DIET ANALYSIS OF TWO SYMPATRIC OWLS TO ASSESS SMALL MAMMALS POPULATION CHANGE IN NAIROBI SUBURBS AND TSAVO EAST NATIONAL PARK, KENYA

BY

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Thesis submitted to the department of biology university of Nairobi in partial fulfillment of the requirements for the award of the degree of Master of Science in Biology of Conservation

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DECLARATION

I wish to declare that this thesis is my original work and has not been presented for award of any other degree in any other university to the best of my knowledge. Where other people's works have been used, this has been properly acknowledged and referenced according to the University of Nairobi's requirements.

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DEDICATION

I dedicate this thesis work to my beloved family: My dear husband Joash Nyamache and our two daughters, Clare Kemunto and Michelle Moraa. Your prayers and words of encouragement kept me moving throughout the journey. Without you this study would not have come into fruition.

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ACROMYMS AND ABBREVIATIONS

MNI	Minimum Number of Individuals
GPS	Geographical Positioning System
ANOVA	Analysis of Variance
UTM	Universal Transverse Mercator
IUCN	International Union for Conservation of Nature
ITCZ	Inter-Tropical Convergence Zone
UN	United Nations
GBO	Global Biodiversity Outlook
CBD	Convention on Biological Diversity
TENP	Tsavo East National Park
NMK	Kenya National Museums of Kenya
KWS	Kenya Wildlife Service

ABSTRACT

Owls are nocturnal raptors that feed on small vertebrate animals and regurgitate undigested food remains in form of oval-shaped pellets. The pellets contain diverse species of small vertebrates and analysis of this pellets can reveal the more cryptic species that may not be trapped using the conventional live trapping methods. To address that knowledge gap, this study sought to conduct diet analysis of Spotted Eagle Owl (*Bubo africanus* Temminck, 1821) and Barn Owl (*Tyto alba* Scopoli 1769) in an urban environment in Nairobi metropolis and in natural habitats of Tsavo East National Park (TENP). The study compared prey composition, seasonal change in diet and its variation between the two owl species as well as compare prey species diversity in owl pellets and in live traps set in the two study areas. A total of 483 pellets were retrieved from Nairobi Metropolis, 371 Barn Owl pellets were collected from Ondiri Swamp and 112 pellets from Spotted Eagle Owl in Alliance Girls School. Further 424 pellets were collected from four Barn Owl nest sites in Tsavo East National, Park but no Spotted Eagle Owl pellets were available from this area. Standard live trapping was conducted across owl foraging areas in all habitats surrounding the nest sites. Data were collected during dry and wet season from December 2020 to August 2021. Small mammals formed the principal prey for all owls across habitats studied. Other species formed the least prey items. Results from ANOVA confirmed Barn Owl diet composition varied significantly in the two sites ($F_{1,40}$= 93.57, $P<0.05$). There was no significant seasonal variation in the diet of Barn Owl in the two study sites ($F_{3, 12}$=0.042, $p>0.05$). Results obtained from ANOVA revealed significant statistical difference in Spotted Eagle Owl diet for the two seasons ($F_{1, 32}$= 4.9891, $p<0.05$). Analysis of Barn owl pellets and trapping results showed significant differences in prey species across habitats ($F_{2, 14}$=2.68, $p<0.05$). However, spotted eagle owl diet composition and trapping did not differ significantly ($t_{2, 9}$=1.44, $P>0.05$).

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

Owls depends on small vertebrates as their main food resource that are important components of many ecosystems (Hope *et al.,* 2013). Small vertebrates exhibit high sensitivity and quick response to environmental change within fine spatiotemporal scales because of their adaptability towards defined micro habitats and survive fairly within small home ranges (Heisler, 2013). Thus, monitoring population dynamics of these small vertebrates can help detect environmental change within a given ecological region. Monitoring of small mammals is normally conducted by conventional trapping methods. However, conventional trapping can logistically constrain small mammal monitoring to relatively small spatiotemporal scales following biases associated with baits and trap types used for sampling which are normally expensive and time-consuming (Mwebi *et al.*,2018; Heisler *et al.*, 2016; Kressler,2021). Owl pellet analysis has been suggested as comprehensive survey for sampling composition of small mammal communities and taxonomic diversity (Hessler *et al.,* 2016).

Knowledge about raptor's diet has been ecologically important for many centuries, because it provides valuable information on prey distribution, abundance, behavior and vulnerability (Djilali, 2016). Besides documenting prey communities within the owl's range, food habits for raptors are key to evaluating predator-prey interactions and their habitat requirements (Wingert, 2015). Although there is some skepticism on how owl diet represents community structure of an area. Extensive studies across owls foraging ranges reports that, pellets analysis provides information on the diet composition of owls and dynamics of prey species communities within local scale compared to conventional live trapping (Kitowski ,2013; Johnson *et al.*, 2018; Mwebi *et al*., 2018).

Owls are nocturnal raptors not related to other diurnal birds of prey despite their similarities in predatory habits (Armstrong and Avery, 2014). They display many specialized adaptations to detect and capture their prey (Wagner *et al*., 2013). They swallow their prey whole and their digestive juices are less acidic and therefore, expel pellets which contain greater proportion of undigested prey remains such as bones, fur, feathers, teeth, claws and exoskeleton, regurgitated through the mouth 6 to 12 hours after the meal (Ghimire,2016; Long, 2020; Saufi *et al*.,2020). The general size, shape and appearance of these pellets are diagnostic features that help identify the owl species they came from and generally reveal the number of feeding bouts, prey species, size and age of individual (Muzzopappa *etal*., 2021). Owls' diet has been extensively studied throughout their range because of the ease of identifying prey remains recovered inside regurgitated pellets (Köhler, 2019). Prey remains in owl pellets is commonly identified to genus or species level, allowing accurate estimates of diet breadth and prey diversity (Marsh, 2012).

Owls diets vary considerably among regions and seasons (Romanowski, and Zmihorski, 2008). Changes in habitats correspond to changes in the small vertebrates' fauna of an area (Demirel *et al*., 2011). Owls are fairly opportunistic predators, trophic structure of their assemblages are strongly affected by the abundance and distributions of prey in any a given region (Fernández-Jalvo, 2016). However, other aspects such as owl preference of foraging habitat and prey size and possibly dietary competition with sympatric owl species have been reported (Wiens *et al.,* 2014). Understanding the spatial and temporal scale of prey dynamics and how sympatric predators utilize them, provides intuition on the manner that lead to ecological change (Andreassen *et al.,* 2021).

Niche partitioning and coexistence between ecologically similar species has been the main focus of many studies. These are aimed at documenting adaptations that contribute to a stable coexistence without competitive exclusion (Bullington *et al.* 2021). For example, sympatric owls may have similar food requirements but may prey on different prey species available. Ecological studies on how they select different prey items locally is crucial in understanding their resource partitioning and segregation (Ali and Santhanakrishnan, 2012).

The Barn Owl *Tyto alba* (Scopoli 1769) and Spotted Eagle Owl (*Bubo africanus* Temminck 1821) that are known to be sympatric in some localities, are primarily predators of nocturnal small mammals, but also feed on an array of other small vertebrates such as insects, amphibians, bird and reptiles, in small amounts (Kopij *et al.*, 2014, Hindmarch and Elliot ,2015). The Barn owl is a medium sized owl with cosmopolitan distribution and well-studied among all birds of prey in tropical and temperate zones (Saufi *et a*l., 2020). Spotted eagle owl is a small-sized owl occurring in almost all habitats however, is less studied (Ali and Santhanakrishnan, 2012). Wherever the two nocturnal predators are sympatric, they demonstrate flexible hunting strategies on a wide range of prey and therefore, considered successful predators capable of adapting to environmental changes (Moysi *et al*., 2018). Their predatory habits exhibit an astounding range of territorial association more especially in urban areas that are highly transformed (Hindmarch *et al.*, 2017).

Studies of owls are limited in Kenya. One published account of Barn Owl diet in Nairobi Suburb (Gichuki, 1987). Another that compared Barn Owl and Verreaux's Eagle Owl (*Bubo lacteus*) was conducted in Lake Naivasha (Kityo,2001). Variation in diet among territories or seasons has received considerably less attention. No information on seasonal changes of owls' diet or study has been conducted comparing Barn Owl and Spotted Eagle Owl diets or any other owls in an urban landscape in Kenya. In this study, comparisons were made on the diets of Barn owl in two study sites with markedly different environmental conditions to evaluate variation in owl diet at each site. This research, also compared the diet of sympatric Spotted Eagle Owl and Barn Owl only in Nairobi suburb because no Spotted Eagle Owl roosting sites were found in TENP. These data are useful in documenting the trophic relationships in the urban landscapes where the two species are sympatric.

This comparison was meant to understand how and to what extent sympatric owls utilize common resources in the same ecosystem, allowing them to coexist. Comparisons of diets of these two species are of great value in understanding the role of food niches in structuring raptor assemblages. The comparisons also highlighted the difference and similarities in prey frequencies between the consumed and available prey through pellet analysis and live trapping. The two sampling methods were crucial because, they classify the level of owls' prey choice and therefore defines whether they are generalist or specialist hunters within a given ecological context. If owls hunt in terms of prey preference, diversity of small vertebrate's communities in their diet become biased and not valid for environmental reconstructions. Seasonality was introduced in this study with the two sampling methods that were complimentary to each other.

Comparisons of data analyzed from pellets collected before this study and current trapping were also done to reveal how contents in owl pellets would infer changes in prey community in the study area. Following the population decline and constant migration of owls in most of their home ranges, information on the diet diversity obtained from this study was crucial in evaluating habitat components that support owl populations.

1.2 Justification of the study

While urban centers may harbor high biodiversity, their status is unknown and little attention is given to wildlife conservation in these landscapes. unprecedented human population growth in urban areas over the past century result to a total footprint that sprawls and extends towards the geographical area of protected landscapes in many dominions due to forest exploitation for timber, production of charcoal for fuel, land clearance for agricultural production by small-scale farmers and increasing rate of urbanization are the major factors accredited to deforestation in tropical African forests. High demand for land in urban centers, results in forest fragments, scattered trees and open grass/herbs patches. This accelerates the global loss of native species and extinction rates. But also gives them new opportunities if they can adapt to urban environments.

These habitat patches support small populations of birds of prey and a variety of small vertebrates that are major food for predators. However, conservation of urban biodiversity has been gaining momentum with greater attention coming from the UN Sustainable Cities as stipulated in the UN Sustainable Development GOAL 11 (Wending *et al., 2018*).

Even though much attention has been given to protected landscapes, there is huge decline of biodiversity in these areas. Semi-arid protected landscape in Kenya supports rich biodiversity and endemism that are highly threatened to extinction due to extreme weather conditions. Persistent drought and seasonal flooding causes severe depletion of food resources resulting in constant shifting, dispersal and migration of predators and their prey.

Owls are bio indicators of ecosystem health, however, the role of owls in the ecosystem services is not well understood by most communities in Kenya. This is due to the superstitions associated with them that often leads to their being unjustly persecuted. A deeper understanding of dietary composition trends of owls would give useful insight into the health of the local ecosystems and further improve the people's general knowledge and attitudes as a way of implementing more effective conservation actions. This therefore stimulated interest in research and collecting data to understand the status of biodiversity in the two study areas.

1.3 Problem statement.

Data on the assessment of owl prey dynamics through dietary analysis and field trapping of potential prey are limited in tropical Africa and Kenya in particular. Owls inhabit a variety of habitats worldwide. However, data are lacking on the food ecology of owls in cases where they are sympatric in urban landscapes. Understanding resource selection of the two sympatric owls sheds more light on what derives their coexistence in an urban environment. Similarly, studies comparing the Barn owl diet, across urban landscapes and semi-arid protected parts of Kenya are extremely scarce. A study of Barn Owl species, occupying different geographical area was to shed light on how environmental change can significantly alter predators diet as a way of adapting to changing environmental condition and survival.

There is limited quantitative information on how owl diet varies with season, availability of potential prey species and habitat conditions. Low population densities and inconspicuous behavior of owls have contributed to very slow accumulation of their basic natural history data. This study also aimed to generate essential data that can improve our understanding on seasonal owl prey dynamics in semi humid and semi-arid landscapes in Kenya. The study provides quantitative information on owl feeding ecology by generating pellet analysis data. Comparisons of data obtained from owl pellets analysis and live trapping, provide aflame work to evaluate owl prey selection, factors affecting their distribution and accessibility of the prey, and the magnitude to which owl diet reflects prey species dynamics in their foraging areas.

1.4 Research objectives

1.4.1 Main objective

The main objective of this study was to evaluate diets of two sympatric owls in semi-humid and semi-arid landscapes with a view to improving protection of threatened species and management of threatened habitats.

1.4.2 Specific objectives

- To compare prey composition of sympatric owls in Nairobi suburbs and conspecific owls in Tsavo East National Park.
- To determine seasonal variation in diet of owls in the two study areas.
- To compare small mammal prey diversity in owl pellets and live trapping and evaluate the potential of using owl diet to monitor changes in ecosystem health.

1.5 Research questions

- How does owl diet composition differ in different habitats found in the two study areas?
- How does the prey composition vary with seasons in the two study areas?
- How does the diversity of the consumed and available small mammal prey differ in owl pellets and live trapping in the two study areas?

1.6 Research hypothesis

This study was guided by two research hypothesis

H1: There are no differences in prey composition in the diet of Spotted Eagle owl and Barn owls in Nairobi and Tsavo East National Park, Kenya.

H2: There are no difference in small mammal diversity in the diet of Spotted Eagle Owl and Barn owls and diversity of available small mammal prey in Nairobi and Tsavo East National park

CHAPTER TWO: LITERATURE REVIEW

2.1 Biology and diversity of owl

Classification of owls has been complex and confusing with different scholars coming up with different proposals (Salter *et al.*, 2020). They were once omitted from the list of raptors, and some other studies considered them to be ‘‘nocturnal equivalent of raptors (Bildstein, 2017; Geen *et al.*, 2019). However, recent studies have included them in the list of raptors (Boal and Dykstra ,2018; Buechley *et al.*, 2019). Early owl classification was based on factors associated with the features instituted outside the ear and facial appearance. However, subsequent authors establish that the outward appearance of the ear was not significant to all species due to similarities in auditory perception and prey location (Salter *et al.,* 2020). Thus owls are currently placed in the order of *Strigiformes*, one of the five raptor orders that include: *Accipitriformes (hawk ,Eagles) Cathartiformes(vultures), Cariamiformes*(harriers) and *Falconformes(falcons ,buzzards)* (Prum *et al.*, 2015).

The order *Strigiformes* has been separated into two distinctive owl families; *Strigidae* (Typical Owls) consisting 194 species and Tytonidae family *(*Barn, Bay and Grass Owls), consisting of 19 species (Le Piane and Clark, 2022, Gutiérrez-Ibáñez *et al*., 2013). *Tytonidae* are further subdivided into two subfamilies: *Phodilinae* (bay owls) and typical *Tytoninae* (barn owls and grass owls) (Sieradzki, 2022). There has been a long debate on the division of family Strigidae (typical owls) (Gutiérrez-Ibáñez *etal*., 2013). The family *Strigidae* was first divided into three subfamilies: *Surniinae* composed of hawk owls which are classified into 8 genera, *Striginae* consisting of Screech owls and Scops and classified into 13 genera and *Asioninae* consisting of eared owls that are classified into 2 genera. It was later reclassified into two subfamilies, *Buboninae and Striginae*. *Buboninae* consists of 21 genera which includes the fish owls (*Ketupa* scops owls (*Otus*), fishing owls (*Scotopelia*), eagle owls (*Bubo*), and the pygmy owls (*Glaucidium*) etc. *Striginae* consists of six genera which includes the majority of medium to small size owl species comprising of the eagle owls' and 'wood owls' and the ordinary tawny owl (*Strix aluco*)/British owl, (Enríquez *etal*., 2017; Wink and Sauer-Gurth, 2021).

To date, two families consisting of 250 species of owls have been recognized throughout the world, ranging from small size owls such as; the Pygmy Owl (*Glaucidium minutissimum) and* diminutive Elf Owl (*Micrathene whitneyi*) measuring 12cm high to the huge Eurasian Eagle Owl (*Bubo bubo*) standing at a height of 71cm (Gill ,2012; Ghimire, 2016). The two owl families have evolved similar features that classify them as owls. However, there are some divergent in physical in physical appearance within the two owl families, particularly in the shape of the skull; The family Tytonidae bears a round head with a heart-shaped facial disk, two notches in the sternum, second and third toes are of the same size and the nails and third toe comprises of comb like serrations (Brazil, 2019). Owls in the genus *Bubo* (Eagle owls) are regarded as huge and heavy weight owls with conspicuous ear tufts and very sharp claws (Ogada, 2016).

Owls share the night skies with other raptors (Sieradzki, 2022). This behavior coincides with the active time of their prey base (Mikkola, 2013). In order to occupy the ecological niche with other raptors, owls had to evolve several adaptations (Ericson, 2012). Their intense, large, forward-looking eyes (''keen eyesight''), and "fluffy" plumage make them efficient nocturnal predators (Bildstein, 2017; Boal and Dykstra, 2018; Salter *et al*., 2020). These features together with soundless flight, complex vocalizations and a sophisticated auditory system are some of the several exceptional evolutionary adaptations that qualify owls as effective crepuscular and nocturnal hunters (Le Piane and Clark, 2022; Geyer *et al*., 2013; Ghimire, 2016, Sangster *et al.*, 2021). Different species of owls vary slightly in regards to the individual physiology, as a result of differences in prey selection and the kind of habitat they occupy. However, all owls have evolved similar unique adaptations that empower them to hunt their prey efficiently while flying with astonishing sense of hearing and localize their prey at night (Williams, 2018; Sieradzki, 2022).

2.2 Distribution and habitat selection by owls

Owls inhabits wide range of habitats across the world ranging from; equatorial rainforests, temperate forests, deserts, grasslands, dense forests to frozen tundra and in some small isolated islands and in almost all continents except Antarctica (Ghimire, 2016; Terborgh *et al.*, 2015). The Barn Owl is the most widespread of all owls. It is found in the temperate parts of Europe, in America are found towards the southern and northern parts, all parts of India, Australia and towards the southern parts of Asia and also in Africa (Riegert *et al.*, 2021). The eagle owls are also widely distributed, found inhabiting in Southern Russia, North Africa, arid and desert zones in the Middle East, occupy woodlands and forest habitats from lowland savannah and high mountains (Iv, 2020). Among the eagle owls, Spotted Eagle Owl is found in majority of habitats throughout sub-Saharan Africa, occurring up to 2100m asl, in most habitats that include: shrub-lands, hearths moors, grasslands, deserts, semi-deserts, rocky hillsides, suburban gardens, agricultural fields, open or semi-open woodland and savanna (Eagle ,2020; Ogada *et al.*, 2016).

