest has a high diversity of tropical hardwood trees and is dominated by species such as *Trichilia emetica, Croton macrostachyus, Combretum molle, Olea africana* and *Ochna insculpta* in the hinterland.

The forest edges have been encroached and is covered by *Lantana camara* which is invasive. Thus, the forest disturbed with evident of burning and adjacent farms of khat (*Catha edulis*) and *Musa sapiena.* Ngaya Forest is an important water catchment, and dry season refuge for elephants and breeding. Other important wildlife species found in the forest reserve include leopard, giant forest hog, buffalo and a number of primate species.

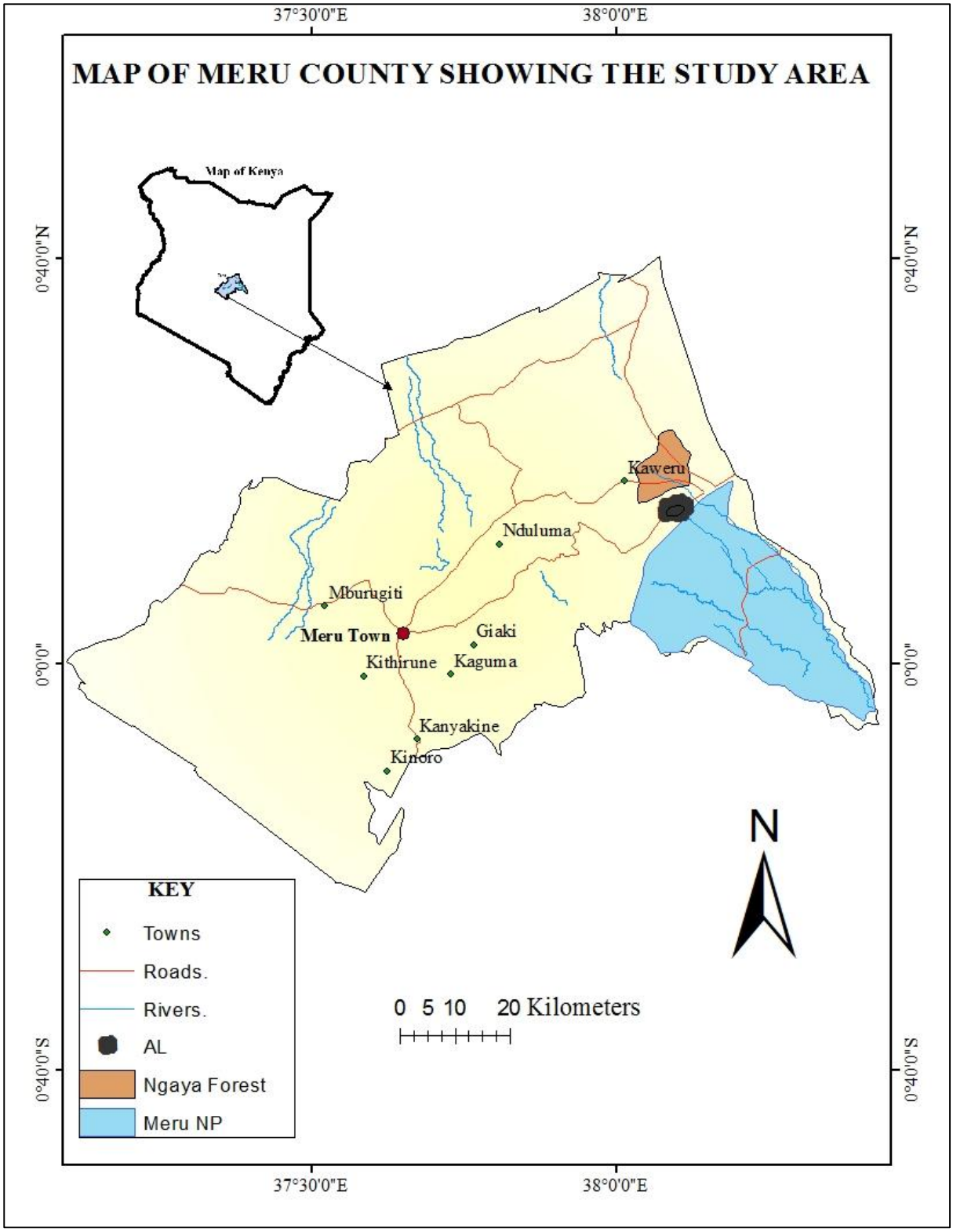

Figure 2: Map of Meru County showing the study area (*source of data, ESRI,2014*)

3.1.3 Population and economic activities in the agricultural landscape

The study area is characterized by high-density population of 195.5 persons/km^2 (Kenya National Bureau Statistics, 2009). Its inhabitants are the Meru people, who are Bantu speakers

and thus practice arable farming. Their population has grown rapidly thus need for more arable and settlement land. Agriculture is one of the major economic activities carried out in the area adjacent to the study sites. However, the kind of crops grown varies depending on the ecological zones which vary in terms of precipitation, temperature and soils. Some of the crops grown near Ngaya Forest include maize, bananas, sorghum, millet, miraa and cassavas. Livestock reared include cattle, sheep, chicken and goats. In the lowland adjacent to MNP the major agricultural activity is livestock rearing where farmers have established ranches that provide the residents with animal products such as milk and meat. One of the crops grown as cash crops in the region is miraa and tobacco. Other cash crops include coffee, tea, sisal, wheat, sugar and pyrethrum.

Miraa growing is one of the major economic activity carried out in the hinterlands and farmers have been growing this crop for many years and the returns generated from the sale of this crop enables them to meet all their financial needs. Other crops that are grown both for domestic and commercial purposes include cotton, maize, beans, millet and Sorghum. Some farmers also practice dairy Farming that has proved to be very lucrative in the area since 1960. Pottery, leatherwork and iron work activities are also carried out by some of the residents of Meru County (Bururia & Nyaga, 2014)

3.2 Research Design

This study employed ecological survey design. Transects measuring 600m long by 100m wide were laid purposively in Meru National Parks, Ngaya Forest and the agricultural landscape, totaling to 19km. The researcher walked through transects and population data was collected at intervals of 100m and where Hinde's Babblers were sighted. Transects were laid parallel to the forest glade with even distance between them. The sampling interval was 100m, which was determined using Global Positioning System (GPS) device. A playback of Hinde's Babbler was played at beginning of transects then after every 100m. GPS readings at the start and the end of transects to determine transect lengths, besides readings were taken at every point where the recorded voice of Hinde's Babbler was played. Hinde's Babbler groups detected outside transects were excluded from the assessment.

3.3 Methods of data collection

3.3.1 The demography and distribution of Hinde's Babbler groups

Hinde's Babbler is highly territorial and aggressively react to playback (Shaw *et al.,* 2001). Taped call recordings of Hinde's Babbler were played at intervals along transects to maximize

detection. The playback recorder was played for 1-2min at intervals of 100m along the transect and then Hinde's Babbler groups observed for 10mins to provide enough time for strugglers and to accurately estimate the group size, if there were young ones, the phenology of the vegetation they were sighted on and the habitat type. Survey in all study sites was conducted between 0600hrs and 1000hrs, and 1600hrs -1800hrs to maximize on detection rate (Shaw *et al.* 2001).

Playback was used at additional locations, mainly adjacent to Meru National Park, that is Murera Springs and Kiruyu farms, agricultural activities were dominant. Individuals were classified as adults or offsprings. For aging purposes the best characteristic that was used is the eye-colour as described in Shaw *et al.* (2001) and Zimmerman *et al*. (1999). Plate 2 shows differences between offspring and adult based on eye colour.

Plate 2: Babbler offspring (left) and Adult (right). ©Peter Njoroge

For estimation of population's size of Hinde's Babbler in the three study sites the ample data was extrapolated to the entire habitat results to determine the population size estimate. Using a modified equation adopted by Davis & Winstead (1980); "*Population estimate = Density (N/km^2)* x *Potential geographical area of occurrence (km^2)*," current population. Density was determined by dividing the total number of babblers (n) sighted by area in square kilometres (a). Hinde's Babbler population density was determined by dividing the total number of Hinde's Babbler/area, as shown in the equation below.

$$P = \left(\frac{n}{a}\right) \times A$$

Where; P = Population estimate of the entire habitat

n = Number of Hinde's Babblers sighted during the survey

a= area surveyed (km^2)

A= Potential geographical area of occurrence (km^2)

3.3.2 Habitat characteristics and correlation with Hinde's Babbler

Habitat characteristics were recorded at points where the Hinde's Babbler play back was played, whether the individuals were encountered or not, as described by Shaw *et al.* (2003). A quadrat of 20x 20m was used to estimate the relative tree, shrub, crop cover and bare while a further 1x1m quadrat used to estimate grass and herbaceous cover near a calling group and at constant intervals of 100m. Within the quadrat, dominant species were identified habitat type based on the composition of the vegetation (Najma, 2012). Quadrat boundaries and habitat dimensions were determined using GPS, while the percentage vegetation cover was done by estimation. Vegetation cover variables associated with Hinde's population were identified as described in Anderson & Willis (2003).

3.3.3 Assessment of habitat threats and disturbances

A quadrant of 20m x 20m was used at sampling points to collect data on threats and habitat disturbances. The intensity and extent of occurrence of all threats and disturbances was relatively determined in percent. The variables included farming, tillage, grazing/overgrazing, firewood collection, and logging, indicators of fire, browsing, vegetation trampling, persecution of birds, hunting, vegetation clearance, and vegetation trampling by animals, presence of animal dung as indicators. For the distribution of Hinde's Babbler groups, waypoints were taken using GPS device during the survey at points of Hinde's Babbler groups detection.

3.4 Data analysis

Table 1: Summary of Data Analysis

Specific Objectives	**Variables**	**Statistical tools**
-To estimate the current population of Hinde's Babbler and compare populations status between protected	• population sizes • Mean group size and densities between sites	-Mann-Whitney U Test

Meru National Park, partially protected Ngaya Forest and unprotected agricultural landscape	• Population composition	-Descriptive statistics (percent, frequencies)
-To assess the influence of vegetation cover type on habitat preferences of Hinde's Babbler in Meru National Park, Ngaya Forest and agricultural landscape.	•Vegetation cover type • Habitat preference	-Spearman Rank Correlation -Kruskal Wallis -Descriptive statistics
-To assess and compare habitat disturbances on Hinde's Babbler population in MNP, partially protected Ngaya Forest and the agricultural Landscape	• Disturbance relationship with Hinde's Babbler • extent of habitat threats in and between study sites	-Descriptive statistics (percent, frequencies) -Spearman Rank Correlation

CHAPTER FOUR

RESULTS

4.1 Current population of Hinde's Babbler at study sites

4.1.1 The demography and distribution of Hinde's Babblers

Data was transformed before analysis was carried out and in situations where it did not meet the threshold for parametric test, non-parametric statistical tools were used for analysis.

Hinde's Babblers were detected at much lower densities at Meru National Park than at Ngaya Forest and agricultural landscape. In terms of mean group size, Ngaya Forest had the highest of 4.7 while the agricultural landscape had the lowest of 3.4 (Table 2). Ngaya Forest Reserve had the highest density of Hinde's Babblers/km surveyed while MNP had the lowest. In terms of offsprings-adult ratio, the highest percent (9.7%) was recorded in the agricultural landscape of Murera Springs and Kiruyu farms while the lowest was in Ngaya Forest (8.5%). The population of adults was more than of the offsprings across at the three sites (Table 2). There was significant statistical difference between the population of adults and offsprings (Mann Whitney U, N=22, P = **0.0001** W=286.5).