Owls are not efficient nest builders. Some owls such as corvids use nests abandoned by other species (Ghimire, 2016; Mainwaring ,2015). However, most of them prefer to use caves, others burrow in the ground and some use tree cavities or roots of trees (Mikkola, 2013). To protect their nests, owls such as Verreaux's Eagle Owl (*Bubo lacteus*) occasionally cover their nests with small amounts of plant fibers and animal dung (Potapov and Sale ,2013). Almost all smaller owls, nest in cavities of some sorts (Valera *etal*., 2019). The eagle owls, find it hard because their huge size becomes a challenge and therefore takeover old nests abandoned by other species or may choose to nest in the rocks or in the ground recesses (Glinski ,2021) .Species such as; marsh owls (*Asio capensis),* grass(*Tyto capensis*) and Short-eared owls(*Asio flammeus***)** prefers to nest in narrow depressions in grassy areas usually in open habitats (County, 2020*) .The* Snowy ow*l* (Bubo scandiacus) nests in the ground and selects most elevated areas to enhance its view of the surrounding environment and easy detection of approaching predators ,particularly the Arctic fox *Alopex lagopus* (Potapov and Sale, 2013).

The barn owl and spotted eagle owl are open habitat foragers that avoid large forests (Duchac *et al.,* 2021). They hunt over fields and prey capture increases with increasing vegetation patchiness or open ground that corresponds with high prey abundance (Scobie *et al.*, 2020). Despite being sympatric in some areas, Barn Owl and Spotted Eagle Owl habitat requirements and nest site selection vary greatly, with barn owls selecting closed areas such as; building interiors, caves, hollow trees and even rocky crevices (Campbell *et al.*, 2018). However, Barn Owl may prefer natural habitats especially forest edges where they create cavities through excavation of holes in barns, tree holes, cavities in cliffs, colonize rocky caves or riverbanks, disused wells and cracks in ravines (Downes ,2021). The spotted eagle owls prefer roosting in more open areas compared to the Barn Owl especially on the ground with undergrowth vegetation or hide under thick vegetation or along rocky outcrops, may perch in tree crowns or occupy tree holes or manmade structures, irrigation wells and natural hollows of tree-trunks (Mohmood, 2018). However, they are often known to co-occur close to human habitats where suitable places for roosting or nesting sites are available (Kajtoch *et al.,* 2015). In many towns and cities, the two species occupy old barns, church steeples, barn lofts, hay stacks, chimneys, and holes that are within the ceiling and roof or walls in old buildings and even use street lights and other manmade structures as perches (Kopij et al., 2014). But they are rarely observed occupying roosts that are close each other (Campbell *et al.*, 2018). Barn Owls readily occupy nest boxes and this promotes their breeding success (Trigo, 2016).

The need to find a suitable habitat to dwell in is a fundamental feature of many organisms (Matthiopoulos *et al.,* 2015). Birds select habitats based on suitable breeding sites and foraging habitats (Tanferna *et al.,* 2013). The fitness of animals is affected by local habitats as a result of changing environmental conditions and resource variability (Webber and Vander Wal, 2018). Owls are known to select habitats at broader scales than their prey species. They are likely to select nest sites where they will have maximum opportunity for successful breeding and lifetime reproductive success (Tapia and Zuberogoitia, 2018). They prefer areas with abundant food resources and therefore, nest site selection depends on prey availability (Apolloni et al., 2013). When prey is sparsely distributed, owls reduce time and energy connected with foraging, by choosing nest sites close to better hunting habitats (Lourenço *et al.,* 2015). An optimal hunting owl always balances costs of food reduction and travelling, especially during the breeding season when taking care of the young. They have to decide whether hunting around the nest may be more cost effective than travelling further to seek for plentiful hunting area (Castaneda, 2018). Eagle owls have been described as good hunters close to the nest site, foraging at approximately a 2 km range (Shin *et al.*, 2013).

Individuals occupying high-quality sites in a heterogeneous environment will enhance their fitness (Long *et al.*, 2014). Predators must balance costs and benefits when selecting habitats for hunting in a heterogeneous landscape (Castaneda ,2018). The differences in body size and flight performance of different species, nest predation risk, starvation, competition and climatic conditions at the time of breeding and foraging, all determines the interspecific nest-site selection for any particular owl species (Morosinotto *et al.*, 2017). Territorial raptors occupy sites for a long time therefore habitat composition is crucial in maintaining their fitness (Donázar *etal*., 2016). Owls may choose to reoccupy the same nesting territories for years provided conditions are suitable (Tapia and Zuberogoitia, 2018).

Habitat preferences may change as a consequence of population responses to anthropogenic landscape alterations (Nordell *et al*., 2017). At larger scales animals may choose to remain in sub-optimal habitats even when better habitats are available to avoid risks associated with nest predation, dispersal, and emigration or travelling long distances procuring foods (Smith *et al.*, 2019). Compared to other large raptors, owls persist in highly modified areas but become highly susceptible to direct human torture (Donáza *et al.*, 2016). Birds found in urban environments are adapted to these habitats by way of wide home ranges compared to those restricted in natural habitats. They perhaps expand their home range by exploiting better hunting areas within fragmented habitats that are within urban areas and benefit from areas that have not been established (Lövy and Riegert, 2013).

2.3 Selection of prey by owls

Owls generally occupy higher trophic levels because of their large body sizes, home ranges, longer life spans and territorial behavior (McClure *et al*.,2019). They form a guild that relatively hunt similar prey categories (Comay and Dayan., 2018). Because they vary in size their diets are equally diverse (Karell *et al.*, 2021). Their prey selection is determined by size and quantity of prey consumed (Embar *et al.*, 2014). However, a controversy exists on size and sex classes of prey consumed. Some studies have affirmed owl consumption constitute either a range of individuals, generally males or adults (Boves and Belthoff, 2012), or small prey individuals composed of juveniles or females (Michel *et al.*, 2016). Others have reported that, owl prey choice do not rely on size or sex (Ratajc *et al.*, 2021). According to Comay and Dayan, (2018), prey size highly correlates with predator size. However, a similar study concluded that; predator food intake is equivalent to prey body mass, and this should be the most important decision to be made by any foraging predator for purposes of measuring efficiency in food consumption (Ratajc *et al.*, 2021). It is risky for a hunting owl to attempt to capture and subdue exceptionally large prey as this can cause injury to it.

Small mammals are the principal prey in owls' diet (Bildstein, 2017). However, insects, birds, reptiles and amphibians are preyed upon in small amounts and a few species specialize in fish hunting (Abd Rabou, 2020). Small sized owls, such as little owls, pygmy owls, the four tiny forest owls and scops owls, prey preference are normally; insects, small reptiles, amphibians, bats and birds and some small mammals (Campbell and Bochenski, 2015). Those that are medium to small size owls, including the spotted eagle and barn owls require primarily small mammals, especially rodents and shrews (Mikkola, 2013). However, they rely on other prey including, chiroptera, reptiles, amphibians' birds and invertebrates in small amounts (Ali and Santhanakrishnan, 2012). The huge owls such as eagle owls prey on larger prey corresponding to their size. Their prey preference includes the foxes, hares, young jackals, rabbits, snakes and deer fawns and also eat on other birds of prey or other owl species. Fish owls specializes primarily on fishing (Seidensticker and Lumpkin, 2016).

Owl hunting strategies categorizes the species as either opportunistic or specialized predator (Romano *et al.*, 2020). They may hunt opportunistically over a variety of prey species, taking whatever is available, or selective, specialize on other prey more than others depending on habitat utilized, time of the year, average size, conspicuousness, anti-predator strategies, morphology and behavior (Mikkola, 2013). If a predator hunts its prey opportunistically in relation to the field density of the prey, it is reasonable to assume that its diet will reveal the community structure of the prey species. In such a case, using pellet analysis to study community structure of prey becomes reliable (Machovsky-Capuska *et al.,* 2016). In contrast, if owls hunt selectively, in terms of prey preference we can expect a bias towards the more favorable prey species in relation to their availability in a given habitat, and thus the diet composition cannot indicate the field density of the prey communities (Viteri *et al.,* 2021).

Predictions made by optimal foraging theory dictates that, as preferred prey becomes less abundant, predators will switch to less profitable prey (Steinmetz *et al.*, 2021). Many animal species change their feeding behavior to survive and adapt to changing habitat conditions (Cavalli *et al*., 2014). The diet of owls varies with changes in prey density and microhabitat type (OWL, 2017). It can also be affected by general hunting strategies of owls (Hindmarch *et al.,* 2017). The plasticity of owls a having broad prey base, explains their ability to colonize a variety of habitats than other raptors (Grzędzicka *et al.*, 2013). They remain in their home ranges even when selected prey decrease and becomes an opportunistic predator by incorporating prey of lower quality in their diets (Isaac *et al.,* 2014). Diet variation in owl pellets is reflected in prey availability within the owl home range as a possible result of habitat modification (Hindmarch *et al.*, 2017). Therefore, changes in diet of the owls may reflect real changes in their prey availability (Baroni *et al.*, 2021). That ecological relationship can be used to monitor or be used to develop a management strategy for important or threatened habitats. If different habitats preference is considered, then the composition and abundances of prey taxa may co-vary with the habitat exploited by the predators (Kenchington *et al.*, 2013). Understanding owls prey selection is essential in quantifying food consumption efficiency and may be important in making accurate inferences of how remains represent fauna in a given geographical area (Steele, 2015).

2.4 Ecological significance of owls

Owls play multiple ecological roles in the ecosystem as carnivores, insectivores, piscivores and scavengers (Sustaita *et al.*, 2018). Owls plays important roles in maintaining the structure and stability changes of the food-webs,since they exist at the apex of trophic levels in aquatic and terrestrial ecosystems (Paunikar *et al.,* 2015; Therrien *et al.,* 2014). Owls occur in low numbers, but play crucial role in organization of communities (Donazar *et al.*, 2016). They maintain natural balance by regulating vertebrate prey populations through their foraging behavior (Browning *et al.*, 2016; Abom and Schwarzkopf, 2016). They are known to control outbreaks of diseases by reducing insects and rodent populations (Buechley & Sekercioğlu, 2016). They have greater impact in prey regulation, which is ecologically important to agriculture (Nereu, 2017, Rico-Guevara *et al*., 2019). They feed on wide range of small animals and therefore, regulate rodent population in agricultural fields (Paunikar *et al.,* 2015). This is evident that, owls are unremarkably helping farmers from losing their farm produce by controlling numerous pests and therefore safeguard huge tons of cereal and cash crops (Browning *et al.,* 2016). For instance, Barn owl has been used biologically as a natural way of controlling pests in the grain fields of Israel, rice paddies and palm oil plantations in Malaysia (Ghimire, 2016).

Owls transfer nutrients between aquatic and terrestrial ecosystems therefore contributing to nutrient redistribution between ecosystems ((Beasley *et al.,* 2019; Buechley *et al.,* 2019). They play pivotal roles in regional forest management plans development, as forest managers can use their highly identifiable prey remains they accumulate to map biodiversity in their foraging habitats or forests (Whelan *et al*., 2015; Smirnov *et al.,* 2021). For example, studying the feeding ecology of the Northern Spotted Owl in the United States helped researchers to understand forest ecology and development of forest management plans (Miller *et al.,* 2018).

Toxicants and environmental changes at a range of spatial scales are profound effects to most owls (Lohr, 2018). They serve as good bio-indicators for ecosystem health, and therefore, conservation efforts that target owls' species ultimately protect a lot of other species, habitat, and ecological functions (Cruz *et al.,* 2021; Mahmood *et al.,* 2018; Fröhlich and Ciach ,2019). Owls are predators of small animal communities and very useful in studying these communities from parts preserved in regurgitated pellets (Campbell *et al.,* 2018). Remains of fossils obtained from owl pellets have played a great role in palaeo-environments reconstructions (Farre *et al.*,2014).

Owl body parts are considered medicinal/aphrodisiac in some parts of the world used to cure several diseases (Altaf *et al.*, 2017)). The owl body parts including their eggs are incorporated in numerous formulae and concoctions (Haussmann *et al*., 2019)). Owls have been a source of entertainment in Diwali festival as a source of sacrifice to their goddess to compel them remain in their homes, thereby bringing good luck and wealth (Gosai *et al.*, 2012). Throughout human history and in almost all communities' worldwide owls have been associated with trepidation, death, knowledge, wisdom and religious beliefs in a spirit world (Clarke, 2016). Besides these, owls play a significant socio-economic role in the tourism industry and are incredibly popular to bird watchers (Ghimire, 2016).

In some parts of the world owls are used by poachers as baits for hunting other birds' species such as parakeets (*Psittacula krameri*), babblers (*Turdoides caudatus* and *T. striatus*) and common myna (*Acredotheris tristis*) to supply the local feather market. These species of birds have a natural trend to cause violence wherever they see the Barn Owl. The hunters exploit this behavior to trap these birds in large numbers (Negro *et al.,* 2016).

The importance of owls to science has contributed to its being intensely studied across the world. Studies of these birds have provided information on their broad history and have drawn much attention to ornithologists (Farber, 2013). Currently nearly all countries across the world have mounted specimens such as, skeletons and skins of owl species in their natural history museums, educational institutions i.e. primary or secondary level schools since the anatomy and physiology of these birds are of great interest.

2.5 Threats of habitat change on owls

The fifth edition of the Global Biodiversity Outlook (GBO 5) by the United Nations Convention on Biological Diversity (CBD) reveals significant fraction of wild species to be at greater risk of extinction (Yu and Zhu, 2020). Currently species exterminations are projected to be 1,000 times higher than pre-human levels (Pimm *et al.*, 2014). Many species are in decline such that, losses of biodiversity could disrupt perilous ecosystem services, along with increasing numbers of extinctions (Valiente-Banuet *et al.,* 2015). Human well-being is compromised by diversity loss and populations (DeVault *et al.*, 2016). Disproportionate number of species are disappearing with extinction in the tropics where most bio- diversity occurs (Buechley *et al*., 2019). Habitat alteration and climate change are the greatest drivers of biodiversity loss for terrestrial ecosystems (Sintayehu, 2018).

Human activities have augmented the worldwide biodiversity loss (Raven, 2020; Taylor-Brown,2019). Overpopulation creates a high demand for land as well as exerting an incredible amount of pressure and threat to wildlife (Garg, 2020). Historical consequences for bird populations decline is largely through human pressures, persecution and habitats modification (Waters *et al.,* 2017). Rapid disappearance of species is worrying which involves , the so-called "sixth extinction" (Pievani ,2014)

Compared to other avian and non-avian groups, owls are disproportionately more threatened with extinction due to their ecology and life history (McClure *et al.*, 2018). Urbanization creates road networks that fragment habitat and expose wildlife to traffic and loss of foraging habitats (Riley *et al.,* 2014). Collision with vehicles, trains and electrocution by power lines due to poor peripheral vision are major threats to owls as a result of urbanization (O'Bryan,2020). Despite the available threats, urban areas also offer supplementary foods for owl prey base (Donázar *et al.* 2016). Great numbers of prospective prey draw raptors to hunt and breed in urban areas. despite the fact that nest sites are limited and few are of bad quality (Mainwaring, 2015). Lack of nest sites would act as ecological traps in these areas leading to long-term non-breeding territories (Isaac *et al*., 2014), ultimately reducing fitness (Luna *et al.,* 2020).

Climatic extremes such as persistent rainfall and drought also compromises owls' survival and productivity due to cyclical fluctuations in prey populations (White, 2013; Iknayan 2018). On the other hand, encroachment into the forest by agriculture and habitat clearance contributes to loss of native habitat, shifting of vegetation structure and reduction of field margins important for the provision of cover (Kassa *et al.,* 2017). Increased use of fertilizers and herbicide adversely affect density and diversity of prey and consequently affects predators that depend on them (Emmerson *et al.,* 2016). Intensification of agriculture may also lead to the increased use of anticoagulant rodenticides to kill pests that are toxic over time and potentially puts owls at greater risk (Emmerson *et al.,* 2016). Owls die as a direct result of secondary exposure to rodenticide (López-Perea and Mateo, 2018)

Other sources of owl mortality include but not limited to; intentional killing or persecution by humans (involves shooting for food, medicines or sport and nest robbing) (Xirouchakis, 2004), deliberate and unintended poisoning (Ogada *et al*., 2016). Owls face substantial illegal trade in some parts of the world in relation to their medicinal uses (Ghimire, 2016).

Species persistence on a global scale as a result of loss of habitat, is considered the most significant risk and directly connected to species extinctions (Rueda *et al.*, 2013). Although owls are well adapted to environmental change and show remarkable tolerance in highly modified landscapes, declining populations is an indicator of changes in the ecosystem (Hoffmann *et al.*, 2015; Ghimire, 2016). Some studies have pointed out owl's sensitivity to small-scale habitat changes across their range (Sekercioglu, 2012). Changes in raptor distribution or abundance can serve as a measure of the impact on landscapes globally (Grande *et al.*, 2018).

2.6 Conservation status of owls

Owls are unique and interesting creatures of nature. People, contemplate over them both with enthrallment and trepidation throughout history and across many cultures, creating contradictory perceptions about them (Slavin, 2014). Owls have been feared and acclaimed, loathed and admired, considered astute and foolish, and associated with a wide range of myths and many other phenomena that put them at a greater risk (Rashid *et al*., 2021). The most obvious belief in almost all cultural communities in African is that the vocalization of an owl near home brings misfortune or signals death (Mikkola, 2013). Due to these misconceptions, the birds may be discriminated against and deliberately harmed. In some parts of the world, owls have been involved in tremendous exploitation by traditional healers and witchdoctors (Ghimire 2016; Abd Rabou,2020).

Owls are entirely nocturnal in habit yet they are almost invariably killed around cities, towns and village suburbs when people comes across them (Tuan, 2013). Despite the misconceptions and the persecutions, they face, owls are important tools that triggers development of conservation strategies worldwide (McClure *et al.,* 2018). The International Union for the Conservation of

Nature (IUCN) has listed the status of 32 owl species as "Vulnerable" to "Critically Endangered", 22 species as "Near Threatened" (McClure *et al.* 2018). However, most of owl species are being listed as of least concern in the IUCN red list (Birdlife International, 2019). Owl conservation status varies from region to region and their population decline is mostly threatened by habitat loss. European assessment of birds and monitoring programs shows disproportionately poor conservation status of owls and substantial decline of these avian predators compared to other birds' species (Hindmarch *et al.,* 2017).