Table 2: The composition and density of Hinde's Babbler groups at three sites, Dry season

Site	Transect(km)	Groups	Individuals	Mean group size	Group skm^{-1}	Adults	Offsprings	% offsprings
Ngaya	6.4	10	47	4.7	1.6	43	4	8.5
MNP	8.4	5	23	4.6	0.6	21	2	8.7
AS	4.2	9	31	3.4	2.1	28	3	9.7
Total	**19**	**24**	**101**	**4.2**	**4.3**	**92**	**9**	**-**

In contrast to dry season survey, survey carried out in wet season (October 15 – November 17, 2015) revealed a much high mean group size with 5.2 individuals per group in Ngaya Forest, 4.0 individuals/group at agricultural landscape and 3.9 in Meru National Park. In terms of densities, it was highest in MNP (1 $groupskm^{-1}$) and lowest in the agricultural landscape (0.7 $groupskm^{-1}$), along 19km transects (Table 3). There was significant statistical difference between the population of adults and offsprings (Mann Whitney U, N=22, P = **0.0002**, W=279.0)

Table 3: The composition and density of Hinde's Babbler group at three sites, Wet season

Site	Transect (km)	Groups	Individuals	Mean group size	Group skm^{-1}	Adults	Offsprings	% offsprings
Ngaya	6.4	6	31	5.2	0.9	29	2	6.5

MNP	8.4	8	31	3.9	1.0	28	3	9.7
AS	4.2	3	12	4.0	0.7	12	0	0.0
Total	**19**	**17**	**74**	**4.4**	**2.6**	**69**	**5**	**-**

4.1.2 Hinde's Babbler group dynamics in the three landscapes.

The number of groups and individuals encountered in Ngaya Forest during the wet season decreased by 25% and 20.5% respectively. This was in contrast with the mean group size that increased by 1.1%. Group density also decreased by 25%, adult by 19.4% while offsprings declined by 33.3% (Table 4)

Table 4: The number and density of Hinde's Babbler groups at Ngaya FR

Season	Distance surveyed (km)	Groups	Individuals	Mean group size	Groups km^{-1}	Adults	Offsprings	% offspring
Dry	6.4	10	47	4.7	1.6	43	4	8.5
Wet	6.4	6	31	4.8	0.9	29	2	6.5
%change	-	-25.0	-20.5	+1.1	-25.0	-19.4	-33.3	-

The survey at MNP showed an increase in number of groups (23.1%), individuals (14.8%), groups/km (22.3%), number of adults (14.3%) and offsprings (20%). The only notable decrease was the mean group size by 10.8% (Table 5). In contrast to Ngaya Forest and AS there was a slight increase in the proportion of young birds recorded in Meru National Park.

Table 5: The number and density of Hinde's Babbler groups at MNP

Season	Transect (km)	Groups	Individuals	Mean group size	Group skm^{-1}	Adults	Offsprings	% offsprings
Dry	8.4	5	23	4.6	0.6	21	2	8.7
Wet	8.4	8	31	3.7	1.0	28	3	9.7

%change								-
e		+23.1	+14.8	-10.8		+22.3	+14.3	+20.0

At the agricultural landscape, the density of Hinde's Babbler groups recorded along a 4.2 km of transects surveyed during the wet season decreased by 50%. There was also decrease in all aspects right from number of groups encountered (50%), mean group size (7.9%) and number of adults (40%). No offsprings were encountered during the wet season (Table 6).

Table 6: The number and density of Hinde's Babbler groups at AL

Season	Transect (km)	Groups	Individuals	Mean group size	Groupskm^{-1}	Adults	Offsprings	% offsprings
Dry	4.2	9	31	3.4	2.1	28	3	9.7
Wet	4.2	3	12	2.9	0.7	12	0	0
%change	-	-50	-44.2	-7.9	-50	-40	-100	-

Meru National park had notably high population of Hinde's Babblers on average followed by Ngaya Forest Reserve and lastly the agricultural landscapes. The population of Hinde's Babblers during the survey is estimated to be 476 Hinde's Babblers, with 540 individuals during the dry season and 411 during the wet season. The agricultural landscape had the highest density during the dry season while the Meru National Park and Ngaya Forest Reserve had the joint high density during the wet season (Table 7). There was no significant difference in the population densities of Hinde's Babbler the three study sites during the dry and wet season (Kruskal Wallis P = 0.171 and P = 0.635 respectively).

Table 7: Population of Hinde's Babblers at the three sites in dry and wet season

Landscape	**Dry season**				**Wet season**			
A	Groups/area	Groups	n/a	P	Groups/area	Groups	n/a	P

Ngaya FR	6.93	7.81	55	36.72	255	4.69	33	24.22	168
Meru NP	10	2.98	30	13.69	137	4.76	48	18.45	185
Agric Sites	4	10.71	43	36.9	148	3.57	15	14.29	58
Total	20.93	21.5	128	36.9	540	13.02	96	56.96	411

4.1.3 Spatial distribution of Hinde's Babbler groups at the three sites

Ngaya Forest Reserve had a relatively even distribution of Hinde's Babbler groups during the survey. Most Hinde's Babbler groups were restricted to sites with shrub cover, 97% of the groups sighted on *Lantana camara* thicket. Figure 3 shows sampling points with Hinde's Babbler groups with and without babblers for the dry and wet season.

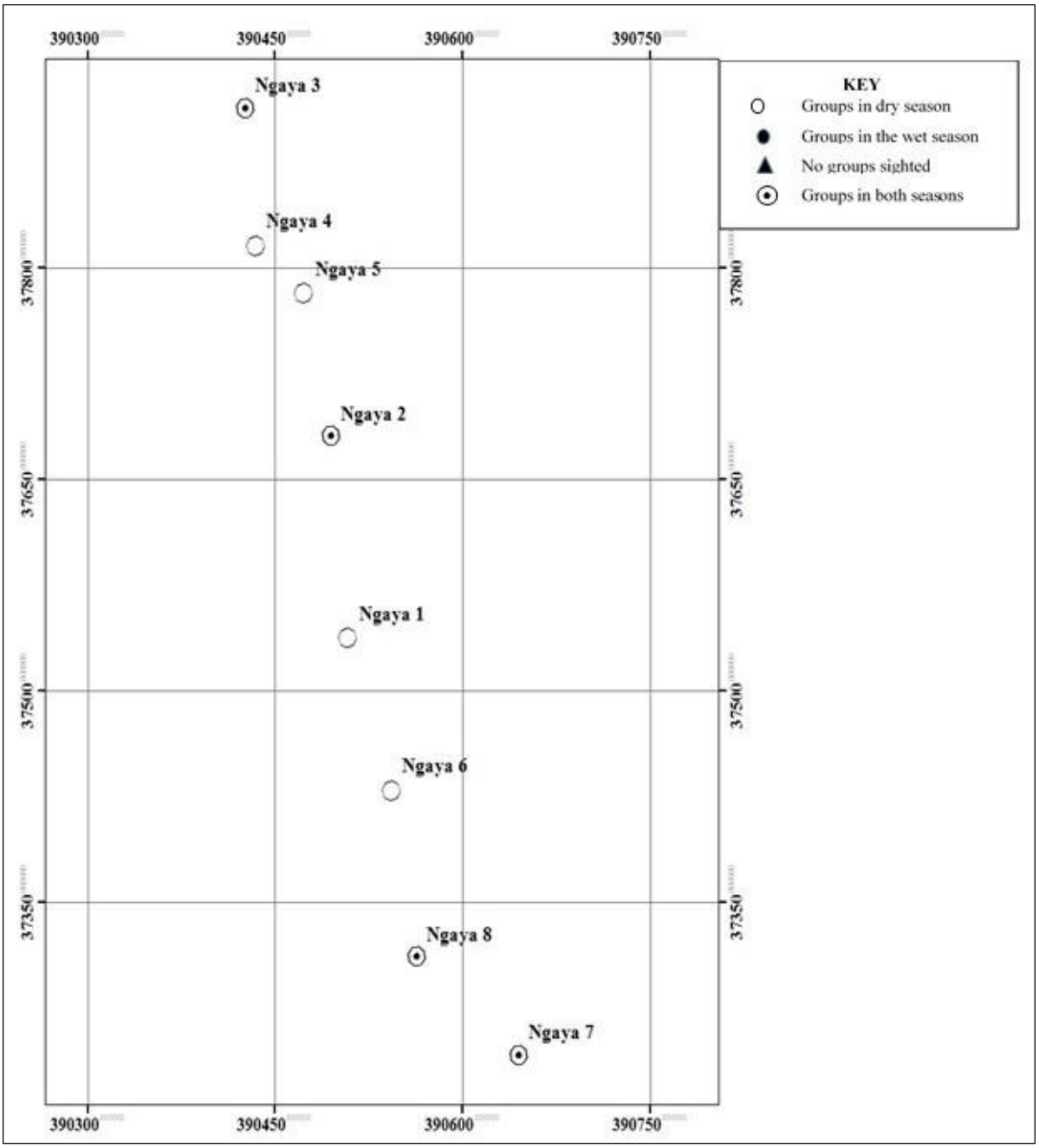

Figure 3: Distribution map of Hinde's Babbler groups, Ngaya Forest Reserve

In MNP, only Rojeweru and Kindani River had groups in both seasons, sites which were relatively close to river valleys which are covered by shrubs. At Kathithi and Prince Camp,

groups were sighted during the dry season only while Pipas Grave, No.37 and Bernard Brown Swamp had groups during the wet season (Figure 4).

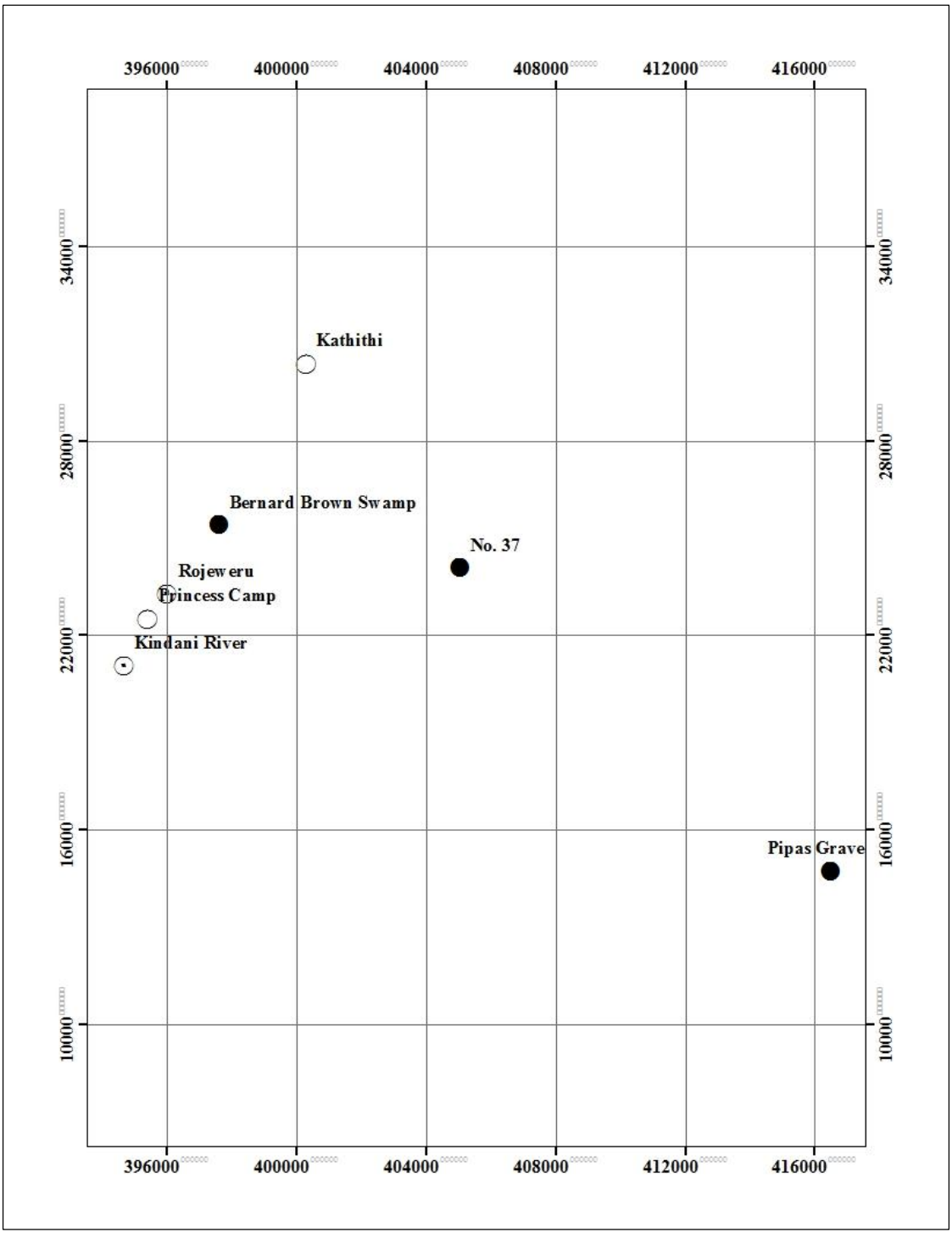

Figure 4: Distribution map of Hinde's Babbler groups, MNP

There was even distribution of groups of Hinde's Babbler in agricultural landscape of Kiruyu and Murera Springs in both seasons. During the dry season, groups were sighted in Kiruyu 3

and Murera Springs 2. Murera Springs 1, 3 and Kiruyu 1 had groups in both seasons while no groups were encountered in Kiruyu 2 and Murera Springs 4 (Figure 5).

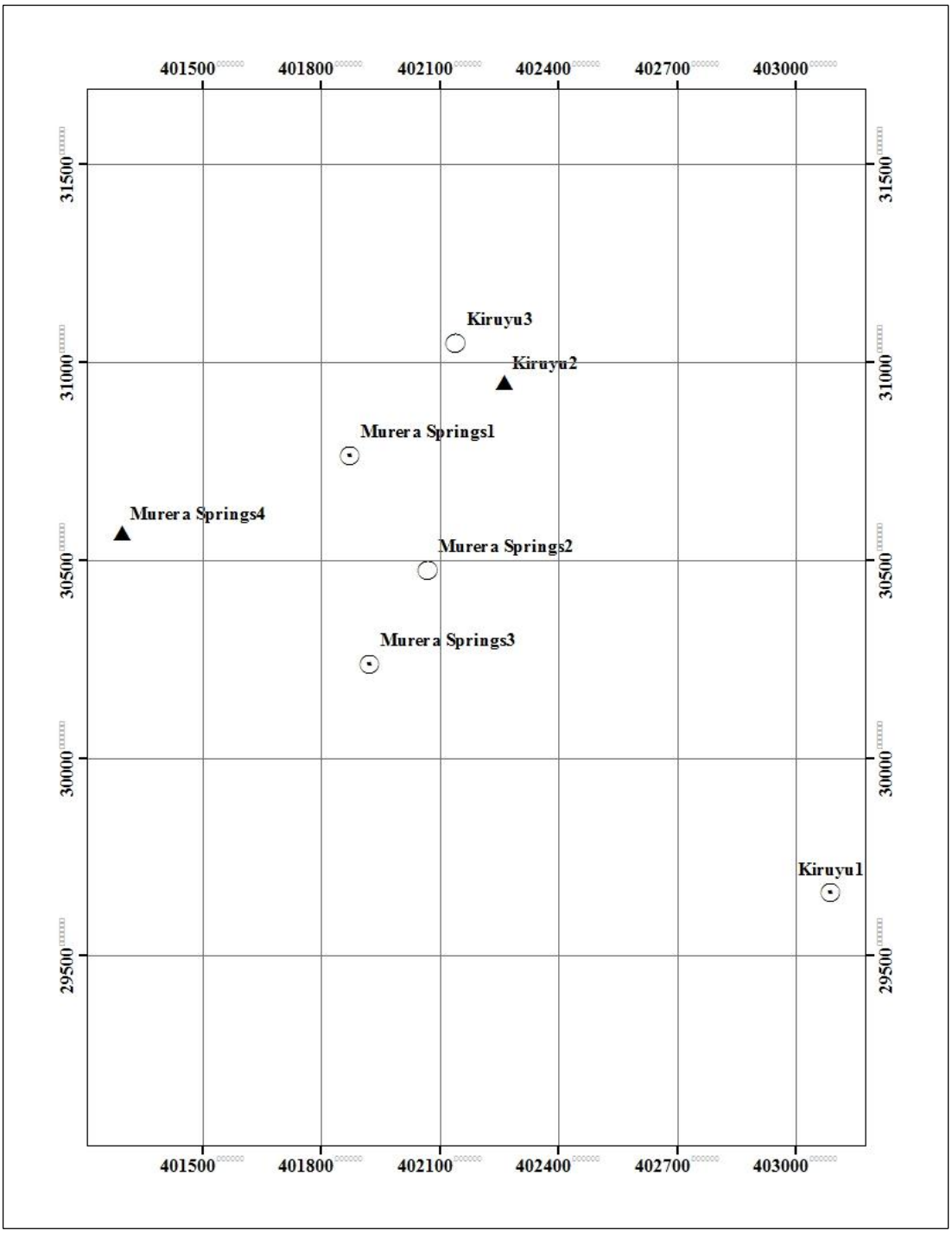

Figure 5: Distribution map of Hinde's Babbler groups, agricultural landscape

4.2 Habitat type and Hinde's Babblers' population status

During the survey, six habitat variables were considered: shrub cover, tree cover, herbaceous cover, grass cover, crop cover and bare landscape. Generally, shrub cover was relatively higher (above 55%) while bare landscape was below 5% (Figure 6). The dominant shrub type was *Lantana camara* (Plate 3). There was significant statistical difference in the percent vegetation cover type at study sites (Kruskal-Wallis test, H = 48.01, d.f. = 5, **P = 0.00).**

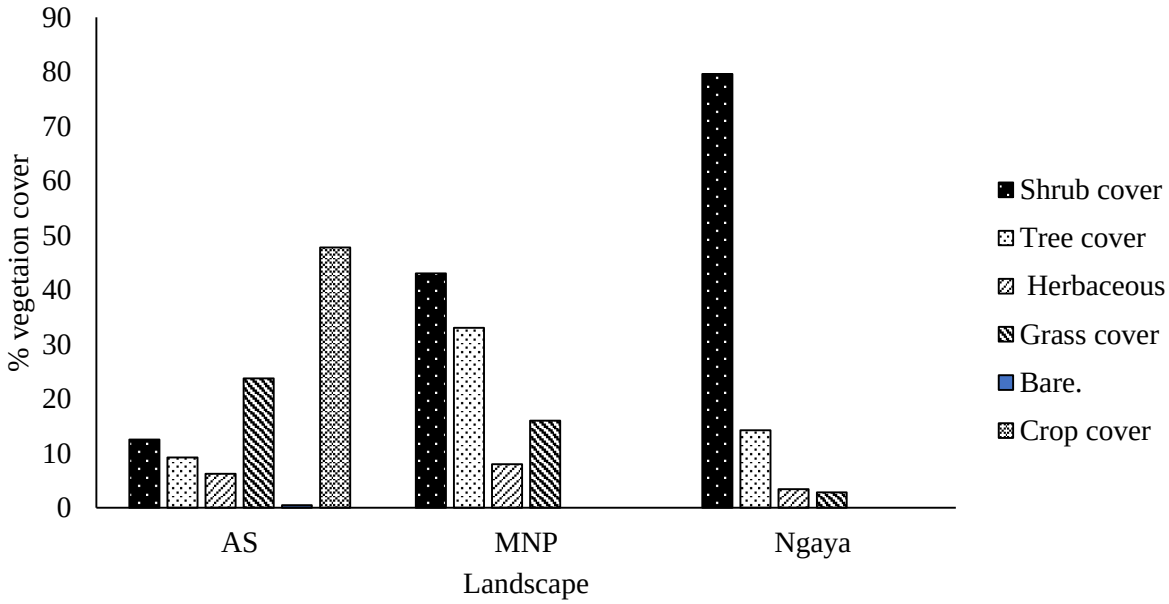

Figure 6: Descriptive statistics, Percentage Vegetation cover

Plate 3: *Lantana camara* thicket around Ngaya Forest Reserve

The ecological survey observation revealed restriction of Hinde's Babbler to certain patches of the habitat with some percent shrub cover. Out of the six habitat variables considered only tree and shrub cover were correlated with Hinde's Babbler group size in both seasons. Shrub cover was positively correlated (dry, r_s = 0.7, P = **0.01**; Wet, r_s = 0.8, P = **0.02**) while tree cover had a negative correlation with mean group size (dry, r_s = - 0.57, P = **0.03;** Wet, r_s = - 0.03, P = **0.05**). Herbaceous and grass cover had negative correlation with Hinde's Babbler group size during the dry season (P=0.00 and P=0.04 respectively) while during wet season there was weak negative correlation. There was no correlation between Hinde's Babbler group size and bare landscapes (Table 8).

Table 8: Habitat attributes correlation with Hinde's Babbler mean group size

Habitat type		Shrub	Tree	Herbaceous	Grass	Bare	Crop
Dry season	Pearson correlation	0.7	-0.57	-0.83	-0.54	0	0.27
	P-Value	0.01	0.03	0.00	0.04	0.8	0.35
Wet season	Pearson correlation	0.8	-0.03	-0.327	-0.19	0	0.27
	P-Value	0.02	0.05	0.137	0.391	0.90	0.35

In Ngaya Forest Reserve shrub cover was positively correlated with the mean group size with a cover of more 60% having a mean group size of 4.7, thus an increase in shrub cover resulted in an increase in mean group size of Hinde's Babbler. Tree and grass cover had a negative correlation with mean group size, an increase in percentage cover of these variables means a decrease in mean group size of Hinde's Babbler (Figure 7).

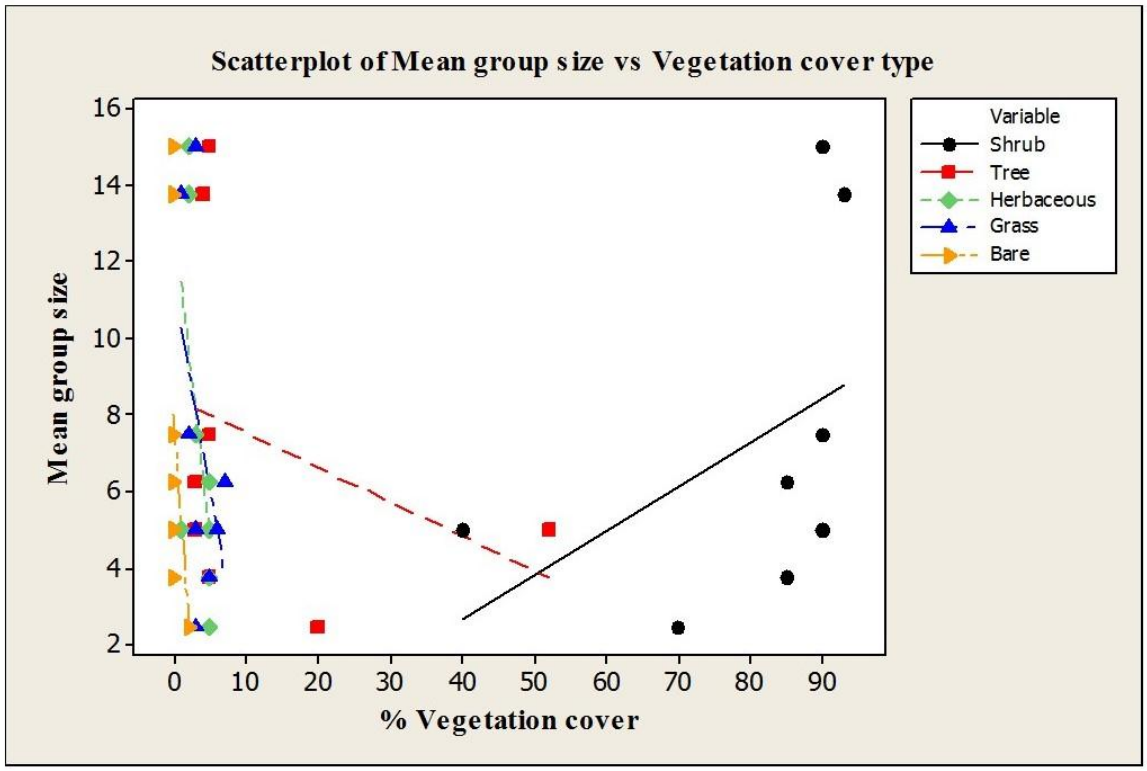

Figure 7: Mean group size vs %vegetation cover type, Ngaya Forest Reserve

In MNP, babbler groups avoid the vast savannah grasslands and most groups were sighted in shrubs along river valleys. Generally, there was a positive correlation with shrub cover (Figure 8). An increase in shrub cover and herbaceous cover resulted in increase in the mean group size of babblers while the opposite was true for tree, bare and grass cover.