Small forest fragments lack many forest raptors both in the temperate zones and in the tropics (Marini, 2017). The decline has been throughout much of their range largely as a consequence of loss of foraging habitats and nest sites. This decline has been going on since 19th century (Blacker, 2013) and prompted a recommendation of Barn Owl as a threatened species in Western Canada (Regan *et al.*, 2018). The barn owls have been placed on the Audubon Blue List because of declining populations throughout much of their range (Wingert, 2015). They are listed as an endangered species in six Midwestern states and are a candidate for endangered status in a seventh state (Smith *et al.,* 2018). In Europe this decline prompted Barn Owl placement in SPEC category 3 and listing in the UK's Red Data Book (Trigo ,2016). This owl has been included on the Amber List of Birds of Conservation Concern in the UK (BoCC) and listed as a species with 'unfavorable conservation status in Europe' (Coyne 2018). In the UK a large numbers of local Biodiversity Action Plans (LBAPs) including those of water companies, such as Anglian Water, internal drainage boards and numerous counties such as, Warwickshire, Sussex, Devon and Norfolk have been produced to include the Barn Owl under Agenda 21 of the International Convention on Biodiversity (Gomez-Ramirez *et al.,* 2014).

Conservation of the focal raptors follows by manipulating habitat conditions within and among vegetation communities in a manner that will enhance the availability of the predator's prey on a landscape (Gardiner *et al.*, 2018). Due to critical conservation issues surrounding owls,they have now received much public and scientific consideration over past decades, (Prakash *et al*., 2003; Ogada *et al.*, 2016). However, in numerous countries and regions, legislation now exists to conserve raptors from majority of threats encountered (McClure *et al.*, 2018). Protected areas have been created especially for raptors (Cruz *et al*., 2021), and best practices have been developed to prevent raptor mortality (CMS, 2014). Where natural nest sites are limited nest boxes have been used as a conservation tools to increase populations in areas owls are declining (Wendt and Johnson, 2017). The use of such boxes has given good results regarding rodent pest control (Labuschagne *et al*., 2016).

CHAPTER THREE

3.0 Materials and Methods

3.1 Study area

Studies were conducted within Nairobi metropolitan area. Nairobi is the capital city of Kenya located in the south-central part of the country, representing a semi-humid environment. The study was conducted in three suburbs within Nairobi and Kiambu counties based on the availability of nest sites. In Nairobi county, Muthangari was identified as sampling site, located 5km from Nairobi CBD, lies at latitude 01°26'837"S**,** longitude 36°.765030"E ,1758 asl. In Kiambu county, Ondiri Swamp was identified located in Kikuyu town, lies at latitude 01.250743^{0}S and longitude 36.659432^{0}E, 2200m asl and Alliance Girls School, lies at S'01.265892^0 E'36.663512^0 ,1973M asl that are 2km apart and all located at 10km from Nairobi CBD. The three suburbs were fragmented habitats linked to high levels of urban population consolidated with rich biodiversity.

Further studies were conducted in Semi-Arid zone, in Tsavo East National Park. Tsavo East is the Kenya's largest and oldest protected area covering 13,747km^2, found in South eastern Kenya in Taita Taveta County. The park lies within longitude 38^{0}46'18'E and latitude 2^{0}46'43'S and altitude ranges from 200m-1000m asl. Four sites with owl nest sites were identified for this study, i.e. Rhino sanctuary located at 03.128^{0}S, 38.893412^{0}E and Trailer located at 03.105156^{0}S, 38.889059^0, all situated towards the southern part of the park. Other sites within the park were located along Tsavo East administration head quarter offices, i.e. Motor vehicle workshop located at latitude 03.354613^{0}S longitude 38.597791^{0}E and residential camp located at latitude 03.360322^{0}S longitude 38.597707^0 (Fig 1)

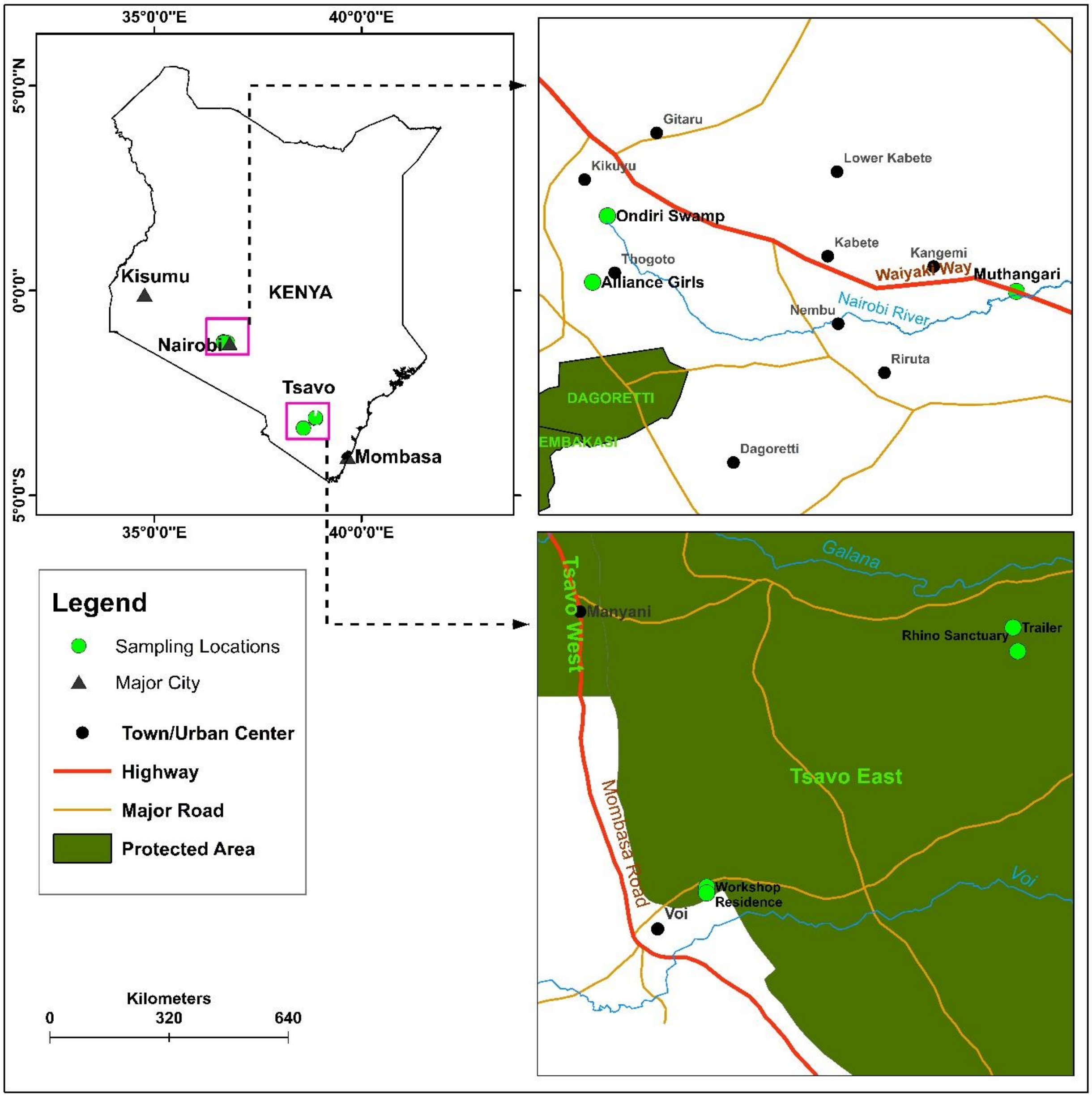

Figure 1 : A map of Kenya showing sampling sites within the two study areas.

3.1.1 Climatic conditions

Nairobi experiences Sub-humid to Semi-humid subtropical highland climate with bimodal rainfall. Long rains come March to May (MAM) accounting for 80% of annual rainfall with mean rainfall of 899 mm, while short rains come from October to December (OND), with mean rainfall of 638mm.The annual mean temperature ranges from 15-18^{0}C, with a minimum of 8- 11^{0}C decreasing in value with increasing altitude (Awuor,2008.). Average annual temperature is approximately 19^{o}C, highest recorded during long rains (MAM) as lowest being recorded in the short rains. Altitude varies from 1758m-1973m asl.

The Tsavo area experiences a warm and dry climate and often receives little and erratic rains driven by the Inter-Tropical Convergence Zone – ITCZ. Tsavo exhibits bimodal rainfall distribution with long rains coming in March to May (MAM) and short rains in October to December (OND). The Park headquarters receives 450-500mm per annum. Average annual rainfall ranges between 200 and 700 mm per annum (Spinage, 2012.). However, in several recent years the long rains have failed. 'Hot dry' seasons are experienced in the months of January, February and March, a 'cool dry' season from the month of June and extends towards October. The average daily temperatures fluctuate between 20^{0}C at night and 31^{0}C during the day. Mean maximum and minimum temperatures vary from about 34°C and 21°C respectively in March to 28^{o}C and 17°C in August.

3.1.2 Topography and geological conditions

Topographic features of Nairobi area are controlled by effects of volcanic activity. The volcanic lava flows originating from the Rift valley flanks gave rise to prominent physiographic units named as Kikuyu highlands, the Ngong hills and Eastern Larva plains of Athi and Kapiti. Significant lava plains overlying Nairobi city are the Athi plains and the Northern section of Kapiti plains. The plains are relatively flat and sloping towards East of Nairobi city Centre and rising gently towards the Eastern margin of the Rift flanks. The drainage is parallel as a result of South Eastern sloping terrain around Westland area created by deposition of Kirichwa valley tufts outcropping in the valleys in Nairobi River.

Tsavo East National Park has rugged volcanic landscape. Compared to Tsavo West National Park, the topography is flatter and with dry plains across which the Galana River flows. The area topography is dominated by gentle undulating and extensive plains that are often interrupted by hills with their associated foot slopes in the South-West and West. In the North-West and South-East, undulating uplands border the plains. Broken by the sinuous Galana River, the area also has the seasonal Voi River in the southern corner of park and the Tiva River which meanders in the remote northern reaches. Special physical features include the Yatta Plateau which rises to about 1200m above sea level developed from various types of parental material (Titus, 2020.)

3.1.3 Sampling site characteristics in Nairobi Suburb

Three sites were selected for study in Nairobi suburb. These were Ondiri swamp and Alliance Girls School in Kikuyu constituency west of Nairobi and Muthangari Estate in the proximity of city Centre. Ondiri swamp is a highland bog whose major vegetation included reeds (Phragmites sp.), cattails (*Typha latifolia*) and water grass (*Vossia sp.).* The area is surrounded by built with residences, service infrastructure and businesses in Kikuyu town. The watershed is dominated by farmland with pasture grass and crops as well as scattered bushes and agro-forestry trees. The swamp is a major source of domestic and farm water for the local community. Ondiri Swamp is the only ground water source in the catchment and it feeds River Nairobi, which drains into the Athi River basin and finally into the Indian Ocean (Fig 2)

Alliance Girls school is a learning institution consisting of built environment e.g. classrooms, hostels, staff quarters, playing ground and pasture fields, swimming pools, poultry and dairy farms etc. Vegetation associated to hunting owl includes; Annual and perennial crops, e.g., vegetables, Maize crops, Napier grass, abandoned bush lands and planted woodlands of Eucalyptus trees suitable for owl roosting and nesting.

Muthangari was one time covered by indigenous trees in the year 2005. This habitat was favorable for Barn Owl roosting and nesting, which made the previous pellets available for this study. But currently the place is dominated by residential buildings, infrastructure networks, public and private offices and no owls roosting or nesting sites were detected during the current field survey. The remaining vegetation includes**:** a few abandoned bush lands yet to be established, dominated by *Lantana camara*, numerous farmlands consisting of perennial and annual crops, grazing field (grasslands*)* and scattered woodlands of Eucalyptus trees that are limited along the river banks and some residential compounds.

Figure 2: Ondiri swamp - Barn Owl hunting area with dense floating aquatic vegetation suitable for rodents and amphibians.

3.1.4 Sampling site characteristics in Tsavo East National Park

Rhino sanctuary and Trailer Sites were covered by grasses and other herbs and sometimes with evergreen or deciduous trees or shrubs, which are either very scattered or in small isolated groups, forming a dense or thin carpet on the ground or in clumps or tussocks, forming a continuous ground cover**.** Grasses species in these areas include*: Brachiaria deflexa, B. leersioides, Brachiaria sp. with scattered Cyperus obtusifloru*s and *C. giolii*.

Workshop and residence were woodland habitats that consisted of open cover of trees, grasses and herbs. Herbs formed the dominant ground cover consisting of perennial and annual species which have been considerably reduced by the activities of elephants and fire. These habitats were dominated by *Commiphora-Lannea-Boswellia Sterculia, S. africana, S. rhynchocarpa, and S. stenocarpa*. Other associated species include, *Cassia abbreviata ssp. kaessneri, Delonix elata, Platycelyphium voense, Melia volkensii, Acacia tortilis ssp. spirocarpa, A. reficiens ssp. misera* and *A. thomasii with Adansonia digitata* as an occasional emergent.

3.1.5 Characteristics of habitats used by owls in the past in Tsavo East National Park

Riverine Forest along the Galana River was hosting owls in the past, but no owl nest sites were found during the present survey. Owl observations and pellets were frequently recorded in this part of Tsavo East National Park. Pellets suspected to be of Vereaux's Eagle Owl had been previously retrieved in the year 2013. But the owls appeared to have migrated away to unknown sites. The forest consisted of two vegetation types: Palm stand of *Hyphaena coriacea*, heavily branched palms of up to15m. tall. There was also a thin line of scattered short trees of *Acacia elatior.* and closed stand of ever-green bushland of succulent shrub of *Suaeda monoica* (Fig 3)

Figure 3: An overview of an important habitat for owls: A palm forest and evergreen undergrowth on the sandy shores of Galana River in Tsavo East National Park, Kenya.

Another important habitat for owls in Tsavo National Park was a Swamp Forest bordering River Voi. This forest consisted of a few dominant tree species, such as *Dobera glabra, Newtonia hildebrandtii var. hildebrandtii*, several species of Acacia and the conspicuous sausage tree *Kigelia africana.* There were also other conspicuous but sparse tree species such as *Albizia glaberrima var. glabrescens, A. zimmermannii, Feces ingens, F. sycomorus, Tamarindus indica and Terminalia kilimandscharica.*

3.1.6 Small mammal community and other forest fauna in Nairobi area

Small mammals in Nairobi metropolitan are distributed along the fragmented habitats. These include residential areas, farmlands, grazing fields, bushlands and protected green space which help to conserve biodiversity. Protected green spaces include: Ololua forest, Nairobi National park, Karura forest, Ngong forest, Nairobi arboretum and Nairobi City Park. Small mammals and other large mammals previously documented by other scholars in Nairobi area are given in (Appendix 2)

3.1.7 Small mammal community and other forest fauna in TENP area

Tsavo East National Park is a haven for Kenya's northern and southern species. The park is one of the most extensive protected areas in Kenya and has more biodiversity than any other park within the country**.** The park is a home for majority of large mammals and variety of small mammals that are highlighted in (Appendix 3)

This study was conducted between December 2020 and August 2021. The study sites were described in details so as to capture the key environmental features that could influence small mammal densities and foraging behavior of the target owls. Identification and location of owl nests and roosts were done through inquiries and information given by locals, rangers, scientists and through follow ups from previous collections deposited in the National Museums of Kenya. Sampling locations were recorded by GPS, using geographical coordinate system. Owl pellet collections and small mammal live trapping were conducted simultaneously in different habitats, seasons and in the two study sites.

3.2.1 Occurrence of nest sites and owl species identification in Tsavo

Residence: A pair of barn owl was nesting inside a chimney in a rarely used house in one of the ranger's camp in a woodland habitat. Accumulation of pellets and feathers inside the chimney and the floor of the house is a clear indication of owl species (Appendix 5a).

Workshop area: The Barn owl nest was confined in a narrow crevice inside a ceiling in a motor vehicle workshop close to Tsavo East National park administration block surrounded by woodland habitat. A pair of barn owls were often seen roosting on top of the rafters during the day and the pellets were dropped on the workshop floor (Appendix 5b).

Trailer: Barn Owl was nesting in a tree cavity/tree hole in grassland habitat. A barn owl was also seen leaving the nest and presence of pellet and feathers confirmed the owl species (Appendix 5c).

Rhino sanctuary: This consisted of four watch towers where barn owls were nesting in grassland habitat. The watch towers consisted of a series of steps for easy access to the tower platform and presence of large accumulation of pellets and feathers inside the tower platform were clear evidence of barn owl occupancy. This was also confirmed by a single Barn Owl seen taking off from one of the watch towers (Appendix 5d).

3.2.2 Occurrence of owl nest sites and owl species identification in Nairobi area

Alliance Girls School: A pair of spotted Eagle Owl (*Bubo africanus*) together with two chicks (owlets) were roosting at the top of a bell tower inside the school compound, where a school bell had been installed. According to the information given, owls have been occupying the same place for many years. A large accumulation of pellets and feathers confirmed a long occupancy of the species. The tower has a series of metal steps for climbing for easy access to the owls nesting platform (Appendix 6a)

Ondiri swamp: A pair of owls was nesting inside the ceiling of a 2 storey residential building, having an opening at roof ledges in a place close to the swamp habitat. Identification of the owl species was based on a pair of barn owls seen escaping from the house, presence of the feathers mixed with pellets inside the ceiling was also a clear indication of barn owl species occupancy (Appendix 6b)

Muthangari: A pair of Barn Owl was roosting inside a chimney in a house that was left unoccupied for a while in residential area in the year 2005 when previous pellets were collected. Nest identification was confirmed through the information obtained from the owner, who had occasional visits to the house. Accumulation of large disintegrated pellets deposited for many years and presence of feathers confirmed the Barn Owl species.

3.3 Sampling of owl pellets from different sites

A total of 907 complete owl pellets consisting of Barn Owl and Spotted Eagle Owl were analyzed during this study. Of these, 483 pellets were from Nairobi area; composed of 371 Barn owl and 112 Spotted Eagle owl pellets. A total of 424 Barn Owl pellets were collected from Tsavo East National park. No Spotted Eagle Owl pellets were obtained from this area because no nests or roost sites were identified. Disintegrated Barn Owl pellets collected in 2005 from Muthangari Nairobi were also analyzed for this study, as no complete pellets were available. However, no more pellets were collected during the present study as efforts to relocate the Barn Owl nest or roosts were unsuccessful. Additional collection during the present study were designed to facilitate comparisons and therefore obtain useful information about changes in the structure of local population of small vertebrate communities in relation to changing habitat conditions.