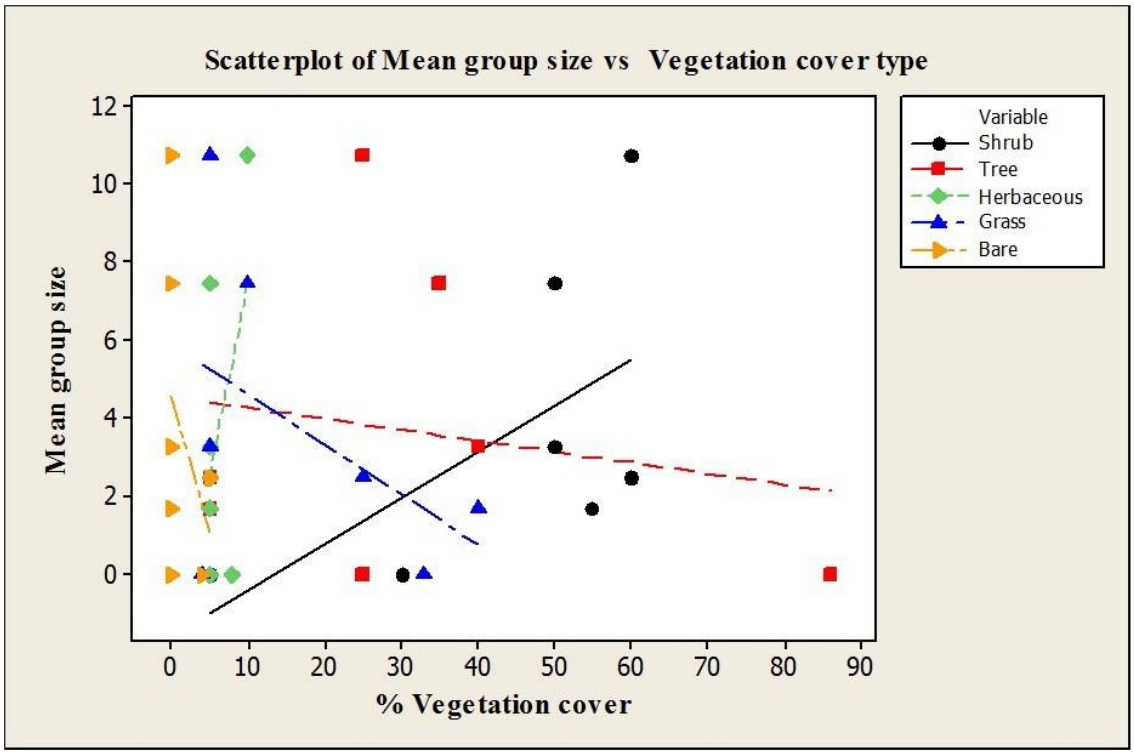

Figure 8: Mean group size vs %vegetation cover type, MNP

The agricultural landscape of Murera Springs and Kiruyu had a higher crop cover (60%) and low shrub cover (10%) at the edges of the farms, close to river valleys. An increase in shrub

cover, bare and crop resulted in an increase in mean group size. Grass, herbaceous and tree cover had a negative correlation in mean group size (Figure 9).

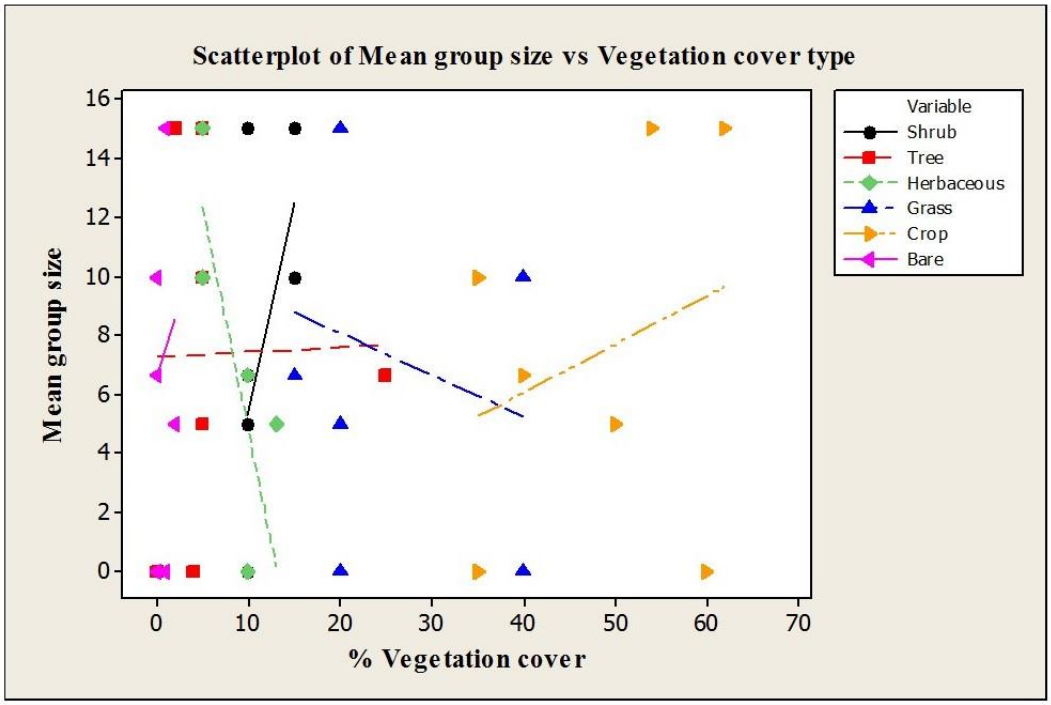

Figure 9: Mean group size vs %vegetation cover type, AL

4.3 Disturbances to habitat and Hinde's Babbler

The increasing human population and intense farming within Hinde's Babbler range has affected its population and habitat. During the survey farming and vegetation clearance was highest while vegetation trampling by animals was the lowest across all sites. Different habitat disturbances exhibited either positive or negative association with population of the Hinde's Babbler species. Out of the seven disturbances recorded during the survey, only use of pesticide had significant negative relationship on the Hinde's Babbler population (Table 9).

Table 9: Threats and disturbance correlation with Hinde's Babbler mean group size

Disturbance and threat variables		**Fire**	**Wood Fuel**	**Vegetation clearance**	**Farming**	**Overgrazing**	**Vegetation tramplin g**	**Pesticide use**
Dry season	Pearson correlation	0.15	0.26	-0.09	-0.08	-0.14	-0.34	-0.25
	P-Value	0.51	0.24	0.69	0.72	0.53	0.12	0.27
Wet season	Pearson correlation	0.24	-0.23	-0.34	-0.17	0.32	0.07	-0.26
	P-Value	0.28	0.31	0.12	0.45	0.15	0.77	**0.03**

Farming in the Kiruyu farms and Murera Springs was carried out during the dry season along the river riparian zone (Plate 4). The area is generally flat and prone to flooding and was thus abandoned during the wet season as most farms were submerged.

Plate 4: Kiruyu farms, cultivation that might pose a threat to Hinde's Babbler habitats

There was an increase in the mean group size of Hinde's Babbler with increase in grazing pressure along the Ngaya Forest Reserve edges that is invaded by *Lantana camara*. Unlike grazing, an increase in the extent of fire, firewood collection and vegetation clearance has resulted in a decline the mean group size of babblers (Figure 10).

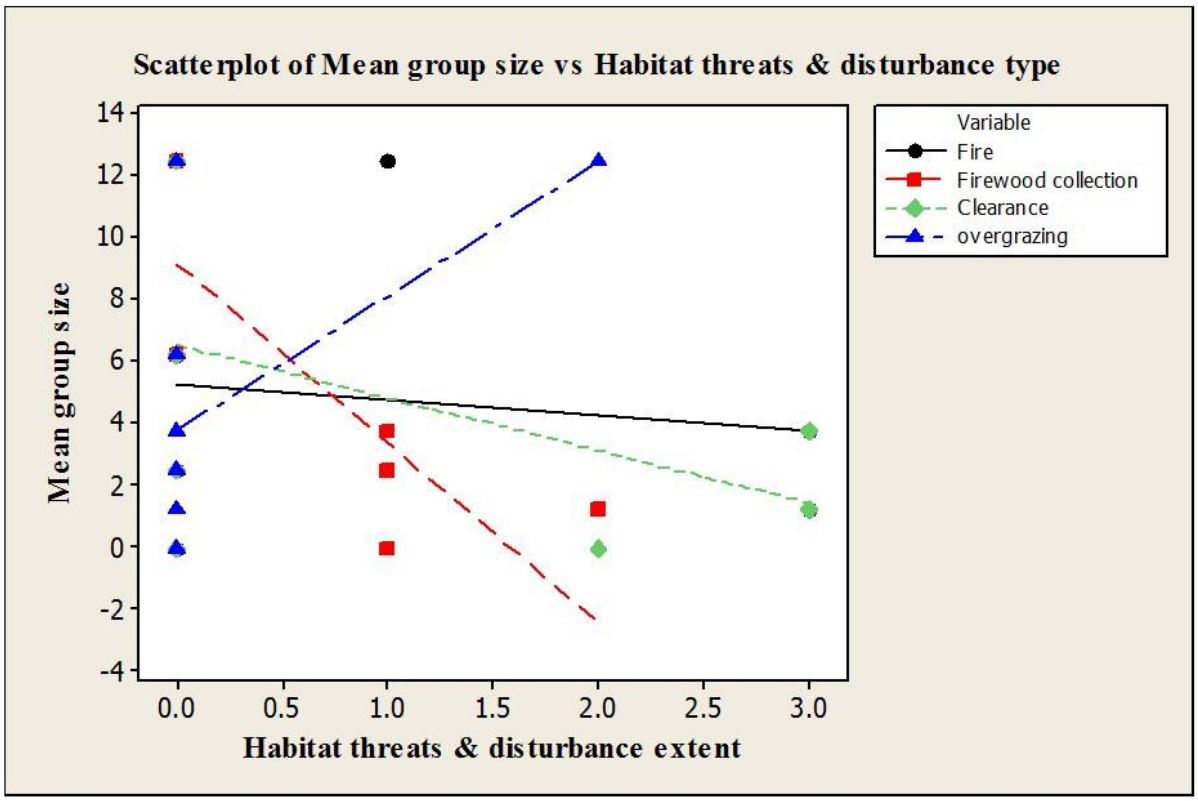

Figure 10: Mean group size vs disturbance relationship, Ngaya Forest Reserve

There was an increase in mean group size of Hinde's Babbler with increase in browsing and defoliation by herbivore during the wet season. Increase in the extent of vegetation trampling by elephants, rhinos and other mammals results in a decrease in the mean group size of Hinde's Babblers. Notably, vegetation trampling had a negative correlation (rs =0.57, P = 0.03) with mean group size (Figure 11).

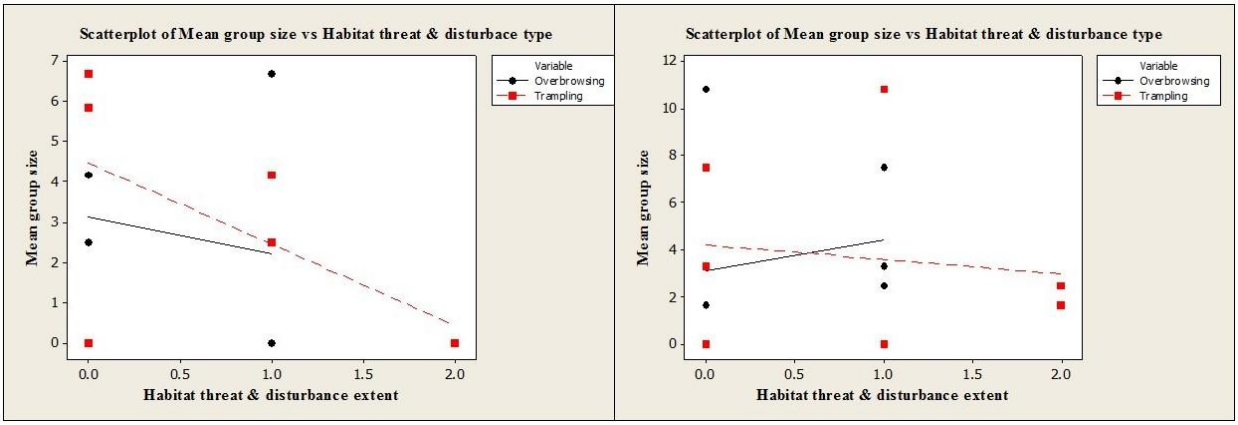

Figure 11: Mean group size vs disturbance relation dry (left) and wet season (right), MNP

The mean group size of Hinde's Babbler decreased with increase in the extent of vegetation clearance, farming, fuel wood collection and overgrazing. Only extend of fire and charcoal burning increase resulted in increase in the mean group size of Hinde's Babbler (Figure 12).

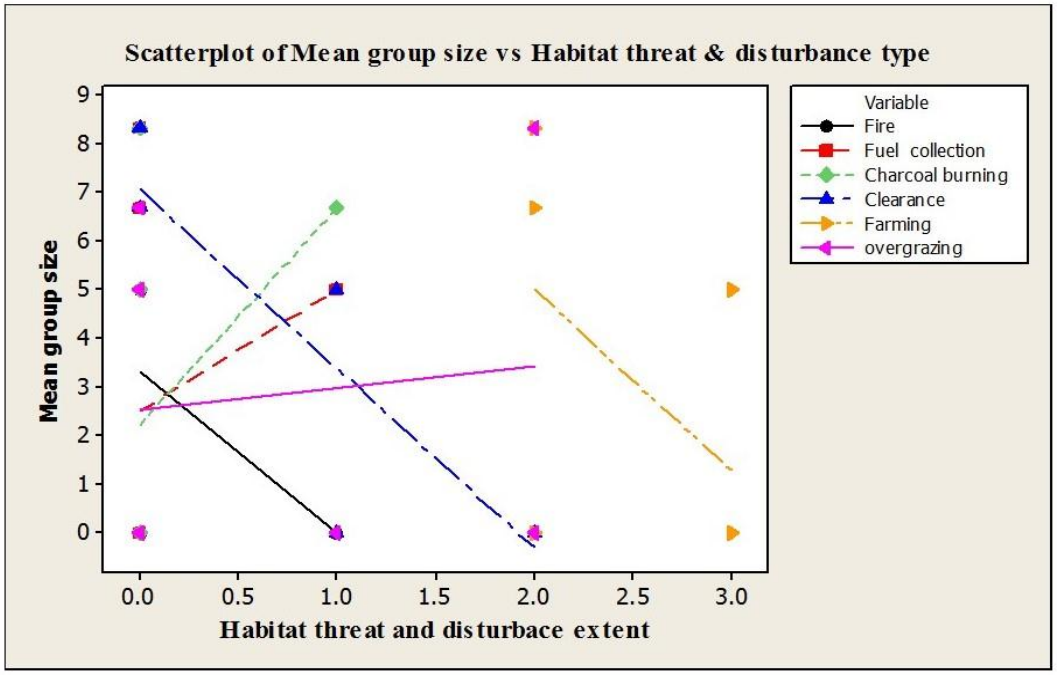

Figure 12: Hinde's Babbler mean group size vs disturbance relation, AL

CHAPTER FIVE

DISCUSSION

5.1 Population and Distribution of Hinde's Babbler

In most sampling sites, Hinde's Babbler were sighted in groups. Notably, there was distinct variation in mean group sizes across the three landscapes with Ngaya Forest Reserve recording the highest of 4.7 while the agricultural landscape of Murera Springs and Kiruyu had the lowest of 3.0 during the dry season. The mean group size was much higher in Ngaya Forest (5.2), agricultural landscape (4.0) and Meru National Park (3.9) during the wet season. This attributed to the fact that Hinde's Babbler is known to breed in the period from March to May and September to October, coinciding with the main periods of rainfall (Shaw & Musina, 2003). Basing argument on this assertion, the higher mean group sizes during the wet season might be due to recruitment of more individuals through breeding. This is a signal of success in breeding

from the previous years or reduction in territorial behaviour leading to formation of bigger groups. The assumption might not hold with the low offsprings ratio in both seasons, thus non-breeders might have joined the breeding pair and delayed their breeding resulting in high mean group sizes during the wet season. These findings compare favorably with the findings of Shaw and Musina, (2003) who reported that Hinde's Babblers are group territorial birds often sighted in groups of 2- 4 individuals though the number of individuals in groups may vary depending on a number of factors.

Hinde's Babbler groups are comprised of adults, immatures, fledglings and nestlings (Shaw & Musina, 2003). The ratio of adults to offsprings reflect the future trends and conservation status. Results from the survey indicated that agricultural landscape had high adults to offsprings ratio during the dry season compared to the other two sites. In support of this findings, Mulwa *et al.* (2013) found that agricultural landscapes have high productivity in terms of insectivores all year around, thus ensuring adequate forage materials for species. The onset of rains makes all sites productive in forage resources and birds will prefer sites as proxy of protection. Thus, Ngaya Forest Reserve recorded highest offspring ratio compared to the other two sites. The fact that productivity was almost uniform during the wet season, babbler might have preferred the Ngaya Forest Reserve for breeding and foraging due to its *Lantana camara* cover. Generally, there were more offsprings during the dry season than the preceding wet season.

The agricultural landscape had a relative high population density of Hinde's Babbler during the dry season and lowest during the wet season. Availability of resources greatly impact on the number of organisms in a defined area (Scales & Marsden, 2008). Regardless of the level of protection, the resources and fitness of organism influences the population densities. Mulwa *et al*. (2012) reported similar results despite a remarkable drop in vegetation structural diversity from forest to farmland, bird density in western Kenya were on average higher in farmland than in forest habitats. This is due to the fact that crop cover in area adjacent to MNP is grown throughout the year. In contrast to Meru National Park which is characterized by vast savannah grassland and sparse shrub that are constantly under disturbance from browsers. Plumb (1979), reported that vast savannah grasslands were avoided by Hinde's Babbler groups as they do not provide the protection and nesting sites. Thus, agricultural landscape and Ngaya Forest Reserve served as a better home to Hinde's Babbler during the dry season due to their ability to support high biomass unlike the Meru National Park.

Seasonal variations have a profound effect on the species' demographics, due to their impacts on resource availability. Onset of a dry season influence reduction of vegetation biomass and thereby reduction of forage resources. This impact on population of species thereafter or immediately. The population of Hinde's Babblers declined by 18.3% during the wet season, this might have been affected by breeding that is known to occur between March to May and September to October, coinciding with the main periods of rainfall (Shaw & Musina, 2003). Based on the breeding facts, breeding pairs might have relocated to vacant territories with better resources. In studies conducted elsewhere, (Njoroge & Mutinda, 1996) they found out that individuals tending to nest (incubating) or hatchlings might not respond to playback. These individuals might have been overlooked during the wet season survey and resulted in low count than dry season. Another factor that might have contributed to the low count was regrowth of the vegetation and flooding of the river valleys. Despite the variation, there was no significant difference in seasonal population densities variation between the landscapes. Mulwa *et al*., (2013) recorded similar results that bird communities are susceptible to seasonal variation due to resource availability and they may tend to change their activities and locality to cope to the situation besides the asynchronous between forest and farmland habitats providing potential for a cross-habitat rescue effect in times of food shortages.

The estimated population of Hinde's Babbler in Ngaya Forest Reserve and MNP is much higher compared to AS. In other studies, elsewhere, Koleček *et al.,* (2014) found out that birds protected by national legislation show improved population trends in Eastern Europe. Thus, protected areas play a crucial role in biodiversity conservation as they are uniquely placed to protect endangered species (Barnes *et al*., 2014). They are home to all species and thus provide an elaborate interaction and inter-dependence among the species (BirdLife International, 2014a). They should remain as a refuge and centerpiece of conservation efforts in the tropics which are under intense threat from anthropogenic activities (Greve *et al*., 2014). Ngaya forest which remained largely unsurveyed and unknown to support Hinde's Babbler provided substantial groups (Shaw *et al*., 2001). The survey results showed that this site had great potential for conservation of the globally threatened Hinde's Babbler. For instance, this site had a mean highest mean group sizes of 4.7 and 5.2 during the dry and wet season respectively. This mean group size was much higher than that recorded in Kianyaga but close to the means recorded in Machakos and Mukurwe-ini (Shaw *et al*., 2013). The average mean group size for the protected landscapes of MNP and Ngaya Forest Reserves emphasizes the significance of these sites in conservation of globally endangered avifauna. Despite the fact that protection is

crucial for species, agricultural landscapes continue to demonstrate great ability to conservation of biodiversity (Jackson & Hobbs, 2009). This is evident from the substantial numbers of Hinde's Babbler groups that were sighted during the survey and thus should not be overlooked. Didham *et al*. (2007) reported similar results that agricultural landscapes have great ability of supporting species due to their adequate vegetation biomass throughout the year.

Hinde's Babbler groups were restricted to shrub vegetation cover in the three landscapes. This concurs with studies by Collar *et al*. (2016) which found out that Hinde's Babbler groups were restricted to *Lantana camara* thickets. There was variation on the percent shrub cover frequently used by groups in the three landscapes. In MNP, groups were restricted to riverine thickets and some *Lantana camara* thickets along the fenceline while in Ngaya Forest Reserve they were encountered in a stretch of *Lantana camara*. In contrast, in the agricultural landscape Hinde's Babbler groups were restricted to thickets at the edges of farms and along the river riparian zone with some thicket cover. These areas experienced little disturbance probably due to their inaccessibility and thereby less disturbance from animals and human beings (Kamiti, 2003). Though, most groups were encountered along river valleys in MNP and agricultural landscape, their occurrence in Ngaya Forest Reserve suggest that they are not dependent on water. The distribution of Hinde's Babbler groups in Ngaya Forest Reserve seemed to follow the distribution of *Lantana camara*. Similar results were recorded by Shaw *et al.* (2014) when assessing the range and habitat of Hinde's Babbler in relation to temporal variation in scrub cover.

In the intensively cultivated areas babblers were missing or the group sizes were low suggesting that shrub cover was crucial in their distribution. Studies in avifauna clearly show that territory quality influences dispersal decisions (Chalfoun & Martin, 2007), thus potential helpers are likely to disperse to vacant habitats. High quality habitats are rich in resources this make it costly and difficult to defend, thus non-breeders are expected to remain within the territory and help the breeding pairs (Plumb, 1979). The high mean group size in Ngaya Forest Reserve with low offspring percentage might be due to the high number of helpers within the territory. Ngaya Forest Reserve had shrub cover of more 70% along its edges, which seemed to had a close association with babblers. Terorde & Turpie (2013) reported the same results that habitat structure and other related dynamics like resources influences the population and distribution of avifauna. High quality habitat increases the fitness of breeders allowing non-breeders to remain within the territory regardless of their roles. Besides, the site was boosted with foraging

resources like insects due to its humid condition hence could support high densities of Hinde's Babbler.