In Nairobi, Pellets were collected in two seasons (wet and dry) from December 2020 to May 2021 from Ondiri Swamp and Alliance Girls School. In TENP, pellets were collected from April to August 2022. Atotal of 258 Pellets were collected in grassland area (Rhino Sanctuary and Trailer) during the wet season (April 2021),120 complete pellets from first tower in Rhino Sanctuary and 138 pellets from trailer. Rhino sanctuary consisted of 4 watch towers, the 3 other towers contained a huge accumulation of old and disintegrated pellets. Disintegrated and old pellets collected from the 3 towers were stored at NMK for further tarphonomic studies. No fresh pellets or any owl were seen in these towers during the survey. However, it was unclear if the Owl seen taking off from the first tower was involved in depositing all pellets in the 4 watch towers. No pellets were collected during dry season (August 2021) from trailer and Rhino sanctuary, because by then owl had migrated to unknown sites and efforts to relocate them were in vain.

In contrast Barn Owl pellets in TENP woodland area (workshop and residence) were collected in the two seasons as owls were found nesting throughout the two sampling seasons. A total of 166 pellets were collected from the area, in the two seasons; 91 pellets from residence and 75 pellets from workshop. Inside the workshop, pellets were collected on the floor during the survey, since it was not possible to have a direct access to the owl nest , daily collections were done by a KWS Research scientist as they were being dropped on my absence.

3.3.1 Pellet analysis and prey identification

All Pellets collected were packed in plastic zip lock bags and transported to National Museums of Kenya's Osteology laboratory for analysis. They were first stored at room temperature until they were processed. In the laboratory photos of complete pellets were taken and given unique numbers. Measurements of complete pellets were taken by using sliding calipers and the total length and width were recorded in the data sheet. Each pellet was soaked individually in a jar containing water mixed with alcohol to kill pathogens and disintegrate the pellets for a day. Disintegrated pellets were passed over a two millimeter sieve and spread over a tray to dry. Prey remains compacted in hair were isolated manually using a pair of forceps (Fig 4). Identification of prey remains was based on comparative material available in Osteology laboratory, National museums of Kenya, aided by skeletal elements (cranial and post cranial) morphology. Minimum Number of Individuals (MNI) was determined based on paired elements and the size to ascertain taxonomic abundances. Most prey remains were identified to genus and some to species. Insects were identified to order level since the exoskeleton was the only portion not digested by the owls, posing problems in identification. However, other species with conspicuous and unique features were identified to species level.

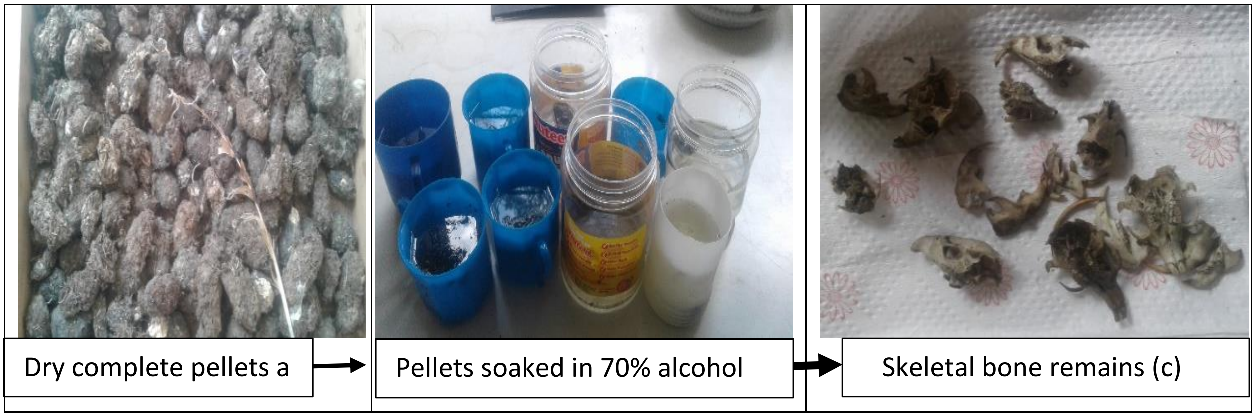

Figure 4: Laboratory steps in pellet analysis

3.3.2 Small mammal trapping

Trapping was conducted in owl foraging habitats in two seasons, including when the owls were absent during the second fieldwork. This was conducted in all habitats surrounding the roosting/nesting sites (within 2-5 km around the site). Transects were laid on the selected microhabitats and a combination of Sherman live traps and Snap traps were set. Each sampling point consisted of two trap station (one Sherman and one snap trap) (Fig 5), laid at 5m from each other. They were baited with a mixture of oats., and peanut, were inspected once a day early in the morning, left open for 3 consecutive days and moved to the next habitat. Trapping effort of about 60-104 trap nights in different habitats were employed for capturing small mammals. Most captured animals were identified to genera and a few to species level following (Kingdon, 2004) and using National Museums of Kenya Mammalogy section reference collection and Mammal species checklist.

Information on every captured animal was recorded into a standard data sheet: date, site, habitat, season, species name, abundance, sex, age class, body mass, individual body measurements i.e. head - body length in mm, tail length in mm, hind foot length, ear length to the nearest mm, recorded (Happold & Happold 1990). Specimens were prepared as scientific voucher specimens in the form of skins and skeletal remains which was preserved as museum reference collection (fig 6)

Figure 5:Sherman set along a rodent path and Snap trap placed in an open patch to trap small mammals in the study area

Figure 6 :Voucher specimens of Gerbilliscus sp. prepared from samples collected in Tsavo East National Park

3. 4. Data Analysis

Total number of each prey individual from pellets were recorded as Minimum Number of Individuals (MNI). The minimum numbers were drawn from the element with the most abundant number of specimens in each of pellet samples taking into account side in the body (left or right). Diet composition was computed as a percentage of prey individuals, by dividing the frequency of occurrence of each prey category by the sum of all the frequency of occurrence in the diet of the owls. Mean consumption was computed as:

Mean MNI = Total number of individual prey items

Number of distinct Taxa

Data were presented as Mean ± SE. Food niche breadth (FND) was estimated according to Levins (1968):

Food Niche Breadth = $(\sum Pi^{2})^{-1}$, where, Pi is the proportion of prey i in the owl diet.

Standardized measures of niche breadth were obtained on a scale of 0 to 1 using the formula

$$B_A = \frac{B-1}{n-1}$$

where B_A = Standardized niche breadth and n-number of prey items found in the diet

The food niche overlap values between owl species and in different landscapes were calculated using Pianka's index (Pianka 1986):

Niche Overlap Index C= ∑ (PijPik) / √ [∑Pij2 Pik2]

where, Pij and Pik are the proportion of prey species i in the diet of predator j and k respectively. An index value of 0 means no overlap and 1 means complete overlap in the diet of the two owl species.

The difference in the mean consumption for owl species was estimated using paired sample t-test. Comparisons of prey items in the diet of owls and those obtained in trapping were computed using chi-square test for independence. Differences in prey diversity obtained from owl pellets in different habitats were calculated using Shannon wiener diversity indices:

Shannon-Weiner Diversity Index H, = -∑ (Pi) (log P).

Where H represent Index of species diversity and Pi=ni/N where ni is the individual of a species and N is the total number of individuals of all species.

Diet diversity between the sympatric owl species was computed using Margalef's Diversity Index. Overall variation in prey items in different habitats, sites and seasons were tested using one –way ANOVA. Variation in diet of barn owls occupying different habitats in the same geographical area were estimated using Mann-Whitney U Test drawn from PAST Statistical Program for windows (version 4). Levels of significance for all tests conducted were set at $p = 0.05$. Tests results were considered statistically different if $\alpha < 0.05$. The data were illustrated with tables, figures and photographic images.

CHAPTER FOUR: RESULTS

4.1 Owl pellet descriptions and diet composition across habitats

There was notable variation in pellet morphology for each particular species both in color, size and shape depending on number and size of prey consumed. This was important for owl species identification. Mean consumption of Barn owl 795 pellets collected from two sites was mean± SE (38.49 ± 0.38) and 112 pellets for spotted eagle owl was Mean± SE(42.35 ± 1.08) (Table 1**).** Many prey items consisted of small sized prey items while pellets with a single prey item normally comprised of a larger prey species consumed.

Table 1: Comparison of pellet morphometry of Barn owl and Spotted eagle owl.

Pellet description	**Barn Owl**	**Spotted Eagle Owl**
Mean length (± SE mm)	38.49 ± 0.38 (N=795) Range: 5.8 to 82.1 Prey/pellet: 1 8	42.35 ± 1.08 (N=112 Range 16.8 to 72.8 Prey/pellet = 1-4
Mean width (± SE mm)	24.94 ± 0.21 (N = 473) Range = 12.8 to 46.4	28.31 ± 0.88 (N=112) Range = 9.7 to 59.2
Colour	Black	Greyish
Density and Shape	Very compact and oval	Loosely packed and round-oval

Barn Owl pellet

Spotted Eagle Owl pellet

4.1.1 Dietary comparison between the Barn Owl and Spotted Eagle Owl in Nairobi

A total of 32 prey species consisting 1106 individual prey items were identified in Nairobi through analysis of Barn Owl pellets retrieved from Ondiri Swamp and Spotted Eagle Owl pellets at Alliance Girls School. 23 species consisting of 798 individuals, were derived from 371 Barn owl pellets retrieved from Ondiri swamp. 23 species consisting of 308 individuals were recorded through analysis of 112 spotted eagle owl pellets. Small mammals were the predominant prey items for both owls. However, the consumed proportion of small mammals were higher in the Barn Owl (98.8%) than in the Spotted Eagle Owl (84.7%). Among rodents *Mus* was the principal prey comprising of 23.6% of the Barn Owl diet. The species *Rattus rattus* was the predominant prey species in diet of the Spotted Eagle Owl consisting of 14.9% of prey species. Shrews of the genus *Crocidura* were the second most abundant prey species consisting of 23.4% for Barn Owl and 10.7% for Spotted Eagle Owl diets. (Appendix 7**).**

The mean consumption was computed to be Mean±SE (36.2 ± 11.95) for Barn Owl and that of Spotted Eagle Owl to be Mean±SE (13.39±3.04). Diet breadth for Barn Owl was estimated to be (DB= 6.708) with standardized niche breadth estimated to be (BA= 0.2718), while that of Spotted Eagle Owl was estimated to be (DB=10.693) and standardized niche breadth estimated to be (BA=0.440). This suggest that Spotted Eagle Owl has a wider niche breadth compared with that of a Barn Owl. However, Pianka's niche overlap calculated to assess the food similarity of the two owls revealed 62% (Index=0.62) dietary overlap between the two species. Suggesting that the two species do not have a complete diet overlap but shares more than half of the resource available to them.

Margalef diversity index was computed to examine the difference in the diversity of diet of the two species. Marglef index confirmed that there was a higher diet diversity in Spotted Eagle Owl (Margalef=3.839) than for the Barn Owl (Margalef = 3.292). Shannon wiener index also confirmed a higher diversity (H=2.567) in spotted Eagle Owl than (H=2.201) in Barn Owl

4.1.2 Barn owl diet composition in Tsavo study area

A total of 424 pellets were retrieved from four Barn owl nesting sites in Tsavo East, two nest sites were in woodland and two others in the grassland. From all the 4 nests, 30 prey species consisting of 1489 individuals were identified. Atotal of 258 pellets retrieved from woodland, yielded 17 prey species comprising of 527 individuals while 166 pellets retrieved from grasslands yielded 28 species comprising of 962 individuals (Table 3). Difference in mean diet composition of the Barn Owl in the four nests were significant; woodland means (workshop=15±8.720, residence = 25±9.454) and grassland means (Trailer= 29±15.983, Rhino sanctuary= 14±4.442) respectively (Fig 7). Mann-Whitney was computed to evaluate the general differences in the two habitats. The test result for Mann-Whitney obtained pooled data revealed significant difference in the diet of owls occupying these habitats ($T=158.5$, $p<0.05$).

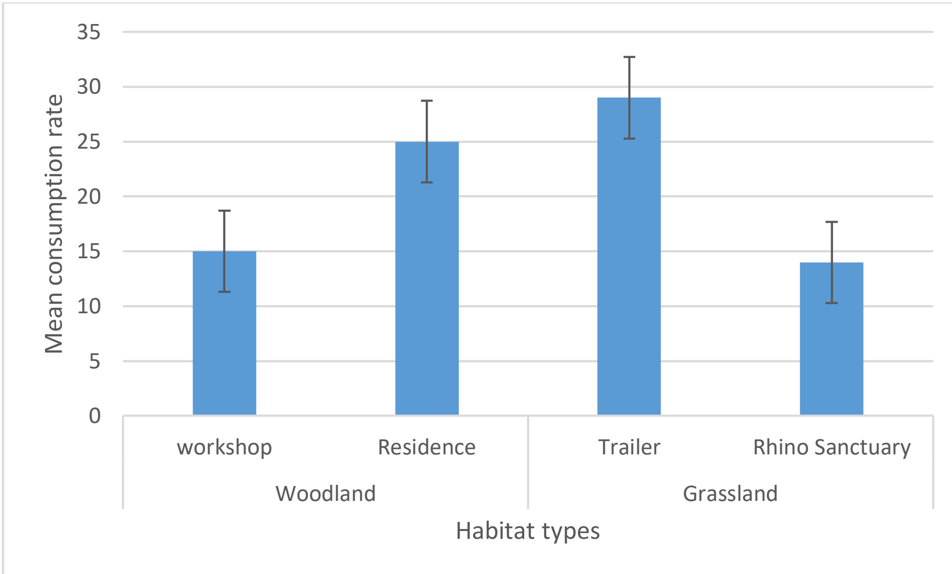

Figure 7:Mean ± (SE) obtained from prey MNI of four barn owls residing in woodland and grassland habitats in TENP.

Rodents formed the principal prey in both habitats consisting of 62.2% in woodlands and 59.6% in grasslands, followed by shrews at (34%) in woodland and (19.2%) in grassland (Table 2)

Overall mean consumption for owls in the two habitats were pooled together and calculated as (32.94 ±14.07) in woodland and 33.17±14.73 in grassland, showing no significant inter-habitat differences. One-way ANOVA was computed to examine whether there was variation in diet composition of Owls in the two habitats in TENP. Results revealed the diet did not vary significantly in the two habitats ($F=0.04613$; ($df=1,29$); $P > 0.05$). A chi-square test was computed to evaluate whether barn owls' diets were independent of the habitats utilized. Test results revealed no significant difference in the diet of the owls occupying the two habitats ($\chi^2=117.2$, $df=1$ $p>0.05$). Levin's niche breadth was computed to evaluate the difference in niche breadth of barn owls within the two habitats. Standardized niche breadth revealed wider niche breadth for woodland owls ($B_A=0.219$) than the grassland owls ($B_A=0.123$). Comparisons of prey items using diversity indices confirmed that grassland owls consumed a higher diversity of prey items ($H=2.023$) than woodland owls ($H=1.72$)

Table 2:Diet composition of Barn Owl in woodland and grassland habitats in TENP presented in MNI and percentage (MNI)

	Prey Taxa	Woodland		Grassland	
		Frequency	(%)	Frequency	**(%)**
Rodents	*Mus sp*	59	(11.2)	17	(1.8)
	Dendromus sp	153	(29)	395	(40.9)
	Mastomys sp	35	(6.6)	18	(1.9)
	Arvicanthis sp	67	(12.7)	48	(5)
	Gerbilliscus sp	12	(2.3)	70	(7.3)
	Acomys sp	1	(0.2)	11	(1.1)
	Rhabdomys sp	1	(0.2)	15	(1.6)
Shrew	*Crocidura sp*	179	(34)	185	(19.2)
Chiropteran	*Cardioderma sp*	2	(0.4)	5	(0.5)
Aves	*Pycnonotus sp*	4	(0.8)	10	(1)
	Aplopelia sp	2	(0.4)	4	(0.4)
	Tadarida limbata	2	(0.4)	0	0
	Plocepasser sp	0	(0)	4	(0.4)
	Miirafra sp cantillans sp	0	(0)	8	(0.8)
	Serinus sp mozambicus sp	0	(0)	1	(0.1)
	Turdus sp	0	(0)	7	(0.7)
	Dioptrornis sp	0	(0)	1	(0.1)
	Colias sp	0	(0)	4	(0.4)
	Oena capensis	0	(0)	1	(0.1)
	Acrocephalus	0	(0)	1	(0.1)
	Nycteris sp	0	(0)	1	(0.1)
	Ploceus sp	0	(0)	3	(0.3)
	Apus sp	0	(0)	1	(0.1)
	Spreo suburbs	0	(0)	0	(0)
Insects	*Orthopteran*	6	(1.1)	60	(6.2)
	Decapoda	1	(0.2)	75	(7.7)
	Coleopteran	2	(0.4)	13	(1.3)
Amphibian	*Bubo sp*	1	(0.2)	1	(0.1)
	Rana sp	0	(0)	1	(0.1)
	Anura sp	0	(0)	1	(0.1)
Reptilia	*Lacerta sp*	0	(0)	1	(0.1)
Total	**30**	**527**	**(100)**	**962**	(99.5)
	No .pellets	**258**		**166**	
	MEAN ± SE	**32.94±14.73**		**33.17±14.73**	

4.1.3 Comparison of diet composition of Barn Owl between Nairobi and Tsavo sites

A total 41 prey species consisting of 2285 prey items were identified from 677 Barn owl pellets collected from the two study sites. The 23 prey species consisting of 798 prey individuals from Nairobi and 30 prey species consisting 1489 prey items in TENP. Small mammals (rodents and shrews) were predominantly consumed by all the owls in both sites, comprising of 97.7% (N=15) in Nairobi and 85% (N=8) in TENP (Appendix 8).

The mean consumption of barn owl in the two study sites were (19.0714±6.800) for Nairobi and a pooled mean consumption from 4 nests (36.3171 ±15.97) for Tsavo East. Diversity indices were marginally higher in Nairobi (H = 2.201, J =0.6924) than in Tsavo (H = 2.015, J = 0.59). Standardized niche breadth revealed that the barn owls in Nairobi had broader diet niche breadth (DB = 0.272) than Tsavo (DB = 0.127). Further, One-way ANOVA results indicated that there was significant variation in prey items consumed by the barn owls from both sites (ANOVA F = 9357 df (1, 40), $P<0.05$).

4.1.4 Diet similarities and prey utilization by Spotted Eagle Owl in Nairobi and Barn Owl in Tsavo

Although Spotted eagle pellets were only collected in Nairobi, its diet was compared with barn owls diet in TENP. Despite inhabiting different geographical zones, the two species exhibit some slight similarities in food habits. Among the prey categories consumed by both owl species, Small mammals dominated their diet, represented by four species (n=4) of the genus *Mastomys Mus, Acomys* and

Crocidura. They constituted of 75 % of the Barn owl diet in TENP and 81 % in Nairobi Spotted Eagle Owl diet **(**Fig 8**).**

Mean consumption of Barn Owl in TENP was 19.96 ± 14.4523 and that of Spotted Eagle Owl diet in Nairobi was 20.08 ± 15.4504. Computation of number of individuals using student t-test, revealed no significant difference in prey items utilized by the two species of owls occupying different ecological regions **(**$t_{2,5} =$,0.00567, P>0.05*)*. Levin's standardized niche breadth was greater in TENP barn owls (DB= 0.178) than with Nairobi Spotted Eagle Owl (DB=0.115).