5.2 Habitat type and Hinde's Babblers' population status

Most organisms select habitats that are suitable and attractive for their survival and secure from potential threats (Doligez *et al.*, 2008). The quality of the habitat determines the ultimate fitness of a species as it impacts on resources such as food, cover, space, breeding and roosting site crucial in the various stages of a species' survival, growth and development (Heikkinen *et al*., 2004). Hinde's Babblers have been linked to thicket cover that offers protection probably from competitors, predators and enemies (Njoroge *et al*., 1998). During the survey carried out on habitat use by Hinde's Babblers revealed varied relationship with six habitat variables tested. The six vegetation cover types considered were shrub cover, tree cover, herbaceous cover, grass cover, bare and crop cover.

During the survey groups of Hinde's Babblers were found to have an association with vegetation cover in the three study sites. Among the six variables assessed, only shrub cover had a positive correlation with the mean group size in both seasons which was consistent results in other studies elsewhere (Shaw & Musina, 2001). For instance, Ngaya forest sampling points had the highest mean group size with most groups sighted in the shrub vegetation. Studies by Shaw *et al.* (2013) indicated that a slight thicket cover of <3% was positively associated with Hinde's Babbler groups. This was clearly exhibited by number of Hinde's Babbler encountered in Ngaya Forest Reserve whose forest edge was encroached and subsequently colonized with a thicket of *Lantana camara*. The status of habitat is important in conservation of avifauna species, especially for protection of young ones (Shaw *et al.*, 2003). Some species have preference for certain habitat cover types which tend to improve their fitness and enhance their survival chances. Thus, habitat cover type determines to some extend species occurrence and occupancy of certain areas. Besides, other indirect factors like level of protection play a crucial role in determining the status and condition of habitat type which in turn impact on population and occurrence of species.

The association of mean group size and habitat types varied across the study sites, though the association of some variables was consistent. Unlike in Ngaya Forest Reserve and MNP, tree cover was positively correlated with mean group cover in the agricultural landscape. This illustrates the significance of tree cover to babblers as they tend to seek refuge on trees in human dominated environments. Njoroge *et al.*, (1998) reported that human dominated

environments play a crucial role in conservation of Hinde's Babbler. Besides tree cover, crop cover too had positive correlation with Hinde's Babbler population. The dominance of the crop and tree cover in farms prompt avian species to readapt to the immediate environment for survival and protection (Cox *et al*. (2014). Hinde's Babblers were often sighted flying to the trees adjacent to shrubs when playback was played. Cox *et al*. (2014) found out that grasshopper sparrow and dickcissel densities were influenced by grassland type, with higher densities in parcels dominated by warm-season grasses. Species-specific changes in density in response to planting diversity reinforced the value of creating heterogeneous habitat for grassland birds. Thus, the presence of the heterogeneous crop cover might have impacted on the mean group size, their presence and absence.

The possibility that sites with higher population density of Hinde's Babbler are of higher quality was supported by the finding that such sites had higher mean group sizes too. Chalfoun, & Martin (2007), reported the same results to that sites with higher quality in terms of food availability will have higher population density. Thus, habitat preferences depend on metrics that increases the species' fitness (Teucher *et al*., 2015). Sites with shrub cover had densities of Hinde's Babblers and mean group sizes. These results are consistent with other studies on the habitat preferences which show that the population density and breeding success of Hinde's Babbler decrease with decrease in thicket cover (Njoroge *et al.,*1998). Teucher *et al*. (2015), found out that more than 97% of the babbler groups encountered during their survey were in sites with *Lantana camara* cover. Similar results were established during the survey, with most groups restricted to *Lantana camara* thicket.

Despite the fact that Hinde's Babbler seemed to prefer thickets, they spent more time in small than in large patches. This is in contrast to other studies that indicated a higher risk of predation for bird species in small patches than those in large patches (Castellon & Sieving, 2006). Large Hinde's Babbler groups are no better at securing and defending large territories unlike most species (Shaw *et al.*, 2013; Plumb, 1979). The survey revealed that Hinde's Babbler defended small space in areas with plenty of resources compared to those with less resources. This was in line with Teucher *et al*. (2015) findings that Hinde's Babbler groups spent significantly longer period in small habitat patches than in large habitat patches. This was supported further as groups of more than four individuals were sighted in close proximity a long river valleys and areas rich in shrub cover. The fact that a number of Hinde's Babbler groups were sighted in proximity meant that they are easy target of threats.

Hinde's Babblers occurred in contrasting habitats but with some percentage of shrub cover that is in the farmlands, river valleys and the encroached forest edges. The encroached and cleared area were subsequently invaded by *Lantana camara*, thus offered habitat and forage ground for Hinde's Babblers. Most Hinde's Babbler groups were sighted in the thickets illustrating their preference for this vegetation cover type. River valleys are protected by law as they form part of the riparian zone, thus they have sparse human population. Consequently, they offer greater scope for conservation based on statutory protection of riparian zones outside protected sites (Shaw *et.al.*, 2001). A number of Hinde's babbler were sighted along river valleys with thicket cover, both in Meru National Park and agricultural landscapes. A key observation was that despite the dense population around Ngaya Forest Reserve and Meru National Park, authorities were keen to protect the riparian zones. Thus, they offered refuge to babblers in a seriously fragmented environment.

At Meru National Park, Hinde's Babblers were absent from extensive areas of bushed and wooded grassland, which, during the dry season, probably supports a lower biomass than riverine vegetation. These findings are similar to those by Plumb (1979), which showed the species' apparent disappearance from a third semi-arid site of Ol Doinyo Sapuk National Park suggest that protected areas of savannah and dry woodland are unlikely to safeguard significant populations of Hinde's Babbler. The relative importance of the riverine vegetation for Hinde's Babbler conservation and emphasizes risk of the babblers becoming isolated if riverine vegetation outside of the protected area is cleared. There was a marked contrast in the distribution of babbler groups in Meru National Park during the two seasons. More groups were sighted during the wet season compared to the dry season elucidating the significance of change in the land cover in relation to distribution of babbler groups. Mulwa *et al*. (2013) reported that seasonal fluctuations of resource abundance affect avian feeding behaviour and in return their distribution on space.

In the agricultural landscape, Hinde's Babbler groups were sighted at the periphery of the farms on thickets and fences. Three groups were sighted in this landscape near the river valleys in both seasons. In Murera springs two groups of between 2-4 individuals were sighted on Acacia and Lantana thicket near a raffia stand. Larger groups might then be better placed to retain or extend their territories (Shaw *et al.*, 2014). In Hinde's Babblers, however, larger groups appeared to be no more successful at securing larger or better quality territories. In most cases two large groups adjacent to each other, clearly suggesting that they are poor at securing better,

large and optimum habitats. This is comparison with other bird species that secure and defend large and attractive habitats.

5.3 Effects of Habitat Disturbances and Threats on Hinde's Babbler.

Rapid human population increase has necessitated the need for more land for agriculture and settlement thus leading to encroachment of forest and marginal lands. This poses a great danger to threatened species as their habitat is encroached and fragmented (Soderstrom *et al.,* 2003). Anthropogenic activities such vegetation clearance, farming and charcoal burning cause great disturbance to avifauna and their social organization. During the survey for instance, farming and vegetation clearance ranked the highest in terms of disturbance to Hinde's Babbler habitat. Shaw *et al*. (2014) reported the same results that habitat disturbance negatively impacted on the occurrence of Hinde's Babbler groups. There was sudden drop in number of groups Ngaya Forest Reserve during the wet season due to vegetation clearance and incidences of fire. Pickett *et al.* (2013) reported that disturbance to habitat had a negative effect of the patch size of avian species.

According to Newbold *et al.* (2013) land use intensity has substantial effect of avian species. This was evident during the survey with babbler groups avoiding intensely cleared and burnt sites in preference of sites with vegetation cover. There were few groups in disturbed sites compared to the adjacent intact sampling points. Vegetation clearance exposes Hinde's Babblers that prefer thicket cover atleast ≥ 3% protection and breeding (Shaw *et al.,* 2003). Incidences of fire were recorded during the wet season in some sampling sites which corresponded to the decline of number of groups and ultimate number of individuals. According to Fahrig (2003), avian species with small range sizes have been shown to be more sensitive to habitat fragmentation than more wide-ranging species. Hinde's Babbler is more susceptible to habitat disturbance and threat bearing mind that it is thought to be more sedentary (Shaw *et al.,* 2001). An increase in disturbance and threat extent have a negative impact on species' distribution on space (Kinnaird *et al.* 2012). Sampling points whose vegetation cover was cleared and burnt were avoided by babbler groups resulting in population decline during the wet season.

Landscape effects are important determinants of biodiversity in human-dominated agro-ecosystems (Tscharntke *et al.* 2008). This is likely to be true of birds, given their high mobility of avian species within space and time in search for suitable habitats. The presence of thicket at the edge of farms was associated with increase of Hinde's Babbler groups. Thus retaining of

thicket cover in human-dominated environments has been shown to increase the number of Hinde's Babbler in farms (Shaw *et al.,* 2013). According to Fordham & Brook (2010) avian species that are endemic and threatened with extinction are affected by habitat disturbance and threats. In this survey, only vegetation trampling was negatively correlated with mean group size of Hinde's Babbler while the rest of the parameters were not correlated with mean group size. The magnitude of threats and disturbances varied across the sites of survey, subsequently affected the population status. Buchanan *et al*. (2009) reported same results that land cover changes threaten avian population status. For instance, vegetation trampling was dominant in MNP while vegetation clearance was prominent in the unprotected agricultural landscape and all resulted in negative relationship with population status.

The highest number of Hinde's Babbler were found in Ngaya Forest Reserve, which is partially protected, while the least number of groups were sighted in Meru National Park. Hinde's Babbler explicted a unique behaviour in relation to habitat selection. The babbler groups preferred the *Lantana camara* thicket within the encroached parts of the forest and nearby farms (Shaw *et al.,* 2003). This was probably due to the high thicket cover around Ngaya Forest Reserve which offered protection, foraging and nesting sites for most groups. The riparian zone and fallow sections within the farmlands were colonized by *Lantana camara*. As human population increases and demand for settlement and arable lands, wildlife habitats are degraded and fragmented. Bhagwat *et al.* (2008) found out that riparian zones and practice agrofoesstry offered additional ground for avian species within a severely fragmented habitat. Protected sites are designated by law for conservation and preservation of wildlife species and offer refuge from uncertainities that wildlife face due to habitat disturbance and fragmentation (BirdLife International, 2014a).

The future of threatened avian species will rely on effective management of agricultural landscape and protected sites, for instance forests and grasslands (Cox *et al*., 2014). Surveys carried out at Meru National Park, Ngaya Forest Reserve and agricultural landscape demonstrated that some endangered species can occur at both sites thus demonstrating their importance in conservation of species. Sampling points in the Ngaya Forest Reserve had extremely high population of Hinde's Babblers relative to the other surveyed sites. This forest reserve has been encroached and subsequent invaded by *Lantana camara,* that had a positive association with Hinde's Babbler occurrence. Forest disturbance in this case seemed to have a positive relationship in supporting Hinde's Babbler. Other notable disturbances included the

vegetation trampling that affected the occurrence of babblers within the Meru National Park and farming activities that impacted negatively on the babbler population status.

Nonetheless, Hinde's Babbler seems to have readapted to the human dominated environment and altered land uses that dominate its habitat across all sites. Similar results reported by Balmford *et al.*, (2005), pointed out that species will adapt and use spared land. For instance, the modified habitats of Ngaya Forest Reserve recorded relatively a large number of babbler groups. Hinde's Babblers' great ability to adapt to habitat change may increase its survival rate especially the exotic *Lantana camara*. Biber (2002) and Hegazy *et al* (2010), reported the same results that avian species have great ability to adapt and co-exist in human dominated and modified environments. The groups formed a close association with environments disturbed by humans, co-existing in places with crop cover.