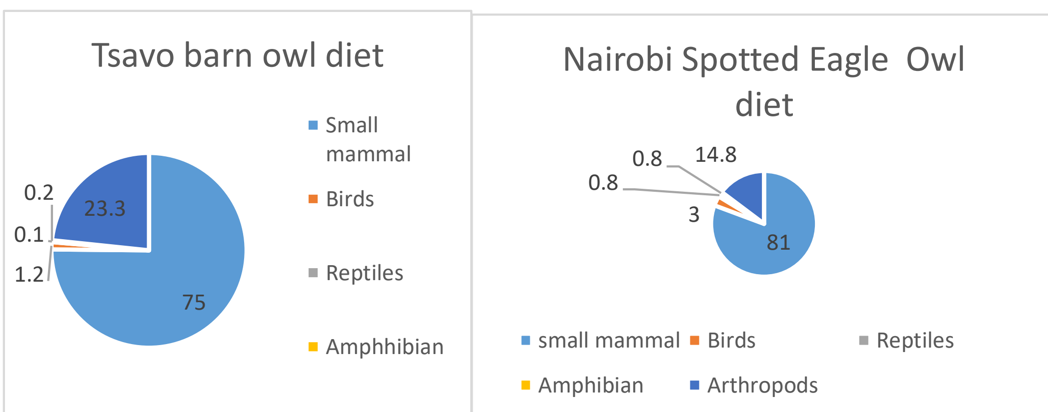

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Figure 8: Percentage comparison of prey items consumed by Barn owl and Spotted Eagle Owl in the two study areas

Table 3: Summary of statistical analysis for each of the owl samples (i.e. Mean consumption, Diet breadth in the two study sites.

Owl Species	Site	Location	Number of Pellets	Mean±SE	Diet Breadth (Db)	Diversity (H)
Barn Owl	Nairobi	Ondiri Swamp	371	19.0714±6.800	6.708	**2.201**
Spotted Eagle Owl	Nairobi	Alliance Girls School	112	13.39±3.04	10.693	**2.567**
Barn Owl	TENP	Rhino sanctuary, trailer, residence &workshop	418	36.3171±15.97	0.127	**2.015**

4.2 Seasonal variation in the owl diet

4.2.1 Seasonal diet variation in Nairobi area

A total of 483 Barn Owl and Spotted Eagle Owl pellets were collected from Nairobi suburbs in two seasons (between December and May,2021). These yielded 32 species consisting of 1106 individuals. A total of 171 Barn owl pellets were collected during the dry season which yielded 17 species of 412 individuals; while 200 wet season pellets yielded similar prey items of 17 species consisting of 385 prey individuals in the year 2021. Atotal of 62 Spotted Eagle pellets were collected during the dry season, which yielded 21 species consisting of 218 prey individuals, while 50 wet season pellets yielded 17 species consisting of 124 individuals. Small mammal formed the principal food prey for both species in the two seasons. These consisted of 98.4%(N=12) in the dry season and an increase in consumption to 99.6 % (N=15) in the wet season for Barn Owl. In contrast, high consumption of small mammals was detected for Spotted Eagle Owl in dry season 80.5 % (N=10) than in wet season 53.3 % (N=9) (Appendix 9).

Difference in mean consumption of prey items for Barn Owl was slightly greater i.e. Mean±SE (13.28 ±4.94) during the dry season compared with Mean±SE (12.45 ±4.56) in the wet season. Mean consumption for Spotted Eagle Owl also was greater during the dry season Mean±SE (9.6087± 2.15) compared with the wet season 5.26±1.81. A paired-t-test confirmed that consumption of the prey items was not significant in the two seasons ($t_{1,32} = -0.0117$, $p > 0.05$) and there was no significant variation in prey items in the diet of Barn Owl in the two seasons as calculated by one-way ANOVA (F=1.097, (df=1,32) p>0.05). However, the ANOVA test, revealed significance statistical difference in the diet of Spotted Eagle Owl in the two seasons (F=1.9891, (df=1,32) P=0.05)

4.2.2 Seasonal diet variation of Barn owl in Tsavo east study area

It should be noted that no pellet was available for collection in the second visit (dry season) in the two nests in TENP where pellets were collected during the rainy season i.e. Rhino sanctuary and Trailer, as a result of barn owls' migration to unknown sites. Therefore, Seasonal diet assessment was evaluated on sites with continuous seasonal nesting.

Two pair of individual barn owls nest sites present in woodland habitat (workshop and residence) were observed to have a continuous nesting, therefore valid for seasonal pellet collections. In April 2021, 58 wet season pellets were collected from Barn Owl at residence which yielded 14 species of 397 prey items and 34 dry season pellets from the month of August yielded 9 species of 92 prey items. Further 16 wet season pellets were collected during Apr 2021 inside the workshop which yielded 8 species of 50 prey items and 24 dry season pellets collected in August yielded 8 species of 130 prey items. Analysis of the assemblages from the two sites in Tsavo show almost similar diet detection in both seasons differing only in proportions. The genus *Crocidura* was the predominant prey item during the dry season while *Dendromus* was predominantly preyed upon during the wet season (Fig 9 & 10)

One-way ANOVA was computed to evaluate whether there was seasonal variation in prey consumption of the two individual owls occupying woodland habitats in TENP. Results revealed that there was no significant variation in the diet of barn owls in the two seasons occupying woodland habitats i.e. ($F=3.0508$, $df=1,26$, $P>0.05$) for Residence and ($F=0.6329$, $df=1,22$, $P>0.05$) for motor vehicle Workshop.

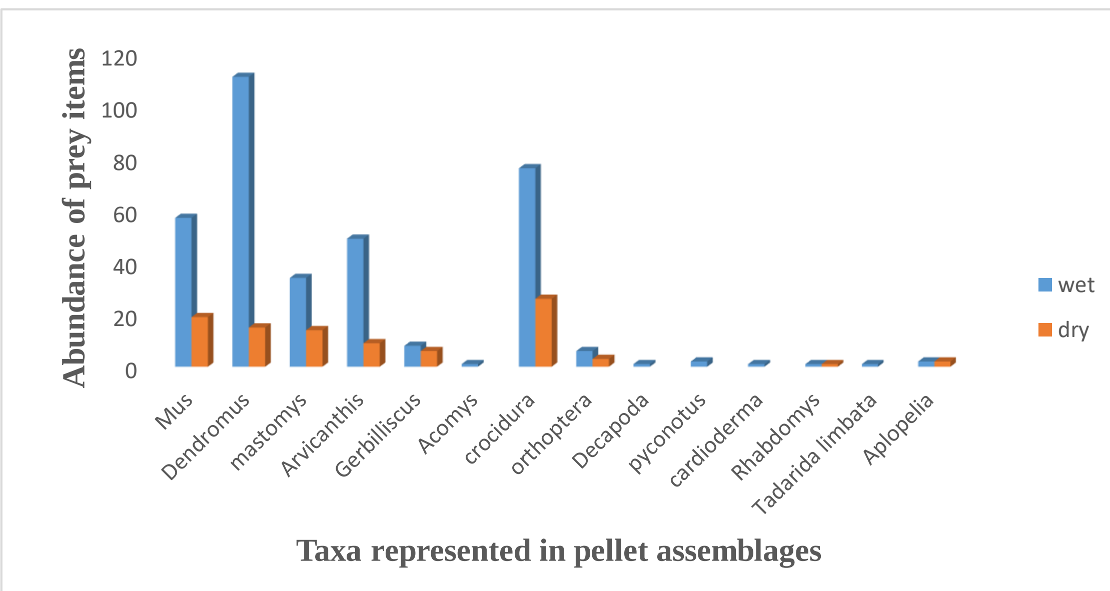

Figure 9:Seasonal variation of prey items for each taxon represented in pellet assemblages in the diet of Barn Owl living in residential building in Tsavo East National Park.

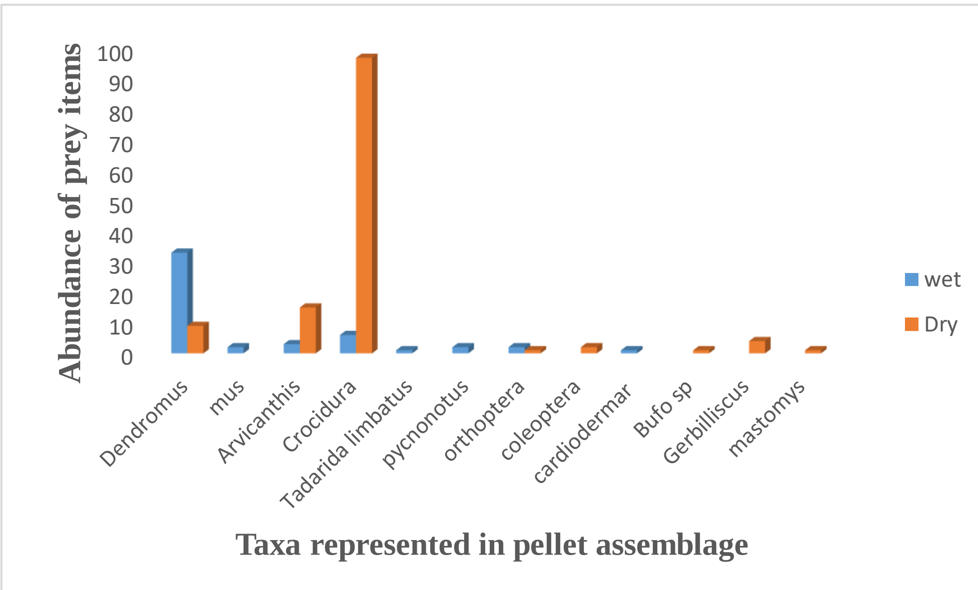

Figure 10:Seasonal variation of prey items for each taxon represented in pellet assemblages in the diet of Barn Owl living in a motor vehicle workshop in Tsavo East National Park

4.2.3 Seasonal diet comparisons of barn owls in the two study areas.

A total of 28 prey species were identified from 503 pellets in both seasons from the two study sites. Twenty-four prey species consisting of 638 individuals were identified during the dry season and 19 prey species consisting of 737 individuals during the wet season in the two study sites. Data from analysis of barn owls' pellets retrieved from two nesting sites (residential house and motor vehicle workshop) in TENP, were pooled together and results compared with Barn Owl prey items in Ondiri Swamp, Nairobi (Table 7). Small mammals formed the principal prey items in the diet of barn owls in the two seasons. However, proportion of small mammal differed per site and season. In Nairobi 98.4%

of small mammals were identified in the Barn Owl diet during the dry season while in TENP 96.3% were identified. During the wet season, small mammal consumption increased to 99.6% in Nairobi and 96.6% in Tsavo. A higher consumption of birds was identified during the wet season 1.5 % (N=2) than dry season 0.9 %(N=1) in TENP, while reverse detection was recorded during dry season 0.8% (N=4) than wet period 0.5% (N=1) in Nairobi. Arthropods were identified only during the wet season in Nairobi accounting for 0.3% (N=1), but in TENP arthropods were identified in both seasons with increasing consumption in the dry season 2.7% (N=2) compared with the wet season 1.7% (N=2) (Table 7)

Diet breadth was computed to evaluate the barn owls' diets in the two seasons and sites. Results from standardized niche breadth revealed that niche breadth for barn owl in Nairobi was slightly wider during the dry season (B_A=0.351) than in the wet season (B_A=0.323) while the reverse is true for Tsavo, a narrow (B_A=0.20) in dry season and considerably wider (B_A=0.375) for wet season.

Table 4:Seasonal diet comparisons of barn owls in the two study areas

	NAIROBI		**TSAVO**	
	Dry	Wet	Dry	Wet
Small mammals	98.4	99.6	96.3	96.6
Birds	0.8	0.5	0.9	1.5
Reptilian	0.2	0	0	0
Invertebrates	0	0.3	2.7	1.7
Total prey	**99.4**	**100.1**	**99.9**	**99.9**

Pianka's measure of niche overlap revealed 13% overlap in the diets of barn owls in dry and wet seasons. A few prey species were shared by the barn owls in Nairobi and Tsavo study sites

One-way ANOVA revealed that seasonal variation of prey items was not significant ($F_{3,12}$=0.042 P>0.05) in the two study sites.

4.3 Seasonal small mammal trapping survey across habitats

4.3.1 Seasonal small mammal trapping in Nairobi study area

Different habitats surrounding owl home ranges were considered sampling points for small mammal trapping survey. Data from different habitats with similar characteristics were pooled together in two seasons. Eight species of small mammal (rodents and shrews) were captured across the 5 habitats surveyed in Nairobi as shown in. *Lemniscomys sp* had the highest captures in both seasons consisting of 78 individuals recorded in all habitats except residential area, *Mastomys sp* followed the second with 74 individuals detected in farmland, Grassland and bushland. No detection of *Mastomys* in woodland and residential area. *Rattus rattus* was captured only in residential, farmlands and grasslands but not detected in bushland and woodland. *Mus* was captured in woodland, farmlands and bushland and no detection in residential and grassland. *Otomys* was the least species detected only in grassland following detection of one individual in both seasons. Among shrews *Crocidura* consisted of 33 individuals detected in bushland, woodland, farmland and grassland but no captures in residential area (Fig 11) Results of ANOVA test, revealed that there was significant difference between small mammal captures across the five habitats surveyed (F=3. 245.df=4, P<0.05)

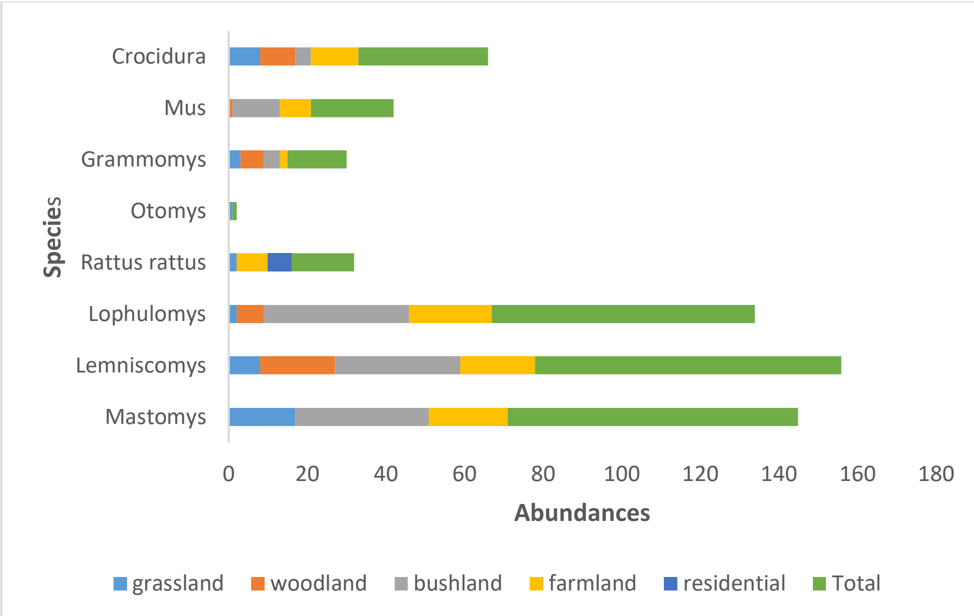

Figure 11:Small Mammal (Rodent and shrews) captures across habitats in Nairobi suburbs (Ondiri Swamp, Alliance Girls school, Muthangari suburb in Kenya.

Across all habitats the most abundant captures were in the bushland with highest captures of 125 individuals. Greater detection was made in the bushland during the wet season (N=75) than in the dry season (N=49). Farmlands mixed habitat yielded 91 individuals with greater detection achieved during the dry season (N=62) than in wet season (N=29). The lowest captures were made in residential areas with one individual detected in wet season and 5 during the dry season. Grassland and woodland had similar captures in wet season (23 each) and almost similar captures during the dry season,18 and 19 individuals respectively (Fig 12).

Mean captures across habitats were 15.63±5.84 in bush land, 11.375±2.94 in farmland.5.25±2.34 in woodland, 5.125±2.004 in grassland and 0.75±0.75 in residential areas. Shannon wiener diversity index revealed 1.513 in bushland,1.782 Farmland,1.355 for woodland,1.579 for Grassland and negligible value in residential area. This suggests that small mammal species diversity was highest in disturbed habitat (Farmland) and lowest in less disturbed habitat (woodland).

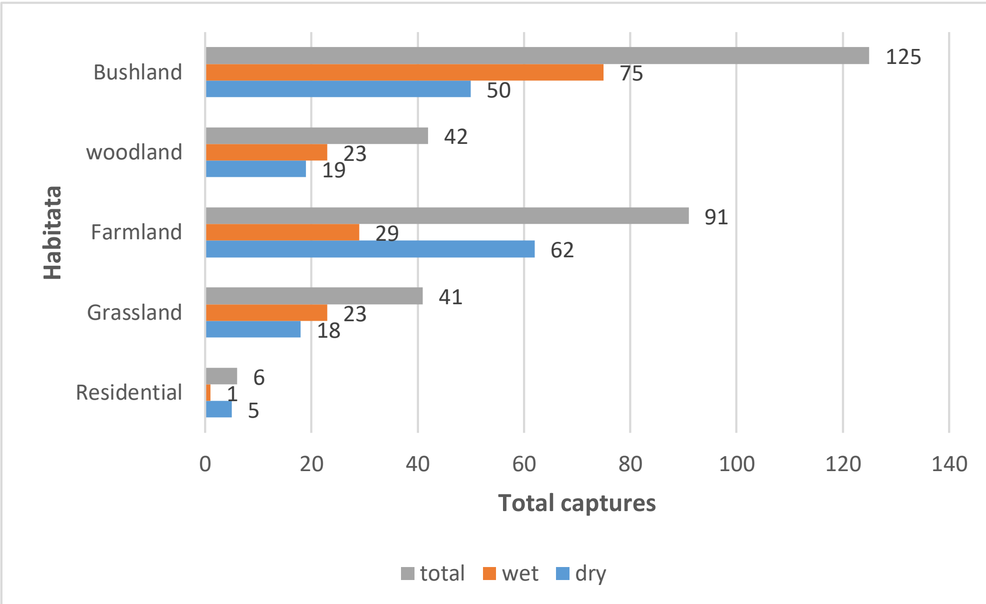

Figure 12:Small mammal (Rodents and shrew) captures across 5 habitats in two seasons combined in Ondiri swamp and Alliance Girls in Kikuyu and Muthangari Estate Nairobi.

4.3.2 Seasonal small mammal trapping in Tsavo East National Park

Live trapping in Tsavo was conducted in three habitats; woodland, grassland and riverine which were considered as owl foraging habitats. Riverine habitat was incorporated in the trapping survey despite the fact that no owl nest was identified. There were previous roost sites in the riverine forest at the past where owl pellets were collected in 2013, but during the present survey no nest/roost site was identified as a result of owl migration to unknown sites. Present trapping was to understand the diversity of the small mammal and possible cause of the migration.

Seven species i.e. C*rocidura*, *Acomys*, *Mus* and *Gerbilliscus sp*, *Gerbilliscus nigricauda*, *Mastomys*, *Arvicanthis* and *Mus* were captured. Small mammal captures depended on the habitat utilized (Fig 13).

Results estimates from ANOVA revealed that there was no significant variation in small mammal species across the 3 habitat sampled ($F=1.352$, $df=2$, $P>0.005$)

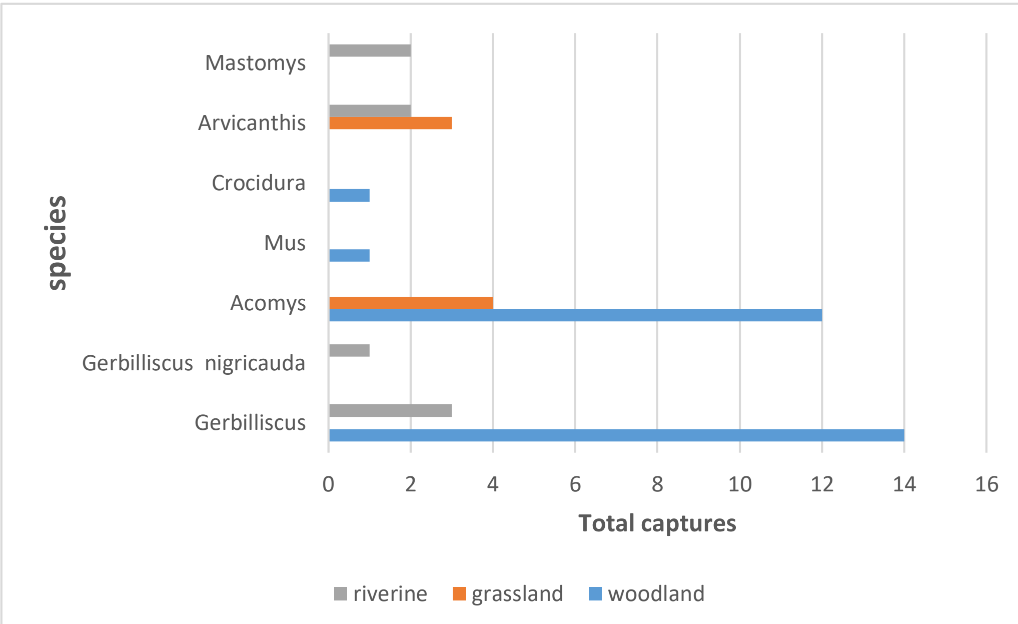

Figure 13:Small mammal (Rodent and shrew) captures across 2 habitats combined (Trailer, Rhino Sanctuary, Workshop and Residence) Tsavo East Kenya

Based on inter-habitat variation, woodland had high captures consisting of 28 individuals of rodent and shrews, greater numbers in the wet season (N=23) than dry season (N=5). Riverine was the second in small mammal abundances in the wet season (N=5) than dry season (N=4). Grassland had the least mammal captures having (N=7) during the dry season and none during the wet season(N=0**)** (Fig.14) Means captures for each habitat sampled were estimated to be Mean±SE (4±2.34) for woodlands, Mean±SE (1± 0.65) for Grassland and Mean ±SE (1.28±0.42) for riverine vegetation. Diversity indices were estimated to be (H= 0.9477) in woodland (H= 0.6829) in grassland and riverine (H=1.321).

Shannon wiener index results revealed that the Riverine forest habitat has high small mammal species diversity of all habitats surveyed in TENP.

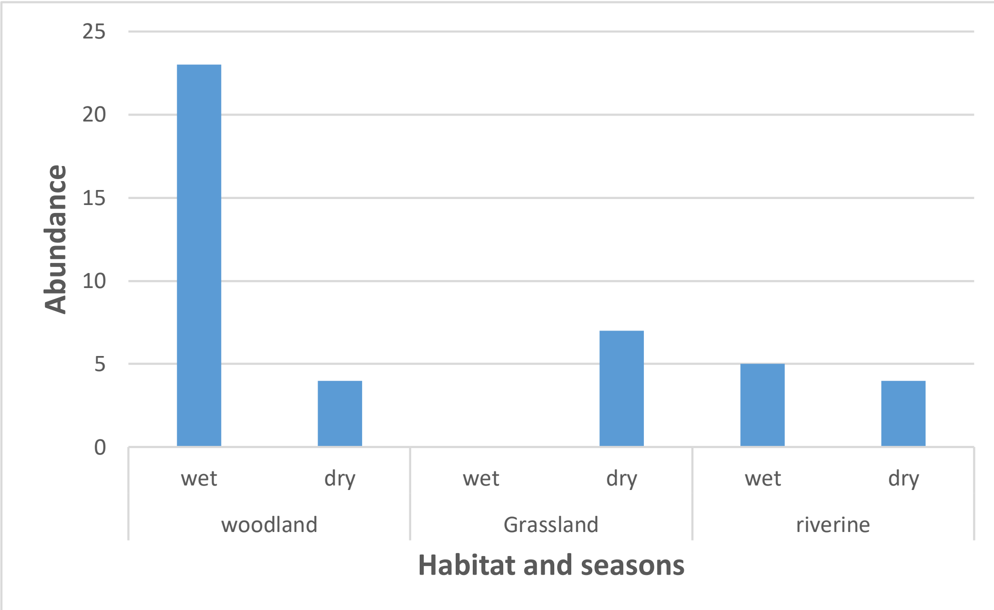

Figure 14:Small mammal (rodent and shrews) captured in two season across three habitats in Tsavo East National, Kenya

4.4 Comparison of small mammal prey remains and live trapping across habitats in the study areas.

Analysis of small mammals (rodent and shrews) from owl pellets were compared with those captured through standard live trapping survey across owl foraging habitats. Among small mammal, remains of chiropteran present in owl pellets were excluded from these comparisons because trapping methods used were inappropriate to capture bats. Data from owl pellets and field trapping collected in two seasons were pooled together across habitats in the two study sites. Data collection from different owl species and sites were treated independently. Test result by one-way ANOVA on pellets and trapping confirmed significant variation across habitats in all sites ($F=2.723$, $df=7$, $P<0.05$)

4.4.1 Comparisons of pellets and live trapping in Nairobi study area

A total of fifteen small mammal species were recorded in Ondiri swamp through analysis of Barn Owl pellets and live trapping surveys. Fifteen small mammals were identified from pellets and seven from live trapping. Eight rodents preyed upon by the Barn Owl were not detected in the trapping survey. However, small mammals detected in trapping were all identified in pellets but in different proportions (Table 8).

Mean frequency of small mammals' recorded by the two methods was calculated as Mean±SE 46.35± 14.6 in pellets and Mean ±SE (9± 5.86) in trapping. A paired T-test was conducted to evaluate difference in prey consumption in prey remains and live trapping survey. Results confirmed that there was significant difference in prey consumption by Barn Owl and live trapping conducted in Ondiri Swamp ($t_{2,14=}$2.68, $P<0.05$). Achi-square test was conducted to examine whether there is variation between the diet of Barn owl and live trapping in Ondiri Swamp, Nairobi. Results confirmed significant variation of prey remains in Barn owl diet and those obtained from trapping survey (χ^2=242.09, df=1, $P<0.05$), categorizing the species as a specialist.

Similar comparisons were conducted for the Spotted Eagle Owl in Alliance Girls School. Ten small mammal species were identified both in trapping and in prey remains. Pellet remains yielded 10 species consisting of 259 individuals while Trapping yielded 7 small mammal species consisting of 130 individuals.

Mean prey items in pellets and trapping were estimated to be Mean±SE (28.77± 14.07) and Mean ±SE (14.44± 7.57) respectively **(**Table 8**).** Estimation from two sample t-test confirmed that there were no significant differences in prey consumption by Spotted Eagle Owl and live trapping survey ($t_{2,9}$=1.44, P>0.05), categorizing the species as a generalist, preying upon what is available. Achi-square test also confirmed no significant variation with prey remains for Spotted Eagle Owl and those obtained in the live trapping survey (χ^2=180.24, df=1 P>0.05)

Table 5:Comparisons of prey remains in pellets and trapping from Barn Owl and Spotted Eagle Owl in Ondiri Swamp and alliance Girls school Nairobi presented as prey abundance for each prey category

Nairobi		**Ondiri Barn Owl**		**Alliance Spotted eagle owl**	
Taxa		**Pellets**	**Trapping**	**Pellet**	**Trapping**
Rodent					
Otomys		98	0	37	1
Rattus		54	2	46	9
Mastomys		49	8	20	38
Mus		188	15	34	5
Arvicanthis		3	0	0	0
Rhabdomys		4	0	0	0
Acomys		42	0	17	0
Thamnomys		9	0	36	0
Lemniscomys		35	21	2	48
Oenomys		1	0	0	0
Lophuromys		69	60	23	7
Tarchyorectes		5	0	11	0
Grammomys		2	3	0	0
Dendromus		42	0	0	0
Shrew					
crocidura sp.		187	2	33	22
Total prey	**15**	**788**	**90**	**259**	130

4.4.2 Comparisons of pellets and live traps in Tsavo East study area

A total of eight species consisting of 1298 small mammals were identified in TENP from 4 barn owl nests in woodland and grassland habitats. Analysis of Barn Owl pellets and live trapping survey was done for two seasons. Trapping identified very low prey categories compared to pellets. Of the eight species identified in owl pellets in grassland, only two species representing seven individuals were captured in trapping survey (Table 9).

Achi-square test was conducted to confirm whether there was variation in small mammal prey consumed by the barn owls in TENP and what was captured in trapping for the two habitats. Test results in grassland revealed no significant difference between small mammal prey and trapping survey χ^2 (7, N=766=130.22, P>0.05) and while significant variation observed in woodland habitat χ^2 (7, N=532=323.46 P<0.05).

A one-way ANOVA was conducted to evaluate whether there was variation in prey frequency between pellet and trapping in the two study sites. Results confirmed very significant variation in prey frequency in both prey remains(pellets) and live trapping in the two habitats (F=3. 022, d f=3, P<0.05)

Table 6: Comparisons of prey remains in pellets and trapped animal species across habitats in Tsavo East National Park

	Habitat				
	Grassland		Woodland		
Taxa	**Pellet**	**trap**	**pellet**	**trap**	**Total**
Dendromus	395	0	153	0	**548**
Rhabdomys	15	0	1	0	**16**
Gerbilliscus sp.	70	0	12	14	**96**
Arvicanthis	48	3	67	0	**118**
Mastomys	*18*	0	35	0	**53**
Acomys	*11*	4	1	9	**25**
Mus	17	0	59	1	**77**
Shrews					
Crocidura	185	0	179	1	**395**
Total	**759**	**7**	**507**	**25**	**1298**

4.4.3 small mammal dynamics from previous pellets in Muthangari, Nairobi

Comparisons were made on disintegrated Barn Owl pellets collected before this study from Muthangari in 2005 with the current live trapping. The aim was to assess whether previous small mammal species preyed upon by the owl are still encountered in the same habitat through trapping survey. Analysis of previous pellets showed significant difference in prey frequency and present trapping. Pellet analysis yielded 20 prey species consisting of 2118 individuals. Small mammals' species formed the principal prey in the diet of barn Owl comprising 68.13 % (N=8) (Appendix 1). Live trapping of small mammal species was conducted in dry and wet months, yielded 5 small mammals, 4 rodents consisting of 41 individuals and one shrew species representing 9 individuals. (Fig. 15)

Shannon wiener diversity index was computed to evaluate the diversity of prey in previous pellets and trapping. Results revealed higher diversity in previous pellet (H=1.88) than in present trapping survey (H=1.21). A chi-square test was conducted to test whether there was similarity in prey species consumed by Barn Owl in previous pellet and the current trapping survey. Results revealed no significant differences between the two data sets χ^2(3, N=931= 6.3292, p>0.05). Meaning Barn Owl consistently consumed the same prey species during this study period just as 17 years earlier in 2005. However, one-way ANOVA revealed significant statistical difference between the abundances of species consumed (F=10.91, df=1, 38, $p < 0.05$).

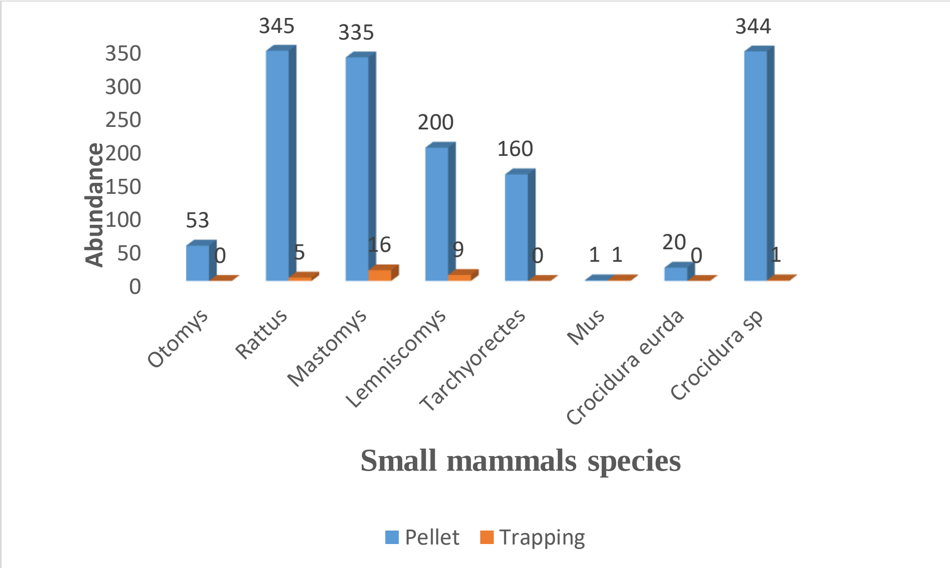

Figure 15:Comparison of 2005 Barn Owl prey remains and current live trapping in Muthangari area, Nairobi.

4.4.4 Small mammal species diversity

Data from pellet analysis together with the standard trapping surveys were pooled together to obtain a comprehensive species checklist list of small mammal documented in both study areas. And so far a total 18 small mammal prey species were documented by the two methods consisting of 4219 individuals in Nairobi and Tsavo East. Nine species from TENP comprising of 1,305 individuals and 16 small mammal species comprising 2914 individuals from Nairobi suburbs. These were represented by 2 orders and 3 families. The order Rodentia was the predominant food category in the two sites. (Table 10).

Shannon wiener diversity indices was estimated to evaluate which site was greater diversity of small mammals. Test results confirmed ,Nairobi to be more diverse (H=2.191) than the Tsavo sites (H=1.571)

Table 7:Small mammals' species occurrence and diversity documented by pellet analysis and live trapping surveys in Nairobi and Tsavo East National Park, Kenya

Order	Family	Species	Tsavo	Nairobi
Rodentia	Nesomyidae	*Dendromus sp*	548	42
	Muridae	*Rhabdomys sp*	16	4
		Gerbilliscus sp.	98	0
		Gerbilliscus nigricauda	1	0
		Arvicanthis sp	119	3
		Mastomys sp	55	553
		Acomys sp	26	101
		Mus sp	77	243
		Lophuromys sp	0	159
		Otomys sp	0	189
		Rattus rattus sp	0	461
		Thamnomys sp	0	45
		Lemniscomys sp	0	315
		Oenomys sp	0	1
		Tarchyorectes sp	0	176
		Grammomys sp	0	5
Soricomo pha	Soricidae	*Crocidura eurda*	0	20
		Crocidura sp	365	597
	Total	**18**	**1305**	**2914**

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Diet composition of the sympatric owls

This study results were largely consistent with previous owl studies that have reported a broad range of prey in the Barn Owl and Spotted Eagle Owl diet. Pellets collected from Barn Owl and Spotted Eagle owls were different in size, shape and color. The Barn Owl pellets were more compact and pure black in color. Variation in pellet size was a consequence of prey items consumed by the owl species. Average Barn Owl pellets size analyzed in this study are within the range of other studies 38.49 mm×24.94mm (Nadeem *et al*., 2012; Gichuki, 1987). More than one prey item in a single pellet normally consisted of smaller sized prey items, while a single prey item in one pellet was mostly of larger sized prey items. Other studies have reported similar variation in size of pellets as a consequence of prey items consumed (Kaunisto *et al*., 2017). Spotted Eagle Owl pellets were loosely packed and easy to disintegrate and thus needed careful handling. Average size for Spotted Eagle Owl pellets was a bit larger compared with Barn Owl pellets possibly due to the kind of prey items consumed. Similar patterns have reported large pellets as a result of insect consumption by the spotted eagle owl (Ali and Santhanakrishnan,2012).

A study of Barn Owl diet in Nairobi reported in this study resonates with previous study conducted in Nairobi's Karen suburb (Gichuki,1987). The genera *Mus*, *Acomys, Lorphuromys* and *Thamnomys* identified in Nairobi in the present survey were not reported in Gichuki, (1987). Further, the genera *Pelomys*, *Dasymys* and *Gerbilliscus* (- formally *Tatera sp*) previously identified in Barn Owl diet in Nairobi (Gichuki ,1987) were not identified in this study. Diet composition of owls is known to be shaped by prey availability, habitat type and hunting techniques (Ali and Santhanakrishnan, 2012). Therefore, diet variation may be attributed to differences in foraging habitats and habitat change between 1987 and 2021, following the fact that both owls were found nesting in residential buildings and closer to a swamp, which no longer existed in the current study period. The differences may also be attributed to dietary differences in microhabitats for hunting owls in the two localities (Karen versus Ondiri Swamp).