For sustainable conservation of endangered avian species both the unprotected and protected site should maintain a complex vegetation structure and cover (Hegazy *et al*., 2010). This is crucial in sustaining a number of endangered species. This is particularly relevant for Hinde's Babbler that rely on shrub or thicket vegetation for its habitat. Human modified habitats will be increasingly required to provide some refuge as some protected site have reduced biomass that support these species (Lens *et al.,* 2002). Invasion of species in degraded IBAs has been critical in reclaiming them for conservation of threatened avian species that quickly readapt (Buchanan *et al.,* 2009). This is true in the case of Hinde's Babbler which has adapted to *Lantana camara* thickets.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

- Protection by legislation is significant for conservation of threatened avian species as there were more Hinde's Babbler groups in Ngaya Forest Reserve and MNP compared to agricultural landscape.
- Seasonal changes affect the population of Hinde's Babblers, more individuals were encountered during the dry season compared to that sighted in the wet season.
- The distribution of Hinde's Babbler groups is determined by the spatial distribution of thicket especially *Lantana camara* in encroached areas.
- Hinde's Babbler population and vegetation cover indicated that only shrub cover had a positive strong correlation. There was no correlation of bare landscape while tree, forbs and grass cover showed negative association with Hinde's Babbler population.
- Population of Hinde's Babbler declines with increase is some form of disturbances like use of pesticides.

6.2 Recommendations

6.2.1. Recommendations for conservation and management of Hinde's Babbler population

- Conservation of Hinde's Babbler in Ngaya Forest by maintaining the thicket ring around, at the edge of farms and along rivers in MNP.

- Curbing forest encroachment and involvement of the locals in decision making about conservation of avian species.

6.2.2. Recommendations for Further Research

- Monitoring studies to check on the population response to conservation and habitat change to Hinde's Babbler habitat.

REFERENCES

Aikman, H., Davis, A., Miskelly, C., O'Connor, S. & Taylor, G. (2001). Chatham Islands threatened birds: recovery and management plans. Wellington, New Zealand: Department of Conservation.

Anderson, M.J. & Willis, T.J. (2003). Canonical analysis of principal coordinates: a useful method of constrained ordination for ecology. *Ecology* 84:511–525.

Anon (2009). Endangered Seychelles Magpie-robin relocation brings hope for the species survival. Available at: http://www.wildlifeextra.com/go/news/magpie-robin.html.

Balmford, A., Green, R. E. & Scharlemann, J.P.W. (2005). Sparing land for nature: Exploring the potential impacts of changes in agricultural yield on the area needed for crop production. *Global Change Biology*, 11, 1594–1605.

Barnes, M., Szabo, J.K., Morris, W.K. & Possingham, H. (2014). Evaluating protected area effectiveness using bird lists in the Australian Wet Tropics. *Diversity and Distributions*.

Bellingeri, M., Cassi, D. & Vincenzi, S., (2013). Increasing the extinction risk of highly connected species causes a sharp robust-to-fragile transition in empirical food webs. Ecological Modelling, 251(0), 1-8.

Bennun, L. & Njoroge, P. (1999). Important Bird Areas in Kenya. Nature Kenya, Nairobi.

Bennun, L., Dranzoa, C. & Pomeroy, D. (1996). The Forest Birds of Kenya and Uganda. *Journal of East African Natural History*, 85(1), 23-48.

Beresford, A.E., Eshiamwata, G.W., Donald, P.F., Balmford, A., Bertzky, B., Brink, A., Fishpool, L.D. C., Mayaux, P., Phalan, B., Simonetti, D. & Buchanan, G.M. (2013). Protected area status reduces land-cover change within sites of conservation importance across Africa.

Bhagwat, S.A., Willis, K.J., Birks, H.J.B. & Whittaker, R.J. (2008). Agroforestry: A refuge for tropical biodiversity? *Trends in Ecology and Evolution*, 23, 261–267.

Biber, E. (2002). Patterns of endemic extinctions among island bird species. *Ecography*, 25, 661–676.

BirdLife International (2016a). Country profile: Kenya. Available from: http://www.birdlife.org/datazone/country/kenya. Checked: 2016-04-12.

BirdLife International (2016b) Important Bird and Biodiversity Area factsheet: Meru National Park. Downloaded from http://www.birdlife.org on 12/04/2016.

BirdLife International (2015). Important Bird Areas factsheet: Kakamega forest. Downloaded from http://www.birdlife.org on 26/02/2015.

BirdLife International (2014a). Effective Protected Area networks can help promote species recovery. Presented as part of the BirdLife State of the world's birds website. Available from: http://www.birdlife.org/datazone/sowb/casestudy/607. Checked: 26/02/2015.

BirdLife International (2014b). One in eight of all bird species is threatened with global extinction. Presented as part of the BirdLife State of the world's birds website. Available from: http://www.birdlife.org/datazone/sowb/casestudy/106. Checked: 26/02/2015.

BirdLife International (2013). Back from the brink: species can be saved from extinction. Presented as part of the BirdLife State of the world's birds website. Available from: http://www.birdlife.org/datazone/sowb/casestudy/267. Checked: 26/02/2015.

BirdLife International (2011). Most threatened birds have small populations. Presented as part of BirdLife State of the world's birds website: Available from: http://www.birdlife.org/datazone/sowb/casestudy/107. Checked: 26/02/2015.

BirdLife International (2008). Threatened birds of the world 2008. CD-ROM. Cambridge, UK: *BirdLife International*.

BirdLife International (2001). Threatened birds of Asia: The BirdLife International Red Data Book. Cambridge, UK: *BirdLife International*.

Bonn, A., Rodrigues, L. & Gaston, J. (2002). Threatened and endemic species are they good indicators of patterns of biodiversity on a national scale? *Ecology Letters*, 5(6),733-741.

Both, C., Bouwhuis, S., Lessells, M. & Visser, E. (2006). Climate change and population declines in a long-distance migratory bird. *Nature*, 441(7089), 81-83.

Boy, G. (2003). Hinde's find. *Swara* 26: 26-27.

Buchanan, G. M., Donald, P. F., Fish pool, L. D. C., Arinaitwe, J. A., Balmain, M. & Meraux, P. (2009). An assessment of land cover and threats in important bird areas in Africa. *Bird Conservation International*, 19, 1–13

Butler, D. & Merton, D. (1992). The Black Robin: Saving the world's most endangered bird. Auckland, New Zealand: *Oxford University Press*.

Bururia, D.N. & Nyaga, J.N. (2014). Demystifying Negativism of *Cartha edulis* (Miraa) and focusing On Its Religious-Socio-Economic and Educational Significance: A Case of Meru North Region in Meru County, Kenya.

Calvert, A.M., Bishop C.A., Elliot R.D., Krebs E.A., Kydd T.M., Machtans C.S. & Robertson, G.J. (2013). A synthesis of human-related avian mortality in Canada. *Avian Conservation and Ecology* 8(2): 11.

Carrete, M., Tella, L., Blanco, G. & Bertellotti (2009). Effects of habitat degradation on the abundance, richness and diversity of raptors across Neotropical biomes. *Biological Conservation*, 142(10), 2002-2011.

Castell´on, T.D. & Sieving, K.E. (2006). An Experimental Test of Matrix Permeability and Corridor Use by an Endemic Understory Bird, Department of Wildlife Ecology and Conservation, 303 Newins-Ziegler Hall, University of Florida, Gainesville, FL 32611-0430, U.S.A.

Chalfoun, A.D., & Martin, T.E. (2007). Assessments of habitat preferences and quality depend on spatial scale and metrics of fitness. *Journal of applied ecology*, 44(5), 983-992.

Collar, N., Robson, C. & Garcia, E.F.J. (2016). Hinde's Pied Babbler (*Turdoides hindei*). In: del Hoyo, J., Elliott, A., Sargatal, J., Christie, D.A. & de Juana, E. (eds.). Handbook of the Birds of the World Alive. Lynx Edicions, Barcelona. (retrieved from http://www.hbw.com/node/59569 on 22 April 2016

Collar, N. (2005). Taita Thrush (*Turdus helleri*). In: J. del Hoyo, A. Elliott, J. Sargatal, D.A. Christie and E. de Juana (eds), Handbook of the Birds of the World Alive, Lynx Edicions, Barcelona.

Collar, N.J. & Stuart, S.N. (1985). Threatened birds of Africa and related islands: the ICBP/IUCN Red.

Cox, A., Wolfenbarger, L., Berkeley, I., Engberg, E., Janousek, M., Klug, E., Rider, L. & McCarty, P. (2014). Grassland bird communities on conservation and marginal grasslands in an agricultural landscape. *Agriculture, Ecosystems & Environment*, 193(01), 53-59.

Dahal, R., McAlpine, A. & Maron, M. (2014). Bird conservation values of off-reserve forests in lowland Nepal. *Forest Ecology and Management*, 323, 28-38.

Dallimer, M., Parnell, M., Bicknell, E. & Melo, M. (2012). The importance of novel and agricultural habitats for the avifauna of an oceanic island. *Journal for Nature Conservation*, 20(4), 191-199.

Davis, D.E. & Winstead, R.L. (1980). Estimating the numbers of wildlife populations. Pp. 221.247 In S.D. Schemnitz (editor). Wildlife Management and Techniques Manual. *The Wildlife Society, Washington DC.*

Didham, K., Tylianakis, M., Gemmell, J., Rand A. & Ewers, M. (2007). Interactive effects of habitat modification and species invasion on native species decline. *Trends in Ecology & Evolution*, 22(9), 489-496.

Doligez, B., Boulinier, T & Fath, D. (2008). Habitat Selection and Habitat Suitability Preferences. In Encyclopedia of Ecology (pp. 1810-1830). Oxford: *Academic Press*.

Eddy, D., Pande, A. & Gardner, A. (2014). Massive differential site-specific and species-specific responses of temperate reef fishes to marine reserve protection. *Global Ecology and Conservation.*

Ewers, M. & Didham, K. (2006). Confounding factors in the detection of species responses to habitat fragmentation. *Biological Reviews*, 81(01), 117-142.

Fahrig, L. (2003). Effects of habitat fragmentation on biodiversity. *Annual review of ecology, evolution, and systematics*, 487-515.

Farwig, N., Sajita N. & Böhning-Gaese K. (2008). Conservation value of forest plantations for bird communities in western Kenya. *Forest Ecology and Management*, 255(11), 3885-3892.

Fordham, D. A., & Brook, B. W. (2010). Why tropical island endemics are acutely susceptible to global change. *Biodiversity and Conservation*, 19, 329–342.

Gane, J., & Burt, A. (2016). Longevity and survival of the Endangered Seychelles Magpie Robin Copsychus sechellarum. *Ostrich*, 87(1), 81-83.

Gardner, T. A., Barlow, J., Chazdon, R., Ewers, R. M., Harvey, C. A. & Peres, C. A. (2009). Prospects for tropical forest biodiversity in a human-modified world. *Ecology Letters*, 12, 561–582.

Ghazoul, J., & Levin, A. (2013). Deforestation and Land Clearing. In Encyclopedia of Biodiversity (Second Edition) (pp. 447-456). Waltham: *Academic Press*.

Githiru, M., Matthysen, E., & Lens, L. (2014). Items of interest from recent ornithological literature: Perspectives from long-term ornithological research in the Taita Hills. *Scopus*, 31, 48-53.

Githiru, M. (2003). Endemic forest birds of Taita Hills: Using model species to understand the effects of habitat fragmentation on small populations. *University of Oxford*.

Greve, M., Chow, L., Rensbur, J., Dallimer, M. & Gaston J. (2014). The ecological effectiveness of protected areas: a case study for South African birds. *Animal Conservation*, 14(3), 295-305.

Hansen, J. & DeFries, R. (2007). Ecological Mechanisms Linking Protected Areas to Surrounding Lands. *Ecological Applications*, 17(4), 974-988.

Hegazy, K., Kabiel, F., Boulos, L. & Sharashy, S. (2010). Conservation approach to the demography and dynamics of protected and unprotected populations of the endemic

Ebenus armitagei in the Western Mediterranean Coast of Egypt. *Journal for Nature Conservation*, 18(3), 151-158.