Based on pellets analyzed from Nairobi and TENP, it is apparent that owls consumed wide varieties of small vertebrates ranging from small mammals, birds, insects, reptiles and amphibians. This research revealed importance of small mammals, mostly rodents and shrews in the diet of Barn Owl and Spotted Eagle Owl. Although the dominant prey species taken by the owl species varied by location or habitat exploited. These results is comparable with similar other studies elsewhere that have reported small mammals as dominant prey group in the diet of the owls, (Hockey *et al*., 2005; Milchev, 2015 ;Torre *et al*., 2015). Other prey items such as birds, insects and Amphibians were preyed upon opportunistically in small amounts (Nadeem *et al*., 2012). High consumption of small mammal by Barn Owl was higher in urban moist habitats (Nairobi) than natural semi –arid landscapes (TENP). Low small mammal prey diversity in Tsavo likely reflects poor small mammal diversity of the area. Habitat conditions favors establishment of a rich small mammal fauna in Nairobi than in Tsavo. Greater diversity and patchiness of vegetation often results in a larger number of prey taxa (Lyman and Lyman, 2003).

No significant inter-habitat differences in the diet of Barn owls was realized in TENP in the two seasons despite the fact that, a wider diet breadth was detected in woodland than grassland habitats but higher diversity in grassland than woodland. A wider diet breadth in woodland habitat was a result of high consumption of small mammals available and a few insects compared with the grassland area. In contrast a higher diversity in grassland habitat was a result of Barn Owl consumption of wide range of prey categories in equal proportion to supplement the lower numbers of small mammal in this habitat (personal observation)

From the results, it’s therefore evident that Barn Owl in Tsavo consumed more of other prey categories due to low small mammal prey, which forced the species to resort to a more diverse diet to meet their energy requirements. Similar other studies have reported Barn owls occurring in unproductive, hot and dry parts of the globe have a tendency to rely less on small mammals while those from moist temperate zones have a tendency to specialize on them (Trigo, 2016). Small mammal in the genus *Tarchyorectes, Grammomys, Lophuromys*, *Otomys, Rattus*, *Lemniscomys*, *Thamnomy*s and *Oenomys* were preyed upon by Barn Owl in Nairobi urban landscape but not detected in Tsavo. Similarly, the genus *Gerbilliscus* was preyed upon by Barn Owl in TENP but no detections were made in Nairobi. *Gerbilliscus sp* is a dry land species and hence its presence in Tsavo barn owl diet was expected.

The genus *Mus* predominated the barn owl diet in Nairobi while the genus *Dendromus* was the dominant prey in Tsavo. This may follow the fact that, they are small in size therefore easy to capture. Several studies have reported *Mus sp* to predominate in agricultural fields and it is available in urban landscapes, prefers climbing sparse and low shrubs for seeds and its slow movement probably made it easier for the hunting owls (Wood and Singleton ,2015).

There were no Amphibians in diet of Barn owl in Nairobi during the study period; however, 0.3% was identified in Tsavo. A study in an urban environment in Namibia showed no presence of amphibian (Kopij, *et al.,* 2014). Another study conducted in Uganda along agricultural fields reported similar findings (Kityo, 2001). However, previous study in Nairobi reported high consumption of Amphibians in Barn Owl diet with a net decrease in shrew (Gichuki, 1987).

Consumption of bats prey in Barn owl diet was negligible in Nairobi and slightly higher detections were made in Tsavo. Other studies have not reported bats in Barn owl diet (Moysi *et al.,* 2018). This probably is due to a greater difficulty in capturing them compared to other mammalian prey or owls have low preference for them. The consumption of bats by Barn owl indicates its opportunistic feeding behavior. Obuch *et al*., (2016) reported that, Barn owl prey on chiropteran when they are abundant or easy to catch and when other prey species are lacking or harder to capture by hunting owls.

Negligible consumption of insects in Barn Owl diet was recorded in Nairobi with higher consumption in Tsavo. These results are also comparable with other studies that have recorded small proportion of arthropods in the diet of Barn owl (Moysi et al., 2018). Low frequency of birds was recorded in Barn owl diet in Nairobi and a slightly higher consumption in Tsavo. A similar study reported birds to have a much smaller share on Barn Owl diet (Roulin, 2015). It is therefore postulated that Barn owls may only increase birds' consumption to complement their food preference when rodents population decline. Findings from other studies have also concluded that, Barn owls may concentrate on birds when other prey are scarce (Ali and Santhanakrishnan, 2012).

Analysis of the barn owl's niche breadth showed a significantly higher value in Nairobi suburb than natural protected landscapes in Tsavo. This study is consistent with other similar studies in urban landscapes (Viganò *et al*., 2020) that have reported high frequency of small mammal to be a major contributor to higher niche breadth in Barn Owl diet. High niche breadth in sub-urban landscapes is caused by high consumption of commensal rodents associated with human activities such as *Rattu*s r*attu*s and *Mus* as additional exotic prey taxa in this landscape. Similar studies have reported an increase detection of commensal rodents increasing with urbanization within Barn Owl hunting habitats (Hind march and Elliott, 2015). Further increase of commensal rodents over time is an indicator of transformation of owl foraging habitats (Magle and Angeloni, 2011).

Diet analysis across habitats in Tsavo, showed greater proportion of small mammals in woodland than in grassland. Diet breadth was wider in woodland than in grassland meaning that owls present in woodland had more small mammal prey opportunities to choose from than grassland Barn owls, which chose to supplement with more of birds, insects, amphibians and reptilians not preyed upon by woodland barn owls. The differences in prey selection in the two study areas therefore appears to reflect the opportunistic hunting strategy of the Barn Owl in relation to the prey abundance and availability (Romano *et al*., 2020).

Analysis of spotted eagle owl pellets collected only in Nairobi suggested the species to be an opportunistic predator. Despite the fact that their diet is predominantly small mammals, high proportion of other prey categories particularly, Amphibians, insects and birds were preyed upon in contrast to what was preyed upon by the sympatric Barn Owl in Nairobi Ondiri suburb. Rattus *rattus* was predominating in the diet of the spotted eagle owl. Similarly, the genus *Rattu*s has been reported to predominate the diet of Spotted Eagle Owl in urban landscapes (Ali and Santhanakrishnan, 2012). This is evident that Spotted Eagle Owl plays a big role in controlling rodent population associated with human habitats. Almost similar consumption of Amphibians and insects were detected in the Spotted Eagle Owl diet. However, some studies have reported insects to be the principal prey followed by rodents in Spotted Eagle diet (Anwar *et a.,* 2021). Results in this survey confirmed the Spotted Eagle Owl to have a broader niche breadth than Barn Owl in Nairobi, therefore suggesting it to be a generalist. Similar patterns have been reported in an urban landscape for the same species (Kopij *etal.* 2014).

A 0.62 index dietary overlap between the Barn Owl and the Spotted Eagle Owl suggested that the two species are partitioning food resources amongst them with slight divergence of some food items. The differences in dietary overlap within the two species might be caused by the different foraging habitats, prey vulnerability, hunting techniques and most importantly difference in the body size. The two owl species were found in urban landscape, nesting significantly in different habitats: Barn Owl in a swamp and Spotted Eagle Owl in a school compound, this could be a consequence of the resource-based segregation, but not a consequence of asymmetrical interspecific competition.

It is therefore evident that competition exclusion will not occur when habitat overlap is low on the two nocturnal predators. The small body size for Spotted Eagle Owl allows the owl to incorporate more prey categories of smaller size such as insects and small birds (personal observation). Significant variation in small mammal prey selection was observed between the Barn Owl and Spotted Eagle Owl, which has also been reported by (Mikkola, 2013). However, several studies comparing the diets of these two owls living in the same area have shown that they generally select the same mammalian prey (Reed, 2011).

The ability to diversify the use of a broad prey base by switching the main prey species to alternatives of low nutritional value, enables owls to be successful predators across a wide distribution range with opportunistic feeding strategy, and allows them to occupy a variety of habitats/territories despite the declining population of their main prey species (Tores *et al*., 2005)

5.1.2 Seasonal differences in diet composition

Prey species vary substantially by season or year at a single location (Kristiansen *et al*., 2011). It is common that owl diet should change with seasons as a result of prey fluctuations due to changing environmental conditions. However, the present study showed no significant statistical difference in the diet composition of Barn Owl in both seasons and at the two study sites. Although some variation in diet was apparent, this mainly took the form of a complementary shift in use of the same prey items available to the barn owls home ranges. This might be as a result of unpredictable weather changes in the course of the year as data was collected expectedly on normal seasons.

Small mammals formed the important food items for owls in both seasons. A wider niche breadth in dry season than in the wet season for Nairobi barn owls was attributed to consumption of alternative prey items to meet the food requirements. A wide diet breadth in Tsavo Barn Owl during the wet season is as a result of increased consumption of birds and other prey items to compliment low numbers of small mammals in the area. Very little rain compared was experienced throughout the year in Tsavo and since the area is semi-arid, this likely is expressed in the lack seasonal changes in the Barn Owl diet, a clear evidence of complimentary shift in the use of same prey items available in both seasons within the area.

A 13% dietary overlap in the two sites was realized, interpreted to be a consequence of different hunting localities. *Mus sp* predominated the diet of Barn Owl in Nairobi, during the dry season and *Crocidura* predominated in the wet season. In TENP, *Crocidura* predominated during the dry season while *Dendromus* predominated during the wet season. Similar variations in rodent population fluctuations have been reported (Eccard and Herde, 2013)

From this study's analysis *Crocidura,* is the most common food preferred for the barn owls in two seasons and in both localities. A peak of *Crocidura* in both seasons in the two sites is apparent; meaning that the species could thrive well in a variety of habitats ranging from moist human disturbed habitats to natural semi-arid protected landscapes, and therefore it tends to be the most important prey for Barn Owl in both localities. However, other authors have confirmed that high detection of *Crocidura* species in the Barn Owl diet could be due to increased diurnal activity of the species (Moysi *et al*., 2018). Higher consumption of birds by Nairobi Barn owl occurred during the wet season compared with the dry season. This might be attributed to greater numbers of bird in the wet season or could also relate to more diurnal hunting by owls in the wet season, or the dense grass cover hindered detection of the small mammals. However, the reverse was true for TENP. Huysman and Johnson, (2021) suggested that Barn Owl may opportunistically increase their use of birds, when the availability of rodents is low. Negligible proportions of insects in the order Orthopteran were consumed by Nairobi Barn Owl in wet season only, but in Tsavo significant numbers of insects were consumed in both seasons. Similar studies have reported insects in diet of Barn Owl, particularly when they are readily available or when the owl is unable to find other preferred prey species (McDowell and Medlin ,2009). However, a study elsewhere has reported barn owl populations to consume large invertebrates such as crickets (Kross *et al*., 2016). Landscapes show heterogeneity, geographic and seasonal variations can cause significant impact on prey items and fluctuation across habitats probably reflected in Barn Owl diet (Hindmarch and Elliot ,2015).

The diet of Spotted Eagle Owl varied significantly between the dry and wet seasons in Nairobi. Seasonal diet differences of the two species occupying the same area may be as a result of difference in habitat that they occupied. The swampy habitat (Ondiri swamp) occupied by Barn

Owl may continue to supply rich prey species despite the changing seasons, therefore not much fluctuation in prey would have been detected between the seasons compared to the Spotted Eagle Owl in Alliance Girls school.

In terms of seasonal variation in prey species consumed by Spotted Eagle Owl, *Mus* was predominant during the dry season while *Rattus rattus* was predominant during the wet season. *Lophuromys* was identified only in the dry season with no evidence for it during the wet season. Higher proportion of birds and insect were detected in the diet of Spotted Eagle Owl during the wet season than dry season, while Amphibians and Reptiles were consumed by the Spotted Eagle Owl during the dry season but not during the wet season. A similar trend of these prey fluctuations in the diet of Spotted Eagle Owl has been previously reported (Ali and Santhanakrishnan, 2012).

5.1.3 Comparison between consumed and available prey

Findings from this study has confirmed owl pellets and trapping employed are complimentary methods for inventorying small mammals. It was noted that, owls depredate small mammal species in slightly different abundances compared to conventional trapping. Test results confirmed that owl pellets are less biased because they capture greater species richness compared to trapping estimates. Even though there are potential biases associated with the use of owl pellet analysis, these do not seriously skew mammal community composition estimates (Heisler, 2016). Results from estimates indicated that some owls' species consumed prey species in terms of preference and others in terms of abundance or availability and ease of capture, depending on the habitat exploited. This concurs with some researchers who have established that barn owls usually make their feeding choices based on energetics and size of prey (OWL, 2017).

Diet analysis and trapping survey in the two study sites revealed significant differences in Barn Owl prey selection across habitats studied. All small mammal captured in trapping were represented in owl pellets but a lot of species captured in pellets were not detected in trapping. However, some few species frequently captured in trapping were not preyed upon by owls, a clear indication of prey preference by hunting owl. There was significant difference in prey selection by Barn Owl Occupying the two localities. Barn Owl in Nairobi predominantly preyed upon *Mus* when *Lorphuromys* was the most abundant prey captured in trapping. In TENP, *Gerbilliscus* sp was frequently captured in traps and also was the principal prey for the Barn owl in the area. These differences in Barn Owl prey selection depending on localities confirms the species to be opportunistic in Tsavo and a selective predator in Nairobi.

There was no significant variation in the small mammal prey in Spotted Eagle diet and those obtained from trapping survey. This therefore confirms the owl as an opportunistic predator, hunting whatever available or what exist in abundance. However, its diet was predominated by *Rattus rattus* while *Lemniscomys* was frequently captured in traps. This might be a result of the diurnal nature of *Lemniscomys* contrasting with the owl's mode of feeding. *Lemniscomys* in owls' diet explains the fact that owl occasionally hunts diurnally (Pierce, 2020).

In general, pellet analysis is confirmed to be an efficient method of sampling small mammals. Pellets detected higher diversity of prey than trapping survey. This concur with other studies that have reported owl pellets to be efficient sampling tool than traditional live-trapping due to lower effort and much weaker species-specific sampling biases (Torre *et al., 2015*). The low frequency of small mammals in traps might be caused by biases in the bait used. However, other authors conclude that some small mammals may become trap shy, therefore avoiding traps altogether

(Byers *et al*., 2019). In some instances, owls might be hunting far away from the study site. Other studies have reported the Barn Owl to hunt in open habitats for up to a maximum of 16 km from the roost site (Boves and Belthoff,2012). The present trapping survey concentrated only in 5km radius field around nesting and roosting sites, and this might cause significance difference in the two methods employed.

5.1.4 Small mammal prey dynamics in Muthangari

Small mammal communities have been used as indicators of habitat integrity and change (De Klerk, 2014). It appeared prudent to compare data collected prior to this study to understand small mammal species dynamics. Disintegrated Barn Owl pellets retrieved from Muthangari, Nairobi in 2005 was compared with current live trapping data. The time elapsed between previous pellet collected in Nairobi Muthangari suburb with the current trapping survey is 16 years. This period is long enough to detect significant changes in the small mammal communities due to habitat change (Balčiauskas and Balčiauskienė, 2021). These comparisons revealed higher diversity of small mammal in previous pellets than present trapping survey. A very low diet breadth was confirmed with trapping data than that of previous pellets. This may be due to increased urbanization within the area. Other studies have concluded that some species, called 'urban avoiders', disappear along with urbanization while others, called 'urban exploiters', invade and thrive well forming a large group that is capable of colonizing man-made habitats (Patankar *et al.*, 2021). Land-use changes in urban landscapes are considered the key drivers of biodiversity change or variation in species distribution especially at local scales (Petsch, *et al* 2021).

Analysis of previous pellets revealed *Rattus rattus* to be the most frequent species preyed upon by the Barn Owl, while present trapping survey revealed *Mastomys* as the most frequent species in the captures. These species are closely associated with human habitation because of their easy adaptability to different environment provided by man. They cause considerable damage to human foods and may become vectors of zoonotic disease and risk to human health. Similar studies have confirmed trivialization of communities with increased frequencies of synanthropic species in human disturbed habitats (Díaz, 2015). High population of commensal rodents is a clear indication of significant habitat modifications in Nairobi Muthangari suburb.

During present survey, no owl roosting or nesting site was identified in Muthangari for more pellet collection, as a result of owl migration. Similar other studies have reported migration of owls from detected active nests in some parts of the world (Rebolo-Ifrán *et al., 2017).* The absence of owl activity from previous nests agrees with the decreasing trend of these birds of prey (Martínez and Zuberogoitia, 2004). Migration of owls from the area and temporal correspondence between the taxonomic differences in the datasets is a clear indication of habitat change having great influence in predator prey relationships. Loss of foraging area, suitable nest sites and disturbance due to increasing urbanization in Muthangari could have been a major bearing in explaining the migration of owls to unknown sites to search for new resources. Similar studies have confirmed owls to be most sensitive to small-scale habitat change of their preferred roost therefore prompting territory desertion in disturbed habitats (Martínez and Zuberogoitia, 2004).

Results from this survey, using the two sampling methods, revealed Nairobi to have greater small mammal species rich compared TENP. It’s deduced that geographical and habitat differences affect small mammal prey diversity. Some populations exhibit fine-scale variability in demographic parameters, a phenomenon that suggests the contribution of local, rather than regional conditions and processes (Hardy *et al.*, 2006)

5.2 Conclusions

- Results from this study revealed small mammals as the most important food items for the owls occupying the two study sites. Other prey species made up complimentary food items.
- A wide dietary niche breath by Spotted Eagle in alliance girls was as a result of high consumption of other prey items in contrast to the sympatric Barn owl at Ondiri swamp in Nairobi area.
- The dietary 0.62 diet overlap index between Barn owl and spotted eagle owl confirmed the them to having no complete dietary overlap, therefore no competitive exclusion will occur. The dietary divergences between the two sympatric species, allows them to minimize potential competition for food, enabling coexistence.
- High diversity and diet breadth of prey species in Nairobi suburban environment than in TENP is attributed to the fact that urban environments are composed of complex mosaics of built up and densely vegetated areas. A clear reflection of moist habitat patches that favored the abundance of rodents and shrews. Human activities such as; irrigated farms and poor garbage disposal provides food for owls all year-round as these habitats are favourable for small mammal prey.
- Although, diet diversity of owls may be high in urban area, may also have negative long-term consequences for owl productivity, because some farming practices will continue to threaten this avian population, particularly through application of pesticides or rodenticides. High exposure of rodenticides may eliminate rodent populations and poses a greater risk to hunting owls.
- Low prey diversity in TENP is an indication of harsh environmental conditions in this landscape which is a major contributor of frequent owl migrations and low nesting rates.

This suggests that barn owls in TENP are dependent upon prey species that usually undergo frequent irruptions due extreme weather changes.