Heikkinen, R. K., Luoto, M., Virkkala, R., & Raino, K. (2004). Effects of habitat cover, landscape structure and spatial variables on the abundance of birds in an agricultural-forest mosaic. *Journal of Applied Ecology*, 41, 824–835.

Jackson, S.T. & Hobbs, R.J. (2009). Ecological restoration in the light of ecological history. *Science*, 325(5940), 567-569.

Jones, C.G. (2010). Back from the brink: The Echo Parakeet story. *Psitta Scene* 22(3): 3–5.

Kamiti, A. (2003). A survey of Hinde's Babbler: 2000-01. *Kenya Birds* 10(1&2): 16-17.

Kinnaird, M.F., & O'brien, T.G. (2012). Effects of Private-Land Use, Livestock Management, and Human Tolerance on Diversity, Distribution, and Abundance of Large African Mammals. *Conservation Biology*, 26(6), 1026-1039.

Koleček, J., Schleuning, M., Burfield, I.J., Báldi, A., Böhning-Gaese, K., Devictor, V. & Reif, J. (2014). Birds protected by national legislation show improved population trends in Eastern Europe. *Biological Conservation*, 172, 109-116.

Ko Chia-Ying., Murphy C., Root L. & Lee Pei-Fen (2014). An assessment of the efficiency of protection status through determinations of biodiversity hotspots based on endemic bird species, Taiwan. *Journal for Nature Conservation.*

Lens, L., Dongen, S, V., Norris, K., Githiru, M. & Matthysen, E. (2002). Avian persistence in fragmented rainforest. *Science* 298: 1236-1238.

Massaro, M., Stanbury, M., & Briskie, J. V. (2013). Nest site selection by the endangered Black Robin increases vulnerability to predation by an invasive bird. *Animal Conservation*, 16(4), 404-411.

Misenhelter, M. D. & Rotenberry, J.T. (2000). Choices and consequences of habitat occupancy and nest site selection in Sage Sparrows. *Ecology*, 81(10), 2892-2901.

Moyle, G., Andersen, J., Oliveros, H., Steinheimer, F. & Reddy, S. (2012). Phylogeny and Biogeography of the Core Babblers (Aves: *Timaliidae*). *Systematic Biology*.

Muchai, M., Len, L & Bennun, L. (2002). Habitat selection and conservation of Sharpe's longclaw (*Macronyx sharpei*), a threatened Kenyan grassland endemic. *Biological Conservation*, 105(3), 271-277.

Mulwa, R.K., Neuschulz, E.L., Böhning-Gaese, K. & Schleuning, M. (2013). Seasonal fluctuations of resource abundance and avian feeding guilds across forest–farmland boundaries in tropical Africa. *Oikos*, 122(4), 524-532.

Mulwa, R.K., Böhning-Gaese, K., & Schleuning, M. (2012). High bird species diversity in structurally heterogeneous farmland in western Kenya. *Biotropica*, 44(6), 801-809.

Murn, C., Mundy, P., Virani, M. Z., Borello, W.D., Holloway, G.J. & Thiollay, J.M. (2016). Using Africa's protected area network to estimate the global population of a threatened and declining species: a case study of the Critically Endangered White-headed Vulture Trigonoceps occipitalis. *Ecology and Evolution*.

Najma, D. (2012). Field Guide to Common Trees & Shrubs of East Africa.

Newbold, T., Scharlemann, J.P., Butchart, S.H., Şekercioğlu, Ç.H., Alkemade, R., Booth, H., & Purves, D.W. (2013). Ecological traits affect the response of tropical forest bird species to land-use intensity. Proceedings of the Royal Society of London B: *Biological Sciences*, 280(1750), 20122131.

Njoroge, P. & Bennun, L. (2000). Status and conservation of Hinde's Babbler (*Turdoides hindei*), a threatened species in an agricultural landscape. *Ostrich*, 71(1-2), 69-72.

Njoroge, P., Bennun, L. & Lens, L. (1998). Habitat use by the globally Endangered Hinde's Babbler (*Turdoides hindei*) and its sympatric relative, the Northern Pied Babbler (*T. hypoleucus*). *Bird Conservation International* (8), 59-65.

Njoroge, P. & Mutinda, D. (1996). Notes on nesting of Hinde's Babbler (*Turdoides hindei*) and Northern Pied Babbler (*T. hypoleucus*) in 'Central Kenya'. *Ostrich* 67: 170-172.

Pickett, S.T., & White, P.S. (Eds.). (2013). The ecology of natural disturbance and patch dynamics. *Elsevier.*

Plumb, W.J. (1979). Observations on Hinde's Babbler *Turdoides hindei*. *Scopus*, 3, 61-67.

Scales, B.R. & Marsden, S.J. (2008). Biodiversity in small-scale tropical agroforests: A review of species richness and abundance shifts and the factors influencing them. *Environmental Conservation*, 35, 160–172.

Shaw, P., Njoroge, P., Otieno, V. & Mlamba, E. (2014). The range, abundance and habitat of Hinde's Babbler Turdoides hindei: fine-scale changes in abundance during 2000–2011 reflect temporal variation in scrub cover. *Bird Conservation International*, 24(04), 453-465.

Shaw, P., Njoroge, P., Otieno, V. & Mlamba, E. (2013). Detecting change in the status and habitat of Hinde's Babbler *Turdoides hindei*: 2000 to 2011. Ibis, 155, 428–429.

Shaw, P., Musina, J. & Gichuki, P. (2003). Estimating change in the geographical Range and population size of Hinde's Babbler (*Turdoides hindei*). *Bird Conservation International*, 13, 1-12.

Shaw, P. & Musina, J. (2003). Correlates of abundance and breeding success in the globally threatened Hinde's Babbler (*Turdoides hindei*) and its congener, Northern Pied Babbler (*T. hypoleucus*). *Biological Conservation* 114: 281-288.

Shaw, P., Musina, J. & Gichuki, P. (2001). Surveys of Hinde's Babbler (*Turdoides hindei)* and Northern Pied Babbler (*T. hypoleucus*) in four Important Bird Areas. Research Reports of the Centre for Biodiversity, National Museums of Kenya.

Soderstrom, B., Kiema, S. & Reid, S. (2003). Intensified agricultural land-use and bird conservation in Burkina Faso. *Agriculture, Ecosystems & Environment*, 99(1-3), 113-124.

Stattersfield, A.J., Crosby, M.J., Long, A.J. & Wege, D.C. (1998). Endemic Bird Areas of the World. *Priorities for Biodiversity Conservation*. Cambridge, UK.

Terorde, I. & Turpie, K. (2013). Influence of habitat structure and mouth dynamics on avifauna of intermittently-open estuaries: A study of four small South African estuaries. Estuarine, Coastal and Shelf Science, 125(0), 10-19.

Teucher, M., Fischer, C., Busch, C., Horn, M., Igl, J., Kerner, J. & Habel, J.C. (2015). A Kenyan endemic bird species *Turdoides hindei* at home in invasive thickets. *Basic and Applied Ecology*, 16(2), 180-188.

Thorsen, M. & Jones, C. (1998). The conservation status of Echo Parakeet (*Psittacula eques*) of Mauritius. *Bulletin of the African Bird Club* 5: 122–126.

Tscharntke, T., Sekercioglu, C.H., Dietsch, T.V., Sodhi, N.S., Hoehn, P. & Tylianakis, J.M. (2008). Landscape constraints on functional diversity of birds and insects in tropical agroecosystems. *Ecology*, 89(4), 944-951.

Torello-Raventos, M., Feldpausch, T.R., Veenendaal, E., Schrodt, F., Saiz, G., Domingues, T.F. & Hur Marimon Junior, B. (2013). On the delineation of tropical vegetation types with an emphasis on forest/savanna transitions. *Plant Ecology & Diversity*, 6(1), 101-137.

Venables, J.C. & Brooke, M.D.L. (2015). The comparative effects of small geographic range and population decline on the adult sex ratio of threatened bird species. *Bird Conservation International*, 25(02), 182-191.

Zimmerman, D. A., Turner D.A., Pearson, D.J. & Ian, W. (1999). *Birds of Kenya and Northern Tanzania.*

APPENDICES

Data collection sheets

Data collection sheet: Population status attributes

Hinde's Babbler Population status sheet															
Surveyor:												Transect No.			
(total observers):						Date:						Survey site name:			
Latitude: (at start of transect)						Start time:						Transect length:			
Longitude: (at start of transect)						Season:						Weather			
site description				Patch Height= Ground level (G), Mid Height (M), Canopy (H)									Field sheet ref:		
Time	GPS reading	Phenology activity	Patch height	Sampling point1				Sampling point 2				Sampling points 3			
				NL	FL	IM	AD	NL	FL	IM	AD	NL	FL	IM	AD
Latitude: (at end thetransect)							Remarks								
Longitude: (at end of transect)						Nestlings=NL, Fledglings=FL, Immatures=IM, Adults=A									

Data collection sheet: Habitat attributes

VEGETATION ATTRIBUTES											
Surveyor:						Transect No.			Field sheet ref:		
(total observers):		Date:				Survey site name:					
General description of site							vegetation cover				
Species Name	1	2	3	4	5	Dominant species	Shrub	Tree	Forbs	Bare	Crop
Coordinates (at start of transect)							Remarks				
Coordinates: (at end of transect)											

Data collection sheet Habitat Disturbances

Habitat disturbances and threats												
Surveyor:	Date:				Field sheet ref:							
site name:					Transect No.							
General description of site												
	1				2				3			
Extent of occurrence	0	1	2	3	0	1	2	3	0	1	2	3
Fire												
Vegetation clearance												
Vegetation trampling												
Logging												
Firewood collection												
Overgrazing												
Persecution												
Farming												
Hunting												
others (specify)												
		0- None, 1-Neglible, 2-Medium, 3- High intensity										
Coordinates: (at start of Transect)									Remarks			
Coordinates: (at end of transect)												

Count of Hinde's Babbler groups at sampling points in the three sites

		Dry season				Wet season			
Landscape	Transect Name	Adults	Offsprings	No. groups	Population	Adults	Offsprings	No. groups	population
MNP	Pipas Grave	0	0	0	0	3	0	1	3
MNP	No. 37	1	0	0	0	2	0	1	2
MNP	Bernard Brown Swamp	0	0	0	0	3	1	1	4
MNP	Kindani River	5	2	1	8	9	0	2	9
MNP	Rojeweru	3	0	1	3	11	2	3	13
MNP	Princess Camp	5	0	1	5	0	0	0	0
MNP	Kathithi	7	0	2	7	0	0	0	0
Agricultural landscape	Kiruyu 1	6	0	2	6	5	0	1	5
Agricultural landscape	Kiruyu 2	0	0	0	0	0	0	0	0
Agricultural landscape	Kiruyu 3	7	2	2	9	1	0	0	0
Agricultural landscape	Murera Springs 1	8	1	2	9	2	0	1	4
Agricultural landscape	Murera Springs 2	4	0	1	4	1	0	0	0
Agricultural landscape	Murera Springs 3	3	0	1	3	3	0	1	3
Agricultural landscape	Murera Springs 4	0	0	1	0	0	0	0	0
Ngaya Forest Reserve	Ngaya 1	5	0	1	5	0	0	0	0

Ngaya Forest Reserve	Ngaya 2	4	0	1	4	4	1	1	5
Ngaya Forest Reserve	Ngaya 3	4	0	1	4	2	0	1	6
Ngaya Forest Reserve	Ngaya 4	3	0	1	3	3	0	0	0
Ngaya Forest Reserve	Ngaya 5	10	1	2	11	1	0	0	0
Ngaya Forest Reserve	Ngaya 6	11	1	2	12	0	0	0	0
Ngaya Forest Reserve	Ngaya 7	4	2	1	6	10	0	2	10
Ngaya Forest Reserve	Ngaya 8	2	0	1	2	9	1	2	10