- There was no significant seasonal difference in the diet of Barn owls across all the habitats studied. However, Spotted Eagle Owl diet showed significant seasonal variation only in Nairobi area. Based on the unpredictable weather changes experienced throughout the year, I therefore, conclude that seasonal changes in the diet of both owl species were not captured well in this study, and further studies for similar owl species is crucial to inform conservationist to what needs to be done regarding protecting owl populations.
- Pellets and live trapping survey revealed significant difference in small mammal prey across all habitats studied. Higher diversity of small mammal was identified in owl pellets than live trapping. Barn Owl was a small mammal specialist at urban landscapes with a narrow diet breadth, only becomes a generalist predator when small mammal decline as was confirmed by TENP Barn owls that consumed their prey opportunistically. And their diets were supplemented by other prey items as a result of low small mammal abundance, therefore exploiting a wide range of habitats.
- No significant variation in the diet of Spotted eagle owl and trapping, confirming the species as an opportunistic predator, hunting on whatever available.
- Comparisons made from previous pellets retrieved from Muthangari, Nairobi, with the present live trapping; revealed high diversity in previous pellets than in current trapping survey. This was inferred to be a result of pronounced habitat change in the area and corresponding change in small mammal prey species.

- All methods employed were complementary for documenting small mammal prey species. The spatiotemporal constraints imposed by conventional trapping were overcomed by using owl pellets. Trapping only took 7 days and owl pellets accumulated over many seasons and covered a larger area sampled for rodents by the owls. Prey remains reflected longer term pattern of species abundance than the seasonal trapping efforts covering a relatively small area of the owl's hunting range. I therefore conclude that the two methods of inventorying small mammal populations are complimentary and can be used to support each other.

5.3. Recommendations

5.3.1 Further research

- I recommend further research to be conducted on the ecology of owls in other ecosystems to better understand the health status of protected landscapes. Information on the occurrence, distribution of owls will be crucial for formulating management interventions, setting realistic goals and monitoring the recovery of declining populations of raptors and small carnivores.
- Habitat changes that have led to the loss of small mammal species recorded in original habitats in urban areas, such as Muthangari Estate, should be investigated.
- Seasonal diet assessment was not captured well in this study due to unpredictable weather changes during the study period. I therefore recommend further long term monitoring to be conducted on seasonal prey dynamics so as to clarify the seasonal and spatial foraging traits of the two nocturnal sympatric owls. Along-term monitoring program would provide data on changes of the prey community structure and abundance.

- Since trapping surveys had species represented in pellets, I recommend longer trapping time to be employed in the same sampling area which would likely expand the small mammal species list.
- Further study using reference hair collection and molecular techniques should be used for identification prey remains in the pellets of the two raptors in future. which might reveal more prey items consumed by owls that have not left behind any bone remains or are broken beyond recognition and lack diagnostic features.
- Further tarphonomic research to be conducted over the prey remains to confirm bone modifications by different owl species.

5.3.2 Management/Conservation Actions

- Habitat degradation and its loss is the most threatening for owls' species and their prey. Therefore, land management is key to biodiversity conservation. Raptors conservation involves preventing mortality by conserving key sites and priority habitats, rehabilitating and restoring degraded habitats.
- These findings emphasize the intensification of human activities in suburban environment that is likely to further increase the abundance of pest and opportunistic species and which may lower overall species abundance and diversity in these areas. Achievement of conservation through biological control management practices such as establishment of owl nesting sites as rodent control measures could be instituted. This will protect biodiversity from the impact on pesticides which is associated with environmental damage and risks to human health.

- Owls are greatly persecuted by people due to superstitions associated to them. I therefore recommend public education and awareness to change people cultural attitudes towards owls so that they can appreciate the role of these nocturnal predators in controlling rodent population
- I recommend public participation in environmental issues directly affecting biodiversity in urban areas particularly in Nairobi suburbs.
- No owl roost or nest site was found around Ondiri swamp and instead owls nest was within people's buildings close to the swamp. I recommend reforestation around the edge of the swamp to provide a favorable habitat for owl nesting or probably artificial nests (construction of nest boxes) would be better alternatives.
- Due to extreme environmental changes within semi–arid protected area, this study recommends the need for maintaining high habitat heterogeneity in areas bordering the protected area to be a safe haven to counteract biodiversity decline.
- Galana riverine forest was hosting owls previously but during the present study, there was no owl nests or roost site identified in this area, probably due to occasional flooding. For instance, Elnino flooding occurred in 2018 rendered thousands of people homeless. It's evident that this flooding led to disappearance of owls foraging habitats and probably resulted to owl migration. I therefore, recommend control of upstream water system to be instituted, as this will go a long way in controlling flooding and management of this threatened habitat from future disasters.

5.3.3 Policy interventions

- The wide range of population decline arises because of substantial uncertainty about the number of species and inadequate monitoring of known species. Conservation stake holders take an opposing approach claiming that resources are scarce to conduct monitoring programs. I recommend policymakers to allocate funds for monitoring owls and their prey and pass legislations that regulate habitat modification in areas that are rich in biodiversity. Improved long-term monitoring would allow conservation to be appropriately targeted and effectiveness of interventions to be assessed particularly for Barn Owl and Spotted Eagle Owl.
- Urban green spaces provide habitats to a rich biodiversity of plants and animals. Regulations and policies on forest conservation are not strictly implemented here. This study recommends policy makers to work towards achieving integrated urban environment and striving to implement the provisions of Sustainable Cities Programme (SDG 11) of the UN Sustainable Development Goals.

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APPENDICES

Appendix 1: Analysis of pellets collected prior to this study from Muthangari in the year 2005

Taxa	**MNI**	**%MNI**
Rodentia		
Otomys	53	1.5
Rattus	345	16.3
Mastomys	335	15.8
Lemniscomys	200	9.45
Tarchyorectes	160	7.56
Mus	1	0.05
Shrew		
Crocidura eurda	20	0.95
crocidura sp.	344	16.3
Chiroptera		
Cardioderma	1	0.05
Hirposidoes sp.	2	0.09
Aves		
colias striatus	85	4.02
Eurocephalus anguitimens	76	3.59
Serinus striolatus	118	5.58
Turdosh hypoleucus	29	1.37
cuculus solitarius	9	0.43
Mandigoa nitidura	209	9.88
Nectarinia olivaceae	1	0.05
Amphibian		
xenopus laevis	127	6
Rana catebiena	1	0.05
Reptilia		
larceta jacksoni	1	0.05
20	**2118**	**102**

Appendix 2 :list of small mammal commununity and other forest fauna previously documented by other scholars in nairobi area

Small mammal previously documented by other scholars in Nairobi area include: black rat*(Rattus rattus),s*triped grass mouse(*Rhabdomys dilectus), s*triated grass mouse*(Lemniscomys striatus)*, natal multimmamate rat*(Mastomys natalensis)*, grey climbing mouse *(Dendromus melanotis)*, southern African Vlel rat*(Otomys irroratus)*, woodland thicket rat*(Grammomys dolicheurus)* boehmi gerbil*(Gerbilliscus boehmi)*, ochre bush squirrel *(paraxerus ochraceus)*, southern giant rat*(crestomys ansorgi) ,*Gray bellied pigmy mouse*(Mus triton),* house mouse*(Mus musculus),* Angoni Vlei rat*(Otomys angoniensis) ,*Gambian pouched rat*(crestomys gambianus),*groove toothed swamp rat *(Pelomys fallax),*Rufous-nosed rat*(Oenomys hypoxanthus),*woodland dormouse*(Graphiurus murinus),* Elgon shrew *(Crocidura elgonius)* Jackson'*s* shrew*(Crocidura jacksoni)* Greater cane rat *(Thryonomys swinderianus)* (Temminck, 1827) *(* Musila *et al 2019*,Gichuki *1987).*

Other large mammals of global interest documented in protected green spaces in Nairobi area include :Bushbucks (*Tragelaphus scriptus*), Genet(*Genetta genetta*), Civet(*Civettictis civetta*), bush babies(*Galago senegalensis*), Porcupines(*Histrix cristata*), Syke's monkeys(*Cercopithecus albogularis***)**, Ground squirrel(*Xerus erythropus*), hares (*Lepus capensis*), Leopard (*panthera pardus),* Buffaloes' (*Syncerus caffer*), Red forest duiker (*Cephalophus natalensis*), Grey duiker (*Sylvicapra grimmia*), Dikdik (*Madoqua kirki*), Warthog (*phacochoerus aethiopicus*), Bush pigs (*potamochoerus larvatus*), Giraffe(*Giraffa Camelopardalis*),Spotted hyena(*Crocuta*

crocuta),Vervet monkey(*Cercopithecus aethiopicus),*Greater galago(*Otolemur garnetii*),White tailed mongoose(Ichneumia albicauda) (Abdullahi,2010

Appendix 3: List of small mammal communities and other forest fauna previously documented by other scholars in TENP.

TENP is a home of large mammal e.g., African Buffalo (*Syncerus caffer*), African elephant, (*Loxodonta africana*), leopards (*Panthera pardus*), lion (*Panthera leo*), black rhino (*Diceros bicornis*), burchells zebra (*Equus burchelii*), hippopotamus (*Hippopotomus amphibious*), waterbuck (*Kobus elipsip rimnus*), reticulated giraffe (*Giraffa camelopardilis reticulata*), grants gazelles (*Gazella grantii*), gerenuk (Litocranius walleri), lesser kudu (Tragelaphus imberbis), impala (*Aepyceros melampus*), warthog (Phancochoerus africanus), dik-dik (*Madoqua kirkii*), Hunter"s hartebeest (*Beatragus hunteri*), eland (*Taurotragus oryx*), fringe –eared Oryx (*Oryx beisa callotis*) (Titus 2020).

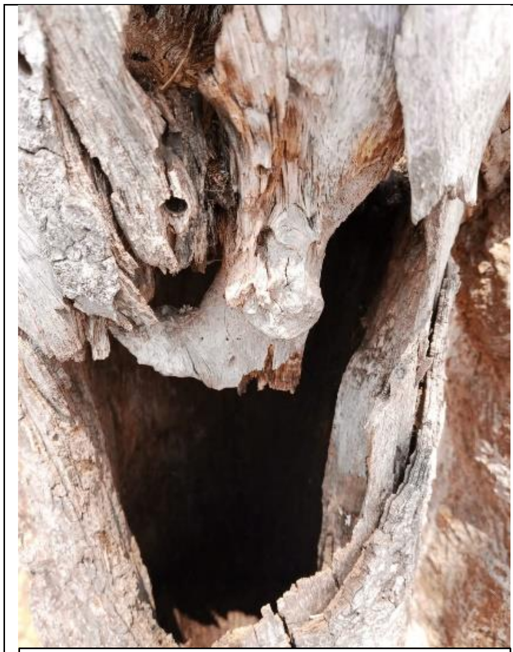
Despite having variety of these large mammals at least 8 species of small mammals' have been documented from previous studies. These include the genus *crocidura fuscomurina*, *mastomys, Acomys ignitus, Dendromus mystacalis, Dendromus melanotis Rhabdomys, Arvicanthis neumanni and Mus triton, Gerbilliscus nigricaudus, Gerbilliscus Kempi, mastomys natalensis, Thallomys paedulcus, Graphiurus microtis (*Musila *et al,.2019)*

Appendix 4: Sherman trap destroyed by Baboon in TENP.

Appendix 5(a, b, c&d): Barn Owl nesting sites in Tsavo East National Park

a. **Residential building** **b. Motor vehicle workshop**

Woodland area



C Trailer

d. Rhino sanctuary

Grass land area

Appendix 6 (a&b): Barn owl and Spotted Eagle Owl nest sites in Nairobi

a. **Spotted eagle owl in Alliance Girls (2 owlets on the left**)

b. Barn Owl nest inside a ceiling in a building close to Ondiri swamp

Appendix 7: The Relative Composition (%) Of The Diet of Barn Owl and Spotted Eagle owl in Nairobi derived from analysis of the Minimum Number of Individuals (MNI).

Prey Species	Common name	Barn Owl		Spotted Eagle Owl	
		MNI	%	MNI	%
Small mammal					
Mastomys sp	Multimammate rat	49	6.1	20	6.5
Rattus sp	Black rat	54	6.7	46	14.9
Tarchyorectes sp	Root rat	5	0.6	11	3.6
Thamnomys sp	Thicket rat	9	1.1	36	11.7
Mus sp	Pigmy mouse	188	23.6	34	11.4
Rhabdomys sp	Grass mouse	4	0.5	0	0
Otomys sp	Vlei rat	98	12.3	37	12
Lophuromys sp	Brush-furred rat	69	8.6	23	7.5
Lemniscomys sp	Striated grass mouse	35	4.4	2	0.6
Grammomys sp	Thicket rat	2	0.3	0	0
Acomys sp	Spiny mouse	42	5.3	17	5.5
Dendromus sp	Climbing mouse	42	5.3	0	0
Arvicanthis sp	Unstriped mouse	3	0.4	0	0
Oenomys sp	Rufous -nosed rat	1	0.1	0	0
Cardiodermar sp	Heart-nosed bat	1	0.1	0	0
Crocidura sp	Musk shrew	187	23.4	33	10.7
Mandigoa sp	African yellow bat	1	0.1	1	0.3
Bird					
Pycnonotus sp	Common bulbul	2	0.3	0	0
Psedonigrita arnaudi	Grey-capped weaver	2	0.3	0	0
Colias solitaries	Speckled Moosebird	1	0.1	1	0.3
Phyllastrephus terrestris	Brown bulbul	1	0.1	0	0
Serinus striolatus	Canary	0	0	1	0.3
Diglossus occipitalis	Long crested eagle		0	2	0.6
Turdus olivaceus	True thrush	0	0	11	3.6
Ploceus sp	Weaver bird	0	0	1	0.3
Eurocephalus sp	shrikes	0	0	1	0.3
Reptiles					
Lacerta jacksoni	Rock Lizard	1	0.1	1	0.3
Amphibians					
Bufo sp.	True toad	0	0	1	0.3
Hemisus mamoratus		0	0	10	3.2
Invertebrates					
Orthopteran	Moths	1	0.1	14	4.5
Coleopteran(beetles)	Beetles	0	0	3	1
Decapoda	Crabs	0	0	2	0.6
Total		**798**	**99.8**	**308**	**100.0**

Appendix 8: Comparison of Barn Owl diet composition in Nairobi and Tsavo East, expressed in MNI and relative abundances

PREY TAXA	FAMILY	PREY SPECIES	NAIROBI		TSAVO EAST	
			MNI	%	MNI	%
RODENTIA	Muridae	Mastomys sp	49	6.1	53	3.6
		Rattus rattus	54	6.8	0	0
		Rhabdomys sp	4	0.5	16	1.1
		Tarchyorectes sp	5	0.6	0	0
		Thamnomys sp	9	1.1	0	0
		Mus sp	188	23.6	76	5.1
		Acomys sp	42	5.3	12	0.8
		Grammomys sp	2	0.2	0	0
		Lemniscomys sp	35	4.4	0	0
		Lophuromys sp	69	8.7	0	0
		Otomys sp	98	12.3	0	0
		Oenomys sp	1	0.1	0	0
		Gerbilliscus sp	0	0	82	5.5
		Arvicanthis sp	3	0.3	115	7.7
	Nesomyidae	Dendromus sp	42	5.3	548	36.8
Shrew	Soricidae	Crocidura sp	187	23.5	364	24.4
Chiroptera	Megadermidae	Cardioderma sp	1	0.1	7	0.5
	Mollossidae	*Tadarida limbata*	0	0	2	0.1
	Nycteridae	*Nycteris thebaica*	0	0	1	0.1
Aves		*Colias striatus*	1	0.1	4	0.3
		Pycnonotus sp	2	0.2	14	0.9
		Phyllastrephus sp Terrestris sp	1	0.1	0	0
		Serinus mozambicus	0	0	1	0.1
		Aplopelia sp	0	0	6	0.4
		Mirafra sp	0	0	8	0.5
		Apus sp	0	0	1	0.1
		Oena capensis	0	0	1	0.1
		Acrocephalus	0	0	1	0.1
		Turdus olivaceus	0	0	7	0.5
		Dioptornis sp	0	0	1	0.1
		Ploceus sp	0	0	3	0.2
		Plocepasser sp	0	0	4	0.4
		Mandigoa sp	1	0.1	0	0
		Pseudognigrita arnaudi	2	0.2	0	0
Reptilia		*Lacerta jacksoni*	1	0.1	1	0.1
Amphibian		Anura sp	0	0	1	0.1
		Rana catebiena	0	0	1	0.1
		Bufo sp	0	0	2	0.1
Insecta		Orthoptera	1	0.1	66	4.4
		Coleoptera	0	0	15	1.0
		Decapoda	0	0	76	5.1
No .of Prey Items	**41**		**798**	**99.6**	**1489**	**100.3**
No. of pellets			**371**		**418**	
H			**2. 201**		**2.015**	
J			**0.6924**		**0.59**	
MEAN ± SE			**19.0714±6.800**		**36.3171 ±15.97**	

Appendix 9: Seasonal changes in the diet of Barn Owl and Spotted Eagle Owl in Nairobi study area expressed in percentage number of individuals

Taxa	Dry	Wet	Dry	Wet
	N%	N%	N%	**N%**
Rodentia				
Acomys sp	9.7	0.5	7.3	0.8
Grammomys sp	0.5	0	0	0
Lemniscomys sp	5.8	2.9	0.4	0.8
Lophuromys sp	11.4	5.7	10.5	0
Mus sp	23.5	23.6	14.2	2.4
Otomys sp	13.1	11.4	12.3	8.1
Rattus sp	3.8	9.9	8.3	22.6
Rhabdomys sp	0.7	0.3	0	0
Tarchyorectes sp	0.2	1	4.1	1.6
Thamnomys sp	1.5	0.8	1.4	4
Dendromus sp	0	10.9	0	0
Oenomys sp	0	0.3	0	0
Arvicanthis sp	0	0.8	0	0
Mastomys sp	6.6	5.7	9.2	6.5
Shrew				
Crocidura sp	21.6	25.5	12.8	6.5
Chiroptera				
Cardiodermar sp	0	0.3	0	0
Aves				
Colias striatus	0.2	0	1.4	0
Phyllastrephus terrestris	0.2	0	0	0
Pseudonigrita arnaudi	0.2	0	0	0
Ploceus sp	0	0	1.4	0
Mandigoa sp	0.2	0	0.5	0
Serinus striolatus	0	0	6.8	26.6
Turdus olivaceus	0	0	2.8	4
Spreo sp	0	0	0	2.4
Dicroglossus occipitalis	0	0	0.9	0
Eurocephalus sp	0	0	0	0.8
Pycnonotus sp	0	0.5	0	0
Reptilian				
Larceta jacksoni	0.2	0	0.5	0
Amphibian				
Bufo sp	0	0	0.5	0
Hemisus marmoratus	0	0	4.6	0
Anthropods				
Coleoptera	0	0	1.6	0
Orthopteran	0.3	0	1.4	8.9
33	**412**	**385**	**218**	**124**
No.pellets	**171**	**200**	**62**	**50**